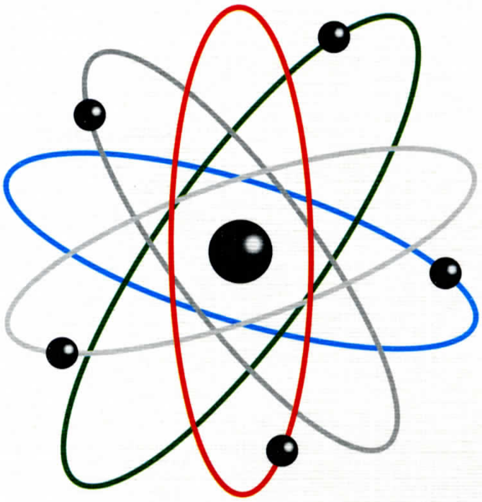
A.V. Aganov
R.K. Safiullin
A.I. Skvortsov
D.A. Tayurskii



PHYSICS HERE, THERE AND EVERYWHERE

Qualitative Problems in Physics

Kazan State University
2003

A.V. Aganov
R.K. Safiullin
A.I. Skvortsov
D.A. Tayurskii

PHYSICS
HERE, THERE AND EVERYWHERE

Qualitative Problems in Physics

Kazan State University
2003

ББК 22.3
А 25

Scientific Edition by Prof., Corresponding Member of RANS A.V. Aganov

A.V. Aganov, R.K. Safiullin, A.I. Skvortsov, D.A. Tayurskii

A 25 **PHYSICS HERE, THERE AND EVERYWHERE** Qualitative Problems in Physics – Kazan: Kazan State University, 2003, 160 p.

JSBN 5-7464-0723-2

This book contains more than 1500 problems in different parts of the physics. They vary in their difficulty and extend from simple to very complex and requiring deep knowledge of physical phenomena. The problems are mainly qualitative, almost all of them have solutions, answers, or notes which can be found in the second half of this book.

We may recommend this edition for both alumni, teachers and professors of high schools and universities.

Publication of this book supported by
REC - 007

Последнее русское издание этой книги вышло с грифом:
"Рекомендовано Министерством общего и профессионального образования Российской Федерации для использования в учебном процессе"

JSBN 5-7464-0723-2

Preface

By solving qualitative problems one obtains the necessary component of his/her education in the physics. Not requiring cumbersome mathematical calculations, these problems make the reader to concentrate its attention on the physical essence of the phenomena, on their interconnections and revealing forms. The analysis of the problems of that kind makes deeper the understanding of fundamental laws and concepts of the physics and excites an interest of the reader in a new perception of the surrounding world.

In creating this book the authors used their large and long experience on both lecturing and teaching the physics. We worked many years with the high school pupils, those who had to pass examinations in physics to be admitted to the Kazan University, and the students of first years of university curricula. This book contains about 1500 qualitative problems in the physics. In a certain part, it is original and composed by the authors for admission examinations and Physical Olympiads of different levels. Other part was composed by problems known in preceding years and from other literature sources. But even these problems were carefully edited and revised. In the second half of this book the authors give notes and solutions to practically all formulated problems. We hope that these solutions will be very useful namely for those readers who will use this book for a self-education.

The problems are divided into traditional sections of the physics: kinematics, dynamics, etc. In spite of rather conditional subdivision and structure of the book, the latter helps to make your knowledge more systematic and reveal and illustrates the variety of laws of the physics and thus of the Nature.

First of all, this book seems to be useful for teachers of the secondary and high schools. It will both help them to prepare better lessons and amplify their course in additional hours. The book also should help them to organize some experiments for their pupils.

It may turn useful also for university professors and lecturers in physics, because it contains a lot of illustrative and problem materials.

The "Physics Around Us" certainly will give a valuable help in autonomous study of this science to the pupils at various preparatory levels and will helps to those who are preparing to enter a higher school.

Professor ***A.I.Fishman,*** Doctor of Science.

From the authors

The main objective which we had put in front of us when started this book of qualitative problems in the physics, was to arouse in both pupils and students an interest to the physics by helping them to understand deeper the various and numerous physical phenomena.

The main part of the problems in this book (containing more than 1500 problems) have the qualitative character and do not require cumbersome mathematical calculations. However, one cannot resolve these problems neglecting fundamental laws of the physics. In some cases an estimation is required, though not exceeding the ordinary scholar elementary mathematics. Our trend was to use rigorous but comprehensive notes and solutions which should be sufficient for understanding of phenomena under consideration without referring to the special sources. This makes us able to say that this book can be used as a rather helpful source for a self-education.

We included into this book the problems published in XX century in other handbooks in Russia, which seem for us most interesting from our point of view. All cited problems were carefully revised; both the questions and the answers were refined in order to correspond to modern physical concepts. Some problems were properly composed by the authors. These problems were suggested to participants of Physical Olympiads of city and republic level in 1986-1995.

This book contains problems of very different complexity: some of problems might seem very simple (and thus will excite a smile of a professional), meanwhile others may turn rather complicated even for a well-prepared reader.

We hope that the book will be useful and interesting for both young people starting their path to the science and even to their moms and dads, who ought to answer quests of their curious children. It was written for all those who wish professionally study and teach the physics.

The authors.

Translation of this book into English was even interesting: you should try to understand how it would be perceived by a reader which uses a different linguistic system. Anyhow, in working on the English version of these problems, I was bearing in mind the trend to supply an adequate physical interpretation of these qualitative physical problems in a different language, but not sense.

I would like to encourage those who will read and work with this book. Anything which could help you in reading and understanding of this book will be pleased if sent to my electronic mailbox: tagir@rumath.kcn.ru.

Tagir S. Tagriov, Ph.D.,
Scientific Translator

Chapter I

Basic Laws of Mechanics

Kinematics

I.1. The graphs of displacement of three rectilinear motions are given below (see Fig. I.1). What is the difference between these motions? Indicate the motions with the greatest and least velocities.

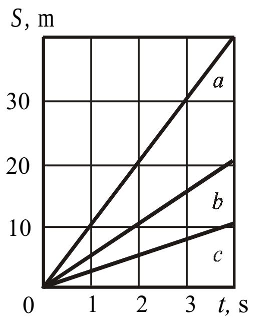


Fig. I.1

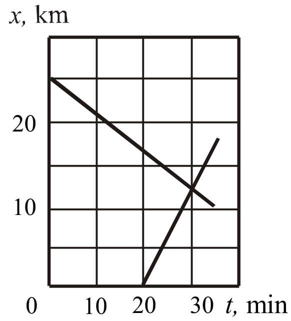


Fig. I.2

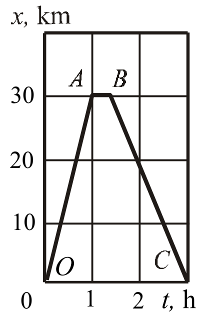


Fig. I.3

I.2. Using the graph (see Fig 1.2), determine the place where the automobiles will meet. Given that they move rectilinearly, determine their velocities and the time necessary for each before they will meet. Note that cars leave at different moments the points with the distance 25 km between them.

I.3. In Fig.I.3 you can see a graph of the motion of an automobile. Indicate the character of the motion at each of graph's segments. Evaluate the velocity of the automobile.

I.4. On its route, a bus must pass a path of 6km between endpoints. Consider the graph given in Fig. I.4 and answer the following questions: a) how many buses are on that line? b) what is their average velocity? c) what is the time necessary to make "there and back" for a bus?

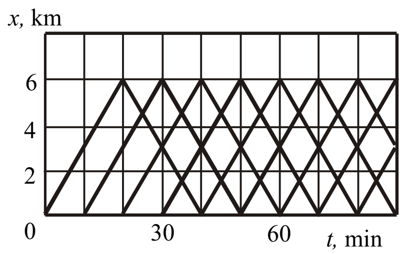


Fig. I.4

I.5. In Fig. I.5 the velocity graph for a body moving rectilinearly is given. What is the type of this motion? What value does equal the area of each square in this draw? What is the way passed by the body in first 4 seconds? last 4 seconds?

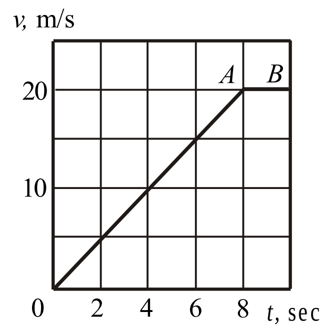


Fig. I.5

I.6. For the motion given in the previous problem, construct the graph of the acceleration with respect to time.

I.7. Two trains go towards each other: one goes with acceleration to the North, other decelerates to the South. What are the directions of the acceleration of each train?

I.8. An automobile moves on road's bend. Whether both the right and left wheels pass the same distance?

I.9. If a body moves under the action of a wind, then its velocity does not exceed the velocity of the wind. A platform on skates with a sale (constructions of that type are called "wind-skates") moves over horizontal ice surface by the force of a wind. It turns out that the speed of this construction may be 2 to 3 times grater than wind's speed. Try to explain why this construction may overpass the velocity of wind.

I.10. May a water-skier move faster than a boat tracking him/her? May the boat move faster than the water-skier?

I.11. You are in a moving train and are looking through the window on another train moving in the opposite direction. After its passage behind your window, you feel as if your train's move now is slower. Explain the reason for this feeling.

I.12. The rain traces over a window glass of a moving bus are skew. Can you explain why? Why do these traces have different slopes?
I.13. On a floating ship somebody threw up (vertically) a ball. Will it fall down on the same place if the ship goes: a) uniformly? b) with an acceleration? c) with a deceleration? d) what is the trajectory of the ball with respect to the shore? Disregard the air resistance.
I.14. In a uniform motion of a train, a ball falls down to the floor from the upper place (recall that trains in Russia have passenger places–beds in two levels – one lower and one upper). Will it fall vertically? Compare the answers of an observer going by this train and an observer who watches from a station.
I.15. A rider is on a horse which gallops directly with a constant speed. The rider wishes to jump through a circle, and then, of course, meet his/her saddle again. What is the way in which he/she must jump? Neglect the air resistance.
I.16. When one fires, in order to hit a target he/she ought to direct his/her riffle a bit above the target. Why? When must this exceeding height be greater – for close targets or for far targets?
I.17. From an airplane, horizontally flying with a constant speed, a weight was thrown downwards. In what place with respect to the airplane will this weight land? Answer with taking into account the air resistance.
I.18. As known, an airplane, which makes the flight Kazan-Moscow, takes off and lands … at the same astronomic time. Estimate the average speed of the plane provided that the geographic latitude of both cities ~56^o on the north hemisphere.
I.19. Earth rotates from West to East. Then, having jumped up, why do we land at the same place and do not move to West?
I.20. To what limit may grow the acceleration of a motion over an inclined plane as its inclination grows?
I.21. In Fig. 1.6 you may see the graphs of the accelerations of: a) a motion of a freely falling body and b) a movement of a ferrous ball attracted by a magnet. Explain the reasons for the difference between graphs of the accelerations of these non-uniform motions.

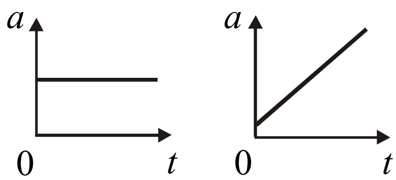


Fig. I.6

I.22. A tractor (on tracks) moves at the speed 9km/h. What are the speeds of its upper and lower parts of the track with respect to the ground?

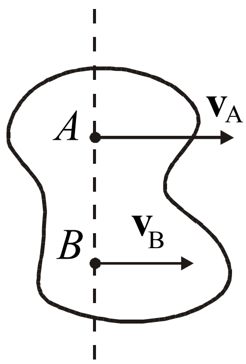


Fig. I.7

I.23. Upon the wheels of a bicycle one can see casings to protect a cyclist against mud. Both the bicycle and cyclist move with the same speed. Then why (and how) can the mud from wheels reach the cyclist in this case?
I.24. Imagine a wheel of a train, which moves. Now explain why at each moment of the motion this wheel has some points which a) are still? b) even move backward? What are these points?
I.25. A wheel rolls over a road. Why sometimes do its upper spokes seem non-sharp as a disk, while the lower ones looks in focus and may be distinguished?
I.26. How will a body (Fig. 1.7) move if some two its points *À* and *Â* have different linear velocities?
I.27. Estimate how would change the quantity of days in a year if we were able to change a) the direction of the Earth rotation or 2) the direction of Earth orbit around the Sun to opposite?
I.28. A boy has in his hands one end of a wooden plank, while another lies on a cylinder. The plank is horizontal. Then the boy moves the plank forward and thus the cylinder rolls without sliding over a horizontal plane. In addition, suppose that the plank does not slides on the cylinder. Given that *l* is the length of the plank, what is the way the boy must walk to reach the cylinder?
I.29. A gear with 6 teeth is in contact with another gear with 18 teeth. How many complete rotations around its axis must the smaller gear make if we know that it will pass one lap around the greater one (the latter does not move)?
I.30. Clearly, the hands of a clock and watches differ. Consider the minute hand. For these two devices, which one will have the greater linear velocity of the end of its minute hand? Give the answer for their angular velocities.
I.31. Visual observations of satellites and their carrying rockets show that, in spite of their very

poorly aerodynamic form, the last ones move around the Earth faster than satellites. Answer why.
I.32. Rails for a tram must be non-smooth, otherwise it will spin. However, on sharp bends, they even grease rails. What for?

I.33. Suppose that cosmonauts are near one of the stars of a star cluster. They see that all other starts of the cluster move out with velocities proportional to distances to these stars from observers. How will change (if ever) the picture of the star motion if now they are near another star of the same cluster?

Inertia and mass

I.34. A train approximates to a station and thus decelerates its velocity. In what direction would it be easier to drag a heavy box on car's floor? Toward the station or in the opposite direction?

I.35. At the room's ceiling in a ship a little load is fixed. The ship goes directly and without acceleration. To what direction will this load move with respect to the room if the ship: increases its velocity? decreases its velocity? turns to the left? or suddenly stops (not Titanic)?

I.36. A man stumbles. Why does he fall? In what direction?

I.37. Invent a way to use the motion inertia to eliminate a drop of ink from the end of a pen (for those who never had seen such writing device as pen: how to remove a drop of a liquid pigment from the end of a tiny brush)?

I.38. A wind engine is often equipped with an inertial accumulator, i.e., with a heavy disk called flywheel. This uniforms the motion of the engine in spite of constant changes of wind's speed. Similar heavy flywheel are used in piston engines (in cars, lorries, vapor engines, etc.). Explain the action of a flywheel.

I.39. How could you explain that in a medical thermometer the mercury almost instantly goes down when one shakes its strongly?

I.40. What are the ways to place an ax on a handle? Explain the processes and events.

I.41. It is not too difficult to juggle with a two-meter stick upon your fingers, but the same is practically cannot de made with a match. Why?

I.42. A cosmonaut in the open space pulls toward himself/herself a halyard fastened to a cosmic station. Why does not the cosmic station assume an observable velocity toward the cosmonaut in this case?

I.43. You are playing in "tag" with your friends. Why it is difficult to catch a partner when he/she permanently turns to different sides?

I.44. If a running man want to change sharply his direction, he embraces a tree or a pole. Explain why does he do it.

Force. Adding and decomposing forces

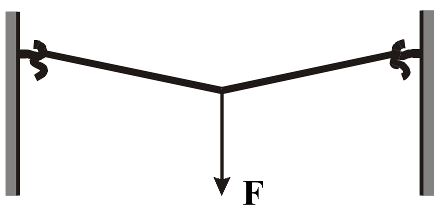


Fig. I.8

I.45. To the middle of a tightly strained cord a less strong rope is bound. They pulled it down (Fig. I.8). The cord has broken while the rope not. Explain the phenomenon.

I.46. A towage of a ship even in a small sea storm is very difficult, because waves may throw ships in opposite directions, strain and broke the cable. To avoid it, sailors fix some heavy loads (anchors, metal pieces, etc.) near cable's center. Why do they do it?

I.47. Your automobile (not you, of course) has got into mud in a forest. Having only a cable, how would you liberate your vehicle?

I.48. Climb the Swedish Wall (a kind of ladder) and hang on your hands. How should one position his/her hands for lesser efforts?

I.49. Could one stretch a rope between two trees in such a way that there was no any sagging?

I.50. When do the ropes of a hammock more tighten: if they have slope, or when they are almost horizontal?

I.51. How may one weight a suitcase of approximately 300N by using spring balance graded up to 200N?

I.52. Two men pull a rope in opposite directions, each with the force 100N. Will this rope tear if its maximal load is 150N?

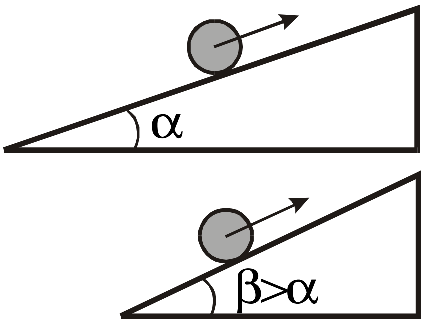


Fig. I.9

I.53. Under what inclination (greater or smaller, see Fig. I.9) will the barrel press stronger upon the plank?
I.54. A pole (for electric supply or for telephone line) must be set on a place where line has a bending. How must one set a support log for this pole? How must one set a guy-rope instead of the support log?
I.55. What is a force to be applied by a man who keep himself by a rope in his arms if the rope is bound to his body and then goes over a fixed pulley?
I.56. Why do fishers use rods with thin and elastic ends and even bound the fishing line to a rod through a ribbon cord?
I.57. To expand elastically a spring for the length l the force F is required. What is the force necessary to expand elastically for the length l two same strings if: they are parallel? consecutive?
I.58. If sausages are cocked in boiling water, why do they burst along their length and not in cross direction? (In Russia sausages are usually produced each in individual polyethilene envelope)
I.59. Why it is easier to cut food not by simple pressing over the knife, but by moving it backwards-towards?

The second Newton law

I.60. How can one determine the average resistance force which acts against a raft in water if observer has no a dynamometer?
I.61. Why does a volleyball mesh strongly tightened can break under ball strokes?
I.62. A man makes long jump. What must be the direction of a force with which a man acts towards the ground in order to make the most long jump? Neglect resistance of air. Consider jumps with some start runs and without.
I.63. The pressure of gunpowder onto a projectile in a stem channel attains 35Mpa. Due to this fact, the projectile may assume the initial speed near 10km/s. Nevertheless, gun was proved to be useless to launch a spacecraft. Meanwhile, by applying a rocket engine, we may impart to a spacecraft the necessary cosmic velocity. Why?
I.64. A heavy anvil is imposed onto the breast of a circus artist. Why does a hammer stroke over the anvil make no harm to the artist, while the same without anvil would simply kill him?
I.65. Why are anvils made massive?

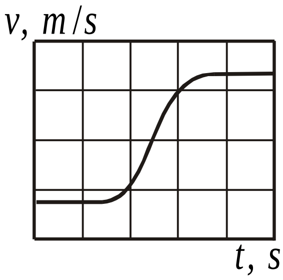


Fig. I.10

I.66. Acceleration of a moving body is directly proportional to the resulting force and inversely proportional to its mass. Explain why, on a horizontal piece of railroad, might a train have no any acceleration, in spite of the tracking force of a locomotive being both constant and positive and the mass of a train being also constant?
I.67. In Fig. I.10 you can see the graph of the speed of a body which moves rectilinearly. What could you say about resulting force acting upon this body?
I.68. A skater wants to stop. Why does the skater have to put the skates at an angle to each other?
I.69. If a locomotive cannot shift ahead a heavy train, then the machinist first puts train back and then forward. What is it done for?
I.70. In a manual weeding why should one take off weeds rather slowly?
I.71. What is the force of a cobra when it moves vertically upwards at the speed v in preparing to jump? Cobra's mass is m, its length is l. At the first moment it lies curved to a ball on the ground.
I.72. How can a boy weaken the stroke of a heavy ball when cuts it with his hand?
I.73. If you land down after a jump, you must cower elastically. Landing with "straight legs" is dangerous for health. Explain the reason for it.
I.74. In jumping down from a third of even forth floor of a building (for example, in a fire) onto a stretched canvas, why might a man have no harm for his health?

I.75. Is falling down onto a frozen ground much dangerous than onto a fresh snow?
I.76. Why does a glass plate break if falls on a stone and does not break in falls onto grass?
I.77. Why do train machinists afraid to stop trains on a rise?
I.78. Mine cages moved by a cable are lifted up: first with acceleration, then uniformly, and then decelerate before the stop at surface. How does the character of motion affect the stretching load of a cable? When, most probably, might the cable torn?
I.79. A plumb line is weighted at the end by a body *A*. To *A* through a spring another body *B* is bound. Whether these bodies will fall with the same acceleration if one has fired up the line?
I.80. Two balls of the same size with masses m_1 and m_2 ($m_2 > m_1$) are bound with a line whose length is much greater than the radii of balls. Balls are thrown down from a sufficiently large height. Determine the tension force between these balls falling in air at a sufficiently large time after throw.
I.81. Why would a parachute be helpless when one must jump down from a rather small height?
I.82. Whether we might apply the formulae of a free fall to the motion of a man who has jumped wit a parachute from an airplane?
I.83. Theoretically, the most distant shot from a gun is attained if the stem slope is 45^0 to the horizon. Practically, this angle of maximally distant shot equals some greater value, for instance 52^0. Explain the reasons.
I.84. A box *A* is filled with water, while *B* contains the honey. In what of the cases a bullet will have a longer trajectory: 1) first through *A* then through *B* or 2) first through *B* and then through *A*? Consider the case where resistance to bullet's motion is proportional to its velocity.
I.85. A sand clock has been put on one of pans of a precise balance. The sand flows freely from the upper part to the lower. At each moment, a definite quantity of sand particles are in air and they thus do not press the bottom vessel. Therefore, if sand flows, the sand clock should weight less than when all sand will be on bottom. But, this does not happen and clock's weight is always same. How could you explain this?
I.86. Suppose you are on the top of body scales and the pointer is calm. When you cower down. What will happen to scales pointer at the beginning and at the end of your squat?
I.87. Estimate the time of elastic stroke between two similar metallic balls.
I.88. A bullet shot from a rifle makes a hole in a door but fails to open it. Meanwhile a finger can open a door but cannot make a hole. Explain why.
I.89. A pneumatic bullet is shot through an empty thin glass cup. Why the inlet hole is lesser than the outlet one?
I.90. Dams for water–power stations have a slanting descent at their tale race, to where the water runs. Explain the reasons why?

The Third Newton Law

I.91. A horse pulls forward a loaded carriage. By the third Newton law, the force with which the horse pulls the carriage equals the force with which the carriage pulls the horse. Then, finally, why does the carriage move behind the horse?
I.92. We are on a railroad. Whether in clashing both buffers of two equal cars are compressed at the same degree? If there clash a loaded car and an empty car?
I.93. The road is covered with thin ice. Why does a car take off so hardly?
I.94. Baron Munchhausen, the hero of famous tall–story taller by Rudolf Erich Raspe, says: "Well, I caught my own hear and with all force of mine I strongly pulled me myself upwards and thus I took from a bog both me and my horse - I embraced it with my legs as a nipper…" So, could he save himself in that way?
I.95. A rope goes over a sheaf (fixed pulley). At one of its ends we see a hanging man keeping the rope with arms. To another end a load is bound equaling the mass of the man. The man starts to climb up by hands. What will happen to the load?
I.96. You have a sailboat and decide to move by using a large onboard ventilator. Whether it is possible? What will happen if your ventilator will blow outside the sail?

Impulse Conservation Law. Jet Motion

I.97. On one end of a straw a grasshopper sits. What is the least velocity v of jump with which it will reach the opposite end? Assume that there is no friction between the table and the straw. Mass of the straw is M, its length is l, grasshopper mass is m.
I.98. Applying the same force, when will you throw a stone at a longer distance if you either a) stay on the ground or b) stay on skates on ice?
I.99. Two similar caretakers roll two on same light carriages over a very slippery ice. They roll in parallel ways and with same speed. Snow starts to fall. One of the caretakers throws the snow from his carriage uniformly in all sides around, while other simply sleeps. Which carriage will pass greater distance? Take into account that carriages cannot move in direction perpendicular to their wheels.
I.100. In a large bath a pan floats. We see a hole in pan's bottom corked with a piece of sugar. After sugar melting to where will the pan move?
I.101. Interior forces cannot change the position of mass center of a system. Then why does a rocket fly?
I.102. What affects rocket motion if exterior forces are not present?
I.103. In a space flight, the velocity of gas jet with respect to the spacecraft may turn to be less than the velocity of the spacecraft with respect to Earth. Does grow in this case the velocity of the spacecraft?
I.104. Why the resulting speed of a multistage rocket drastically exceeds the final velocity of a one-stage rocket of the same mass and same volume of fuel?
I.105. A meteorite burns in atmosphere and does not reach the surface of Earth. What happens to its impulse?
I.106. The hand launcher of a counter-tank gun is a tube open from both sides. Explain why can one shoot with large and rather heavy rockets from these big–calibre guns, which is not possible from ordinary lock–guns?
I.107. How is realized "soft–landing" of a spacecraft?
I.108. A large closed glass bell jar with a bird is placed on a scale pan. If the bird will fly up and soar inside the jar, the balance should seemingly lose their equilibrium since the pressure upon the scale pan done by the bird will vanish. Is it true?

Angular Momentum. Torque

I.109. Why it is much easier to unscrew a nut with a long key than with a short one?

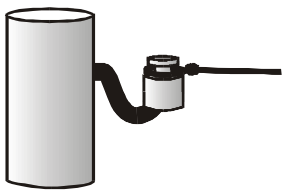


Fig. I.11

I.110. Why it is easier to break a long rod than a short one?
I.111. Wires which supply electric power are fixed at a pole by means of isolators (see Fig. I.11). Why do they bend the hook of isolator so that the axis of hook's screw lie in one plane with the wire?
I.112. If one sharply brakes a car, why does the front part of the car go down?
I.113. A bicycle both front and rear brakes. What is the they should be switched on if a sudden stop is required?
I.114. On a rope loop a stick is hanged horizontally. One of stick ends is much thicker than other end. Let us cut the stick at the place where the rope was bound. Compare the weight of obtained two parts of the stick.
I.115. A ring (see Fig. I.12) lies on a table, a line is bound to it at the point A. Explain how will the ring move under action of the force F of the line's stretch.
I.116. An electric coffee mill is a closed cylinder with an electric engine. Can you determine direction of engine rotation without disassembling it?
I.117. Why do they use at least two propellers on a helicopter?
I.118. A coin rolls over table. Why does its stability depend on the rotation speed?
I.119. Two solid balls similar in size and mass roll without slipping from the same height along an inclined plane within different times. When is it possible? There is no any other field except gravity.

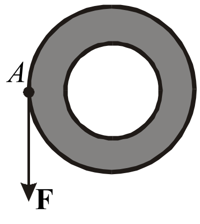


Fig. I.12

I.120. Two hollow spheres, one made of copper and other of aluminum, have the same volume and weight. Moreover, they are paint into same color. How may one distinguish them?
I.121. How would affect the “easy run” of a bicycle an increase of wheels’ diameter? All other parameters are assumed to remain same.
I.122. Explain the action of an oar considered as a lever.
I.123. An adult man stands at the left edge of a deep trench and a boy is on the opposite edge. They need to cross the trench. Each has a wooden plank whish is slightly shorter that the trench width. How could they pass from one edge to other?
I.124. A trolley driver needs to disconnect a trolley from upper wires. Before to make it the driver forces the rope bound at the trolley it as back as possible. What is the reason for this action?
I.125. In cutting by scissors a metallic wire, it is convenient to put the wire as close as possible to scissors’ screw axis. Explain the reasons.
I.126. Why they do make tin snips with much shorter blades than scissors for tissue?
I.127. A log is hoisted along an inclined plane by a rope as shown in Fig. I.13. Do they gain in force? In work?
I.128. A tower crane for hoisting heavy bodies has an arm, which usually makes an angle with the horizontal. By changing this angle of slope the loading capacity of the crane will also change. How and why does it change? In what position the crane will have the least capacity?

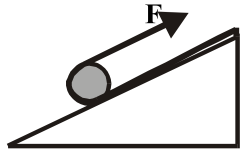


Fig. I.13

I.129. Under what condition can a screw serve for fastening details?
I.130. Why is not it possible to augment the pitch of the screw in metal worker’s vices? Seemingly, the wider pitch would make the gripping of details in a vice faster (in a lesser quantity of screw rotations).
I.131. Why a fastening made with screws is much firmer than that with nails?
I.132. Screws for wood and metal differ by their shape. Explain the reasons.
I.133. A sheaf gives no advantage in force. However, experiments show that the force necessary to keep a load on sheaves is less than load’s weight, while the force necessary for a hoist of a load is slightly greater than its weight. What are the reasons for it?
I.134. Both the reels and bicycle gears, but in reels the force is applied to the smaller gear while in bicycle the large gear is loaded. Please give reasons for such a difference.

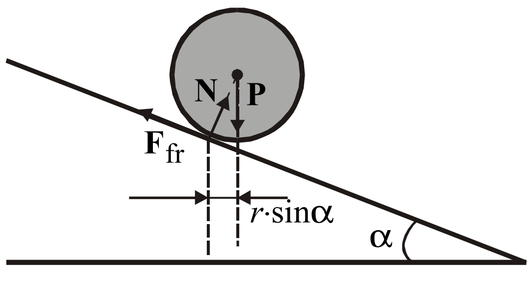


Fig. I.14

I.135. Consider the handles, pedal, and gears of a bicycle. In what of these machines we gain in force? Where do we gain in velocity? For are the purposes in each case?
I.136. A solid ball rolls down without slipping over a sloped plank (Fig. I.14). It is subject to: the gravity force **P**, the force of friction over plank $\mathbf{F}_{fr}$, and the reaction of the plank **N**. The Figure shows that the force **P** creates a torque (rotating moment) $M = |\mathbf{P}| r \times \sin\alpha$ (r is the radius of the ball, $r \times \sin\alpha$, stands for force arm **P**) with respect to an instant horizontal axis passing through the touch point between the ball and the plane. In the presence of the torque, the angular speed of the ball must grow continuously. Consequently, the motion of the ball should be accelerated, and a uniform descent along the inclined plank is not possible. Is right such an assertion?

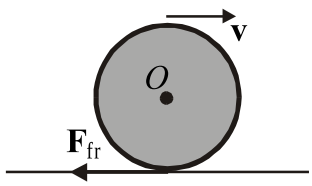


Fig. I.15.

I.137. Along a horizontal plane a wheel rolls at the velocity v without slipping. Seemingly, the friction force is directed to the left (see in Fig. I.15). Therefore, the wheel speed decreases. But the moment of this force with respect to the axis *O* should increase its rotation velocity. What is the matter?

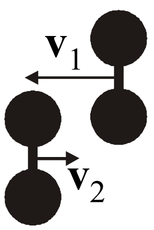


Fig. I.16

I.138. Incline a stool, which stays on a sufficiently glance floor, at a small angle and free it. Explain the resulting motion of the stool.
I.139. Two similar small dump–bells fly towards each other (see in Fig. I.16). What will they move after collision? Consider the size of masses at the ends of dump–bells as small with respect to the their whole sizes.

I.140. Why can a cyclist move “without hands”?
I.141. What is the role of a fin of a sailboat (yacht)?
I.142. Which of the ways to make a car to get move is easier: if one applies the force to the front tracking hook or to the upper edge of wheels?
I.143. Why do skaters swing their hands when accelerate?
I.144. How is the stability of various industrial and home-used machines (turners, cars, flower vases, tables, etc.) attained?
I.145. Why does not a crane fall to the side of a load when hoists it and backwards when leaves the load?
I.146. Three similar lorries are loaded with three loads of the same weight: hay, breaks, and wood. Which of then is steadier?
I.147. Why does a dug waddle when it goes, but not a hen?
I.148. In sportive struggle a man puts legs widely. Why does he do it?
I.149. Why do sailors have a specific “sailor gait”?
I.150. If a balance has different arms, then they cannot stay in equilibrium. But one may return it in equilibrium by hanging some load on one of their pans. But even now it is not possible to weight correctly. Explain why.
I.151. Whether the center-of-gravity of an airplane changes within a flight with respect to frame of reference related to the airplane?
I.152. Where approximately the center-of-gravity of a man is situated? Does it change when he does gymnastic exercises?
I.153. Somebody pours water into a cylindrical glass. When does the center-of-gravity of the glass with water attain its lowest position?

Work and Energy

I.154. Let a body with the mass m lie in train going at the velocity u. With respect to the road it has the energy $mu^2/2$. Then the body is thrown in direction toward the head of the train with the velocity v with respect to the train thus giving it the energy $mv^2/2$. Consequently, its complete energy equals $mu^2/2+mv^2/2$. But one might have the following arguments: with respect to the road tis body moves with the velocity $u+v$ and thus must possess the energy $m(u+v)^2/2$. The latter is greater than former by muv. Which or these arguments is false?

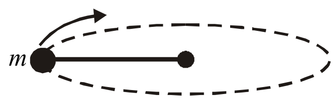


Fig. I.17

I.155. A ball of the mass m, fastened on an imponderable bar, rotates with a constant linear speed v in the horizontal plane (see in Fig. I.17). Its kinetic energy in the frame of reference immobile with respect to the center of rotation is constant and equals $mv^2/2$. In the frame of reference in the horizontal plane, which move rectilinearly with the velocity v_0 with respect to the rotation center ($v_0 = v$), the kinetic energy of the ball varies in time from zero up to $4\times mv^2/2$ (see the previous problem). What is the cause of such a change of energy?
I.156. In which of the cases the energy for launching a satellite is lesser: in launching along a meridian or to East along the equator?
I.157. Even in sharpest braking, a car passes a certain (sometimes not small) path before it stops. Why does it do so? What are the causes of the length of the brake-path?
I.158. In elevating uniformly, as usual, from the window of Baby to his place on roof, in that day when he was entertained to with a jam, Carlson noted that he wasted 21 seconds more than usually. Evaluate the mass of the jam eaten if Carlson’s engine power is always 14 Wt and the highness of elevating is 10 m?
I.159. A passenger upstairs uniformly over an escalator which moves up, too. Whether the work and power expensed by escalator engine will change?
I.160. As known, gravitation on Moon is 6 times lesser than on Earth. Therefore a sportsman which may jump up by 2 m should jump over 12 m on Moon surface. Is it true?
I.161. Imagine that a cosmonaut makes a tour around spacecraft by means of a jet engine. When he returns to the spacecraft, he forgets to switch off the jet and collides with it. Seemingly, it must not be very painful since both the cosmonaut and spacecraft are imponderable. What do you think about it?

I.162. Two cars with engines of power P_1 and P_2 may achieve the speed v_1 and v_2, respectively. What could be a speed v of them joined by a rigid coupling?
I.163. What is the work (in the mechanical sense) when one goes, writes, stretches a line, presses a ball, digging a soil, descending from a mountain?
I.164. Why does a loaded lorry have a slower speed than if it were unloaded?
I.165. Why does acceleration of car requires greater power than its uniform motion?
I.166. What is the role of the gear–box of a car?
I.167. Within the same consumption of gas, car's speed decreases when it starts to move upwards over a hill. What happens to it?
I.168. Average power of engines of a railroad locomotive and a tugboat is same. But locomotive can pull a train which has load 15 times lesser than that for tugging. Expose your reasons.
I.169. By settling a dam across a river during construction of a water–power station three problems are resolved. What are these problems?
I.170. The hydrostatic head of the Sayano-Shushenskaya water-power station is 194 m. If in each second through its turbines 3666 cubic meters of water pass, the power of station equals 6.4 million kWt. Evaluate the efficiency of hydro-turbines of the station.
I.171. Why is the output speed of water passing through a hydro-turbine greater than its input speed?
I.172. Explain the words by Leonardo da Vinci: "Possessing a short, almost instant life, a stroke produces in an oppositely lying object its great and quick action" ("On The Help of Mathematics and on Quantitative Study of Phenomena ", 1508.).
I.173. Answer the question of Greek philosopher Aristotle: "If to apply to a wood an ax onerous with a heavy load, then why will the three be injured insignificantly? But if one rises the ax without any load and strikes over the wood, it splits in parts. Meanwhile the falling body is much lighter than the pressing body" (Aristotle. "Mechanical Problems").
I.174. By means of a stroke we may gain in power. In what way? Cite examples.

The Law of Conservation and Transformation of Mechanical Energy

I.175. To a bar of the mass M, which lies on an ideally smooth table, a piece of plasticine of mass m, which before flied horizontally with the velocity v, strikes the bar and adheres to it. Evaluate the quantity of heat Q, which will appear within the impact?
I.176. In what way one should trough a ball downwards on the floor for it could jump higher than the level it was thrown from?
I.177. In hammering in a nail its hat is weakly heated after first strokes. But when it will be near the surface, it will be heated much quickly within strokes. What does happen to it?
I.178. A train moves at speed u. A bullet of mass m, which had the speed v, reaches the train and penetrates its last car's wall. Find the energy produced as a heat during the blow. In solving this problem, a pupil thought as follows: Before the impact the kinetic energy of the bullet was $mv^2/2$, after impact it is $mu^2/2$. Therefore, the energy lost by the bullet equals $mv^2/2–mu^2/2$. Consequently, the same is the heat energy appeared after impact. Another pupil thought that since the bullet velocity with respect to the train is $v–u$, therefore the energy which appeared as the heat equals $m(v–u)^2/2$. Who of them is right?
I.179. Two similar bodies fall from the height H: one in the air, other in vacuum. Do they had the same potential energy before they started to fall? Do they have same kinetic energy at the end of fall?
I.180. A ball was thrown vertically upwards. What quantity is greater: ascending or descending time? How will move two similar balls after a central elastic collision in absence of exterior forces if one of them was in rest before the impact?
I.181. A resting ball suffers a central stroke of another similar ball. When will the first ball have a greater velocity: for an elastic or non-elastic impact?
I.182. A ball falls from height of 2 m, then jumps up to 1.5 m. How will you coordinate this to the Energy Conservation Law?
I.183. Collect some little color stones on a seashore and then through them on a solid cement floor from a small height. It is known that after the first impact to a solid floor a body must jump again for lesser height, since a part of its kinetic energy vanishes with the impact. As for our stones, after the second impact they sometimes elevate almost twice higher than after first one. Knowing the low of conservation of complete mechanical energy, how would you explain this seeming

contradiction?
I.184. A ball with the initial velocity u falls from the height H and then makes a series of jumps. In doing so, it loses the k-th part of beforehand reserved potential energy. Determine on what distance l from the place where it was thrown these jumps will completely stop. Assume that the friction is absent and the horizontal component of the ball's velocity does not change.
I.185. On the boundary of atmosphere a satellite loses consecutively its energy due to the air resistance. In what manner will change the satellite's velocity in this process?
I.186. Both a stone and a tennis ball received the same strike made by a wooden rod. Why does the tennis ball fly longer under equal remaining conditions?
I.187. There are two ways to make high jumps: in a wave manner and simply vertically (not swinging your body). Why is the first manner more efficient than the second?
I.188. We see two cups with mercury on Fig I.18. Two vessels without air have been put into these cups. These vessels are almost similar by their shapes with the unique difference – their ball-like cavities A and B are situated at different heights. The mercury in these vessels will ascend and then stop at the same level (see Fig. I.18). In this situation, in both cases the air pressure p will execute the same work equaling pV (V is the volume of mercury displaced from cups). In the left vessel the main mass is posed on a greater height than in the right vessel. Therefore, by expense of the same work two different individual potential energies are accumulated, which contradicts the law of conservation of complete mechanical energy. Find an inaccuracy in the arguments cited above.

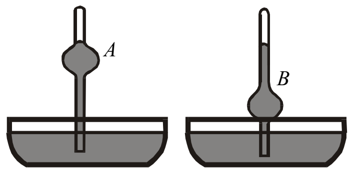


Fig. I.18

I.189. By means of a hydraulic ram (see in Fig. I.19), the water can be supplied to a height, which exceeding essentially its level in the source 1. The action of ram is as follows. The water flows itself along the pipe 2 and with growing velocity flows out via the valve 3 and makes a pressure on it. At a certain velocity the valve 3 closes suddenly. The water then continues its motion opens the valve 4 and ascends along pump–feed pipe. The pressure in the pipe 2 goes down and water again starts to flow via the valve 3. Thus, having a source which is 2 to 3 meters above the valve 3, one can supply water up height of some dozens meters. What is the energy, due to which the ram is acting? Whether its work contradicts to the law of energy conservation? What are transformations of energy in this device?

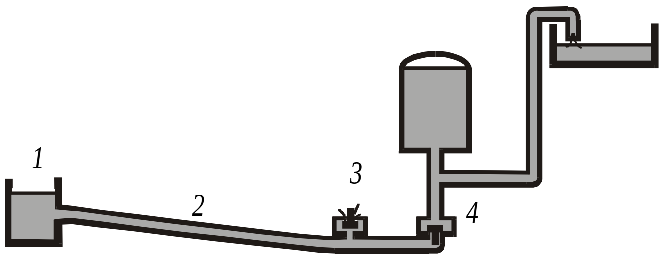


Fig. I.19

I.190. Tires of automobile wheels (as well as springs, railroad car buffers, etc.) reduce impacts and shocks. Explain the reasons.
I.191. Dominoes (bones) are put so that the first as falls makes to fall the second, and so on. Estimate the time for a series of 100 dominoes to fall down.
I.192. Usually, gamma–quantums irradiated by nuclei of a radioactive material cannot be absorbed by similar nuclei. Explain why this happens. Take into account that the energy of a nucleus, which is considered as a quantum system, might possess only some fixed values.
I.193. Explain why do not affect the response effects, described in previous problem of response, in studies of the visible light?

Motion with respect to inertia-free frames of reference

I.194. Imagine that you are in a car of accelerating subway and go toward the motion of the train with velocity constant with respect to train. Easily sensible force tries to resist against you and you certainly make a work against this force. But, seemingly, your mechanical energy is not changed. Then what is the work made by your muscles wasted for? Do you violate the law of energy conservation?
I.195. You are in a satellite and have lever scales and a set of weights. How will you determine the mass of a body?

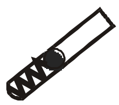


Fig.I.20

I.196. Into a massive tube a spring is placed, which occupies in unloaded state the whole tube. Then a ball is put over the spring, thus compressing it approximately twice (see Fig. I.20). In a position with slope the tube starts to fall. What will happen to the ball?

I.197. A closed lantern with a candle is put in a rectilinear accelerated motion. One can see that candle flame will slightly incline toward the direction of acceleration. How will you explain such a phenomenon?

I.198. In a closed pick-up of a lorry moving uniformly, a watermelon lies at the center of floor. Over the watermelon a very light rubber ball filled by hydrogen. How will move the watermelon and the ball if the lorry will brake? Air resistance and friction of the floor are small.

I.199. How must place himself a cosmonaut in the cabin of a spacecraft in order to meet least pressure from the "pressing" wall of the cabin?

I.200. Point out components of the centripetal force acting on a body lying at the surface of Earth.

I.201. Estimate minimally admissible duration of a day for a planet with mass M and radius R.

I.202. What does produce the centripetal force acting on a satellite?

I.203. At road bends a car slightly "sits" from one side. Given a left bend, indicate from what side will the car sit? Explain why?

I.204. A car makes a sharp bend. A passenger citing at the right door felt a pressure from that door. What is the side to which the car turns?

I.205. Under rotation of the wheel of a centrifugal water pump an underpressure arises which attracts the water. How is this underpressure produced?

I.206. On a merry-go-round's platform a carpenter level is posed along radial direction. Determine to which side the small air bulb will be displaced if the rotation will start?

I.207. You are in a train and wish to determine the slope of the railroad. Under what condition this can be done?

I.208. You picked up with you a lantern with a candle. To what side the flame of candle will incline if you sit on a rotating merry-go-round?

I.209. A stone is bound to a rope and now is rotated along a circle in the vertical direction. Whether the stretch of the rope remains same in highest and lowest points of the circle?

I.210. A small pail with water is bound to a rope and a man rotates it in the vertical plane so that the water does not leave the pail. Explain the phenomenon in both the inertial frame of reference and in that related to the rotating pail.

I.211. On bends cyclists, bikers, and runners incline to the side to which they should turn. What are reasons for it?

I.212. Rotation of a liquid with respect to vertical axis of a bottle is known to help to the liquid leave a bottle much quicker. Explain it.

I.213. A line goes over the sheaves A and B (see Fig. I.21). Two loads P and Q equal in mass are bound at its ends. What will happen if one declines the load P from equilibrium and allows it to swing freely back and forth? Consider two cases: a) friction in sheaves is small and b) friction is essential.

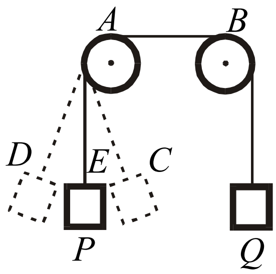


Fig. I.21.

I.214. A line does not snap under action of a load. Then why may the line snap is one declines the load and allows it to wing??

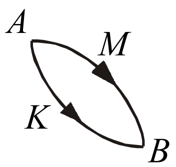


Fig. I.22.

I.215. A body slips down from the point A to the point B (Fig. I.22). For the first time it goes along the arc AMB. Another time it descends along the arc AKB. The friction coefficient is same in both the cases. In what case the velocity of the body will be greater at B?

I.216. Why they do some bridges convex upwards?

I.217. For what purposes do the screens over bicycle wheels serve? What determines their sizes?

I.218. Why does a driver decrease the speed of his car at sharp bends?

I.219. High speed of rotation of machine details is known to be dangerous. What is the danger?

I.220. The rivers of North hemisphere are known to wash away their right shores more than left ones. Give explanations.

I.221. On one-way railroads the rails wear out at the same degree, while on two-way roads the rails wear out differently. Explain the phenomenon?

I.222. Explain the direction of trade winds (winds which blow from tropics to equator and West).
I.223. A jet projectile was sot along a meridian. What will be the direction of its deviation?
I.224. To prove that Earth rotates Jean-Bernard-Lion Foucault suggested to use a pendulum consisting of a heavy load suspended on very long and thin steel wire. The swings of Foucault's pendulums have a very slow fading and the plane of swinging moves together with the rotation of Earth. Explain the phenomenon of Foucault's pendulum. Determine either clockwise or counterclockwise will rotate the plane of swings.

The Law of Gravitation. Weight

I.225. On a massive table a sensitive equal-arm balance stands having two pans hung on each arm as shown in Fig. I.23. Two equal weights (each 1kg) are put upon left and right sides, one on the left upper pan, second on the right lower pan. Will then the balance show equilibrium?

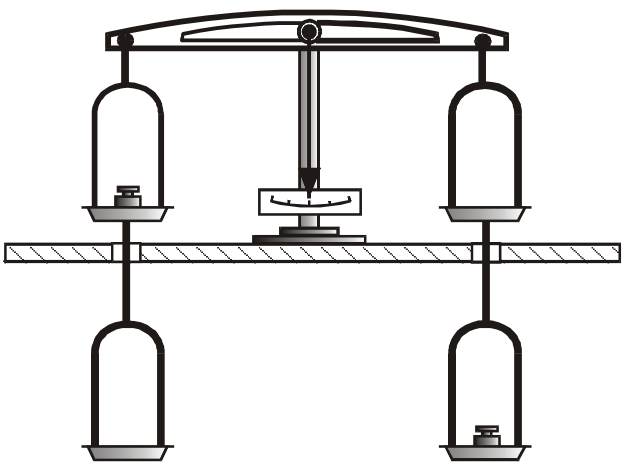


Fig. I.23

I.226. A body mass is known to be determinable by weighting or by studying or testing of its inertia. Which one of these two ways should one apply when he/she: a) holds consecutively the bodies to be compared on extended hand; b) consecutively throws upward and then catches these bodies?
I.227. The force of attraction of bodies is known to decrease as they increase the distance from the Earth's center. Therefore, it seems that, as a 1kg weight approximates to Earth's center, its attraction must grow and turn infinite at the proper center. Practically, the weight is lost as one goes toward the center. Give your reasons.
I.228. Bodies at Earth surface make revolutions together with Earth's rotation. How does it affect the specific weight of a body? Where this effect must be maximal and minimal? Answer the same question concerning the density.
I.229. Spring scales were graded on the equator. What will happen to measurements made by same scales on a pole?
I.230. Explain the reasons for necessary use of mechanical balances (e.g., Roberval balance) instead of spring balances in commerce.
I.231. Is it necessary to take into account the geographical position of a place, where competitions in high jumps or weight-lifting occur?
I.232. Whether one can lift a body from ground by applying a force equaling its weight?
I.234. A sixteen-kilogram dumb-bell is in a man's hand. The man jumps downwards from a stool. What is the weight of the dumb-bell during the fall?
I.235. Attraction of the Moon by Sun of approximately twice greater than the attraction by the Earth. But the Moon is the Earth's satellite, not of the Sun. May you explain?
I.236. Assuming known all parameters of the Earth and that one Moon month duration (time between two same phases of the Moon) equals 28 days, estimate the velocity of Moon's revolution around the Earth.
I.237. When does the Earth move along its orbit about the Sun: in Winter or in Summer (for Northern hemisphere)?
I.238. In XVII century a problem was published in a book. Assume that around the Earth a bridge has been constructed, homogeneous by its material on the whole length and equal by weight in each of its parts. Afterwards all supports are eliminated. What then will happen to it? Will is fall? Can it be applied for any practical purpose?
I.239. As known, to launch a satellite to Moon the second cosmic velocity is required. However, theoretically, the same can be done in a rocket possessing the speed of a car. Could you explain the situation?
I.240. If the Earth were rotating so that bodies on its equator had no weight (being imponderable), then how long were a day in this case?
I.241. Answer the following questions: a) in zero gravity how one could pour water from one vessel to another? b) how will affect zero gravity the boiling of water? c) how can one rotate a rocket about its orbit? How can one change the direction of its flight? d) how one can measure the mass of bodies in zero

gravity? e) how one can create an “artificial” gravity?
I.242. What shape has the orbit of a satellite?
I.243. A spherical cylinder with an unfrozen liquid (for instance, a liquid fuel) is on an orbit around the Earth. There is a piece of metal in the liquid. How will it move? If instead of metal a bubble of air will be in cylinder, how will it behave?
I.244. If the mass of Earth were equal to the mass of Sun and the distance remained same, how will change duration of a year on the Earth?
I.245. Whether a satellite might have stable revolutions around the Earth if its orbit plane were not passing through the Earth’s center?
I.246. For communication so-called “immovable” satellites are used which move around the Earth with an angular velocity equaling the rotation of Earth and thus every time are over the same point of Earth. Determine the requirements on the orbit of such a satellite.

Friction

I.247. What is the force ensuring the displacement of a man when he walks? Where is it directed to?
I.248. Explain why a man must make small and frequent steps when he want to go quickly over an iced surface, meanwhile on a solid ground he even might make long jumps?
I.249. A heavy box is being pulled uniformly over a horizontal floor. What is the force to get over in this process? Of what genuine?
I.250. What will be easier: to pull a carriage in front of you or behind you?
I.251. Whether the way passed by a hockey puck until stop depends on its mass if all other conditions are same?
I.252. As known, on a smooth surface one can more readily slip and fall than on a rough one, because roughness increases the friction. But then why is a rough ice more slippery than a smooth ice?
I.253. To make sawing easier one must file and set a saw (“widen” ends of neighboring teeth). What is the reason for it?
I.254. When grain flows out of a sack, it does not form a uniform layer, but a heap of a conic shape. Why?
I.255. Why do the surfaces subject to friction wear out?
I.256. What is the work against friction forces wasted for?
I.257. On gripping jaws of metal worker’s vices and pliers you can see teeth. What are they made for?
I.258. Handles of tools, heads of bolts, circular nuts for screwing by hand possess are rubbed (corrugated). Explain the aim.
I.259. Is it so bad that nails hammered in do rust?
I.260. Why does a rusted needle make sewing difficult?
I.261. Why are sharp the ends of gear axes in watches and clocks?
I.262. Why is it easier to pull out a nail from a log by pliers if you rotate the nail head?
I.263. Why may a car skid in sharp braking?
I.264. Why do tires have a tread pattern? Why do they make both lengthwise and crosswise relief?
I.265. On the bottom side of skies they do a lengthwise channel. Why?
I.266. For a tram driver, there is a sign: “Be careful! Falling leaves!” What about does this sign warn about?
I.267. As known, a motion of a train is possible when there are both traction and friction forces (friction between wheels of a locomotive and rails). At the same time, the friction between car wheels and rails brakes the motion. But wheels of both locomotive and cars are made of same material. Moreover, cars weight more than locomotive. But then why can a locomotive move the train?
I.268. In contrast to airplane, an electric-powered locomotive is not made of light metals and alloys. Can you explain why?
I.269. Why does a loaded automobile slip less that non-loaded one on a ground road after a rain. Why?
I.270. A lorry with a trailer must transport a heavy machine. What is more efficient: to load the machine on the lorry or on the trail? Why?
I.271. Why do both skies and skates slip well over ice? Why does slipping turn harder when it is frosty and the temperature is too?
I.272. Blades if skates for runners are thinner than those for hockey or sportive skating). May you explain the reason for it?
I.273. In winter, when all around is covered by the snow, peasants change their carriage to slates? Why so the do so? It is known that friction coefficient for rolling is less friction coefficient for slipping.
I.274. The friction is less in ball bearings than in needle ones. However, in present time the wheels of heavy railroad cars have needle bearings. Can you give a reason?

I.275. Why does ironed and starched linen become less dirty than not starched linen?
I.276. Lubrication of ribbing surfaces decreases the friction. Then why is it more difficult to hold ax handle by a dry hand than by a wet hand?
I.277. A shift of machine is made of steel while in bearings they use copper and other metals and alloys. Give an explanation.
I.278. In mechanical watches (and less in clocks) the bearings are usually made of stones (agate, sapphire, ruby, etc.). Why do they use stones and not steel?

Fig. I.24.

I.279. In what case the tracing force of an automobile is greater: when it goes over dry or wet road?
I.280. A worker sharpens his tool. He makes it for short times and often takes the toll of the turning stone. What is the reason for these interruptions?
I.281. Why is the front part of an ice-crusher ship slanted?
I.282. In putting an ax or a hammer on its handle they usually insert a wedge *K* made of a rigid wood (see in Fig. I.24). Why do they make it?
I.283. For fastening something to a wall, a hole should be made and corked by a wooden cork *C*. To reinforce the construction, the cork is hammered into wall with a wedge *K* made of more rigid wood (see Fig. I.25). Explain why in that case is it difficult to pull out such a cork from the wall?

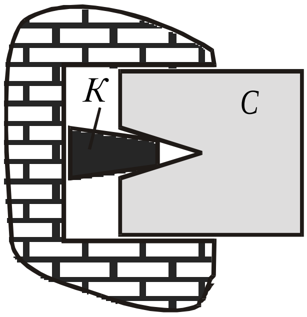


Fig. I.25

Chapter II

Fluid and Gas Mechanics

Pressure of Liquid and gas. Atmospheric Pressure

II.1. It is difficult to walk over marshland. One must waste a lot of energy for each step. May you explain why?
II.2. Describe the process of filling an ink fountain-pen.
II.3. In what way could one evaluate the mass of atmosphere?

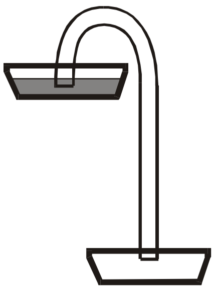


Fig. II.1

II.4. Whether the atmospheric pressure affects the possible height of pumping up water in pipes? Whether the atmosphere has an influence on the flow of water in an open cylindrical tube?
II.5. Whether one can pump out the mercury from an open vessel via a vertical tube of length 1m by applying a suction pump?
II.6. A liquid flows from the upper vessel to the lower one by means of siphon as shown in Fig. II.1. The liquid running from lower end of siphon possesses kinetic energy. Where it takes this energy?
II.7. Whether a siphon will work if its short leg is of the height 9m? 11m?
II.8. Evaluate the pressure of a water pumped by fire0pump to the ninth floor of a modern building.
II.9. To restore the losses of air on an orbital space station, a transport rocket carries cylinders with air. Does air press the cylinder walls in the zero gravity condition? Whether must a cylinder for reserving gas on space station be as strong as on Earth?
II.10. In a low flying apparatus the air is pumped under the apparatus bottom by means of a propeller. Estimate the redundant pressure in the air pillow under an apparatus with the mass 32 tones and the bottom area 160m^2.
II.11. To pass easier soft grounds, sands, or snow, they usually blow out some air from tires. What is the reason for this operation?
II.12. The head (difference between upper and lower levels of water near a dam) of Sayano-Shushenskaya water-power station is 194m. What is the pressure on the dam at this depth?
II.13. A pressure gauge on a bathyscaph shows that exterior pressure of water equals p. How you cloud determine on what depth the bathyscaph is now?

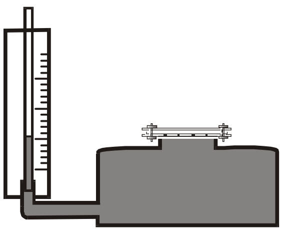


Fig. II.2.

II.14. A hermetic reservoir is filled with a liquid (see in Fig. II.2). If we suck out the air from the open part of the device for determining depth (i.e., the tube demonstrating the level of the liquid in vessel), then whether the liquid in tube will ascend along the tube? Whether we might to make the liquid to flow out the tube if the hatch of the reservoir remains firmly closed?
I.15. Under forming details without pressing they put a hot plastic foil *1* (Fig. II.3) on a matrix-form *2* and suck the air from the volume under foil. Why does make the plastic foil to bend into matrix and to take its form?

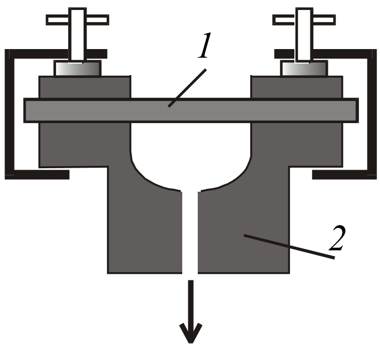


Fig. II.3

II.16. Fill a glass (better with thick walls) up to upper edge and cover with a sheet of dense paper. Turn over the glass keeping the sheet by hand, Then take off you hand. Explain the result.
II.17. Whether a cosmonaut can fill in a pipette (medicine dropper) with a liquid if on the board of spacecraft the normal atmospheric pressure is kept?
II.18. Imagine that on the Moon in a certain laboratory the normal atmospheric pressure is kept. If we repeat the Evangelista Torricelli experiment in this laboratory, what will be the result? Would not the mercury flow out the tube completely?

II.19. What is the difference between actions of a hydraulic press on the Earth and on the Moon?
II.20. Measurements produced by Russian automatic space station “Venera–7” show that atmospheric pressure on the Venus surface is about 10,3 MPa. The gravity on Venus is almost 1.2 times less than on Earth. What will be the height of mercury column in Torricelian experiment realized on Venus?
II.21. Whether the Pascal law acts on a satellite?
II.22. Whether one can measure the air pressure in the cabin of a spacecraft by applying a mercury barometer? a barometer- aneroid?
II.23. To determine the pressure why on airplanes do they use barometer-aneroid instead of liquid barometers?
II.24. Why the sucking inlet pipe of suction pump is thick-wall strengthened with steel wire?
II.25. If one shoots to a glass then: a thin wall empty glass gets two holes (inlet, outlet), a glass filled with water blows into pieces?
II.26. A pail is hung with a thin rope and is filled with water. On its lateral side a little hole lets water flow out. How will the shape of water flowing out change if we fire up the rope and pail will start to fall?
II.27. One consecutively puts into a vessel filled with water three different bodies of the same volume but with distinct densities so that bodies do not touch the bottom. Whether these bodies will change the pressure of water in the same way?
II.28. Into the cap of a barrel filled completely with water a high tube was built in. When the tube has been filled with water, the barrel blows up. Why does so small quantity of water blow up the barrel?
II.29. Why diving is not possible with a simple device: one end of a rubber tube is in diver’s moth, another is over water surface? Invent a device for diver could breath in water.

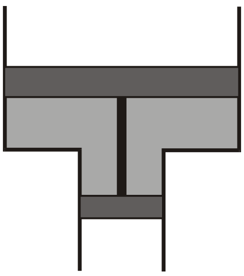


Fig. II.4.

II.30. How will you determine the weight of am automobile not weighting it but studying its tires?
II.31. In Fig. II.4 two pistons of different diameter, rigidly connected to each other by a stick. The space between pistons is filled with water. It seems easy to shift pistons downwards, since for upward movement we must overpass the resistance of the weight of both water and pistons. However, in practice all is contrary. How can you explain the situation?
II.32. To vessels with water communicate as shown in Fig. II.5. the level of water in the right vessel is lower due to a cap. Seemingly, in this case, the pressure of water at the points *À* and *B*, lying at the same horizontal should differ since they are pressed by different columns of water. Whether this is true?

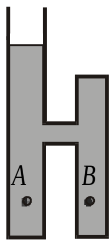


Fig. II.5

Communicating Vessels

II.33. In communicating vessels (see Fig. II.6) the water is at temperatures T_1 and T_2 (besides, $T_1 > T_2$). The valve V is closed. What will happen if we open this valve? Consider that the construction of both vessels guarantees very quick change of the temperature of the water, which flows in them.

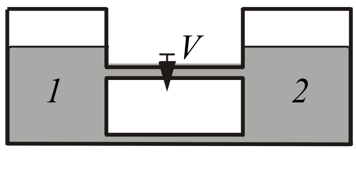


Fig. II.6

II.34. Two mercury barometers (See in Fig. II.7) sands at different heights and are connected with tubes filled with mercury. One of tubes is horizontal, while the second connects points with different values of pressure. Both the tubes have valves. What will happen if one of these valves will be open?

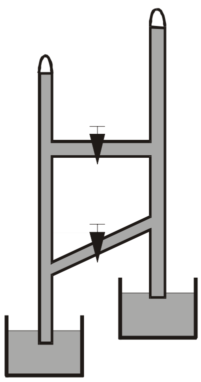


Fig. II.7.

II.35. Whether the water surface of river is horizontal?
II.36. During reconstruction of theater it was necessary to draw a horizontal line on its walls. How can this be made with use of the law of communicating vessels?

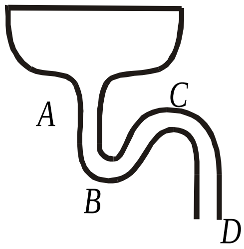


Fig. II.8.

II.37. Why are the output pipes of wash-basins and sinks bent in an S-shaped form (Fig. II.8)?
II.38. To restore the function of oil wells which stopped "spout" by virtue of a decrease of pressure in oil layer, the following technique is applied. Using special pipes the compressed air is pumped into well. The air penetrates the oil layer with tiny bubbles. Oil foam rises and forms an artificial spout. Hoe could you explain it?

Archimedes' Principle. Floatation

II.39. Whether the law of communicating vessels is valid (homogeneous liquid ion communicating vessels has the same level at each of vessels) if in one of vessels a body is floating?
II.40. Water is poured into two communicating vessels of diameters D_1 and D_2. Its level is H_0. How does change the levels of water in vessels if we put a piece of wood of mass m into the first vessel? Into the second vessel? Water density is ρ.
II.41. A bubble of air buoyed to the surface from the bottom of a lake. By expense of what did increase its potential energy?
II.42. Whether the buoyant force experienced by the same body floating first in water and then in kerosene is same?
II.43. What is the mass of a wooden cube with the side a if during transfer from oil to water its submerging height reduces by a quantity h?
II.44. A wooden bar is floating in water with its largest face submerged. How are situated gravity centers of the bar and the displaced water? Whether this equilibrium of the bar is stable?
II.45. A wooded rod with a stone bound at its lower end floats in water vertically. Explain why does this happen?
II.46. Iron does not float in water. But ships are made mainly of iron. Why do they float and do not sink?
II.47. Which of two ships is more stable on waves: with freight in its holds or light one? Why do they place engines in the lower part of ships?
II.48. Where does a ship submerge deeper: on a sea or on a river?
II.49. A model of ship is placed to float in kerosene, oil, water, and mercury. In which of the liquids will the model float more steadily?
II.50. On large ships floating on seas and rivers they draw so-called "load water-line". Which of the marks given in Fig. II.9 does correspond to submersion into summer sea; winter sea; river?

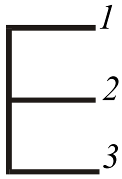


Fig. II.9.

II.51. Why burning kerosene cannot be put out by water?
II.52. On the hook of dynamometer an empty pail is hung. Whether the readings of dynamometer will change if we pour the pail with water and merge it into water?
II.53. A cup is floating in a pan, the pan is filled with water. How will change the level of water if the cup sinks?
II.54. In a tank with water a glass floats. If we ladle a bit water into the glass and then put it to float again, whether the level in tank will change?
II.55. A pail full of water is hung on the hook of a dynamometer. We merge a piece of iron hung on a thin line into the pail. Will the dynamometer readings change?
II.56. On one arm of an equal-arm balance in equilibrium a can (with water) is hung. In the water a musk-rat swims. From another arm by means of a lever a rope is hung reaching the water surface. The musk-rat starts to climb upwards along the rope. Will remain the equilibrium?
II.57. A body floats in water so that $1/n$ of its volume is under water. If a tank where the body floats will move upwards (downwards) with a uniform acceleration, which part of the volume will merge into water?
II.58. A submarine when lands over a soft ground (a silty bottom), sometimes heavily buoys from it. How can you explain this sticking of the submarine to the bottom ground?
II.59. A body with the mass $m = 2.5$kg and volume $V = 60$l closely lies on the bottom of a pool filled with water up to the height $h_0 = 3$m (see in Fig. II.10). For what value one must decrease the level of water in the pool for the body start to buoy to the surface? The area of flat surface S of the body which is in contact with the pool's has the area 50cm^2.

II.60. A pan containing a certain quantity of water floats in a larger pan filled up to edge with a liquid lighter than water. The interior pan starts to be uniformly filled with water by a thin jet. Draw the graph of the change of readings P of scales under the larger pans (see Fig. II.11) with respect to the time. Both the liquids are assumed not to mix when contacted to each other, the kinetic energy of the jet is supposed to be insignificantly small.

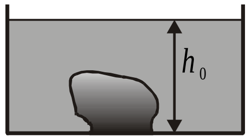


Fig. II.10

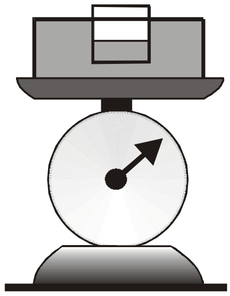


Fig. II.11.

II.61. In a glass with water a piece of ice is floating. How will change the level of water when the ice will be melted? Consider the cases where: a) the ice is homogeneous; b) inside the ice a small stone is frozen; c) the ice contains a wooden piece; d) inside the ice a bubble of air was frozen.

II.62. In a cylindrical glass a small cork cube is floating, over it an even smaller metallic ball rests. Moreover, the upper face of the cube coincides with the level of water in glass. How will the level change if the ball rolls down to the water? The area of the glass' cross-section is S, the mass of the ball is m, metal density equals ρ_m, water density is ρ.

II.63. A steel ball is floating in the mercury. Will the position of ball with respect to mercury level change if we pour some water over the mercury?

II.64. It is convenient to measure the density of a liquid by the submerged volume of a body with known density. If we graduate this body by using its submersion into liquids with known densities, then we get a device called "aireometer". The question is as follows: whether one can measure the density of a liquid on the board of a spacecraft?

II.65. A piece of ice is floating in sea. Its part over the sea level has the volume 100 m^3. Given that the density of ice is $\rho_i = 0.9 g/cm^3$, and the density of seawater is $\rho_w = 1.1 g/cm^3$, find the volume of that piece of ice.

II.66. Two shells with equal weights are made one of thin rubber and other of a rubberized tissue. Both are filled with same quantity of the hydrogen. Which of these balls will rise higher (assume that there are no hydrogen losses).

II.67. Since a certain time instead of hydrogen they started to fill balloons with helium. This decreases essentially the possibility of blowing. But helium is twice heavier than hydrogen. So, in order to reach the same buoyant force, the balloons filled with helium must be twice larger than those with hydrogen. Is this argument correct?

II.68. For floating over Moon's surface, whether a man can use balloons?

II.69. Whether the buoyant force will change for a balloon with its rising if its shell is assumed to be non-stretchable and the temperature at various heights is set constant? May a balloon rise up to any arbitrary height?

II.70. Whether the pressure inside a balloon filled with a light gas (e.g., hydrogen) is greater or less than atmospheric?

II.71. Whether a hypothesis by Otto Herike tts is valid? He asserted that vessels with rarefied air must buoy in the air. Is this realizable in practice?

II.72. Wishing to weight the air, an ancient philosopher had blown a bull bladder and then weighted it. The weight in both cases (for both blown and empty bladder) was same. Hence the philosopher derived that air weights nothing. Find his error.

II.73. In a flask a certain quantity of water is present. In this water a cork is floating. Given that the air is completely sucked from flask, estimate in percent the change of the cork's part over water surface. Neglect the density of water vapor after suction. Densities of water and air are ρ_w and ρ_a, respectively.

II.74. For storage of oil and similar liquids in seawater, they use to fill them into special shells made of synthetic materials. Then they fasten some loads to these shells, sink them, and fix on bottom. Why do the make it? Whether it is necessary to apply a pump for hoisting the oil and supplying a ship?

II.75. For training of cosmonauts on Earth surface in zero gravity condition various ways exist. One of them is as follows: a man in special costume is merged into water where he does not sing but floats. When is this possible?

II.76. The mass of floating amphibian tank is 14 tons. Determine the volume of its part submersed into water.

II.77. Whether Archimedes' principle is applicable in Moon's conditions?

II.78. Admit that in a laboratory on the Moon an investigator puts a stone into water. What result will he obtain? Will the stone float one the surface of water since on the Moon it weights six times less than on the Earth?

II.79. On the board of orbital space station a small balloon was filled with hydrogen. Will it buoy there if the environment pressure is as the atmospheric one the Earth? Give arguments justifying your decision.

II.80. A glass with water and a wooden bar were put on the pan of a balance and put into equilibrium by some weights. Then the bar is put into glass. Will the equilibrium be violated? Answer the same for a stone instead of wooden bar.

II.81. When are to be weighted, materials of what kind need no consideration of the air's buoyant force?

II.82. On a sensitive balance a wooden cube was put onto equilibrium with weights. After that, the whole system was covered by a glass bell jar and all the air was sucked out. This resulted in a change of air pressure on scale pans. Whether the equilibrium will remain?

II.83. To the arms of an equal-arm lever two similar weights are hung. If we place one weight into water and other into kerosene, what will happen?

II.84. On balance with two pans a vessel with kerosene was set in equilibrium with a set of standard weights. If we heat the kerosene, will balance remain in equilibrium?

II.85. Two levers are in equilibrium. First lever has on its arms two different loads of the same material, on arms of second one two different materials having same volume. Whether the equilibrium of levers will be lost if both are merged in water?

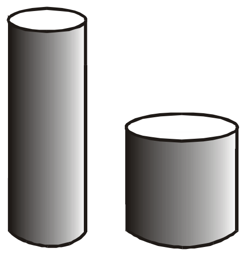


Fig. II.12.

II.86. Three equal pieces of wood were places into three similar pails. To each of them a similar load was bound and water was poured to pails' upper edges. In the first of pails, both the wood and load were floating. As for the second one, the rope became flabby in part and the load slightly touched the pail's bottom. It the third pail rope was unbound and load lies on the bottom. Which of pails will be the heaviest?

II.87. Two similar open vessels of same volume but different forms are shown in Fig. II.12. We merge then vertically with their open sides down so that former bottoms be at the same depth under water. Whether the same force is necessary for this action?

II.88. In Kaucasus mountains a three called "box tree" (samshit) grows. It is 1.2 times heavier than water. A bar was made of this wood, a similar by volume bar was made of lime-tree (which is 1.2 lighter than water).Both bars were bound together and thrown to water. What happens to then?

II.89. An open glass vessel has a round bottom and its volume is 250cm^3. It is poured up to half with a solution. The pair (vessel and solution in it) weights 2.5N. A certain body was merged to the vessel and the common weight became 4.5N, while the solution ascended to cylinder's edge. The weight of the body in the solution is 0.5N and it is by 0.5N less than its weight in water. Decide what is the shape of the vessel: either cylindrical or conical?

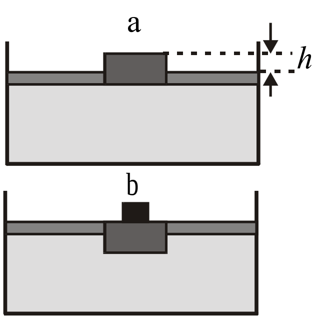


Fig. II.13.

II.90. On a balance a vessel with water (not full) is set into equilibrium. Then somebody lower his finger into water (not touching the vessel's walls). What will happen to the balance?

II.91. Draw an approximate graph of the dependence of the buoyant force acting on a rubber ball on the depth of merging.

II.92. In a vessel with water a piston floats with a cylindrical hole of square S_0. Into the hole a cork is tightly settled. The lower face of the cork is at the same level with the lower surface of the piston (see Fig. II.13a). The upper cut of the cork if above the piston by a height h. The cork may freely move inside the piston. A small load was put onto the cork. The common position of all three bodies at the equilibrium reached is shown in Fig. II.13b. Determine the mass of the load.

Flow of Liquid and Gas. Bernoulli Law. Viscosity

II.93. How can one determine experimentally, with the help of a stopwatch and a long straightedge, the distance covered by a falling table tennis ball without a significant resistance of air?
II.94. Estimate the time necessary for completely flow out of water from a filled bath.
II.95. Why do in the rivers' estuary some banks and small islands form?

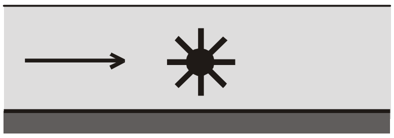


Fig. II.14.

II.96. Why do they make the end of fire-pump nozzles narrow?
II.97. A wind is known to be weaker on the ground than at a certain height. Explain the phenomenon.
II.98. The stream of a river is from the left to the right as shown in Fig. II.14. In what direction will the wings of the paddle-wheel (shown in the figure) turn if submerged into water?
II.99. Imagine that the paddle–wheel from the previous problem is symmetrically settled in a pipe through which the water runs from the left to the right. How will it turn?
II.100. Explain why do the ships with paddle-wheel have it half-submerged into the water, while the propeller of modern ships is immerged completely?
II.101. Two cylindrical tubes are similar everywhere except for a small segment, which is long from tube ends, where the first one has a thickening (bulb) while the second is narrower at the same place. By means of a pump, a flow of water is created filling both of them completely and such that water velocity is same at the input of each tube. In tubes no curls rise. At the input they mixed to water a bit of paint. In what tube the paint will quicker reach other end? Whether the time of paint appearance depends on the position of the bulb (or tightening)?
II.102. Under an open water faucet a small bath stands and the water flows upon it. Under the water jet, a light small ball is placed. Whether it can remain is equilibrium?
II.103. A parachutist before landing pulls toward himself the front lings. In this case, in what direction does he go to fly?
II.104. Within testing of a jet non-controllable projectile designed to protect an airplane from back and thus placed at the tail of airplane, a surprising fact was established: after launch, the projectile turns backwards and try to catch the proper airplane. How could you explain such a phenomenon?

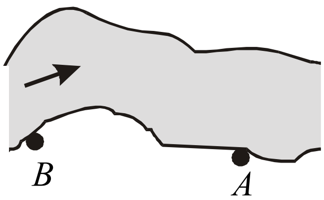


Fig. II.15.

II.105. A stone is bound at the end of rod. The result then is thrown directly forward. Why in its motion does the tone fly always first?
II.106. It is necessary to row with minimal expense from *A* to *B* against the current (Fig. II.15) and then return back to *A* (by the current). Is it better to row near the shore or through the middle of river?
II.107. When water is high, the river surface is upwards convex. When water is low the surface is concave? Can you give an explanation?
II.108. Why does dust curl behind a moving car?
II.109. Why do they retract the landing gear when airplane flies?
II.110. The exploitation rules on railroads require that that car doors be necessarily closed even if cars are empty?
II.111. How do the residues (e.g., scum) on pipe walls affect the quantity of liquid passing in a unit of time (consumption) of a liquid or a gas?
II.112. In days with string frost the gas flows rather slowly in kitchens though gas station supports the same pressure of supply. May you explain this phenomenon?
II.113. If one closes with finger the nozzle of a water cock, the water jet flows out from the remaining space with much greater velocity than it flowed out earlier. Could you explain the reasons for it?
II.114. Vegetable oil in hot summer days easily flows from a bottle, in winter it flows significantly more slowly. Why?
II.115. Over an inclined plane two bottles roll down. One is filled with water, other by a mixture of sand with sawdust. Both masses and distribution of masses around the rotation axis the bottles are same. Consequently, the bottles must have the time to reach the bottom. But, in practice, the bottle with water will make it faster. May you give an explanation?

II.116. How could one know whether an egg was or was not boiled, not destroying its shell?
II.117. The bed of a channel (river) on straight segments of constant cross-section represents an inclined plane along which the water is flowing down. But then why does water moves without acceleration on these segments?
II.118. The trajectory of the motion of raindrops under a constant horizontal wind is not a parabola, but a straight line. Can you explain why?
II.119. In competitions of runners some participants try to run behind their rivals and make a spurt only near the finish line. May you explain why do they do so?
II.120. Swimmers tend to keep their heads in water. May you give an argument to explain such a manner?
II.121. Flying to long distances, bird form a chain or a wedge in the sky. What for do they make it?
II.122. Why do the wings of anemometer have the sharp of a semi-sphere, not of a flat blade?
II.123. Why is wide and slightly concave the end of an oar?
II.124. In the cupola of a parachute one can note a small hole? For does it serve for?
II.125. Why does a ski-jumper inclines ahead his body when jumps-off?
II.126. Due to gravitation all bodies fall on Earth. Clouds are known to consist of small drops of water. Therefore they must fall down. But nobody sees such an event. How can you explain this paradox?
II.127. What is the shape of a liquid in a vessel sliding without friction along an inclined plane making angle a with the horizon?
II.128. In falling from a large height, a raindrop consecutively evaporates. How does this affects the character of its motion?
II.129. Which of raindrops fall down faster: big ones or small ones? Justify your answer.
II.130. If we cut out a piece of paper in the shape of a coin and then throw down them together (with coin covered from above by paper), then paper follows together with coin as soon as paper's edges are inside the surface of the coin. If you throw them not gathering together, paper will fall more slowly than the coin. Please give your explanation of this fact.
II.131. Why does a large stone fall to Earth quicker than the same stone partitioned into smaller particles?
II.132. If future cosmonauts will arrive at the surface of Mars they would have to use steel umbrellas, since ordinary ones will give too weak protection. What reasons can explain this proposition?

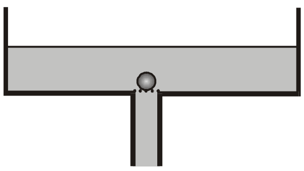


Fig. II.16

II.133. On the bottom of a wide vessel there is a narrow tube. The water filling this vessel may flow out it (see Fig. I.16). Between the vessel and the tube a grid is situated. If we put a light ball on the bottom of vessel (as sown in Figure) at the moment when water flows out, this ball does not buoy. But of we close the tube, ball buoys. Why?
II.134. We mix tea in a glass with small by rotating a tea–spoon. After taking off the spoon, we can see that tea-leaves try to join in the center of rotation. Why do they behave that way? The liquid keeps turning and, seemingly, the centrifugal force should move them to the walls of the glass.
II.135. One inventor suggested the following simple project of a perpetuum mobile: A hermetic vessel is divided into two parts by a hermetic membrane. Through the membrane a tube goes and a water turbine of a special design (see in Fig. II.17). The turbine has cameras with automatically closing caps. The pressure in the lower part of the vessel is greater than in its upper part. The water rises in the tube and fills the open camera of turbine. After that the camera closes and the wheel turns. In the lower part of the vessel the camera opens automatically, it returns the water and then closes hermetically, and so on. Why will not work perpetually this machine?

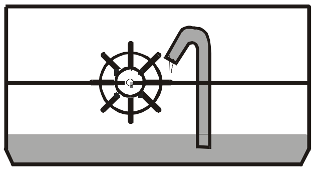


Fig. II.17.

II.136. A hurricane may blow out a house roof and throw it upwards. Explain the source of this "buoyant force".
II.137. Many houses have dormer-windows in their roofs. What do they serve for?
II.138. Why do travel dunes and sandbanks?
II.139. In snowy winters some parts of railroad or highways, situated in lower places, are open covered by snow even is snow does not falls. How could you explain this?
II.140. In windy winter days some snowdrifts appear behind trees and poles. Can you explain this

fact?

II.141. If we direct a jet of air through a tube, which is perpendicular to a plate (Fig. II.18), then the jet will press upon this plate and it shifts downwards for a certain distance. Now let us change the experiment: take two plates and fasten to immobile upper one a tube, while the lower parallel plate will be made movable. So the distance between plates may vary (see Fig. II.19). If the distance between plates is small, then in blowing a jet of air through the tube these plates will move apart each other. Under a small distance between plates they do attract to each other so that a significant force must be applied to separate them. Can you explain this phenomenon?

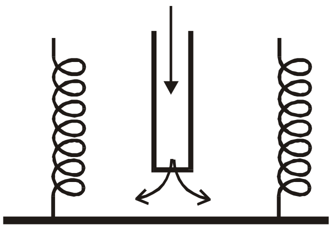


Fig. II.18.

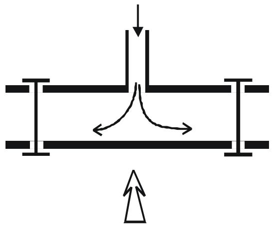


Fig. II.19.

II.142. A floating body displaces a volume of water whose weight equals the weight of the body. Why does a heavy motor boat runs almost over the water?

II.143. To support an airplane in the air a very small difference between pressures under and over a wind is necessary. For example, it suffices to have the pressure 10^5 Pa under wing and 9.9×10^4Pa above wing. In this situation, a heavy machine, which might weight some tons, is supported in air. Give explanation how is so heavy body supported by so small difference of pressures?

II.144. How will change the attack front resistance and the buoyant force of a wing if, not changing the velocity, one changes the angle of wing's inclination with respect to the horizon?

II.145. How does change the buoyant force of an airplane wing as it foes up? What is the upper bound of an airplane?

II.146. Why do high-speed airplanes fly, as a rule, on large heights?

II.147. What is the function of wings on racing automobiles (for instance, on car of class "Formula-1")?

II.148. From the mechanical standpoint explain the difference between the work of an airplane wing and a bird wing.

II.149. Bound to a line, a kite (see Fig. II.20) rises if, setting its plane at an angle with respect to the direction of kite motion, one runs quickly. Why does a kite rise?

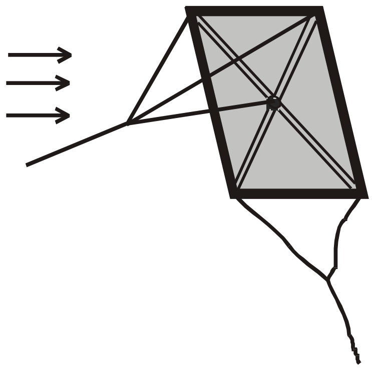


Fig. II.20.

II.150. Why do airplanes take off and land on runway against wind?

II.151. What are forces against which an airplane realizes a work in taking off?

II.152. There is no wind, but a socker ball flies by a curve in the horizontal plane. What is the mechanism of this phenomenon?

II.153. To make a ball to fly longer, in what direction it must twirled?

Chapter III

Molecular Physics

Foundations of Molecular-Kinetic Theory of Matter Structure

III.1. From the molecular-kinetic point of view explain: a) the feature of bodies to be subject to compression under a pressure applied; b) impossibility of an infinite compression of bodies; c) expansion of bodies under heating; d) solution of a salt in the water; d) the fluidity of liquids and the conservation of forms by solid bodies.
III.2. If you sprinkle perfume in one corner of a room, after a certain time its aroma will be felt in other corner. How can you explain this phenomenon? Having a watch, one can evaluate the average speed of smell propagation (it is near 0.6–0.9 m/s). How will this speed agree with the large velocity of a motion of molecules (~10^2 m/s)?
III.3. Why is the diffusion between liquids is significantly slower that that between gases? Under what conditions can diffusion occur between solid bodies?
III.4. A smith heats to white two pieces of iron. Wishing to weld them he puts them on each other and strikes with hammer. Pieces join, say ''weld". tts Explain the phenomena.
III.5. An alloy can be obtained without making its components to pass into the liquid state. Explain how can this be done.
III.6. The superficial layer of an iron thing can be made stronger by a carbonization. To do this, one must heat for several hours a piece of iron placed in a box filled with carbon. Explain what physical phenomenon is related to the iron carbonization, which is a saturation of the superficial layer of iron by the carbon with forming the carbide of iron?
III.7. Why does a piece of sugar solute faster in hot water than in cold?
III.8. Put upon each other two glass plates. Why is it difficult to displace one plate with respect to other? What are the forces to be overcome in this case?
III.9. In storing large sheets of polished glass, why do they put between them paper bands?
III.10. To reduce the friction, they polish surfaces, which are to contact each other. But, in dependence on the quality of polishing, the friction does not disappear limitlessly – within further polishing the friction starts to grow. Explain the cause of this phenomenon.
III.11. Explain the process of gluing from the standpoint of the molecular-kinetic theory.
III.12. As glasses are harder, so it is more difficult to glue them. Justify your answer.
III.13. Why does stucco slip if the rainwater gets between it and a break wall?
III.14. In the air filling a room, in accordance with the words by the great physicist Maxwell, under any temperature there are both molecules moving quickly and slowly. Divide the room by a membrane with a small door and let this door be controlled by a robot, which is able to distinguish quick and slow molecules. If we open the door for quick molecules and close for slow ones, then after a certain time we shall have in one half of the room all quick molecules. Consequently, the temperature will differ in different parts of the room. In this situation, a possibility rises to explore this difference between temperatures for production of a mechanical work. Therefore, one can construct a perpetuum mobile? Are his arguments true?
III.15. In order to determine losses of a natural gas (it almost has no smell) they use a special addend with specific smeller. The norm of mixing is 16g for 1000m^3 of the natural gas. A man may feel such a small quantity of the smeller in if it were diluted hundred times. Evaluate the quantity of molecules of smeller in one cubic meter of air for it could be felt by a man if the mass of one molecule of the smeller is 10^{-22}g. Estimate how many molecules will reach the nose when make a breath.
III.16. Why does the Brown motion is observable in a microscope only if particles are very small and saturated in a liquid?
III.17. Consider a very thin powder (for example, the flower pollen). As soon as it is mixed with water, why does not it sink on the bottom of a glass but always is in a suspended state? Whether the distribution of powder particles is uniform in the whole volume of water?
III.18. Any paint is a suspension of tiny particles of ferment in a solvent. Why do the particles of ferment remain long in suspension though their specific weight is greater than that of a solvent?
III.19. In 1883, in Indonesia at the Krakatoa island, a great volcano discharge happened destroying the half of the island and throwing into the air huge amounts of tiny dust and ash. Presence of the

dust and ash in atmosphere was observed during some years later. Habitant of many countries could observe unusual intensively red sunshine in those years. Why was the dust suspended for so long period?
III.20. Why are nuclear weapon test accompanied with formation of great quantities of radioactive dust are so dangerous for world human society when are made in atmosphere?
III.21. The milk is a suspension of tiny particles of fat. What is to be done to obtain the cream more quickly?
III.22. A gas is in a closed vessel. Its molecules in their impacts with walls transfer a part of their kinetic energy. This results in an assumption: an isolated vessel must become hot. It is true?

Thermometers

III.23. The balls of the two thermometers are same. One contains water, other one is filled with mercury. Under similar condition, why does the mercury thermometer become cold twice quicker than the water one?
III.24. In medicine, why do they use the mercury thermometers but not those of spirit or ether?
III.25. Which thermometer (under same other conditions) is more sensitive: with mercury or with spirit?
III.26. In modern fluid thermometers water is used as working liquid. May you explain the reasons for it?
III.27. Whether one could measure the temperature of a drop of hot water using a mercury thermometer?
III.28. The taking the temperature by a medical thermometer requires a long time (5 to 10 minutes), by short shakes put it back almost immediately after measuring?

Heat and Macroscopic Work.
The First–Law of Thermodynamics. The Heat Capacity

III.29. On the second floor the potential energy of firewood is greater than on the first floor. Whether burning of firewood will give a greater energy than if it were burst on first floor?
III.30. A boy which is at the height H over water lets go a stone which finally reaches the bottom of a pond of depth h. What is the quantity of heat which discharge the fall of the stone if its mass is m and its volume equals V?
III.31. The gas temperature inside an engine reaches 1800^0C. Why is it not so hot at exhaust pipe's outlet?
III.32. If a teapot is full, the water long remains hot in it. But if teapot was filled poorly, it quickly loses its temperature. Explain this phenomenon.
III.33. In the pipes of central heating the heat carrier is water. Why do they use water and not another substance?
III.34. Even in hot summer days the temperature of upper layers of water in ponds, rivers, and lakes is always lower than the temperature of air over them. Explain why.
III.35. How can you explain that at the beginning of frosts (in autumn) the water in rivers and lakes is not frozen (ice) though the temperature of ambient air may be negative for some degrees (measured in ^{0}C)?
III.36. In a strongly blowing jet of air does a candle go out?
III.37. The climate on islands is more moderate and uniform than over large continents. Explain the reasons.
III.38. In deserts, it is very hot in daytime, but at nights the temperature may fall below 0 ^{0}C. Explain the phenomenon.
III.39. The interior vessel of calorimeter is often filled not by water but kerosene. Why do they do it?
III.40. Estimate a maximal radius of a cave, which is formed in an underwater explosion on the depth $h = 1$km of an explosive charge with the mass $m = 1$kg. The energy of explosion of 1g of the explosive equals $\lambda = 4$ kJ.
III.41. Why do they make the brakes of airplanes of a material with high temperature of lighting and large specific heat capacity?
III.42. A spacecraft has special heat shields. Why do the shields of a spacecraft destroy when it enters to dense layer of atmosphere?

III.43. The temperature of atmosphere changes with the distance from Earth surface. Thus, at height 80km the temperature is about 80 °C, and at the height 150–200km attains hundreds degrees above zero. Nevertheless, space vehicles do not suffer from overheat at high orbits. Cosmonauts say that shields “burn” namely in layer with low temperatures. Do they contradict something?
III.44. Producing a shot, the steel of the barrel of a gun does not melt, though the temperature attains there 3600 °C. (Steel melts at 1400 °C). Why does the melting not happen?
III.45. In what case for heating of a metallic ball more energy is required: when it is hung on a line, or when it stands on a support? Assume that neither line, nor support require an additional energy.

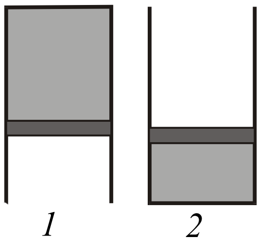


Fig. III.1.

III.46. In attempt to determine the specific heat of a substance of sample they found that the water in calorimeter is heated poorly when the sample is sink into it. This results in a very small change in thermometer readings and thus the accuracy of measurements is poor. Suggest a way for this experiment in order to increase the accuracy of measurements?
III.47. In a cylinder provided with a piston a certain mass gas is posed. In what case will a greater quantity of heat be required to warm up the cylinder: either in position *1* or *2* (see Fig.III.1)? The initial temperature of gas is same in both the cases.
III.48. Might the heat capacity of an ideal gas be negative?
III.49. How will the temperature in a room change if we open for a certain long time the door of refrigerator?
III.50. The gun-powder cannot be used as a fuel, while the gasoline does not serve for projectiles. Explain the reasons for it.

Heat conduction

III.51. You are going to take your breakfast and pour coffee into a glass. But due to something you have to leave the room for some minutes. Explain what should be done for the coffee be more hot: pour milk just before you leave the room or after you come back?
III.52. Two teapots are taken to prepare the tea, both can take a mass m_w of water. One teapot is made of copper and has the mass 200g, while other is of porcelain and its mass is 300g. Tea is more testy of prepared in water with higher temperature. Which of the teapots will bring a more testy tea if the boiling water is poured at room temperature $t = 20$ °C and we may neglect the heat radiation to the outside environment? (Specific heat of substances are: of water $c_w = 4180$ J/kg×Cal, of porcelain $c_p = 900$ J/kg×Cal, of copper $c_c = 390$ J/kg×Cal). Does a preliminary heating of a teapot by rinsing with boiling water give an advantage? In presence of exterior cooling what of teapots is really better?
III.53. Pour the same quantity of hot water of temperature T into both glass and aluminum cylinders. By touching these vessels you may easily verify that aluminum is warmed quicker than glass though specific heat of these substance is almost same (≈ 900 J/kg×Cal). Explain this phenomenon.
III.54. Why do we feel sharper a hot water when drink from aluminum cup than from a porcelain cup?
III.55. Why are metallic things felt more cold than wooden ones when you touch them in a room?
III.56. A thin copper wire melts over a gas burner while a copper nail even does not turn red?
III.57. Experienced housekeepers do not like to fry food on aluminum frying-pans, but on cast-iron ones?
III.58. Where is greater the temperature of an electric lamp: at the center of filament or on its surface?
III.59. Let us apply electric current through a wire without isolation and through isolated one, both being of the same section. Seemingly, the isolated wire should be hotter. But, in practice, the situation is contrary. What is the reason?
III.60. What will be the difference if you take by hand in a string frost a thick metallic bar and a thin-wall tube of the same diameter?
III.61. Heat a frying-pan on gas or spirit burner. From time to time sprinkle a drop of water over it and observe the rate of its heating. Explain why at height temperatures the drops of water are long “dancing” over pan and not disappear.
III.62. In a lake a heap of stones was covered by water. In winter the ice over this heap is thinner than in other places. Explain the cause of this phenomenon.
III.63. It is necessary to cool a bottle with cola as soon as possible. What is the best place to put it

into: snow or a dropped ice?
III.64. If a pot is in long use, the water will boil in a greater time. Why does it occur?
III.65. A wet wooden plank seems to be colder than the dry one. Give an explanation.
III.66. Which soil is heated more rapidly by sun: the wet one or the dry one?
III.67. A man does not feel cold in air with the temperature 20 °C. Then why does he feel the cold in water with the temperature 25 °C?
III.68. Give examples of the use of air in the capacity of a building material?
III.69. In dependence on rate of volume occupied by pores in a foam rubber its density varies from 40 to 100 kg/m^3. Does the thermal conductivity of the foam rubber depend on its density? How could you explain it?
III.70. Why does the “goose-flesh” appear when a man feels the cold?
III.71. If it is windy, why are hard to overpass both frost and hot in a desert?
III.72. When it is windy and cold in winter somebody can get his nose frost-bitten. Apropos, in books they write that meteorites become in the air red-hot due to friction. Why does not nose become hot?
III.73. Iron has a greater specific heat capacity that copper has. Therefore, being made of iron, the point of soldering devices would have large reserve of interior energy than the same made of copper if their both masses and temperatures were equal. Then why do they make points of soldering devices of copper?
III.74. If a man is caught by frost on a street, he tries to move more agitatedly to not become bitten by frost. Well, then why do the birds die of cold when fly?
III.75. The thermal conductivity of metals is known to be greater than that of a glass. Then why are calorimeters made of glass and not metal?
III.76. Wishing to compare the heat conduction in various metals, the Russian physicist Rikhman heated metallic balls and then observed the rate of their getting cold. He found that the led ball makes it more quickly than those made of other metals. Whether it implies that the led has a greater thermal conductivity than other metals?
III.77. Whether one can conserve frozen food in a thermos?
III.78. Is it true to say that a fur coat warms a man?
III.79. Is it true that the snow warms the ground?
III.80. It is known that fresh snow very well preserves the soil against frost, because it has a lot of air, which is a bad hear conductor. But a soil not covered by snow has even much more air over it. Then why does it turn strongly frozen?
III.81. Water is heated on an electric cooker of a constant power. Among two following processes, which does require more time: to heat water from 10 to 20 °C or from 80 to 90 °C?
III.82. Which of two electric boilers requires less energy to make water to boil in a pan: of power 600Wt or of power 1000Wt?
III.83. It is known that a heating battery keeps the temperature in a room +20°C if it is –20 °C outside, and keeps +10 °C if outside temperature is –40 °C. Find the temperature T of the battery.

Convection

III.84. Why do leaves of aspen sway even in a windless day?
III.85. Why are sounds more audible at night that in day?
III.86. Why sugar and salt dissolve easier when they are not on the bottom of a vessel but near the upper surface of liquid?
III.87. In the workrooms of orbital space stations fans work constantly. Explain the reasons.
III.88. Stick a candle to the bottom of a glass pan. Then light it and elevate over a box with sand. Let it go down and observe the flame of candle. What a phenomenon can be observed and who can it be explained? Make some conclusions, which could serve for the equipment of a spacecraft.
III.89. Once lighted, flame must be extinguished by itself, because burning produces the carbonic acid gas and water that both are non-burning substances and incapable to support burning. Therefore the flame immediately is surrounded by non-burning substances which make difficult the income of air. Without air any burning is not possible and thus the flame must be die. Then why is it quite opposite in practice?
III.90. As known, a jet of air which goes from a fan bring us a cool freshness. You may try to preserve the ice-cream of melting. From first argument it seems to be better conserved near a fan. But reality if opposite. Try to explain the situation.

III.91. In a cold winter day we readily feel how it blows out of a tightly closed window without any space for street air. How can you explain it?
III.92. Walls of some constructions are made double. Air is known to be a good thermal isolator. Then why do not they leave the space between walls with air but fill it with a friable material?
III.93. You may observe that the ceiling or lampshade above an electric lamp darkens. May you explain the causes?
III.94. In the systems of central heating working on hot water in spite of the presence of circulation due to convection, they put additional pumps. What for is it done?

Properties of Gases

III.95. If a ball was perforated, it do not jump when thrown on floor. Can you explain why?
III.96. Sometimes the water from a water cock runs white as milk. May you explain this phenomenon?
III.97. How does the buoyant force hoisting an air bubble in water change?
III.98. Blow into a small children balloon and tie it firmly. To determine the volume of the ball, use two pans: one with water at room's temperature and one with hot water. After evaluation, explain the difference.
III.99. If a deep-water fish is taken of water, its bubble goes off the fish. Can you explain the phenomenon?
III.100. In following Boyle—Mariotte's law for an ideal gas we have $pV=\text{const}$ at $T=\text{const}$. But then why when we inflate cheeks both the pressure and the volume grow in our moth?
III.101. When a dry fire-wood burns, sparks jump from it. Can you say why?
III.102. Where the morning frosts are more probable: in lower or places or at heights?
III.103. Smoke pipes of large factories are very height. Why do they construct them in that way? Which pipes are better: made of iron or made of breaks?
III.104. If you put on a plate with some water a hot glass cylinder, some time later you will observe that water in glass stands above the water in plate. Could you explain it?
III.105. Medicine doctors sometime recommend to apply cupping-classes. Why does a cupping-glass "sticks" to human skin?
III.106. Why is a breech ring made in a fire-arm?
III.107. In the cylinder of engine the air is subject to quick and strong compression. What for is this done?
III.108. Whether the same quantity of air is necessary to pump tires in winter and in summer? Justify your answer.
III.109. In the production of electric lamps their bulb is filled by nitrogen with pressure significantly lower that the atmospheric pressure. May you give an explanation?
III.110. Air is pumped into a vessel equipped with manometer. Its pressure is higher than atmospheric. Then they close the valve and let the air to equal the pressure. Afterwards they close the valve. But after a certain time the pressure in vessel grows again. Explain the phenomenon.
III.111. A bicycle air-pump turns warmer when one pumps tires. What happens in this situation?
III.112. Warm air goes up. But then why is air warmer in the lower part of the troposphere than in its upper part?
III.113. In heating a gas, the following dependence of pressure on temperature was obtained (see Fig.III.2). What does the gas do: is either tightening or widening?

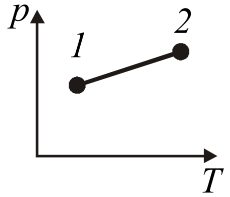


Fig. III.2

III.114. It is known that wet things are heavier than same but dry ones. It is explained by the fact that to the weight of a body we must add the weight of the water in it. However, if one takes precision balance and weight a liter of dry air and then a liter of humid air, the last one will be lighter. How could you explain this seeming contradiction?
III.115. To the handle of a cylindrical pail a stone is bound. Then the pail was put into water with its bottom upwards. To night the temperature became lower but the pressure was steady. How did the position of pail and the level of water change?
III.116. A glass of mass m was put into water with its bottom upwards. How will rise the bottom if we heat the water up to 100 °C and keep his temperature? The area of bottom is S. The pressure of the saturated water vapor under a temperature which water had at the beginning is significantly less than the atmospheric pressure p_0.

III.117. Arguing by a graph, explain how the gas volume changes within heating if the change of its pressure and temperature is given in Fig. III.3.

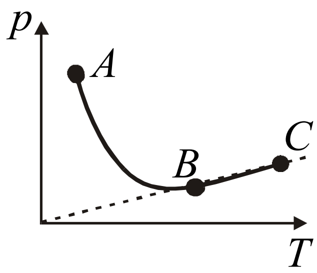
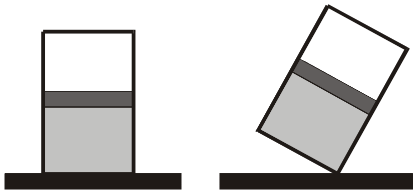


Fig. III.3

III.118. In a thermally isolated vessel standing on a table an one-atom ideal gas is under a piston which can freely move (see Fig. III.4a). On the other side of the piston we have the vacuum. The piston is fixed and the vessel is inclined by the angle $\alpha = 60^0$. Then the piston is liberated again (see Fig.III.4b). For what factor will the volume of gas change after the equilibrium will take place?



a b

Fig. III.4

III.119. For how many degrees must the air inside a balloon be heated for it could take off? The volume of balloon is $525m^3$, shell's mass is 10kg, the atmospheric pressure is 765 mm of mercury, the temperature is 27 °C, the molar mass of the air is $M = 29$ g/mol. The shell of the balloon is non-tensile and has a small hole at the bottom.
III.120. We have an unknown substance. Give a simple way to determine its molecular mass.

Features of Liquids.
Surface tension

III.121. In an explosion of water boiler with pressure only 10 to 15atm consequences may be very hard. Meanwhile is rupture of a hydraulic press with pressure 100 to 200atm, damages are not too significant. Explain the reasons.
III.122. Molecular pressure of water is 1.1×10^9Pa. In swimming and diving why do not we feel this huge pressure?
III.123. A rope is stretched between two poles. How will the sagging of the rope change after a rain?
III.124. Why does new linen sometime become smaller after first washing?
III.125. Why do the hairs of a paintbrush diverge in water but "glue" when are taken off it?
III.126. Heat a glass tube with a not straight (e.g., broken) edge on a flame of gas or spirit burner. When melted, the edge becomes smooth. Explain the reason.
III.127. Sand is significantly heavier than water. Then why does wind make clouds of sand in desert, but only small waves on water?
III.128. What is the reason for pouring water upon streets in hot days?
III.129. As known, the density of glass is less that the density of mercury. This explains the fact that a glass plate put into a vessel with mercury does not sink. But if we first put a glass plate on vessel's bottom and then pour mercury, the plate will not float up. Why?
III.130. Into a vessel with water put a piece of thin paper so that it lie upon water. Then put on it a small needle. After a certain time the paper will sink, while the needle will float over water. Paper's density is known to be less than that of water, contrary with steel needle. What is the matter?
III.131. On water surface two matches are floating. Before this they have been half-merged to liquid paraffin. It turns out that both clean and paraffin ends of matches are attracted to each other, while those with "different names" move away from each other. Explain this phenomenon.
III.132. Pour water in a vessel and throw into it some similar corks, they all will float on their sides. One can make them to float in vertical position as follows: densely push corks one to other and then sink completely into water. After that, keeping them tightly under the water, rise them up to water surface and then slowly deliberate. Corks will float vertically. Explain why do the float so now.
III.133. Pour water into a wide plate and throw there some 8 to 10 matches. Take a piece of sugar and touch water. Matches will join near the sugar. Now touch water with a piece of soap. Matches will run off it. Explain why do matches "distinguish tastes".
III.134. A drop of water of the radius r falls from the height h and drops out into n equal drops. What quantity of heat will be radiated? Surface tension coefficient of water is σ.
III.135. A tarpaulin tent well protects against rain. But why does it start to leak if in rain one touches its upper surface?
III.136. Why does one cannot make bubbles of water, but soap solution?

III.137. Take a not too high tin and make a small hole of the diameter 1 to 2mm. Melt paraffin and put your tin into it. If the hole will be closed by paraffin, make a hole again with a needle. Pour some 7 to 10mm of water into tin. Why does not water flow out?

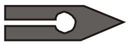


Fig. III.5

III.138. Estimate the average size of capillary of filter paper by means of a straightedge and a vessel with water.

III.139. A light non-closed paper frame, whole form is shown in Fig.III.5, is floating on water. What will happen if we drop inside it soap solution?

III.140. Into a vessel with water an L-shaped glass capillary of the radius *r* is submerged (see Fig. III.6). The temperature dependence of the coefficient of surface tension s is given in Fig. III.7. In what range of temperature will the water will flow out the vessel?

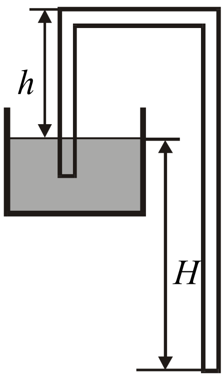


Fig. III.6

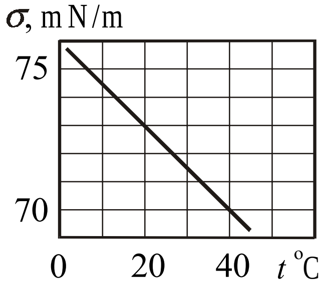


Fig. III.7

III.141. When the soap film blows up, to where does it disappear?

III.142. Some insects may freely run over water surface as over a floor. How do they do it?

III.143. What are the characteristics of water, which determine its behavior in zero gravity?

III.144. Whether it is possible to cast metals into forms moistening by this metal?

III.145. Before to start solder one should carefully clean the surfaces of oxides. For what is it done? What can you say about molecular forces between molecules of solder and oxides?

III.146. Aluminum fails to be soldered by tinny solder. What is the cause?

III.147. Why does not Indian ink flow out drawing-pen?

III.148. To make easier unscrew of nut from corroded bolt, they moisten it with kerosene or machine oil. What are the reasons for such action?

III.149. One must not close a vessel with kerosene or fuel with a cork enveloped by a cloth. Why?

III.150. Why is a canister, where one keeps kerosene, often covered from exterior with a thin layer of kerosene?

III.151. What happen to a liquid which is poured into vessel one a spacecraft?

III.152. Whether lubricators must moisten the metallic parts in friction?

III.153. What is a liquid, which can be poured into a glass “over edges”?

III.154. Why can the hands (covered by oil) be poorly cleaned by a wool or silk tissue?

III.155. It is not recommended to keep near each other a chalk and a humid cloth at blackboard. Explain the reasons.

III.156. If we put a chalk upon a wet sponge, it will be humid. But if a dry sponge is placed over a humid chalk, it will remain dry. Explain the phenomenon.

III.157. If paper is bad, you may see blur of ink on it. Why does it occur? Which is a way to treat paper for it could server for writing by an ink-pen?

III.158. In ramming a ground, why do the underground water rise?

III.159. If the upper layer of a soil becomes caked, this soil dries more than a loosed soil. Explain the cause. Why does a ploughed up soil dries more slowly that non-ploughed?

III.160. In order to avoid quick dry of soils, they plough it up and then cultivate. Why is it done?

III.161. A pen for writing with ink has a cut along its end. What for they make this lengthwise cut?

III.162. Explain an experiment made by M.V. Lomonosov: “Through a sheeted of lead, bent and formed as a siphon and merged into mercury with one end, the mercury flows out from its vessel within 24 hours”.

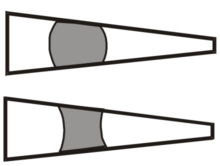


Fig. III.8

III.163. There are two thin glass tubes, which are narrowed to one end. A drop of mercury and a drop of water were put into tubes (see Fig. III.8). Point out where is mercury and where is water. Will these drops stay as they are shown?

III.164. On a humid ground the traces of a man become wet. Why does this happen?

III.165. Into a vessel with hot water a capillary tube was submerged. Whether the level of water in tube will change when the water will become colder?

III.166. To enrich ore, i.e., to increase the concentration of useful parts, flotation is of often use. Its essence is as follows. Ore is fined (to particles of 0.5mm to 1mm) and then is merged into reservoir with water and oil-like liquids, which may cover the particles of a useful mineral with very thin films. Now these particles are not moistened with water. The mixture is strongly mixed with air and it forms foam. In doing so, we make the useful particles to float up to surface. Explain the physical basements of the flotation.
III.167. Why is it necessary to cover a wooden surface with drying oil before painting?
III.168. A falling jet of water always breaks apart into drops. Explain the cause. Whether it is possible to lengthen unboundedly a water jet?
III.169. In which case from the tap of a "samovar" (Russian traditional water boiler for tea, representing a metallic vessel with a duct inside it for fire and a tap at its bottom for flowing out hot water) are heavier the drops which fall down: when the water is hot or when it is cold?
III.170. Liquid drugs are often measured in drops. Is such manner of measuring sufficiently exact?
III.171. Blow a soap bubble using tube and soap solution. Take off the tube with which you blew it not letting go to the bubble. **1**. Explain the phenomenon observed. **2**. Derive a formula for additional pressure which takes place inside of soap bubble.
III.172. The two soap bubbles with radii r_1 and r_2 are joined into a single bubble with the radius r. Determine the atmospheric pressure. The surface tension of soap film is σ.
III.173. Estimate the size of an atom of mercury if there are known the surface tension in units of energy/square, as well as the density and the specific heat of vaporization of the mercury.
III.174. Clean a glass jar with boiled cold water and then pour clean water. Make some experiments: a) sink to jar a tomato, cherry, or grape. Observe the volume of fruits. After a certain time of merging fruits into water, you may see that they swell, which finally leads to bowing of their shell. Explain the phenomenon observed; b) take a carrot and cut off its top. Turn over the top by a sticking tape or even a line (for the carrot's body not be destroyed). Hen make a cylindrical hole of diameter 1cm and length 5cm to 6cm. Fill the cave with concentrated solution of sugar. Cover the hole with a lid into which insert a glass tube (approximately 30cm) for observation of the level of sugar solution. Then take a piece of cartoon or plywood, make in it a round hole for settling the carrot. Now place the system into water so that it be merged in water almost completely. Trace the behavior of sugar solution. To this end it is convenient to use a small rubber ring put onto tube. The "readings" should be done each hour during 4 to 5 hours. The level of solution must grow; c) draw the graph of dependence of the level on time.

Properties of Solid Bodies. Crystal Structure of Matter

III.175. The property of a metal to resist against penetration of another metal is called its strength. It is determined by means of a steel ball. What is the pressure produced by a ball on the surface of steel under action of the force 1500N if the area of trace of the ball equals 0.01mm^2?
III.176. A crystal of salt divides after a stroke of hammer into various pieces, but they always have the form of rectangular parallelepiped? Why does it occur?
III.177. As a liquid, amorphous bodies possess an isotropy, i.e., their properties are equal in all directions. In contrast to amorphous bodies, the crystals are anisotropic, i.e., some physical properties exist (elastic, electric, magnetic, optical, etc.) which differ in different directions. A solid metal is a collection of a large quantity of tiny crystals engages to each other. Will this mean that properties of such a substance will differ in different directions?
III.178. Is the glass a solid body?
III.179. Why does a ball turned out of a mono-crystal can change not only its volume but also the shape?
III.180. All metals possess crystal structure, meanwhile the anisotropy in mechanical, thermal, electrical features properties are rare for metals. May you explain the reasons?
III.181. A tin covered by zinc has patterns on surface. What is their origin?
III.182. Steel is more plastic than the cast-iron. What does give us the right for this conclusion?
III.183. The plasticity of a single crystal copper is some times greater than the plasticity of a multi-crystal copper. What is the cause?
III.184. Why does snow squeak in frost under feet?
III.185. Why does the salt thrown on red-hot coals rattle?
III.186. In the nature, carbon is rarely met in the form of diamonds, but not the graphite. Explain the reason.

III.187. Steel can be cold in tow ways: quickly and slowly. In which of these cases will it give more heat? Why?
III.188. Which are the advantages of cosmic technologies enabling us to obtain materials with unusual properties?
III.189. A fire-wood can be easily broken along filaments but not across. May you explain it?
III.190. The frame of a bicycle is usually made of steel tubes but not bars. May you explain the reasons?
III.191. What is the meaning of tube structure or our bones?
III.192. In the modern construction and building the reinforced concrete columns are of often use in the capacity of supporting elements. What for does its steel pattern inside it serve? Which kind of deformation we meet here?
III.193. Consider two steel machine bars, one uniform, other is hollow (a pipe). The hollow one turns to be stronger, but only if its walls are sufficiently thick. Explain the causes.
III.194. Determine the maximally admitted height of a reinforced concrete column which cannot be destroyed by proper weight if the admissible pressure for concrete is 5000kPa.
III.195. The Ostankino Tower in Moscow bases on a fundament by ten "legs", each having the area of support 4,7m^2. The mass of the whole tower is 32 thousand tons. Determine the pressure produced by the tower upon the fundament with regard for that under strong wind the pressure on some "legs" might increase by 2.7MPa.
III.196. Why is a diamond more strong than the graphite?
III.197. How can one augment the strength of a metal?
III.198. In what manner does the purity degree of a material affect its strength?
III.199. Which state of a metal (thin grains or large grains) does correspond to a greater strength? Why?
III.200. As does the strengthening affect the strength of a metal? What are the changes in its structure in this process?
III.201. The cooling of metals within its strengthening is not usually made usually in water but mineral oils. May you explain why?
III.202. For what purposes they do anneal metals? Which changes in their structure will characterize the process?
III.203. Exterior parts of supersonic airplanes are cooled with special equipment. What is it done for?
III.204. In sharpening tools on a rotating stone it is necessary to cool the tools. Why do they cool them by water from time to time?
III.205. In order to make a certain steel spring, one can proceed as follows. A steel wire is heated up to it turn red on burner's flame or by electric current. Then they slowly cool it. Afterwards the wire is to be taken on a cylindrical surface. Then it is heated again and quickly cooled. You may make the same yourselves. Explain the processes holding in the steel.
III.206. Tourists and boy scouts sometime have to take off the handle of a broken ax. They usually apply the fire. What should they do in order to preserve ax properties?

Thermal Expansion

III.207. In heating whether the sizes of an utter bar and a hollow tube with both the same diameter and length will differ?
III.208. At sharp oscillations of temperature a stone gives rifts but not metal. Explain the cause of this phenomenon.
III.209. Why are glass vessels necessary for works in high temperatures made of thin glass?
III.205. Under sharp change of temperature rifts appear on enameled dishes. Explain the cause of these rifts.

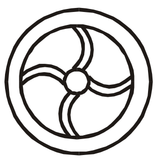


Fig. III.9

III.206. If a ring is subject to heating, how will change its aperture?
III.207. Over an iron cylinder a silver ring was tightly fitted at the room temperature. What can you propose in order to remove it?
III.208. Over an iron cylinder a copper ring is tightly fitted. If we simultaneously cool both objects, will we succeed in removing it? If heat?
III.209. Wheels made by casting of a cast-iron often have not straight but curve spokes (see Fig. III.9). What is the aim?
III.210. Why do the rules of safety exploration strictly forbid washing of a hot

boiler with cold water?
III.211. Dishes made of quartz sustain sharp changes of temperature. An overheated cup made of quartz can be safely put into cold water. What does explain this property of quartz?
III.212. Precision measuring devices and their details (calibrated plates, tools, bows of precision balances, balances of watches) are made of an alloy (in Russian "invar", consists of the nickel 35–37%, the rest is iron). Explain why is this sort of steel used for these purposes.
III.213. To make a concrete construction stronger (for example, a dam), they build it on a steel framework. The whole construction is called "reinforced concrete". Why do such constructions (in spite of difference in materials properties) behave as a single unit?
III.214. What does support a continuous motion of water in central-heating systems?
III.215. Why does not the thermal expansion of water break ducts and pipes in central-heating systems?
III.216. If one opens a hot water cock after a long interval, the flow of water reduces and can even stop. At the same time, if one leaves cold water tap open for a bit, the flow does not stops. Why this happens?
III.217. Communicating vessels are filled with a liquid. The temperature of the liquid rises in one vessel and remains same in other. Whether the level of the liquid will change in the second vessel?
III.218. How will the level of mercury change in a barometer if the temperature grows? Does affect the thermal expansion of the barometric tube the accuracy of barometer?
III.219. A body is floating in water, not merged completely. Will float this body if one heats the water?

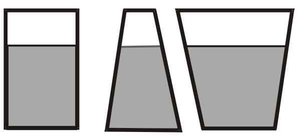


Fig. III.10

III.220. The force of pressure on the bottom of vessels shown in Fig. III.10 is same (vessels have bottoms of the same square). How will change the force of pressure on the bottoms if one heats the liquid? Assume that the thermal expansion of vessels can be omitted.
III.221. A vessel filled with kerosene is in equilibrium on a pan of a sensitive balance. Kerosene is heated for several dozens degrees. One may suppose that the equilibrium of the balance is not to be violated, since the mass of kerosene has not changed. Then why does the balance show a reduction of weight?
III.222. Air is known to expand under heating. Then why does a bubble of air in the device called "level" become smaller in hot days and greater in cold days?
III.223. On a coin a straight line was draw by a thin chalk. Whether will it remains straight if the coin will be heated?
III.224. Used for covering the south part of the Bristol cathedral, a lead sheet climbed down along the roof for 50cm. They were trying to prevent this climbing down by hammering nails, but the sheet was wresting all the nails. The roof was not too steep, and the sheet might lie on it under action of the gravitation. Then why finally did the sheet climbed down completely?

Phase Transitions.
Change of Aggregate State of Matter

III.225. Human beings learnt to treat bronze much earlier than iron. How can you explain it?
III.226. A quartz glass is very strong and never burst. Resources of quartz on Earth are very rich. Then why people do not use quartz for producing kitchen dishes and cups?
III.227. In winter, calm lakes are covered by ice in winter earlier than rivers. Why?
III.228. Ice melts longer if wrapped into a wet paper. Why?
III.229. Why water in lakes starts to turn into ice from upper layers?
III.230. Take two wide open wooden vessels: one with cold water and other with the same quantity of hot water. Put then outside your house in winter frost. Which of the vessels will earlier be covered by ice? You may guess that the vessel with cold water. Your reason might be as follows: While the hot water will turn colder, the cold will turn into ice. But, in practice, the situation is opposite. How can you explain his phenomenon?
III.231. Sometimes in autumn snow falls and a small frost (–1°C to -2°C) stands for some days. But when weather becomes warmer, many plants remain alive, they continue grow and even give flowers. How can they survive?
III.232. A wire loop is put on a bar of ice. To lower part of the loop a load is bound. The wire rather quickly will cut the ice, which will be melted under the wire and turn frozen again above it. However,

if the wire will be of same diameter bit now plastic (e.g., of nylon), ice will practically remain uncut. Explain the difference.
III.233. Estimate the maximal thickness of a glacier, which might exist on Earth.
III.234. In a light frost snowballs are easy to make, but not in a strong frost. Explain.
III.235. In winter frosts the window glass is covered by ice patterns. Why? On which side of glass must these patterns appear?
III.236. Whether always the temperature of melting equals the temperature of crystallization for the same substance?
III.237. Water can be cooled below 0 °C. In this situation, if one shakes a vessel with such overcooled water, it will rapidly crystallize and warms up to 0 °C. How could you explain this?
III.238. Why are mists more often in towns than in fields?
III.239. In winter in a clean air outside cities or on high mountains one almost cannot note mist produced by his/her respiration. Explain the phenomenon.
III.240. After a jet plane we see a trace which is like a straight long could. Why does it appear?
III.241. In spring, sometime in mornings a rime appears on plants and grass. How does it affect the cooling of plants?
III.242. A wet thing turns to be frozen in a frost quite quickly. But in frosts, a humid soil becomes frozen in depth more slowly than the dry one. Why does this occur?
III.243. Gas ducts in inhabited rooms without heating are usually covered for by something for winter. Why do they make it?
III.244. Why cannot one melt wood and paper?
III.245. Will be melted ice taken at 0 °C if one pours over it water 0 °C and puts it into a room at the temperature 0 °C?
III.246. Prepare in a chemical glass a mixture of snow and water and place a thermometer into this mixture. Whether the readings of thermometer will change if we would accelerate melting by heating the glass?
III.247. It is recommended to add salt over ice surfaces in ice-houses. What is the reason for that manipulation?
III.248. In cold Russian winters streets sometimes are covered by ice. To avoid slipping of people and cars, it is a custom there to disperse a mixture of sand and salt over roads. Why do they add salt in sand?
III.249. In a popular scientific journal “Science and Life” a useful advice was given: To prevent a medicine warmer fast cooling (a rubber vessel which in filled with hot water) add a teaspoon of salt into hot water”. If you have a warmer of this type, you may verify the usefulness of the advice. Explain the results obtained.
III.250. If one sinks one icicle into puts into water which freezes, and one icicle into solution of salt of the same temperature, them within some hours the diameter of the first icicle will noticeably grow, but the second will become thinner. Why?
III.251. For winter exploitation into radiators of cars not water, but a special liquid is filled. For is the reason for this action?
III.252. In bid cooling cameras instead of water a salt solution is used in circulation tubes. Explain the reason.
III.253. In cellar, where people use to keep vegetable for winter, if a frost may damage vegetables, they often leave there a wide basin filled with water. How does water save vegetables against frost?
III.254. What is the role of specific heat of melting of ice in the nature? What might happen in the spring if the specific heat of melting of ice were not 333, but 11,7 kJ/kg (as the mercury has)?
III.255. What is the weather, which helps icicles to born? They grow down even on roofs of inhabited places, Were it a frost, where from would appear the water? If it were rather warm air, how would they freeze?
III.256. In times when the driving of ice occur in the spring, it is more cold near the river, than far from it. How can you explain this phenomenon?
III.257. When snow falls, the temperature usually goes up. Why?
III.258. Why does the water, when freezes and thus expands in a bottle, burst it, but not push off the cork?
III.259. Why does the rime, covering branches of trees in winter mornings, disappear, even if a thaw does not come?
III.260. Whether one can heat milk packed in paper on open flame?
III.261. When can ice serve as a heater?
III.262. Why does a newly baked bread weight more than if it were cooled?

III.263. Why do many things buckle when dry?
III.264. How one can reduce the rate of water vaporizing in an open vessel?
III.265. Why does the fat soup cool off more slowly than the same quantity of water?
III.266. A cold autumn rain drizzles outside house. Washed linen is hung in kitchen. Will it dry quicker if we open window?
III.267. What is the meaning of sweating for a human organism?
III.268. Why is it more difficult to overpass big hot in a humid climate than in a dry one?
III.269. Why may a man bear temperatures exceeding 100 °C if the air is dry?
III.270. Due to large heat capacity the water warms more slowly than air, therefore even in hot summer day the water in a pond is colder than air. But why do you feel cold after bath?
III.280. Why we feel cold in wetted clothes?

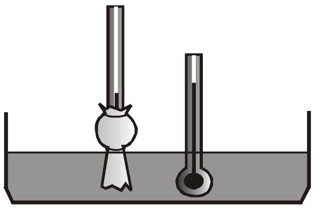


Fig. III.11

III.281. The temperature of a body sunk in water should be same as if it were moisten by water. See in Fig. III.11 two thermometers, one being merged in water and other is only moistened with water since it is wrapped with a tissue, whose edge is in water. Why does the merged thermometer show a higher temperature than that above water?
III.282. After washing the floor, why can feel a nice cool in that room?
III.283. Will a pot boil quicker if we add some hot water in it?
III.284. As known, the water has greater heat of vaporization than the alcohol. Therefore, if we pour water on a hand, by vaporizing it will cool the hand quicker than alcohol, which contradicts the experience. Why?
III.285. Two different quantities of water were poured in two similar vessels. Temperature was same. Air was eliminated from vessels and they were connected with a rubber tube. Vessels stand one pan of a balance; the balance is in equilibrium. How will change the equilibrium in time?
III.286. When weather turns colder, usually the formation of clouds grows. Explain why do cloud disappear to evening, while air turns cooler in this time?
III.287. To prevent the milk of turning sour, a vessel with milk should be put into water and covered by a napkin whose ends are in water. Explain this way for conserving milk fresh.
III.288. Both te humid and dry thermometers of a psychrometer show the same temperature. What should it say us about the state of air?
III.289. How changes the air humidity in a room if the difference between readings of the thermometers of psychrometer starts to decrease?
III.290. Why is the summer humidity of air in rooms greater than the winter one?
III.291. As known, in normal atmospheric pressure the water boils at 100°C. Let us sink into a big pan with boiling water a vessel with water. Water will heat up to 100 °C. Well, now it must start to boil, but… We might wait as much as necessary, but it would not boil. Why?
III.292. If we add some spoons of salt into the pan from previous problem, will we get the required result?
III.293. Will water boil inside long macaroni?
III.294. To prevent the carpenter glue from turning burnt, they heat it in special pans. A jar with glue is to be put into a pan with water, which must be heated. Explain why will such a device preserve the glue of becoming burnt?
III.295. They poured similar quantities of water of the same temperature in to similar pans. The only difference is that now one pan contains water from tap, while water in other was previously already boiled. In equal remaining conditions, which pan will boil first?
III.296. If we heat water in a pot to boiling and then increase flame, it will boil more intensively, which shows increase of vapor formation. But if now we turn of the burner, the vapor jet becomes even greater. Can you explain it?
III.297. Does anyone could prepare a hard-boiled egg on Mars?
III.298. The boiling temperature for mercury is 630 °C. How one could explain the use of mercury thermometers for measuring temperatures up to 600 °C?
III.299. Why are humid matches so hardly fired?
III.300. How does water kill a fire?
III.301. To make better the burning of coal, they add some water to it. Why?
III.302. Why is it forbidden to apply water to extinguish burning resins and bitumen?
III.303. If one drops vegetable oil into boiling water, nothing special happens. Why do we not

recommend to drop the water into the boiling oil?
III.304. Why is more dangerous burn obtained by vapor at 100 °C than by water at the same temperature?
III.305. In 0 °C by suction pump one can rise water to height up to 10m. How and why will change this height for warm water?
III.306. May one elevate boiling water by a suction pump?
III.307. In heating, air bubbles form first at the bottom of a vessel. Give arguments to explain this phenomenon.
III.308. Why does a pot noise before it start boil?
III.309. Why does the water hiss if is accidentally poured on a burner, which is heated to red-hot?
III.310. Does the temperature of boiling water in a pot differ from the temperature of the vapor in it?
III.311. If temperature is same, whether average kinetic energy of vapor, water, and ice are at the same temperature?
III.312. How can one refine mercury, which contains additions of zing and tin?
III.313. Sometime one can see as, in order to make cooking quicker, a housekeeper makes greater the flame under pan, which already boils. Is such a way correct?
III.314. Why does a small hole exist in the tap of a pot?
III.315. Under critical temperature specific heat of vaporization equals zero for all liquids. Explain the causes.
III.316. How change the absolute and relative humidity of air ina closed room in heating?
III.317. Why is a dampness felt in cold rooms?
III.318. In winter does are man's hear, lashes, and moustache covered by the rime if he passed a certain time in frosty air?
III.319. In Russia, they use to build bath-houses near main farmer's building. This bath-house is the place where people take bath and use steam-room in long cold winters and even summers). Now imagine that you are in a hot well-heated bath-house. Winter is frosty and outside the bath-house thermometer shows some dozens below 0 °C. If you open a small hinged window pane zero in the bath-house, where will flow the vapor (mist) to?
III.320. Why does a mist flow from moth (when one breathes or speaks on street) in winter?
III.321. Why in autumn does mist over river usually stand for a long time after sunshine?
III.322. Why are the clouds closer to ground in autumn than in summer?
III.323. The dew usually appears at morning when sky is clear. At nights with dense clouds one does not meet the dew. Why?
III.324. Under a wide bushy tree dew does not appear. Explain the reason.
III.325. Why is rainwater unsalted even over seas?
III.326. If you tenderly breathe upon your hand, you fill warm, but if you blow to it, you feel cooling. Explain the difference.
III.327. In order to know whether the mineral machine oil contains some water, one can test it by heating it up to 100–110 °C. If water is present, oil rattles and sprinkles. Explain this way of testing.
III.328. Wet fire-wood "hisses" in a stove and give less heat. Explain the situation.
III.329. Tow similar vessels with the same quantity of water are heated on flame, one being open, other closed hermetically. In which vessel will the water warm quicker?
III.330. Why does the water almost immediately stop to boil as burner is turned off?
III.331. Where is the boiling water hotter: on a mountain, on sea level, or in a deep mine? Why?
III.332. In bakery, evaporation of a sugar solution is made at temperatures significantly lower than 100 °C. Why? In what way can thus evaporation be realized?

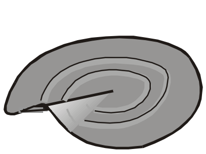


Fig. III.12

III.333. To sterilize medical surgery dressing materials and tools why do they use autoclaves under increased pressure (to 0.3MPa)?
III.334. Wool is to be ironed with a hot iron through a wet cloth. Why do they make it such way?
III.335. To prevent the "running off" of the milk in boiling, an enameled disk with a wave shape us to be on the bottom of a pan. This disk has at one side a channel with nose-shape (see in Fig. III.12). Explain the action of this "milk-guard".
III.336. To obtain metals of high quality, electric melting under vacuum is used. Which are the advantages of this technology?
III.337. As known, in evaporation the temperature of a liquid decreases. In this case, why are temperatures of gasoline, alcohol, and so on in usual conditions is almost same as the temperature

of air, though the surface of liquids is open?
III.338. Why does the flowers begin bloom earlier in the center of a city than in its suburbs?
III.339. In winter, the front window of cars is to be blown with a special fan. What is the aim in this case?
III.340. If the hay is dried on sun, its alimentary value worsens. A special agriculture machine picks up and presses the hay into bales with end-to-end holes it them. What is the meaning of these holes?
III.341. Under conditions of vacuum, vegetables and fruits become dry more quickly than in normal conditions? Can you explain why?
III.342. Dried milk is obtained by evaporation of natural milk in a vessel from which the air is constantly pimped out. Besides, the temperature in this vessel is significantly below 100 °C. What are physical laws put into basement of this process?
III.343. Carbon-acid fire-extinguishers are charged with carbon-acid gas. In acting, these such extinguishers give not a jet of liquid, but so-called “carbon-acid snow” which is a dense whitish cloud of gas? What is lying in the principle of such fire-extinguishers?
III.344. Reservoirs for holding petroleum and derivatives have valves for exit of gases. How do appear gases in reservoirs?
III.345. Why cannot a cistern be filled up completely with gasoline?
III.346. To transport and hold gas, it must be dried. Suggest a way to dry it.
III.347. The clean oxygen, which is widely applied in production ad economy, is obtained from air. What is the simplest way to derive the oxygen from air if you known that boiling temperature for the oxygen and nitrogen (main component of air) are –183 °C and –196 °C, respectively?
III.348. Heat condition from one body to other takes place only if a temperature difference exists between them. Then why is vaporizing the water (having the temperature of the ambient) being poured into a dish? For water vaporizing a certain quantity of heat is necessary which cannot be obtained from neighboring ambient. Then how does vaporization occur?
III.349. In a glass tube, sealed of at both ends, air is pumped off. The tube contains a column of water inside it. If shaken, the column strikes the end of water as if it has no resistance. However, it is known, that in spite of air being pumped out, the space over water is filled with water vapor. Moreover, to a certain temperature, a definite pressure of this vapor corresponds. Explain the phenomenon observed.
III.350. In a vessel at temperature $t = 0$ °C water is placed with a piece of ice which is frozen to the bottom of the vessel. As soon as the heat $Q = 60$ kJ was applied to the content of the vessel, 10% of ice melted and the remaining part floated up to surface. What is the new level of water in vessel if at initial moment it was $h = 20$cm? The square of cross section of the vessel is $S = 200$cm^2, the density of water equals $\rho_w = 1$g/cm^3, the density of ice is $\rho_i = 0{,}9$g/cm^3, specific heat of melting for ice equals $q = 333$ kJ/kg.
III.351. Estimate the speed which with a fly must impact a wall in order to burn out completely.

Efficiency. Internal-combustion engines

III.352. The ocean possesses practically inexhaustible reserves of the interior energy. Why do not people build machines, which could use this energy?
III.353. Whether a body always gives out in cooling the same quantity of energy, which was earlier obtained in heating by the same body?
III.354. Why do they construct the walls of a boiler of steel of copper? Why do they clean off the scum from walls?
III.355. The vapor in boilers of vapor turbines is overheated. What is it necessary for?
III.356. The greater is the compression in the piston of a the carburettor engine, the greater is its power. However, the volume of air with fuel in piston is reduced for only by 7 to 8 times. How can you explain this?
III.357. Sadi Carnot, a French engineer and scientist, evaluated the maximum of possible efficiency of a heat machine which works with a heat carrier of temperature T_h and a refrigerator of temperature T_r: $\eta = (T_h - T_r)/T_h$. The formula shows that the efficiency of a heat machine is as higher as greater is the difference between temperatures of heater and refrigerator. An automobile is a heat machine. It bases on fuel which increases its temperature of working body (gases) in the combustion of fuel, while the refrigerator is the atmosphere; besides, the temperature of the gases formed by combustion is practically same in winter and in summer. Then why does automobile

consume more gasoline in winter? The temperature in winter is lower than in summer.
III.358. Why does the power of jet engines decrease as temperature of ambient grows?
III.359. Why are the internal-combustion engines are more efficient than steam ones?
III.360. Why are four-stroke engines equipped with flywheels?
III.361. To what type of engines could one relate the fire-guns?
III.362. Between the sparking of engine plug and the ignition of gas in cylinder a certain delay takes place. Therefore the spark must occur earlier than the piston will rise the upper “dead” point of compression (it must work in advance). What does affect the value of advancing time?
III.363. As noted in the previous problem, the ignition of the fuel in cylinder takes place with a certain advance with respect to piston’s reaching of upper “dead” point. Give your ideas about the processes in early or late ignition (i.e., where the ignition occurs after passing the upper point).
III.364. As known, among four strokes of an engine only one works while other are auxiliary and are moved by inertia. How is ensured a smooth and uniform work of the engine?
III.365. Explain why does the presence of muffler in car leads to loss of power of engine and decrease of its efficiency?
III.366. The work made by an internal-combustion engine and the work of a jet engine consists of four strokes: suction, compression, expansion, and output. What is the essential difference in these four-stroke processes? Which stroke does work in a jet engine?

Chapter IV
Electricity and Magnetism

Electrifying of Bodies. The Coulomb Law

IV.1. Sometime they say that electric field lines of force are the trajectories, which were followed by a positive charge inserted into an electrical field. Is this assertion correct?
IV.2. May a same body (e.g., ebonite) be charged by means of electrifying once positively, once negatively?
IV.3. In wrapping a photo film in complete darkness some parts of the film turn to be lighted. How may this happen?
IV.4. In touching each other, bodies may electrify. Explain the phenomenon. Why is it difficult to see this electrifying in experiment than charge by rubbing?
IV.5. In transfusion gasoline from one cistern to other it may flare up if not prevented by specific measures. What are the source of flaring up and these measures?
IV.6. Why is it not recommended to use plastic (PHV) canisters for transportation of gasoline and other easily inflammable liquids, but metallic ones?
IV.7. May one electrify a conductor by rubbing, e.g., a copper bar? If your answer is "Yes", then explain the mechanism of that electrifying?
IV.8. There were cases when quickly rising balloon inflamed in air. How could you explain this?
IV.9. May one charge opposite ends of a glass with opposite charges by rubbing?
IV.10. Why do birds fly off the wires of high voltage as soon as a current is switched on?
IV.11. Will the tension of homogeneous electric field between two (parallel) oppositely charged planes change if the distance between then will grow twice?
IV.12. A charged conductor is placed on an isolator. How may one take off a half of its charge?
IV.13. To charge an electroscope it is recommended not simply touch on its ball, but hold at the part of surface of the ball. Why might a simple touch be insufficient for charging electroscope?
IV.14. If we put a charged ebonite stick on flow, will it lose all charge it had earlier?
IV.15. To decrease the dust accumulation on the walls of buildings these are covered by a special paint. Which of electric features must posses such paint if it is known that the dust rising in the air is usually charged positively?
IV.16. Why inflammable objects, e.g., gun-powder stores, are sometimes covered by a metallic grid connected with the ground?
IV.17. Consider a positive charge. How can one charge (not losing the main charge) two other charges equally with opposite signs (one positive, other negative) by means of the first charge?
IV.18. How one can determine the sign of the charge of electroscope without touching it with a charged stick?
IV.19. If one approximates hands to an electrified "sultan", its sheets are attracting by these hands. Explain the causes.
IV.20. A small charged speck of dust may "be hung" between two oppositely charged plates. What will occur if the charge of speck decreases? What is to be made to restore the equilibrium?
IV.21. Posed between two horizontal plates (one being charged, other connected with the ground), small pieces o paper permanently "jumps" and touch alternately both plates. Explain.
IV.22. In making an oil well, the oil may suddenly gush up and start to burn. Explain what are the forces, which create the fire. Why does the danger of inflammation grow if the weather is dry?
IV.23. Why, in placing vegetables and fruits into electrostatic field (the process is called "electric-septic"), does their period of consuming grow?
IV.24. Preparatory cleaning of the cotton, it is passed through homogeneous electrostatic field. Why in this case becomes easier posterior treatment for deleting mechanical addends?
IV.25. In rubber producing plants the rough rubber is subject to forge-rolling, i.e., it passes thorough rolling cylinders. How is it necessary to connect the cylinder axis with ground? Why is it necessary to have well settled ventilation in such rooms?
IV.26. In designing and producing drive belts for plants with a high danger of inflammation, either graphite or metallic powder must be added into rubber. What are the objectives of this addition?
IV.27. Being charged, the coal dust in mines, flour dust on mills, particles of wool on weaver fabrics, etc. may cause accidents and lead to troubles. Suggest measures for prevention.
IV.28. In print-shops and rooms of weaver fabrics special devices called "neutralizers" are used.

These neutralizers divide air molecules into positively and negatively charged ions. Answer the question: Why does it reduces the electric charging of steering parts of machines and goods (paper in printing machines, tissues in weaver machines) and thus helps to avoid accidents?
IV.28. If we create an electrostatic field between the pulverizer for sprinkling the paint and a small object to be painted, then painting becomes less harmful for men and even more economical (residues of paint reduce by 60%, productivity grows by 50–70%, the quality of painting also grows). Explain the physical essence of this technology.
IV.30. To separate loose materials by the size of particles (sorting of flour, eliminating dust from grain, floatation of residues of useful minerals) electric separators are used. The action of a separator is based on the motion of small particles in an electrostatic field under the gravity. Explain the principles of separation: a) if the particles are charged by a contact with charged electrode of separator; b) if the separation bases on charging by rubbing.
IV.31. Why do small drops of chemical agents used in the struggle against insects in agriculture, better sustain on leaves of plants if sprinkling is made in an electrostatic field?
IV.32. A ring made of thin wire tears if charged with a charge Q. The diameter of both ring anf wire are increased n times. Determine the charge Q_1, which will break the new ring.

Conductors and dielectrics in electric field

IV.33. Why are conductors used in electrostatic experiments made hollow?
IV.34. Two metallic balls of the same size charged with same sign are put into touching. One of them is hollow. How will it distribute the charges in both balls?
IV.35. An uncharged ball is placed into electrostatic field. Does the field affect the ball?
IV.36. For cleaning the air of dust and smoke electrical filters are applied. The simplest electrical filter is a metallic pipe with a wire strained at its axis. Between the wire and the pipe an electrostatic field is generated; besides, the wire is connected with the negative pole of a source of electric current. Explain the principles of cleaning the air taking into account that both negatively and positively charged particles may be in air.
IV.37. A charged ball A is at the distance R from an uncharged ball B and attracts the latter with the force F. Diameters of balls are assumed to be small with respect to R. How does F depend on R?
IV.38. How can two positively charged balls attract each other?
IV.39. If one charges a conductor A, then on the conductor B induces charges appear, and if we charge the conductor B, then one the conductor A the induced charges do not appear. In what case can this be observed?

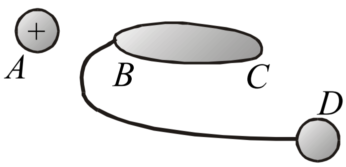


Fig. IV.1.

IV.40. The field of a positively charged ball *À* induces charges on an uncharged conductor BC (see Fig. IV.1). After that the left half of the conductor BC was connected with the uncharged ball D. Will the ball be charged D?
IV.41. Is the density of charge on a surface of a conducting ball uniform at all points?

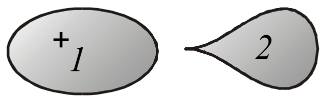


Fig. IV.2.

IV.42. On a handle made of isolator we have a metallic ball. What is the way for one might transfer to electroscope a charge equaling the charge of the ball?
IV.43. Why do they make smooth the metallic parts of devices, machines, and constructions which works under high electric tension and wit a trend to avoid sharp edges?

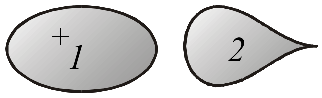


Fig. IV.3.

IV.44. Why does a conductor covered by dust quickly lose its charge?
IV.45. An isolated charged conductor was approached to other isolated conductor with its edge turned to the charged conductor(see Fig. IV.2). What then will happen?
IV.46. An isolated charged conductor was carried to another isolated conductor with edge directed backwards to the charged conductor (see Fig. IV.3). What then will happen?
IV.47. How will affect a charged stick on a magnetized needle?
IV.48. Why do they use lightning rods with a sharp edge?
IV.49. A pupil explained the action of lightning rod as follows: “Electric charges of a cloud through the edge, conductor, and wire went to ground and made caused harm to the building”. Is correct

that explanation?
IV.50. In what conditions may a lightning rod become dangerous for the building?
IV.51. Above wires of a high-voltage line they place one or two wires which are connected to metallic supports of the line (or with the ground if poles are made of reinforced concrete). There is no current in these wires. What is the aim for which they are placed?
IV.52. In thunderstorms it is forbidden for radio operators to work on portable stations if their antenna is not connected to the ground. Explain these measures of safety.
IV.53. The stroke of lightning is more probable in places where the upper layer of soil well conducts the electricity (for instance, marshlands) . Why?
IV.54. When they are in high mountains the rock-climbers try to conserve metallic things somewhere far of their camp. Why do the do so?
IV.55. Why is it dangerous to hide beneath trees in thunderstorm?
IV.56. To investigate the surface structure of metals metallographic microscopes are very useful, the electronic microscope among them. It consists of a vacuum tube into which the edge of the metal under investigation is placed. The interior surface of the tube is covered by a luminescent paint (material which gives light when absorbs particle with high kinetic energy). Between the tube and the edge a high voltage is applied: the edge serves as cathode, the screen works as anode. Electrons leave the edge and fly in radial directions. If they met fluorescent screen, they give the image (electrogramme) of the edge with a magnification equal to the ratio between the radius of tube and the radius of the edge. Why so distinctly is the micro-relief of the edge visible on the image?
IV.57. Inside an uncharged sphere a positively charges ball is placed. Explain: a) where will exist electric fields? b) will appear charge on the sphere? c) in what places will proceed changes in the electric field if the ball will be moved inside the sphere? d) in what way will the field inside and outside the sphere change if we bring from to this sphere from outside a charged body (the ball in this case is steady)?
IV.58. Suggest effective protection measures for workers of laboratories where electric charges and action of electric charges are investigated.
IV.59. A hollow brass ball *A* with a small hole is positively charged. Will charge a metallic ball *B* of one connects it by a wire with the interior of the ball *A*?
IV.60. Electric fields affect essentially the functioning of vacuum tubes. How one can protect a vacuum tube against electric fields?

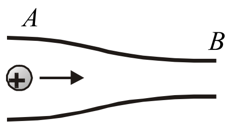


Fig. IV.4.

IV.61. Along the axis of a metallic pipe, which turns narrower on the segment *AB* (see Fig. IV.4), a charged particle is moving with a constant velocity. Will change the velocity of the particle when it passes the narrowing?
IV.62. How the answer of previous problem is related to the energy conservation law?
IV.63. A charged metallic ball is surrounded by a thick layer of dielectric. Draw the picture of the lines of electric field inside and outside the dielectric. Why does the electric field change on the boundary of the dielectric?
IV.64. Positive and negative point charges are attracted to each other by a force *F*. How will change this force if we place between them a ball made of dielectric?

Potential of Electric Field

IV.65. Draw a rough view of equipotential surfaces and lines of force of the electric field of a point charge placed near the Earth's surface.
IV.66. What happens when we connect a charged electroscope with the Earth? Consider two cases: when the electroscope is charged positively, and when it is charged negatively.
IV.67. A man touches the head of a charged electroscope standing on isolated support. In doing so, he sees that the foils of electroscope fall. Explain what caused the divergence of the leaves when the man took his hand off the electroscope.
IV.68. A metallic ball is charged to the potential of 1V. This ball is carried into spherical conducting surface charged to potential of 1000V and they touch its interior surface. Charges leave the ball and pass to spherical conductor. How can you explain this seeming contradiction?
IV.69. The conductors *A* and *B* are at a far distance from other bodies. The conductor *A* is charged, but not the conductor *B*. When they are connected thorough a wire charges flow from *A* to *B*, and

also from B to A. Give examples of conductor of that kind.
IV.70. Will change the electric field generated by a conductor if we surround this charge with a thin uncharged metallic surface coinciding with one of the equipotential surfaces?
IV.71. We have two copper hollow concentric balls. The exterior one is charged to the potential of $5V$ and the interior is charged to the potential of $10V$. The balls are connected by means of a wire. How will change the potentials of these balls?
IV.72. A copper ball A is positively charged, while a copper ball B is not. Balls have the same size and almost tangent each other. When they were connected with a wire, the charge of the ball A decreased twice. How strong is changed its potential?
IV.73. Two conductors are charged positively. Moreover, the potential of the first one equals $100V$, while the potential of the second is $50V$. Will positive charges pass from one ball to other if the conductors will touch each other? Assume that no any other bodies are close to these two balls.

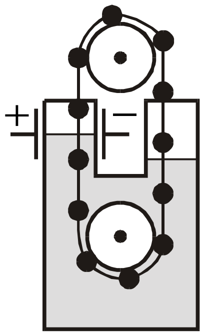


Fig. IV.5.

IV.74. How one can change the potential of a conductor without touching it and changing its charge?
IV.75. The following project of a perpetuum mobile was suggested (see Fig. IV.5). Kerosene is poured into communicating vessels. One leg of the common vessel is placed into a strong electric field between two coats of a capacitor. Since the bodies are pulled into the electric field (see Problem IV.35), the level of the kerosene is higher in this leg that in other. Through two sheaves a chain of balls goes, the density of balls is less that the density of kerosene. In following the inventor, the Archimedes' force acting on balls will be greater in the left leg than in the right one, because in the left leg the quantity if balls merged into kerosene is greater. The chain should start to move clockwise. Why in practice no rotation will arise.
IV.76. Whether always between a conductor charged positively and other conductor charged negatively a difference of potentials exists?
IV.77. On a smooth horizontal table, a metallic bar of length l and weight **P** lies. To one of ends of this bar a non-conducting line is bound, spread one the sheave fix at the edge of table. On the other end of the bar, the second bar with same features is bound, so the system is in motion. Find the difference of potentials, which arises between ends of each of the bars. The friction of the line on the sheave and the weight of the line are small.

Electric capacity. Capacitors

IV.78. What will happen to the difference of potentials between the plates of a capacitor if we decrease the distance between plates? And if we increase it?
IV.79. On a electric capacitor we can read the next data: 10 μF, $300V$. Explain their meaning.
IV.80. A conducting sphere is broken into several pieces, which are dispersed in large distance between each other. The parts are connected in an arbitrary order by thin wires. What is greater: the electric capacity of the new system of parts or the electric capacity of the sphere? Do not take into account the electric capacity of wires.
IV.81. If to metallic balls of different diameters one gives equal charges, will the current be generated if after charging one connects these balls by a wire?
IV.82. The field of a flat air capacitor has the strength E, and the charge of the capacitor equals Q. What is the force acting on each of the plates? Is it equal to $Q \times E$?

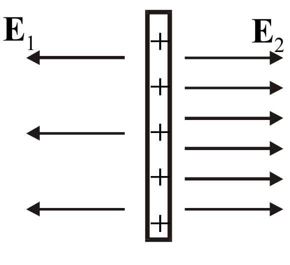


Fig. IV.6.

IV.83. A charged metallic plate is in an electrostatic field (see Fig. IV.6). The charge of the plate is equal to Q. To the left from plate the field strength equals E_1, and to the right is E_2. What is the force acting on the plate?
IV.84. In stamping, plastic details are charged in view of contacts with metallic forms. When a detail is taken off a form, its potential with respect to Earth grows. May you explain why?
IV.85. One metallic ball was charged and other not. When they were connected with a wire, charges flowed from the uncharged ball to the charged one. When is it possible?
IV.86. Will change the difference between potentials of plates of a flat air capacitor if one of these plates is grounded?
IV.87. Among two capacitors of equal capacities with similar dielectrics and similar plates the one

designed for higher tension has greater size. Why?

IV.88. As known, the force of interaction between two electric charges is less in water than on air. It seems to help to create a perpetuum mobile as follows. Take two opposite charges at the points A and B (see Fig. IV.7) and carry them to each other in the air. Let us merge both charges into water and then draw them apart under water. Then simultaneously hoist them from the water and repeat the process again. In doing so, we see that the work obtained in rapprochement exceeds the work is spent for drawing them apart, because the forces of electric interaction are greater in air than in water. Find the error in arguments.

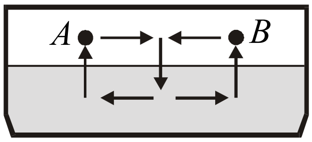


Fig. IV.7.

IV.89. The surface of a rubber ball, placed on an insulated support, is covered by a conducting layer of soap solution. Now, if we charge the ball and connect it with an electrometer, the pointer will deviate for a certain angle. By increasing the size of the ball, we shall note that the angle between the pointer and the bar will decrease in spite of the fact that the charge of the ball has not changed. Is it follows from these arguments that the potential of the conductor charged with the same charge can take various values?

IV.90. Take a flat capacitor and charge its plates by similar in value but opposite charges $+q$ and $-q$, respectively. Almost all electric field will be concentrated inside the capacitor. The energy of this capacitor $W = q^2/2C$ remains constant. As it appears in the electric field of the capacitor, an electron will be accelerated. Therefore it gets a kinetic energy. From where has it got this additional energy?

IV.91. The capacity of a flat air capacitor is less as far, as greater is the distance between its plates. But if we draw apart these plates at an infinite distance, then the energy will equal zero. Is this argument correct?

IV.92. After having been connected to a battery of accumulators, a capacitor is charged and gets the energy of $1J$. What is the work made by the battery in this case?

IV.93. A flat air capacitor is connected to an accumulator by its plates. In order to reduce the electric field strength in the capacitor, we place it into a dielectric liquid with dielectric permeability equaling ε. Have we made a correct step?

IV.94. Having been connected to an accumulator, the plates of a flat air capacitor start to attract each other with the force F. What is the way in which this force will change if we insert between the plates of the capacitor a dielectric plate with the dielectric permeability ε?

IV.95. Similar metallic balls S_1 and S_2 are at a long distance from each other and are charged positively. An uncharged metallic ball s is essentially smaller than the balls S_1, S_2 and is far from them. In one of experiments the ball s was connected with the ball S_1, next time they connected it with the ball S_2. In the first of cases, the ball obtained the charge q_1, in the second case it got the charge q_2. What will be the charge of the ball s if one connects it by a wire simultaneously with both the balls S_1 and S_2?

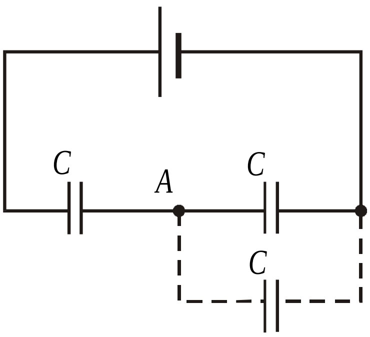


Fig. IV.8.

IV.96. The difference between potentials of the points A and B of the electric circuit shown in Fig.IV.8 is U. If we connect to these points a capacitor of the capacity C, will this charge equal $C \times U$?

IV.97. Two similar metallic balls are at a long distance in vacuum. If we give them different positive charges Q_1 and Q_2, then the potential energy of this system will be equal to $Q_1Q_2/(4\pi\varepsilon_0 r)$, where r is the distance between balls. If we then connect these balls by a wire for a short time, the charge of each ball will be $Q = (Q_1+Q_2)/2$, and the potential energy of the system, as one can easily see, will increase. From where has an "additional" energy been taken?

IV.98. Suggest a way to test a capacitor.

IV.99. In radio devices they sometime apply nonlinear capacitors (varicaps), whose electric capacity may vary in dependence on the value of the applied electric field strength and the temperature. What are the features possessed by the dielectric for the production of these capacitors?

IV.100. To protect the Power transmission lines against overvoltage (for example, produced by lightning), gated discharges are applied: the power transmission line is grounded through a spark gap and vilite disks (vilite is a dielectric whose resistance sharply decreases as tension grows). Explain the principle of protection of power transmission lines by means of this device.

Magnetic Field of Moving Charges

IV.101. How one can determine the signs of the poles of a source of current by applying a compass?

IV.102. In Fig. IV.9 three pairs of conductors with current are given. Draw the direction of the Ampere forces applied to each of the conductors. Justify the validity of the third Newton law for the last case.

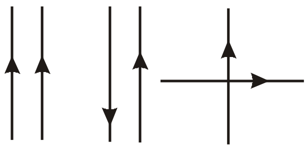


Fig. IV.9.

IV.103. Determine the magnetic poles of a solenoid shown in Fig. IV.10. Why does its magnetic action grow if an iron core is inserted?

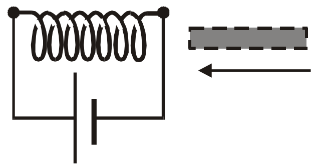


Fig. IV.10.

IV.104. Which one of the electromagnets shown in Fig. IV.11 possess the greater hoisting force (under same force of current, equal number of turns, and same core)?

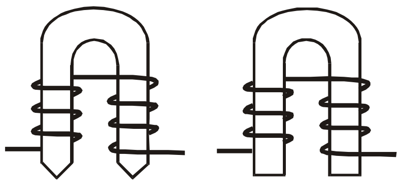


Fig. IV.11.

IV.105. Which of the electromagnets shown in Fig. IV.12 is wrong winded?

IV.106. Two movable conducting rings with similar diameters are placed in mutually perpendicular planes so that their centers coincide. What will happen with the rings if a current is passed through the rings?

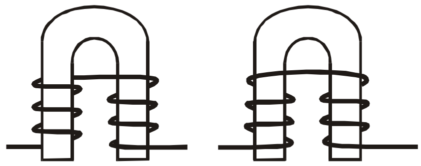


Fig. IV.12.

IV.107. The wire of a table lamp which is supplied with alternating current is carried to a magnetic needle. Will the needle deviate in the magnetic field of the current?

IV.108. A constant current flows on a copper hollow cylinder in the direction parallel to its axis. If we place inside it a steel bar, will the bar be magnetizes?

IV.109. To kill electric arc which rises in disconnecting large currents, they palace near the switch an electromagnet so that the induction lines of the magnet field would be orthogonal to the rising arc. Explain this phenomenon.

IV.110. Why do two parallel conductors attract each other if the current flows in them in the same direction and why do two electron beams repel if they flow in opposite directions?

IV.111. If an electric current is passed through ionized gas (plasma), then the plasma is contracted in the form of a plasmatic lace (pinch-effect). The pinch-effect is used for thermal isolation between the hot plasma and the walls of tube in obtaining the thermonuclear synthesis reaction. Why is the plasma compressed in these conditions?

IV.112. If one passes current through the jet of melted metal, then it becomes more narrow in cross section. How will you explain it with regard for the proposition that a liquid is usually incompressible?

IV.113. Below you may see the principal scheme of a mass-spectrograph (a device which divides beams of charged particles with a different ratios between a mass of a particle and its charge). In the mass-spectrograph charged particles are accelerated on the segment *AB* and enter into a magnetic field (see in Fig. IV.13). Determine the direction of the Lorenz force acting on a particle at the moment when it enters into the magnet field.

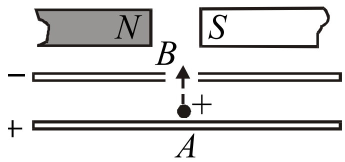


Fig. IV.13.

IV.114. In the mass-spectrograph (see Fig. IV.14) charged particles, by leaving the source *1*, pass through the velocity filter *2*. Into a narrow output hole of the filter only the particles with close velocities can get. Further the particles hit a homogeneous magnetic field. Compare the masses of particles moving along the trajectories a) and b) of their charges are same.

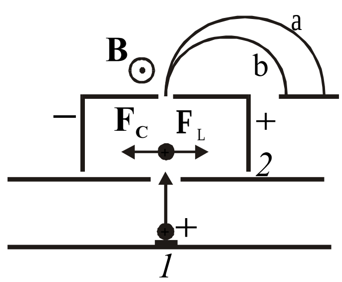


Fig. IV.14.

IV.115. Coils for resistance boxes and measure bridges are winded so that under a direct current a magnetic field around them is practically absent. Suggest the method for winding such coils.

IV.116. A cable is composed of a central (axial) *2* and exterior *1* conductors (see in Fig. IV.15). Is there a magnet field around the cable if in conductors the currents pass if the same force and opposite direction? Same direction?

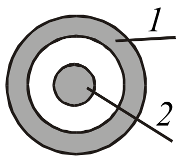


Fig. IV.15.

IV.117. The principal part of an electronic microscope are magnet lenses. The simplest magnetic lens is a coil with a current. A dispersed beam of electrons is focused by passing the magnet field of the coil. How can this be explained?

IV.118. How can one determine the poles of a horse-shoe shaped unmarked magnet with the use of a television set?

IV.119. In a homogeneous magnet field with induction **B** a metallic ball of the radius R moves with a constant velocity **v**. Determine the points on the ball where the maximal difference of potentials will be reached. Evaluate it by assuming that the angle between the velocity and the direction of the magnetic field is α.

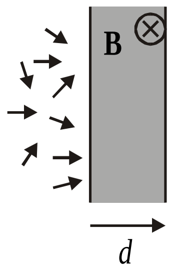


Fig. IV.16.

IV.120. To contain the plasma in thermonuclear reactors the magnet field is applied. Let us consider a simplified model as in Fig.. IV.16. In a thin layer of height d, a homogeneous magnetic field is created with the induction B being parallel to the walls of the layer (perpendicular to the figure's plane). At the left from the layer a gas is present consisting of charged particles with the charge q and the mass m. These particles move in arbitrary directions with a velocity v uniform by the absolute value. Under which meaning of the induction B will not the particles hot the domain at the right from the magnet wall?

Magnetic Properties of Substances

IV.121. A ball made of the magnetically soft iron was first placed into a weak magnetic field and then into a strong magnetic field. However, in the second case he experienced a force lesser than in the first case. When is it possible?

IV.122. To transport incandescent metallic blanks why do not they apply electromagnet hoist cranes?

IV.123. A piece if iron is heated in a furnace situated between the poles of a magnet. Why may the orientation of a sample change during the heating?

IV.124. As known, a nail can be magnetized by winding around it an isolated wire connected to a galvanic battery. Will be the nail magnetized if we replace the battery with a charged capacitor?

IV.125. To investigate the microstructure of a metal (for example, to examine the presence of ferromagnetic or non-magnetic components) the magnetic metallography is applied. To this end, a treated surface of a metal is covered with a very fine layer of a magnetic powder (magnetite) and then they investigate the position of magnetite particles under a microscope. Explain the physical essence if the magnetic analysis of the structure of metals.

IV.126. To support metallic pieces in polishing, instead of mechanical keepers they use electromagnet ones. What are their advantages? What are the forces which hold a detail on polishing machines?

IV.127. Steel pieces which may accidentally hit the lungs of a man, can be extracted without lancet. To this end, a bronchoscope is used (an apparatus for investigation of bronchial ways): Through the mouth a tube with light conductors is introduced into the bronchial tubes. By means of light conductors one can illuminate and revise the interior surface of organs. How can one extract steel particles from bronchial tubes by means of a bronchoscope?

IV.128. In transporting loads by means of electromagnet cranes it may occur that a part of a load does not break away the core when the current is turned off. What must be done in this situation?

IV.129. The packing of nails into boxes is sometime made by applying a strong magnetic field. What is the advantage of this way of packing?

IV.130. In the saucer of tractor engine a hole is made for exhausting of worked oil. Its closed with a magnetized cork. What is it serving for?

IV.131. To what end on the poles of the core of electromagnet crane copper soldered rings are sometimes made?

IV.132. The magnetic micrometer is designed for the measurement of layers of a paint or vanish covering ferromagnetic pieces or details. The action of the device is based on measurement of the change of attraction force in moving off a magnet from a painted piece. How do they determine the thickness of a paint layer?

IV.133. In atomic reactors liquid metal is often used. This metal is usually pumped by magnet pumps (see in Fig. IV.17). In what direction will flow a metal by the tube A if we pass a current in the direction shown in the figure?

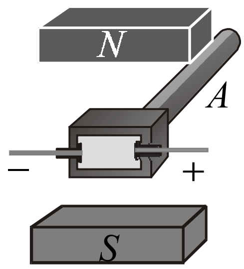


Fig. IV.17.

IV.134. Presently, ferroalloys (magnetic materials) are widely applied. These materials represent chemical combination of the iron oxide Fe_2O_3 with oxides of other metals. In addition to ferromagnetic properties, the ferroalloys possess also properties of semi-conduction. Explain why are losses of energy in magnetically soft ferroalloys significantly less than in metallic ferromagnets?

IV.135. To clean the seeds of grass, flax, etc., possessing rough surface, a special electromagnetic cleaning machine is applied (see Fig. IV.18). Its principal part is a drum of nonmagnetic material and an electromagnet fixed inside the drum. Explain the principle of cleaning if in the bunker C seeds are loaded treated with iron powder which well sticks to the feeds of weeds. In which volume A or B will the seeds be collected?

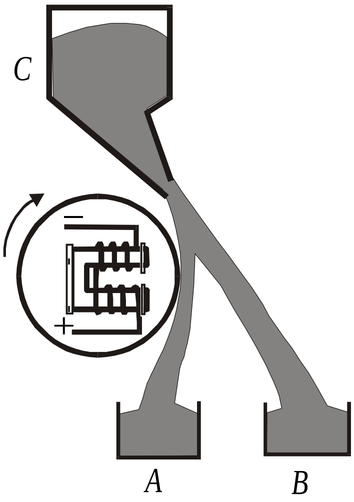


Fig. IV.18.

IV.136. A light steel wheel is put on a vertical axis. At small distance from the edge of the wheel a constant magnet is put. In the place nearest to one of the poles of the magnet the steel edge is heated with an alcohol burner (see Fig. IV.19). The wheel starts to rotate. Explain the experiment.

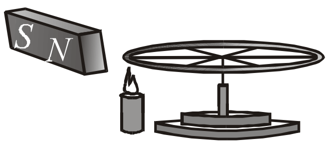


Fig. IV.19.

IV.137. Let us make the following experiment. Take a magnet bar and put on one of its ends a bar made of magnetically soft iron, which is slightly longer than the magnet (see Fig. IV.20). Then, supporting the magnet with bar in the vertical position, let us carry its free end to iron filings. They will immediately be attracted to the bar. Now, not disconnecting the magnet, down it slowly along the bar. As soon as the magnet will approximate filings to a certain distance, these will fall down. Explain why?

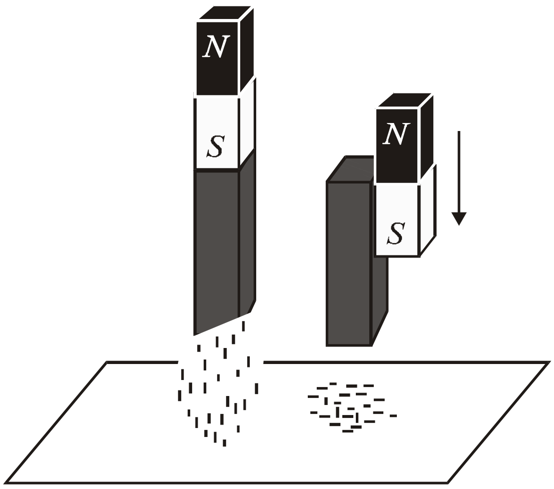


Fig. IV.20.

Magnetic Field of The Earth

IV.138. Why does steel window grading become magnetized after a certain time?
IV.139. In what place on the Earth the magnet needle shows South by its both ends?
IV.140. Why do the corps of ships, tanks, blinded-cars always become magnetized?
IV.141. In the book by William Gilbert, one of first investigators of magnets, the following experiment was described: If one strokes with hammer over an iron band which is looks from North to South, the band becomes magnetized. Why? How the poles will be situated?
IV.142. What is the direction of induction lines of the magnetic foeld of Earth on its surface - from North to South or opposite?
IV.143. Why are the stored steel rails become more magnetized than those which are explored on railroads?
IV.144. Why are the ships for investigation of Earth magnetic field built of wood and have copper

screws for fastening details?

Electromagnetic Induction

IV.145. The turns of coils of electric generators or transformers may be deformed and even break when a big force current passes through them (e.g., in short circuit). Why?
IV.146. What is the shape to which tends an elastic conductor when a current flows in it?
IV.147. How do neighboring turns of a solenoid interact when a current flow in solenoid?
IV.148.A coil is said to be bifilar if it is made of a single wire folded in two. Will be induced a current in a coil with a bifilar winding?
IV.149. Two coils are on a table: one is connected into a circuit with a galvanometer, other is not. Into both coils similar magnets are inserted with the same speed. Will the work be also same?
IV.150. A vertical conductor is displaced in the magnetic field of Earth from West to East. Is an electromotive force of induction generated in this conductor?
IV.151. Whether the electromotive force of induction arises on the ends of a steel axis of an automobile in its movement in the magnet field of the Earth? In which directions of motion will this e.m.f. be maximal and minimal? Whether its value depends on the speed of automobile?
IV.152. The frame of some automobiles represents a closed contour. When they move, will there arise an induction current?
IV.153. It is not recommended to combine the wires of street illumination supply and those of telephone lines at same poles. May you explain why?
IV.154. Why sometimes may one hear a telephone talk which takes place on a neighboring line?
IV.155. After strong thunderstorm and a strike of lightning, one can find that the sensitive electrical measuring devices (mainly, semiconductors) are damaged, fuses are fired out in illumination supply network. Why does it happen?
IV.156. To investigate the homogeneity of the material of iron bars, rails, etc., these are first magnetized, then a coil winded with an isolated wire is put on a sample under investigation and then connected with a galvanometer. Afterwards it is moved along the whole construction. If any non-homogeneity of the material of construction is met (rifts, caves, etc.) then a current arises in the galvanometer. Explain the phenomenon.
IV.157. If an electromagnet is switched into an electric circuit, why is the complete force of the current established not instantly?
IV.158. To what aim (except for the overcoming Ohm's resistance) is the energy of the source spent at the moment of completing a circuit?
IV.159. If one shorts the circuit with the source supplied by an ordinary radio battery, nothing will be felt. But we include into circuit an electric bell, hands will feel sharp pushes. Why are they felt?
IV.160. Why is it forbidden to settle cables which carry AC supply to enterprises and houses near gas, water, and heat communications?
IV.161. In the production of electric bulb lamps it is necessary to heat metallic parts inside the bulb with air already pumped out. This is made by applying a high-frequency magnet field. The glass in this process does not get notable heating. Explain the action of this method.
IV.162. An isolated super-conducting ring with a current is bent into two circles with the shape of 8. Then it is put in two. How will change the current in the new ring?
IV.163. On the axis of a constant magnet which is in vertical position there is a light wire ring whose plane is perpendicular to the magnet axis. At a certain moment the ring starts to fall, its plane remains horizontal. What is the difference between the behavior of a ring with a finite resistance and a ring made of a superconductor? The ring has not current at initial moment.

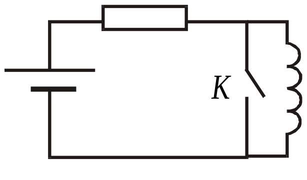


Fig. IV.21.

IV.164. A ring made of superconductor is near a constant magnet and is permeated by the magnetic flow Φ. There is no current in the ring. What will be a magnetic flow through the ring if we take of the magnet?
IV.165. An effective experiment is well-known: If one place a magnet above a pan made of a superconductor, then the magnet levitates over the pan. How will you explain this experiment?
IV.166. How depends on the time the current through a super-conducting solenoid if the key *K* (see in Fig. IV.21) oscillates with a certain frequency?

IV.167. A magnet may fall inside a thin copper pipe and outside it, not touching the pipe in both possible cases. Will the time of these falls be same?

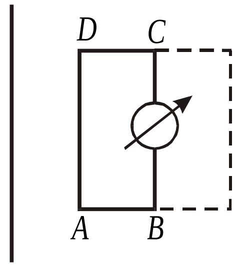


Fig. IV.22.

IV.168. A rectangular frame and an infinite rectilinear conductor with a current flowing are placed in a plane so that the sides *AD* and *BC* of the frame are parallel to the conductor (see Fig. IV.22). In the middle of the side *BC* the device measuring the charge already flowed is connected. The frame can be placed into a new position, which is given in the figure by dotted lines, in two ways: 1) by displacing it parallel to itself; 2) by rotating it about *BC* by the angle 180^0. In which of the cases the charge passed through the device is greater?

IV.169. Prove that the inductance of a coil is proportional to the square of the number of turns.

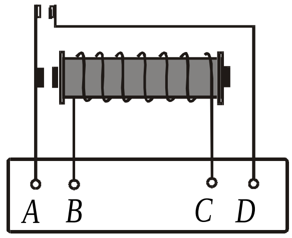


Fig. IV.23

IV.170. A wire solenoid is connected to a battery. How will change the current in the circuit if the wire is quickly straightened?

IV.171. In Fig. IV.23 you may see the scheme of a contactor, i.e., a strong electromagnetic relay used for switching on heavy work circuits, for example, an electric engine by means of auxiliary circuit with a current of a small force. Explain the action of the contactor. Draw the scheme of switching the electric engine.

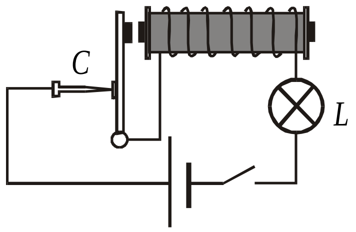


Fig. IV.24.

IV.172. Using the scheme given in Fig. IV.24, where *L* is a lamp, *C* is a sharp metallic contact, explain the action of an electromagnetic current interrupter .

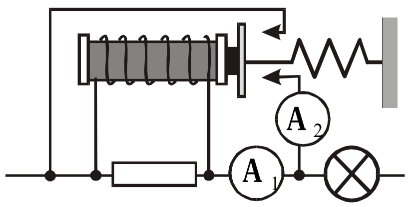


Fig. IV.25.

IV.173. In very important cases (for instance, in power circuits of airplanes) some devices are set double. If the principal device fails, its duplicate is automatically switched on. In Fig. IV.25 the scheme of closing a circuit with a lamp, an ammeter A_1, and its duplicate A_2 is shown. Explain how the automated switching of duplicate ammeter is realized.

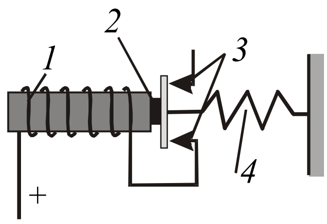


Fig. IV.26. The scheme of a maximal current relay: 1- coil, 2 - mobile core, 3 - relay contacts, 4 - spring.

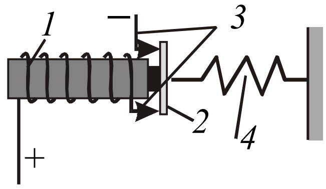


Fig. IV.27. The scheme of a minimal current relay: 1- coil, 2 - mobile core, 3 - relay contacts, 4 - spring.

IV.174. In Fig. IV.26 the scheme of maximal current relay is given. It is used for switching off a circuit when the force of current grows in it above an admissible value. How does the relay work?
IV.175. In Fig. IV.27 the scheme of the relay of minimal current is shown . It is used for switching off a circuit when the current in it becomes below a certain definite value. How does it work?
IV.176. In Fig. IV.28 a simplified scheme of automatic protection (auto-blocking) is given. It is used in railroads to signalize whether a distance (a segment of railroad path) is either free or occupied by some trains. How is realized the automatic signalizing on the occupation of a distance of railroad?
IV.177. To find electric supply wiring inside walls of buildings and also for determination of the path of underground supply cables and lines without striping the ground, one can apply a device whose principal part is a coil connected with an indicator (for example, a telephone handset). What is the principle of action of this device?

IV.178. In braking engines of subway trains, their electric engines are switched off the supply and then put into a short circuit (or connected to special rheostats). What is this way of braking basing on?

IV.179. To measure the induction of the magnetic field of Earth magnetometers are used. A magnetometer (see in Fig. IV.29) consists of a metallic frame *1*, connected via rings to a galvanometer *2*, and an electric engine *3*, which puts the frame into a uniform rotation. Explain the principle of action of the magnetometer.

IV.180. Electromagnetic non-destructive flaw detection is widely used to control the quality of metallic details. This way of control is as follows. First a sample detail of exemplar quality is put inside of or near a coil with a high frequency current. Afterwards they put a detail to be checked. Why does the reading of the galvanometer depend on the presence of defects (rifts, cavities)?

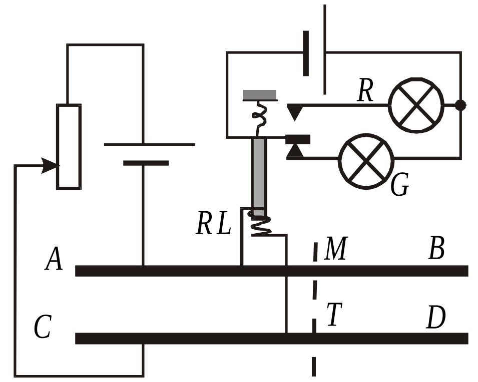


Fig. IV.28. The simplified scheme of automatic protection: *AB* and *CD* - rails, *MT* - carriage rolling stock, *R* and *G* - the red and green lamps respectively, *RL* - the relay.

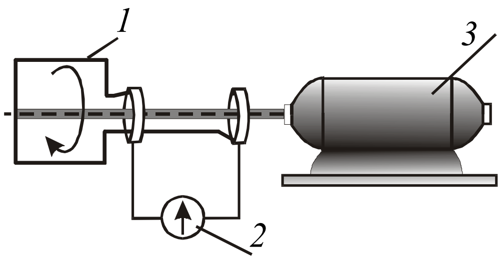


Fig. IV.29.

IV.181. Why is it non-recommended to call by phone in rural places in thunderstorms?

IV.182. An inductive heater consists of metallic tubes into which isolated wires are inserted. An alternative current is passed through the wires. Why are tubes heated in this case?

IV.183. To warm reinforced concrete constructions in winter the inductive method can be applied. An isolated wire is wind over a reinforced concrete construction, alternative current is passed through the wire. Why is the reinforced concrete heated in this situation?

IV.184. Wood placed into alternate electromagnetic field of high frequency is warmed and thus dries. What are the advantages of this technique of drying in comparison with ordinary ways?

IV.185. By applying a high frequency current, one can harden metallic detail in such a way that their core will remain soft while the surface layer will be hardened. How can it be reached? What are the advantages of this technique of hardening (for example, of crankshafts of automobiles)?

IV.186. To measure the thickness or gauge of flat metallic details (sheets, foils, bands) and also details with closed surfaces (pipes and ducts, cisterns) special devices measuring the gauge are applied. Their action bases of shield action of a metal introduced into a space between the primary coil supplied by high frequency alternative current and secondary inductive coil. Explain the principle of action of these devices.

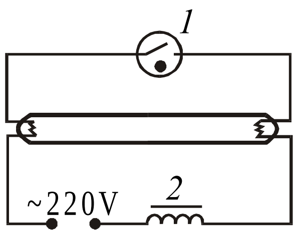


Fig. IV.30.

IV.187. Fuses of radio and TV sets usually are melt not within their work, but at switching them on or off. Why does it happen in these moments?

IV.188. To ensure a stable work of the arc in the electric welding, it is consecutively connected to a stabilizer, e.g., a coil with steel core. How does this device work?

IV.189. The scheme of an illumination circuit containing a fluorescent tube lamp(see in Fig. IV.30) contains a starter *1* and a choke (a coil with a core) *2*. The starter represents a bimetallic relay (starting device), which closes the circuit with lamp electrodes and automatically disconnects it in a certain time. Why at the moment of disconnection of the circuit the lamp starts fluorescent though for setting up a glow discharge in the lamp a voltage greater than in supply is required?

IV.190. Which of the two currents in the induction coil is more advantageous for ignition of fuel-air mixture in a carburetor interior combustion engine: that arising in closing the circuit, or that arising in disconnection of the circuit?

IV.191. The rules of secure exploitation forbidden re-switches in supply circuits if they at are above the voltage of 30V. Why are such switches specifically dangerous if chokes, transformers, electric engines, etc. are present in circuits?

IV.192. In closing and disconnecting circuits containing coils with cores (electromagnets, engines, etc.), an arc charge arises destroying the contacts of disconnecting devices. In which moment an interrupter gives more sparks: in interrupting or in connecting? What is the origin of this phenomenon? Which are the ways to avoid destruction of the contacts?

IV.193. If a capacitor is connected in parallel with an interrupter, why does the sparking stop (see the previous problem)?

IV.194. Why do sparks arise between the arc of tram and the air wire? Spark are significantly less if the tram moves with disconnected engine and the current flows only through illumination lamps. Explain the origin of this decease.

IV.195. Why must the disconnection of powerful electric engines be made smoothly and slowly through rheostats?

IV.196. In switch on or an overload of an electric engine (i.e., in forced down of its rotation) the current in the circuit is essentially greater than in its normal work. Explain the origin of this phenomenon.

IV.197. A flat disconnected frame rotates in a vertical homogeneous magnetic field about the horizontal axis with the angular speed Ω. Induction of the magnetic field changes in accordance with the rule $B = B_0 \times \sin\Omega t$. Find the frequency of the electromotive force of induction arising in the frame.

Chapter V

Electric Current

Fundamental Laws of Electric Current

V.1. Answer to the question: may there exist currents flowing from a lower potential to a higher potential?
V.2. An electric current in a conductor represents an oriented motion of free electrons. For example, electric signals in a telephone talk are an alternating electric current. They are propagated through telephone lines with a speed practically equal to that of light. Will it mean that the electrons run in wires with the speed of light?
V.3. As known, near the Earth's surface an electrostatic field with a tension exceeding 100V/m can be observed. Then why cannot one obtain a direct current by means of this field?
V.4. Whether the work done by the source of current in the interior part of a circuit is a constant value for this source of current?
V.5. One may apply an analogy between the flow of a liquid and an electric current. For example, the force of a current equals the consumption of a liquid (the quantity of liquid which passes a cross section of the flow within a unit of time). A dam is built on a river. Which electric circuit will be analogous to this part of the river?
V.6. What are indicators for knowing whether a current flows or not in a circuit? Give or cite examples.
V.7. Possessing a balance and two metallic plates of a known square S, how can one measure the difference between potentials on clipses of a source of a constant voltage?

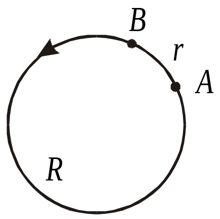


Fig. V.1.

V.8. Suggest a method for measurement of the tension in a circuit of alternating current by means of an electroscope.
V.9. Assume that in a ring conductor (see in Fig. V.1) an induction current whiose direction is marked by a pointer. The resistance between smaller part of the ring - between the points A and B is equal to r, the resistance of the larger part equals R, and the fall of the tension on the smaller part of the conductor in the direction from A to B at the moment under consideration equals U_{ArB}. In these conditions the current on the part from A to B by the Ohm law must be equal to $I = U_{ArB}/r$. Since the current must be same in all cross-sections of a conductor and the fall of tension between the same points by via the long path from B to $\grave{A}$, i.e., U_{BRA}, must be equal to $U_{BRA} = -U_{\grave{A}rB}$, therefore by the Ohm law the same current must equal $I = -U_{\grave{A}rB}/R$. By comparison of these relations we establish that $r = -R$. In what place have we made a mistake?

Current in Metals and Semiconductors. Resistance of Metals and Semiconductors

V.10. A piece of wire was cut into two parts and wind, both parts together along their length. How has the resistance of wire changed?
V.11. On electrified railroads on the edges of rails they make connectors in the form of a multifilament copper wire welded to both ends of neighboring rails. What they make it for?
V.12. Whether a glass conducts an electric current?
V.13. In switching on an electric incandescence lamp, the current at the initial moment differs from the current which is established when lamp begins to illuminate. How will change the current in a lamp with a metallic filament?
V.14. In a part of electric circuit they connect first one amemeter and then another ammeter. The first shows the value of current lesser than the second does. Among these amemeters which one has the least resistance?
V.15. Having an electric stove with working voltage 220V, how can one verify the functioning of a 6V lamp with the normal 220V supply?
V.16. As we open the door of a refrigerator, a lamp is switched on inside it, when we close this door the lamp is switches off, too. Compose the scheme of the corresponding electric circuit.
V.17. If the air were a good conductor, what would be the difficulties for electrical technique?

V.18. In humid rooms with ground or concrete floor only the low voltage currents can be used (not exceeding 36*V*). What is the origin of this limitation?

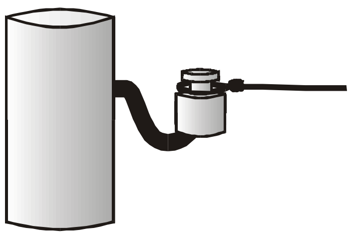


Fig. V.2.

V.19. Ceramic isolators for power transport lines are of a shape (of the form of a bell) which ensures that their interior part remains dry even when it rains or in snowfalls (see Fig. V.2). What are advantages of that form of isolators?

V.20. Why do electricians work wearing rubber gloves and shoes, using rubber carpets and tools with plastic handles?

V.21. Is it sufficient to isolate a man from ground in order to exclude hitting by a current?

V.22. If the isolators of a high voltage of power supplying lines are dirty, their dielectric features worsen. Therefore they wash them from a special fire-pumps, which ensure a dotted jet of water with simultaneous grounding of their shells. Explain the physical sense of these rules of safe exploitation.

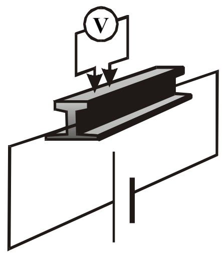


Fig. V.3.

V.23. To find defects (rifts, cavities, etc.) on details which have the same cross section (e.g., rails) a device is used whose scheme is given in Fig. V.3. How does it locate a defect?

V.24. To measure deformations in various constructions (for example, in various points of airplane wing) strain gauges are used. Usually, they are a thin mica plate, inside which a thin nickel-chrome or other wire is fixed with the resistance 150–200*Ohm*. Such a strain gauge is rigidly foxed over a construction (see Fig. V.4). What is a way in which one can determine the value of deformation by the readings of a galvanometer?

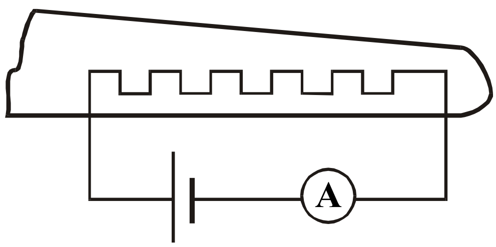


Fig. V.4.

V.25. In Fig. V.5 one can see the scheme of a level gauge which is used to control the level of gasoline in automobile tank. Explain its functioning.

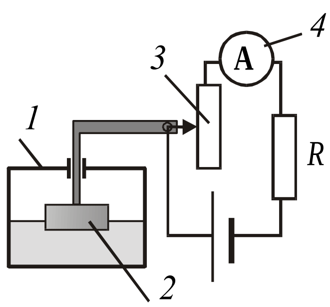


Fig. V.5. The scheme of a level gauge: 1- fuel tank, 2 - a float, 3 - rheostat, 4 - device demonstrating a tanking by fuel

V.26. Phone cables have many separated wires. In laying a telephone cable, one must determine the beginning and the end of each wire in the cable. How can this be made?

V.27. In starting some electric engines it is necessary to increase gradually the supply. To this end a thermal resistor (thermistor) can be applied, which is a semiconductor device whose resistance decreases as temperature grows. Thermistor is included in circuits consecutively with the engine. Why does this ensure a smooth start of the engine?

V.28. For a stable work of many electric devices a constant effective supply (voltage) is necessary (in industrial supply lines the voltage varies due to changes of consumption). To this end some special devices, called voltage stabilizers, are used. In Fig. V.6 you may see a scheme of a version of such device, its main element being the thermistor R_t. Explain why in changing voltage on the contacts *AB* does the voltage on the load *R* not change practically?

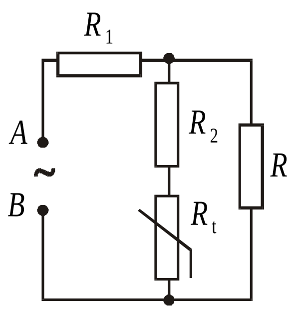


Fig. V.6.

V.29. Basing on thermistor's idea, suggest a scheme of a device for measuring the velocity of air flow; same for water flow (thermoanemometer).

V.30. Using the dependence of the resistance of a metallic conductor on the temperature, design a device for determination of the wind speed, i.e., anemometer. Draw the scheme of its electric circuit and explain the action of the device.

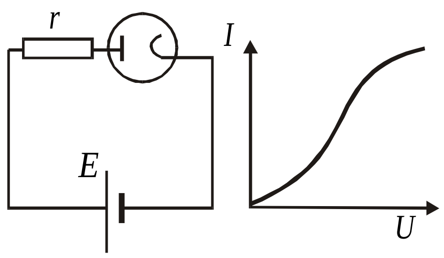


Fig. V.7.

V.31. Conductors with a constant cross section possess electric resistance R directly proportional to the length l and inversely proportional to the square of cross section S, so that $R=\rho l/S$, where ρ is the specific resistance of the conductor's material. Therefore, if we merge huge batteries of electrodes into sea, we could seemingly to obtain an infinitesimal resistance, because in that case we dealt with a conductor with a huge are of section. It were unnecessary to lay expensive underwater cable for telegraph connection between continents. Is such argument correct?

V.32. A diode is connected to a source of the electromotive force E through the resistance r. Find the current in that circuit if the dependence of the current flowing through the diode on the voltage on it (volt-ampere characteristic) is as shown in Fig. V.7.

Electric circuits.
Ohm's Law for Completed Circuit

V.33. 1996 nails are hammered into a door. Each of these nails is connected with each of the remaining 1995 nails. All connecting conductors have the same resistance R_0. Determine the resistance between two arbitrary nails.

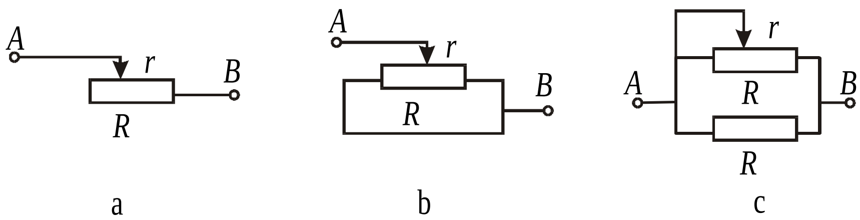


Fig. V.8.

V.34. For the schemes of connecting an rheostat into a circuit (see Fig. V.8) draw the graphs of the dependence of the ohmic resistance of the circuit between the points A and B on the resistance of the right side of the rheostat (till the runner).

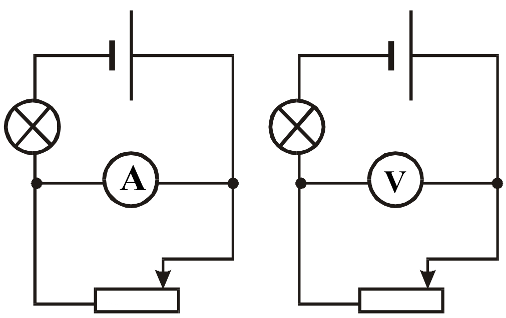


Fig. V.9.

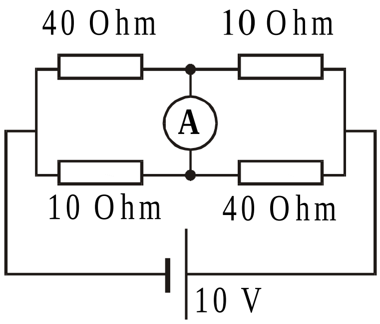


Fig. V.10.

V.35. How will change the readings of measuring devices when the runner is displaced? How will change the glow of lamp filament in both schemes? (see Fig. V.9).

V.36. What is the current flowing through the amemeter in the scheme shown in Fig. V.10? Assume that internal resistance of the amemeter is small.

V.37. In determining the resistance of a conductor by means of an amemeter and a voltmeter (see in Fig. V.11) why do they take as more high-resistance voltmeter as greater accuracy of the result is required?

V.38. Having a amemeter and a voltmeter with unknown internal resistance, how can one measure the value of an unknown resistance?

V.39. One of the wires of a twin-core cable was connected to ground. The cable's length is several kilometers and it lies under the ground. How can one determine in simplest localize a fault?

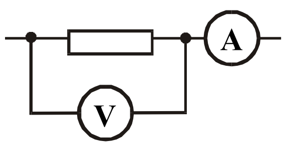


Fig. V.11.

V.40. In Fig. V.12 the schemes for measuring resistance by means of an amemeter and a voltmeter are given. What is a scheme which will supply the most accurate result?

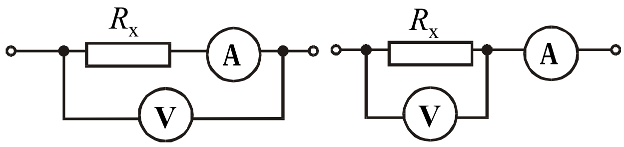


Fig. V.12.

V.41. The voltage on the poles of a power source is always less than its electromotive force. Why? By what value?

V.42. What is the system of voltmeter which might give the most accurate measuring of the electromotive force of a galvanic element?

V.43. Will change a current on an electric circuit if we replace one galvanic element with other possessing plates of a greater size?

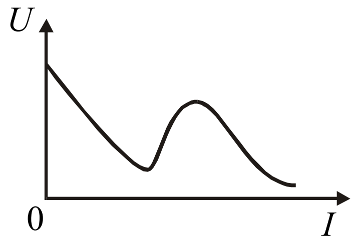


Fig. V.13.

V.44. In measuring the electromotive force of an old battery for pocket lantern a voltmeter shows 4.3V. However, the lamp does not work on this battery. Why?

V.45. A power source has the volt-ampere characteristic as shown in Fig. V.13 (Here *U* is the voltage on the source, *I* is the current flowing through it). Draw a graph of the dependence of voltage at the resistance to which this source is connected on the value of the resistance.

V.46. To obtain powerful light impulses through a gas-discharge lamp, they use a battery of capacitors of large capacity, charged up to a potential difference *U*. Why do not they use to this end a battery of galvanic element with electromotive force equaling the same *U*?

V.47. In measuring the value of current in a lamp, a pupil has connected instead of an amemeter a voltmeter. What happens then?

V.48. A pupil connected instead of a voltmeter and amemeter. What are the consequences of this error?

V.49. If a high voltage wire breaks and falls on the ground, in which case will a man near this accident be in less danger: when the ground is humid or dry? How can you explain your answer?

V.50. Wires of power transmission lines of high voltage are isolated by series of isolators of their supporting poles. Nevertheless, why is it dangerous to touch these supporting poles?

V.51. May one make a short circuit in repairing a convenience outlet; an interrupter?

V.52. Compose a scheme of switching on (and off) an electric lamp which could be done in two independent places, e.g., a scheme of illumination of a corridor with two entrances (use only two-pole switches).

V.53. A three-lamp chandelier with two switches was connected to the supply. In testing it, it turns out that some errors have been made resulting in: 1) in switching on the first switch only one lamp lights; 2) in switching on only the second switch all lamps are alight but with an incomplete incandescence; 3) when both switches are on, only one lamp is alight. Draw possible scheme of such a connection and explain the effects.

V.54. Draw a scheme of connection of five-lamp chandelier with a double switch so that one could switch on and off two, three, or five lamps.

V.55. On the cover of an electric element it is written: «EMF 4.5*V*», while a lamp is for the voltage of 3.5V. Why is such a difference in voltage admissible?

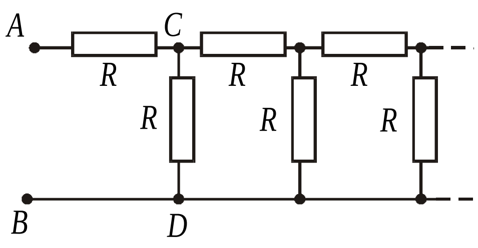


Fig. V.14.

V.56. In Fig. V.14 an infinite electric circuit is present. What is the resistance between the points *A* and *B*?

V.57. A galvanic element is closed on two parallel conductors. Whether the currents in these conductors decrease if we increase their resistance?

V.58. An electric stove and an amemeter are switched into a circuit. If one blows onto red-hot spiral of the stove, what will the amemeter show?

V.59. For strong-current circuits in power stations why do they use wires of a non-circle section?

V.60. The electric main supply of trams has voltage 600*V* and supply the elecetric energy to both engines and illumination lamps in a tram. What is the sort of connection used to connect lamps into tram circuit?

V.61. Why can birds «land» on wires of high tension power transmission lines without any harm?

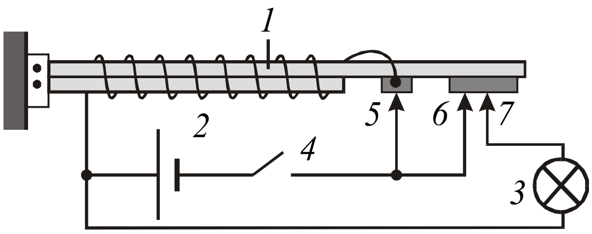


Fig. V.15.

V.62. Why will the voltage in a circuit will be more stable, i.e., it will less change with changes of load, if in the capacity of a source one takes a battery of elements connected in parallel?

V.63. In automobiles the turn is shown by twinkling lamps. The main part of the mechanism (see in Fig. V.15) is a bimetallic plate *1* (two rigidly connected plates of metals which differ by their thermal expansion). It is placed inside a spiral *2*, which is heated by a current. Explain why the lamp *3* will twinkle if the key *4* will be closed?

V.64. Are you acquainted with the electric circuit in your flat? Can you decide the next questions: 1) which devices in your flat are connected in series and which are parallel with respect to each other? 2) where stand the main fuses in your flat and how are they designed? 3) what are causes for fuses interrupt the circuit even when wires are well-conducting and there is no a short circuit? 4) why are poorly connected wires (e.g., near a self-made plug) of supply heated when current passes? 5) why do the sections of wires differ for different rooms? 6) why is it forbidden to set switches in bathrooms but not outside?

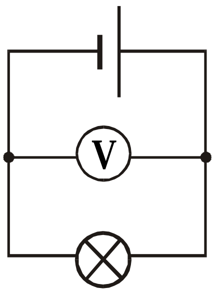


Fig. V.16.

V.65. What is a damage made by the electric arc in knives of knife-blade switch and contacts of switches, in current collectors of trams, trolleys, and electric trains?

V.66. As known, the electric power is to be evaluated by the formula $P = U^2/R$. Does it mean that if we connect a lamp designed for 220*V* into a circuit of voltage 127*V*, then the power of lamp will grow three times?

V.67. If a filament of lamp in the circuit given in Fig.. V.16 would burn out, then the voltmeter seems to be connected in series and show the current. Is it true?

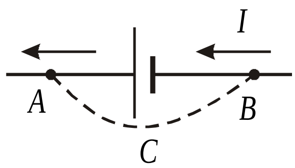


Fig. V.17.

V.68. In a certain circuit, there is a part shown in Fig. V.17. Two pupils discussed to where will the current flow to on *ACB* if one connects *A* and *B* by a conductor shown by a dotted line. The first pupil said that since the current always flows from plus to minus and plus is on the side of *A*, therefore on the dotted segment it will flow via *ACB*. The second pupil said that since on the main circuit the current flows from *B* to *A* and at the point *Â* the circuit bifurcates, therefore on the «dotted» part the current must go in the direction *BCA*. Who is right among them?

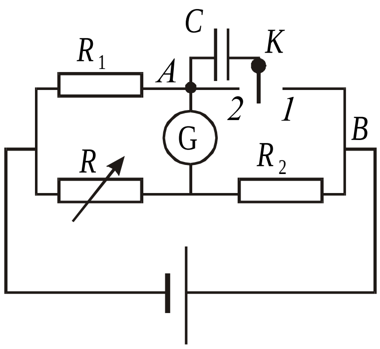


Fig. V.18.

V.69. To determine the value of rather small capacities they sometimes use the bridge scheme shown in Fig. V.18. The tale *K* vibrates with a frequency ν. What is the capacity of the capacitor *C* if the value of the variable resistor is *R*, while the fixed resistors are R_1 and R_2. The pointer of the galvanometer *G* is steady.

Work of Current. Joule-Lentz Law

V.70. By the Joule-Lentz law we have $P = U^2/R = I^2\times R$. Thus, assuming that both the formulas are valid, we arrive at a contradiction: the quantity of heat radiated in a conductor when a current passed through it is both directly and inversely proportional to the resistance *R* of a part of circuit! Explain this contradiction.

V.71. The Joule-Lentz law asserts that the quantity of heat produced in a conductor with current is proportional to the resistance of the conductor. Hence it follows that one can obtain an unbounded quantity of heat by using a very small current and very huge resistors. In this situation, the electric heating were the most profitable. But it takes no place in the reality. Why?

V.72. Two lamps are designed each for $220V$. One has the power $60Wt$, other $100Wt$. Which is a lamp with greater resistance?

V.73. A railroad car is illuminated by 10 lamps which are connected in series. How will change the consumption if we decrease the quantity of lamps to five?

V.74. The filament of a lamp becomes thinner due to vaporization of its material and dusting out of its surface. How will it affect the power of consumption of this lamp?

V.75. A current passes through a steel wire, the latter become rather hot. If we merge one part of this wire into water, the remaining part will by heated even more. Why? The difference between potentials at the end of the wire is supported constant.

V.76. Why so electric lamps usually burn out in switching them on and very rarely in switching them off?

V.77. If you connect to supply an electric device of large consumption (iron, electric pot), the brightness of lamps switched on changes. It is more visible at first seconds, then they turn brighter but less than before switching the device. Explain the phenomenon.

V.78. Electricians say: “Cold welding is hot, hot welding is cold”. What is the sense of this expression?

V.79. Why in the process of electric welding are the greater amounts of heat produced on the places where pieces are welded?

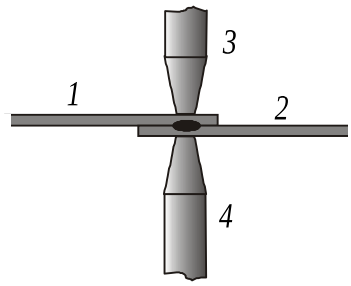


Fig. V.19. The scheme of a point electrical welding:
1 and 2 - the sheets to be welded, 3 and 4 - the copper electrodes

V.80. When one works on a turning lathe with wrong-shaped tool, why does the consumption of electric power increase?

V.81. On automobiles and tractors the electric battery (accumulator) is usually placed as close to the starter engine as possible and connect them by a thick copper wire. Explain the reasons.

V.82. In welding and cutting metals by means of arc, why do they use currents reaching several hundred amperes?

V.83. In a point electric welding (see in Fig. V.19) the sheets are pressed to each other by electrodes and then a current is passed. Why in this process are welded only contacting places on sheets and not electrodes?

V.84. The section of wires supplying energy to spirals of heating devices is usually greater than that of proper spirals. May you explain why?

V.85. Plugs, convenience outlets (sockets), or switches of electric circuits sometimes become sensitively hot. What is the reason of this phenomenon and how can one repair this heating?

V.86. In a tram two engines are set. The drive may swintch them both in parallel and in series. What are the reasons for providing both ways of switching?

V.87. Electric stoves may contain two similar spirals heated by a current; these can be connected both in series and parallel ways. In which of these connections will the stove give more heat?

V.88. A steel wire has a resistance twice greater than a copper one. In which of these wires will the greater quantity of heat arise in the same period of time: a) in parallel connection; b) in series connection into a circuit with a constant voltage?

V.89. In a short circuit why is the voltage on battery terminals close to zero? To what end the work extraneous forces go in this case?

V.90. How do depend the losses of power related to the internal resistance of the electric power source on the resistance of the external circuit? May these losses be zero?

V.91. What are the necessary devices and in what way can one verify the work of electric power meter?

V.92. A ring is made of a homogeneous wire. The voltage of a power source is constant. In what position of the runner (see in Fig. V.20) will the minimum heat be produced in the ring?

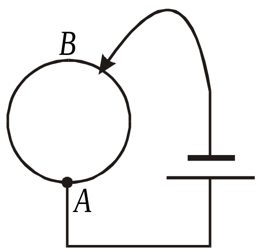


Fig. V.20.

V.93. Explain why in moving the runner to the point A (see in Fig. V.20) we get an infinite value of the heat power. Is this situation real?

V.94. A current in a coil grows linearly from zero to $5A$ within 9 seconds. During this time, in a conducting ring which is near the coil, the $0.5J$ of heat was produced. What s the quantity of heat to be produced in the ring if the current in the coil grows linearly from 0*A* to 10*A* within 3 seconds?

Current in Gases

V.95. Experience shows that none body that could be charged infinitely. After a certain value of charge (depending on the shape and the size of body, as well as on the features of environment), a further increase of charge cannot be attained. Why?
V.96. Why the wires of air power transmission lines are not covered by an isolating shell for a greater safety?
V.97. Is a semi-self-maintained discharge between wires of a power transmission lines (air) possible?
V.98. In a spark discharge through a gas why is the greater voltage ~$10^6 V$ required for a distance between electrodes ~1m, while for an arc discharge the voltage ~45–50V is sufficient?
V.99. In cooling a gas, its conductivity reduces. How can you explain it? Where are ions hidden?
V.100. In decreasing the pressure, the electric conductivity of a gas first grows and then, from a certain value of pressure, decreases and turns into a negligible value?

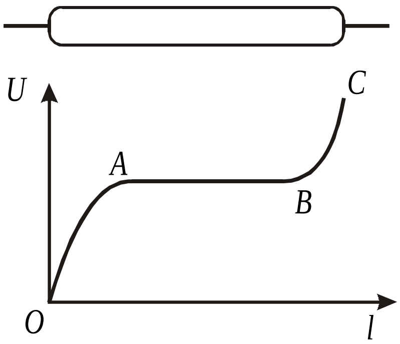


Fig. V.21.

V.101. What is the cause by which the glass of bulbs of electric lamp darkens after a long use?
V.102. On Fig. V.21 you may see the distribution of the potential alongside a tube in which a glow discharge is produced. In which domain the electric field strength is maximal? Where does it equal zero?
V.103. For advertising and decorative purposes gas-light tubes with glow discharge are used. What does the color of glow in them depend on?
V.104. Why must one avoid the air entering in the glow discharge tubes?
V.105. If one rubbers the balloon of neon lamp with wool, the lamp may be alight. How will you explain this phenomenon?
V.106. For signalizing neon lamps, working on the glow discharge, are widely used. A neon lamp is a balloon provided with two electrodes and filled with an inert gas (e,g., the neon). In contrast to incandescent lamps, why do the neon lamps start to glow at a strictly defined voltage?

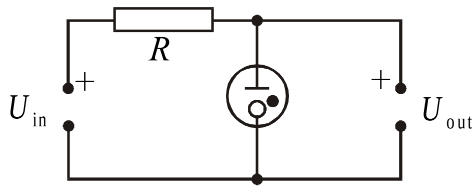


Fig. V.22.

V.107. A glow discharge is used for the method of cathode vaporization of metals, based on the fact that the substance of cathode step by step passes into a vapor and sets on the walls of tube or things inside the tube. By applying this method, the high quality mirrors are produced, piezo-quartz plates are coated, etc. Why does the cathode substance vaporize in the glow discharge?
V.108. In Fig. V.22 you see the scheme of connection of a device (called stabilitron), which is applied in stabilization of the voltage in electric circuits. The action of a stabilitron bases on the property of a glow discharge to support practically unchanged the voltage in the discharge distance under changes of anode current. How can you explain it?
V.109. Explain why in an electric welding, strong cooling of the cathode kills the arc, but in cooling of anode the arc continues to burn?
V.110. One must weld a massive detail with a thin one. Which of details should be connected to the positive pole of the power source and which to negative?
V.111. In the flight of an airplane, its structure may be electrized up to potential about half million Volts, which leads to glow discharge on outstanding parts of airplain and makes difficult the radio communication. In this connection, at some places of airplane steel needles are fixed. Why do these needle reduce radio noise?
V.112. In order to reduce energy losses for glow discharge, why do they increase the diameter of wires and make them hollow?
V.113. In some cases each wire of a high voltage of a power transmission line are made triple with wires diverged on a certain distance (see Fig.V.23). Why does this solution reduce the losses to glow discharge?

V.114. Why do the losses of electric power to glow discharge in power transmission lines sharply grow in a bad weather (fog, rain, snow-fall, etc)?

V.115. To separate seeds they use a machine based on the crown discharge (see in Fig. V.24). The

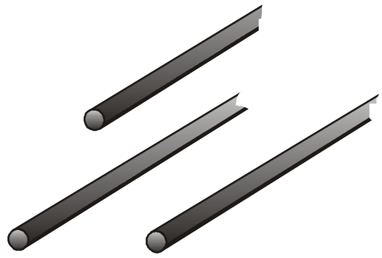


Fig. V.23.

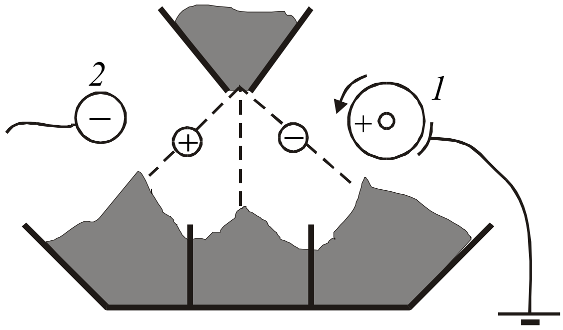


Fig. V.24.

machine consists of a rotating drum *1* and an electrode *2* which produces the crown discharge (a thin wire); between these parts a strong electric field arises. As a consequence, the crown discharge electrify and ionize the air molecules around. The ions thus produced charge the grain flowing from a bunker. Why is a separation of seeds realized?

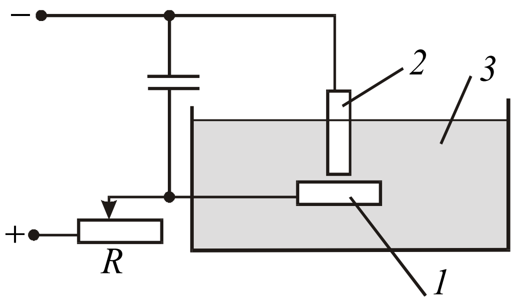


Fig.V.25. The scheme for the treating of metals by electric-sparking technique: 1- the treated piece, 2- the electrode, 3 - a dielectric liquid

V.116. What is the objective to supply on the electrodes of a spark plug in an internal combustion engine the high voltage (near 20*kV*)?

V.117. Explain the physical basements of the treating of metals by the electric-sparking technique (see the scheme in Fig. V.25).

V.118. What are the advantages of the electric-sparking method of treating metals in comparison with turning and milling?

V.119. A neon tube and an incandescent lamp filled with hydrogen are connected in parallel to a power source. Only the neon lamp is alight. In merging both the lamps into a liquid helium, the neon lamp stops its light, but the incandescent one starts to burn. Why?

V.120. Wrap into a thin tin foil (e.g., the wrap of chocolate) the bulb of an electic lamp and then wind above foil a thin copper wire. Connect the free end of the wire to an electroscope. Connect in series with lamp a rheostat to make the lamp to be alight not in full power. Then make the following experiments: a) charge the electroscope positively and switch on the lamp; b) charge the electroscope negatively and then switch on the lamp; c) in continuing the experiment, move forward the runner of the rheostat to make the lamp be alight in full power. Explain all the three phenomena observed.

V.121. In a certain quantity of the air is inside a vacuum bulb, its cathode is quickly collapses. Why?

V.122. If a high voltage (several thousand Volts) is applied between the cathode and the anode of a vacuum tube, the anode is strongly heated and might even melt. Can you explain the reasons for melting?

V.123. In industry, both the vacuum and gas-filled lamps are produced. Why do the gas-filled (they use inert gases to fill the bulbs) lamps serve more long time than vacuum ones?

V.124. Radioactive radiation forms elementary particles possessing high energy and thus able to ionize the gases. Design a device (gauge) which could react on ionized particles.

Electrolysis

V.125. On gas ducts the negative pole of electric generator is connected with the duct, while the positive pole is grounded. Why does this method, called «cathode protection», keep the ducts away of corrosion?

V.126. Both clear distilled water and salt are isolators. Then why is their solution a conductor?

V.127. In the electrolysis the metals' ions from a solution deposits at cathode, losing their charge. In what way is the quantity of metals' ions complemented in the solution?
V.128. In the capacity of an anode, place into an electrolytic bath a copper plate covered by a wax. Before this, draw (scratch!) a picture on the surface of the plate. What will be the result after making to pass a current and posterior cleaning off wax from the plate?
V.129. A concentrated sulfuric acid can be kept in both glass and iron vessels, but a diluted must be kept only on glass vessels. Explain why.
V.130. To determine the poles of a power source, they connect it with wires merged in a glass of water (water must not be distilled). Then they observe at which wire more gas is extracted. How do they determine by these data the signs of the poles?
V.131. As known, both trams and electric trains use the direct current for their motion. The air wire of supply is connected to positive pole of the power source, while the rails are connected to the negative pole. Why?
V.132. Why must the wires designed for electric circuits in humid rooms be covered by a substance non-permeable by the humidity (e.g., by synthetic resin)?
V.133. The aluminum, sodium, magnesium and many other metals are obtained by the electrolysis of oxides melt. Thus, the aluminum is produced by the electrolyzing melt oxide of aluminum solved in the cryolite, which is added to reduce the melting temperature of this melt. Explain the physical basements of the process of producing aluminum.
V.134. In the industry, the electrolysis is widely applied for purification (refining) various metals. On this process the metals are cleaned out from various residues and additions. Thus, the copper extracted from ore contains some sulfurous addends reducing its electrical conduction. Such copper in the form of plates is merged into electrolytic bath as an anode, the electrolyte being a solution of the sulfuric acid and the copper sulfate. Explain the physical foundations for producing clean copper.
V.135. Both cathode and anode covering of details by a metal are used in the industry. If the metal for covering is chemically more active than the metal of detail, the covering is said to be «anode» (otherwise «cathode»). Determine the way of covering for a zinc-coated iron and a tin-plated iron by using the series of chemical activity of metals.
V.136. Before to proceed with an electrolytic covering (plating and coating) details must be carefully treated: polishing, fat removing, oxide-films removing from surfaces. Why does the covering metal to be keyed better to the detail in this case?
V.137. To avoid the atmospheric corrosion of steel details, the zinc is used; to protect them against the action of sulfuric acid and sulfates they use the lead; for protecting decorative finishing the nickel and chrome are applied. What does stimulate the choice of the metal for protection of details?
V.138. In small electrolytic baths why do they use as a rule two anodes between which the detail is placed?
V.139. Zinc-coating and nickel-plating of small details are made in electrolytic baths of the bell type (drums) which rotate in the process of electrolysis. What for are these baths turned?
V.140. In order to improve the quality of electrolytic covering of products they use reversing which is the alternating of the current's direction in baths. Why does it improve the quality of covering?
V.141. Does the velocity of precipitation of a metal in electrolytic covering depend on the distance between electrodes?
V.142. The anode-mechanical treating of metals is used in the industry. To this end a draft detail is connected with a positive pole of the power source and the cutting tool is connected with the negative pole. At the place of a tool-detail contact an electrolyte is supplied. In treating the anode metal's dissolving in the electrolyte is used as well as its later destruction resulting of spark discharge. How can one apply these processes for tools' sharpening?
V.143. How could one cover by metal product made of non-conducting materials (wood, gypsum, leather)?
V.144. If through an electrolyte with two electrodes merged a current passes, then on anode a metal is formed in quantities determined by the value of the electric charge passed through the electrolyte. In discharging a capacitor via an arbitrary number of baths connected in series, whether one can extract any prescribed quantity of a metal?

Direct Current Sources

V.145. Connect in series a metallic pot (made of either iron, or copper) and an aluminum vessel of a calorimeter or an aluminum mug with a galvanometer. Pour into pot water with tea and dissolve a bit of salt. Now pour the water to a glass. Why does the galvanometer show that a current is passing?

V.146. Some animals stun their victims by electric current. For instance, an electric eel may produce an impulse of a current of 1*A* with voltage 600*V*. Electricity is produced in special cells, so-called «electric pockets», which may rapidly discharge when a nerve signal comes into. A set of these electric pockets are connected together to obtain the necessary voltage. At the same time the eel does not suffer of electric shock which is stipulated by the way in which electric pockets are connected. An electric pocket discharges a difference between potentials of 0.15*V* and may survive without destruction of its structure an electric current up to 1*mA*. Determine the umber of electric pockets of an electric eel and the way of their connection.

V.147. Assume that we have as many as necessary elements for a small pocket lamp. May one put alight a lamp designed for a very strong current?

V.148. To a accumulator battery with the electromotive force E_1 n accumulators with the electromotive force of each E_2 are connected in series and then close the new battery thus made with an external resistor. In what case the current passing through the resistor does not depend on the quantity of connected accumulators?

V.149. May we use a common vessel in making a battery of parallel connected galvanic elements?

V.150. Electrified ebonite or glass stick attracts small pieces of paper. Why paper pieces are not attracted to terminals of an accumulator or a battery?

V.151. From the electrostatics we know that all points of a conductor must have the same potential. Why then in Volt element does arise the difference between potentials of zinc and copper plates? All its components: plates and the solution of sulfuric acid between them are conductors.

V.152. Why the hydrogen in a galvanic element is produced on the positive electrode and not negative, as within the electrolysis?

V.153. Is the term «dry element» correct? Why do the cover «dry elements» with a synthetic resin?

V.154. To extend the resource of an element it can be accurately rumpled. After this procedure why do battery features restore?

V.155. In a galvanic element why is the zinc a negative electrode? Can an element with positive zinc electrode exist?

V.156. To produce galvanic elements why do they use not a chemically pure zinc but that with various impurities?

V.157. A tank for water made of aluminum sheets with copper rivets quickly decays cue to corrosion. Why?

V.158. Electrolyte reduces in car accumulator battery with time. In what case will it suffice to add distilled water and in what case must one add a ready-to-use electrolyte?

V.159. The degree of charge of a battery can be tested by the density of the electrolyte with the help of an areometer. Give foundations to justify this method of testing.

V.160. A car lamp of 6V and 24Wt connected to a 6V car/bike battery burns brightly, but connected to consecutively connected elements with common tension 8V glows weakly. Why?

V.161. Usually, an automobile starter is a rather small electric engine consuming large (~100A) current under small (~10V) voltage. Whether one can turn on a car possessing instead of a car battery several elements for pocket lamp connected consecutively?

V.162. One has an unlimited quantity of elements for pocket lamp. Can he obtain any great current by connecting elements consecutively?

V.163. Why is it forbidden to admit short circuit for acid batteries?

V.164. Interior resistance of alkaline accumulators is greater that that for acid accumulators. Prove that the efficiency of acid accumulators is above the efficiency of alkaline ones (under equal remaining conditions).

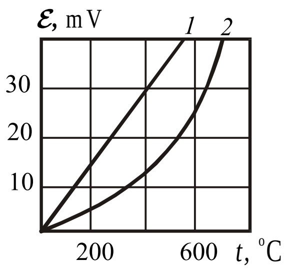


Fig. V.26.

V.165. Alkaline batteries weight less than acid ones, they are resistant against short cicuit (i.e., possess large interior resistance), but their electromotive force strongly depends on the temperature. Why do the use in automobiles not alkaline but acid batteries?

V.166. Why are the plates in batteries so close to each other?

V.167. How can one increase the efficiency of a battery composed of similar elements?

V.168. In Fig. V.26 the graphs of dependence of the electromotive force arising in heating nichrome-constantan (*1*) and nickel-nichrome (*2*) welds. Which among these pairs requires a less sensitive galvanometer in designing a thermoelectric thermometer? Why?

V.169. There are certain reasons to suppose the in future the magneto-hydrodynamic (MHD) generators of current will have bright perspectives. Their samples are already working in practice.

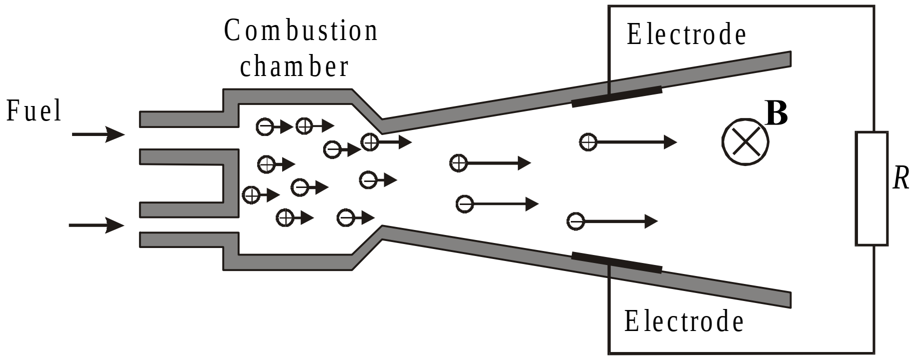


Fig. V.27.

They directly transform the interior energy of a gas into electric one. The current in the generator is produced as follows. A jet of plasma (i.e., partially ionized gas) is directed into an interval between two plates which are in a string magnetic field (see Fig. V.27). In this situation, between the plates an electric tension arises. Explain the causes of its arising. If one connects by a conductor these two plates, what will be the direction in which the current will flow in exterior circuit if the direction of magnetic field induction is as shown in the figure?

V.170. Why in an MHD-generator they add to the products of combustion the vapors of metals (e.g., potassium and cesium) whose atoms are easily ionized at high temperatures?

Electric Engines and Generators of Electric Current

V.171. When it rotates in the magnetic field of a stator, the rotor of a working electric generator is subject to (in addition to friction) braking forces. What is the origin of these forces?

V.172. In Fig. V.28 you may see the scheme of a voltage regulator in a car. If the number or engine rotations increases, the generator gives increased voltage which increases the current in the electromagnet *1*; the latter attracts the contact *2*, by overcoming the resistance of a string *3*, and thus disconnects the circuit *4*. Why will the tension decrease in this case? What will happen later to these contacts?

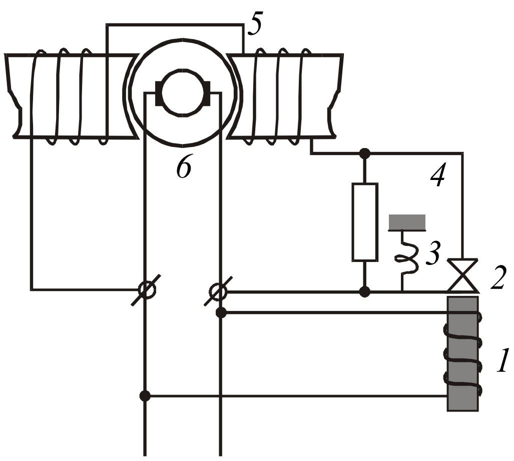


Fig. V.28.

V.173. How can a generator of a direct current, which supplies energy to electromagnets of its stator, start to supply the current into mains of for its excitation a magnet field is necessary?

V.174. If we connect two generator of a direct current consecutively and start to rotate the rotor of one by applying an external force, then other will start to rotate, too. Why?

V.175. In generators of direct current there always is a mark showing to which side its rotor must turn. It is forbidden to rotate in opposite direction. Why? What will happen if one starts to rotate it in opposite direction?

V.176. Automobile batteries are said to be discharged if a) the illumination lamps of the car are glowing poorly; b) incandescence of the lamps changes if one increase the rotations of the engine. Give explanations to these criteria.

V.177. Serving to start up an automobile engine, a starter is an electric engine working from an accumulator battery. The current needed for starter is about hundred amperes. What is such a big

current necessary for? Why is it forbidden to switch on the starter for a long time?
V.178. As known, the start of powerful electric engines is produced by means of starting rheostats in order to avoid burning out of winding of armature. Why is the starter switched on without these rheostats?
V.179. Prove that if among two machines of the same type one works as the engine and other works as a generator and the currents in armatures and magnet windings of both machines have the same direction, then armatures of these machines will rotate in opposite directions.
V.180. Let there be given an electric machine with a constant magnet. Its rotor is provided with two absolutely similar windings, connected with separate collectors. One of these windings is connected to a direct current source and the machine works as an engine. In this situation, the second winding can serve as the source of current. Determine how does the current in windings depend on the resistance of the load to which the second winding is connected?
V.181. The direction of the rotation of a rotor of a direct current engine depends on the direction of current in the windings. How may a tram go forward and back while the air wire has always a positive potential of 600V with respect to rails?
V.182. May a tram in its motion not only consume the energy, but return it into circuit?
V.183. At first glance it seems that in rotation of electric engine rotor the quantity of the consumed energy is as greater, as more fast are rotations of the rotor. But in practice all in contrary. How could you explain it?
V.184. In powerful generators of alternating current the inductor rotates (electromagnet) fixed on a rotor, the current is induced in windings of the stator. In a generator of a direct current, the stator is an inductor, while the current is induced in the winding of the rotor. What does determine this difference?
V.185. May a generator of alternating current supply the inductor with its current?
V.186. Generators put into action by hydro-turbines are multi-polar (i.e., the rotor represents an electromagnet with many poles), while turbo-generators are always two-pole. Why?
V.187. Why the number of rotations of a stem turbine which is a component of a turbo-generator is usually equal to 3000 rpm? What is this value related to?

Alternating Electric Current

V.188. In measuring the resistance of solutions why is it recommended to use only a direct current?
V.189. Two incandescent lamps are equipped with amemeters which register the current passing through them. One of the lamps is connected to an *ac* and other to *dc* sources. Readings of amemeters are same. Which of lamps will be brighter?
V.190. An isolated wire is winded about an iron bar. Will its resistance to *dc* change? To *ac*?
V.191. In a parallel connection of a capacitor to the circuit of a fluorescent lamp, why does the power coefficient increase?
V.192. In consecutive connection of conductors the common resistance equals the sum of each resistance. Into a circuit of alternating current with the frequency w we include a lamp with resistance *R*. Afterwards, consecutively with this lamp we include a coil with the inductance *L* and a capacitor with the capacity *C*. The resistance of the circuit seems to grow and exceed *R*; however, if $LC = 1/\omega^2$, the resistance of the circuit will be *R*. How must one understood this situation?

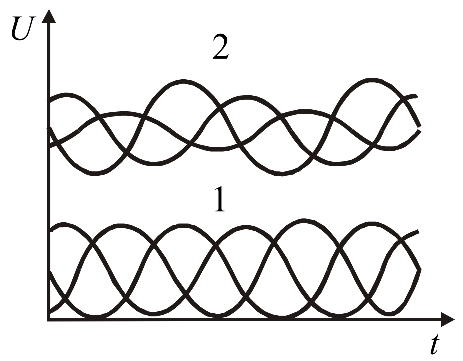


Fig. V.29.

V.193. A lamp an a capacitor are included consecutively into AC mains. How will change the glow of the lamp if we include one more capacitor in parallel to the first one?
V.194. Into a circuit of a battery they included a winding of an electromagnet and an incandescent lamp. Will change the glow of the lamp when the electromagnet will attract a load?
V.195. How can one visually distinguish among three wires of air power transmission three-phase line a phase-wire an the zero-wire?
V.196. What is the pulsation frequency of directed three-phase current of the industrial standard under two-half-period direction?
V.197. In Fig. V.29 one can see graphs of two three-phase currents. Which of them does need a

zero-wire? Why?

V.198. Sometimes, when home fuses burn out, lamps glow but dimly. Why? Is it possible in three-phase supply net with the zero-wire?

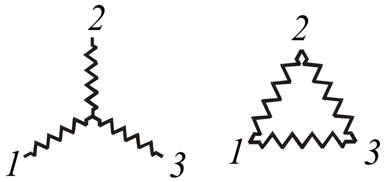


Fig. V.30.

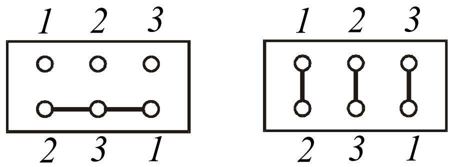


Fig. V.31.

V.199. An electric engine is connected to three-phase supply first in star-shape way, then in trangle way (see Fig. V.30). When do its windings get a greater voltage?

V.200. In Fig. V.31 you may see a terminal block of an electric engine with three pairs of terminals. To these terminals beginnings and ends of three its windings are connected. What way are connected the windings of the engine, star or triangle, in both cases?

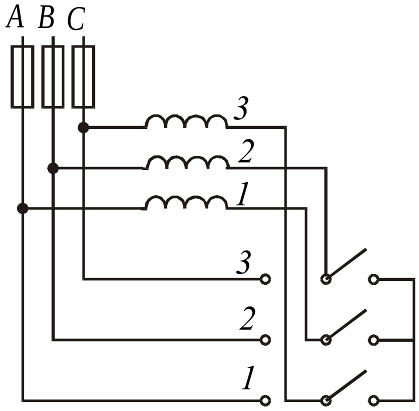


Fig. V.32.

V.201. In starting up powerful engines of three-phase *ac*, the interrupter first is positioned to right contacts (see Fig. V.32), and, after the engine will reach necessary rotation, to left ones. Why do they do it in this way?

V.202. Why is the transformation of *ac* to high voltage and back necessary in transmitting the electric energy for long distances?

V.203. Does change the power of current under transformation in a transformer?

V.204. What will happen to a coil of a transformer if we straighten it not disconnecting from the mains?

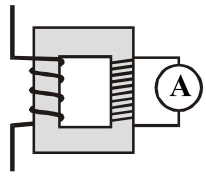


Fig. V.33.

V.205. The primary coil of a transformer is connected to a source, the second being disconnected. Is the transformer consuming electric energy?

V.206. Why do the rings work on a battery must have an interrupter, while those working on *ac* do not need it?

V.207. For measuring *ac* of large force so-called «current transformers» are applied in electric circuits (Fig. V.33). A version of these devices are so-called measure clutches (Fig. V.34), which are specially convenient to measure the current in power transmission lines without disconnecting them. The clutches consist of a metallic core *1*, an amemeter *2*, and dielectric handles *3*. The wire of a line *4* is placed via a regularized gap *5* into interior domain of the core *1* and by the amemeter the force of current in the line can be determined. What are physical laws which enable the action of the devices? Why cannot one include the amemeter directly to the circuit with a high current?

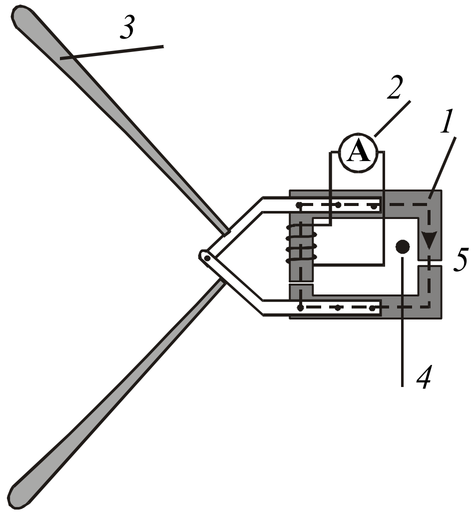


Fig. V.34.

V.208. In Fig. V.35 a scheme of a transformer for welding is given. The electrodes *E*, between which the arc is excited, are connected to the secondary winding of a transformer. Will either grow or decrease the tension of electrodes' terminals if one moves the handle *H* from *A* to *B*?

V.209. Why do not they use for illumination *ac* with the frequency 15 Hz?

V.210. Will change the ratio between the tensions of terminals of primary and secondary windings if the iron core will be replaced with copper one? One made of aluminum?

V.211. Why does a transformer fail if at least two winds are short circuit?

V.212. Why does a transformer with load toot? What is the frequence of the sound of a transformer

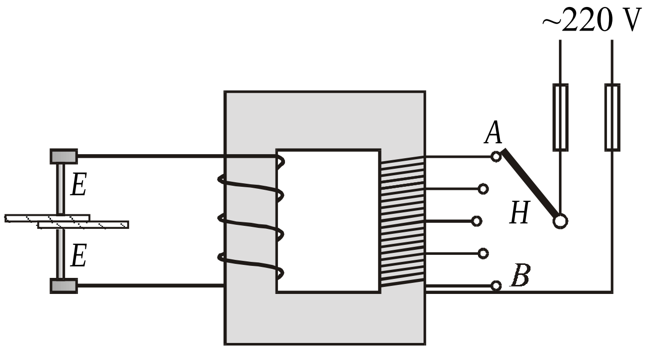


Fig. V.35.

connected to the mains of an industrial power circuit?

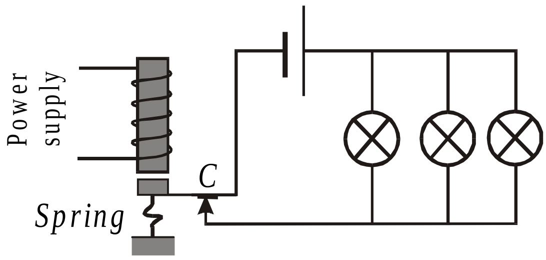


Fig. V.36.

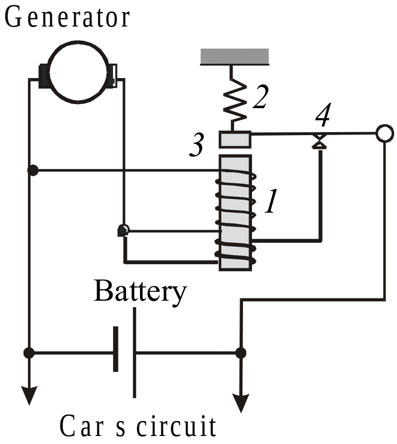


Fig. V.37.

V.213. In interruption of current from mains or in jumping off wires of its trolleys, lamps supplied by accumulators are automatically switched on. Using the scheme in Fig. V.36, explain the action of such a device.

V.214. In Fig. V.37 a scheme is given which allows to switch off the generator from the battery of a car when the latter gives current into car's circuit. Explain the scheme.

Chapter VI

Oscillations and Waves

Mechanical Oscillations

VI.1. How will change the period of a pendulum if it will be carried from the air into the water or a viscous oil?
VI.2. Two similar hollow balls with holes are filled: one with the water and other with sand. They are hung on lines of the same length, and inclined to the same angle. Will they have same period of oscillations? Will they oscillate within the same time?

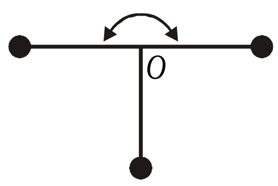


Fig. 6.1.

VI.3. A flat T-shaped construction consists of three small balls and can freely turn in the vertical plane about the axis *O* (Fig. VI.1, the plane of the draw is perpendicular to the axis *O*). The length of each spoke is *L*, and its mass is neglectible in comparison with the mass of the balls. Determine the period of small oscillations of the construction.
VI.4. Given a clock with its second pendulum established for Moscow, how will is go on a pole and on equator?
VI.5. In a rocket which goes up with the acceleration ***a***, a mathematical pendulum is put. Explain the character of oscillations of the pendulum in a moving rocket and determine on which height the period of oscillations will be same as in a rocket standing on the Earth.
VI.6. Will remain same the period of a mechanical pendulum of a clock if we transport it from the Earth to the Moon?
VI.7. How will change the period of oscillations of a pail with water which is hung on a long rope if the water will permanently leak from a hole in its bottom?
VI.8. What should be done with the pendulum of a clock if it goes faster?
VI.9. Does a change of temperature affect the accuracy of a pendulum clock?
VI.10. By means of a mathematical pendulum, how one can determine the acceleration of gravity at a given place?
VI.11. By the change of the period of oscillations of the second pendulum, how can one estimate the volume of ore if he knows the density of the ore $\rho_o = 8000 kg/m^3$ and the average density $\rho_E = 5600 kg/m^3$ of the Earth?
VI.12. If one carries pails on yoke, then in a certain temp of walk the pails start to oscillate strongly. How can you explain this phenomenon? How may one reduce such oscillations?
VI.13. Why do the glasses in an old bus start to tinkle at a certain frequency of engine rotations?
VI.14. If one puts a wooden circle upon the water in a pail, the water will not sprinkle out in walk. Why?
VI.15. What are the reasons to install all vibrating devices in sky-scribers (electric engines, diesel engines, and so on) on rubber or metallic shock absorbers?
VI.16. In what maximal speed of a train may the resonance of vertical oscillations of cars arise in view of strokes of wheels on rail-ends if the length of a rail is 25 m, and the period of proper vertical oscillations of a car is approximately 1.25 second?
VI.17. A spacecraft moves with a certain acceleration when its engines are turned on. By using a mathematical pendulum hung in the spacecraft cabin, how one can determine the acceleration of the spacecraft?
VI.18. Two tuning forks stated one resonance boxes have the resonance frequencies ω_1 and ω_2, respectively. In striking one of the tuning forks, other, practically, does not respond. By exciting one tuning fork, how one can make to respond another one?

Waves in Elastic Media. Sound

VI.19. The radius of the front of shock wave under a nuclear explosion depends on the energy of the explosion *E*, the time of its propagation *t*, and the initial density of the air ρ_0. Basing on the method of dimensions, find this dependence.
VI.20. The sound speed in a gas may be represented by the formula $v = f(p,\rho)$, where p is the pressure and ρ is the density of the gas. Basing on this information, determine the ratio of speeds

in a gas in two different states which are characterized by the values p_1, ρ_1 and p_2, ρ_2.

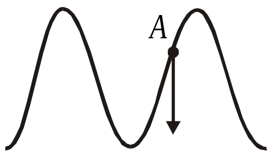


Fig. VI.2.

VI.21. In a running transverse wave, a particle A (see Fig. VI.2) has the direction of velocity shown in the figure. In what direction «moves» the wave?
VI.22. In approximating to a shore, the sea waves increase their height reaching sometimes 50 m. Why does it occur?
VI.23. When small sea waves approximate an inclined shore, foam ridges appear on them. Why?
VI.24. In formation of waves, particles of water do not move toward, but participate in an oscillation about a certain mean position. Then why do sea waves often throw onto the shore some floating things?
VI.25. If a shore is slanting, why do the waves reach the shore at an angle close to direct independently of the wind direction?
VI.26. Sometime we see the flash of lightning but do not hear the sound of thunder. As a rule, the thunder are rarely audible at distances exceeding 25km. However, the sounds of fire-guns are heard at much longer distances. Why do we hear no thunder at the same distances? Take into account that the sound velocity in gas is approximately proportional to its temperature.
VI.27. If one observes how marsh soldiers accompanied with an orchestra, it seems that they go wrong and do not hear the music. Why?
VI.28. The watch was tuned by means of the sound of signals from a radio at rather far distance. In which season will this tuning be more accurate: in winter or in summer?
VI.29. It is easy to find a propeller airplane in sky, but not a jet. Why?
VI.30. On heights exceeding 3km over the Earth's surface, one cannot obtain any sound whose source is on Earth. Why?
VI.31. Why are sounds in a fog heard for longer distances than in a sunny day?
VI.32. The most insects produce noise when fly. What does generate these sounds?
VI.33. Which of the following insects does make more frequent waves by their winds: a fly, a bumblebee, or a mosquito?
VI.34. By the frequency of sound of a bee one can know where the bee flies to or from: to home with a honey, or from home to collect the honey. How can you guess it?
VI.35. In testing wheels of a train, workers strike them with a special hammer (with a convenient long handle). Why do they strike wheels?
VI.36. Before playing, musicians who play on musical instruments with a bow, rubber bows with a rosin. What do they make it for?
VI.37. The sound of a circular saw lowers when it starts to saw a wooden plank. Why?
VI.38. Bass strings are winded with a wire. What for?
VI.39. How does the tone of a string or a tuning fork change if the temperature grows?
VI.40. You have two tuning forks. You hold one in your hand for a minute, and then excite both the tuning forks. Why do you hear beatings now?
VI.41. In striking with a metallic bar a car tire, how does depend the tone of a sound on the pressure of the air in the tire?
VI.42. If one blows near a hole of a tube closed from one end, a sound of a certain tone can be heard. How can you determine the height of tone without blowing?
VI.43. The water is poured into a bottle. The water jet produces a noise with an distinguishable tone. In pouring, this tone becomes as higher as much water was poured. Explain the phenomenon.
VI.44. Will the height of the basic tone of a tube change if we bend it for an angle?
VI.45. If one puts on a table a tuning fork which sounds, the sound becomes more laud. Where from it takes an additional energy?
VI.46. May non-elastic substances conduct a sound? Why? Give an example.
VI.47. How do curtains and soft furniture influent upon the audibility of sound?
VI.48. Why are a singing and orator speeches less audible in an open air than in a closed space?
VI.49 The air conducts sounds significantly more poorly than a wood or a glass. Then, if the doors and windows are closed, why do we hear less noise from the street?
VI.50. Musical instruments are «tuned» before playing. What is the physical essence of tuning a violin, a mandolin, other string instruments?
VI.51. Experiment to sing some different tones into a closed glass can. In a certain tone the can will amplify the sound and start to vibrate. Why?
VI.52. If somebody excites a sound before an open piano and then presses its pedal, the piano starts to sound in response. How can you explain it?

VI.53. In checking the work of an engine, why do car mechanics often put one end of hammer’s handle upon the engine and other draw to ear?
VI.54. If the engine of a supersonic jet is behind the pilot, and the airplane flies with a supersonic speed, will the pilot hear the sounds of the engine?
VI.55. Can cosmonauts in the open space communicate by voice?
VI.56. If one hears the quality record of his proper voice, he badly recognizes it. Why?
VI.57. Why the hollow shell of a violin is made in so figure shape?
VI.58. A vibrator is merged into water, its membrane produces musical sounds. Will a an underwater swimmer hear the same melody as he hears it one the air?
VI.59. Could the sound of a strong explosion on the Moon be heard on the Earth?
VI.60. If one strikes by a hammer one end of a pipe, another person hears a double stroke at another end of the pipe. Why?
VI.61. Why does a bullet whistle of shot by a gun, but gives no sounds if thrown by a hand?
VI.62. If both higher and lower tones were propagating with different speeds, how would we accept such a music?
VI.63. Sometime we hear a voice at a long distance, but cannot distinguish words. How can you explain this situation?
VI.64. In large rooms echo may arise. Is it useful or not for a theater; a concert hall; a lecture room?
VI.65. Why do the orators making a speech on big squares, say their words slowly, separating words by pauses?
VI.66. If a thunderstorm is close, why do we hear sharp laud blows, but only a rolling thunder if it is far from us?
VI.67. Why do not we hear echo in a living room?
VI.68. May arise the echo in a steppe?
VI.69. Why is so multiple the echo in mountains?
VI.70. In its marsh, a brass band turns over a street corner. After a while, we hear only the bass tubes and the drum. Why cannot we hear flutes and clarinets?
VI.71. When someone tries to hear a far noise, his/her moth becomes open automatically. Why does it occur?
VI.72. If we draw a cup, a glass, or a seashell closely to our ear, we hear a sound similar to the noise of remote sea waves. How can you explain the origin of this sound?
VI.73. Before starting to boil, why does a pot (not filled completely) make a greater than that filled completely?

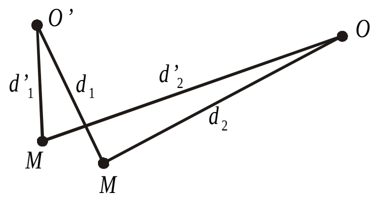


Fig. VI.3.

VI.74. Why the poles of power transmission lines sounds in wind?
VI.75. Accidentally flying into a room, a bat may «land» on one’s head. Why does it prefer this place?
VI.76. As known, higher is the frequency of sound waves, shorter is the distance after which they weaken. In this case, why are the ultrasound vibrations used by some species of animals (bats, dolphins, guinea-pigs) as the main mean of communication and location?
VI.77. On a free surface of a liquid they got a stable picture of the interference from two coherent sources *O* and *O’* (see Fig. VI.3), which vibrates with the frequency $f = 100$Hz. Using the figure, evaluate the speed of propagation of waves on the free surface of liquid. The closest minimums of the interference picture are situated at the points *M* and *M’*.

Electromagnet Oscillations and Waves

VI.78. In a tuned circuit, consisting of an induction coil and a capacitor, why do not the oscillations stop when the capacitor is discharged completely?
VI.79. How will change the frequency of electromagnetic oscillations in a tuned circuit if we introduce an iron bar into the coil? If we increase the gap between the plates of the capacitor?
VI.80. A mine detector is a generator of undamped electromagnetic oscillations of a sound frequency. The inductance of the tuned circuit is made in the form of a wire ring. When the ring is moved upon the ground surface and approximates to a metallic body, the high tone in telephones change for lower. How can you explain it?
VI.81. Both a direct and a high-frequency alternating currents are transmitted through the same line. How can they be separated?

VI.82. Using the block-scheme of a radio-transmitter in Fig. VI.4, explain the function of each element and the principle of device's action in the whole.

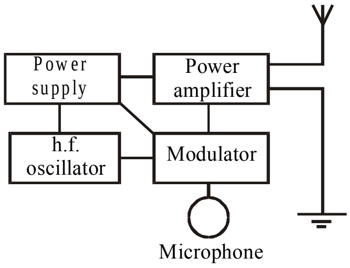


Fig. VI.4.

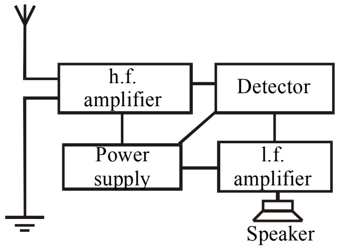


Fig. VI.5.

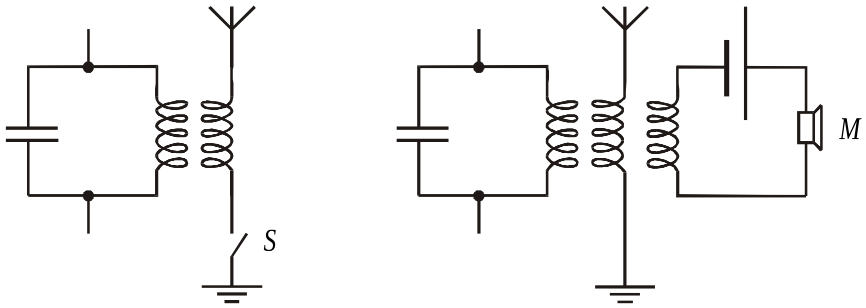


Fig. VI.6.

VI.83. Using the block-scheme of a radio-receiver in Fig. VI.5, explain the function of each element and the principle of the function of the whole device.
VI.84. In Fig. VI.6 you may see the schemes of radio-transmitters for transmitting of signals. Explain their functioning.
VI.85. Why is the radio receiving better in winter and at nights than in summer and in day-time?
VI.86. In radio communication at short waves the receiving is not good in all places; in some places (maybe close to transmitter) so-called «silent-zones» are fomed. What is their origin?
VI.87. A radio receiver can be tuned on different frequencies and thus catch radio stations of different lengths. What is to be done for receiving more long lengths: to approach or to draw apart the plates of the capacitor of the tuning circuit?
VI.88. For the resonance, the length of the antenna must be four tomes shorter than the length of the electromagnetic wave to be received. Why in practice do they apply antennas of a less length?
VI.89. What causes a noise in receiving when a tram passes near your house?
VI.90. If one switches on and off illumination lamps in a room a short noise is heard in radio-receiver. What are the causes of that noise?
VI.91. If an airplane flies near your house, you may see double picture on our TV receiver. What causes this double image?

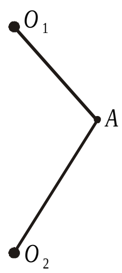


Fig. VI.7.

VI.92. Why does a car radio work poorly when the car passes under a bridge or a trestle? What causes this poor work?
VI.93. Why are TV tower built so high?
VI.94. A radio communication is impossible for submarines which are merged into the ocean. Why?
VI.95. Waves interfere under certain conditions, either strengthening or weakening each other. Weakening takes place if the difference of wave phases equals $(2n+1)\pi$ (n is an integer). In this situation the energy of oscillations equals zero at these points. Does it contradict the law of conservation of te energy?
VI.96. As known, if the difference of waves path lengths equals $k\lambda$, where k is an integer and λ is the length of a wave, then waves strengthen each other. Sources are at the points O_1 and O_2 (see in Fig. VI.7), whose waves reach the point A. The distance $O_2A–O_1A$ is equal to λ. Can we assert that the point A is the interference maximum?
VI.97. If two antennas irradiating electromagnetic waves are drawn to each other at a distance less

than $\lambda/2$, then at all the points of the space the condition of interference maximum will be fulfilled. Does it contradict the law of conservation of the energy?

Chapter VII

Optics

Propagation of Light

VII.1. If one draws the symmetry axis of the incomplete Moon visible in day-time, will it pass the Sun?
VII.2. What does differ the light produced by: a firefly, an incandescent lamp, a fluorescent lamp, and a neon lamp?
VII.3. Why does not the quality of image on the screen of a panoramic cinema suffer due to the fact that the beams of different projectors intersect in space?
VII.4. One can look calmly on fluorescent lamps in contrast to incandescent lamps: the first ones do not «cut eyes». Why?
VII.5. A beam of a projector is perfectly visible in fog but worse when weather is clear. Explain this difference.
VII.6. Why do shadows not darken completely even with a point source of light?
VII.7. Why does the landscape become more visible before the proper sunrise?
VII.8. In day-time, one can see everything in street through from an open window; but why is it difficult to recognize something from street something in a room even with open window?
VII.9. May one read a book under the light of a full Moon?
VII.10. Why do we see no stars in day-time?
VII.11. Why are less bright the stars near the horizon?
VII.12. Will one can see the reflection of the Sun in the bottom of a deep pit or well?
VII.13. A fork is lighted by a candle and produces a shadow on a wall. When the fork is in the vertical position, the shadow clearly reproduces the form of its teeth; but if you hold it horizontally, the shadow is blurred and teeth are not sharply visible. What is the cause for it?
VII.14. In surgical operations, the shadow of surgeon's hands might cover the operational field. How to avoid this obstacle?
VII.15. For most workers, why is it difficult to work in rooms with a diffused light?
VII.16. Shadows of telegraph poles are longer in morning and evening light. Whether the length of horizontal wires changes within a day?

Reflection of Light

VII.17. A laser is known to produce narrow beams of light with a high density of energy. But, in practice, the expensive production makes difficult their wide application. So, let us propose a more cheap way for obtaining such beams. Let light rays of a powerful projector fall into the wide bottom of a conic tube, its interior surface being polished and silver-coated (see in Fig. VII.1). After a series of reflections, the beams will get out from the right hole which can be made arbitrarily small. By means of this device, can one obtain a large concentration of energy in the light beam flowing from the output hole?

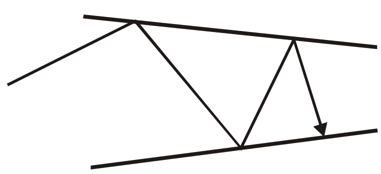


Fig. VII.1.

VII.18. In the plane of a mirror one can see the flame of a candle. What will happen if we put between the candle and the mirror a flat-parallel glass plate?
VII.19. A man stands in front of a mirror with one his eye closed. He covers the image of the closed eye on the mirror with a piece of sticking paper. What will he see when he opens the closed eye and closes that which was open before?
VII.20. In order to see his/her face better in a mirror, how must one place a lamp near a mirror?
VII.21. More closely to a mirror stands a man, the greater part of a street might be seen in the mirror. But if in a mirror vertically hung on a wall he sees his reflection only from knees to head, no attempts to draw himself closer to mirror will give a result which were essentially better. Explain what happens.
VII.22. What will you see in looking into the two mirrors placed at a direct angle to each other?

VII.23. If the surface of water has waves, why do the images of things turn very strange by their form?
VII.24. In looking through an window of a tram or bus in evening, one can see a vertical train around bright sources of light (e.g., street illumination lights) on window's glass. Explain the origin of this train.
VII.25. Why is not cinema screen made of mirror?
VII.26. Why do they use to hang lampshades over lamps?
VII.27. Why does the end of a finger not coincide with its reflection in a mirror? In what mirrors will this phenomenon take no place?
VII.28. What is that round mirror which physicians, specialized in the otolaryngology, use to wear on their foreheads? What does the hole at the center of such a mirror serve for?
VII.29. For one could see his/her reflection in a flat mirror, the height of the mirror should be at least one half his/her height. Prove it.
VII.30. Why are so clearly seen the pictures drawn over a misted glass?
VII.31. Sunny summer days, the asphalt road seems to have a bright mirror if one looks far ahead. Why?
VII.32. Why do shoes shine when well polished?
VII.33. If one stands on a bridge, the fish in water is better visible than from a low shore. Explain the reasons.
VII.34. Why is it better to recognize both submarines and shoals of fish from an airplane or a helicopter?
VII.35. If one looks down from an airplane flying over a sea, the water beneath the airplane seems to be darker than near the horizon. Why?
VII.36. In testing one's vision, an ophthalmologist usually propose to read aloud the characters on a special table posed at 5 meters away from your eyes. What should the ophthalmologist do if the size of his cabinet is less than this distance and he has no other table?
VII.37. If one draw almost close to a mirror a small flat dark object, three images of this flat dark object will appear in the mirror. In practice, the second and third images will not be so clear, as the first one is. Why does it occurs?
VII.38. Why do they use to paint in black color the side of a propeller which is visible to a pilot?
VII.39. Why do special metal-coated (covered by a thin layer of tin foil) suits of the steel-makers protect them against strong hot?
VII.40. In day-time, why do the windows seem so dark from a street?
VII.41. Why are the images of things and people in a metal pot so reduced?
VII.42. How is a lamp of a car headlight situated with respect to its concave mirror?

Refraction of Light

VII.43. If one wears a diving mask, why does he see much better all things under water?
VII.44. In many optical devices the prisms with a right triangle in their bottom are used. What are the objectives for applying these prisms?
VII.45. Why are the glasses of headlights made not smooth, but fluted as being composed of three-face prisms?
VII.46. In what case does the angle of incidence equal the angle of refraction?
VII.47. There are animals (for instance, feather-moustache midge), which are invisible in the water due to their transparency. But these animals possess eyes which are well visible as black points. Why are these animals invisible in the water? Why are their eyes non-transparent? Will they remain invisible in the air?
VII.48. How can you explain the blinking of starts?
VII.49. Religious people assert that only in the Easter day the Sun rising in this morning «plays» (the disk of Sun oscillates changing its form and color). How can you explain the variation of the disk of a rising Sun?
VII.50. How would change the positions of stars on the sky if the Earth's atmosphere had suddenly disappeared?
VII.51. Why do the Sun and the Moon seem both oval near the horizon?
VII.52. Why is the true length of a day is slightly greater than that evaluated by the astronomic calculations?
VII.53. What must be the refraction coefficient of a medium, on whose boundary one could observe

the complete reflection of a ray of light arrived from the vacuum?
VII.54. Why does the water lose its transparency when is in the form of a fog or a cloud?
VII.55. Why is the ice transparent, but snow is white?
VII.56. Why does a color glass seem almost white if ground into a fine powder? How can you know again the color of the glass?
VII.57. It is well-known that the fur of a white bear consists of transparent hollow hairs. Then why is a white bear white?
VII.58. If we cover a draw with a dull glass with its dull side downward, the lines of the draw will be rather visible. But if now we put the dull glass with its glance side downward, the draw will be hardly seen or seen in a blur. Why?
VII.59. Why are a paper, a soil, a wood, and a towel seem more dark if wet?
VII.60. Why does an oiled paper become transparent?
VII.61. If one mix the water with an eau-de-cologne, why does the mixture become a milky liquid, though both its components were transparent?

Lens. Simplest Optical Devices

VII.62. Why do children call a magnifying lens «the firing glass»?
VII.63. How can one distinguish by his/her fingers a converging lens from a diverging one?
VII.64. May you distinguish a converging lens and a diverging lens by simply sighting through it?
VII.65. Is always a concavo-concave lens diverges, and a convexo-convex lens converges?
VII.66. Falling on a large convex lens, the sun rays join in a focus, which are visible due to specks flying in the air. If we put a screen not in the proper focus, but either more close to the glass, or a bit distantly from it, we shall see a small bright white pot bounded by a think band which is blue in the first case and red in the second case. Explain the phenomenon.
VII.67. Describe qualitatively the dependence of the pressure of a light upon a lens on the distance between the lens and the light source, which is at the optical axis of the lens. Assume that the part of reflect light is neglectibly small.
VII.68. Given two spherical retorts filled one with water other with alcohol, how can one distinguish theese liquids by directing sunlight on them?
VII.69. A semi-sphere is made of a transparent material with the index of refraction $n=\sqrt{3/2}$. A parallel beam of light falls upon this semi-sphere (see Fig. VII.2). The plane bounding the semi-sphere from the left, is closed by a diaphragm except for a small circular hole around the principal optical axis and a thin ring-shaped slot. The angle α_0 is equal to $\pi/4$, the radius of the spherical surface R is 10cm. First the ring-shaped slot was closed and a shield was placed so on it a point arises. The central hole was then closed and the ring-shaped slot was opened. What shall we see on the screen? The answer must be supported by evaluations and a draw of the path of rays. Diffraction may be omitted.

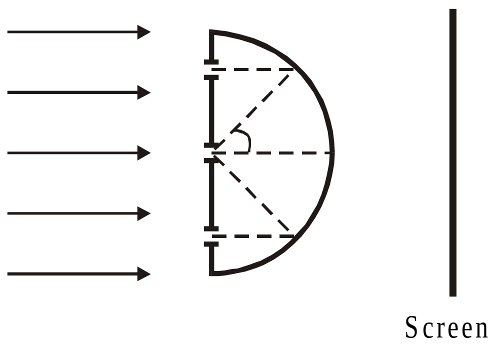


Fig. VII.2

VII.70. A candle is drawn from a long distance x to a position almost close to a converging lens. How will the image of the candle move in this case? Compare the velocities of displacements for both the candle and its image.
VII.71. A photographer saw how a fly sat on the lens of his camera. Will appear the fly's image on the shot?
VII.72. Under exploitation of a photographic camera, some scratches appear on the surface of its lens, which worsens the resolvability of the camera. To restore the resolvability of the lenses, these scratched may be filled with black Indian ink. Explain the physical principles which allow to restore the quality of shots in this way.
VII.73. It is required to place two converging lenses so that parallel rays after passing these lenses remain parallel. How can you do it?
VII.74. A telescopic system consists of two lenses with a distance between them equaling the sum of their focal lengths. Coming from far stars, a parallel beam of their light passes through lenses and the image of stars is obtained at the focal plane of the lenses. This image serves as a target for

an ocular, which is left by rays which are again parallel. Thus they cannot make an image. Therefore, astronomers must not see images. But how then do they see stars?
VII.75. In a receipt written by a physician it is written: spectacles, +1.5D. Decode: what spectacles? For what eyes?
VII.76. How will the focal length of a lens change if its temperature grows?
VII.77. Whether any converging lens may serve as a magnifying glass?
VII.78. Why do they use long-focus lenses in the telescopes and short-focus lenses in the microscopes? Why do telescopes need lenses of possibly large diameter, while it suffices to use very small lenses for microscopes?
VII.79. Why do they use relatively short-focus lenses for photographic cameras?
VII.80. Lenses of a modern photographic camera is a combination of 8 to 10 and even more separate lenses. What is the aim of collecting so many separate lenses?
VII.81. If one looks on rails toward to the horizon, they seem to converge to a point. Explain the situation.
VII.82. Consider the path of light rays and prove that a projector is a photographic camera but with the inverse path of the rays.
VII.83. How does the function of lenses' diaphragm affect the image?
VII.84. Explain: why does a shortsighted man squint his eyes to obtain a sharper vision of an object?
VII.85. In considering a spore of a mushroom in a microscope, a biologist determined that the diameter of its image d equals 1.2cm. What is the real diameter of the spore if the objective lenses magnify 100 times and the ocular makes the 6-times magnification?
VII.86. Invent a way to obtain a fire by means of ... ice!
VII.87. To make models of optic devices one must select appropriate lenses. How can one do it if, in addition to a set of lenses, he has a screen and a straightedge with ruler?
VII.88. What are spectacles for a man with normal vision?
VII.89. Whatever were a telescope one could construct, the stars will remain only some points of light due to the huge distance from us to them. Then why do men tend to construct large telescopes?
VII.90. A grain of a metal is coincided with the image of a point light source by a converging lens. When the source stands at the distance a_1 away from the lens, the grain is heated by Δt_1 degrees each second. What will be the value Δt_2 of the degrees of heating if we put the same light source at a longer distance a_2? Both the distances a_1 and a_2 are assumed to be much greater than both the double focal length of lens and the diameter of the objective.

Features of Eye

VII.91. What is the physical interpretation of the phrase «Stars went out from his eyes»?
VII.92. Why do they often make to blink light signals (for example, in lighthouse)?
VII.93. Why does a quickly moved glowing object (for instance, a glowing cigarette) make a trace (or train) in its motion?
VII.94. Why do we see a rain as jets, though it consists of drops?
VII.95. In a thunderstorm night, in the flashes of lightning we see moving objects as is they were still. Why?
VII.96. In a fog, a lamp on a pole seems to be hung higher than usually. How will you explain it?
VII.97. A incandescent filament of a lamp seems more thick than the same in «cold state». Why?
VII.98. A source of light seems at nights more close than indeed it is. Why?
If you press slightly by a finger upon a corner of your eye, you may see double images of surrounding things. Why?
VII.99. Why do drivers switch off far headlights and leave only half-lights when another car approximates?
VII.100. Explain the reason for welders' wearing dark glasses in their work.
VII.101. Take a brightly colored book from your book-shelf, for instance that of red color. If it has big letters, look at a point where two lines intersect. If the book has no letters, make a small sharp sign on its colored surface. Keep your head without moving and stare at this point without an interruption for a half-minute. Then quickly pass your sight to a large white surface. Seemingly, you ought to see a clean white surface; by in practice you would see the image of your book, but in other colors. Explain why does it happen.
VII.102. Why does a the whole chain of street illumination lights seem equally bright along all its

length?
VII.104. Explain why do Russians call a hare «skew-eyed»?
VII.105. Eyes of many insects have a cellular structure. Explain its meaning for insects.
VII.106. Why do horses rise up their heads when a man approximates?

Emission and Absorption of Light. Action of Light

VII.107. Why does an electrical lamp of power 100Wt burn so bright, while an electric stove of power 600Wt gives almost no light?

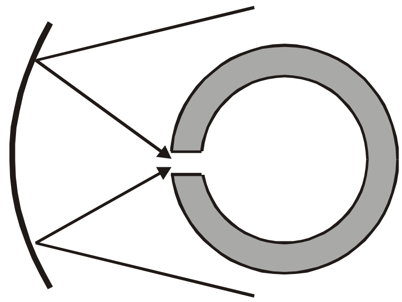


Fig. VII.3.

VII.108. Let us focus by means of a concave mirror (see in Fig. VII.3) the sunlight rays into a small hole of a closed cavity with the walls not conducting the heat. By increasing the size of the mirror, we can succeed in collecting more and more energy and therefore the energy inside the cavity will permanently grow. However, in practice, above a definite size of the mirror, the temperature will cease its growth. Explain why.

VII.109. In the Dewar vessel, the thermal isolation is achieved by producing the vacuum between two walls of a container (see in Fig. VII.4). **1**. Evaluate the losses of heat within a time unit for a cylindrical container of the height 30cm an with the diameter 10cm. It is assumed that the emission capability of the container is 10%, the temperature inside the container is 100°C and 20°C outside the container. The distance between the walls of container is small. **2**. What times will change the losses of heat if we introduce an additional wall between the two given? Note: The blackbody either radiates from or absorbs onto a unit of the area of its surface within a unit of time the quantity of the heat which can be evaluated by the Stefan-Boltzmann law: $W=\sigma T^4$, where s is the Stefan-Boltzmann constant ($\sigma=5{,}67\times10^{-8}$Wt/m^{2}K^4) and T is the absolute temperature. The radiation ability of a bogy shows which part of the energy radiated by the blackbody is radiated or absorbed by the given body.

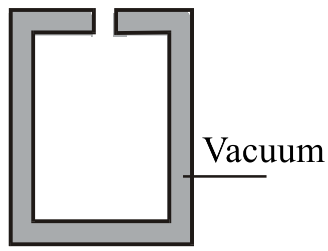


Fig. VII.4.

VII.110. Estimate the energy lost in the unit of time by a man due to radiation if the temperature of ambient were 1K.
VII.111. Two concave mirrors are placed in a room, facing each other. If at the focus of one mirror we set a cooled body and put a thermometer at the focus of another mirror, then the thermometer will show a decrease of the temperature. Why?
VII.112. Which soils are better heated by the Sun and quicker return the energy by radiation: black soils or podzol soils?
VII.113. In a clear summer day, the greater hot is felt not by the noon, but somewhere afternoon. Why?
VII.114. Which of the snows will melt quicker: clean snow or dirty snow?
VII.115. Under equal other conditions, which pot will boil earlier: a clean one or one covered with smoke?
VII.116. The length of the wave of the red light in the water is equal to the length of the green light in the air. The water is illuminated by the red light. What color will a diver see under water if he opens his eyes?
VII.117. On photographs of locations, made from an airplane, one can clearly see military disguises made to produce imagination of green threes and grass, which might be hardly guessed within a direct recognition. What must be the specific feature of the photographic equipment on airplane board, making possible to obtain these shots?
VII.118. Why is the flame of an electric arc is not harmful for human vision if the arc burns in the water?
VII.119. A red kerchief was illuminated by a blue light. What will be the color of the kerchief for an observer?

VII.120. Why do artists paint their masterpieces only in daylight?
VII.121. In evening, why is it difficult to know what will be a color of a tissue in daylight?
VII.122. To protect the health against the sunlight, both white and red umbrellas more practical. Why?
VII.123. A red glass and a green glass are put together. Which rays pass through this pair of glasses?
VII.124. In observing through a spectroscope the Sun's crown at Sun eclipse, the dark lines in the spectrum are not visible and some color lines start to occupy their places. Why?
VII.125. Observations of a spark which jumps between electrodes made of unknown metals allows to determine the chemical composition of these metals. In what way?
VII.126. Whether the infrared rays pass well through a glass? What is the meaning of the use of glass in building?
VII.127. Whether ultraviolet rays pass well through a glass? Is the role of this feature of the glass is positive or negative? Why?
VII.128. One may notice that a pigment in clothes is fading mostly due to the rays which are additional to the color of the pigment. How would you explain it?
VII.129. In order for a linen to seem whiter, why do in washing they color blue the linen?
VII.130. Why do they add into a mixture of water and chalk for painting the ceiling a bit of blue pigment?
VII.131. An electron beam in a TV tube produces the light by striking its fluorescent layer at a certain point. What is a negative consequence of this glow?
VII.132. For X-raying a human body they use a soft radiation, while for X-raying metals they apply hard radiation. Explain: what is the qualitative and quantitative differences between these rays?

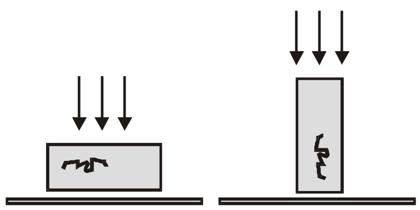


Fig. VII.5.

VII.133. In Fig. VII.5 you may see a scheme for X-raying metallic products in order to verify their quality and find possible cavities. How do they do it? Why do they apply double or even triple X-raying?
VII.134. A great Russian scientist K.A. Timiryazev said: «The food is the source of forces in our organism only because it is nothing else but a concentrate of the sunlight... A man has the right to call himself the son of the Sun» («Life of Plants» by K. Timiryazev). How can you explain these words?
VII.135. Why do they usually develop photographic films, plates, and paper in a dark room or under a weak red light?

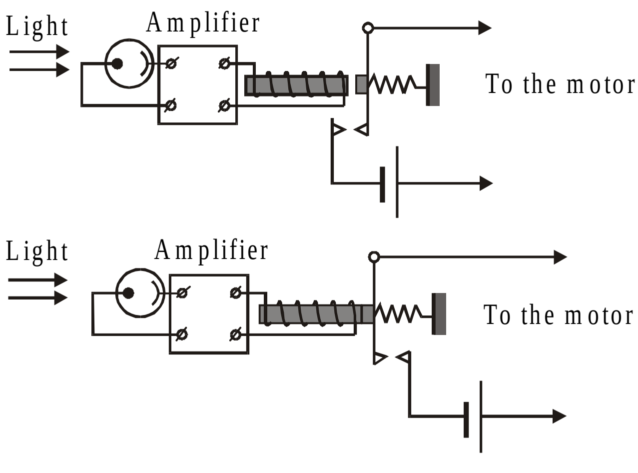


Fig. VII.6.

VII.136. Why do red subjects appear black in b/w photographs?
VII.137. Can you photograph subjects in a completely dark room?
VII.138. In Fig. VII.6 you may see simplified schemes of photo-relays, which alert: a) if a light hits a photocell; b) if a light ray permanently falling upon a photocell, is ceased. Explain the functioning of these schemes.
VII.139. Among the schemes shown in Fig. VII.6, which one can serve for the purposes: a) to open gates by headlights; b) to count production on a fabric transporting line?
VII.140. Given two surfaces: black and white; which one will be subject to a greater pressure produced by the same light source?
VII.141. Why is it easier to observe the photo-effect upon the alkaline metals, e.g., on the cesium?
VII.142. By means of a thermovisor (a device for scanning differently heated objects), one can distinguish different bodies which are heated (even slightly), independently on whether they are illuminated or are in a complete darkness. What is a physical phenomenon applied in this device?
VII.143. The brightness of the glow of overheated objects is determined by their temperature. Then why does a piece of metal glow brightly, but not a piece of a glass with the same temperature?
VII.144. How can workers in workshops, where metals are treated by heat, estimate the temperature of the detail to be hardened by simple observing the process of the heating through a hole in an

electric furnace?
VII.145. Why do they introduce into observation windows of blast furnaces not the usual glass but the quartz one? What are the features to be possessed by this glass?
VII.146. A simplest hotbed is a firmly hammered wooden box, to which a soil is put. The upper face of the box is made of the glass. Sunlight equally heat both the hotbed and the ground around it. However, the temperature in the hotbed is essentially higher than on the ground. Where is the additional heat being taken from?
VII.147. Who is more heated under the sunlight: a man already bronzed, or a man with a whiter skin?

Scattering of Light Waves

VII.148. It is known that the sunrise is red, while the sky is blue. Basing on this information, explain which rays, red or blue, are more scattered in the atmosphere.
VII.149. Why do spectacles with a bluish color enable a better vision in a light fog?
VII.150. The flame of a candle viewed through a mist, seems to be red. How will you explain it?
VII.151. Why are both the balloons of divers and the «black-boxes» of airplanes painted in bright-orange colors?
VII.152. Why do we see the Sun red in sunrise?
VII.153. Why does the forest near the horizon seem to be rather covered with a bluish fog than green?
VII.154. Why do we see the water deep-blue in an open sea, while it seems greenish on shallow places?
VII.155. Why did the astronauts see on the Moon not a blue sky, but black?
VII.156. On photographs made in the infrared rays, in contrast to the situation in visible spectrum all the objects are clearly viewed till the horizon. How can you explain it?

Dispersion of Light

VII.157. After rain, sometimes we see a rainbow. Why «after» and in a sunny weather?
VII.158. Explain the arc shape of a rainbow.
VII.159. Can one observe a rainbow in the noon of a summer day in Moscow? In Tokyo?
VII.160. When a rainbow is higher: at 16 p.m. or at 17 p.m.?
VII.161. Standing at one of rainbow's ends, may one see the proper rainbow?
VII.162. In what part of the sky can one see a rainbow in early morning?
VII.163. Refracting in a brilliant, why does the light give more sharp colors than in a strass (a glass imitation of a brilliant) of the same form?

Interference and Diffraction of Light Waves

VII.164. In blowing a bubble and observing it in a reflected light, one can note that its surface is colored. Explain the phenomenon.
VII.165. If a drop of kerosene falls on asphalt surface, the trace dot appears to be colored in different colors. Explain the observation.
VII.166. In heating, the objects made of steel are usually covered by a visible color film. To see this, take a used razor blade and heat it over a burning match. Then delete the smoke and consider the film appeared on its surface. Explain the phenomenon observed.
VII.167. What does explain the visible coloring of the wings of dragonflies, beets, and some other insects?
VII.168. If we cover the surface of an optical glass by a transparent film, whose index of refraction is less than that of the glass, with a thickness $\lambda/4 \approx 137.5$nm (here λ is the length of the wave of falling light), then the glass surface will not practically reflect the light, it will almost all pass through the glass. This method is called «lightening». Explain the reasons for lightening the lenses of modern optical devices.
VII.169. To lighten a lens (see the previous problem), it must be coated with a film whose index of

refraction should be $n = \sqrt{n_g}$ (here n_g is the index of refraction for the glass). Why? What will happen if this condition is violated?

VII.170. In a reflected light, the lenses of modern optical devices seem to be colored? Explain this coloring.

VII.171. With what factor can you explain the rainbow colors of the compact disks for CD-ROM?

VII.172. To produce artificial mother-of-pearl buttons they make on the surface of buttons a very fine hatch. After this operation, why do the buttons seem to be made of mother-of-pearl?

VII.173. What does determine the limit to which one may close the diaphragm of a photographic camera?

VII.174. Whether a steel ball can be used as a lens to get a photo-shot?

VII.175. How can one determine the size of cells in feather by looking through it in front of the sunlight?

VII.176. If you look on the light of a far lamp through a thin tissue, you may see a set of clear dots set in a definite order. If you stretch the tissue or place it at a certain angle to the light source, these dots change their position. Explain why.

VII.177. In frosty foggy days and at nights one can see concentric bright colored rings around the Sun, the Moon, and even street illumination lights. How can you explain their nature?

Chapter VIII

Basements of The Atomic and Subatomic Physics

VIII.1. What is the difference between atoms of the filament of a burning electric lamp and the atoms of the same filament but if the lamp is in a cold state?
VIII.2. Now the dreams of alchemists, who wanted to transform the mercury into the gold, may be fulfilled. Explain how can it be made?
VIII.3. Is it possible to replace X-rays used in metallurgy for X-raying metals with the gamma-rays emitted by a certain artificial radioactive substance?
VIII.4. Why may the bombings of the uranium nuclei by slow neutrons give even greater effect than that by quick neutrons?
VIII.5. In a piece of uranium, a single neutron may initiate the chain reaction producing huge amounts of energy. How can arise a neutron in this piece? Where might it come from?
VIII.6. Why does the natural uranium fail to be an atomic fuel and why is its storage not related to a danger of explosion?

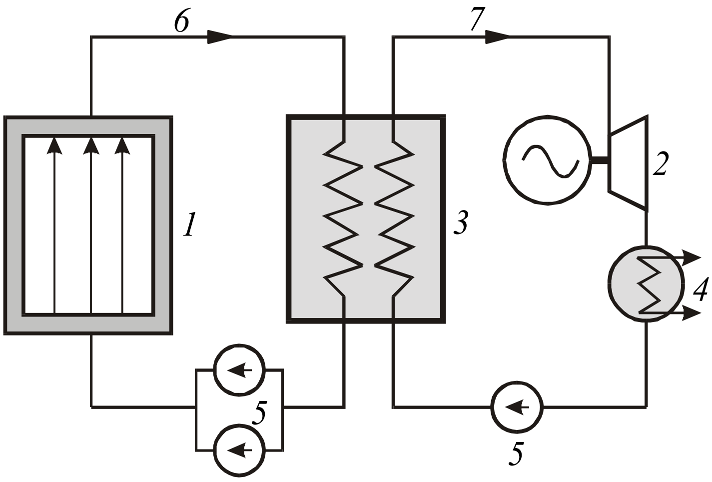


Fig. VIII.1 The scheme of the atomic power station: 1- reactor, 2 - turbogenerator, 3- heat-exchanger, 4- condensor, 5-the pumps, 6- the first pipeline (for water), 7- the second pipeline.

VIII.7. In Fig. VIII.1 the principal scheme of one of the first atomic power stations of USSR Academy of Sciences is given. Explain this scheme.
VIII.8. Immediately after the experimental discovery of neutrons, D.D. Ivanenko and W. Heisenberg suggested the proton-neutron model of the atomic nucleus. This model was confirmed by experiments with nuclear transformations. In following the proton-neutron model, the nuclei consist of the protons and neutrons. The quantity of protons in a nucleus equals the atomic number of the element Z in the periodic table by D. Mendeleyev, while the quantity of neutrons equals $N = A – Z$, where A is the mass number. No any other particles exist in the nuclei. However, in the radioactive beta decay, an electron flies out from the atom. What is it originated from?
VIII.9. As known, greater are the density of a medium, greater is the resistance it produces to a material particle moving in the medium. But why does a layer of lead weaken neutrons less than a layer of graphite of the same thickness?
VIII.10. What is an animal which reacts on a radioactive radiation?

Chapter IX

Basements of The Special Theory of Relativity

IX.1. A spacecraft flies near the Earth with the speed 0.8×c (where c is the light speed). Describe how will change the length of 1 meter bar which is slowly rotated from a position perpendicular to the motion of the spacecraft into a position parallel to its motion. Make it from a standpoint of a) a member of spacecraft team, b) an observer standing on the Earth.
IX.2. Imagine the following situation: a runner looks it himself into a mirror which he holds ahead on a stretched hand. Will he see himself in the mirror if he will run with a speed close to that of light? Consider this question within the frames of the special theory of relativity.
IX.3. Take a pole of the length 20m. Toward its length we give him a motion with a speed such that its length becomes equal to 10m with respect to the laboratory reference system. Then, at a certain moment, this pole may enter completely into a shed whose length is also 10m. But now let us consider the same in a reference system of a runner with a pole. For this runner, the shed turns to be half-shortened. Well. How might a 20m pole be placed into a 5m shed? Do not you see that this quite impossible conclusion shows that something is very strange and contradicting in the proper theory of relativity?

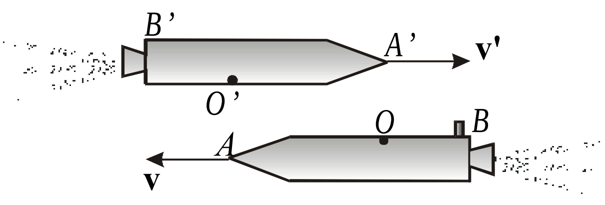


Fig. IX.1.

IX.4. Two rockets, possessing equal length in peace, fly toward one other with relativistic speeds **v** and **v’** going to pass near each other (see Fig. IX.1). An observer O has a fire-gun at the tail part of his rocket, the steam of the gun is directed

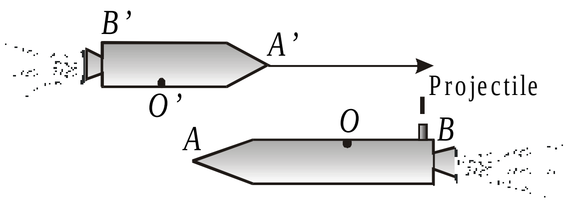


Fig. IX.2.

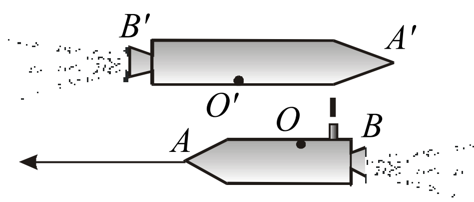


Fig. IX.3.

perpendicular to the motion of rockets. At the moment when the points A and $B’$ are drawn even with each other, he fires from his gun (see Fig. IX.2). In the reference system of O the passing rocket is subject to the Lorenz transformation, so the observer O waits that his projectile will hit the opposite rocket missile. But, in the reference system of other observer $O’$, the rocket of O seems to be Lorenz shortened. Therefore, at the moment of time when the points A and $B’$ are opposite, the observer sees a different picture as in Fig. IX.3. Will indeed hit the projectile the rocket or will it pass by it? Give a detailed answer, point out onto errors in the problem statement and the error in one of the diagrams.
IX.5. Let us suppose that the speed of light is infinitely large. What will happen with the predictions of the special theory of relativity with respect to the slowing time, shortening of length, and increase of mass in that case?
IX.6. A constant force is applied to a body with mass of rest m during an infinite time. How will change within the time the speed and the mass of the body?
IX.7. A incandescent to white-hot iron stick was cooled to a room temperature. Will change its mass?
IX.8. Are equal to each other the masses of a compressed and decompressed strings?
IX.9. Two spacecrafts start from the Earth in opposite directions with the speed 0.5×c with respect to the Earth. Questions are: a) what will be the speed of the first spacecraft with respect to the second spacecraft? b) what will be the speed of the second spacecraft with respect to the first spacecraft?
IX.10. A spacecraft starts from the Earth with the speed equaling 0,68×c. The second spacecraft starts from the firs one with the speed 0,86×c with respect to the first spacecraft. What is the speed

of the second spacecraft with respect to the Earth, if it starts: a) in the direction of the motion of the first spacecraft (which already moves); b) in the direction opposite to the direction of the first spacecraft (i.e., back top the Earth).

IX.11. Consider a simple problem concerning the electromagnetism. Assume that along a conductor with a current an electron flies toward the current's direction. The Ampere experiments show that the electron will certainly be attracted to the conductor. In the inertial reference system, where the electron moves with the charge $-e$ has a speed v different from zero, this attraction can be easily explained. The Lorenz force from the side of the magnet field of the conductor with the induction B acts on electron by the rule $F = evB$, being directed to the conductor. However, if we pass to the reference system related to the electron, this force becomes zero. We have arrived at an absurd result: the phenomenon depends on a reference system arbitrarily chosen by us?! Explain the matter.

Answers

Answers to Chapter I

I.2. The meeting point is the middle of the path. The speeds of the automobiles are 25km/h and 75km/h, respectively. The time of motion is 30min. and 10min., respectively.
I.3. We have that on *OA* a uniform motion takes place with the speed 30km/h, *AB* is a stop for 30 minutes, *BC* is a uniform motion in the contrary direction with the speed 20km/h.
I.4. a) 4 buses are on that route; b) 18km/h; c) 40 minutes.
I.7. Both the accelerations are directed similarly (to the North).
I.8. Traces are different.

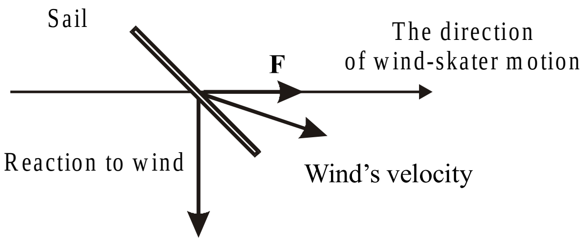


Fig. A.1.

I.9. The wind-skater can move only along the direction of skates. If with respect to the wind-skater the wind's velocity has a component perpendicular to the direction of the motion, then one can set the sail is that the force **F**, acting on the wind-skater would pull it forward (Fig. A1) thus the velocity of the wind-skater can exceed the speed of the wind.
I.10. They may differ. The necessary condition is only the equality (at stretched rope) of components (projections) of the velocities of both skateboat onto rope's direction.
I.11. This occurs because, first, you observed your motion with respect to a fast moving train, and, secondly, after the train has passed, you observed you motion with respect to static landscape around the railroad.
I.12. With respect to a bus, the drops participate in a complex motion in two directions: downward and toward the bus's motion. Touching in their motion the glass of bus's window, the drops make traces. Their slope depends on both the bus's speed and the size of drops. Drops of different weight fall with different velocities (we did not consider the wind).
I.13. a) yes; b) it will fall back to the place of threw; c) it falls in front of the place of threw; d) a parabola.
I.15. Vertically upward.
I.17. The load will fall behind of the airplane.
I.20. Up to the value of free fall acceleration.
I.21. In the first case, we deal with a motion with a constant acceleration, while, in the second case, the motion varies (namely, it grows because in approaching the magnet the force of the attraction by the magnet grows).
I.22. The lower part of the track is steady with respect to the ground, therefore it moves backward with respect to the tractor with the speed 9km/h. Consequently, the upper part of the track will move forward with respect to the tractor with the same velocity. Thus, as concerns its velocity with respect to the ground, the upper part of the track has the speed 18km/h.
I.23. The upper points of the wheel moves with a speed which exceed the speed of the bicycle (see the previous problem). Therefore the particle of mud, which fly away from the upper part of the wheel, certainly can overtake the cyclist.
I.24. The point of the wheel, touching the rail, has the zero velocity. The points of wheel's frange, which are below the rail, move into the direction opposite to the car's motion.
I.26. The body revolves about a point which lies on the intersection of the straight line *AB* the straight line passing through the ends of the vectors $\mathbf{v}_A$ and $\mathbf{v}_B$.
I.27. The difference is two days.
I.28. When the cylinder moves without slipping over a horizontal plane, its generatrix is tangent to the plane is fixed at the moment of touching; the proper cylinder is revolve around this fixed straight line. Therefore the point tangent to the plank moves with the speed which is twice greater than the speed of the cylinder's axis. Within the time while the boy pushes the plank passes a path *l*, the cylinder passes the distance *l*/2. Thus, to reach the cylinder, the boy must pass the distance 2*l*.
I.29. Four laps. In general, if the ratio of the number of teeth of large gear to the number of teeth of small gear equals *N*, in revolving around the large gear the small one makes (*N*+1) laps (rotation) about its axis.

I.31. Usually, the carrier is above the satellite thus has less period of revolution.

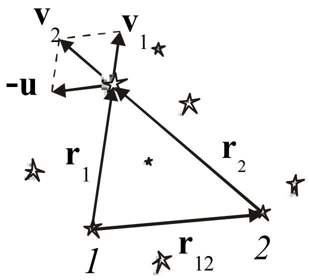


Fig. A.2.

I.33. The velocity $\mathbf{v}_2$ of any of the stars in the reference system related to the star *2* equals $\mathbf{v}_2 = \mathbf{v}_1 - \mathbf{u}$, where $\mathbf{v}_1$ is the velocity of this star in a reference system related to the star *1*, while $\mathbf{u}$ is the velocity of the second star with respect to the first star (see in Fig. A.2). Since these velocities are proportional to the corresponding radius-vectors, i.e., $\mathbf{v}_1 = \alpha\mathbf{r}_1$ and $\mathbf{u} = \alpha\mathbf{r}_{12}$, we have $\mathbf{v}_2 = \alpha\mathbf{r}_1 - \alpha\mathbf{r}_{12} = \alpha\mathbf{r}_2$. The latter means that being near the star *2*, the cosmonauts will se the same picture of stars'motion, as if they were near the star *1*, because all the stars are going out with the velocities proportional to the distance to thee stars..
I.34. In the direction of the train motion.
I.35. It will forward; turn to the right; sharply move forward.
I.37. Keeping the pen in hand, easily strike by hand on the edge of a table, on which a blotting paper has been put. At this sharp stop, the drop of ink will fly out from the end of the pen.
I.39. In the medical thermometer the basic reservoir of the mercury (at the end of the thermometer) the capillary with a scale are connected through an even thinner capillary. After a measurement of the temperature, the column if the mercury is fixed due to a breakup in the narrow capillary (the mercury cannot sop there the glass walls). When one shakes the thermometer, the mercury returns back into basic reservoir due to the inertia of its motion. However, the breakup in the narrow capillary quickly restores.
I.40. Usually, an axe is settled upon a handle by striking the handle on a heavy thing or by hammering upon the end of the handle. In the first of cases, they use the inertia of a moving heavy axe; in the second case, they apply the inertia of a resting axe. So, in both the cases, they do use axe's inertia.
I.41. The rod possesses a greater inertia.
I.42. The mass of a cosmonaut the mass of the station are very different. Therefore so do the changes of the velocities of both subjects. Note that these velocities are inversely proportional to the masses.
I.43. It is required to change constantly both the direction the value of the velocity, thus overcoming the inertia of the body.
I.44. To change the direction of a motion, a force is necessary. The interaction between hands and a tree or a pole gives this force.
I.45. A small force **F** imparts large components $\mathbf{T}_1$ and $\mathbf{T}_2$ of the force **T**, which puts the cord in equilibrium (see in Fig. A.3). The breakup of the cord occurs under the stretching forces $\mathbf{T}_1$ and $\mathbf{T}_2$.

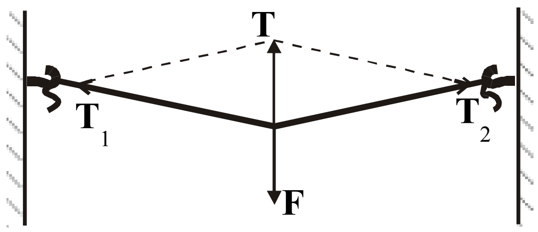


Fig. A.3.

I.46. For the cable, this method allows to ensure a greater freedom for displacements of both ships without varying drastically the stretching forces stipulated by the storm's waves.
I.48. The arms must be vertical (i.e., at the distance of shoulders).
I.49. No, cannot. Any rope possesses a mass, which generates the sagging due to gravitation.
I.50. When they are almost horizontal.
I.51. The suitcase can be weight, for example, in the following Take a rope, bound it to the suitcase, tie one end to a tree, put over under the handle of the suitcase, then tie to the balance. The balance will show the half of the suitcase's weight.
I.52. No.
I.53. Under a lesser slope the pressure will be greater.
I.55. The force equaling the half of the man's weight.
I.56. To decrease the force of a jerk in hooking a fish.
I.57. The required force for a parallel joining is $2F$, it is F for a consecutive connection of the springs.

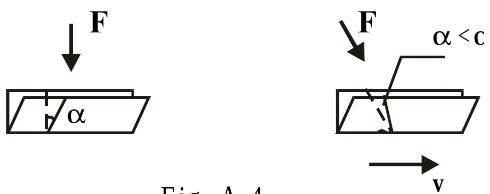


Fig. A.4.

I.58. If the overload pressure inside a sausage equals p, then for a unit of length in cross direction we have the force $F_1 = p{\cdot}S/2\pi R = p{\cdot}R/2$, where R and S are the radius and the section of a sausage, respectively. But along the sausage of the length l, for a unit of area we have the force $F_2 = \pi{\cdot}l{\cdot}2R/(2l+4R) \approx p{\cdot}R$. The force F_2 is almost twice greater than F_1.
I.59. In a move of a knife, its "cutting section" (see Fig. A.4) is not the section perpendicular to the

cutting edge (as in the case where we vertically press upon the knife), but a skew section which makes an angle with the perpendicular section. This angle grows as the speed of our movements grows. Thus, this “section” is “sharper” .

I.60. After repulsing the raft out of shore, one must determine the initial velocity of the motion of raft. To this end it suffices to measure the distance which will be passed b the raft within the first second. Knowing the mass of the raft, one can evaluate the initial impulse. By calculation of the time of raft’s motion, one can determine the resistance force.

I.62. 45^o and, practically, 90^o, respectively.

I.63. Though the pressure in the steam of gun exceeds the pressure of gases of a jet engine, the rocket in launching obtains a greater impulse because the action of the jet is longer. As for a projectile, having obtained the initial velocity of order 10km/s, it loses this speed due to the air resistance.

I.64. In the interaction between the human body over which a massive anvil is placed (whose mass is greater than that of a man), the summary mass (human body + anvil) obtains a small acceleration. Therefore, the small displacement of the anvil is not dangerous for a man.

I.66. The tracking force of the locomotive is balanced by the friction force.

I.67. First, we have a uniform motion; therefore the resultant force equals zero. Then the body obtains an acceleration; therefore the resultant force differs from zero. After attaining a certain velocity, a uniform motion takes place, which means that the resultant force is again zero since all the forces acting upon the body are in equilibrium.

I.68. The forces of resistance, which give to the skater a negative acceleration (deceleration) are thus increased.

I.69. The traction force is not sufficient to put into motion the whole train. If, before the motion, all links between the train’s cars were stressed, a breakup may occur more close to the locomotive because here the stress of links has a greater value.

I.71. Within the time Δt a piece of snake of the length $\Delta l = v{\cdot}\Delta t$ is involved into motion obtains the impulse $mv\Delta t{\cdot}v/l$. Therefore the force of the pressure produced by the snake upon the ground in greater than its weight by the quantity $F = mv^2/l$.

I.72. The force of ball’s stroke depends on the time in which its velocity decreases to zero. So, if one touches the ball by hand moves the hand in the direction of ball’s flight with a deceleration, the ball’s stroke may be weakened.

I.73. It is necessary to decrease the velocity at possible large path. Then the acceleration will be smaller so will be the force which gives to the body a negative acceleration generating the termination of the motion.

I.79. The center of gravity of the system will move with the free fall acceleration. Till the string is expanded, the body *À* will fall with a greater acceleration and the body *Â* with a lesser acceleration than that of free fall. After compression of the string, the picture is inverse.

I.80. After a sufficiently large time, the balls will fall with same constant speed, the heavier one being above. The second Newton law, rewritten for each ball in its projection onto the axis of motion, gives us: $m_2g–T–F = 0$, $m_1g+T–F = 0$, where T is the force of line’s stretch, F is the force of the air resistance acting on each of the balls. Hence $T = (m_2–m_1)g/2$.

I.81. One needs a certain time to open the parachute and transform a uniform accelerated motion into a uniform motion without acceleration. Within this time the parachutist goes a very long distance.

I.82. No. The motion in a resisting medium is not a free fall.

I.83. By directing a projectile into higher layers of the atmosphere where the resistance of air turns small the horizontal component of the velocity changes less, results in the greater range of the projectile’s flight.

I.84. When a bullet passes through a box with water, the resistance force is $F_r = \alpha_1 v$, while to penetrate through a box with honey there is required the force $F_r = \alpha_2 v$. Assume that the water is first is water. In bullet’s passing through a thin layer of water, we may assume that the resistance is constant equal to its mean value. By splitting the path into small pieces, we have that in passing through an n-th interval, the bullet’s impulse decreases by the quantity:

$$\Delta(mv)_n = F_r \cdot \Delta t = \alpha_1 \cdot \frac{v_n + v_{n-1}}{2} \cdot \frac{\Delta x_n}{\frac{v_n + v_{n-1}}{2}} = \alpha_1 \cdot \Delta x_n,$$

where Δx_n is the length of an interval passed through within the time Δt. In passing through the whole box, the impulse with change for the quantity $\Delta(mv)_w = \sum_n \alpha_1 \Delta x_n = \alpha_1 l$, where l is the length of the box. In a similar way, we can find that in passing through the box with honey the bullet's impulse reduces by the quantity $\Delta(mv)_h = \alpha_2 l$. The complete variation of the impulse equals $(\alpha_1+\alpha_2)l$. It does not depend on the order in which the boxes are passed. Therefore, the range of bullet's flight does not depend on the order in which the boxes are passed.

I.85. The loss in weight, which occurs in view of the fact that a part of sand is in the air, is compensated by the force with which other sand is strike the bottom of lower vessel.

I.86. In the beginning of cowing the pressure on the balance is less than the gravity. The balance shows a reduction of body's weight. At the end of cowing, the stress of man's muscles grows the man's body thus obtain an acceleration directed upwards. At this moment the balance will show a greater weight.

I.87. For the estimation we shall assume that the balls' collision takes place as follows: in the collision the touching parts of the balls are deformed compression waves moves in the balls with the speed of sound. These waves are reflected by ball's surface and come back. The balls "are diverged". Then the desired time is $\tau = 4R/v$, where R is the radius of balls, v is the speed of sound in the ball's material. For steel balls ($v = 6\times10^3$ m/s) with the radius 5cm, we have $\tau \approx 3{,}3\times10^{-5}$ s.

I.88. The time of the collision between the bullet and the door is very small, The deformation stipulated by bullet's pressure is not propagated for long distances. Therefore the impulse lost by the bullet is transferred upon a small area, thus the bullet makes a small hole in the door.

I.89. The output velocity of the bullet when it leaves the glass is less than that when it starts to penetrate the glass. Therefore the deformation generated by the pressure of the bullet is propagated upon a greater area.

I.90. A slanting basement of the dam allows to change water's velocity within a greater path, which decreases the destructive action of the water on the dam's body.

I.91. A note: take into account the friction forces acting between the bodies: carriage-ground and horse-ground.

I.92. By the third Newton's law, the springs are compressed in the same way.

I.93. Due to smallness of the friction force, the wheel practically makes no force upon the road in the horizontal direction. Consequently, there is no reaction from the road onto the wheel.

I.94. No.

I.95. The man the load will go up with the same speed.

I.96. When the whole flow of the air hits the sail, the boat stands at one place. If the flow of the air even partially passes near the sail, the boat moves in the opposite direction.

I.98. The range of the flight of a body thrown at a slope to the horizon is maximal at the angle 45°. If we are interested in the minimal speed with which the grasshopper should jump, it must be at 45° to the horizon. The law of impulse conservation gives us that within the jump of the grasshopper the straw will obtain the velocity

$$u = \frac{m}{M}\frac{v}{\sqrt{2}}.$$

Therefore the horizontal component of the grasshopper velocity with respect to the straw is

$$v' = \frac{v}{\sqrt{2}}\left(1 + \frac{m}{M}\right).$$

The time of grasshopper flight is. During this time it flies the distance l with respect to the straw. It means

$$\frac{v}{\sqrt{2}}\left(1 + \frac{m}{M}\right)\frac{v\sqrt{2}}{g} = l,$$

whence

$$v = \sqrt{\frac{M}{m+M}gl}.$$

I.98. No, the distance is greater in the first case.
I.99. That where the caretaker sleeps. Consider the carriage from which the snow is being thrown and assume that its velocity is v. If within the time Δt the mass of snow Δm has been fallen onto this carriage, then the velocity of the carriage v_1 can be found via the law of impulse conservation: $Mv = (M+\Delta m)v_1$, where M is the mass of this carriage with the mass of caretaker taken into account. If the caretaker throws the snow from his carriage, this does not change the velocity v_1. From the law of impulse conservation it is clear that $(M+\Delta m)v_1 = Mv_1+\Delta mv_1$. Thus, after the next portion of snow will have been fallen upon the carriage, the carriage's velocity will be v_2. Then, by the law of impulse conservation, we have: $Mv_1 = (M+\Delta m)v_2$, whence $v_2 = Mv_1/(M+\Delta m) = M^2v/(M+\Delta m)^2$. In throwing the snow, this velocity does not change. Obviously, after n-th portion of snow will have been fallen upon the carriage, its velocity will be $v_n = M^nv/(M+\Delta m)^n$. As for the carriage, where the caretaker sleeps, we have the following chain of equations: the velocity of the carriage u_1 after the first portion of snow can be found from the equation $Mv = (M+\Delta m)u_1$; after the second portion we have $(M+\Delta m)u_1 = (M+\Delta m+\Delta m)\times u_2$, whence $u_2 = (M+\Delta m)u_1/(M+\Delta m+\Delta m) = Mv/(M+2\Delta m)$ and so on. As a result, after n-th portion of snow we get: $u_n = Mv/(M+n\Delta m)$. Obvisouly, $u_n > v_n$. Evaluations cited above show that the snow when it falls upon a carriage changes it impulse as less as its mass is greater.
I.100. At the moment when the cork will be melted, the pan will move into the direction where it has the hole. Afterwards, it will sink as soon as will be filled with water.
I.101. Any rocket consists of a shell and the fuel contained in this shell. In launching the rocket, the fuel burns and turns into a gas of high pressure and high temperature. Due to its high pressure, the gas flows out from the nozzle of the rocket. By virtue of the impulse conservation law, the shell of the rocket moves in the opposite direction. The velocity of the flow of the gas is much greater than the velocity of the proper rocket. A heavy rocket moves up from the place of launching rather slowly, while the gases move away in the opposite direction very quickly. But the gravity center of the system remains fixed if the motion were in a vacuum.. In a real motion of a rocket one must take into account the motion of the air, its interaction with the Earth. In this situation, the position of the center-of-masses of the whole system (rocket-gases-Earth-atmosphere) does not change.
I.102. The velocity of the rocket depends on the mass of burned fuel which is thrown out within a unit of time (mass consumption)the velocity with which the combustion's products are thrown.
I.103. The velocity will increase. To understand this fact, consider the change of the impulse of the rocket in the reference system with respect to which the rocket is resting.
I.104. Both the complete reserve of fuel and the device for its exploration require to design a rocket with a greater mass. But as soon as the fuel is combusted, a part of this mass start to disturb the jet velocity of the useful part of the moving rocket system. In the case of a multistage rocket, the worked out parts are gradually divided from the principal part.
I.105. The meteorite's impulse is transferred to the air molecules and thus to the Earth.
I.106. When one fires from a simple gun, the expanding gases give impulses to both gun bullets, though directed oppositely. By virtue of the smaller mass of the bullet, it obtains the greater velocity. The flight of a rocket is possible as a result of interaction between the rocket and the gas worked out is thrown backwards. But, in the case of a hand launcher of anti-tank rockets, it represents a pipe, the gas does not give an impulse to the launcher. Therefore, in firing from this launcher, there is no return.
I.107. In turning on the braking engines for soft landing, a jet of gas is thrown along the direction of the spacecraft's motion thus reducing its velocity to zero.
I.108. When the bird will soar under the bell jar, the equilibrium will not be violated, because the bird will throw the air downward to in order keep itself on the air. The air thrown downward will create an additional force of pressure upon the bottom, its mean value equaling the weight of the bird. In the taking off, sharp motions, some oscillations of balance pointer about the equilibrium position may occur due to a change of this pressure.
I.111. The arm of the stress of wire with respect to the axis O (see Fig. A5) must be equal to zero.
I.112. In braking, a non-compensated moment of friction force about the braking wheels arises, thus tending to rotate automobile's body. This results in a lowering motion of the front part of the automobile. This lowering is compensated by the suspension device.

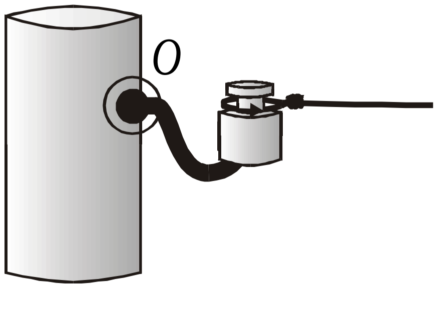


Fig. A.5.

I.113. The bicyclist must first apply the rare brake and only then the front brake to avoid falling caused by the rotating moment of the friction forces.
I.114. The thicker part of the rod has a greater weight.
I.115. Both the friction force and the applied force **F** constitute a pair of forces which results in a rotating-onward motion of the ring. In this situation, the point *À* at the beginning makes fading oscillations "to the right – to the left" with respect to the direction of the force **F**. After complete fading of this oscillations, the ring will move onward.
I.118. A rolling coin is gyroscope with its horizontal rotation axis tending to conserve its direction in the space as much as greater is the rotation speed.
I.119. The masses of balls are to be distributed not uniformly. The ball whose density grows from center to peripheral surface will roll down more slowly. In this case a greater goes for initiating the rotation of the ball. (The momentum of this ball is greater than that of ball possessing greater density in its center.)
I.120. The ball in which a greater part of the mass is concentrated near the center will roll down faster (see the previous problem). In our case it will be the aluminum ball (the density of the aluminum is less than that of the copper).
I.121. Bicycle gives an advantage in speed by a loss in the force. Greater is the diameter of a wheel, large is the gain in speed. Consequently, to move with the same speed the cyclist must press pedals with a greater force.
I.122. The point of support is in the rowlock, hands are the small arm, the resistance of water is the large arm. By using a row we gain in the force but lose in the path (our hands pass a path less that the end of the row).

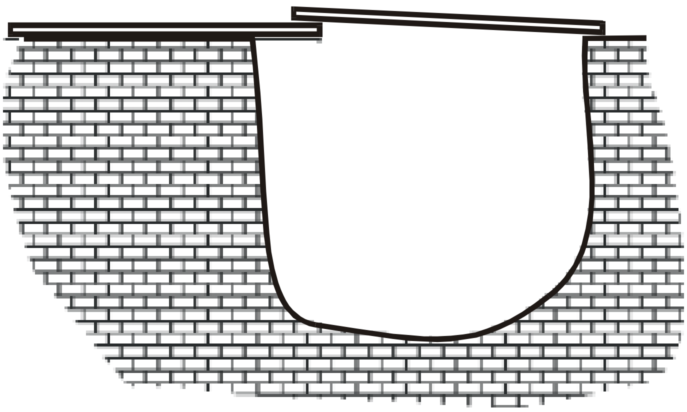


Fig. A.6.

I.123. The way in which the planks must be combined is clear in Fig. A6. The plank which lies above must be set by the adult man. Namely he must first cross the trench. As for the boy, he must stand on the edge of "his" plank to put in equilibrium the momentum generated by the adult man's weight and the weight of the upper plank. After crossing the trench by the adult man, they change places and then the boy crosses the trench.
I.124. To create a greater arm and thus reduce the force necessary to overtake the action of the string which presses the trolley to the wire.
I.125. This gives a possibility to reduce the force applied to the ends of scissors' handles.
I.127. The gain in force is as much as twice. In addition, one must choose the twice longer rope than in the case when the log is bound to the rope. Therefore we have no gain in the work.
I.128. When the arm changes its angle, the momentum created by the load also changes. The largest arm is when the crane's arm is horizontal, therefore the load limitation will be minimal in this case. As the crane's arm goes up (thus increasing the corresponding angle) the arm will decrease thus enabling us to increase the weight of a load.
I.129. The fastening screws are those which obey the inequality

$$\mathrm{tg}\left(\frac{H}{2\pi r}\right) < \mu,$$

where r is the radius of a screw, H is screw's step, μ is the coefficient of friction between the screw and the detail to be fastened. In this situation, one must also take into account the chemical inertia of screw's material, absence of string vibrations, etc.
I.130. When the step of screw increases, the force of normal pressure on a one turn of screw decreases. This results in the reduction of the friction force which prevents an "unscrew". For greater step of a screw an automatic unscrew may occur under the action the elasticity force of the detail deformed by the vices.
I.132. The conical form of screws serves to draw apart the fibers of the wood. For the screws which

are to be screwed into ready holes, the cylindrical form with slanting thread gives the greater gain in force and thus ensures more firm fastening of metallic details. The thread step for a wood screw must be greater than that for a screw applied in metals because the wood is less firm than metals are.

I.133. In the first case, the friction in sheaves helps to support the load. In the second case, one must apply additional force to overtake it.

I.134. Using reels, they get a gain in the force, in going by bicycle they gain in the speed (with a loss in force).

I.136. The error is in neglecting the force of rolling friction. In Fig. I.14, the reaction of the inclined plane is shown perpendicular to the plank passing through the gravity center if the ball. This draw

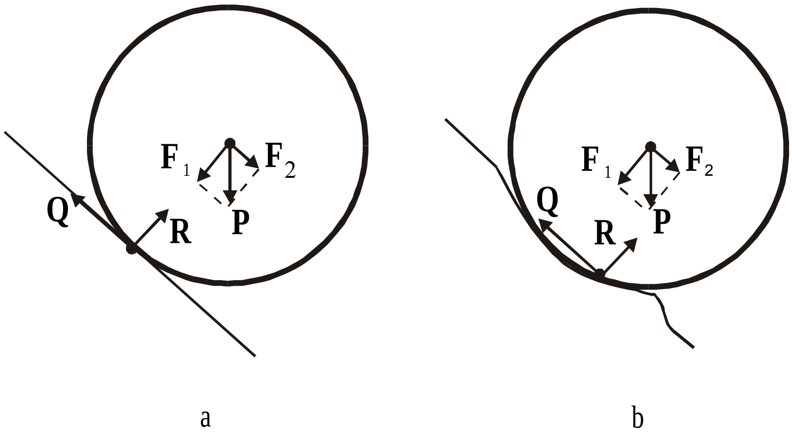


Fig. A.7.

could be right in the case where the elastic forces depended only on the value of deformation did not depend on whether the deformation increases or decreases. In this case, if the coefficient of friction in rolling were zero, the ball would roll down with an acceleration. Indeed, decompose the weight of ball **P** into two components (see Fig. A.7a): the normal component $\mathbf{F}_1$ is balanced by the force of the plank's reaction **R**, while the component force $\mathbf{F}_2$, which is parallel to the inclined plane, together with the static friction force **Q** compose a pair of forces whose moment increases the angular velocity of the ball. Therefore the same is the speed of rolling. In practice, in the part of the area, where the ball touches the plank the deformation increases, i.e., in the front part of this area, the elasticity forces are greater than in the rare part (|where the deformation decreases). As a result, the point of application of the reaction force in rolling of the ball (Fig. A.7b) is displaced forward along the motion. The perpendicular component of the gravity $\mathbf{F}_1$ along with the reaction of the plank **R** form the second pair of forces, whose momentum is opposite to the momentum of the pair $\mathbf{F}_2$ and **Q**. If the sum of moments of these two pairs of forces is equal to zero, angular speed of the ball is constant, i.e., the ball will roll down uniformly.

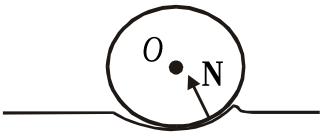


Fig. A.8.

I.137. The friction between the wheel and the plane is namely the rolling friction. It cannot be reduced to a horizontal force $\mathbf{F}_{fr}$. In rolling, the wheel slightly deforms and is impressed into the plane, which results in the force **N**, directed (roughly) as shown in Fig. A.8. Since the horizontal component of this force is directed to the left, the velocity of the wheel will decrease. Obviously, at the same time, the moment of this force with respect to the axis *O* brakes the rotation of the wheel.

I.138. In the motion of the stool at the moment when its front legs touch the floor the center-of-mass describes an arc with the center lying on a straight line passing through the rare legs of the stool. At the moment of stroke on the floor, the center-of-mass will have both the vertical and horizontal components. The stroke is not elastic, and the vertical component of the center-of-mass' velocity is quenched. The horizontal component of the velocity of center-of-mass $\mathbf{v}_{hor}$ turns into zero if the friction force $\mathbf{F}_{fr}$ acts in a certain time *t*. This time interval can be estimated via the equality $F_{fr}t = mv_{hor}$, where *m* is the mass of the stool. Within this time the stool will move a certain distance forward.

I.139. Let us consider the motion of dump-bells in the coordinate system related to the common center-of-mass. In this system the dump-bells fly toward each other with same velocities. At the moment of collision the balls *2* and *3* exchange the velocities (Fig. A.9a), and the dump-bells start to rotate around the proper center-of-mass (Fig. A.9b). Then a collision of balls *1* and *4* takes place, in which these exchange the velocities (Fig. A.9c). After that the dump-bells will move into the same direction which they followed before the collision and with the same velocities.

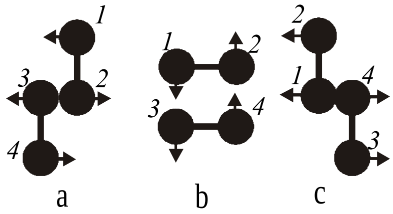


Fig. A.9.

I.140. By virtue of the impulse moment conservation law. By changing the position of center-of-mass, one can change the arm of forces acting on the front wheel, which must lead to a change of moments of impulses of rotating wheels. Under fixed velocity and mass, this results in a turn of the vector of angular speed of rotation.
I.141. The role of a keel of a sailboat is to resist a big rotating moment which arises in action of the wind upon the sail. When the sailboat is inclined, the gravity acting on the keel forms a moment directed to return the ship into equilibrium position. Another purpose of the keel is the resistance to side displacement of the ship (side driftage) of the sailboat by virtue of action of the wind on the sail.
I.142. It is easier to apply the force to the upper edge of the wheels: we then have a greater momentum (the arm of force equals the diameter of a wheel, while, in the first case, it was only its radius).
I.143. Sharp motions of legs give rise to a moment of forces which tries to turn the corpus about the vertical axis. Therefore, a skater swing arms in order to compensate the motion of legs, so both thew motions are in a counter-phase. In swinging arms, a moment of force arises which counteracts to the moment generated by legs and thus compensating it.
I.144. The stability is reached by increasing the support area (wide paws of machine tools, wide supports) and lowering the center-of-mass by placing the most heavy and large parts as low as possible.
I.145. The construction of crane and the maximally admissible weight of load are such that the vertical axis drawn through the center-of-mass of the crane always passes the area of support of the crane.
I.146. That loaded with break, because in this case the center-of-mass occupies the lowest position.
I.147. Ducks have their paws more widely set that those of a hen. Therefore its center-of-mass is longer from the support point. For a step (whose length is rather similar for both dug and hen), the dug turns for a greater angle than the hen: the moment of gravity with respect to the support point is greater. Therefore both the acceleration and the angular velocity are greater in the case of a dug.
I.149. Though the balance are in equilibrium, the loads of equal masses placed on its pans will create different moments of forces with respect to the axis of scales' beam.
I.150. No. The fuel tanks in an airplane are so placed that the center-of-gravity to remain at same position either the tanks are full or not. If contrary, the aerodynamic properties of the airplane were changing.
I.152. The center-of-gravity of a glass with water is at the lowest position if it coincides with the level of the water in the glass. Indeed, of the level of the water is below the center-of-gravity of the system, then by adding the water we add a mass with its center-of-gravity lying above the center-of-gravity of the system. In doing so, we have that the center-of-mass of the system will lower. The center-of-gravity of the system will also lower if it is below the level of the water and we flow out the water which is above the center-of-gravity.
I.154. The quantity of the kinetic energy indeed depends on the choice of the reference system, because, by the definition, $E_k = mv^2/2$, where v is the velocity of the body with respect to the chosen reference system. In this problem the body with respect to the road possesses the kinetic energy $E_k = m(v+u)^2/2$, but with respect to the train $E_k = mv^2/2$. In any of the cases, the answer $E_k = mu^2/2 + mv^2/2$ is wrong.
I.155. In a reference system fixed with respect to the center of rotation, the elasticity force **F** of the bar does not produce any work, because it is always perpendicular to the vector of the velocity of the ball. In the moving reference system, the angle between **F** and the velocity of the ball **u** hanges from zero to 2π (Fig. A.10). Consequently, the force **F** produces a work. Thus, the kinetic energy of the ball changes due to the

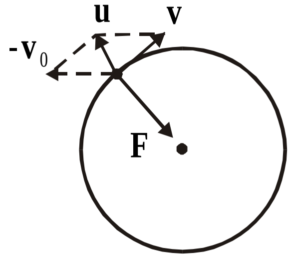


Fig. A.10.

work of the elasticity force of the bar.

I.156. In launching along the equator in the direction of Earth's rotation. To launch a satellite onto an orbit, it must obtain the first cosmic velocity with respect to the center of the Earth. In launching from the equator in the direction of Earth rotation, the initial velocity with respect to the Earth's center equals $v_0 = v + v_E$, where v is the start velocity of the rocket, and v_E is the linear velocity of the equatorial points of the Earth. Obviously, v_0 is greater if the launch is made along the meridian.

I.157. In braking, the automobile cannot stop instantly due to the inertia. The length of braking path depends on both the quality of path and the speed of the automobile. On a wet asphalt road the braking path is essentially larger than that on a dry sand road.

I.158. Let us find the work necessary to hoist Carlson at the height H: $A_1 = mgH$ and $A_2 = (m+m_j)gH$. Here m is Carlson's mass, m_j is the mass of the eaten jam. On the other hand, $A_1 = Pt$ and $A_2 = P(t+\Delta t)$, where P is the power of his engine, t is the time of hoist without jam, $\Delta t = 21$s. Thus, $m_j = P \cdot \Delta t/gH$, and after substitution of numerical data we get $m_j = 3$kg.

I.159. If the man climbs upstairs by an escalator with a constant speed, the mean pressure upon the stairs remains unchanged. Consequently, the same is the force with which the engine must drive the stairs. However, the man going upstairs will earlier reach the top, and thus the path will be shorter than that if the man stands still on the escalator. Therefore the work produced by the escalator engine for lifting a moving man will be less than the work produced by the escalator engine for lifting a steady man (the remaining part of the work is made by the proper man, not engine). The power of engine remains same since a smaller work is made within a shorter time.

I.160. A sportsman makes the jump starting in vertical position and passing the height at horizontal position. Therefore his center-of-gravity is at the height of 1.2m before the jump and 2.1m at highest point. Consequently, he must hoist himself for only 0.9m. Producing the same energy on the Moon, he could hoist his center-of-gravity for $6 \cdot 0.9$m $= 5.4$m. Thus, he could jump over the height 1.2m + 5.4m = 6.6m. This is almost twice lower than one could think at the first sight. But here we have not taken into account that sportsmen rather cower before jump and therefore the general hoist of the center-of-gravity will be slightly greater.

I.161. The zero gravity is not related to stroke, because in striking one must regard for both masses and velocities, but not the weight. The kinetic energy of the cosmonaut is spent partially for the heating of bodies under collision, in part it is spent for their deformation. The pain of the cosmonaut will depend on the ratio of masses spacecraft/cosmonaut. In any case, it will not be greater than if a cosmonaut has fallen onto ground with the same speed (because the mass of the spacecraft is much less than the mass of the Earth). In a collision with the spacecraft a noticeable part of the kinetic energy will transfer to the kinetic energy of the spacecraft and the latter will obtain an additional velocity.

I.162. Let $\mathbf{F}_1$ and $\mathbf{F}_2$ be the force of resistance against the motion. Then $P_1 = \mathbf{F}_1\mathbf{v}_1$ and $P_2 = \mathbf{F}_2\mathbf{v}_2$. For the automobiles connected by a rigid hitch, $P_1+P_2 = (\mathbf{F}_1+\mathbf{F}_2)\cdot\mathbf{v} = (P_1/v_1+P_2/v_2)\cdot v$. Hence $v = (P_1+P_2)v_1v_2/(P_1v_2+P_2v_1)$.

I.164. A loaded lorry presses with a greater force upon the road, which increases the rolling friction force acting on the wheels. This is the main reason for decrease of the speed at the same power of the engine. In addition, the increase of the mass of the lorry leads to the increase of the friction forces acting on the axes of the lorry.

I.165. In the start, the power of the engine is spent not only to overtake the friction force and the resistance of the air, but also to produce the kinetic energy of the automobile.

I.166. The gear box does not change the power of the engine but reduces the speed of rotation of the driving wheel with an increase of the pulling force ($P = \mathbf{F}_{pull} \cdot \mathbf{v}$).

I.167. At the same power of the engine, an additional work is to be made to increase the potential energy of the automobile in the gravitation field.

I.168. There are some reasons. First, a significant part of the work is spent to overtake a greater resistance of friction. Second, an additional work made against the gravity on ascending parts of path not always is compensated by the gravity on descending parts. This is stipulated by limitations in the speed: on descents the locomotive must brake, thus transferring the potential energy into heat. Third, the proper cars have significantly greater weight with respect to a ton of load than ships.

I.169. The increase of the potential energy of water, irrigation, control of water level.

I.170. 92%.

I.171. The speed of the water leaving the turbine turns lesser, because hydroturbine produces its work buy expense of loss of the kinetic energy of the water flow.

I.172. The efficiency of the stroke is explained by the fact that the energy (permanently accumulated before the stroke) is spent within a small time, therefore the mean power $P = A/t$ is large. But if the stroke is made upon an elastic body, then the path S in which the stroke was made will be small. Therefore the force will be large: $F = A/S = Pt/S$.
I.173. In addition to the said in the previous problem: the action of an axe is strengthened by a small area of the stroke, i.e., a large pressure is made.
I.175. From the laws of the conservation of the impulse $mv = (M+m)u$ and the energy

$$\frac{mv^2}{2} = Q + \frac{(M+m)u^2}{2},$$

(where u is the speed of the bar with plasticine after the stroke) we get the next expression for the desired quantity of heat:

$$Q = \frac{mM}{2(m+M)}v^2.$$

I.177. First the work is spent to overtake the friction forces; when the nail will have been hammered in, the strokes will increase the interior energy, i.e., the nail will be heated.
I.178. Generally speaking, both are wrong, since they do not consider that within the stroke the train obtains an additional impulse and the speed of the bullet after shock will not be equal to u. However, if one takes the mass of the train infinitely large, the second pupil is right.
I.179. The potential energies of the bodies are same. The kinetic energy of the first body at the end of motion is less than that of the second body.
I.180. If there were no air resistance, the time of ascent and descent would be same. Due to the resistance of the air the kinetic energy of the ball in descending path is less than in the ascending path, the difference equals the work spent for overtaking the resistance of the air. Consequently, at any height the speed of ascent is greater than that for descent. Therefore, the time of ball's falling is greater than the time of rising.
I.181. The ball which moved before the collision will stop, while the rested ball will adhere its velocity. The greater is the speed obtained by the ball at the elastic stroke.
I.183. If the stones possess a ball-like shape, the height of their jumps after fall upon a smooth floor were gradually decreasing. The sea stone are not uniform, therefore they may start to rotate after shock. In this case, two possibilities of producing the kinetic energy exist: one is determined by the velocity of the onward motion of the stone's center-of-mass and thus helps it to rise, other is related to the rotation. It depends on a way in which the stone fall upon the floor. Its rotation may increase and may decrease. Respectively, the kinetic energy of rotation will grow or lower. Therefore after a jump the stone might make the second jump for a lower height. In the second case the result is contrary. After the next jump,. A redistribution of the energy might take place and thus the stone might jump higher than in the previous jump.
I.184. The vertical component of the velocity of the ball after n-th stroke over a plate is
the time of motion of the ball between the n-th and n+1-st shocks is

$$v_{\text{n}} = \sqrt{1-k}\cdot v_{\text{n}-1} = (1-k)^{\frac{n}{2}}v_0 = \sqrt{2(1-k)^n gH},$$

and the time of flight before the first collision with the plate equals

$$t_{\text{n}} = \frac{2v_{\text{n}}}{g} = 2\sqrt{\frac{2(1-k)^n H}{g}},$$

Then the complete time of ball's motion is

$$t_0 = \sqrt{\frac{2H}{g}}.$$

By summing the geometric progression within the square brackets, we get

$$t = t_0 + t_1 + \ldots + t_n + \ldots = \sqrt{\frac{2H}{g}} + \sqrt{\frac{8H}{g}}\left[(1-k)^{\frac{1}{2}} + (1-k) + \ldots + (1-k)^{\frac{n}{2}} + \ldots\right].$$

$$t = \sqrt{\frac{2H}{g}}\left(1 + \frac{2\sqrt{1-k}}{1-\sqrt{1-k}}\right).$$

Within this time the ball will cover the distance

$$l = \sqrt{\frac{2H}{g}} \cdot \frac{1+\sqrt{1-k}}{1-\sqrt{1-k}} u.$$

I.185. The complete mechanical energy of the satellite is the sum of its kinetic energy $mv^2/2$ and potential energy $-gM_E m/R$, where m is the mass of the satellite, v is the velocity of its motion along the orbit of the radius R, M_E is the Earth's mass, g is the constant of gravitation. The velocity of the satellite motion along the orbit is determined from the condition that the centripetal acceleration of the satellite is generated by the gravitation attraction force: $mv^2/R = gM_E m/R^2$. Hence the kinetic mass of the satellite motion along the orbit equals $gM_E m/2R$, and the complete mechanical energy of the satellite on the orbit is $-gM_E m/2R$. Therefore the decrease of the radius of the orbit makes to decrease both the negative complete and potential energies, while the kinetic energy increases. Therefore the speed of the motion of the satellite along the orbit grows.
I.186. Let us assume that the stroke between the rod and the ball is elastic. Within the stroke, a part of the energy of the rod is spent to the work for creation of non-elastic deformation of the proper rod at the place where the rod and the stone touch each other. Therefore the stone gets less velocity than the ball does.
I.187. In the jump in a "wave" manner a man has not to elevate his body's center-of-gravity as high as in jumping with "straight legs". Therefore he must not make an additional job against the gravity.
I.188. To analyze the problem, let us consider how the filling with the mercury takes place for the cylindrical vessels. The mercury goes into an empty vessel forced by the pressure of the atmosphere. In doing so, the mercury in the tube moves with an acceleration which is reduced by the gravity of the column of the mercury in the tube and by the force of friction which grows as the mercury speed grows. When the force of gravity and pressure compensate each other, the mercury continues its path upwards due to the inertia. Finally, the forces of friction and gravity compensate stop the ascent of the mercury column. At this moment the force of friction turns into zero, and the gravity will exceed the pressure. Thus the column will start to fall. In the tube the oscillations of the mercury column will fad due to the friction. Now let us turn the question formulated in the problem. In the setup shown in the right draw, the mercury will fill the cavity with higher speed. Therefore in this cavity the greater energy is spent against the friction. Finally, the law of energy conservation is not violated: in the setup show in the left draw the potential energy of the mercury is larger, while the vessel in the right draw is more heated.
I.189. They use the potential energy of the water in the source. The work of the hydraulic ram does not contradict the law of conservation of the energy, because not the whole mass of water is hoisted at a high level, but a part. The potential energy of the water in the source is transformed into kinetic energy which makes a part of water to rise upwards.
I.190. The "softer" is the tire, the longer is the time for pull acting on the automobile. Therefore the less will be the force acting on the automobile. The pull's energy in this case is transformed into thermal energy.
I.191. Let us choose the simplest model: the inclination angle φ is small at the moment of collision (i.e., $x<<l$, Fig. A.11), and the next domino will fall due to stroke but this practically does not affect the reserve of its energy. By the law of the conservation of energy,

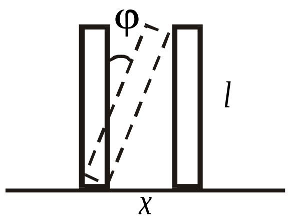


Fig. A.11.

$$\frac{mv^2}{2} = mg\left(\frac{l}{2} - \frac{l\cos\varphi}{2}\right) = mgl\sin^2\left(\frac{\varphi}{2}\right) \approx \frac{mgl\cdot\varphi^2}{4} \approx \frac{mgx^2}{4l}.$$

Then

$$v \approx x\sqrt{g/2l},$$

and for the mean velocity of the motion of one domino we get

$$\langle v\rangle \approx \frac{v}{2} = \frac{x}{2}\sqrt{\frac{g}{2l}},$$

whence for the get for the desired time the following estimate:

$$t = 100\frac{x}{\langle v\rangle} = 200\sqrt{\frac{2l}{g}} \approx 20 \text{ s}$$

(with $l = 4$cm).

I.192. Assume that the interior energy of the excited nucleus equals E. In ejecting a quantum, a part of the interior energy of the nucleus transfers into the quantum's energy, while a part passes into the kinetic energy of the nucleus W, so-called the recoil energy. This is related to the fact that the quantum possesses a finite impulse. Therefore, the same by magnitude impulse must be absorbed by the nucleus. Here we see a complete analogy with a firing gun. In the absorption of a γ-quantum by the nucleus, the energy of the latter must be distributed between the kinetic energy of the absorbing nucleus and its interior energy. However, the latter cannot change by the quantity E–2W, and there is no absorption of γ-quantum. The unique situation arises in some crystals, where, by the expense of the connection between the nuclei, the impulse of recoil is transferred not to a unique nucleus but to the whole crystal. In this situation, practically, the recoil energy becomes zero and the γ-quantum can be absorbed by analogous nuclei in the crystal, which possess similar inter-nuclei connections. The effect of absorption and recoil of γ-quanta by nuclei was discovered by Rudolf Mossbauer in 1957; now it is called Mossbauer effect.

I.193. The energy of recoil (see the answer for the previous problem) is proportional to the square of impulse, and thus to the square of the emission frequency. For the γ-scale, the frequency of emission is of order 10^{20}–10^{23}Hz, for the optical emission it is 10^{15}Hz. In other words, the recoil energy in emission of quanta of the visible light is at least a factor of ten power of ten less than in the emission of γ-quanta.

I.194. The law of the conservation of energy takes place only in inertial reference systems. Only an non-inertial reference system can be related to the electric train moving with acceleration. In this system you must make a work against the inertia force $\mathbf{F}_{in}=-m\boldsymbol{a}$ ($\boldsymbol{a}$ is the acceleration of the electric train, m is the mass of a man). Obvisouly, one may consider the situation also in an inertial reference system. The forward motion of the man must be accompanied by rising of train's acceleration directed oppositely. Thus, the work of muscles is spent to change the kinetic energy of the train. This change, however, cannot be observed since it is compensated with great abundance by the work of the friction force between the rails and wheels, which accelerates the electric train.

I.195. One must pull the center of the balance beam. In this situation, in a difference between the masses of body and loads, the beam must turn. But if the masses are equal the equilibrium will not be violated. In other words, the balance will behave as if it were fixed in the field of the gravity. Consideration of similar situations helped to Albert Einstein to formulate so-called the equivalence principle. By this principle, all physical phenomena in a gravitation field occur same as if they were in the corresponding field of inertia forces if the forces of both the fields coincide at the respective points of the space and the initial conditions are same for all bodies of a closed system.

I.196. Consider the forces acting on the ball (Fig. A.12). As the tube does not move, the ball experiments the gravitation $m\mathbf{g}$, the reaction of the support $\mathbf{N}$, determined by the presence of a component of the gravity which is perpendicular to the tube, and the elasticity force $\mathbf{F}$ of the compressed string. When the tube starts to fall freely, the gravity gives to both the tube and the ball the same acceleration. Consequently, $\mathbf{N}=0$. Under the action of the elastic force of the string the ball will move along the tube and then fly out it. It will appear near the edge of tube with a horizontal velocity and will further fly along a parabola as any body thrown at an angle to the horizon.

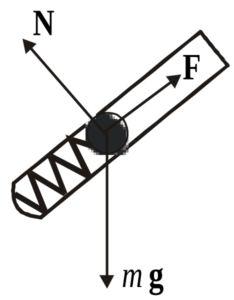


Fig. A.12.

I.197. To explain the problem, one can apply the equivalency principle (see the answer to the problem no I.195). By this principle, we may replace the inertial force with the homogeneous gravitational field. Then the summary (with regard for the gravity) gravitational field is directed downward and against the acceleration of the torch. The behavior of the flame will be explained by the Archimedes' force: the air which is more dense "sinks" while the less dense flame "buoys".

I.198. A watermelon will move forward, while the ball backward (see the previous problem).

I.199. From the side of the wall of the spacecraft a force acts on the cosmonauts which provides him with an acceleration a. The pressure, i.e., the force related to the unit if area, equals $p=ma/S$. Hence it is clear that the cosmonaut will feel lesser pressure when it is in the horizontal position, where the force is distributed along a greater area.

I.200. In order for the body with the mass m to move with the speed v along the circle of the radius R, an acceleration is necessary, directed to the center of the circle ands having the value v^2/R, i.e., the centripetal acceleration. By the second Newton law, the force generating this acceleration (centripetal force) has the magnitude mv^2/R and is directed to the axis of the circle. Now consider the forces acting on the body on the Earth's surface (Fig. A.13). Obviously, a force directed along the parallel must act on the body to ensure its motion with the Earth's frequency. It is also obvious that the presence of the universe gravitation $\mathbf{F}_g$ directed almost to the center of the Earth (do not mix with the gravity), and the force of the support reaction **N** directed perpendicularly to the Earth's surface. However, these forces do not suffice to keep the body under a given linear speed on a given distance from the rotation axis– there remains a probability to displace along the meridian (perpendicular to the forces **N** and $\mathbf{F}_g$). The friction force $\mathbf{F}_{fr.N}$, directed to the North, may be opposite to this action. Thus, the centripetal force in this case is the sum of projections onto the direction perpendicular to the Earth's rotation axis of the gravity, reaction of the support, and the friction force $\mathbf{F}_{fr.E}$.

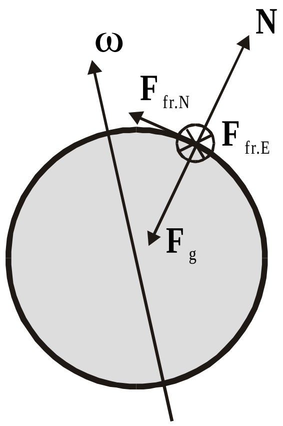


Fig. A.13.

I.201. Let us consider this problem in an non-inertial reference system related to the rotating planet. The centripetal force acting on bodies on the plane's surface is maximal on the equator. To avoid the leaving the equator by a certain element of the mass Δm, the centripetal force must be balanced by the force of the gravitational attraction $\Delta m\omega^2 R = \gamma M \cdot \Delta m / R^2$, where ω is the maximally possible angular speed of the planet's rotation about its axis under which a substance does not leave the planet for the space, γ being the constant of gravitation. Hence

$$\omega = \sqrt{\gamma \frac{M}{R^3}}.$$

This means that the minimal time of a complete rotation is

$$2\pi\sqrt{\frac{R^3}{\gamma M}}$$

Note that the answer depends only on the density of the planet's substance!

I.202. By the attraction of the Earth.

I.203. The right ones. The explanation depends on a reference system. In the inertial reference system, this behavior of the automobile is explained by the inertia of the automobile's corp. As for a non-inertial reference system. The same is explained by the action of the centripetal inertial force.

I.205. Let us give an explanation in an inertial reference system. In a centrifugal pump, the p[articles of the water obtained the velocity from the blade of the wheel, cannot be kept by the centripetal force on a circumference and diverge creating a rarified atmosphere in the center.

I.206. To the center of the circle of rotation.

I.207. The measurement by a level of a longitudinal slope can be made in a uniform motion of the train, while the level in cross positions can be measured on rectilinear parts of the path.

I.209. To the axis (see the problem no. I.197).

I.211. The stretching force of the line is maximal at the highest point and is minimal at the lowest point.

I.212. In such a motion along the axis of the bottle a hollow "tube" is formed. Through the tube the air can freely enter into the bottle to replace the liquid which flows out.

I.213. When the load *P* assumes the positions *C* or *D*, it stresses the line with a force which is less than *Q*: a) in this situation the load *Q* goes down. When the load *D* passes the position *E*, it stresses the line with a force greater than *Q* and the load *Q* is hoisted. The oscillations of the load *D* generates vertical oscillations of the system; b) under the friction in sheaves, which is comparable with the change of the stress of the line of load *D* in the position *C*, there will be no oscillations of the load *Q*.

I.215. The velocity of the body at the point *B* depends on the friction. Since the surface *ÀMB* is convex and *AKB* is concave, the force of normal pressure onto *AMB* is less than on *AKB*. Therefore the friction force on *AMB* is less than on *AKB*. The velocity of the body at the point *B* is greater in the case when the body moves along the path *AMB*.

I.217. The mud stuck to the wheels is then ejected along a line tangent to the edge. It can reach the cyclist and soil the bicycle. In order to avoid this situation, it suffices that the casks tts cover a quarter of the front wheel and a half of the rare wheel.

I.218. In sharp bends of automobile at high speeds the friction force (which is a centripetal force) can be insufficient for keep the automobile on the circle of road. Then the automobile will slip to

a side due to inertia.
I.219. The hitching forces between the particles may be insufficient to keep them on a circle of a certain radius. In addition, the detail can destroy and the residues, moving with high speed, may hit a man.
I.220. The Earth rotates from West to East. As known, the linear speed of different places on the Earth's surface depends on their geographic latitude. Higher is the latitude, lesser is the speed. Therefore the water in a river which flows to the North, in passing to a higher latitude will deviate to the East due to the inertia, thus washing its right shore. The same serves as explanation of the fact that the rivers which flow to lower latitudes deviates to the West and wash their left shores. In consideration of this problem in the non-inertial reference system related to the Earth, this phenomenon is explained by the action of the inertia, so-called Coriolis force. The magnitude of the latter is equal to $2mv\omega\sin\theta$, where m is the mass of a body experiencing this force, v is its velocity, ω is the angular frequency of the Earth's rotation, and θ is the angle between the vectors $\mathbf{v}$ and $\boldsymbol{\omega}$. The direction of the Coriolis force is perpendicular to the plane where the vectors $\mathbf{v}$ and $\boldsymbol{\omega}$ lie and coincides with the direction of the displacement of a right screw when the latter is rotated from the direction of $\mathbf{v}$ to the direction of $\boldsymbol{\omega}$.
I.222. Note: take into account the answer to the previous problem.
I.223. In the equatorial regions the air mainly is warmer than on higher latitudes. Being more light, the warm air is replaced upwards with the colder air from higher latitudes. The situation is even more sharp due to absence if friction (see the problems I.200 and I.220) for keeping the circulating masses of the air on higher latitude. This results in near-surface motion of the air from the higher latitudes to the equator, so-called trade winds. In an inertial reference system, the deviation of the trade winds to West is treated as a revelation of the inertia of the air.
I.224. A projectile launched along a meridian to higher (lower) latitudes will deviate to East (West). Such its behavior, related to non-inertial reference system of Earth, is explained by the Coriolis force.
I.225. Note: consider the action of the Coriolis force acting on the load.
I.226. Generally speaking, the answer is "no". Each of the loads is undergo at least two forces: the gravity and the gravitational interaction with the table. Both these forces depend on the mutual position of massive bodies. For both the left and right loads these forces will add to and subtract from each other, respectively. Thus, one can easily see that the equilibrium can be violated to any side. The most interesting is the case where the table has a large mass while all the lines are small. Then we may assume that gravity acting on the loads are same, and by the deviation of the balance one can measure the force of the gravitation attraction of the loads to the table. As a result, we can derive the constant of universal gravitation. In a slightly modified form, this experiment was carried out in 1878 by the German physicist Philipp von Jolly.
I.228. If we assume that the density of the Earth is constant, then in penetrating the Earth the weight of a load will not grow but decrease, because the attracting parts of the Earth will be disposed at different sides from the load.
I.229. In considering the problem in non-inertial reference system related to the Earth, the weight of the body is stipulated by the universal attraction force and the centrifugal force of inertia. The first one does not depend on the Earth's rotation, while the second one is proportional: to the square of the angular velocity of Earth's rotation and to the distance from the rotation axis determined by the geographic latitude. The bodies possess the greatest specific weight on the poles and the least one on the equator where the centrifugal force of inertia attains the greatest value. The density does not depend on the geographic latitude of a place.
I.230. Spring scales realize the absolute measurement of the weight, which depends on the mass of a body in different form for different places on the Earth (see, for example, the previous problems). Arm balances execute a comparison between the sought-for weight and a sample weight. Such a comparison does not depend on the place where is carried out.
I.232. One must take it into account.
I.233. No; to move upwards, a body must obtain a velocity, i.e., accelerate a body resting on the Earth. Therefore the initial force must be greater than the gravity.
I.234. The weight of the load equals zero.
I.235. The accelerations which are given to both the Earth and the Moon by the Sun are approximately similar. Therefore both the Earth and the Moon form a unique system of two celestial bodies which revolve around a common center-of-mass, and the center-of-mass of the system Earth-Moon revolves around the Sun.
I.238. The motion of the Moon along its orbit occurs due to the attraction of the Earth. Therefore

$$\frac{M_M v^2}{R} = \gamma \frac{M_M M_E}{R^2},$$

where M_E and M_M are the masses of the Earth and the Moon, respectively, R stands for the radius of the Moon's orbit, v is the velocity of Moon's motion along the orbit. Hence we have

$$v = \sqrt{\gamma \frac{M_E}{R}}.$$

On the other hand, the period of evolution of the Moon along its orbit is $T = 2\pi R/v$. Then

$$v = \sqrt{2\pi\gamma \frac{M_E}{v \cdot T}}$$

and we finally have for the velocity

$$v = \sqrt[3]{2\pi\gamma \frac{M_E}{T}} \approx 540 \text{ m/s}.$$

I.237. In winter, because it moves near its perihelion.

I.238. The bridge will stay without supports since all its parts are attracted to the center of Earth with a similar force. However, this bridge cannot be used. If a fly will "land" on this bridge, the equilibrium will be violated and the bridge will fall.

I.239. One make take a flight around the Earth with a velocity less that the first cosmic speed if one holds engines turned on. For example, it can be made on an airplane. The same concerns a flight to the Moon. With engines turned off one can reach the Moon only if the spacecraft obtained the second cosmic velocity near the Earth. As for the flight with engines permanently turned on, it can be made at any speed. In this situation, the rocket will fly uniformly and rectilinearly. There will be no overload, no zero gravity. Within the flight one must regulate the pulling force so that the sum of the pull force and the gravity were equal to zero. In approximating the Moon, one must brake the spacecraft in a certain way.

I.241. a) The water can be pressed out from the vessel by applying the compressed air or by pressing its walls if these are elastic; b) in heating, there will be no convection, therefore only a series of local volumes of water will be heated up to a boiling. The vapor in its expansion will displace the water from the vessel before it could start to boil; c) by means of additional jet engines fixed in a special way or by changing the direction of flowing out combustion products from the main nozzle of the rocket; d) one must act onto the body with known elastic force and measure the acceleration obtained by the body; e) put the spacecraft into a motion with acceleration; in particular, start to rotate the spacecraft about one of its symmetry axis.

I.242. The trajectory of a satellite is a spiral winding around the Earth.

I.243. The gravitation force of attraction to the surrounding mass of liquid act on the piece of metal as well as the pressure of the liquid. If the volume occupied by the piece of metal were occupied by the liquid, it would be in equilibrium, i.e., the resultant of the forces of gravitational attraction to the remaining mass of the liquid would be equal to the resultant force of hydrostatic pressure. But if instead of this volume of a liquid we place a piece of metal, then the resultant force of the pressure does not change while the resultant force of the gravitation attraction increases. Moreover, the resultant of the gravitation attraction is directed to the center of the cistern since a body which is inside a spherical layer does not undergo its attraction. The resultant of all the forces acting on the piece of metal is directed to the center and equals

$$F = \gamma \frac{4\pi}{3} \rho_0 r \cdot V \left(\rho - \rho_0\right)$$

(ρ_0 is the density of the liquid, ρ is the density of the metal, V is its volume, r is the distance from the center of the cistern). In other words, it is proportional to the displacement of the piece of metal with respect to the center of the sphere. Hence it follows that, if there is no friction, the piece of metal will oscillate harmonically about the center of the cistern. Due to the interior friction, these oscillation are fading. If a bubble of the air is in the cistern, it will move to the shell of the spacecraft, because we have $\rho < \rho_0$ for this bubble and thus the resultant force is directed outward the center of the spacecraft.

I.244. In the first approximation, we may neglect the masses of all other planets of the system Sun-Earth. Since the mass of the Sun exceeds many times the mass of the Earth, we may assume that the center-of-mass of the system coincides with the center-of-mass of the Sun. If the mass of the Earth were growing up to the mass of the Sun, the center-of-mass of the system would occupy the middle of the distance between the Earth and the Sun, which reduces two times the orbit radius of the Earth. If we denote by T_1 the period of Earth's evolution in the firs case and by T_2 on the second case, then by the Kepler law we can derive

$$\frac{T_1^2}{T_2^2}=\frac{R^3}{\left(\frac{R}{2}\right)^3},\ \text{or}\ T_2=\frac{T_1}{2\sqrt{2}},$$

which means that the earth year will decrease by $2\sqrt{2}$ times.

I.245. The answer is "no". For a stable motion in a plane it is necessary that the acting forces lie in the same plane.

I.246. The satellite must be launched in the plane of the equator. The radius of the orbit R and the linear speed v of the satellite can be evaluated as follows. The centripetal acceleration is given to the satellite by the gravity. Therefore $mv^2/R = gM_E m/R^2$, where m and M_E are the masses of the satellite and the Earth. Denoting by T the period of satellite's evolution (it equals 24 hours), the same speed can be expressed as follows: $v = 2\pi R/T$. From these two equations we get

$$R=\sqrt[3]{\gamma\frac{M_E T^3}{4\pi^2}}\quad\text{and}\quad v=\sqrt[3]{\gamma 2\pi\frac{M_E}{T}}.$$

I.247. The force of friction is rest, which is directed forward.

I.250. If we push it in front of you, the pushing force obtains a horizontal component directed downward and thus increasing the weight. The friction also grows in this case. If you pull it behind, the effect is inverse, the force applied by you reduces both the weight and the friction. Thus the second variant is preferable.

I.251. The answer is "no".

I.252. If a man stands on a rough ice, he makes a greater pressure on the support area because he rests upon some salience and fragments of the rough surface. Greater is the pressure, much ice is melted and therefore the rough ice is more slippery than a mirror-smooth one.

I.253. A saw is "set" to increase the width of the kerf (groove) since if the kerf is narrow the saw is "squeezed" (the friction between the saw and the cut of wood becomes too large).

I.254. Granting to the friction between the grains and the grains and the floor.

I.255. In the motion, between the steering rough surfaces some their irregular parts of surface clutch each other which leads to their gradual rubbing out.

I.256. To rub out and heat the rubbing surfaces.

I.259. No, it is not. If a nail is rather rusted over its surface, this cannot change essentially its toughness, but helps to increase the friction between the nail and the walls of its hole.

I.261. It decreases the work made by friction forces in rotation of gears axes, because, with respect to fixed parts of clock or watch, the points of axis end make a lesser path at any turn.

I.262. In this case we deal with an interesting feature of the forces of dry friction, because they do not exceed the maximal force of the state of rest. In the case where the body moves, the friction of slipping is directed against the velocity and practically has always the same value. Suppose that, first, in order to take out a nail, you are only rotating it. If you, in addition, use pliers in the capacity of a lever, therefore you have to apply less efforts to overtake the force of friction between the nail and the wood. In this case, the slipping friction's force is perpendicular to the nail axis and thus it does not resist to a motion along the nail. If you will now try to take out the nail, a component of friction will appear directed along the nail. Moreover, the ratio between the components of the friction along the nail and in perpendicular direction equals the ratio of the corresponding components of the velocity of any point at the nail's surface. By increasing the rotation, one can reduce the ratio of velocities mentioned above. This leads to a decrease of the component of friction directed along the nail (because the magnitude of the friction force does not change), which gives you the desired effect.

Note that arguments cited above concern the case when in the process of rubbing the state of rubbing surfaces does not change. In practice, all is often contrary. The surfaces of touch between the nail and the wood are polished in the rotation and thus make less difficult the extraction of the nail.

I.263. First, under a sharp braking the force of rest friction between the wheels and the road tend to its maximal value. In addition, the direction of this force (see the previous problem) is opposite to the direction of the velocity of motion and does not prevent a drift to side which may be caused by a rough road surface. Second, in sharp braking the wheels may start to slip over the road and the slipping friction force is less than the friction force of the state of rest, which "works" in a motion

without braking.
I.264. The tread pattern serves to increase the friction (or the hitch between the wheel and the road). The crosswise relief is necessary for accelerations in onward direction; lengthwise strips and longitudinal relief prevent the displacement to a side.
I.266. They warn about the change of the motion of car's wheels over rails covered by fallen leaves (the hitch between the wheels and rails reduces and thus may lead to wheel-spin).
I.267. To start the motion of a resting body, one must apply to it a force which is greater than the maximally possible friction force of a body in the state of rest. Since the wheels of both the locomotive and the cars do not slip over rails, we have $F_1 \leq k \cdot P_1$ and $F_2 \leq k \cdot P_2$, where P_1 is the weight of the locomotive, P_2 is the weight of cars, F_1 is the friction force between the wheels of the locomotive and rails, F_2 is the friction force of cars' wheels and rails, k is the coefficient of friction between steel and steel. But from the inequalities written above and from the fact $P_2 > P_1$, it is clear that we cannot derive $F_2 > F_1$. Obviously, $F_2 \leq F_1$. It is connected to the fact that the friction of cars' wheels and rails is the rolling friction while the friction between the locomotive wheels and the rails is the friction of the sate of rest.
I.268. Electric locomotive must possess a big weight (so-called hitching weight) is order to ensure the greater value of friction between its wheels and the rails, which is necessary to pull a train.
I.269. First, the wheels of a loaded automobile "sink" into coil more deeply and thus reach there some solid layers, where the coefficient of friction is greater than that for a "liquid soil". Second, the force of friction is proportional to the force of normal pressure which is greater for a loaded automobile.
I.270. On the lorry. In this case the pressure of rare driving wheels upon the road grows. Therefore the hitch with the road also grows. If one puts a heavy machine on a trailer the probability of wheel-spin grows (over a wet road, on ascents).
I.271. In general, the mechanism of sliding over ice is different for skates and sleigh. In both cases the slipping is possible due to creation of a thin water layer between the ice and a sliding surface. But in the case of sleigh, the water appears due to friction. In the case of skates (if the temperature is not too low), the sliding layer of water is produced by a high pressure of a skate edge. When the temperature is too low (which is not something unusual in Russian winters), skates "go hard". We should add that sleigh experience the same situation, the friction of their runners produces an insufficient water for "easy motion".
I.272. In order to increase the pressure upon the ice and thus ensure the creation of water layer in high speeds of motion.
I.273. The wheels possess less area of support and thus sink into the snow. This changes the nature of forces which hinder the displacement of carriage – the force of the friction of rolling is replaced with the frontal resistance of the snow, which is many times greater than the friction of slipping. In addition, in its slipping, the sleigh runners produce a water layer which reduces the friction.
I.274. The needle bearing sustain significantly greater loads because they have a greater support area.
I.275. The ironed linen has a smooth surface which badly attracts the particles of mud and dust.
I.276. Within an easy moistening of a wood, its small fibers are swelling and thus increase the friction between a hand and a handle.
I.277. The slipping bears are made of a material less hard than that of the shaft. So, in friction they are worked out quicker than the main details. This enables a fast repair.
I.278. To decrease the friction. In addition, these minerals can be well-polished and possess a greater hardness.
I.280. To cool the cutting tool and restore the speed of the stone.
I.281. The principle of ice-crushing consists of a crawling onto the ice and breaking it by the weight of ice-crusher.
I.282. The wedge splits the end of the handle and press it with a greater force to the walls of the tool thus increasing the friction between the wood and the steel. The tool becomes more strong in work.

Answers to Chapter II

II.1. In a marshland a space arise under a foot, to which the air cannot penetrate. Therefore, in walking and elevating his feet a man must overcome the resistance of a viscous soil and the atmospheric pressure.
II.2. By pressing upon the rubber balloon of a fountain-pen, we squeeze out the air. When the balloon assumes its previous form due to elasticity of the rubber, a space with reduced air pressure let the ink to flow in due to the suction.
II.3. The normal atmospheric pressure equals approximately 10^5 N/m^2. Therefore the weight of the air column with the basement area of 1m^2 equals 10^5 N. Knowing the radius of the Earth globe $R_E \approx 6400$km, one can find the area of Earth's surface. By multiplying the result by 10^5 N/m^2, we get the weight of the whole atmosphere (approximately 5×10^{19}N).
II.4. Does not affect.
II.6. By the expense of the potential energy of the liquid which is in the upper vessel.
II.7. The siphon will work in the first case and will not in the second case.
II.9. The air produces the pressure upon the walls of the vessel on the orbital station, because the chaotic motion of the molecules exists as well in the zero gravity conditions. The cylinder for keeping air under zero gravity must be as strong as on the Earth.
II.10. 2kPa.
II.11. As one lowers the pressure in a tire, the area of contact with the ground increases; consequently, the pressure upon the ground decreases.
II.12. 1.9MPa.
II.13. The depth on which the bathyscaph rests can be found by the formula $h = (p-p_0)/g\rho$, where p_0 is the atmospheric pressure, g is the acceleration of free fall, ρ is the density of the water.
II.14. The liquid will not go up. (Usually, the liquids move up under a piston under the action of atmospheric pressure. In the case under consideration the air does not press upon the liquid.) To make the water to flow out from the tube, one must pump in the air into the reservoir. Its pressure will make the liquid to flow out.
II.17. Yes, he can.
II.18. The height of the mercury column in these conditions will be 6 times greater than on the Earth and is about 456cm, because the gravity on the Moon is 6 times less. For the Trickle's experiment a tube of the length 5m would be required.
II.19. There will be not difference.
II.20. In Earth's conditions the pressure 10.3Mpa could set into equilibrium the pressure of a nervure column of the height 76m, but on the Venus the gravity is 1.2 times less. Therefore, the height of the mercury column as much greater, which gives us 91m.
II.22. No, he cannot, because the mercury column makes not pressure since is imponderable; barometer-aneroid will serve well.
II.23. The reading of the liquid barometer depend on the vertical component of the airplane acceleration.
II.24. To avoid the collapse of the pipe under the pressure of the atmosphere.
II.25. In its penetration into the water, a bullet produces an elastic wave of compression (similar to the hydraulic hammer) which destroys the glass.
II.26. If the air resistance were absent, the water would not flow out. Due to the resistance of air, the water will flow more slowly than before the fall of the pail. In addition, the water will fall more slowly than the pail does.
II.27. The answer is "yes " if they both are merged completely.
II.28. The layer of water in the high tube produces a great pressure upon the walls of the barrel. As a result, its material is highly stressed. If the stress exceed the limit toughness of the material of barrel's hoops, these will be broken.
II.29. In order for a man can breathe the difference between the pressure of the air inside and outside the lungs must be near 0.1atm. Therefore, even at a depth close to 1 meter, a man cannot breathe in the air from a tube over water surface, because the force acting on his thorax will be very large (estimate the thorax area and the value of this force of pressure). However, is one fills a rubber camera with the air and gives it to a diver, the diver will be able to breather when this camera is near him under the water, because the pressure inside the camera will equal the pressure near the diver. Though it is not very easy to dive with such a "balloon". Therefore they use metallic balloons with the compressed air. These balloons are provided with an automatic device (reductor) changing the

pressure of the air to flow into lungs in accordance with the depth of diving.
II.30. The weight of the automobile can be easily found by summing the pressure upon the road, produced by each wheel. The pressure can be determined if one knows the pressure in the tires and the are of contact between tires and a flat concrete road.. In the tires of the car "Volga", for example, the normal pressure is $p = 170$ kPa. Let us assume that the measurements show the contact area with the road plane is near $S = 280\text{cm}^2$, then the force of pressure is $F \approx 4760$N. If the load is distributed uniformly upon all the wheels, the weight of the automobile is $P = 19000$N. The pressure in tires can be measured by a manometer.
II.31. The force necessary to displace the pistons down turns to be several thousand times greater than for displacing them up. The secret consists of the practical incompressibility of the water. In the downward motion of the pistons, a compression of water takes place since the volume of space between the pistons reduces. To this end, it is necessary to apply a force of some millions newtons. In the upward motion of the pistons, the volume between then increases, above the water a saturated vapor is created, whose pressure is much less than the atmospheric pressure. Therefore, in the upward motion, a difference between the forces created by the atmospheric pressure acting upon the upper edge of the greater piston and the lower edge of the smaller piston must be overtaken as well as the weight of the water and the pistons with the rod. In a typical size of the device of order some centimeters, the sum of these forces will be measured by only several thousand newtons.
II.32. The pressure at the points A and B will be same. At the point A it will be created by the weight of the column in the left vessel. At the point B is equal to the weight of the water in the right vessel and the reaction of the lid of this vessel. By the Pascal law, the last equals numerically the weight of a column of the liquid with a height equal to the difference between the levels of liquid in vessels.
II.33. The pressure upon the bottom is same in both the vessels (otherwise the liquid were not in the equilibrium). Therefore the level of liquid in the vessel with a greater temperature and, respectively, with a lesser density, will be higher than in the other vessel. Let us draw a graph of the dependence of pressure at each of the vessels on the height (Fig. A.14). Here p_a is the atmospheric pressure. On the height h, where the upper tube with a valve is set, the pressures in the vessels will be equal, respectively, to p_1 and p_2. Since $p_1 > p_2$, therefore in opening the valve the liquid will flow along the upper tube from the vessel with a greater temperature to the vessel with a smaller temperature. But the level of the water in each of the vessels must be unchanged, because only in this case the pressure upon the bottom will be the same. Therefore, along the lower tube connecting the vessels the liquid will flow from the vessel with smaller temperature to the vessel with greater temperature.

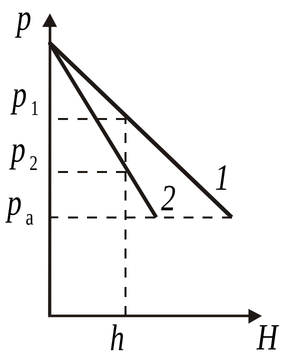


Fig. A.14.

II.34. In both the cases the mercury will flow out along the tube of the barometer which is placed at a greater height. In addition, the level of mercury in the tubes will not change. The mercury will flow from the ditch of the right barometer to the ditch of the left barometer.
II.35. The answer is "no". Otherwise the water will not flow along the riverbed.
II.36. Two glass tubes must be connected with a long rubber tube and filled with the water. Holding one of the tubes on a certain level, the other tube must be displaced along the perimeter with marking a horizontal line.
II.37. In the leg *ÀBC* a water cork is formed which prevent the penetration of gases from sewerage into rooms.
II.38. The petroleum foam has lesser specific weight than that of the proper petroleum. Therefore the height of column of the foam will be greater than the column of petroleum which supports the pressure in the oil layer. This results in a fountain of petroleum foam.
II.39. It is valid.

II.40. The level of the water in both the vessels rises by the height $\Delta h = \dfrac{4m}{\rho(D_1^2 + D_2^2)\pi}$.

II.41. The increase of the kinetic and potential energies of the bubble tales place by the expense of reduction of the potential energy of the water, because when the bubble buoys its place it occupied by the water.
II.42. Yes, because, if a body floats, the buoyant force equals its weight.
II.43. The bar is floating in the water, therefore its weight equals the Archimedes' force $mg = \rho_w g V_w$,

where V_w is the volume of the displaced water, ρ_w being the density of the water. But the bar was floating as well in the oil, therefore the weight of the bar equals the weight of the displaced oil. Since the density of water ρ_w is greater than the density of oil ρ_o, the volume the displaced oil exceed by $a^2{\cdot}h$ the quantity V_w. Therefore $\rho_w V_w = \rho_o(V_w + a^2{\cdot}h)$; hence $V_w = \rho_o{\cdot}a^2{\cdot}h/(\rho_w - \rho_o)$, and from the first equation we get $m = \rho_w{\cdot}\rho_o{\cdot}a^2{\cdot}h/(\rho_w - \rho_o)$.

II.44. Both the center-of–gravity of the bar and that of the water displaced by the bar lie on the same vertical straight line; besides, the center-of-gravity of the bar is directly up the center-of-gravity of the displaced water. The equilibrium of the bar is stable if its floats on its greater face: the center-of-gravity of the system bar-water occupies the lowest among the possible positions.

II.45. This position is stable because the center-of-gravity of a rod with a stone is above the center-of-gravity of the displaced water and thus occupies the lowest position.

II.49. In the kerosene.

II.50. *1* stands for a river, *2* is the summer sea, *3* is the winter sea.

II.51. The kerosene floats up over the surface of water and continues to burn.

II.52. The reading of the dynamometer will decrease.

II.53. Will lower.

II.54. The answer is “no”.

II.55. It will not change.

II.56. If the musk-rat will pull the rope with a force **F**, then the force acting on the arm of the beam of the balance, where the lever is fixed, increases by a quantity equal to this force. As for the force applied to another arm, it equals the resultant force of the weight of glass with water and the force **Q**, which by its value equals the buoyant force, acting on the musk-rat but directed oppositely. As the musk-rat will appear from the water, the force **Q** will decrease. The equilibrium of the balance will be violated and the pan with lever will go down.

II.57. In the motion of the vessel upwards with an acceleration a, the second Newton law for a floating body will be written as follows: $F_{\text{Arch}} - mg = ma$, or $\rho_w(g+a)V_1 = \rho(g+a)V$, where ρ_w is the density of the water, ρ is the density of the substance of the floating body, V is the volume of the body, V_1 is the volume of its merged part. Hence $V_1 = \rho V/\rho_w$. Since in the motionless vessel $\rho Vg = \rho_w gV/n$, we have $\rho/\rho_w = 1/n$. Therefore, $V_1 = V/n$, i.e., the depth of body’s merging in the motion of the vessel upward with the acceleration will not change. The same takes place in the motion downward.

II.58. If the submarine lie over the bottom so that there is no water between the submarine and the bottom, then the pressure upon the lower part of the submarine is absent. The latter means that there is no buoyant force. Moreover, the pressure of water prevent the floating up.

II.59. The buoyant force F, acting on the body, equals $F = \rho Vg - pS$, where $p = p_0 + \rho gh$ ($p_0 = 10^5$Pa is the atmospheric pressure, $\rho = 10^3$kg/m^3 is the density of water). The first addend in the expression for F is the Archimedes’ force, which would act on the body if it was not lying tightly upon the bottom. Note that the expression for F may be both positive and negative in dependence on the ratio between the volume of the body V and the area S of its touching the bottom, i.e., on the form of the body. The condition for floating up is given by the inequality $F > mg$. Thus, $\rho Vg - p_0 S - \rho ghS > mg$, whence

$$h < \frac{V}{S} - \frac{p_0}{\rho g} - \frac{m}{\rho S} = 1.5 \text{ m}.$$

If the level of water in the pool h is less than 1.5m, the body floats up. Consequently, the level of water should be lowered by $\Delta h = h_0 - h = 1.5$m.

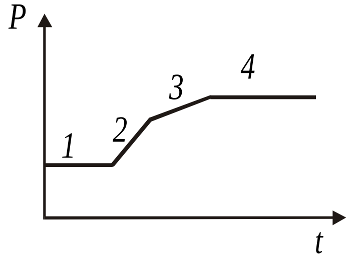


Fig. A.15.

II.60. In the Fig. A.15 the value of the segments is as follows: *1* is the small pan with water, from the large pan the light liquid is displaced, *2* the small pan stands on the bottom of the large pan and is being filled with water, *3* the small pan has been filled with water, water displaces out the light liquid from the large pan, *4* both the pans are filled with water.

II.61. In cases a), c), and d) the level of the water in the glass will not change. In the case b) the level will be lower.

II.62. The rolling down of the ball from the cube lowers the level of water by $h_1 = m/\rho_w S$, while the sink of the ball in the water elevates the level by $h_2 = m/\rho_m S$. This results in a lowering of the water level in the glass by the quantity

$$\Delta h = h_1 - h_2 = \frac{m(\rho_m - \rho_w)}{S\rho_m\rho_w}.$$

II.63. The ball will slightly floats up with respect to the level of mercury.
II.64. No, cannot, because buoying force does not act on bodies merged in water.
II.65. The condition for floatation of this piece of ice gives us: $\rho_i Vg = \rho_w g(V–100)$, whence $V \approx 792{,}3$ cm^3.
II.66. The ball made of a thin rubber will rise higher because it will increase in volume as it rises.
II.67. The buoyant force for balloons and blimps is determined by the difference between the density of the air and the density of the gas filled into a balloon. For the hydrogen this difference equals 1.293 g/cm^3– 0.09g/cm^3 = 1.203g/cm^3. For the helium it is 1.293g/cm^3– 0.18g/cm^3= 1.113g/cm^3. In other words, the buoyant force of two blimps filled one with helium and other with hydrogen will be almost same.
II.68. No, because there is no an atmosphere on the Moon.
II.69. The buoyant force acting on a balloon decreases as the height grows in view of reduction of air's density. This is the reason explaining why cannot a balloon float up as high as one wants.
II.70. Inside the shell of the balloon the pressure is greater than the atmospheric pressure, which leads to its convex form.
II.71. In this argument there is a rational idea because no buoyant force acts on the vessel. However, in practice, this way of rising cannot be realized because the weight of a strong vessel which could resist against the ambient atmospheric pressure will be greater than the buoyant force of the air.
II.72. The philosopher was not acquainted with the Archimedes' law. The blown bull bladder undergoes the buoyant force which equals the weight of the air in it. To weight the air, one must take a vessel whose form does not change in pumping out the air.
II.73. Let us denote by V the volume of the cork, by V_1 and V_2 the volume of the part of the cork which is above the water before and after pumping, respectively; ρ is the density of the cork. Write the condition for the cork be floating before and after pumping: $\rho Vg = \rho_w(V–V_1)g + \rho_0 V_1 g$ and $\rho Vg = \rho_w(V–V_2)g$. Whence

$$V_2 = V_1\frac{\rho_w - \rho_0}{\rho_w}.$$

The part of the cork above the water level lost in volume $\frac{\rho_0}{\rho_w}\cdot 100\%$.
II.74. The density of oil (petroleum) is less than the density of the water, therefore the balloons with oil not fastened to the bottom would float on water's surface. A pump is not necessary, because the pressure of the oil column is less than the pressure of the water upon the balloon. The oil will flow out due to the difference between the pressures.
II.75. The gravity acting on the special costume with a man must be set equal by the Archimedes' force.
II.76. 14m^3.
II.78. The result of the experiment will be same on the Moon and on the Earth. Indeed, the stone weights six times less than on the Earth, but the weight of displaced by the stone liquid is also six time lesser.
II.79. The ball will not rise. There is no Archimedes' force in the zero gravity.
II.80. No, will not.
II.81. In weighting a material whose average density equals that of the loads.
II.82. In following the Archimedes' law, the pan with a wooden cube undergoes greater buoyant force than on the pan with loads. Therefore, if the air is sucked out from the bell jar, the wooden cube will lower the balance.
II.85. In the first case the equilibrium remains; in the second case the heavier eight will go down.
II.86. In the third pail the wooden bar is merged less than in both first and second, therefore it has displaced less water. Consequently, the third pail is heavier than both first and second ones.
II.87. Since the opened end of the long vessel is merged on a depth larger than the open end of the wide vessel, the air in the long vessel is more compressed. Therefore the long vessel displaces less water than the short does, and by the Archimedes' law one must apply a lesser force to merge it into water in comparison with the force necessary for the short vessel.
II.88. The bars sink because their average density is greater than the density of water.

II.89. The weight of the body is 2.0N and it lost in the solution 1.5N, therefore the weight of the solution in body's volume is 1.5N. The body weights 1.0N in the water. Therefore its volume is 100cm^3. If the capacity of the vessel is 250cm^3, the volume of the solution will equal 150cm^3. Since the vessel was filled with the solution up to the middle, for the cylindrical form of the vessel the volume of the solution must be $250/2 = 125$cm^3. In fact, it is 150cm^3. Therefore the vessel is a truncated cone with the area of bottom being grater than the area of the upper hole.
II.90. The balance will show an increase of the vessel's weight. When a finger is merged, a buoyant force starts to act on it, which grows with the depth of merging. By the third Newton law, the finger also will act on the liquid with a force numerically equaling the buoyant force. This force is transmitted onto the balance.
II.91. By the Archimedes' law, the buoyant force is proportional to the volume of the part of a body merged into the liquid. As for the rubber ball, the volume of the merged part is determined by the two factors: 1) by the downward displacement of the center-of-gravity of the ball and 2) by the compression of the ball by forces of the hydrostatic pressure. The first of these factors "works" till the ball is merged partially. The influence of the second factor grows as the ball is being merged and turns decisive tts when the whole ball sinks in the water. As we need to find an approximate functional dependence of the buoyant force on the depth h, for an elastic ball we may neglect its compression for $h \le 2R$. For $h \le 2R$, the volume of the merged part of the ball (see Fig. A.16) is determined by the expression $V = \pi h^2(R - h/3)$. Therefore, for $h \le 2R$, we get the plot of the dependence of the buoyant force on the depth of merging, shown in Fig. A.17 (the segment a). In further merging, the volume of the ball is determined by the compressing forces acting from the side of the liquid. Besides, the pressure of the air in the ball is balanced by the hydrostatic pressure on a given depth ρgh, where ρ is the density of the water. From the equation for the state of the gas inside the ball: $\rho gh \cdot V = \nu RT$ (ν is the quantity of moles inside the ball), we get the volume of the ball $V \propto 1/h$. Therefore, for $h \ge 2R$, the buoyant force decreases as the ball is merged (the segment b) in the Fig. A.17).

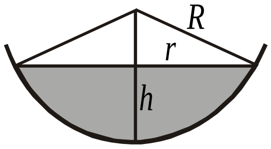


Fig. A.16.

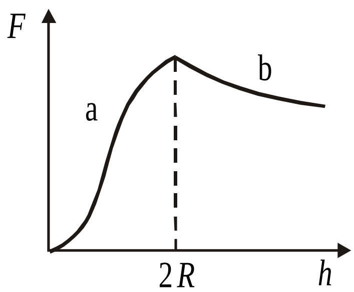


Fig. A.17.

II.92. The pressure of the liquid in the cases a) and b) is same since the piston is movable. The condition for the floating for the case a) can be written as follows: $p = p_{atm} + m_1 g/S_0$, for the case b) it will be $p = p_{atm} + (m_1 + m_0)g/S_0 - \rho gh$, where m_1 is the mass of the cork, m_0 is the mass of the load, ρ is the water's density, p_{atm} is the atmospheric pressure. Hence $m_0 = \rho S_0 h$.
II.93. By the expense of the air resistance the motion of the tennis ball is not a free fall with acceleration g. But the force of resistance depends on the velocity and its action starts to be noticeable under a certain speed of falling. One of the possible ways to solve the problem is to verify the dependence between the initial height h of the ball and the time of falling t: $h = gt^2/2$. The height h_0, for which the difference between evaluated and measured times will exceed a given value (for example. 10%), will be the desired height. As we know h_0, it is of interest to estimate by the formula $v = \sqrt{2gh_0}$ the velocity of the ball under which the air resistance plays an essential role.
II.94. Let S_1 be the area of discharge hole, h the height of the water level in the bath. Consider a water column of the height h and base S_1, which is directly above the discharge hole. Clearly, the time of flowing out of this column can be roughly estimated (neglecting the friction) by the formula .$t = \sqrt{2h/g}$. If S_2 is the area of the bath, the quantity of such columns is $N = S_2/S_1$, and the time of discharging the water from the bath is

$$T = t \cdot N = \sqrt{\frac{2h}{g}} \frac{S_2}{S_1}.$$

Taking $h = 0.3$m, $S_2 = 1$m^2, $S_1 = 10^{-3}$m^2, we get $T \approx 4$min.
II.95. The speed of the flow slows down in the deboucher and particles earlier suspended in the water sink over the bottom.
II.97. Due to the friction between the air and the Earth's surface with objects over it.
II.98. The paddle-wheel will rotate clockwise.
II.99. The paddle-wheel will not rotate.

II.101. In the tube with a narrowing the pigment will earlier reach the end, because by the Bernoulli law the velocity increases. The time of the motion of the pigment in tubes does not depend on the position of a bulb or a narrow place.

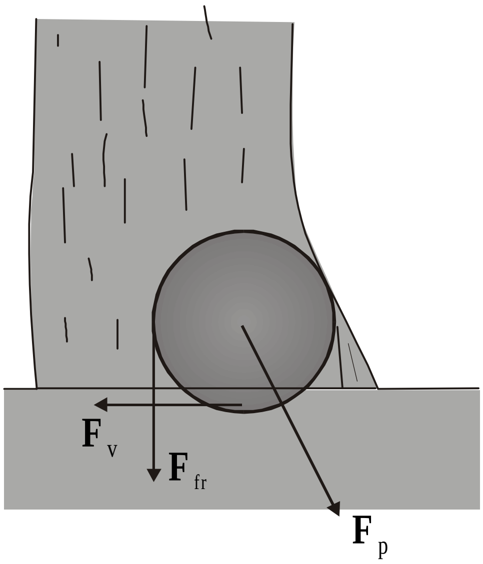


Fig. A.18.

II.102. Let the center of the ball have slightly moved with respect to the jet's axis (see Fig. A.18). Upon the ball under a jet of the water two forces act: the pressure $\mathbf{F}_p$, which tends to expulse the ball from the jet, and the friction force $\mathbf{F}_{fr}$, directed along the tangent and tending to rotate the ball. Since the ball has been partially merged into water, the viscous friction forces $\mathbf{F}_v$ act on it. The rotation of the ball gives rise to its rolling to the jet. The greater is deviation of the ball from the axis, the less is the horizontal component of the force $\mathbf{F}_p$ and greater if the action of the friction upon the ball. Therefore the ball will return under the water jet. Thus, the ball will oscillate under the jet. If the jet is weak, the returning forcers will be weak, too; the oscillations will be slower and with a greater amplitude. If the amplitude will exceed the radius of the jet, the ball will jump out it.

II.103. Forward.

II.104. The stability of a rocket in its flight is ensured by tail stabilizers. If the axis of the rocket starts to deviate from the direction of the velocity, the force acting on the stabilizer return the rocket axis to the least resistance position. Clearly, if a rocket will be launched with its tail forward, the same forces will return it into a normal position. The speed of a rocket with respect to the air depends (it is the sum of the speed of airplane motion and the velocity of the rocket with respect to the airplane) at the initial moment is directed to the same side as the velocity of the airplane, i.e., the rocket moves with its tali forward. Stabilizers return it into "normal position".

II.106. It is better to move from *A* to *B* near the shore, and return near the middle of the river.

II.107. Due to the greater speed of the water in the middle of the river with respect to the speed of water near its shores. Within the high water, the water arrives from high part of the river in quantities larger along the middle current than along the shores. Namely this explain the convexity. In low waters, the water passes in the middle current faster than near shores. Its surface turns concave.

II.108. Swirls are formed behind the automobile. The cause of their rising is the toungn tts between the air layers moving with sharply different velocities.

II.110. Because the formation of swirls in the motion of a train leads to an increase of the necessary tracking force and thus increase the expense of fuel.

II.111. The expense of a viscous liquid (gas) decreases.

II.112. First, upon the interior walls of pipes the water is condensed and frozen (see the previous problem); second, the diameter of pipes reduces due to lower temperature.

II.113. From the law of the continuity of a flow of water is follows that through a lesser section of the flow the same quantity of water must follow in a unit of time, therefore a partially closed hole of a crane is passed by the water with a higher velocity.

II.114. The viscosity of oil decreases in heating.

II.115. It will be easier to put into rotation the bottle with water since, in this case, there will rotate the proper bottle and a thin layer of the water near its walls. The rising friction is small in the water since the viscosity of water is also small.

II.116. It is possible. To this end the egg must be pout upon a table and turned to rotates a consequence of the action of forces of viscous friction, the fresh egg will stop earlier that the cooked one.

II.117. The gravity produces a work to overtake the forces of interior friction and those of the friction with the bottom. The potential energy of the water in its passing from an upper level to a lower level is completely spent to make this work.

II.118. Under attainment of a certain vertical velocity, the fall of drops becomes uniform.

II.119. Behind the first runner the pressure of the air is lesser than in front of him, because here the front resistance force is not present. For the second runner the pressure of air in front of him and behind him are almost the same.

II.120. The force of front resistance decreases.

II.121. In this order the resistance of the air for each bird is the least. In the waving of the wings of the leader, a wave of air is formed. If the waving produced by other birds are well-coordinated, a force supporting the next bird and making its flight easier arises. Observations made on the flights of a flock of cranes shows that the ends of their wings are lying at a sinusoid.
II.122. The resistance is different of the frontal and rare sides of a half-sphere. This leads to a revolution of the wings of the device.
II.123. To reduce the property of being streamlined.
II.124. Through the hole a jet of the air compressed by the parachute flows out. Without such a hole, the parachute turn less stable, auto-oscillation may arise in descent of a man
II.125. The inclination reduces the air resistance and thus a jump can be more far. On the other hand, at the moment of landing the body of ski-jumper is in a more stable position.
II.126. The water drops from clouds in their fall do undergo a great resistance, which explain why do clouds lower so slowly. This can be explained by the fact that the area of a drop is large with respect to its volume, so the force of resistance is close to the gravity acting on the drop. Therefore the upward air flows may "hoist" small drops of water.
II.127. Let us select a small volume Δm of a liquid near its surface. From the neighboring layers of the liquid this volume obtains action of forces perpendicular to its surface (since the liquid moves and something integer). If we take this volume as a part of a thin layer, the forces acting on its lateral faces will be very small and the resulting force of the reaction **N** of the lower layers will be normal to the surface of the selected volume. In addition to the force **N,** the gravity $\Delta m\cdot\mathbf{g}$ will act on the volume. These two forces must give to the selected volume an acceleration which equal the acceleration with which a vessel moves along an inclined plane, which is $g\times$sina. Thus, the resultant of the forces **N** and $\Delta m\cdot\mathbf{g}$ must equal $\Delta m\cdot g\cdot\sin\alpha$ and be directed along the inclined plane. Therefore, **N** is perpendicular to the inclined plane, and the surface of the liquid is parallel to it.
II.128. Within the vaporization of a drop, its radius r decreases. In addition, the air resistance, which is proportional to r^2, reduces more slowly than the gravity does (which is proportional to r^3, their ratio, which is inversely proportional to r, grows as the radius decreases.) Therefore the velocity of a drop decreases as the drop is falling.
II.131. The parts of the stone has a very large surface with respect to their weight and thus meet a greater resistance of the air, which explain why do they fall more slowly.
II.132. In a very rarified atmosphere of Mars the velocity of the fall of drops could attain hundred meters per second (on the Earth, it is near 10–12m/s). At this speed the drops were possessing a significant kinetic energy and could easily destroy an umbrella made of a tissue. But there is a very small quantity of water in the atmosphere of the Mars, and string rains are hardly possible.
II.133. In a flow of a liquid the pressure decreases with an increase of the velocity of the flow. The velocity of the flow of the water in the vessel is certainly less than the velocity of the flow in the tube. Consequently, the pressure of water in the vessel is greater than the pressure of water in the tube Therefore the ball placed on a grid will be pressed to this grid and will not float up.
II.134. The tea has the greatest velocity at its surface and near the center since here it has no friction with walls and bottom of the vessel. In view of a difference between the velocity of the motion of tea near the surface and the bottom, a gap of pressures arises generating two flows: the central flow from the bottom to the surface of the glass, and the bottom flow which moves from the walls to the center. These flows overtake the centrifugal force and join the tea at the center of the glass.
II.135. The presence of a paddle-wheel makes it impossible to make the parts of vessel completely hermetic. The pressure will gradually equalize and the machine will stop when the difference between the pressures in lower and upper parts will be insufficient for hoisting the water to the upper part.
II.136. If the storm wind has a great velocity, the difference between the pressures above the roof and below the roof will attain large values, which destroys the roof.
II.137. These small windows make possible top balance the difference of the pressures (see the previous problem).
II.138. The swirls which are formed when the wind flows around dunes, create zones of a lower pressure. The result is that the sand particles are involved into this domain by an over-pressure from the flowing wind. Due to the smallness of the pressure from the windward side of dunes, the gerbils cannot fly on air jets and fall. The same mechanism tales place for sand banks.
II.141. The experiment can be explained by the Bernoulli tts law: with an increase of the velocity in a jet of air the pressure there decreases.
II.142. A motor boat which does not move is merged into water to balance its weight and the weight of the displaced water. When it moves fast, a buoyant force arises conditioned by the grow

of the dynamical pressure of water $\rho_{water}v^2/2$ (of courser, the dynamical; pressure of air also grows, but it is small with respect to the dynamical pressure of the water since the water is more dense). This dynamical pressure balances the most weight of the motor boat and it almost "flies" slipping over water surface.

II.143. Due to the large area of the wings (airfoil). For instance, if the wings have area 50m^2, we hoisting force is $50\text{m}^2\times10^3\text{N/m}^2 = 5\times10^4\text{N}$.

II.144. As the angle of inclination with respect to the horizon grows (the angle of attack), the lifting force grows by expense of the growing difference between the speeds of the air flows over and under a wing. After attaining a maximum value at a certain angle, the lifting force will decrease (a smooth flowing of an airfoil is destroyed by appearing swirls which come off from a wing and thus increase the resistance). The frontal resistance permanently increases with the increase of the angle of attack.

II.145. The lifting force of an airfoil decreases with growing altitude due to reduction of the air density. Each airplane has a certain altitude, above which neither the construction of wings and structure, nor the engines' power might ensure a lifting force equaling the weight of the airplane. Airplane cannot fly higher than this "ceiling".

II.146. The density of the atmosphere decreases with altitude. Therefore the higher is the flight the less resistance of air must be overtaken and greater speed an be attained.

II.147. The wings (airfoils) made on automobiles are designed to press the automobile to the road at high speeds in order to increase the stability of the automobile.

II.148. The wing of an airplane is motionless with respect to its fuselage and the lifting force is created by the flowing air flowing around the airfoil. The wing of a bird obtains the lifting force by expense of its motion: masses of air are thrown downward by the wing and the bird rises up.

II.149. A motion of air around the kite arises. In this situation, the force of the pressure of the air can be decomposed into the resistance force and the lifting force.

II.150. The lifting force grows with the speed of airplane with respect to the air.

II.151. Against the gravity and the friction of the air.

II.152. By rotation of the ball. The flying ball involves into motion the layers of air around it. If the ball is rotating, the side where the linear speed of the points of the ball's surface with resect to the center-of-gravity coincides by its direction with the direction of the ball, an additional pressure arises. The matter is that at this side of the ball the speed of the air flow is minimal with respect to the ball, because the coming air flow faces the flow involved by the ball rotation. The arising of an exceeding pressure is called the Magnus effect.

Answers to Chapter III

III.2. In spite of the huge speed of the molecules, the diffusion is slow. This can be explained by a great quantity of collisions of molecules in their motion. An average free run of the molecules of the nitrogen, for example, is only $6{\cdot}10^{-8}$m.
III.4. By the strokes of the hammer, the smith draw close to each other two pieces of iron so that they join die to the forces of molecular attraction.
III.5. By a gradual diffusion between two well-polished in their join pieces of metal.
III.6. Formation of the carbide of iron is certainly a chemical process. However, for it could take place even at a small depth, the diffusion of the atoms of carbon into the iron has to take place.
III.7. With an increase of temperature both the velocity of diffusion and the solubility of the sugar in the water grow (the heat of dissolving of sugar in water is negative).
III.8. To draw close plates with large surface, a small difference between the pressures from outer and interior sides suffices. This difference though creates a sensitive force drawing the plates to each other. The presence of this force results in gradual displacement of the air between the plates. The latter makes to increase the difference between pressures and this results in growing of the attracting force. This force may attract plates so that between the molecules of touching surfaces a strong interaction appears.
III.11. The essence of gluing is in the creation of connections between the molecules of the objects and gluing substance; the glue displaces the air from the interval between the objects to be glued and involves these molecules into the domain of the action of glue's molecules.
III.12. Inter-molecular forces work on small distances. Therefore the quality of the gluing depends on how great is the surface of a close contact between the glued objects. For solid bodies it is more difficult because they contact only in some parts ort points of their surfaces. Hence one can derive the value of pressing force in the gluing.
III.13. The molecular hitch between the stucco and water is less than between the stucco and break.
III.14. Modern physics explained the Maxwell paradox. To distinguish the molecules approximating the door, the robot must see them or have another information. The transfer of any signal requires additional energy, say one quantum (there is a lesser energy). A modern robot is a complex cybernetic device. It works by all the rules of modern science: put light on molecules and receives answers as a reflected light. Exact calculations that even most sensitive robot which may distinguish a molecule by a single reflected quantum will spent more energy to know the information about molecule's motion than a power station produces using the difference of temperatures created by the robot. We do not take into account other expenditures (for instance, the energy to open and close the doors). So, even the expenditures for a robot cannot be covered by a useful production. Therefore, this device will not work as necessary.
III.15. In one cubic meter of air $1.6{\cdot}10^{17}$ molecules are present. A man sucks in one breathe near a liter of the air. Therefore $\sim 10^{14}$ molecules of the smeller pass through the nose of the man. Let us note that the sensitivity of men to some molecules is so great that they can feel the response of even several molecules in the air.
III.17. A permanent and order-free motion of water molecules which bomb the particles of flower pollen supports them is a suspension. The distribution of these particles in water is not uniform, more particles in lower layers and less particles in lower layers.
III.18. The most cause for suspended particles not to fall as a sediment is their heat (Brown) motion. If the volume of a particle decreases, so does its mass. For a very tiny particles their weight becomes commensurable with the force of non-balanced pressure which is determined by the change of the summary impulse of the molecules "bombing" a particle in view of its heat motion. Within a size lesser than 0.1 μm the particles are in rather balanced suspended state.
III.21. Since the stability of a suspension is conditioned by heat motion of molecules, to settle faster a suspension, one must reduce the motion. In a cooled milk the cream settles faster.
III.22. The vessel will not heat because in some collisions with walls the molecules transfer their kinetic energy to the walls and become "cooler", while in other collisions with hotter walls they get a part of energy from those walls. The process results in the thermodynamic equilibrium.
III.23. The mercury ball possesses the lesser thermal capacity and the greater thermal conduction that that of water.
III.24. A greater thermal conduction and lesser heat capacity of the mercury with respect to the ether or alcohol reduces the time for measuring the temperature.
III.25. The alcohol one, because the coefficient of volume thermal expansion is greater for the alcohol than for the mercury.
III.26. Mainly due to the anomaly of water expansion. The same readings of the scale were corresponding to different temperatures. The lowest point of the scale were the temperature +4 °C, because in freezing

the water expands. In addition, the water thermometer were possessing a small range of the temperatures to measure: the point of boiling of the water is rather low, while the point of freezing is rather high. Finally, the specific heat is great while the thermal conduction is relatively small. This results in a greater time of measurement, and in the case is the heat capacity of the object to be measured is about or less than that of a thermometer, the result of the measurement can carry errors due to the change of temperature within the measurement.

III.27. This is not possible since the temperature of the drop will be strongly changed.

III.28. In measuring the temperature the thermometer must be heated from the room's temperature to the temperature of a body, i.e., 15–17 °C. One can "shake" the thermometer when its temperature is lowered by 2–3 °C, because the scale of the thermometer starts at 34 °C. We should also note that in heating or cooling of bodies the speed of the change of temperatures is proportional to the difference of the temperatures of the body and the ambient. Therefore the dependence of the temperature of the thermometer (do not mix with the readings of the thermometer!) on the time has the form shown in Fig. A.19. This leads to the fact that the time in which the thermometer is cooled to a temperature when at one may shake it, is much lesser than the time of measuring the temperature.

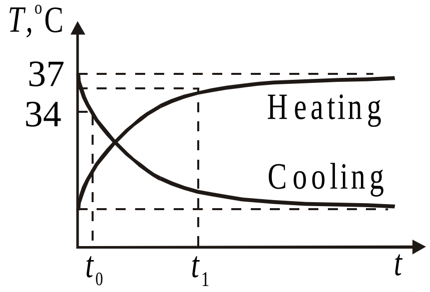


Fig. A.19.

III.29. The answer is "no". The energy of the body does not depend on its position in exterior fields.

III.30. The decrease of the potential energy of the stone $mg(H+h)$ is equivalent to the increase of the potential energy of the water by the quantity $\rho_{water}Vgh$ and the emission of the heat $Q = mg(H+h) - \rho_{water}Vgh$.

III.31. The work of gases is made by the expense of the decrease of their interior energy. In addition, the gases are cooled due to heat exchange in the muffler.

III.32. The heat capacity of the body is greater than its mass.

III.33. The use of the water is economically advantageous: possessing large specific heat capacity, the water is present almost everywhere and makers no chemical harm to man's health.

III.34. There are two reasons: 1) greater heat capacity of the water leads to a slow water heating; 2) the cooling of the water goes due to the vaporization from its surface.

III.35. By the greater heat capacity of the water.

III.36. By removing the flame from candle's filament, the jet of the cool air lowers the temperature of the vapors of the paraffin below a value at which the paraffin may join with the oxygen of the air.

III.38. The sand possesses small heat capacity and thus is quickly heated and quickly cooled.

III.39. The temperature changes which occur in the calorimeter will be more noticeable due to the lesser heat capacity of the kerosene.

III.40. The thermal energy emitted in the explosion goes mainly to the work against the forces of the hydrostatic pressure and is a much lesser degree to the formation of vapor in the bubble (within the time of explosion a great volume of water has no time to be heated and evaporated by virtue of large heat capacity and large heat of vaporization): $Q = p(V_{final} - V_{init}) \approx pV_{final}$ ($p = \rho gh$ is the hydrostatic pressure at the depth h, ρ is the density of the water). Hence it follows that

$$m\lambda \approx \rho gh \cdot 4\pi r^3/3 \text{ and } r \approx \sqrt[3]{\frac{3m\lambda}{4\pi\rho gh}} \approx 0.5 \text{ m}.$$

III.41. In the braking, the mechanical (kinetic) energy of the airplane transforms through the friction into the interior energy of the brake shoes. The brake shoes with a low temperature of inflammation and small specific thermal condition may quickly tts inflame.

III.42. The kinetic energy of a molecule of the air with respect to the spacecraft is large first of all due to its large speed. Within in collisions of molecules with the sheeting of the spacecraft, a part of their energy is transferred to the sheeting. This result in overheating of the sheeting up to melting and vaporization of the sheeting materials.

III.43. The answer is "no". The sheeting of the spacecraft is strongly heated by the friction between it and the air in penetration into dense layers of the atmosphere is spite of their low temperature. As for the altitude 150–200km, the density of the atmosphere is there 10^9 times lesser than on the sea level. Under so small density, the heat capacity is so small that it is not dangerous for the spacecraft.

III.44. One cannot heat the large mass of a steam with a very small mass of these gases even by expense of their heating to a high temperature. So, the steam cannot be heated to the temperature of melting. Take into accept also the heat necessary to overpass the melting process. In addition, the steam is permanently cooled by the ambient air.

III.45. To heat the ball standing on a support one must use more energy because within the heating the center-of-mass of the ball will go up and this requires an additional heat energy to increase the potential energy of the ball. As for the ball which is hung, its center-of-mass lowers.

III.46. In the calorimeter one must use a liquid with a lesser heat capacity, for example, the kerosene.

III.47. In heating the gas under a constant pressure, it expands. If the cylinder is in the position *2*, the gas in its expansion makes a work spent to the hoisting of the piston, i.e., to the increase of its potential energy and the potential energy of the proper gas. Take into account that expanded volume will have a higher center-of-mass. This work is made by expense of the heat drawn to the gas. But if the cylinder is in the position *1*, the piston goes down. The work spent to reduction of the potential energy of the gas and potential energy of the piston is done by the gravity. Thus, from the law of the conservation of energy it follows that, in this case, top heat the gas up to the temperature T one needs less heat than in the case considered above.

III.48. Yes, it can. If the work produced by the gas exceeds the heat draw to the gas, the gas will be cooled and thus its heat capacity will be negative. Let us write out the definition of the heat capacity and use the first principle of the thermodynamics:

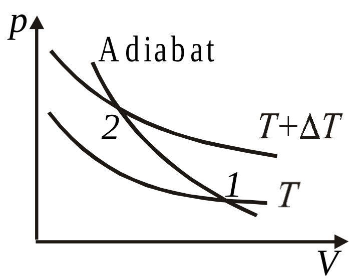


Fig. A.20.

$$C = \frac{\Delta Q}{\Delta T} = \frac{\Delta U + p\Delta V}{\Delta T},$$

where ΔQ is heat drawn to the gas, ΔT is the corresponding change of the temperature of the gas, ΔU is the change if the interior energy of an ideal gas ($\Delta U = C_V \Delta T$, C_V is the heat capacity at a constant volume), ΔV is the change of the volume of gas, p is the pressure which is related to the temperature and the volume via the equation $p = \nu RT/V$ (ν is the quantity of the moles). In order to have $C<0$, the following inequality is necessarily required , i.e., with $\Delta T>0$ one must have $\Delta V < 0$. Consider on the plane (p,V) the two isoterms corresponding to the temperatures T and $T+\Delta T$ ($\Delta T>0$) (see in Fig. A.20). Any adiabatic curve on the plane (p,V) meets two isotherms. Consider the sates *1* and *2*. In the transition from the state *1* to the state *2*, the temperature grows by ΔT, and the volume lowers ($\Delta V<0$). But, in an adiabatic process we have $\Delta Q = 0$ and thus $C= 0$. Therefore the process with a negative heat capacity will be shown on the plane (p,V) by a line which is more slanting than the adiabatic curve, but more steep than the isotherm.

III.49. At the beginning the temperature in the room will decrease: the frozen food in the refrigerator will go to a thermal equilibrium with the ambient. Then the refrigerator, tending to return a low temperature, will start to work intensively. In this situation, the heat drawn from the food will be transferred to the air in the room. In addition, the efficiency of a refrigerator is less that 1, the energy spent for cooling the food is greater than the quantity of heat drawn from the food. A part of this exceeding energy is transferred into heat (friction, Joule heat, etc.). This leads to the situation, in which the temperature in the room will grow and thus will exceed the temperature which took place before we opened the door of the refrigerator.

III.50. The gun-powder cannot be use as a fuel in view of: a) large speed of its combustion; b) small specific heat of combustion. The gasoline cannot replace the gun-powder in view of its combustion being carried out due to the oxygen in the air, which is not present in sufficient quantities in a steam of a gun. As for the gun-powder, it contains the oxygen as a component and thus does not need the air in its combustion.

III.51. The speed of cooling is proportional to the difference between the temperatures of the heated body and the ambient air. Therefore, one should cool the coffee by adding the milk to slow the posterior cooling.

III.52. Let c_p be the specific heat of the substance of the pot, t_1 being the temperature to which the pot will be heated when the mass of water m_w at the temperature of boiling t_b will be added. Using the equation of heat equilibrium, we find $t_1 = (x \cdot t_b + t)/(x+1)$, where $x = m_w c_w / m_p c_p$. Obviously, as greater is x, so greater is t_1. Therefore, if an external cooling is not present, the copper pot is more advantageous for preparing a tea (carry our the numerical evaluations by applying the necessary data). In a preliminary heating by a boiling water, the pot takes a heat and the water poured for tea becomes hotter. The previously warmed up porcelain teapot has a greater heat capacity and lesser thermal conduction than a copper one, therefore it is better than that of the copper.

III.53. At the same temperature the walls of glasses possess different thermal conduction. The thermal conduction of the aluminum is essentially greater than of that made of glass.

III.54. When we touch the mug by lips, we thus cool a part of the mug, a greater quantity of the heat is transferred to lips through the aluminum mug than through that made of porcelain (the thermal conduction of the aluminum is greater than that of the porcelain.)

III.55. When we touch wooden things possessing poor thermal conduction, only a small part of a thing is heated under our fingers. The metals possess a good thermal conduction, therefore in touching metallic things we should heat a larger part of them. This leads to a greater evacuation of heat from our fingers.
III.56. The quantity of heat transferred to the bar which is in the flame is proportional to its lateral surface area. The heat evacuation along the bar is proportional to the cross-cut section of the bar. The ratio of these quantities is proportional to the radius of the bar. Therefore the thermal equilibrium of a nail takes place at a significantly less temperature that that for a thin wire.
III.57. The heat capacity of the cast iron frying pan is than that of an aluminum frying pan of the same size, and thermal conduction of the cast iron is less than of the aluminum. This ensures a more uniform distribution of the temperature over the frying pan..
III.58. The heat runs away the surface of the filament. Since a draw of heat to the surface of the filament also takes place and the temperature inside it is greater.
III.59. An isolated wire is less heated since its "dress" (the oscillation) possess greater thermal conduction than the air.
III.60. A solid cylinder will seem to be cooler.
III.61. First, then drops hit a hot frying-pan, they hiss and quickly evaporate. As the pan turns hotter, the process turns becomes quicker, but till a certain limit. There is a moment, when the drops fallen upon the pan are not evaporated but roll in the form of balls (as the ball if mercury). It is explained as follows. The drops touching the pan's surface start to being vaporized very quickly. The vapor under them supports them and they seem to "fly" over the heated pan as upon an "air pillow". The layer of vapor which supports them simultaneously isolates the drops from the pan, which results in their long dance over pan's surface.
III.62. The thermal conduction of stones is greater than that of the water. Therefore the heat is easily transferred along the stones from lower stones to the upper ones. Therefore the ice here is thicker.
III.63. Into the ice, because the presence of the air in the snow reduces its thermal conduction and decreases its heat capacity with respect to the ice.
III.64. A layer of scum on the walls of an old teapot decreases its thermal conduction and increases its heat capacity.
III.65. As a consequence of evaporation, the temperature of a humid plank is lower than that of a dry plank. In addition, the heat runaway from the surface of a hand in its contact with a humid wood is greater in view of greater heat conduction of the water.
III.67. The thermal conduction and the heat capacity of the water is essentially greater than those of the air.
III.68. To these objective they widely apply porous breaks, foam materials, mineral wadding, other thermo-isolating materials possessing a small heat conduction.
III.69. Greater is the density of a polyfoam, greater is its thermal conduction. A polyfoam with low density has much pores filled with the gases, therefore it has a lesser thermal conduction.
III.70. When a "goose-flesh", the heirs on the skin try to occupy a vertical position thus preventing a free motion of air layers above the skin. This created an "air-coat" around the body helping to conserve the heat emitted by the body. Seemingly, the same process takes place for cats. They usually are more feathery when walk on a cold winter air.
III.71. One must take into account the action of two factors: the evaporation of the moisture from the skin surface and the heat convection between the skin and the air flow.
III.72. The wind's velocity is small with respect to the velocity of chaotic motion of the molecules. Therefore the cooling of the nose by expense eof the heat transfer is essentially above the friction between the nose and the air.
III.73. The copper possesses a greater thermal conduction, therefore when a copper end of a solder cools after meting the tin, it quicker restores its temperature.
III.74. In frosts the birds are ruffling their feathers and thus create an air shirt Aaron their bodies. In the flight the air around a bird always changes taking away the heat. These losses can be so huge that the bird frozen tts.
III.75. A metal has a greater thermal conduction and a smaller specific thermal capacity, which results in a quick balance of temperatures inside a calorimeter and small expenditures for its heating. In addition, the heat emission of a metal is significantly less than that of a glass, which reduces the heat losses.
III.76. No, it does not. Because the rate of cooling of the balls depends not only on their thermal conduction, but also on their heat capacity. The specific heat capacity of the lead (130 J/kg) is lesser than for most metals. As for the thermal conduction of the lead, it is lesser that of many metals.
III.77. Of course.
III.78. No, a fur coat has a poor thermal conduction and thus only keeps the heat of a human body.
III.80. The air contacting with a soil not covered by snow is always in a motion and is being mixed. This

moving air removes the heat of soil and increases the evaporation of the moisture As for the air which is inside the particles of snow, it is rather motionless and prevents the soil against being frozen solid since it is a poor conductor of heat.

III.81. The quantity of the heat emitted to the ambient in the unit of time is proportional to the difference between the temperatures of the body and the ambient. Therefore to heat the water in the second case it is require much time because the greater quantity of heat will pass to the ambient (air).

III.82. By the that of power 1kWt since in this case the water is heated more rapidly and thus less heat will be given to air ambient.

III.83. The heat is proportional to the difference between the temperatures. Let us introduce the notation:: T_{s1}, T_{s2} and T_{r1}, T_{r2} are the temperatures on the street and in the room for the first and second cases. The heat given by the battery in the unit of time equals $k_1(T–T_r)$, where k_1 is a certain factor and T is the temperature of the battery. The heat given out from the room to street in the unit of time is $k_2(T_r–T_s)$, where k_2 is another factor. The equations of heat balance for the two cases are: $k_1(T–T_{r1}) = k_2(T_{r1}–T_{s1})$, $k_1(T–T_{r2}) = k_2(T_{r2}–T_{s2})$. By dividing one equation by other, we find $(T–T_{r1})/(T–T_{r2}) = (T_{r1}–T_{s1})/(T_{r2}–T_{s2})$, whence it follows $T = (T_{r2}T_{s1}-T_{r1}T_{s2})/(T_{r2}+T_{s1}–T_{s2}–T_{r1}) = 60\ ^{o}C$.

III.84. Even in most calm weather some vertical convection flows of the air over ground exist. The leaves of aspen have thin and long hafts and thus are sensitive to a very small displacements of the air.

III.85. The basic cause is in weakening of air convection flows at night with respect to the day-time.

III.86. Convection flows guarantee a higher temperature about the surface of a liquid. Since in the dissolution of sugar and salt an energy is absorbed, the dissolution of these substances is faster at a higher temperature.

III.87. For mixing the air and creation of a uniform temperature.

III.88. In the fall of the glass pan with candle the latter goes out. It is explained by interruption of convection as a result of zero gravity. Hence it is clear that, in particular, for mixing the air in a spacecraft it is necessary to provide a special ventilation.

III.89. The gases created in the burning and vapors expand due to heating and become less dense. Therefore their leave their place and are replaced upwards by the clean air.

III.90. The ice-cream melts because it absorbs the heat from ambient. As the air near the ice-cream turns cooler, it goes down and becomes replaced with a more warm air. Quicker is this exchange, faster will melt the ice-cream. The fan makes the melting even faster.

III.91. In any room, there are always invisible air flows generated by heating and cooling of the air. Having been heated, the air expands and its density decreases. The cooled air have thus greater density. The cool air goes down from the window to the floor, then it is heated again and thus "travels" over the space of the room. Namely this motion is felt by us when we stand near a window.

III.92. To avoid the losses of energy by the convection of air between the walls.

III.93. The flows of convection hoist tiny particles of dust which then form sediments on a lamp-shadow or over a ceiling.

III.94. In the increase of the velocity of circulation, more heat is drawn away from the sources of heating and thus less losses take place.

III.95. In compressing a string, the air flows out the ball and doe snot reserve the energy necessary for going up

III.96. As the pressure grows and the temperature decreases, the air dissolves better in water. When the water flows out from a tap, a part of the air solved in the water goes out as a huge quantity of air bubbles. Due to multiple reflections in water, it turns like a milk. After a certain time, by the Archimedes' force action these bubbles leave water and it turns transparent again.

III.97. The buoyant force is proportional to the volume of the bubble. When a bubble floats up, its volume grows and the buoyant force also grows.

III.98. The volume of the ball can be determined by the volume of the displaced liquid. The ball displaces slightly greater amount of hot water because its volume grows due to heating and thus expansion of the air.

III.99. The interior pressure of gases of a deep-water fish is greater than the atmospheric pressure. Therefore, in the air, fish's bubble expands and blows up the fish's body.

III.100. The Boyle-Mariotte law is valid for a constant quantity of an ideal gas. In one's blowing his cheeks, the quantity of the air grows and thus the Boyle-Mariotte law is not fulfilled.

III.101. The pressure of the air which is contained in the pores of a wood grows in heating. The fibers of the wood blow up and we hear a crackle and the particles of hot charcoal jumps over a log.

III.102. In a valley, because a greater amount of cold air is accumulated there due to its greater density.

III.103. The smoke pipes are built high to increase their pulling force: at the bottom end of the pipe the pressure is greater than at the upper end. This exceeding pressure grows as grow the temperature of a gas. Therefore the break pipes are better than the iron ones, because the heated gas emits tts less heat to the ambient air through a break wall.

III.104. When the heated air is cooled in the glass its pressure upon the walls and bottom decreases. This sucks the water into the interior of the glass.

III.106. When the gun-powder explodes namely in the thicker part of a steam, it produces giant pressure in rather small room. Namely to prevent an explosion the walls are thicker in the part where the beginning of the explosion takes place.

III.107. Mainly to for ignition of the fuel by a heat emitted under strong adiabatic compression.

III.108. It varies. It is less in summer. Clearly, it follows from Clapeyron-Mendeleev's law ($\nu = pV/RT$).

III.109. To avoid the exceeding by nitrogen of the atmospheric pressure in heating of incandescent filament of the lamp.

III.110. The pressure will grow, because the temperature of the air, which has been lowered in practically adiabatic (due to high speed) expansion, will go up until an equilibrium with the temperature of the ambient air. By the value of this pressure and by the pressure before the air was liberated, one can evaluate the power of adiabatic curve and the heat capacity of the ideal gas under a constant volume and pressure (the Clement-Desormes method).

III.112. The Earth's troposphere obtains a heat energy in the exchange with the Earth's surface, which is heated by expense of the strong absorption of the solar radiation. In its way upwards, the air cools due to expansion. Finally, in the troposphere, the lower layers have, as a rule, a higher temperature with respect to the upper layers. Which leads to a convection.

III.113. Expands.

III.114. A humid air is a mixture of a dry air and a water vapor. The water vapor is lighter than the atmospheric air. Therefore a liter of dry air weights more than a liter of a humid air under other condition being equal.

III.115. Considering the expansion, one can neglect the pressure of saturated vapors in the pail, because at temperatures near the temperature in a room this pressure is almost 50 times lesser than the atmospheric pressure. The pressure of the air under a pail is determined by the weight of the load and remain unchanged. Therefore in a decrease of the temperature, the volume of the air also decreases. Since the value of the atmospheric pressure does not change, the difference of the levels of the water in the lake and inside the pail does not change. This means that the pail will slight sink deeper into water.

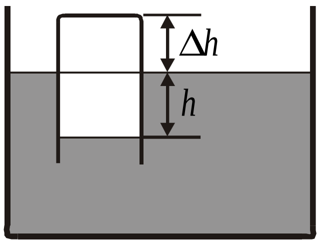


Fig. A.21.

III.116. The pressure inside the glass p is same for both the temperatures ands is determined via the condition for the equilibrium of the glass $mg = (p - p_0)S$. Under the initial temperature the pressure in the glass equals that of the air. After heating up to 100°C the pressure of the saturating water vapor in the glass becomes equal to the turns atmospheric pressure p_0. By the same quantity the pressure must decrease by expense of its expansion. To the air in the glass we can apply the equation of the state of gas: $pV_1/T_1 = (p - p_0)V_2/T_2$. Since $p = p_0 + \rho gh$ (see Fig. A.21), $V_1 = Sh$, $V_2 = S(h + \Delta h)$, we get

$$\frac{(p_0 + \rho gh)hS}{T_1} = \frac{\rho gh(h + \Delta h)S}{T_2}.$$

Taking into account that $mg = \rho ghS$, we have

$$\frac{p_0 + g\dfrac{m}{S}}{T_1} = \frac{\rho g\left(\dfrac{m}{\rho S} + \Delta h\right)}{T_2}.$$

Hence

$$\Delta h = \frac{1}{\rho g}\left[\left(p_0 + \frac{mg}{S}\right)\frac{T_2}{T_1} - \frac{mg}{S}\right].$$

III.117. On the segment AB the volume of the gas increases, it does not change on BC. To understand this, draw isochors in the plane p,T.

III.118. The process which takes place in the system may be divided into two stages. First takes place in the turn of the vessel. The state of the gas here does not change (the vessel is thermally isolated and the walls are motionless). The second stage takes place after deliberation of the piston. In this situation, since the weight of the piston now is compensated by both the gas's pressure and the reaction from the walls of vessel, the gas expands. Since the vessel is isolated against heat transfer and has firm walls, the energy conservation law takes place. Denote by ν the quantity of moles of the gas, m is the mass of the piston, T_1, V_1 and T_2, V_2 are the initial (their value does not change after rotation of the vessel) and final temperatures and volumes of the gas, respectively, S stands for the area of the piston. Write out the law of conservation of energy for the process of adiabatic expansion of the gas

$$\frac{3}{2}\nu RT_2 - \frac{3}{2}\nu RT_1 = mg\frac{V_1 - V_2}{S}\cos\alpha$$

For the initial and final state of the gas we have from the Clapeyron–Mendeleev equation $V_1 mg/S = \nu RT_1$ and $V_2 mg\cdot\cos\alpha/S = \nu RT_2$, whence

$$\frac{V_2}{V_1} = \frac{3+2\cos\alpha}{5\cos\alpha} = 1,6.$$

III.119. The ball will float up if the buoyant force is greater than the weight of the sheet and the hot air inside the shell: $F_{Arch} > (m+m_1)g$, where m is the mass of the shell, m_1 is the mass of the hot air. The buoyant force equals the weight of the displaced cold air $F_{Arch} = m_2 g$ (m_2 is the mass of the displaced air). Then the condition for ball's taking off is $m_2 > m+m_1$. Considering the air as an ideal gas, we have $m_2 = MpV/RT$, $m_1 = MpV/RT_1$, where Ò is the temperature of the cold air, T_1 is the temperature of the hot air. From the condition of taking off we have

$$T_1 - T = \frac{mRT^2}{MpV - mRT} \approx 5\text{ K (!)}.$$

III.120. Yes, it is possible. One may turn this substance into gas state and determine the density of the gas obtained. . Using the density of a known gas, which is under the same conditions, one can determine the molecular mass of the unknown substance: the ratio of the molecular masses of these gases equals the ratio of their densities.

III.121. This is explained by a small and insignificant expansion of the liquid in the hydraulic press when the pressure is taken off. But if an explosion of a water boiler occurs and vapor quickly runs off out the boiler, the pressure over the liquid surface sharply decreases and the almost all volume of water turns immediately into a vapor. The latter in its expansion produces huge destruction.

III.122. The molecular pressure in the liquids is not a pressure in the ordinary sense. This is the effect of the mutual attraction between molecules, which makes them to draw closer to each other as if somebody compressed the liquid from exterior space. We cannot directly measure the molecular pressure. By merging a manometer into a liquid we only read the hydrostatic pressure. The attraction forces acting on the molecules of the surface layer of the liquid are directed inside the liquid and thus they do not affect an object which is in the liquid. Practical incompressibility of liquids testifies that this pressure is great by its value.

III.123. On the value of the sagging two factor are acting: the surface tension and the weight of the water suck by the rope. If the moistening is not strong, the force of the surface tension overtake and the sagging is less. The stronger is moistened a rope, the greater is its sagging.

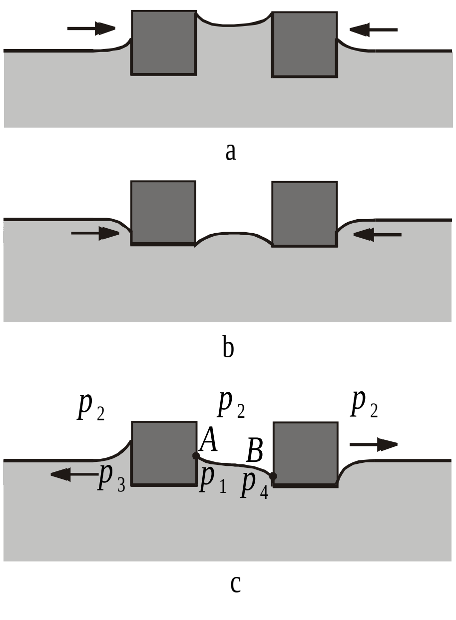


Fig. A.22.

III.126. As a consequence of the surface tension, the melted end of the tube takes a round form which gives the least surface.

III.127. Between the molecules of the water attracting forces are acting. Large force of wind is required to overcome these forces. As for the particles of the sand, these are easily hoisted by the air since there are practically no forces of mutual attraction. However, if the sand is moistened with water, the wind cannot so easily hoist them, the surface tension starts to work.

III.128. First, to reduce the temperature of the air by expense of the absorption of hidden heat of vaporizing. Second, to reduce the dust in the air (see the answer to the previous problem).

III.129. The mercury does not moisten the glass, therefore it cannot to flow under the glass plate.

III.130. The paper sinks in view of the water which penetrates into its pores and displaces the air. A small needle which is not moistened by water does not sink due to surface tension.

III.131. Consider the interaction between the match ends not covered by paraffin. In this case the surface of the water takes the form shown in Fig. A.22a. The pressure in the part of the

liquid which goes up becomes lesser than that of the atmosphere. The latter tends to draw the ends of matches closer to each other. When the end of moth matches are covered by paraffin, the surface of water takes the form shown in Fig. A.22b. In this situation, the pressure of the air is less than the pressure of the water on other sides of the matches. The ends of the matches are attracted to each other. The surface if water in the case of "different charges" of the ends is shown in Fig. A.22c. Given that these ends are near each other, the surface of water between them is not horizontal. It has a saddle point somewhere between the matches. The result is that the water between these matches rises greater near the left match and does down more near the right match in comparison with the water in remaining part. Namely this factor generates the "repulsion" between the "different" ends of matches. The pressure of the water at the point *À* is equal to the pressure of the outside water p_3 at the same height. The pressure of the air p_2 is greater than p_1, because the surface near the left match is turned to the air by its concave side. The pressure p_3 decreases with height, meanwhile p_2 remains practically same. Therefore the difference between the pressures tends to displace the left match to the left. At the point *Â* the pressure of the water p_4 is greater than p_2, since the surface of water is turned to the outside by its convex side. The same is also correct for the pressure below this point. The resulting difference between the pressures p_4-p_2 will displace the right match to the right.
III.132. The water after moistening the corks closely drawn to each other will keep them close by the surface tension forces.

III.134. $Q = mgh - 2\pi r^2\sigma\left(\sqrt[3]{n} - 1\right).$

III.135. The lines of the tarpaulin of which the tent is made form a capillary system which are not moisten with water. In this capillaries a little columns of water are kept, their radii equaling a half of the size *d* of a cells formed by lines of tarpaulin. These columns will be pressed through cells if their height (the thickness of rainwater covering the tent's ceiling) is greater than

$$h = \frac{2\sigma}{\rho g \dfrac{d}{2}}.$$

If one touches the wet tissue from inside the tent, some columns give a drop of a greater radius. This drop already cannot be kept by capillary forces (the force of the surface tension which keeps the drop grows proportionally to its radius while the weight of a drop grows as a square of the radius (the drop is flat), i.e., which quicker). The ceiling stops to sustain against the rain.
III.136. The coefficient of the surface tension of a soap solution is less than that of water, therefore the water tend to shorten its surface (turn into a drop) stronger than the soap solution.
III.138. We merge an edge of the sheet of paper into liquid, keeping the sheet vertically. Then we measure the height of water rising *h*. By the formula $r = 2\sigma/(\rho gh)$ we find the radii of capillaries.
III.139. A soap solution will "flow out" the frame, involving the surface of water due to a lesser surface tension; the whole frame will move in opposite direction (a kind of a jet engine).
III.140. Denote by *l* the height of liquid which gone up in a straight capillary height $l = 2\sigma/\rho gr$. In order to elevate the water along the tube it is necessary that $l > h$. To start to flow out from the lower end, there must hold $H > l$. Then we get that the liquid will flow out if

$$\rho gh \cdot \frac{r}{2} < \sigma < \rho gH \cdot \frac{r}{2}.$$

By substitution of the data, we get 69,3 mN/m $< \sigma <$ 73,5 mN/m. Hence we get the desired range of the temperatures 17°C $< t <$ 45°C.
III.141. It turns into some drops of soap water, whose surface is much smaller than that of the soap bubble.
III.142. The ends of the legs of insects are not moistened with water and thus cannot penetrate its surface film.
III.143. The force of surface tension. Though in the Earth conditions a liquid may be kept in volumes and each time takes their form, in the zero gravity conditions any quantity of a liquid can freely "fly" or "hang" in a space. Under the action of the surface tension the liquid takes the form of a sphere (if the temperatures are same in all parts), not needing any vessel to keep it inside. This phenomenon obtained the name of levitation.
III.144. No, in this case the casting cannot be drawn away of the form or matrix.
III.145. The forces of attraction between the molecules of the oxides are weak, there is no moisturizing. The cleaning of the metallic surfaces before soldering is necessary for obtain the moisturizing of surfaces by

the solder.
III.146. Aluminum cannot be moisten by the melted tin.
III.148. Both the kerosene and gear machine oil well moisten the iron. Penetrating into thin slots between contacting surfaces, these liquids play role of a lubricator in unscrewing a nut.
III.151. Non–moistening liquid will tend to take the form of a ball, the moistening one will flow over the surface of the vessel.
III.152. They must. A lubricant moistening a metallic surface fills its cavities. After that a dry friction between metals is replaced with a lesser friction between the layers of a lubricator.
III.153. A liquid which does not moisten the surface of the glass.
III.154. These tissues are poorly moistened by water.
III.155. The chalk is porous; it will absorb the water, i.e., its cap9illaries will be filled with a moisture from the tissue. The chalk stops to write.
III.156. The chalk possesses the capillaries of lesser diameter than the foam.
III.157. The moistening of a paper by glue reduces its porosity (name the latter provides the capillaries of the paper, which "helps" to ink "run away" of pen's trace).
III.160. The ramming of soils and the cultivation after plowing lead to destroying its capillaries, the water inside the soil then cannot go up, and the soil keeps water inside itself better than with old capillary system.
III.161. By pressing upon a pen, we draw apart the cut at its end, thus making this "capillary" thicker. Ink gradually goes on the paper. If there were no such a cut, the ink cannot be kept over pen.
III.162. The mercury moistens a pure lead. Closely packed sheets of the lead form small capillary channels and slots which "suck up" the mercury from the vessel.
III.163. Adherent tts is the mercury in the upper tube and water in the lower tube. The mercury will be pushed in the direction of the thicker end of the tube, the water to the narrow end.
III.164. The soil becomes more dense, along the capillary system the water goies up and moisten the trace.
III.165. The level of the water in the tube will grow.
III.166. The bubbles of the air stick to particles whihc are not moistened by water and thus hoist them up.
III.167. Without a "ground painting" by drying oil the solvents of paints are suck by capillaries into wood. This increases the consumption of a paint, while on the painted surface a powder of its pigment remains which can then be easily removed. The "ground painting" fills the capillaries and a later painting creates a glancing firm and beautiful covering.
III.168. Consider two drops of water: one has just left the tube, while other has fallen a certain distance, moving with an acceleration caused by the gravity. The velocity of the lower drop is greater than that of the upper drop. This means that the distance between the drops will grow with time. The jet of water will turn more and more narrow until the force of surface tension will cut it into drops. Therefore in the breaking apart of the jet of water falling in the gravity field not the exterior force (shakes) are guilty, but the forces of surface tension.
III.169. The surface tension of a hot water is less than that of a cold water. Therefore the weight of a drop of the hot water kept by surface tension is less than that of the cold water.
III.170. Yes, it is. For a definite drug under a permanent temperature and the same diameter of dropper's end, the weight of drops will be practically same..
III.171. 1. The soap bubble with a hole contracts its size. Due to the action of the surface tension forces the soap film of spherical form presses the air inside it. **2**. Let us mentally cut the bubble through the center of its sphere. Then each half of the film will act upon the other with the force $F = 2\pi r\sigma$ (r is the radius of the bubble). The film will also act on the circle hole through the air $p = F/\pi r^2 = 2\sigma/r$. Since the soap film has two surfaces, the air will experiences additional pressure $p = 4s/r$.
III.172. Usually, the exceeding pressure under the spherical surface is $\Delta p = 2\sigma/r$, but the soap bubble has two boundaries liquid-air. Let p_0–be the atmospheric pressure, p_1, p_2, and p the pressures of air in the bubbles of the radii r_1, r_2, and r, respectively. Then $p_1–p_0 = 4\sigma/r_1$, $p_2–p_0 = 4\sigma/r_2$, and $p–p_0 = 4\sigma/r$. The Clapeyron-Mendeleev equation for the air inside the bubble gives

$$p_1 \frac{4}{3}\pi r_1^3 = \frac{m_1}{M}RT,\ p_2 \frac{4}{3}\pi r_2^3 = \frac{m_2}{M}RT,\ p\frac{4}{3}\pi r^3 = \frac{m_1 + m_2}{M}RT,$$

whence

$$pr^3 = p_1 r_1^3 + p_2 r_2^3.$$

Then the atmospheric pressure is

$$p_0 = \frac{4\sigma(r_1^2 + r_2^2 - r^2)}{r^3 - r_1^3 - r_2^3}.$$

III.173. In a close packing each molecule has 12 neighbors: 6 around it, 3 at each side of the plane of ring. In creating a free surface, we delete three neighbors of twelve, which is we break out a quarter of connections. If s is the coefficient of the surface tension (which is the energy necessary to increase the area of a surface by a unit), and r is the specific heat of vaporizing, then $A = \sigma S = r\cdot m/4 = r\cdot\rho V/4 = r\cdot\rho Sd/4$, where d is the diameter of a molecule (the height of one layer). Hence $d = 4\sigma/\rho r$. For the mercury we have σ= 0,47J/m^2, r = 2,95·10^{5}J/kg, ρ= 13,5·10^{3}kg/m^3 and $d \approx 4{,}7\times10^{-10}$m.
III.174. The phenomena observed are explained by diffusion whose velocity in one direction (to the interior of a fruit) is greater than in opposite direction (out of the fruit). This phenomenon, called osmosis, is similar to the diffusion of gases through a porous membrane.
III.176. Any crystal, can be represented as elementary combinations of atoms called elementary cells. The symmetry of any crystal is determined by the symmetry of elementary cells. The elementary cell of the crystal of salt has the form of a cube. Therefore the piece of this salt can take only the forms with direct angles.
III.177. Different orientation of small crystals leads to the fact that poly-crystal bodies possess features equals in all directions.
III.178. In the physics they understand by a solid body a crystal. The glass in this sense cannot be called a solid body; it is related to the class of amorphous bodies, whose state is not stable and changes with time.
III.179. As a consequence of the anisotropy of a crystal, it may expand differently in different directions.
III.180. Usually, the metals have a poly-crystallic structure. In this situation, correct mono-crystals are chaotically joined. By virtue of a great number of macro-crystals, in a sample of a macroscopic size anisotropy is not detected..
III.181. The pattern is a result of crystallization of the zinc.
III.182. To obtain the residue deformation of a steel sample (for example in bending) less force is required than for a sample of cast iron.
III.183. A poly-crystal consists of a set of grains-crystals. In a plastic deformation this makes difficult the sliding of atom surfaces in grains and the displacement of proper grains.
III.184. A huge set of snow-flakes (crystals) is being broken.
III.185. The water inside the salt in boiling breaks the crystals.
III.186. For creation of a diamond the high temperatures (2×10^3 ^{o}C and higher) and high pressures (near 10^{5}atm) are necessary. The diamonds might be formed only in depths of Earth. The graphite might be formed at lower temperatures and pressures. These domains are many on the Earth.
III.187. Under a slow cooling a large quantity of heat will be emitted. In the hardening of a steel, the surface energy of faces of small crystal grains “is kept”.
III.188. One of the advantages is the absence of heat convection. The quality of the samples made in zero gravity is essintially higher than in Earth. Thus, in the crystals obtained in the space, the density of dislocations is several thousand times less than in Earth samples. In the space one can obtain the alloys of metals which differ essentially by their densities, grow from the liquid phase crystals of semiconductors and dielectrics with homogeneous distribution of addends and components, prepare superclean biomedical substances. In addition, the experiments of covering with a thin metallic layer (thin films) of various objects by vaporizing in absolute vacuum conditions are of a significant interest.
III.189. A tree is an anisotropic fiber material, its properties differ in different directions. Dividing the fibers require less efforts than the cross-cutting.
III.192. The metallic patterns are necessary to make the column harder, to increase its resistance against the compressing deformations. Deformation does not result in a destruction if the compression of the reinforced concrete and the metallic patterns are same (this takes place if the steel is used to reinforce the concrete) and their load does not exceed the limit of elasticity.
III.193. The shafts in work undergo the torsion deformation. A tubular shaft with thin walls under rather small deforming loads overpasses the limits of elasticity and crushes (turns flat).
III.194. 230m.
III.195. 9,5 MPa.
III.196. The crystal structure of a diamond has higher symmetry than the crystals of graphite. In the crystal of graphite distances between atoms exceeds those for a diamond is some directions. The graphite may be broken apart in directions perpendicular to these segments.
III.197. Since the plastic deformation precedes the destruction, to make metal stronger one must augment its resistance against plastic deformations. The main mechanism in a plastic deformation of ac crystal is the relative sliding of the atomic layers, which rises when dislocations are moved. Other defects prevent the motion of dislocations. The quantity of defects grows under doping (the adding of tinges), mechanical or thermal treatment. In low temperatures the distances between grains also prevent the motion of dislocations in poly-crystals. Therefore, the fining of grains by means of mechanical or/and thermal treatment also

increases the resistance against plastic deformations.
III.198. As the purity of a metal grows, so does its toughness. For example, copper samples of high purity sustain the loads up to 6 GPa.
III.200. In the hardening, both the hardness and the toughness of a steel grow. The steel adheres a tiny-grain structure.
III.201. Since the temperature of the boiling of mineral oils is significantly higher than that of the water, in cooling a sharp contrast of temperatures does not appear, which resells in less frailty of the steel and higher hardness and toughness.
III.202. To give to the metals necessary combination of the hardness, toughness, and elasticity they anneal metals. After this procedure the density of dislocations sharply decreases, the anisotropy is practically vanishes..
III.203. These parts could lose their toughness due to string heating by the friction with air.
III.204. In sharpening, the tools are strongly heated by friction. If one will not cool them, they lose their hardness.
III.207. In same degree.
III.208. A metal possesses a larger thermal conduction than a stone. In oscillations of the temperature, no rifts appear in metal because no thermal tensions happen.
III.209. If the vessel is made of a thin glass, its parts are heated almost simultaneously and expansion of vessel's walls goes almost uniform.
III.211. The aperture will grow.
III.212. Must heat both the cylinder and the ring.
III.213. No; Yes.
III.214. In heating, the spoke expands and bends not causing the deformation of the wheel in the whole.
III.215. Because the washing with cold water gives rise to non-uniform cooling of separate parts and thus dangerous interior tensions in these parts. These tensions may cause destruction (for example, a breakup of the tubes in the boiler which are cooled first of all).
III.216. This property is explained by a very small coefficient of the thermal expansion of the quartz.
III.217. Even a small change of the temperature (e.g., given by holding the device in hands) may cause a serious and intolerable error of measurements in view of thermal expansion of details. The invar tts possesses a very small coefficient of thermal expansion.
III.218. The steel and the concrete have the same coefficient of thermal expansion. Therefore under expansion the concrete remains close to the steel reinforcement patterns. Neither cavities, nor interior tensions arise which could lead to a destruction (the latter could take place in the steel patterns were expanding quicker than the concrete).
III.221. As the hot water heats the tap, its metallic details also expand and close the flow of the hot water.
III.222. Will not change if we neglect vessel's expansion; will be smaller if the expansion of the vessel is observable.
III.223. The level will grow. In the expansion of the tube , the reading of the device will be lowered.
III.224. The body will sink if the initial temperature is greater than 4°C.
III.225. Under a heating the density of water decreases, but its level increases. It is necessary to note that the pressures upon the bottom of the vessels are stipulated by different factors. In the cylindrical vessel the pressure is determined by the weight of the liquid and thus is independent of its expansion. In a vessel which turns narrower to its bottom, the reaction of the lateral walls is added to the weight of the liquid (by virtue of the Pascal law). In such a vessel under thermal expansion o the liquid the force of the reaction of lateral walls increases (due to the increase of the are of their contact with the liquid) as well as the pressure upon the bottom. In a vessel which is expanding to its top, the reaction of the lateral walls decreases the pressure on the liquid upon the bottom. In heating of the liquid in such a vessel, the force of the reaction of walls is also increasing, which in the present case leads to a decrease of the pressure upon the bottom.
III.226. The balance will show a smaller weight because in heating the volume of the kerosene increases. Consequently, the volume of the air displaced also grows.
III.227. The matter is in the thermal expansion of materials. Since the air possesses the greater compressibility than water does, the change of the volume of the bubble is determined by the change of the volume of water.
III.228. It will remain.
III.229. The lead sheet is heated by the Sun and thus expands. Since the gravity helps it to move downward, the upper edge will go up for less distance than the lower one will go down. In its cooling during the night, the upper edge goes down slightly more than the lower goes up, and thus the sheet goes down in the whole.
III.230. A significant role was played by the point of melting of the bronze, which is lower than that of the

iron.
III.231. The high temperature of melting of the quartz (1625 °C) requires greater expenses of energy in its production.
III.232. The motion of the water carries up more warm water from the bottom of the river.
III.233. usually, the water formed in melting of ice runs off immediately. But if the ice is covered with a wet newspaper, the heat from outside must first pass through the layer of water "arrested" by the newspaper. Therefore its access to the ice decreases. In addition, the heat is spent with the evaporation of the water.
III.234. The water possesses the greatest density at the temperature 4 °C. Therefore the layers of water, possessing the temperature near 0 °C, are on the top due to the Archimedes' law.
III.235. The water freezes at 0 °C. First it is cooled to this temperature and then the ice starts to form. However, of the vessels are made of a thermo-isolating meterial, the heat transfer through the walls will be very small, and the cooling will proceed only through the evaporation from the surface. In evaporating, a vapor appears over the surface of liquid, whose pressure changes with time. If the vessel is closed, this vapor quickly becomes saturated with the pressure p_{sat}, equaling the pressure of the saturated vapor at the given temperature. Then the further cooling takes place only by the expense of heat transfer. In our case, both the vessels are closed. The pressure p_{sat} depends on the temperature and grows as it increases. Therefore over a hot liquid the pressure the vapor is much lesser and the liquid quickly cools in view of intensive evaporation. In evaporation the mass of the liquid permanently decreases, therefore when the temperature of the water reaches 0 °C, in the "hot" vessel there will be noticeably less water than on the cold one. The crystallization in both the vessels will follow in same conditions. Thus, under certain conditions, when the exchange with ambient is difficult and the open surface is large, the boiling water will freeze faster than the water taken under a tap.
III.236. The plant is filled not by water, but a physiological solution, which freezes at a temperature below zero. While the plant has not been frozen, the current of the solution continues (though at a slow speed). In addition, the temperature of the liquid pumped from the root part of the plant is slightly but above the zero. Moreover, many plants have small hairs which delay the motion of air. A layer of the air around the plant is a good isolator.
III.237. With an increase of the pressure the temperature of ice melting decreases. Within the melting of ice, the heat of melting is absorbed by the ice and the temperature under a wire or a line falls to the temperature of the ice melting at this pressure. The further melting of ice is determined by the heat which incomes to the domain of lower temperature due to the thermal conduction. When a wire is used, the heat will income also by virtue of high thermal conduction of metals from the water above the wire and the ice will quickly be cut. If a nylon line is used possessing lower thermal conduction the heat will mainly arrive by expense of the cooling of the whole mass of ice, and the process will be very slow.
III.238. In the melting of ice at the bottom of a glacier its height lowers by Δh. The decrease of the potential energy equals $q \cdot \Delta m$, which is spent to the melting of ice of the mass $\Delta m = \rho S \Delta h$ (ρ is the density of the ice, S is the section of the glacier, $q = 333$kJ/kg is the specific heat of melting of the ice). For a glacier of height H we get $\Delta mgH = q \cdot \Delta m$, whence $H = q/g \approx 35$ km.
III.239. In a compression of snow at a small frost the snow starts to melt (see the previous problems). In addition, the forces of surface tension keep snowflakes together. After discharge of the pressure, the water created in melting may freeze again, which even more strengthens the connections between some separate snowflakes. Under a strong frost the pressure for melting of snow must be so great that it cannot be produced by human muscles.

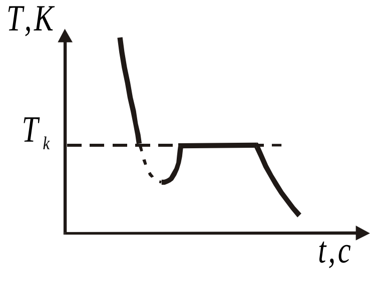


Fig. A.23.

III.240. The vapor breathed by men in a room in its touch to cold glasses of window is condensed as water. The water freezes and form crystals.
III.241. The process of crystallization similarly to that of condensation must take place if there already are centers of crystallization in the form of a very small crystals. If there are no such crystals, one can overcool a liquid in a quick cooling. This state is shown in Fig. A.23 by a dotted curve. In a sufficiently strong overcooling, an spontaneous process of crystallization may start and the liquid is quickly crystallized. In the crystallization of an overcooled liquid, its temperature grows due to emission of the hidden heat freezing and if the cooling was not to strong, it attains the normal temperature of crystallization T_c.
III.242. Note: consider the answer to the previous problem..
III.243. In a district of a city, specially in days when fabrics and plants are working, the air contains a huge quantity of dust particles in suspension, each serving in cooling as a center for condensation of the atmo-

spheric vapor.

III.245. The water vapor which is at large altitudes is over-saturated. Tiny particles resulting of fuel combustion in the airplane engine turns to be centers of condensation, thus forming a cloudy trace behind the airplane.

III.246. The time serves as a cover for plants and thus prevent their overcooling.

III.247. When a humid soil freezes, a significant quantity of heat is emitted (the hidden heat of the melting of ice), which is spent to heating of the soil.

III.248. A gas contains the water vapor, which touch the cold walls of a pipe, are condensed, then freeze, and thus stop the flow through a pipe.

III.249. These organic substances under a sufficient heating turn into coal and burn without melting.

III.251. Generally speaking, it will change if the thermometer is sufficiently sensitive. The matter is that in heating a glass we deal with a non-balanced process in which the temperature of water can be higher than that of ice.

III.252. I the dissolving of a salt an energy is spent, the temperature thus lowers.

III.253. The solution of salt in water has the temperature of freezing below 0 °C, therefore in adding a salt, a quick melting of ice (snow) takes place.

III.254. Note: consider the answer to the previous problem.

III.255. In a freezing water an icicle is the center of crystallization, i.e., on its surface the molecules of water are settled (in the same way as drops of water are centers of condensation in overcooled vapor). Since the temperature of freezing of salted water is below the temperature of pure water, it does not crystallize when an icicle is merged into it. Moreover, the icicle dissolves in a solution of salt as the sugar crystals dissolves in the hot tea.

III.256. An antifreeze is an ethylene-glycol mixture which does not freeze even at the temperature –40 °C. In addition, the antifreeze posses properties which stops the corrosion and prevents scum formation.

III.257. Because the temperature of freezing of a salt solution can be significantly below 0 °C (for example, –10, –15 °C); special machines cool this solution and it is pumped over a system of pipes in cameras where the food is stored.

III.258. In view of a large specific heat capacity and large hidden heat of melting of water, the vessel with water will play a role of heat energy accumulator. In the formation of ice in the vessel a large quantity of heat is released, which results in a certain delay of a further cooling of the air. For example, within the complete freezing of a pail of water, approximately $3{,}3\times10^{6}$J of heat are produced which is equivalent to the heat emitted by a 1kWt heater which works 55 minutes.

III.259. Due to large heat of the ice melting, the melting of snow and ice is gradual in spring, and the melted water has the time to penetrate into the soil. The decrease of the heat of melting could lead to a sharp increase of high water (inundation) and overdrying of soils in summer.

III.260. The icicles arise at the temperature of the air below 0 °C. But in the day-time the temperature of a roof is above the temperature of the air. The matter is in two factors: the roofs are inclined and thus may posses a better declination angle for absorption of the solar energy and may be covered by a dark material which also helps to accumulate the part of the absorbed solar energy.

III.262. The formation of the crystals of snow and ice is related to the emission of heat into the ambient. Therefore it turns warmer when snow falls.

III.264. The snow (ice) may pass from the solid state into the gaseous state not passing through the liquid state.

III.265. Yes, he/she can if the pack has walls well-conducting the heat. The temperature of the packing material if the milk is inside it cannot be much greater than the temperature of the milk boiling. Usually, this temperature is not enough to destroy the package.

III.266. When another body has a lower temperature.

III.268. One surface dries quicker and thus contracts quicker.

III.269. One can pour an oil over the surface of water. Oils are slowly vaporizing substances..

III.271. The vapor outside the room is saturated. In the room, when the window is closed, due top evaporation from wet linen, the vapor may quickly become saturated and the drying of linen will stop. However, the temperature outside the room is lower than this inside the room. Therefore the density of vapor is lesser in street than in the room. Therefore a part of vapor will flow out the room through the open window and the vapor in the room will remain non-saturated. The linen will be dry earlier than if the had not open the window.

III.272. The sweating and evaporation of the sweat prevent our organism against the overheating. In addition, sweat extract unnecessary substance from the body.

III.274. If the air is dry, the sweat is quickly evaporated and cools the human body.

III.275. When you go out the water, the evaporation of the drops of water which remain on your body starts. Require a lot of energy, this process takes the heat from both air and you. The body is cooled and the air is felt colder than the water.

III.277. The ball of the left thermometer is wrapped by a material sucking the water. Due to its porosity, the material has very large exterior surface, which helps water to turn to a vapor. In a dry air the greater art of water is evaporated from the wet cover of the thermometer's ball. A heat necessary for evaporation is obtained from the water. When the layer of water in the porous cover of the ball will be significantly cooled, the water starts to absorb the heat of the thermometer glass, which takes the heat of the mercury. This results in a contraction of the mercury and its lesser volume. The thermometer shows a lower temperature.

III.279. No, it will not. Assume that the hot water does not mix with the water in the pot. Then the problem is double: to make to boil the water in pot and the added hot water.

III.280. The alcohol evaporates much quicker than water does and emits in a unit of time a greater quantity of heat than water can. This makes you to feel cold of the alcohol sprinkled upon your hand.

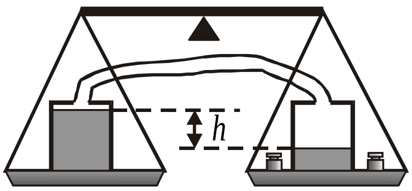


Fig. A.24.

III.281. The levels of water in vessels are different, therefore the pressure of the vapor over their surfaces will be different. The pressure of vapor over the quarter in a vessel with a smaller quantity of liquid will be greater by the weight of column of vapor of the height h with the area of base 1m^2 (see in Fig. A.24). Consequently, the vapor will be always formed over the surface which is at a higher level and condensed near the surface which is lower.

III.282. To nights the heating and rising of the air stops and the process of its cooling by the soil which turn cold in evening starts. The clouds which consist of tiny drops of water start to go down. Hitting the more warn layers of air, they are heated and turn into invisible water vapor.

III.286. In winter there exists a large difference between the temperatures of the air in a room and outside at rather same absolute humidity of the air. Therefore on winter the relative humidity is in a room is significantly lower than that on a street. In summer the difference between the temperatures in the room and on the street is significantly less than in winter.

III.287. After equaling of the temperatures in the tank and in the vessel, the heat transfer to the water in vessel will be terminated. It will not start to boil because it will not receive heat necessary for formation of vapor.

III.288. Yes.

III.289. No.

III.291. The non-boiled water will start to boil earlier, because in the water which already boiled there is a lesser quantity of the dissolved air.

III.292. When the burner is turned on, the vapor of water hits into currents of hot gases thus remaining invisible. When the burner is turned off, the vapor hits the cold room's air and is condensed as a visible tts fog.

III.293. To hard-boil an egg on the Mars is not possible. Due to a rarified Mars atmosphere, the water will boil at a temperature insufficient for coagulation of egg's white.

III.294. In these thermometers the space of the capillary over the mercury is filled with nitrogen under high pressure, which leads to a significant increase of the temperature of boiling .

III.295. To the evaporation of the moisture which is contained in a humid match the most part of the energy obtained in friction with the match box cover. Therefore the match cannot be heated to a point of ignition.

III.296. The vaporization of water lowers the temperature of the burning wood so that the burning dies. In addition, the vapor surrounds the burning body and thus ceases the access of oxygen to the zone of burning.

III.297. Under the action of the water on the surface of hot coal rifts arise. The surface of the contact between coal and air increases and it starts to burn better. In addition, the mixture of the carbon oxide and the hydrogen which is created in this process burns very well.

III.298. The temperature of the boiling for resins and bitumen is higher than that of water, therefore when water hits the surface of burning resin is quickly evaporates and turns into vapor sprinkling the boiling resin.

III.299. Note: use a handbook and the previous problem.

III.301. The column of water of the height H is supported in the pump by expense of the difference between the atmospheric pressure p and the pressure of the saturated water vapor p_s: $\rho gH = p - p_s$. Since with an increase of temperature the pressure of the saturated vapor also increases, the height to which the

water can be hoisted lowers. It should be noted that with an increase of temperature the density of water decreases, but this decrease is not significant and does not affect the whole situation..
III.303. A layer of water which contacts the heated bottom of the vessel has the greatest temperature. In addition, on the surface of the vessel there are more centers of vaporization.
III.304. Bubbles of vapor formed near the bottom of the vessel go up and hit colder layers of water. Here the vapor is condensed and the bubble is "blowing out". The massive disappear of vapor bubbles creates the noise.
III.305. A drop of water is quickly evaporated. The vapor expands and creates some oscillation in the air which are heard as hissing.
III.306. If salts are dissolved in the water, the temperature of boiling of a solution will be greater than the temperature of the water vapor over it. If the water is distilled, the temperature of the water and the vapor will be same.
III.308. By the distillation, because the point of boiling of the mercury is lower than those for zinc and tin.
III.309. No, because, if the temperature of water is already reached 100 °C, it will not grow further until the while water will be evaporated. It is only necessary that the supplied heat be sufficient to keep the boiling and compensate the losses of the heat.
III.310. Without this hole the vapor can expel the water through the nozzle of pot.
III.312. The absolute humidity will not change, while the relative humidity will be lower.
III.315. The vapor will go both from bath-house's window to the street and from the street to the bath-house. Intake bath-house air contains the saturated vapor. If the window is open, the warm air flows out to the street and condenses. The penetrating into bath-house cold air mixes with the contrary flow of the hot vapor and this results in a condensation.
III.317. The absolute humidity of the water over a river is greater than that over the ground.
III.318. In autumn the cold layers of the air are closer to the Earth surface than ion summer. Therefore the condensation and formation of clouds take place at a lower level.
III.319. The dew is formed when the ground is cooled. The clouds prevents such a cooling.
III.323. The temperature of oil boiling is significantly higher than that of water. Therefore if the water hits into boiling oil, it boils earlier causing the mentioned phenomena.
III.328. To prevent the burning of the sugar. Evaporation is hold in special vacuum machines under low pressure.
III.329. The temperature of boiling of water in autoclaves is significantly higher than 100 °C, because a high pressure of water vapor is kept in them. The high temperature kills micro-organisms in the within the sterilization process.
III.330. The iron is heated to 300 – 400 °C and may burn tissue in a direct contact. In the process of ironing through a wet clothe, a part of heat goes for creation of the vapor at temperature near 100 °C, which does not damage the tissue. The moistening in ironing plays an additional role: the surface of wet tissue is more smooth (due to the surface tension) and thus may be ironed better.
III.331. In heating the milk forms a film on its surface. Under this film a saturated water vapor is accumulated and it hoists the film (they say that the milk "runs away"). The "milk-guard" makes a small jet of the hot milk from the bottom to go up and break this film. Thus the vapor gets its way up.
III.332. In smelting metals in vacuum both the processes of oxidation and dissolution of gases in melted metals are absent.
III.333. The liquid gets heat from the ambient. But we should note that its temperature is rather lower than that of the ambient.
III.334. In the center of a city the temperature of the air is always slightly higher than in its suburbs. The reasons are: 1) the asphalt and buildings accumulate more heat than soil; 2) in the center of city the wind blows weaker and thus the evaporation which is accompanied with absorption of a great quantities of heat is also weaker; 3) other (but not less significant) factors are the emission of heat by various machines, cleaning of snow, etc.
III.335. The blowing air evaporates the small crystals of ice which are formed on the glass.
III.336. By the expense of holes the surface of evaporation grows.
III.337. In the vacuum, the inverse process (condensation of moisture on vegetables and fruits) is absent (the water vapor is pumped out by equipment).
III.338. Since the air is permanently pumped out from the vessel, intensive boiling takes place at temperatures below 100 °C.
III.339. In the evaporation of the liquefied carbonic acid, an energy is absorbed and the temperature lowers. The vapor of the carbonic acid and the water vapor contained in the air form crystals of "snow". The carbon dioxide lowers the temperature and prevents the access of oxygen to the zone of burning.
III.340. The gas in the reservoir is formed by evaporation of oil derivatives: its quantity depends on the

temperature of ambient.
III.342. The gas may be cooled to make to condense the water vapor and then easily remove it in its liquid phase.
III.343. To liquefy the air. The nitrogen boils out first from the liquefied air, because its boiling temperature is lower than that for oxygen.
III.344. In any liquid and at any temperature, there are "quick" and "slower" molecules. If the quick molecules are withdrawn, the average speed of the remaining molecules decreases, the temperature of the liquid also decreases. A heat exchange becomes possible.
III.345. In shaking the tube, the column of water moves from one end to another. In this situation, both the ends are filled with saturating vapor. The pressure of the saturating vapor depends only on the temperature and does not depend on the volume. Therefore the pressure of the vapor at both ends of the tube is always same. Consequently, the forces of the pressure upon both ends of the water column are balanced and its motion can be taken as free if we neglect the friction between the column and the walls of the tube.
III.346. The heat balance equation gives us the initial mass of the ice: $m = Q/(0{,}1 \cdot q) = 18$kg. To determine the new level of the water h' we write $S \cdot h = V_0 + m/\rho_{ice}$, $S \cdot h' = V_0 + m/\rho_{water}$, where V_0 is the initial volume of water. Hence $h' = h - m(\rho_{water} - \rho_{ice})/S\rho_{water}\rho_{ice} = 19$cm.
III.347. One may assume that the fly consists only of the water. The law of conservation of energy gives us

$$v = \sqrt{2 \cdot \left(c \cdot \left(t_b - t_0\right) + q\right)},$$

where $c = 4.18$kJ/kg ×K and $q = 333$kJ/kg are the specific heat capacity and the specific heat of vaporization of the water, t_b is the temperature of boiling of the water, t_0 is the room temperature. Hence $v \approx 1200$m/s.
III.348. Almost insuperable difficulties arise in the creation of the refrigerator.
III.349. The heat supplied to the body in heating increases the energy of the thermal motion of molecules of body and also is spent to the work to overcome the forces which prevent heating and other related changes.. For example, if we heat a gas in a cylinder covered by a motionless piston, a part of the heat energy goes to hoist the piston. As known, the thermal capacity of a gas in this case is greater than that of a gas heated in a constant volume. In the slow cooling of the cylinder with the gas, the piston goes down and thus returns the energy spent to its hoisting, and the quantity of the heat emitted by the gas in cooling will be equal to the quantity spent in its heating. The situation changes if the piston cannot return to the gas the work spent by the gas for its displacement. This is the case of any (thermal) heat engine. Here in the cooling of vapor of gas the quantity of the heat emitted is less than the quantity of heat spent for heating. The missing heat has been transferred into mechanical energy which is supplied by the engine.
III.350. To improve the heat condition of the walls of boiler and thus increase its efficiency.
III.351. the overheating of the vapor excludes its condensation of walls of pipes which increases the efficiency.
III.352. Under a large compression, a self-ignition of the fuel mixture may occur before the piston reaches the "dead-point".
III.353. The efficiency of an ideal heat machine grows in winter with respect to summer. However, the losses of energy spent for friction in winter increase due to greater viscosity of the oils in engine, gear box, bearings, etc. Therefore the real efficiency of an automobile in winter is less than in summer. In addition, in winter more gasoline must be spent for heating cold engine in start. In the whole, the consumption of the gasoline is greater in winter.
III.354. With growing temperature the density of air decreases, and thus the mass consumption of the air which is supplied to the engine.
III.355. Engines of internal combustion have the greater temperature of the working body.
III.356. The flywheels accumulate the mechanical energy, which is obtained in the working stroke of engine. The flywheel energy is used for auxiliary strokes of the engine.
III.357. To the internal combustion engines.
III.358. The value of the advanced ignition time depends on the speed of rotation of the crankshaft: at greater speed a greater advancing is necessary. In addition, the value of the advance (measured in angular degrees) depends on the speed of combustion: if the fuel mixture is rich and burns quicker, the advance must be lesser.
III.359. If the advance is too large some strange strokes can be heard in the engine: the expanding gases push the piston earlier than it run to the upper "dead" point. If the ignition is too late (small advance), the fuel mixture will not burn out completely and will be evacuated to muffler together with worked-out gases. Thus explosions of mixture in a heated muffler are possible. In both cases the efficiency of the engine becomes lower.

III.360. The smoothness of the shaft rotation is ensured,, first, by the presence of flywheel in the engine, second, be presence of several cylinders in the engine (4, 6, and more), which work not simultaneously, but each at its turn.
III.361. One must make an additional work against the forces of the pressure of the worked-out gases, which are in the muffler.
III.362. In a jet engine all the strokes take place simultaneously, but in different parts of the engine. In an internal combustion engine, all strokes are at the same place (cylinder), but take place in diferent time. The working stroke in a jet engine is the output of the worked-out products of combustion.

Answers to Chapter IV

IV.1. No. The direction of the tangent to a stream line coincides with the direction of the force acting on the charge. Therefore it coincides with the direction of acceleration of the charge. The trajectory of the motion of the charge is the line whose tangent coincides with the direction of the velocity of a charged particle.
IV.2. Yes, it can.
IV.4. Electrifying in a touch is explained by a displacement of electrons from one body to other through the point of touch. In the rubbing, the bodies touch in greater quantity of points than in a usual touch.
IV.5. In its flowing out a tube, the gasoline is electrified so that an electric spark may rise which ignites the gasoline. To avoid a dangerous situation, the cisterns must be grounded.
IV.7. The answer depends on how one understands the word "electrify". In its strict meaning, the word means "to give an electric charge". In this interpretation the answer to the question must be positive with the unique clause: both the bar and the body applying which the bar was rubbed must be isolated from each other. However, often the word "electrify" is understood as "give an observably large electric charge", e.g., so large that one can hoist small pieces of paper. In this situation, one must remember that a human body is a good conductor. Therefore in attempts to electrify a copper wire without isolating it from the body, the observer does electrify its proper body. Moreover, if he/she is not isolated from the Earth, he/she also tries to electrify the Earth. Due to a huge size of the object to be electrified (bar + man + Earth), the charge which is distributed over a small part,e.g., the bar, does not generate a field around itself which could be observed.
IV.8. If the friction between the shell of the balloon and the air the first one has been electrified so that an electric discharge arisen. If the shell were filled with hydrogen, the latter would burn in discharge.
IV.9. Yes, it is possible.
IV.10. In connecting to the wire a high voltage source, the feather of the bird obtains the natural electrostatic charge, which makes the feather to pucker and diverge. This scares the bird and it leaves the wire.
IV.11. No.
IV.12. In order to remove from a charged conductor placed on an isolator a half of its charge, it is necessary to touch this conductor by a conductor of the same form and properties. Namely this way was used by Coulomb in his experiments.
IV.15. The paint must contain substances which are electrified positively in their contact with the air.
IV.17. If we draw to a charged ball (not touching it) two other balls which are drawn to each other and isolated from ambient, then under the action of the field generated by the positively charged ball, these two will obtain opposite changes. After drawing apart these two balls, these will have charges of opposite signs.
IV.20. A speck of dust may levitate if its gravity is balanced by the electrostatic force. If the charge of the speck decreases, it starts top fall. To restore the equilibrium, one must increase the charges on plates. This idea was used by Ioffe and Milliken in experiments for determination of the elementary charge.
IV.22. A fire may start due to electrifying of the oil and its sprinkling in the air. If the weather is dry, the oil is greater electrified..
IV.23. The electrostatic field kills the microorganisms which initiate deterioration of the food.
IV.24. The fibers of the cotton are straightened along the stream lines of the electric field which results in their easier cleaning .
IV.26. Both the graphite and metallic powder are good conductors of an electric current. Their addition to the rubber helps to remove charges and reduces the probability of inflammation of fire by sparks.
IV.27. Sufficient ventilation, sprinkling of water, increase of humidity of the air, and its ionization.
IV.28. The charge molecules of the air are attracted to parts of machines and products which has the opposite charge and thus neutralize them.
IV.29. Charged particles under the action of the electrostatic field lay uniformly over the surface to be painted and give away no sprinkles.
IV.30. The charge (by contact or rubbing) particles of a matter fall and are deviated at a different angle depending on their mass.
IV.31. Tiny drops of the chemical agents are charged in the electrostatic filed. Be virtue of the electrostatic induction, on the leaves opposite charges arise, thus attracting the agents to leaves.
IV.32. The problem can be solved by using the theory of dimension. The rupture of the ring takes place under the action of the mechanic stress σ arising in it. From the arguments of dimensions we have $\sigma \propto F/S$, where F is the force, S is the section area of the wire, and the force is $F \propto Q^2/R^2$, where Q is the charge, R is the radius of the ring. Since the rupture takes place at the same stress σ, we have

$$\frac{Q^2}{R^2S}=\frac{Q_1^2}{n^2R^2n^2S}, \text{ whence } Q_1=n^2Q.$$

IV.33. For the economy of the metal, because the static charges are distributed over the exterior surface of a conductor.
IV.34. Equally.
IV.35. The electrostatic field polarizes the ball, which leads to deformations in the direction of the vector of the tension of the field. Moreover, if the field is inhomogeneous, the polarizing charge from a side of the ball, where the tension of field is greater, stronger interacts with the latter. A non-compensated force arises directed to the side of the greater tension of the electric field.
IV.36. Specks of dust positively charged will move to the wire, negatively charged will move to the tube. Having been polarized, the neutral specks will move (in majority) to the side of increase of the tension of the electric field, i.e., to the wire.
IV.37. If we consider the ball *B* as a rigid dipole, then $F \propto R^{-3}$. But since the charge induced (or polarized) on the ball *B* decreases as *R* grows, the force *F* decreases faster than R^{-3}.
IV.38. They can.. First, in the case of small charges, a prevalence of gravitation forces over the electric forces is possible (for example, if the charge of the ball will be less than 10^{-14} Ql, and the mass is greater than 1g). Second, in the case where the charge of one of the balls is essentially less than the charge of the other ball. Here a decisive role can be played the polarization of this ball (see the previous problems).
IV.39. For example, in the case of concentric hollow balls.
IV.40. The ball *D* will be positively charged.
IV.41. No if the ball is in the field of other charges.

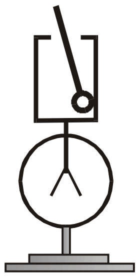


Fig. A.25.

IV.42. The charges are distributed over the whole exterior surface of a conductor. Therefore the problem can be resolved by touching by the ball the interior surface of the vessel with a narrow hole. For example, it can be a cylinder fixed on an electroscope (see Fig. A.25).
IV.43. The density of the electric charge is greater at the edge than on a smooth surface, therefore near the edge electric fields arise sufficiently strong to ionize the air. The latter increases the consumption of the electric power and makes the use of electric devices dangerous.
IV.44. Over the surface of a conductor the electric charges are distributed not uniformly: the most dense distribution can be observed on sharp angles and convex parts, and also on the specks of dust which settle over devices. The air around such places becomes a conductor, and the body loses its charge. To prevent the discharge the devices of that kind are made with round corners and without sharp angles. In their exploitation they must be kept clean.
IV.45. First, as a result of polarization of the second conductor, on its edge the negative charges will accumulate. By virtue of the large tension of the electric field the charges will flow from the edge until the tension of the field of the positive charges on the second conductor near its edge would become equal to the sum of tensions of the field of negative charges on the first edge and its field. The negative charges flowing from the second conductor will, mainly, settle on the first conductor and decrease its charge. This will result in a partial discharge of the first conductor and a positive charging of the second conductor.
IV.46. The second body will be negative charged. The explanation can be found after an analysis of the previous problem .
IV.47. The pointer will move with its nearest end to the electrified bar. Magnetic properties of the pointer has no importance in this situation.
IV.49. No, the action of the lightning-conductor thunder is in that on its edge in the field of a charged cloud charges opposite to the charge of the cloud are accumulated. A strong electric field near the edge leads to ionization of the air (breakdown) of the air and arising of the electric current (lightning) between the edge and the cloud. This current “discharges” the cloud.
IV.50. The lightning-conductor is dangerous for a building if it is poorly grounded.
IV.51. These wires a re the lightning-conductors.
IV.52. In the thunderstorm on the antenna (edge) under the influence of the electrostatic field of a heavy cloud a large density charge is accumulated. This results in a discharge (lightening) and, if the antenna is not grounded, the radio-station may be damaged and the operator can be injured and even killed by the lightning. .
IV.53. At the placed where the upper soil better conducts the electric current, a charge of a greater quantity is accumulated, therefore the electric field between the could and this place is greater. Therefore, the probability of the air ionization grows and therefor a lightning may arise.

IV.56. From a microscopic “hills” of the metallic surface a greater quantity of electrons flows out than from the “valleys”. Therfore o the screen these places will be lighter.
IV.57. à) the field will exist everywhere except for the interior oif the conductor of which the sphere is made; b) on the interior surface of the sphere the negative charge will arise, on the exterior side the positive charge will appear; c) the electric field inside the sphere will change; d) only the electric field outside the sphere will change.
IV.58. During the experiment the workers of the laboratory must be inside metallic hutches.
IV.59. It will charge if the ball *B* is not inside the ball *A*.
IV.60. To this end the shielding serves, which is surrounding the vacuum tube within a metallic shell with posterior its grounding. In the rise of electric field, about the tube charges are induced o the shell, whose field compensates the exterior electric field inside of the shell.
IV.61. The speed will increase because on the interior surface of the tube the charges of opposite sign are induced, and in the narrowing of the tube a component of the force arises directed to the side of narrowing.
IV.62. The complete energy of the system does not change. The kinetic energy of the particle grows by the expense of reduction of the electrostatic energy of the interaction with the walls of the tube (when a particle approximates to walls this energy decreases).
IV.63. As a consequence of the polarization of the dielectric, in the field of the charge on the ball on the interior surface of the dielectric connected charges of opposite sign (on the exterior surface – of the same sign as the charges on the ball arise. As a result, the tension of the electric field (and therefore the “richness” of streamlines) inside the dielectric will be lesser; outside the dielectric it will be same as if is were absent.

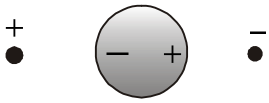


Fig. A.26

IV.64. The force will grow, because to the force *F* a force acting from the side of the polarized ball will be added. The direction of the additional force can be readily seen in the Fig. A.26 – the force of attraction of each of the point charges to the ball is greater than the repulsing force.
IV.66. The result will depend on whether the shell of the electroscope is grounded or not. If it is grounded, the angle at which its leaves stand apart will show the potential of the body, touching the electroscope’s head, with respect to the Earth. Therefore, if the head will be grounded, the leaves will fall independently of their initial charge. In the case where the container of the electroscope is grounded, the solution depends on how the container of the electroscope has been charged previously.
IV.67. The container of the electroscope was previously charged.
IV.68. There are not contradiction. The ball drawn to the interior surface of the sphere will have the potential of 1001V, because in carrying the ball the work has been made which increased its potential by 1000V.
IV.69. Set, for example, that the conductor *A* is hollow, while the conductor *B* is inside of *A*.
IV.70. Will not change.
IV.71. The potential of the interior ball will decrease, the potential of the exterior ball will remain unchanged. Let *r* and *R* be the radii of the interior and exterior balls, respectively. Assume that before their connection by a wire, the charge of the interior ball was *q*, while the exterior ball had the charge *Q*. Then $\varphi_1 = q/(4\pi\varepsilon_0 r)+Q/(4\pi\varepsilon_0 R)$, $\varphi_2 = q/(4\pi\varepsilon_0 R)+Q/(4\pi\varepsilon_0 R)$, where φ_1 and φ_2 are the potentials of these balls before they were connected by wire. After connection, the balls will have the potential $\varphi = (q+Q)/(4\pi\varepsilon_0 R)$, because the interior ball will be uncharged and the charge of the exterior ball will equal $q+Q$. Obviously, $\varphi<\varphi_1$ and $\varphi=\varphi_2$.
IV.72. Since the clearance between the balls is small, their potentials before connection were close. After connection, the potential of the ball *A* start to decrease with increase of the potential of the ball *B*. The potentials of both the balls changed insignificantly.
IV.73. This is not obligatory. For example, if the first conductor is a hollow ball with a hole and the second is a small ball which is drawn into the first ball and connect with the surface of the first ball. In this case, the positive charges flow out from the second ball to the first one. You must take into account that within a displacement of the balls with respect to each other their potentials do not change..

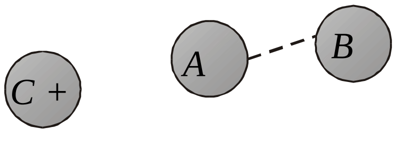


Fig. A.27.

IV.74. By changing the position of surrounding conductors.
IV.75. Upon any mentally selected volume of the kerosene in the left leg in addition to the gravity directed downward electrostatic forces do act. This results is a weakening of the hydrostatic pressure of the kerosene in the left leg as if its density had been were decreased. Therefore the summary Archimedes’ force acting on the balls in the left leg will be same as in the right leg.

IV.76. If these conductors are in the electric field generated by other bodies, the difference between potentials may be absent. For example, let uncharged metallic balls *A* and *B* be in the field of a positively charge ball *C* (Fig. A.27). If one connects the balls *À* and *B* with a wire, the ball *B* will be charged positively and the ball *À* negatively; moreover, their potentials will be equal to each other. Taking the wire off, we get two oppositely changed conductors without a difference of potentials between them.
IV.77. The accelerations of the bars are same and equal $g/2$. To give to an electron inside bar this acceleration, one must apply the force $mg/2$, where m is the mass of an electron. Therefore in the bars a redistribution of electrons takes place such that inside the bars an electric field exist directed oppositely the velocity of the motion. Denoting by E_1 and E_2 the tensions of this filed for the horizontally and vertically moving bars, respectively, we have $mg/2 = eE_1$ and $mg/2 = eE_2$, respectively. Consequently, $E_1 = E_2 = mg/2e$. Since all the electrons move with the same acceleration, the field in bar is constant along its length, i.e., is homogeneous. Therefore, for the desired difference between potentials, we have $\Delta\varphi_1 = \Delta\varphi_2 = mgl/2e$.
IV.78. As the distance between the plates decreases under unchanged charge, the potential difference $U = Q/C$ between the plates with a decreased distance and unchanged charge will decrease because the capacity increases. With an increase of the distance between plates the potential difference will grow.
IV.79. The readings say that the electric capacity of the capacitor is 10 μF, and the maximal designed tension (voltage) between its plates. If the voltage will be grater than that marked on the capacitor, a puncture of the isolating layer may occur, and the capacitor will be damaged.
IV.80. The electric capacity of a sphere is less than that of the system of its splinters. Let us give to the system splinters a charge $q>0$. If we start to join a sphere from this splinters, the joined part will have a positive, and in drawing to it a next charged splinter we must produce a positive work $À>0$. The charge of the already joined system will equal q, and its electrostatic capacity will be equal to $W_{sph} = q^2/2C_{sph}$, where C_{sph} is the eleactric capacity of the sphere. The energy of the system of splinters is $W_{spl} = q^2/2C_{spl}$, C_{spl} is the electric capacity of the system of splinters. By the law of conservation of energy we have $W_{sph} = W_{spl} + À$, whence $W_{sph} > W_{spl}$ and $C_{sph} < C_{spl}$.
IV.81. The direction of the motion of positive charges is taken as the direction of an electric current.The current always flows from a greater potential to the lesser potential. In equal charges, the greater potential belongs to a body with less electric capacity (the small ball in our case). (Certainly, this concerns the case of insulated bodies.) If we take into account that the charge on the balls is negative, we may assert that the greater potential before the connection of balls was at the large ball , and the current will flow from it to the smaller ball.
IV.82. The electric force of the field generated by one of the plates of the capacitor equals $E/2$. Therefore the force acting upon another plate is $Q{\cdot}E/2$.
IV.83. It is obvious that the plate was placed into an external homogeneous field E directed to the right. Assuming that this direction is positive, we get for the projections of the tension $E' - E = E_1$, $E + E' = E_2$, whence $E = (E_2 - E_1)/2$. Here E' is the proper field of the plate. Therefore the action of the force from the external field upon the plate is $F = Q{\cdot}(E_2 - E_1)/2$.
IV.84. As a consequence of the decrease of the electric capacity of the system detail–form.
IV.85. It is possible if the balls are in an electrostatic field generated by other bodies.
IV.86. Will not change.
IV.87. To avoid the voltage of a puncture of the dielectric, in high tensions a thicker layer of the dielectric is required. In order to preserve the given capacity, one must increase the area of plates.
IV.88. The error is on that we have not taken into consideration thew work for merging charges into water and hoisting them from water. When approximating of charges to the boundary water-air, an ordered arrangement of molecules arises on the water surface. So, we cannot omit the work for transportation of charges in vertical plane. Thew work spent in vertical displacement of charges drawn apart will be greater than for drawn to each other (because the field on the boundary of a dielectric is greater), and the complete work of a cycle will be equal to zero.
IV.89. Yes, it follows. By the angle at which the leaves of the electroscope are drawn apart we may know the potential of the ball, which is known to be defined by the formula $\varphi = q/C$, where j is the potential of the conductor, q is its charge, C is the capacity of the ball, equaling $4\pi\varepsilon\varepsilon_0 R$ (ε_0 is the dielectric constant, ε is the dielectric permeability). In the present case the radius R of the ball changes, which namely determine the change of the potential.
IV.90. To place an electron into the electric field of a flat capacitor one must produce the work against the forces of his field. Therefore in the space between the plates of capacitor, the electron will possess a potential energy. By the expense of the transformation of a part of this energy into kinetic energy, the electron in its motion between the plates of a flat capacitor will accelerate.
IV.91. The answer is "no". The formula $C = \varepsilon\varepsilon_0 S/d$ is valid only for small (with respect to linear size of plates) d. Let us give to the plates of the capacitor the charges q and $-q$. Then, if the plates are rather far

from each other, we can write that the potentials of both plates are $\varphi_1 = q/C$ and $\varphi_2 = -q/C$, where C is the capacity of one plate, which can be considered as a solitary conductor. Consequently, the capacity of the capacitor formed by these plates is

$$C_1 = \frac{q}{\varphi_1 - \varphi_2} = \frac{1}{2}C > 0.$$

IV.92. The energy of the capacitor equals $W = Q\cdot\mathcal{E}/2$, where $\mathcal{E}$ is the electromotive force of the battery, Q is the charge of the capacitor. The work produced by the battery is equals to $A = Q\cdot\mathcal{E}$. Consequently, $\grave{A} = 2W = 2$ J. In this situation, a part of the energy of the battery of the value $\grave{A} - W = 1$ J was transferred into the heat. This magnitude does not depend on the resistance of the connecting wires.

IV.93. A wrong solution may arise: since the tension of the field in a flat capacitor is

$$E = \frac{\sigma}{\varepsilon\varepsilon_0}$$

(σ is the surface density of the charge on plates), in merging the capacitor into a dielectric the potential of the field seems to decrease ε times. But in this argument we have not taken into account that to keep a constant tension U between the plates (the capacitor is connected to an accumulator), the charge on the plates q (and therefore σ as well) must increase ε times:

$$q = CU = \frac{\varepsilon\varepsilon_0 S}{d}U,$$

(S is the area of plates, d is the distance between them). This results in unchanged potential. Another solution is also possible. As known, for a homogeneous field we have $E = U/d$. Since the difference between the potentials of plates has not changed, the tension of the field also will not change.

IV.94. If the dielectric completely fills the space between the plates, the capacity of the capacitor increases as well as the charge ε times. But the tension of the field inside the capacitor will not change, because so does the difference between the potentials of plates. Therefore the attractive force is increased in ε times.

IV.95. Let the potential the ball S_1 be equal to φ_1, and the potential S_2 to φ_2. Since the small ball s is significantly than the balls S_1 and S_2, in connecting it with these balls the potentials of the latter will not practically change. Therefore $q_1 = C\varphi_1$, $q_2 = C\varphi_2$, where C is the capacity of the small ball s. Under a simultaneous connection of the small ball s with the balls S_1 and S_2, the potentials of these two balls will become same and will equal $\varphi = (\varphi_1+\varphi_2)/2$. Therefore, the small ball s will gain the charge $q = C\varphi = C(\varphi_1+\varphi_2)/2 = (q_1+q_2)/2$.

IV.96. No, will not. Because the connection of the capacitor changes the difference between the potentials of the points $\grave{A}$ and B. Let the electromotive force of the accumulator be equal to $2U$. Then $\varphi_A - \varphi_B = U$. If we now connect to the points $\grave{A}$ and B the capacitor shown in the dotted line, the capacity of the segment $\grave{A}B$ will be $2C$, and the difference between the potentials will be $\varphi_A - \varphi_B = 2U/3$.

IV.97. In addition to the energy of electrostatic interaction between the balls, they possess proper electrostatic energy $W = Q_1\cdot Q_1/2C + Q_2\cdot Q_2/2C$, where C is the capacity of each. In connection by a wire, their proper energy decreases. The complete electrostatic energy of the system also decreases, because a part of the energy transfers to the Joule heat when the current flows along the wire.

IV.98. Check the absence of a contact between the terminals and metallic body and also the presence of a puncture in the dielectric.

IV.99. The dielectric permeability of a dielectric must depend on the electric force of the electric field and the temperature. To the substances of this class so-called “ferroelectrics” do belong (for example, the tytanate of barium).

IV.100. In a sharp increase of the tension, the power transmitting lines are grounded via the spark interval and vilite disks and thus are discharged. With decreasing potential difference between the vilite disks, their resistance increases and the power transmission line is again isolated from the ground.

IV.102. The left-hand rule implies that in parallel position of conductors in the case of the similar direction of currents the attraction between conductors appears. If the currents move oppositely, the repulsion arises. In the third case the conductors will tend to turn so that the currents flow in them to one side. This does not contradict the third Newton’s law, because in the last case the resultant force acting on each conductor equals zero.

IV.104. The electromagnet with sharpened ends of the core.

IV.106. Rings will turn so that the currents in them flow parallel.

IV.107. If the wire is twin-core, the pointer remains calm.

IV.108. No, it will not.

IV.109. The arc goes aside and dies.

IV.110. The Coulomb force for any speed of motion of charges which is less than that of light, exceeds the

Lorenz force. In the case of currents flowing along the wires, the electric field of moving electrons is shielded by the field of movable ions of the crystal lattice.

IV.111. The compression of plasma is a result of the Lorenz force action on charges moving in parallel directions.

IV.113. Outward the observer.

IV.114. $m_a > m_b$.

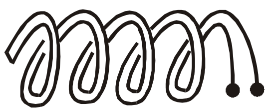


Fig. A.28.

IV.115. The wire is to be folded in two (bifilar) and the coil is to be winded as shown in Fig. A.28.

IV.116. If the currents have opposite directions, then the field outside the cable does not exist. In similar directions of currents the field outside the cable is twice stronger than the field of the sane current passing through a unique wire.

IV.118. It is better to make this experiment when they transmit the grid for tuning the TV picture. If in the center of such a grid a small circle were shown (this standard was earlier applied tuning on Soviet TV), the experiment would be very impressive. Draw the magnet to the screen so that the magnet plane be horizontal and one of its poles be closer to screen. The circle at the center of tuning grid will displace up or down. The image on the screen is made by a beam of electrons which goes from the rare part of TV toward the screen. The magnet deflects the moving electrons and thus the picture is disturbed. The direction of action of the magnet upon the charge is determined by the left-hand rule. The lines of the magnetic induction go from the north pole to the south pole of the magnet. By the direction of the current in the left-hand rule we shall take the "technical" direction from pus to minus. The positive charges were moving that way. In the kinescope the electrons move (fly!) toward us. Therefore the fingers of the left hand must be directed toward the screen. By the shift of the central circle of grid we determine which pole of the magnet was drawn to screen: north or south.

IV.119. In view of the Lorenz force action, the free electrons will be distributed along the ball's surface so that the resulting electric field inside the ball be homogeneous and compensating the action of the magnetic field: $qE+qvB\cdot\sin\alpha=0$, $|E| = vB\cdot\sin\alpha$. After that, the directed motion of the electrons will by ceased. The maximal difference between the potentials $\Delta\varphi_{max}$ will arise between the end points of ball's diameter which is perpendicular the plane at which the vectors **v** and **B** lie: $\Delta\varphi_{max} = 2R\cdot vB\cdot\sin\alpha$.

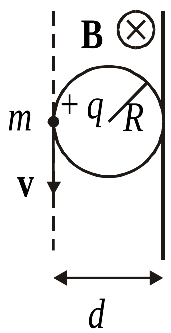


Fig. A.29.

IV.120. Deeper, at a small distance $l = 2R$ a particle penetrates the field, with the velocity directed in parallel to the wall and perpendicular to **B**, as shown in Fig. A.29: $mv^2/R = F_L = qvB$. Hence $B = 2mv/ql$. Consequently, with $B > 2mv/qd$ the particles will not penetrate the domain situated at the right from the magnet wall.

IV.121. The action of the magnetic field upon the ball will be dual: first, the ball will be magnetized in the direction of the magnetic field; second, the already magnetized ball undergoes a force directed to the side of the increase of the magnetic field and proportional to the velocity of the change of the magnetic induction along this direction. If the magnetic field is homogeneous, the force acting upon the ball equals zero. Consequently, the case described in the conditions if the second field will be more homogeneous than the first one.

IV.122. The iron at a temperature greater than 770 °C (the Curie point) becomes a paramagnet. In this situation, by some powers of ten the force of interaction between a blank and the field of electromagnet reduces.

IV.123. In heating, the iron may pass from the ferromagnetic into the paramagnetic state.In this situation, the orienting action of the exterior magnetic field weakens.

IV.124. No, it will not be magnetized. In connecting a capacitor to a wire winded about a nail, in the formed tuned circuit fading oscillations of current will rise. They will lead to a series of re-magnetization of the nail, and its magnetization will fall from step to step and thus will turn to zero.

IV.126. 1. Electromagnetic supports do not bound the displacement of the tools, do not damage the surface of details, allow to change quickly blank details. **2.** A detail is kept on the machine by the force and magnetic interaction.

IV.127. Steel things will be attracted to the constant magnet placed into the bronchoscope.

IV.128. Change the direction of current in winding of the electromagnet.

IV.129. The nails are closer packed in a box.

IV.130. The magnetized cork joins tiny metallic particles which may appear in the work of engine, and does not give them to hit again the interior parts of the engine.

IV.131. To avoid the keeping of a detail to be displaced by remaining magnetic field of the core after switching it off.

IV.132. The thicker is the layer of paint, the less is the attraction of the magnet to the object. The scale of the device is graded with the use of known thickness of samples.
IV.133. Toward the observer.
IV.134. In ferromagnetic substances the losses stipulated by the heating of a sample by the Foucault currents: under the same electromotive force of induction, the resistance of ferrite materials is higher than that of metallic ferromagnetic materials, because by the Joule law the quantity of heat emitted on the segment of a circuit with the resistance R within the time t in the potential U is equal to $Q = U^2t/R$.
IV.136. The steel possesses ferromagnetic properties and is magnetized in a magnetic field. Hence the attraction of the steel to constant magnets follows. Under a heating, the ferromagnetic properties vanish, therefore new parts of wheel are attracted to the magnet. This results in the rotation of the wheel. Note that this heat engine does not work without a refrigeration.
IV.137. When we draw down the magnet along the bar, a closing of a magnetic circuit takes place due to the iron bar, and the magnetization of its end stops.
IV.138. the induction of the magnetic field of the Earth has a vertical component.
IV.139. On the North geographic pole.
IV.141. Under strokes, elementary tiny magnets are oriented in the magnetic field of the Earth. On the north end of the band the north pole will arise.
IV.142. From the South to the North, because the North magnetic pole of the Earth is situated near the South geographic pole.

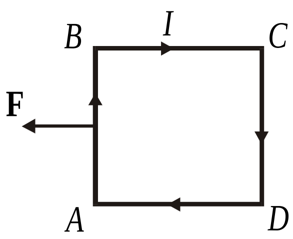


Fig. A.30.

IV.145. Replace a wind with a rectangular frame with a current (Fig. A.30). Upon each of the sides of the frame (say, AB) there act forces stipulated by magnetic fields of currents which flow over other sides of the frame (BC, CD, and AD). By applying the right-hand rules we determine near the side AB the direction of the vector of magnetic induction created by the currents flowing along the sides BC, CD, and AD (outward the observer). By the left-hand rule we find that, on the side AB of the frame, a force acts directed to the left. Similar arguments carried out for other sides of the frame show that it undergoes an extension deformation.
IV.146. The form of a ring.
IV.147. The winds of the solenoid are attracted to each other.
IV.148. This will not happen.
IV.149. Different. Larger in the first case.
IV.150. Will.
IV.151. Arises. The greatest electromotive force arises in a motion along a magnetic parallel, the least is when one moves along a magnetic meridian. The value of the electromotive force depends on the speed of the automobile (on the speed of intersecting lines of magnetic induction of the Earth's field).
IV.152. No, because the flux of the vector of the induction of a magnetic field through an area bounded by a frame (contour) does not change.
IV.153. A magnetic field of the alternating current which changes with the frequency 50Hz excite alternating currents of sound frequencies in the telephone wires. We shall hear a character "noise" in the phone.
IV.155. Powerful magnetic fields which are generated by the discharge of a lightning give rise to an electromotive force of induction in various conductors as well as in the power supply. The generated currents may cause the phenomena mentioned in the problem.
IV.156. Appearance of a non-homogeneity in the material of the construction leads to change of the magnetic flux which permeates the coil of the defect-scope, and thus to excitation of an electromotive force in it.
IV.157. The magnetic field arising around the electromagnet excites in its winding an electromotive force of the self-induction which generates a current directed oppositely to the current created by the power source. Namely this makes the current to grow gradually.
IV.158. To formation of the electromagnetic field around the conductor.
IV.159. When the ring works the circuit is periodically disconnected and in its electromagnet the electromotive force of induction arises. It is rather large in view of the large number of winds in the electromagnet's coil. This force generates the feeling of sharp pushes.
IV.160. Because of large losses of the electric power in this case of transmitting. The alternating magnetic field which surrounds the cable will excite in the metallic pipes the Foucault currents producing the Joule heat.
IV.161. In the metallic parts of the lamp in fast changes of the magnetic field induction currents are excited, their energy being transferred into the Joule heat.
IV.162. In a superconducting contour the electromotive force cannot act, because by the Ohm law the

current in this contour must be infinitely great. Consequently, the magnet flux through a superconducting contour must always be unchanged. As known, the magnetic flux Φ and the current I, flowing in a system, are related as follows $\Phi = L \cdot I$ (L is the inductance). The inductance of a ring L_r is proportional to the square of the radius. Therefore each of the rings of the "eight" described in the condition will possess inductance four times lesser than that of the initial ring. In calculation of the inductance of the system of two folded rings, one must take also into account the mutual influence between the rings. This leads to a square dependence on the inductance of the system of winds on their quantity. Thus, the inductance of the system will not change and the current in the ring remains same.

IV.163. If the ring is superconducting, in its motion the current will change so that the complete magnetic flux through the ring be unchanged (see the previous problem). At a certain moment the force, acting upon the ring from the side of the magnet, will balance the gravity. Moving by the inertia, the ring will pass over the point of equilibrium and will move further until the increasing force of its interaction with the magnet will turn its velocity to zero and will make it to move backward. In the second pass through the point of balance the ring will possess a velocity directed upwards. It will again pass over the equilibrium point, and so on. Since in passage of a current through a superconductor no heat is emitted, in absence of the air resistance non-fading oscillations of the ring about the equilibrium point will arise. If the ring is not superconducting, the value of the current will be determined by its resistance and the electromotive force at a present instant of time, i.e., by the speed of motion. In this case, the ring also will oscillate but with a fading.

IV.164. If the magnet has been removed, in the ring the induction current arises, its magnetic field generating the flux Φ through the ring.

IV.165. When the magnet starts to fall, ion the pan the induction current arises with its magnetic field acting upon the magnet with the force directed upwards. The force quickly increases and stops the magnet. Since the pan is made of a superconductor, the induction current does not cease and we see the levitation of the magnet.

IV.166. When the tail close the circuit, a superconducting contour arises, the magnetic flux through this contour cannot change. Therefore, the same does the current through the solenoid.

IV.167. In a pipe the magnet will fall for a longer time.

IV.168. In the second case a greater charge ($\Delta q = \mathcal{E} \cdot \Delta t/R \approx \Delta\Phi/R$) will flow through the device. In both the cases the magnetic flux through the contour decreases, but in the first case the flux varies from one positive value to another (lesser), while, in the second case, from the same initial value to the same by absolute value but with the opposite sign.

IV.169. The magnetic field inside the coil is proportional to the quantity of winds. Since each line of induction of this field penetrates the contour of the coil as many times as the quantity of winds is, the flux of induction through the coil (and therefore its inductance) is proportional to the square of the number of winds.

IV.170. Since the current is constant, its value before and after straightening of the coil is determined by the electromotive force of the battery and the Ohm resistance of the wires. When the wire is straightened, the flux of the magnet field through the coil will decrease, therefore the induction current will be co-directed with the current of the battery. Thus, in straightening of the coil, the current will first increase and then become equal to its initial value

IV.178. If we simply disconnect the engine from the circuit, the rotor will turn due to the inertia. If the winding of the engine will be set in a short circuit, it will become a generator, in which the arising induction current is directed so that in interaction with the magnetic field of the generator it brakes the rotation of the rotor and thus brakes the train. In a large speed of the train (and thus quick rotation of the rotor),m this current may damage the engine. In this connection, they usually connect to engines special rheostats.

IV.184. The wood then is warmed up along the whole volume, which results in a uniform drying. In this way of drying, the wood will not have rifts in it.

IV.185. The currents of a high frequency exist only in a small superficial layer of the metal. Namely this layer will be heated and then hardened. The hardening the superficial layers allows to combine in a detail the hardness of the surface with the elasticity.

IV.186. The absorption of the electromagnet field of the primary coil depends on the thickness of the metal.

IV.187. As a consequence of the electromotive force of induction, which arises in connection and disconnection of the circuit.

IV.188. Under change of the current in the arc, in the coil (stabilizer) an electromotive force of self-induction arises counteracting with the change of the current's force.

IV.189. As a consequence of the electromotive force of self-induction arising in the choke under disconnection of a circuit, in the circuit of the lamp a tension arises sufficient for ignition of the discharge.

IV.190. It is better to use the current arising at the moment of disconnection of the circuit, because it has a

large value (in a decrease of a current in the coil, the self-induction current is co-directed with the current created by the power source).
IV.191. In disconnection of these circuits a high tension may arise (due to the electromotive force of the self-induction), which is dangerous for human life.
IV.192. At the place of disconnection of circuits a sparking discharge arises due to the self-induction, which passes to the arc discharge. The discharge is more intensive in disconnection of a circuit. To prevent the destruction of the contacts, these can be, for instance, placed into oil which isolates better than the air.
IV.193. Due to the large electric capacity of the capacitor the tension arising in the flow of the self-induction's current does not suffice for a "puncture" of the air.
IV.194. 1. The electromotive force of self-induction arises in disconnection of the circuit. **2**. Lamps possess a neglectible inductance.
IV.195. To decrease the electromotive force of self-induction .
IV.197. The flux of the magnetic induction through the rotating frame changes by the law
$\Phi(t) = B_0 S \cdot \sin\Omega t \cdot \cos(\Omega t + \varphi) = B_0 \cdot S \cdot [\sin(2\Omega t + \varphi) - \sin\varphi]/2$, whence we see that the frequency of the electromotive force of induction equals 2Ω.

Answers to Chapter V

V.1. The electric current may flow from a lower potential to a higher potential under the action of external forces, for example, inside a galvanic element.

V.2. Does not mean. In practice, the speeds of the directed motion of free electrons is some millimeters per second, which is smaller than even heat speeds by seven powers of ten. If the current were propagated with this speed, a telephone conversation between Moscow and Kazan would be as long as some dozen years. Moreover, in alternating current the free electrons make oscillations about a mean equilibrium position and are not displaced for pong distances. What is the matter of this paradox? The matter is in impossibility to consider the motion of electric charges without accompanying change of the electromagnetic field. Namely the changes (propagated practically at the speed of light) in the electromagnetic field stipulated by a directed motion of charges in a certain place of an electric circuit make electric charges to move along the whole electric circuit.

V.3. The difference between the potentials of the Earth's surface and conducting layer of the atmosphere is about 400000V. In addition, the summary current through the air of the atmosphere equals 1800A. Thus, the complete power of such an "atmospheric power station" is only 720MWt. For a comparison: the power of all power stations of USSR in 1980 was 300GWt. Therefore, with regard for technical difficulties in designing and constructing atmospheric power stations, it "does not worth" (literally in Russian, "the game does not worth the candles for its illumination").

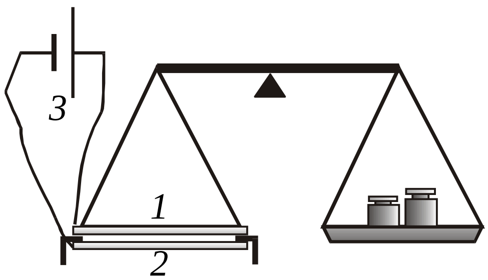


Fig. A.31.

V.4. Only the sum of works made in the internal and external parts of the circuit is constant. With the growth of external resistance so does the work on the external part and, respectively, the work made in the internal part of the circuit decreases.

V.7. The scheme of the experiment is given in Fig. A.31. If, avoiding their direct touch, we draw closer metallic plates *1* and *2* to each other, we get a capacitor. In connecting its plates with a power source *3*, on the plates charges of different sign arise, which will be attracted to each other. Let the value of the charge at each plate be q. The tension of the electric field between the plates E will be $E = U/d$, where U is the tension on terminal of the source, d is the distance between the plates *1* and *2*. In this situation, $U = qC$, where C is the capacity of the created capacitor. Taking into account that for a flat capacitor we have $C = \varepsilon_0 \cdot S/d$ (for simplicity we assume $\varepsilon = 1$) and that E is created in equal degree by both the plates, we get of the force acting on the upper plate $F = q{\cdot}E/2 = q{\cdot}U/2d = = U^2/2Cd = U^2/2\varepsilon_0 S$. Hence

$$U = \sqrt{2F\varepsilon_0 S},$$

where the value of the force F is determined via the condition of the equilibrium of the balance. However, it seems very difficult to realize this experiment in practice, because the force of interaction between the plates is significant only for very small distances.

V.8. The leaves of the electroscope are drawn apart independently of the sign of the charge of the leaves and container, becuase these charges are always opposite. In the case of an alternating current, the leaves will be attracted to the container within each semi-period and the angle at which they will be drawn apart will increase as a greater tension is applied. However, in the experiment with the voltage 220V, the leaves of the electroscope will not diverge in view of a small magnitude of the tension amplitude. Therefore the measuring method described above works at voltage of tens an thousands of kilovolts (for example, in the case of use an electrophorus machine).

V.9. To solve the paradox recall that by an electric U_{12} between the points *1* and *2* of an electric circuit we understand the work done by Coulomb and external forces for displacement of a unit positive charge between the points *1* and *2*. Let us turn to the problem. The induction current is same in all sections of the conductor, the conductor is homogeneous and has the same thickness along its length. This means that the density of electric charges of any sign is same in all points of the conductor. Consequently, the potential of different points is same. Therefore, in our case, the electric tension is determined by the work of external forces. The role of an external force here is played by the tension of the swirl electric field arising in the contour as a consequence of the electromagnetic induction. The work of forces of the swirl field depends, in contrast to the work of the Coulomb forces and other forces, on a trajectory along which the charge moves from one point to other. For our case this means that $U_{ArA} \neq U_{BRA}$! When we can write for the cur-

rent in the contour $I = U_{ArB}/r$ and $I = U_{BRA}/R$. Hence, in particular, $I = (U_{ArB}+U_{BRA})/(r+R) = \mathcal{E}_i/(r+R)$, where $\mathcal{E}_i$ is the complete electromotive force of induction in the ring determined by the Faraday law.
V.10. The resistance is 4 times less.
V.11. 1. To decrease the resistance of the end-rails' contact (and thus to diminish the energy losses in this passage). **2**. To ensure sufficient elasticity electric joining in the oscillations of rails caused by train motion and their thermal expanding.
V.12. At the room temperature the glass is a good isolator, and in the melted state (at temperatures above 300 °C) is a conductor.
V.13. After the lamp will be switched on, the current decreases.
V.14. The second one.
V.15. Connect the stove with open spiral to the supply. Holding two electrodes which are connected to the lamp and are close to each other, touch the middle of the spiral. Then draw apart one of the electrodes permanently touching the spiral and observing the incandescence of the filament of the lamp.
V.17. It would strongly complicate the isolation: the layout of wires and connection to devices should be made as on a submarine – its wires nowhere contact the water.
V.19. Absolute insulators do not exist, therefore between the wires and the ground a leakage current arises. It grows as isolators are covered by a layer of water. But their shape minimize the leakage because the interior part of an isolator is dry.
V.20. To prevent an electric current through the human body.
V.21. It is not sufficient. In a contact with two poles of a power source, a man isolated from the ground might be the victim of electric shock.
V.22. A permanent jet of water (conductor!) might injure man by electric shock, because between the wire and the Earth (man) a high voltage exists. The grounding of the fire-pump is necessary for the case of its fault.

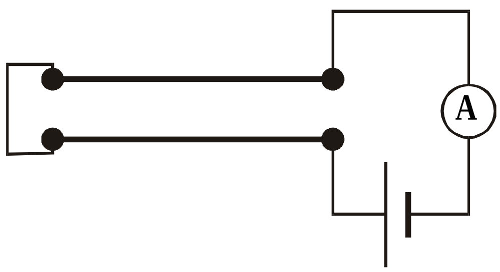


Fig. A.32.

V.23. The resistance of the segment of detail with a cavity is greater, therefore the tension is also greater on this segment.
V.24. In a deformation of the construction the wire is also deformed and its resistance changes.
V.26. For example, on both ends of a cable one may connect two wires through an indicator and a source of current (see Fig. A.32).
V.28. With an increase of tension of terminals *ÀB* the current in thermistor grows which leads to its heating and reduction of its resistance. This originates the redistribution of the tension between R_1, R_2, and R_t.

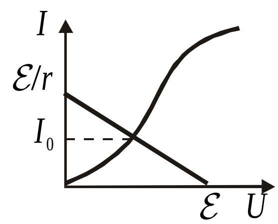


Fig. A.33.

V.29. A thermistor can be surrounded by a spiral with a current. In a change of the air (water) flow, the thermal conduction also changes and therefore the temeprature of the thermistor (thermoresistor) .
V.30. If we join into a circuit a power source, an ammeter, and a thin wire, in the circuit a constant current of a certain force will be established, which will heat the wire to a certain temperature. If we blow upon the wire, it will be cooled and the resistance will decrease, the ammeter will show an increase of the current in the circuit. This principle may be put into a model of an anemometer. In the capacity of a gauge one can use the filament of an ordinary broken lamp.

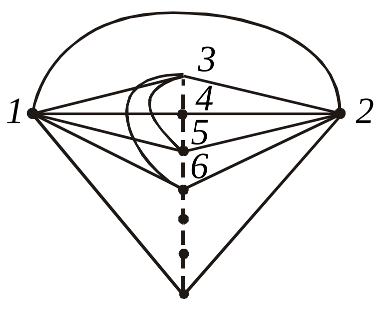


Fig. A.34.

V.31. The resistance will be practically infinitely large. The matter is that, in such a current, only a layer of water with section of order of the surface of merged electrodes will participate efficiently. In this situation, the gain in the area of section of conductor (water) turns into an essential loss in the specific conductivity (this is much greater for the water than for a metal).
V.32. Obviously, $\mathcal{E}=U(I)+I\cdot r$, where $U(I)$ is the voltage on the diode. The current I_0 in the circuit can be found as the coordinate of the point of intersection of volt-ampere characteristic of the diode $U(I)$ with the straight line $\mathcal{E}$-$I\cdot r$ (see Fig. A.33).
V.33. The resistance between two nails, say *1* and *2*, does not depend on the disposition of remaining nails. Let us dispose mentally the nails as in Fig. A.34. The figure shows that, if we connect the points *1* and *2* to a power source, the

points *3,4,5* and so on will have the same potential. Therefore we may neglect the conductors connecting these nails. We shall get as a result a parallel connection of 1994 similar circuits with the resistance $2R_0$ and a conductor with the resistance R_0:

$$\frac{1}{R_x}=\frac{1}{R_0}+\frac{1994}{2R_0}=\frac{998}{R_0},\quad R_x=R_0/998.$$

V.34. The graphs are given in Fig. A.35.

$$R_1=r,\quad R_2=\frac{rR-r^2}{R},\quad R_3=\frac{rR}{r+R}.$$

V.35. First of all let us consider the scheme given in right draw. If we move the crawler, say to the left, the resistance of the part of the rheostat, which is connected into the circuit, will decrease and same will do the readings of the voltmeter. The lamp, in this case, will get a greater tension from the source and will burn brighter. In moving the crawler of the rheostat of the left scheme, say to the left, its resistance will decrease, approaching the resistance of the ammeter . In this case,the reading of the ammeter will decrease, because the current is divide into two comparable parts. Thsi motion of the crawler will not affect the brightnessos the lamp, because the decrease of the tension on the segment rheostat-ammeter with regard for its small resistance in parallel connection will be neglectable.

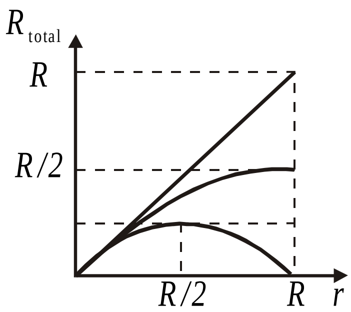


Fig. A.35.

V.36. The resistance of the circuit:

$$R_{total}=2\frac{Rr}{R+r}=16\text{ Ohm}.$$

Therefore through the battery the current is $I=5/8$A. At the point *A* (see. Fig. A.36) this current is branching into non-equal parts I_1 and I_2. At the point *C* the current I_1 "chooses" the direction *CD*, because the resistance is null on the segment *CD* while on the segment *CP* is differs from zero. The same arguments make the current I_2 at the point *D* "to choose" the direction *DC*. Thus, the current through the ammeter is $I_A=I_1-I_2$. In addition, obviously, we have $U_{AP}=I_1\cdot 2r=I_2\cdot 2R$. Then with regard for $I_1+I_2=I$, for the current through the ammeter we finally have

$$I_A=I\frac{(R-r)}{(R+r)}=\frac{3}{8}\text{ A}.$$

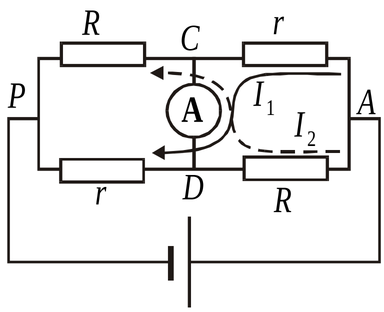


Fig. A.36.

V.37. The current shown by ammeter is greater than that flowing through the resistor, it is the summary current through the resistor and voltmeter. The greater will be the resistance of the voltmeter, the lesser will be the error in determination of the force of current flowing through the resistor, because the resistance of the part of circuit with voltmeter and resistance connected in parallel will be approximate to the value of the resistance of resistor. In addition, intrinsically, the accuracy in the determination of the resistance will grow.

V.38. It suffices to make to measurements (Fig. A.37). The firs allows to measure the internal resistance of the ammeter $r_a=U_1/I_1$, while the second gives us the value of the unknown resistance$R_x+r_a=U_2/I_2$. Hence $R_x=U_2/I_2-r_a$. The problem has been resolved. But if we make also the third measurement, then we can get the value of the internal resistance of the voltmeter $r_V=U_3/I_3$.

V.39. The ends of the cable from the side *BC* (Fig. A.38) must be connected; from the side *ÀD* the ends must be connected with a rheochord (a linear open resistor) *EG* and then supply to the latter a certain difference of potentials. Having grounded one of the terminals of the ammeter, by the wire of other terminal one must a point with potential equaling zero. In this situation, the lengths of the cable *ABCL* and *LD* relate as the segments of the rheochord *EK*

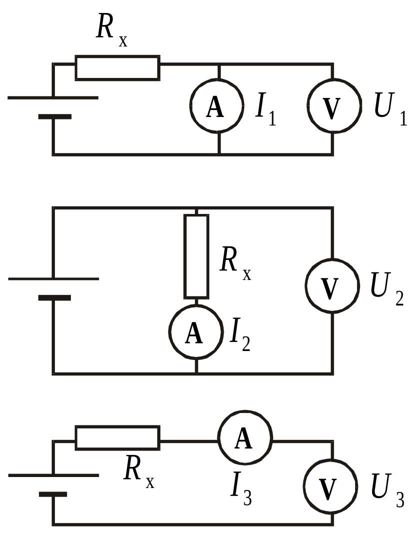


Fig. A.37.

and *KG*. We arrived at the scheme of so-called Wheatstone bridge.

V.40. The answer depends on what device is more exact. If the resistance R_x is measured by the right scheme, the voltage U is determined on this resistance, and the current flowing through it is certainly unknown. The error in the measuring of the current ΔI under unknown voltage results in an error ΔR_x in the determination of R_x, which can be easily found by the Ohm law $I{\cdot}R_x = U$; $I{\cdot}\Delta R_x + R_x{\cdot}\Delta I = 0$. Denoting by R_V the internal resistance of the voltmeter, we have $|\Delta I|R_V = I{\cdot}R_x$. Therefore,

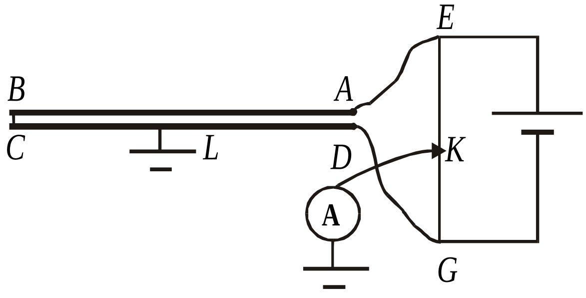


Fig. A.38.

$$\left|\Delta R_x\right| = R_x\left|\Delta I\right| / I = R_x^2 / R_V.$$

For the left scheme we have in a similar way $\Delta R_x = R_a$, where R_a in then internal resistance of the ammeter. Thus, if

$$R_x / R_V < R_a / R_x\ ,$$

the it is more advantageous to use the right scheme and vice versa.

V.41. The tension is less than the electromotive force in view of a present internal resistance. The difference between the tension on the poles of the source and the electromotive force equal the rpoduct of the current through the source by the internal resistance of the latter.

V.42. By a voltmeter of electrostatic system.

V.43. The current will grow, because the internal resistance of the element will decrease.

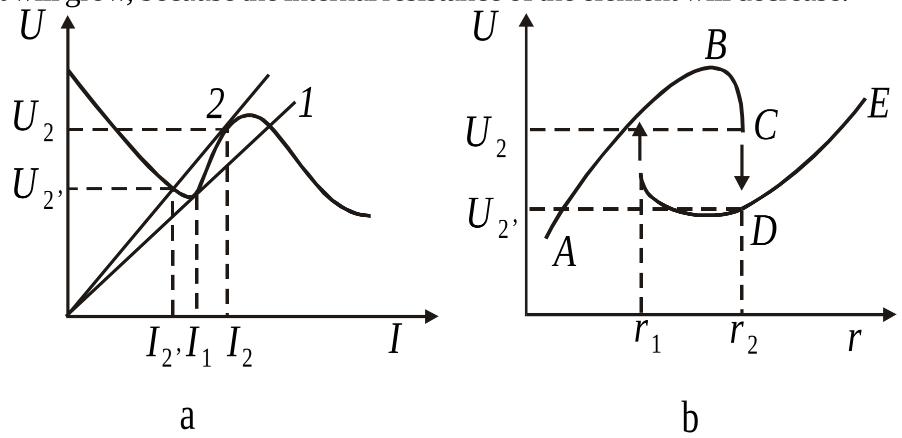


Fig. A.39.

V.44. The greater internal resistance of an old battery leads to a decrease of the current in the circuit.

V.45. If the current I flows in a circuit, the decrease of potential on the resistance r will be $I{\cdot}r$. Therefore, under a given value of the resistance, the current in the circuit and the voltage on this resistance converge graphically as coordinates of the point of intersection of the straight line $U = I{\cdot}r$ with the volt-ampere characteristic curve of the source (Fig. 0.39a). Under an increase of the resistance of the rheostat the angle of inclination of this straight line to the axis I will grow. In addition, the potential on the resistance (the segment *AB* in Fig. 0.39b) will also grow. The resistance, which corresponds to the position of the straight line *1*, is denoted by r_1. Starting from this value, the current in the circuit may take three values. However, up to the resistance r_2 (the straight line *2*) the current will continuously change. The current I_2 corresponds to an instability in the system. A slight decrease of the current leads to its jump-like weakening to the value I_2' (Fig. 0.39a). Moreover, the potential on the resistance will fall by a jump (the segment *CD* in Fig. 0.39b). In further increase of the resistance of the rheostat the tension on it will grow continuously (the segment *DE* in Fig. 0.39b). In switching off the rheostat, an instability arises if the resistance is r_1.

V.46. The battery of galvanic elements has a finite internal resistance. Therefore the voltage on the lamp is less than the electromotive force of the battery by the quantity of the decrease of the tension on the internal resistance. If one discharges a capacitor through the lamp, all the tension will fall on the lamp. As the capacitor discharges, the tension on the lamp will decrease, but if the capacitor possesses a large capacity, the charge accumulated in it will be larger and within a certain interval of time the difference between the potentials of the plates of the capacitor (therefore the tension on lamp) will be practically constant.

V.47. The lamp did not burn on.

V.49. When the ground is wet. The human body and the ground between its feet are parallel parts of a circuit, where the currents are inversely proportional to resistances. In order for a small current to flow through the body, it is required that $R_h >> R_E$. Since the resistance of the human body R_h is constant, the less of the resistance of ground R_E (wet ground), the more safe is the situation.

V.50. Since ideal insulators do not exist, a leakage current exists (in rainy and dusty weather it grows). If a man touches a support (a pole), almost all current of leakage might pass through his body, because the resistance of his body is much less than the resistance of the part of supporting pole from the place of touch to the ground (especially in the case of concrete supports).

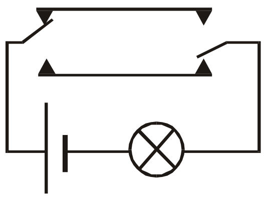


Fig. A.40.

V.51. In repairing a socket one might make a short circuit, but not in repairing a switcher.

V.52. The scheme of switching a lamp from two different places is given in Fig. A.40.

V.53. One of the possible schemes of erroneous connection is given in Fig. A.41: in simultaneous switching on two switchers, only the upper lamp burns, because the lower lamps are in a short circuit.

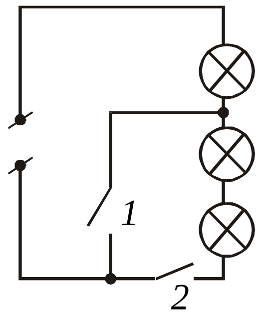


Fig. A.41.

V.55. In switching the circuit the tension on the lamp is less than the electromotive force.

V.56. We denote by r the desired resistance. Then the resistance of the infinite circuit lying to the right from the points C and D will also equal r. Consequently, the initial circuit is equivalent to that shown in Fig. A.42, and for its resistance the relaiton is valid $R+Rr/(R+r)=r$, whence we get

$$r=\frac{1+\sqrt{5}}{2}R.$$

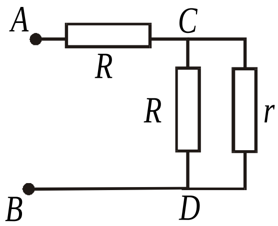


Fig. A.42.

V.57. The summary current flowing in both the resistors will decrease. As for the currents passing through each of these resistors, one will decrease while other may both decrease and increase. For example, if we sharply increase R_1 but slowly R_2, the current in the conductor R_2 will grow.

V.58. The reading of the ammeter will grow. The cooling of the spiral results in a decrease of its resistance and therefore to an increase of the current under a constant tension.

V.59. To augment the area of cooling of the conductor.

V.60. The lamp are connected consecutively.

V.61. The currents in the branches (the segment of wire between the toes and the body connected through toes to the wire as another branch) are inversely proportional to the resistance of the branches. Since the resistance of bird's body is many times greater than the resistance of the segment of the wire between its toes, a very insignificant current will flow in the body of bird.

V.62. The change of the tension in the external circuit is related to the change of its resistance due to the fact that under a change of the current in the circuit the decrease of the tension on the power source poles also changes, because the source possesses internal resistance. In a parallel connection of power sources, the interior resistance of the battery obtained will decrease. Therefore less will change the tension on the battery in variation of the current and, in particular, also due to the load resistance.

V.63. The different thermal expansion of the joined plates results in their bending when a current passes and to the disconnection of the terminals *5,6,7*. The current stops, and the lamp turns out; in cooling, the bi-metallic plate restores its form and closes again the terminals: the closing of the circuits of the spiral takes place (the terminal *5*) and the lamp (terminals *6* and *7*). In heating, the spiral again deforms the bi-metallic plate and so on. The lamp will blink.

V.64. 2. Fuses, which somewhere are called "corks", are usually situated in places of common use (in the entrance to flats and houses). 3. In an overload of the supply due to switching large devices consuming much power (Russian standard fuses are designed for the voltage 220V and the current 6.5A). 6. To avoid the electrical shock in broken switches (in wet rooms the conductivity of both air and some surfaces (to which a man may touch) grows).

V.66. Under the tension 127V the filament of an electric lamp will be less incandescent, i.e., it will have a lower temperature and thus lesser resistance. Therefore the power consumption of the lamp will decrease less than 3 times.

V.67. The voltmeter will show the electromotive force of the source (if this voltmeter is of electrostatic system). Voltmeters of other systems will show value of the tension on their own.

V.68. The desired direction depends on the circuit in whole. For example, if it has the form shown in Fig. A.43, the first pupil will be right. But if the circuit will be as in Fig. A.44, and $\mathcal{E}_2$ will generate on the segment *ACB* a current which is greater than $\mathcal{E}_1$ does, then the second pupil will be right.

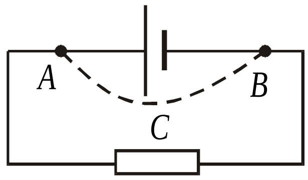


Fig. A.43.

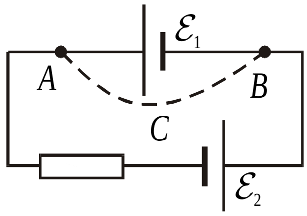


Fig. A.44.

V.69. When the tail is connected to the source (position *1*), the capacitor charges up to a certain tension U. In addition, on its plates the charge $Q = C{\cdot}U$ arises. In switching the tail to the position *2*, a discharge of the capacitor tales place. Thus, the shoulder *AB* of the bridge has the average current $I = C{\cdot}U{\cdot}\nu$ in a potential on this shoulder equaling U. Consequently, effective resistance of this shoulder is $1/C\nu$. The balance condition of the bridge can be written if ones looks again on the solution of the problem no. V.36. We get

$$\frac{R_1}{R} = \frac{1/C\nu}{R_2}. \quad \text{Hence } C = \frac{R}{R_1 R_2} \cdot \frac{1}{\nu}.$$

V.70. Both the formulas are identical since $U = I{\cdot}R$. In the consecutive connection of two conductors the quantity of heat emitted on them is proportional to their resistances $P \propto R$, since at a current of same force the quantity of heat will depend on the tension, which is greater on a conductor with a greater resistance. In the parallel connection of two conductors the quantity of heat emitted in each conductor is inversely proportional to their resistances, i.e., $P \propto 1/R$, because at the same potential the quantity of heat will depend on the force of current, which is greater for a conductor with a lesser resistance.

V.71. The misunderstanding is originated by forgetting to take into account the inverse proportional dependence between the current and the resistance at a fixed potential. Then for a definite tension we cannot take an arbitrary resistance, because by the Joule-Lentz law $P = U^2/R$, whence it is seen that the increase of the resistance implies the decrease of the quantity of heat emitted in a conductor with a current.

V.73. It will increase.

V.74. The consumed power decreases.

V.75. In a cooling of a part of wire it complete resistance decreases, the current increases. In addition, the fall of potential on non-cooled part of the conductor increases. As a result of an increase of both potential and current on this part, the quantity of the emitted heat grows.

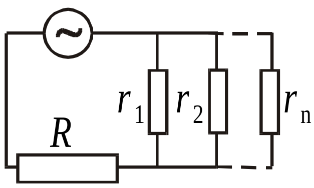


Fig. A.45.

V.76. The resistance of a cold metal is less than that of a hot one. Therefore at the same potential in the switching on the quantity of the heat emitted per the unit of time will be greater.

V.77. An equivalent scheme of electric circuit is represented in Fig. A.45, where R is the summary resistance of the generator and wires, r_i are the resistances of the devices connected to the circuit. In connecting to the circuit devices with a small resistance, the complete resistance of the part of circuit r, where r_i are connected parallel, decreases. This results in a fall of potential on the resistor R and, as a consequence, to decrease of the power emitted on r.

V.78. This means that firmly soldered wires are almost not heated by the passing current and remain cold, while the winded together wires without soldering are heated at the place of contact due to its significant resistance.

V.80. By the augment of forces of friction, the work of the electric engine, which should be spent to treatment of details, goes to heating in a greater degree.

V.81. Connection made by a thick copper wire allows to avoid the fall of potential on its and thus reduce the losses to its heating.

V.82. To emit greater quantity of heat.

V.83. The resistance of sheets at the place of their contact is greater than the resistance through electrodes, therefore greater heat is emitted at namely this place.

V.84. To reduce the losses of energy for heating of the wires.

V.86. In the consecutive connection a half of potential goes to each engine, in the parallel connection each works in normal regimen. In the last case the power will be greater and the tram will be able to go with a greater speed.

V.87. In the parallel connection the heat emitted will be four times greater than in the consecutive connection.

V.88. a) in the copper one; b) in the steel one.
V.89. Under a short circuit the resistance of the external circuit is zero. Therefore by the Ohm law the potential is also zero. The work of external forces is completely spend in this case to overcome the internal resistance of the power source.
V.90. a) the less is the resistance of the external circuit, the greater is the current in it. Therefore, the greater is energy spent to overcome the internal resistance of the power source; b) the losses of power on the resistance of the source can be made zero only if the external circuit is disconnected, when the current is absent.
V.91. By means of an ammeter, voltmeter, and watch. Having evaluated the real consumed energy $W = UI{\cdot}t$, we compare it with the difference between the reading of the electric counter in the same interval of time. If the resistance R of the power consumer is known, then is suffices to have watch and ammeter (or voltmeter).
V.92. The quantity of heat which is emitted in a circuit under a constant potential of the source, is inversely proportional to the resistance of the circuit. Let the resistance of a half of ring be r. In moving the runner from point B to an oppositely posed point A, the resistance of one part of the ring increase, which decrease for other part, say by a quantity x. Then the resistance of the circuit is

$$R = \frac{(r+x)(r-x)}{r+x+r-x} = \frac{r}{2} - \frac{x^2}{2r}.$$

Obviously, R is maximal if $x = 0$, i.e., when the runner is at the point B.
V.93. This situation is not real, because the internal resistance of the source was not taken into account.
V.94. The magnetic flux through the ring is proportional to the current I in the coil: $\Phi = L{\cdot}I$ (L is the mutual inductance). If the current in the coil changes linearly, then in the ring a constant electromotive force arises

$$\mathcal{E}_{\mathrm{i}} = -\frac{\Delta\Phi}{\Delta t} = -L\frac{\Delta I}{\Delta t},$$

where ΔI is the change of the current in the time Δt. The current in the ring which has the resistance R equals

$$I_{\mathrm{r}} = \frac{\mathcal{E}_{\mathrm{i}}}{R} = -\frac{L}{R}\frac{\Delta I}{\Delta t}.$$

Within the time Δt in the ring the next heat energy will be emitted

$$W = I_{\mathrm{r}}^2 R\Delta t = \frac{L^2}{R}\frac{(\Delta I)^2}{\Delta t}.$$

In the first case

$$W_1 = \frac{L^2}{R}\frac{(\Delta I_1)^2}{\Delta t_1},$$

in the second case

$$W_2 = \frac{L^2}{R}\frac{(\Delta I_2)^2}{\Delta t_2} = W_1\left(\frac{\Delta I_2}{\Delta I_1}\right)^2\frac{\Delta t_1}{\Delta t_2} = 6\ \text{J}.$$

V.95. With an increase of the charge of a body, the same does the electric force of the electric field surrounding this body. At a certain value of the force of the electric field, the molecules of air are ionized. The air ceases to be an isolator, and the body start to lose charges through the air. Obviously, one cannot charge infinitely bodies even under the vacuum, because the charges will start to flow out the body due to the electric field which they have created.
V.96. There is no reason since in the normal conditions the air is an insulator.
V.97. It is possible. In the capacity of ionizing substance, the quick cosmic particles may act, the particles irradiated by a radioactive substance in the Earth, etc.
V.98. The mechanisms of ionization are different: in the first of cases, it is the high potential which ensures the ionization of gas molecules in collisions of molecules, atomic electrons, and ions with each other, in the second case, the presence of a high temperature leads to ionization of the air (by expense of the kinetic energy of the particles in a collision) and arising of thermoelectric emission from electrodes.
V.100. If a rarifying of a gas its electric conduction first grows in view of growing free pass of ions. In a string rarifying, the electric conduction decreases in view of decreasing concentration of charges particles.
V.101. Evaporation of the wolfram in its heating and consequent condensation on the surface of a container.
V.102. The electric force of an electric field in related to the difference between potentials via the relation $E = \Delta\varphi/\Delta l$, where Δl is an infinitely small distance at which the change of the potential by $\Delta\varphi$ arises. The electric force of the field is most large near the electrodes (the points O and C) and vanishes on the

segment *AB*.
V.103. Depends on the kind of a gas.
V.104. If air hits the tube, the pressure there rise and the free pass of electrons turns lesser; the potential becomes insufficient for the existence of a glowing discharge (electrons fail to obtain the energy necessary to ionize the molecules of gas).
V.105. For glow of the gas in neon lamp an electric field must be created there, which is reached by rubbing the glass.
V.106. A neo lamp starts to glow in a tension sufficient for arising of a glowing discharge. The brightness of incandescent lamps grows as tension grows, because, in this situation, gradually increases the temperature of the filament of a lamp.
V.107. By virtue of bombing of the cathode by positive ions of the gas.
V.108. The interior resistance of a stabilitron is inversely proportional to the anode current, which results in an unchanged potential on the stabilitron.
V.109. The cathode is the source of electrons and in its cooling the thermoelectric emission may end.
V.110. A thin-wall detail must be connected to the negative pole of the power source, because the negative electrode heats less than the positive one.
V.111. Through these needles the structure of the airplane gradually discharges at relatively low potentials and the radio noise is reduced.
V.112. In an increase of the diameter of a wire the tension of the electric filed near it decreases, which leads to a decrease of the intensity of ionization of the air. Hollow wires are used for economy of metals, however, with a provision that their resistance be small.
V.113. Replacement of one wire with three wires is equivalent ot an increase of the diameter of a wire, which results in a reduction of losses for glowing discharges.
V.114. The electric conduction of the air grows.
V.115. The seeds with different physical properties are charged differently.
V.116. For arising of a spark discharge a high voltage is necessary.
V.117. Over outstanding places of the surface the electric force of the field is great, sparks arise meting these outstanding places.
V.118. Electric-spark treatment of metals does not depend on its hardness, nor frailty. The evacuation of the metal takes place over the whole treated surface which corresponds to the shape of the electrode and does not depend on the shape of a detail. In this situation, a preliminary treatment of the surface of detail is necessary in order to remove a large scale asperity.
V.119. In the first of cases the incandescent lamp does not burn, because the heat from the filament is evacuated through the hydrogen which is placed into bulb. After sinking bulbs into helium, the hydrogen freezes out and the lamp burns again. In the neon lamp, the neon also freezes and the discharge disappears.
V.120. a) In the switching the lamp on, the leaves of the electroscope converge. This is explained by charges' "flowing down" from the electroscope to the foil, because inside of the bulb a negative charge arise due to electrons emitted by the filament of the lamp. b) In a negative charging of the electroscope, its leaves in the switching lamp on do not converge, since the gas of the lamp practically contains no free positive charges. c) In string incandescence of the lamp's filament, a partial ionization of the takes place. In this case, the leaves of negatively charged electroscope are draw to each other. The mechanism of the phenomenon is similar to the case a).
V.121. Positive ions of the air bomb and destroy the cathode.
V.122. In a strong electrostatic field the electrons obtain large kinetic energy, which turns into heat in the process of bombing of the anode.
V.123. The live of lamps become longer since in the atmosphere of inert gases the incandescent metal is less evaporated.
V.124. A gauge for the counter of ionized particles can be done of a glass tube with inert gas under a definite pressure and two electrodes sealed in (Fig. A.46). If we give on the electrodes a high voltage, then each ionizing particle will cause an impulse of a current in the gauge, which can be registered by a sensitive device. Such a gauge is called the Geiger gauge.

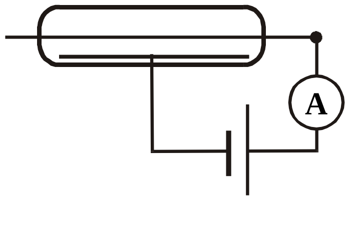


Fig. A.46.

V.125. The electrolyze takes place, with which upon the duct, as on a cathode, the metals settle supplied from the ground which works as an electrolyte.
V.126. The molecules of salt in water are dissociated into ions which chaotically move in it. If in such a solution one creates the electric field by merging two plates connected to poles of the power source, then the ions start to move orderly thus creating a current in the solution.

V.127. To renew the ions in the solution, the anode is taken as a plate of the same substance which is accumulated on the cathode. Ions flow down from the anode and pass to the electrolyte.
V.128. The ions of copper from the places without wax will pass into solution thus creating cavities (embossment over copper). The places covered by wax remain untouched.
V.129. The dissolution of the sulfuric acid with water makes to increase due to dissociation the quantity of ions in the solution. The local currents, arising in such a solution (electrolyte) by virtue of the electrolyze, cause the corrosion of the vessel.
V.130. The presence of salts in a simple water makes it to conduct currents (electrolyte). The resulting within the secondary reaction in electrolysis products of dissociation of water give birth the hydrogen and the oxygen; besides, the volume of the hydrogen is twice greater than the volume of the oxygen. Therefore, on the negative pole of the power source a greater quantity of gas will be formed.
V.131. If the rails were connected to the positive pole of the power source, then by virtue of the electrolyze of the underground waters (the Earth would possess a negative charge) the oxygen were produced on the rails. This will significantly accelerate the corrosion of rails. In addition, it were very dangerous to cross tram rails.
V.132. The vapors of water contained in the air in their condensing and settling on wires may cause a short circuit, since the water formed in this process is an electrolyte.
V.135. The zinc-coated iron is an anode covering, the tin-plated iron is a cathode covering.
V.136. This result in the increase of the forces of interaction (attraction) between the molecules of a product and the molecules of the metal which is used to cover the product.
V.137 By the conditions of exploitation and the chemical properties of the metal.
V.138. For a uniform covering by the metal, because in this process the covering goes on both sides.
V.139. The rotation of baths facilitates uniform covering of the details and accelerates the electrolysis due to washing out the mud from drums, which decreases the current in the electrolyte.
V.140. The metal settled on convex micro-relief is partially dissolved and the surface of the treated details becomes smoother.
V.141. This depends on the way in which the resistance of the electrolyte changes with a change of distance between electrodes. The latter affects as well the force of the current. This leads to a variation of the intensity of the electrolyze.
V.142. Thew cutting tool must be connected with the positive pole of the power source, and the metallic disk for sharpening with the negative pole.
V.143. It is necessary to make the surface to conduct the electric current by covering it a layer of a conducting substance (for example, graphite).

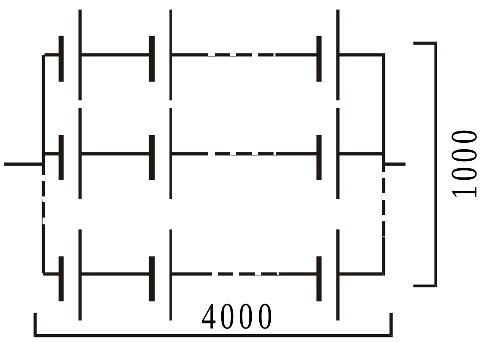


Fig. A.47.

V.144. In the passage of an electric current through an electrolyte, near the electrodes charges of opposite sings are accumulated, whose electric field is directed oppositely to the electric field generated by the capacitor. When the electric forces of these fields will become equal by their value, the current will be stopped. More baths are connected consecutively, the less charge passes through them.
V.146. To obtain the potential of 600V, 600 V/0,15 V = 4000 electric pockets must be set in a series. To obtain a current of 1A, 1 A/0,001 A = 1000 electric pockets must be in parallel. This gives near 4 millions pockets. The way of their commutation is given in Fig. A.47.
V.148. The current in the circuit is $I = (\mathcal{E}_1 + n\cdot\mathcal{E}_2)/(r_1 + n\cdot r_2 + R)$, where r_1 and r_2 are the internal resistances of the accumulators, R being the external resistance. This expression does not depend on n as $dI/dn = 0$, i.e., when $\mathcal{E}_1/(r_1+R) = \mathcal{E}_2/r_2$. In this case, $I = \mathcal{E}_2/r_2$.
V.149. This is possible.
V.150. Near the terminals of the accumulator the electric field is too weak.
V.151. Among the plates and the solution of the acid non-electrostatic forces act. In this case, the different parts of the conductor will have different potentials.
V.152. Inside the element the electrolysis takes place in the passage of a current directed from the negative pole to the positive pole. The ions of hydrogen go along the direction of the current.
V.153. This term is not very correct, electrolyte is a viscous liquid. Therefore the element is covered by a resin.
V.154. In “rumpling” an element we mix the electrolyte.
V.155. The signs of electrodes in a galvanic element are determined by relative position of chemical elements,

which are they made of, in the electrochemical series of tensions. Each element displaces from salts all other which are at right from it in this series. The zinc stands to the left from carbon and copper in the series of tension, therefore in a pair with them it is a negative electrode. Once can make a galvanic element with positive zinc electrode one selects the cathode material among substances which are at the left from zinc in the electrochemical series, for instance, the calcium or the manganese.
V.156. The chemically pure zinc is less solvable in acid than that with addends.
V.157. Destruction of the tank occurs due to formation of galvanic pair aluminum-copper and the simple water is an electrolyte. Under the action of this "galvanic element" the dissolution of the metal (aluminum) and the formation of hydrogen on the copper take place.
V.158. In a leakage we must add a ready-to-use electrolyte; in evaporation from the surface we may add a portion of the distilled water
V.159. If an accumulator is charged, the density of the electrolyte increases by expense of reduction of the water contained in it. The matter in a secondary reaction, which result in decomposition of water. The hydrogen goes to cathode; a molecule of SO_4, being unstable and ejecting an ion of the oxygen O^{2-}, turns into a molecule of sulfuric anhydride SO_3, which forms with water the sulfuric acid. If the accumulator is discharged, the density of electrolyte decreases.
V.160. The internal resistance of the dry elements is significantly greater than the internal resistance of accumulators. Therefore, at the same the electromotive force, the fall of potential on a lamp connected to dry elements is less than if it were connected to an accumulator.
V.161. No, cannot. Because the most part of the potential will fall inside the battery. The potential on the starter will be insufficient for a work.
V.162. $I = \mathcal{E}\cdot n/(r\cdot n+R)$, where n is the quantity of elements, $\mathcal{E}$ and r are the electromotive force and the internal resistance of one power element, R is the resistance of the external circuit. Hence $I = \mathcal{E}/r$ for $R = 0$. Therefore one cannot obtain a current of arbitrarily large force.
V.163. The acid accumulators possess small internal resistance. If the resistance of the power source is small, then, in a short circuit, a huge current arises in the circuit, which may lead to a destruction of the source.
V.164. In the alkaline accumulators a greater power goes to overcome the proper internal resistance.
V.165. The starter consumes a large current (about hundred amperes), therefore in the alkaline accumulators there were a big fall of potential and in a change of the temperature (in view of the change of resistance) the voltage on the poles of accumulator also would change.
V.166. To reduce the internal resistance of the accumulator and thus increase its efficiency.
V.167. Use the parallel connection of elements, in this case the internal resistance of the battery is minimal.
V.168. In the range of temperatures from 0 to 600 °C – the first, because in heating by 400 degrees it generates the electromotive force of 30 mV, while the second gives only 12 mV.
V.169. The electrons and positive ions in plasma are deviating in a magnetic field to different plates. In the given direction of the magnetic field (see Fig. V.27), the electrons are deviated to the lower plate while the positive ions go to the upper plate. Between the plates an electric potential arises. The current is directed from the upper plate to the lower plate through the resistance of load.
V.170. The greater is a degree of ionization of a gas which enters in a magnet field, the greater is the quantity of charged particles which hit the plates (electrodes). This results in a greater value of the potential.
V.171. By virtue of the electromagnetic induction, it the rotor the induction current arises, upon which Ampere forces act from the side of the magnetic field of the stator and thus brake it.
V.172. In the disconnection of the circuit *4*, into the circuit of bypass winding of the inductor *5* a resistance in included, which by weakening the current in the bypass winding reduces the tension of the magnetic field of the generator until the electromotive force excited in its armature *6* decreases. Then the electromagnet will release the terminal which will put the resistance in a short circuit. This process repeats, the contact *2* will vibrate.
V.173. The primary excitation in the machine is by expense of the residual magnetism of the core of the inductor.
V.175. Excited in the armature when it rotates in opposite direction current will weaken the magnetic field of residual magnetism but not support it. There will not be an excitation of the machine.
V.176. a) When the engine of machine does not work or work at a slow speed, the lamps are supplied from accumulator battery; poor incandescence of the lamps testifies a discharge of the battery; b) when the rotation of the engine has been increased and the rotor of the generator will turn with a necessary speed, the lamps burn with the normal brightness, but the latter lowers as soon as the rotation speed has been lowered (because the accumulators are not switches on to work).
V.177. A large current is necessary to obtain a greater power, which is necessary to turn on the crankshaft

of the engine. In a rather long work with such a great current, the winding of the starter is strongly heated.
V.180. By the Lorenz law, the momentum with which a magnetic field of the stator acts upon the generator winding of the rotor is contrary in its direction to the momentum of the winding of the rotor working as an engine. By their value the both momentums must be same (it is assumed that the rotor rotates uniformly).This means that the forces of currents in both windings of the rotor are also equal to each other. It is clear that the electromotive forces of induction $\mathcal{E}$ are also equal. Therefore $I = (U - \mathcal{E})/R, I = \mathcal{E}/(R+r)$. By excluding $\mathcal{E}$, we get $I = U/(2R+r)$.
V.181. To change the direction of tram's movement there is a device in it which change the polarity in windings of the engine. The terminal, which in the forward move is connected to the air wire, in move backward is connected to the rails.
V.182. A tram may return the energy into the supplying circuit. Electric engine of a constant current, which is applied in the tram, is reversible, i.e., in a rotation of the shaft of engine it generates a current as a dynamo machine. In very fast rotation of the rotor, e.g., when a tram moves downwards over a hill, it may happen that the voltage generated in the windings of the engine will be greater than the voltage in the circuit; thus this tram will supply an energy to the circuit.
V.183. In the rotor of an electric engine, an induction current arises directed oppositely to the current which puts engine to work. The electromotive force of induction is proportional to the angular speed rotation of the rotor. The greater is this angular speed, the lesser is current supplied from the circuit to the engine.
V.184. In order to avoid sliding contacts in the transmission of a current of a large power into external circuit (sparking and arcs lead to quicker destruction of both the brushes and rings).
V.185. The answer is "no"; the constant magnetic field of the inductor is generated by the *dc* source, which is a special generator of *dc* called "exciter".
V.186. In Russia, the *ac* frequency standard is 50 Hz. For fast-rotation machines (vapor turbines), which rotate at the speed 50 rps (rotations per second), it suffices to have one pair of poles for e a generator. Then one complete rotation gives one period. As for a generator which is moved by a slow-rotation hydraulic turbines, it must have as many pairs of poles as much times its rotation speed is lesser than that of a vapor turbine. Then the frequency of the generated current will equal 50 Hz.
V.188. To avoid the electrolysis which may cause errors in measurement of the value of resistance.
V.189. The brightness of the both lamps is similar in the mean.
V.190. The resistance of the wire against a direct current has not changed. For *ac* its resistance has been increased.
V.191. The reactive resistance of the circuit decreases.
V.192. The complete resistance of the circuit of *ac* in consecutive connection of a resistor, coil, and a capacitor is determined by the expression

$$Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2},$$

where R is the resistance of the lamp, $\omega \cdot L$ is the inductive resistance, $1/(\omega \cdot C)$ is the capacity resistance. Hence the result described in the condition of the problem is evident. The essence of the phenomena is in the specificity of the resistance produced by the coil and capacitor against an alternating current. In definite phases of the oscillations of the current, its energy passes into other forms (the energy of the electric field of the capacitor and the energy of the magnetic field of the coil). In other phases this energy, accumulated by the coil and the capacitor, is returned into the circuit. Since the oscillations of the potential at the coil and capacitor are in counter-phase, by the choice of the capacity and inductance one can make so that the energy, say returned into the by the capacitor be exactly equal to the energy drawn from the circuit by the coil and vice versa. Obviously, in this case the energy of the power source is spent only for overcoming the active resistance of the circuit.
V.194. The incandescence of the lamp's filament will decrease. A part of the battery power will be spent to magnetizing and hoisting of load.
V.195. The zero wire has usually a smaller diameter.
V.196. 300 Hz.
V.197. For the second one: the phases are loaded non-uniformly.
V.198. The consumers are connected consecutively and receive a part of the tension (Fig. A.48). In the three-phase supply with zero (Fig. A.49) such a situation is impossible.
V.199. In the second case each winding gets a linear (inter-phase) voltage while in switching "in star" between any two phases not one but two windings are present; in this case, each gets a lesser phase voltage.
V.200. a) the ends of three windings are connected together by means of a jumper – this is the connection

"in star"; b) the end of one winding is connected with the start of other winding – this is the "triangle".
V.201. In switching on to the right, the windings are connected into circuit "in star" and get a lesser voltage; afterwards, when the engine will get sufficient rotation, the complete voltage is supplied to its windings by re-switching to the "triangle" scheme of connection (turn of interrupter handle to the left).

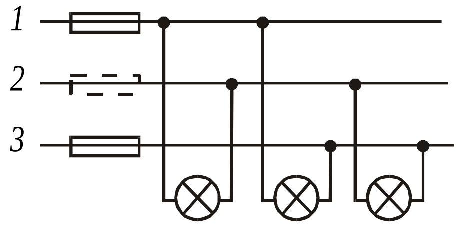


Fig. A.48.

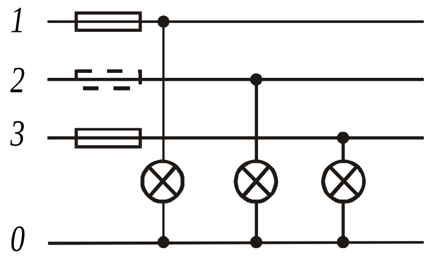


Fig. A.49.

V.202. Further transmission without transformation implies large losses of power in wires to the Joule heat. In a near transmission these over-losses can be avoided by applying thick conductors, called "bus" (which are applied, for example, in electric power stations in the transmission of energy from a generator to the distribution panel). In a longer transmission it is not worth to apply thick conductors (buses).
V.203. It changes, but insignificantly (decreases by 1–2%).
V.204. A burning out of the coil is very probable, because its inductive resistance will strongly decrease and therefore the flowing current will strongly grow.
V.206. An interrupter is necessary to stop the action of the electromagnet: then the clapper is drawn apart from the bell, it closes again the circuit. In applying *ac*, the changing magnetic field generates the vibration of the clapper.
V.208. In moving the handle from *A* to *B* the quantity of winds in the primary winding decreases; therefore the potential on the grips of electrodes will grow and the force of the current in the secondary winding decreases.
V.211. The wind with a short circuit loses approximately twice its inductive resistance, which results in a significant increase of the heat emitted on this part of the winding. The transformer may be heated up to a high temperature and be thus damaged.
V.212. In re-magnetizing of a steel sound waves arise with the double frequency of re-magnetization, i.e., 100Hz.
V.213. In supplying the current from the mains, it passes through the winding of an electromagnet which, holding the armature, disconnects the terminal *C*. If the supply it cut, the armature under action of the spring goes back, closing the circuit of the accumulator battery; lams are switched on.
V.214. In a reduction of the rotations of engine, the potential produced by the generator goes down, the magnetic action of the electromagnet *1* weakens, and the spring *2* draws back the armature *3* thus disconnecting the terminals *4*. In this situation, the accumulator battery is switched off from the generator.

Answers to Chapter VI

VI.1. Will grow.
VI.2. The periods of oscillations of the balls will be practically same. In both the vacuum and the air first will stop the pendulum with water, because a part of its energy will be spent to interior friction between the layers of water.
VI.3. Potential energy of the system of three balls in the equilibrium state is assumed to be equal to zero. Then in a deviation of the construction for a small angle α the potential energy of the system will be equal to

$$E_{\mathrm{p}} = mg\left(L\text{-}L\cos\alpha\right) = 2mgL\sin^2\frac{\alpha}{2} \approx \frac{1}{2}mgL\cdot\alpha^2$$

while the kinetic energy is

$$E_{\mathrm{k}} = \frac{3}{2}mL^2\left(\dot{\alpha}\right)^2,$$

w h e r e $\dot{\alpha}$ is the derivative of with respect to the time, equaling the angular speed of rotation. The complete energy of the system remains constant $E_{\mathrm{k}}+E_{\mathrm{p}} = \mathrm{const}$. By substituting in it the expressions for both E_{p} and E_{k} and after differentiation the result with respect to time, we have after some simplifications:

$$\ddot{\alpha} + \frac{g}{3L}\alpha = 0.$$

This is a differential equation describing harmonic oscillations with the cyclic frequency

$$\omega = \sqrt{\frac{g}{3L}}$$

and the period

$$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{3L}{g}}.$$

VI.4. On the pole the clock will go faster, on the equator it will go slower.
VI.5. For two periods of oscillations we have:

$$T_1 = 2\pi\sqrt{\frac{l}{\gamma\dfrac{M_{\mathrm{E}}}{\left(R_{\mathrm{E}}+h\right)^2}+a}} \quad \text{and } T_2 = 2\pi\sqrt{\frac{l}{\gamma\dfrac{M_{\mathrm{E}}}{\left(R_{\mathrm{E}}\right)^2}}},$$

where l is the length of the pendulum, R_{E} and M_{E} are the radius and the mass of the Earth, respectively, h is the height at which the rocket is now, γ is the constant of gravitation. By equaling these quantities we get

$$h = R_{\mathrm{E}}\left(\sqrt{\frac{1}{1-\dfrac{aR_{\mathrm{E}}^2}{\gamma M_{\mathrm{E}}}}}-1\right).$$

VI.7. For the system described in the problem a good approximation is given by the model of the mathematical pendulum. If the pail is filled completely, first its period will increase, because, if the water flows out, the center-of-gravity of the system (pail–water) will first lower, and thus the length of the pendulum will grow. Then an decrease of the period will take place by virtue of an upward growth of the center-of-gravity of the system (pail–water). When the water fill be exhausted, the period of oscillations will turn to be equaling the initial one, because the initial length of the pendulum is restored.

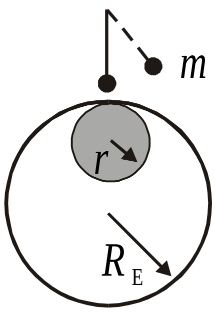


Fig. A.50.

VI.11. Assume that the deposit of ore has the shape of a ball, then the attraction force of the bob of pendulum of mass m to the Earth at the given place (Fig. A.50) is

$$F = \gamma\frac{M_{\mathrm{E}}m}{R_{\mathrm{E}}^2} + \gamma\left(\rho_{\mathrm{O}}-\rho_{\mathrm{E}}\right)\frac{V_{\mathrm{O}}}{r^2}m$$

and provides it with the acceleration

$$a = \frac{F}{m} = g + \gamma\left(\rho_{\mathrm{O}}-\rho_{\mathrm{E}}\right)\sqrt[3]{\frac{16\pi^2 V_{\mathrm{O}}}{9}},$$

where $V_O=4\pi r^3/3$ is the volume of the ball of ore, γ is the constant of gravitation, g is the acceleration of the free fall far from the ore deposit, M_E is the mass of the Earth. The period oof oscillations of the pendulum far from the ore deposit is

$$T_0 = 2\pi\sqrt{\frac{l}{g}},$$

and near the deposit is

$$T_1 = 2\pi\sqrt{\frac{l}{a}}.$$

Then

$$\eta = \frac{T_0}{T_1} = \sqrt{1+\frac{\gamma(\rho_O-\rho_E)}{g}\sqrt[3]{\frac{16\pi^2 V_O}{9}}}.$$

Hence the mass of the ore deposit equals

$$M_O = \rho_O V_O = \left(\frac{\eta^2-1}{\gamma(\rho_O-\rho_E)}g\right)^3\frac{9\rho_O}{16\pi^2} \approx \left(\eta^2-1\right)^3\cdot 10^{23} \quad \text{tons}.$$

VI.12. By the phenomenon of resonance (closeness of the frequency of free oscillations of the pail and the frequency of the compelling force created by the movement of a man). To decrease the swinging back and forth, one must change the rhythm of walk.
VI.13. The work of engine generates vibration of the body of automobile and all its parts. The most strong oscillation of glasses happens when the period of vibration of engine becomes equal to the period of proper oscillations of the window glasses.
VI.14. The piece of wood floating in water prevents formation of waves of a large amplitude.
VI.15. To avoid transition of vibration to the structure of the building.
VI.16. 72km/h.
VI.17. The acceleration is $a^2 = 4\pi^2 l/T^2$.
VI.18. The oscillations of one tuning fork can be modulated by their amplitude by periodical closing and opening the resonator with hand. If we close the resonator of the first tuning fork periodically with the frequency Ω. Then the change of the amplitude of the sound which it generates follows the law:

$$A(t) = A_0\cos\Omega t\cdot\cos\omega_1 t = \frac{1}{2}A_0\left[\cos(\omega_1-\Omega)t + \cos(\omega_1+\Omega)t\right].$$

If $\Omega = \omega_1 - \omega_2$, or $\Omega = \omega_1 + \omega_2$, the second tuning fork will start to sound.
VI.19. In following the technique of the method of dimension, we represent the solution in the form

$$R = E^a t^b \rho_0^c.$$

By requiring the coincidence of dimensions in the right-hand side and in the left-hand side of this formula, we get a system of equations for determination of a, b, and c: $a+c=0$, $b-2a=0$, $2a-3c=1$. Finally,

$$R = k\left[\frac{Et^2}{\rho_0}\right]^{1/5},$$

where k is a certain dimensionless constant.
VI.20. By the method of dimensions we get $[v]^2=[p]/[\rho]$, whence

$$\frac{v_1}{v_2} = \sqrt{\frac{p_1\rho_2}{p_2\rho_1}}.$$

VI.23. In approximating to the shore the lower layers of water are braked by the friction between them and the bottom, while the upper layers are moving forward and thus ahead the lower ones. They take a sharp shape so that their vertices come off and molder forming a foam ridge.
VI.24. At least, there are three reasons. First was explained in the previous problem. The second cause is the current. The third is that some objects represent a kind of a sail.
VI.25. An analogy with the geometric optics takes place here. In shallow waters the speed of waves decreases. Therefore we may assume that a wave enters a zone with a greater coefficient of refraction. The law of refraction gives us that the direction of the wave's propagation in passing from one medium to another medium with a greater index of refraction occurs more close to the normal of the boundary of a media interface.
VI.26. Arising in a discharge of a lightning, sound waves as they approximate the ground hit the layers,

where their velocity becomes greater, and therefore the lesser is the index of a refraction of a medium.In addition, the direction of propagation of sound waves more and more goes upward (Fig. A.51). Under a definite height of the discharge and a certain distance from the ground, a situation is possible in which the waves, before they reach the ground, are reflected from a warmer layers of the air. The fire of heavy guns are made on the surface of Earth. Their sound, heard by us, runs directly in layers with the same temperature and is not refracted. The length of its propagation is subject to only a reflection on surface barriers (buildings, relief. forests) and the absorption by the air.

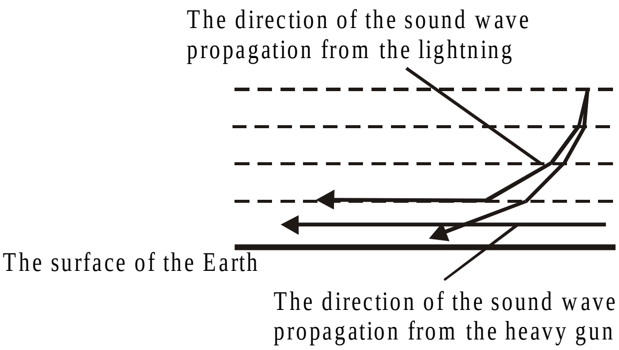


Fig. A.51.

VI.27. Because propagated by marching solders and their orchestra, the sound needs a certain time to reach our ears: the speed of sound in the air is not huge, being about 340 m/s; as for the speed of light, it is greater by many orders of ten (about 3×10^8m/s).
VI.28. In summer, because the speed of sound in the air grows as temperature grows.
VI.29. The speed of a jet airplane is close to the speed of sound or exceeds the latter. Therefore we see the airplane not at the place from which the noise of engines reaches us, but somewhere ahead of this place.
VI.30. The sound waves are not propagated from the surface of the Earth to a latitude exceeding 2.5–3km. Passing into the air of a lesser density, these are refracted and return to the surface. The cause is that with a decrease of air's density the speed of propagation of sound waves grows and thus the coefficient of their refraction decreases. In other words, here we deal with an effect analogous to the effect of complete internal reflection in the optics.
VI.31. In a misty weather the air is more homogeneous (in the scale of sound waves) and the convection flows are absent.
VI.32. By the oscillations of the wings of the insects.
VI.34. After filling with honey, the bee emits a sound of a lower frequency.
VI.35. The stroke of the hammer generates the oscillations of the wheel which generates a sound. An integer and good wheel and a wheel with a rift make different sounds, which is used by the observer.
VI.36. To increase thew friction between the bow and the string, one must develop conditions for excitation of oscillations in the string.
VI.37. First, the speed of rotation of the saw decreases; second, the mechanical parameters of the system "saw-support-plank" are changed.
VI.38. To decrease the frequency of oscillations.
VI.39. Lowers.
VI.40. In view of a heating produced by hand, the length of the tuning fork increased and the frequency of proper oscillations changed. Therefore in adding oscillations some beating appear.
VI.41. With the growth of the pressure, the sound frequency in the cylinder increases.
VI.42. The length of a sound wave is approximately equal to four times of the length of the air column inside the tube.
VI.43. The interior space of the bottle serves as a resonator, selecting from the noise a tone of a certain frequency. As the content of the bottle increases, the length of the resonator shortens and the height of the tone goes up.
VI.44. Will not change.
VI.45. The sound is amplified by expense of a shorter duration. The leg of the tuning fork excites in the table compelled oscillations which create the laud sound.
VI.46. The answer is "no". In non-elastic bodies (cotton, etc.) elastic oscillations, which are transferred from one point of body to other, do not arise.
VI.48. On the open air only sound waves which go directly from the source of sound, are perceived. In closed rooms a man perceives also waves reflected from walls, ceiling, and other objects.
VI.49. Closed doors and windows are damping sounds, because the sound waves which hit their surface are partially reflected and the quantity of energy which enters into a room reduces significantly.
VI.51. The walls of the can may oscillate generating a sound. A can sounds more aloud when the frequency of its proper oscillations is equal to the frequency of one of tones of the sound produced by you (resonance).

VI.53. The sound is propagated in solid bodies better than in gases.
VI.54. Yes, because the sound goes over the solid details of the fuselage and inside it through the air.
VI.55. No at any distance, because in the space vacuum there are no condition for propagation of sound waves. However, if the cosmonauts will touch each other by their helmets, they may hear each other.
VI.56. The human organism is a resonator of sound waves, which also changes its frequency spectrum. A man perceives his proper voice as a combination of oscillations which go both in the air and through his proper body. Listening to his own voice in a Hi-Fi record, he hears only the waves which are propagated in the air.
VI.57. To widen the spectrum of eigenfrequencies.
VI.58. The melody will sound same, because the frequency of sound in any medium remain same.
VI.60. First we shall feel the sounds of the stroke propagated by the pipe. After that we shall hear the sound propagated in the air.
VI.61. A bullet shot from a gun moves with a supersonic speed. Therefore, a shock wave is created which gives the sound of a high tone.
VI.62. As a disharmony.
VI.63. The sound of high frequencies is stronger absorbed than the a low-frequency tone. This makes the speech illegible.
VI.64. The echo may be both useful and harmful. If it amplifies the sound and slightly increases its duration, it is useful.
VI.65. To avoid a superposition of sounds reflected from buildings on the new sounds. The length of a pause depends on the size of square.
VI.66. If the lightning is close, we hear only the sounds accompanying the lightning. If it is far, we hear also the sounds reflected from various barriers.
VI.67. The size of a room is rather small. The sound from a source and its reflections are arriving practically simultaneously to our ears.
VI.70. On corners of buildings short-length sounds diffract on some small angles in view of their small length.
VI.71. The mouth serves as a resonator of sounds.
VI.72. By amplification of weak sounds, whose frequency coincides with the frequency of free oscillations of the air in the mentioned objects.
VI.74. In a wind, the wires make chaotic oscillatory motions thus acting upon the isolators fastened on poles. In these poles the standing sound waves are excited.
VI.75. A bat excites an ultrasonic sound and then perceives its reflection from barriers. Human hairs well absorb ultrasonic waves, there fore the bat "does not hear" this barrier.
VI.76. Ultrasonic waves are reflected from objects possessing a size exceeding the length of an ultrasound wave. In this situation, a high accuracy of location is ensured.
VI.77. From the condition of interference minimums for the point M we have

$$\Delta d = d_2 - d_1 = \frac{\lambda}{2}(2k+1),$$

and for the point M' we have

$$\Delta d' = d_2' - d_1' = \frac{\lambda}{2}(2k+3).$$

By measuring in the Figure both Δd and $\Delta d'$, we evaluate $\lambda = \Delta d' - \Delta d$ and $v = \lambda \cdot f$.
VI.78. When the capacitor discharges completely, the current in the tuned circuit attains the maximal value. To this instant the energy of the magnetic field reserved in the coil attains its maximal value. Namely the presence of a reserve of this energy causes an uninterrupted process of the discharge of the capacitor. The further change of the current in direction of its weakening generates an electromotive force of induction of a direction at which by expense of the decrease of reserved magnetic energy both the value of the current and the former direction are supported. This process results in vanishing of the magnetic energy and also in recharge of the plates of capacitor. The last state of the capacitor is not an equilibrium, and its discharge in opposite direction starts.
VI.80. The metallic shell of a mine increases the inductance of the tuned circuit. In addition, the frequency of sound oscillations decreases.
VI.81. By means of consecutive connection to the circuit of a capacitor (it makes to pass only the alternating component of the current) or a coil with large inductance, called choke, which possesses large inductive resistance for *ac*.
VI.82. The oscillations of high frequency of a generator are varied under action of oscillations of sound frequencies obtained in the modulator; their power is increased in a special amplifier. The antenna emits modulated electromagnetic waves.

VI.83. Modulated oscillations of high frequency, excited in the antenna circuit , then are amplified by the high frequency amplifier. In the detector the low-frequency (sound) component of the signal is detected and then increased in their amplitude by the low-frequency amplifier. After that the electric oscillations thus obtained are transmitted to the speaker (phones), where are transformed into the sound.
VI.84. In the left circuit which is connected into a circuit of generator (the latter is not shown in the figure), unfading oscillations of high frequency arise, which excite same oscillations in the antenna circuit. By means of a key, short and long teams of electromagnetic waves are transmitted, which realizes the transmission of signals by radio (so-called "manipulation") by means of the Morse alphabet. In the antenna circuit of the second scheme, unfading oscillation of high frequency are also generated, whose amplitude, however, does not remains same, but changes permanently, being modulated. These changes take place granting to the action of the magnetic field of the coil of the microphone circuit. I this circuit, as soon as sounds reach the microphone, constant by direction but varying in force electric currents are excited (|currents of sound frequency). Modulated oscillations in antenna generate modulated electromagnetic waves, which carry the sound over space.
VI.85. In winter and summer the layer of ionosphere which absorbs radio-waves is at a higher altitude (300– 600km above the sea level). In daytime this layer stays lower (80–100km) and absorbs the radio-waves more intensively. The difference in reception is more sensible on middle and long wave bands; it is less sensitive on short wave bands; the latter are refracted and reflected by the ionosphere.
VI.86. The "dead zones" are generated by two peculiarities of the propagation of electromagnetic waves: a) their strong absorption by the Earth's surface; b) refraction and reflection in ionosphere (the ionized layer of the atmosphere, which is situated on altitudes 80–600km above the Earth).
VI.88. To decrease the sizes of a receiving device. Reception by short antennas gives a weaker signal which then is amplified by the high-frequency amplifier. Thus, this fault of antenna is compensated by high features of the amplifier of the radio-receiver.
VI.91. The signal reflected from the airplane hits the antenna of the TV slightly later than the direct signal from the TV tower. On the screen of TV the image created by the direct signal appears. A weak "twin" moves along the screen as the airplane approaches or leaves the zone of TV antenna. The second image is to the right from the real image because the unrolling of electronic beam is left-to-right if we see on the screen.
VI.93. The TV centers work on ultra-short waves (λ<10m). These waves are not diffracted on hills, ravines and so on, therefore the receiving TV and the transmitting TV antenna must be in a direct sight.
VI.94. Being a conductor, the sea water absorbs radio waves.
VI.95. In the interference of waves a redistribution of energy takes place. In some places the summary energy of oscillations equals zero, but if other places it exceeds the sum of energies of waves which interfere.
VI.96. The rule exposed in the problem for interference maximum is valid for sources which send waves at the same phase. If the difference of phases of oscillations sent by sources is π, then at the point $\grave{A}$ we get an interference minimum.
VI.97. No. In this position of antennas an additional energy is drawn from the power source. Such positioning of antennas is widely used in practice.

Answers to Chapter VII

VII.1. This effect is stipulated by illumination of the Moon by the Sum. Moreover, through the Sun only the straight line drawn by a straightedge will pass. A mentally drawn line will not pass the Sun in view of erroneous perceive of the sky's cupola.
VII.4. The light from fluorescent lamps is emitted from a surface whose area is many thousand times greater than the surface of the filament of an incandescent lamp. Therefore on the retina of human eye the image of the fluorescent lamp covers many photosensitive cells. The quantity of the light energy per one cell will be essentially less than from an incandescent lamp.
VII.5. Due to dissipation of the light by small drops of water.
VII.6. The domain of shadows is illuminated by reflections of the daylight from surrounding objects.
VII.7. Because the rays of the Sun rays which is under the horizon are reflected and diffused by the higher layers of the atmosphere.
VII.8. Outside house the objects are illuminated much better than in a room and therefore more reflect the sunlight.
VII.9. For free reading the luminosity (luminous intensity) at least on level of 40 lx is required. The luminosity in a full Moon without clouds is near 0.1 lx.
VII.10. Stars are not visible because the sunlight diffused by atmosphere is significantly brighter than starlight.
VII.11. The starlight passes a long way in Earth's atmosphere and therefore is more diffused.
VII.12. It is possible in equatorial countries.

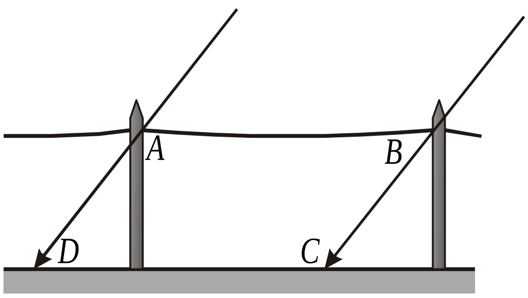


Fig. A.52.

VII.13. The cause is in vertical position of the light source (flame of a candle). When the fork is vertical, then for each teeth the boundary of light and shadow on the screen is situated at almost same places. When it is horizontal, the boundary of the light and shadow is shifted on the screen and intersect the boundaries of other points, therefore we see its shadow in blur.
VII.14. Place more lamps.
VII.15. In diffused illumination it is more difficult to recognize the true shape of object.
VII.16. The shadow of wires is parallel in a plane which is parallel to wires, while the shadows of poles are projected onto a plane which is vertical to them. Therefore these shadows behave differently. The length of the shadow of a wire is practically same during the day. This can be readily seen in Fig. A.52. If the wires are illuminated by a parallel beam of light, whose rays are, in particular, the rays *AD* and *BC*, then the quadrangle *ABCD*, formed by these rays, the wire, and the shadow of wire is a parallelogram.

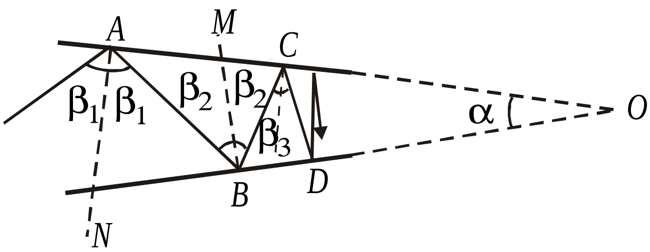


Fig. A.53.

VII.17. Let us consider the path of rays in a conic tube (Fig. A.53). In this figure *AN* and *BM* are normal to the conic surface of the tube. Let us establish the between the angles of reflection for the first reflection β_1 and for the second reflection β_2. It is easily seen that $\beta_2 = 180^o - (\angle BAO + \angle AOB + \angle OBM)$, where $\angle BAO = 90^o - \boldsymbol{\beta}_1$, $\angle OBM = 90^o$. Hence it follows $\beta_2 = \beta_1 - \alpha$. Then the angle of reflection for the third reflection $\beta_3 = \beta_2 - \alpha = \beta_1 - 2\alpha$, and for the *n*-th reflection $\beta_n = \beta_1 - (n-1)\cdot\alpha$. Under a certain *n* the angle β_n may turn zero and even negative. Therefore only a very small part of the falling light will reach the lesser hole of the conic tube. So, it is not possible to achieve a noticeable concentration of the energy in this beam of light.
VII.18. In Fig. A.54 it is seen that the image of the candle will be closer to the mirror. By the letter *A* we denote the path of rays without plate, *B* stands for the pass of rays with plate.
VII.19. The man will see a piece of paper on the place of the image of closed eye.
VII.20. Make this experiment and explain results.

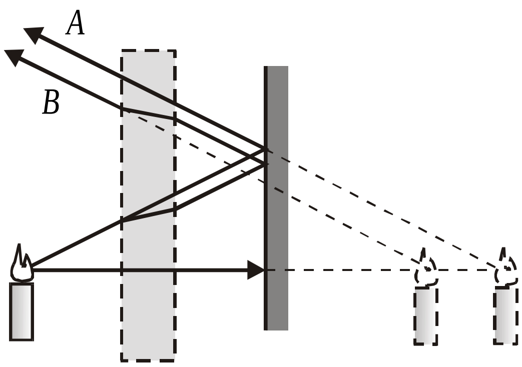


Fig. A.54.

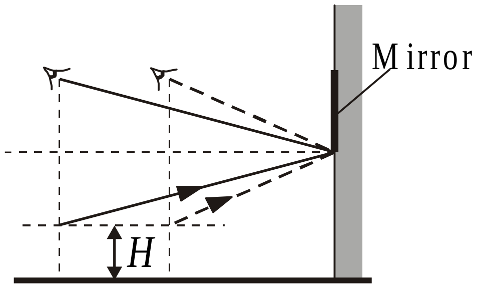


Fig. A.55.

VII.21. From Fig. A.55, where the path of rays is shown, it is seen that independently on the distance between the mirror and the man, the latter cannot see below the part of his body on the height H over the floor.
VII.22. Maximally, you may see three your images. In the middle image we shall see yourselves as you are seen to other people. The images on sides are same as if you have used a single mirror.
VII.23. The waving surface of the water represents a series of convex and concave mirrors, which give different images.
VII.24. When glass of windows get older it will be covered by tiny scratches (made by dust specks, brushes in washing, sand, etc), the side windows will have more horizontal scratches. This results in the following. If one sees through such a glass light sources, on a dark background he can see many reflections from the faces of scratches (the effect of "moon way").
VII.27. The mirror has a thickness, and the reflection is produced by its rare wall. Such a phenomenon takes no place in mirrors of surface silver-coating.
VII.28. The concave mirror joins the light beam from a lamp, which stands behind a patient, into a narrow beam. This beam illuminates the necessary place, say the throat of the patient, thus sharply increasing the luminosity of the places it hits. Through the hole in this mirror the doctor observes these sharply illuminated places.
VII.31. The coefficient of the reflection of the light from the asphalt tends to the unit as the angle of incidence approximates to the direct angle.
VII.33. When fish is considered from a bridge, the rays which go from this object have a small angle of incidence and therefore their reflection from the water surface is small in comparison with the case when the fish is seen from a low shore. In addition to these rays, in the latter case the sunlight reflected from water surface is added. They add the bright background to the whole picture. If the observer stands on a bridge, less sunlight is reflected from water and thus the picture has less bright background than if he stands on a shore. This happens because less rays are reflected from water due to small angle of incidence.
VII.34. Note: consider the answer to the previous problem.
VII.36. The doctor may ask patient to consider the image of the table through a mirror.
VII.37. First, the exterior surface of the glass partially reflects the light and creates an additional (though non-bright) image of the object. Second, a part of the light rays which are reflected from the amalgam of the mirror, is also reflected from the boundary glass–air and again hits the amalgam and repeatedly reflects in it. These causes create the second image.
VII.38. To decrease the intensity of the reflection of sunlight from propeller and protect the pilot against their blinding effect.
VII.39. Because the foil reflects the infrared rays.
VII.40. Transparent windows reflect less light than walls of buildings.
VII.43. The eye refracts light. If the water touch the eye, the rays of light weakly refract, because the refractive index of water is close to that of the lens of the eye. In a diving mask a layer of air remains between the eye and glass and the rays refracts in the usual way.
VII.45. A set of prisms in this glass collects the light and declines it downward to the road.
VII.47. The refractive index of the insect's body is close to that of water, but not the refractive index of its eyes. Through completely transparent eyes the light were passing not exciting the optic nerve. In the air these insects are visible.
VII.48. The refractive index of the air depends on the temperature and density, therefore the convection flows of non-uniformly heated air generate an oscillation of the starlight.
VII.49. In spring the soil is differently heated in different places. The air over these places possesses varying density an its refractive index changes. Due to convection the air moves, light passes through the layers of air with changing refractive index. This results in oscillations of the visible disk of the Sun. This

“play” of the Sun can be seen in any day when the thermal and thus optical non-homogeneity of the air arises

VII.50. The stars would be “displaced” to horizon.

VII.53. Less than the unit; for example, the silver and the gold.

VII.54. The opacity is stipulated by the diffusion of light in an inhomogeneous medium; in each transition of the light from one medium to other, a partial reflection of the light. The part of the light reflected on the boundary between two mediums is greater when so is the difference between their refractive indices.

VII.56. The color can known by sinking the powder into glycerine, whose refractive index is close to that of the glass.

VII.58. The dull surface diffuses uniformly into all sides the rays which fall on it. If the glass is put with its dull surface down, the luminosity of this surface is not uniform. Therefore the intensity of the light diffused by different parts of this surface is different. If the glass is put with its dull surface up, the reflected beams from various places of the draw are overlapped on the dull surface. The dull surface is illuminates almost uniformly and therefore it is difficult to read the draw

VII.65. the answer is “no”. If the lens is in a medium whose refractive index is greater than that of the material of the lens, then the convexo-convex lens will be diverging and the concavo-concave will be converging.

VII.66. The positions of the focus of a lens differ for light of different length of wave.

VII.67. If the assumptions made in this problem are valid, the quantity of the impulse of a light wave in passing through the lens does not change. If the light source S (Fig. A.56) is on the optical axis of the lens, then the complete change of the impulse of the light wave which falls on the lens equals zero. Therefore on the lens a force is acting which is parallel to the optical axis. In the case of a converging lens, with $0 < x < 2F$ the projection of the impulse of the light wave onto the optical axis before the its passage through the lens is less that the projection of the impulse of the light wave which has passed through the lens (Fig. A.56). Therefore the force acting on the lens is directed to the source. If $x > 2F$, then this force is directed outward

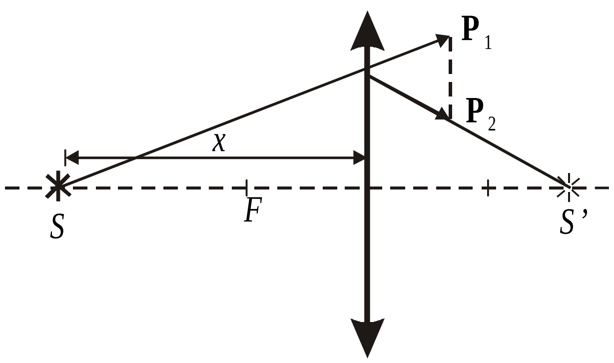


Fig. A.56.

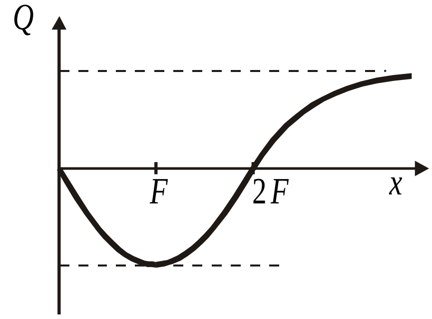


Fig. A.57.

the source. A rough graph of the dependence of the force Q, which acts on the lens, is shown in Fig. A.57.

VII.68. The refractive index of the water $n = 1{,}33$, alcohol $n = 1{,}36$. The rays after passing through the retort with alcohol will converge more than after passing the retort with water.

VII.69. From the triangles OCB and BCO' (Fig. A.58) we get

$$S_{\text{screen}} = l + R\cos\alpha - R, \quad R\sin\alpha = l\cdot\tan(\beta-\alpha).$$

By the law of light refraction we have $n\cdot\sin\alpha = \sin\beta$. Then

$$S_{\text{screen}} = R\left[\frac{n}{n^2-1}\left(n\cos\alpha + \sqrt{1-n^2\sin^2\alpha}\right)-1\right].$$

In the second case (Fig. A.59) we see on the screen a clear dot of the radius

$$r = \tan(\beta_0-\alpha_0)\left[S_{\text{screen}} - R\left(1-\cos\alpha_0+\sin\alpha_0\cdot\cot(\beta_0-\alpha_0)\right)\right]$$

(from the geometrical similarity of the triangles $OB'C'$, $B'C'O'$ and $O'AP$). Evaluation for

$$n = \sqrt{\frac{3}{2}}, \quad \alpha_0 = \frac{\pi}{4}, \quad R = 10\ \text{cm}$$

gives us $r = 1{,}98R = 19.8$ cm.

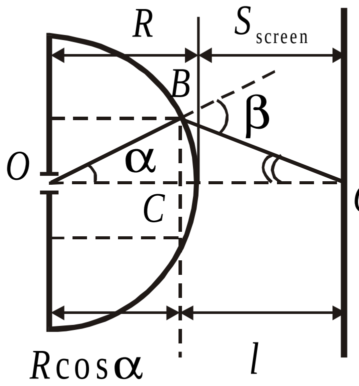


Fig. A.58.

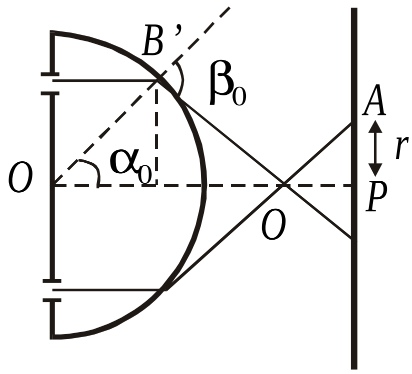


Fig. A.59.

VII.70. In the first part ($\infty > x \geq 2F$) the image moves away from the focal point to a point on a double focus distance from the lens. If $x=2F$, the candle and its image will stay on same distances from the lens. In the second part, $F \leq x < 2F$, the image continues to move away from lens to the infinity (for $x=F$). In the third part, $x<F$, the image becomes imaginary, and in drawing candle closer to the lens it also tends to infinity. On the first part ($\infty > x \geq 2F$) the movement of the image is slower than that of the object. On the second ($F \leq x < 2F$) the situation is contrary.
VII.71. There will be no any image of the fly. It covers a part of the lenses thus playing a role of a diaphragm. The luminosity of the film will slightly decrease, but the image will remain same.
VII.72. Reduction of the resolution is related to a "parasite light" reflected from scratches on the lenses. The filling of these scratches with black Indian ink reduces the possibilities of such a reflection.
VII.73. The lenses should be placed so that the right focus of the left lens and the left focus of the right lens coincide (telescopic system).
VII.74. Of course the parallel beam emerges form the ocular, but passing through the lens of the eye and refracting it becomes by converging beam and gives the object image on the retina.
VII.76. It will be greater.
VII.77. No; the lens which is a magnifying glass has a small focal distance, significantly less than 25cm, which is the optimal distance for a man. The lesser is the focal distance of a magnifying glass, the greater magnifying is obtained.
VII.86. One can get fire by means of ice in a sunny day. To this end one must make a convexo-convex lens of the ice which may converge parallel rays into a point. At this point a high temperature may be obtained and thus an inflammable material can be lighted.
VII.88. In following the law of refraction, $n_1 \sin\alpha = n_2 \sin\beta$, where n_1 and n_2 – are the absolute refractive indices of the mediums, α and β are the angle of incidence and the angle of refraction, respectively. The ray from a far source undergoes the refraction twice on the two surfaces of the lens of the human eye (Fig. A.60). When the air is in front of the eye, the ray on the entering surface of the lens is refracted greater than in the case when the water is in front of the eye. Therefore, if in the water the image of a far object is formed on the retina, in the air the image of this object will at a small distance in front of the retina. Therefore the man is shortsighted.

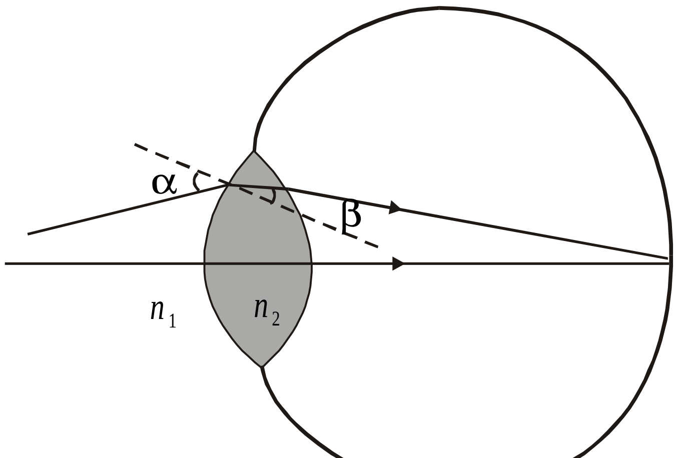


Fig. A.60.

VII.89. The quantity of light which hits the eye increases as much times as the area of the telescope objective is greater than the area of pupil of the eye. A photocell one which the starlight falls becomes more

intensively illuminated, therefore the stars seem to be brighter for us, and we can see those which cannot be observed without a telescope.
VII.90. If the absorption of the energy by lens is absent, then the grain absorbs the energy E, which falls from the source on the lens. This energy is proportional to the solid angle at which the lens is visible fromthe point, the source is set. The solid angle is inversely proportional to the square of the distance from the source to the lens. Therefore

$$\frac{E_1}{E_2} = \frac{a_2^2}{a_1^2}, \text{ and thus, } \frac{\Delta t_1}{\Delta t_2} = \frac{a_2^2}{a_1^2}, \text{ i.e., } \Delta t_2 = \left(a_1/a_2\right)^2 \Delta t_1.$$

VII.91. The irritation of the optic nerve and any way gives the sense of a visible light.
VII.92. First, to select these signals among the others. Second, to avoid fatigue of the eye; the light whichfalls at the same place of the retina decreases its sensibility.
VII.93. An eye may keep an image for a certain time.
VII.95. The illumination produced by lightning is very short, so the moving objects make a small displacement which is not noted by the eye.
VII.96. It is an illusion. All objects which are not sharply visible are thought placed at a long distance. Therefore the man mentally magnifies the size of lamp and thinks that it is hung high.
VII.97. Strong irritation produces by a light or bright object is propagated over the retina of the eye. Therefore bright objects on a dark background are seemed greater than their are indeed (phenomenon of irradiation).
VII.98. As a consequence of irradiation (see the previous problem) the source of light is seemed greater by its size than it is indeed, and therefore we think it is closer.
VII.99. In two eyes two images arise, which are perceived by the brain as a unique image only if they are lying in identical points of the retinas.
VII.100. In the darkness the human eye is tined to perceive small doses of light. A sharp light may make a man blind for a while.
VII.101. The electric arc possesses powerful radiation in ultraviolet and visible parts of the light spectrum. Ultraviolet radiation is well absorbed by the usual glass. The darkening of the spectacles of a welder is necessary to decrease the radiation in the visible part of the spectrum.
VII.102. The color will be additional to the initial one, which is the color which with the initial light gives the white color. If the book is light- red, then we shall see a green its image, and vice versa. For the yellow color, the blue color is additional , etc.
VII.103. The area of the image of the lantern produced by the lens of an eye is inversely proportional to the square of the distance between the eye and the source. The light flux which falls on the eye is also inversely proportional to the square of the distance to source. Therefore the luminosity of the image does not depend on the distance to the lantern.
VII.104. The eyes of a hare are posed so that give it the maximal panoramic view, but this does not allow to see objects in front of it. To consider these objects, the hare must turn its head, or “to skew” in Russian.
VII.105. In contrast to a human eye, the eyes of insects have no retina. Therefore their brain decides and determines how far objects are by analyzing the images of objects in different cells of their eyes.
VII.106. To see him better. The lens of the horse eye cannot accommodate in a range of the human eye. This is compensated in significant measure by non-spherical of the eye of horse (Fig. A.61). To distinguish the objects of different distances the horse changes the inclination of its head and thus achieve a sharp vision on a certain part of its retina, disposed at different distances from the lens of horse eye.

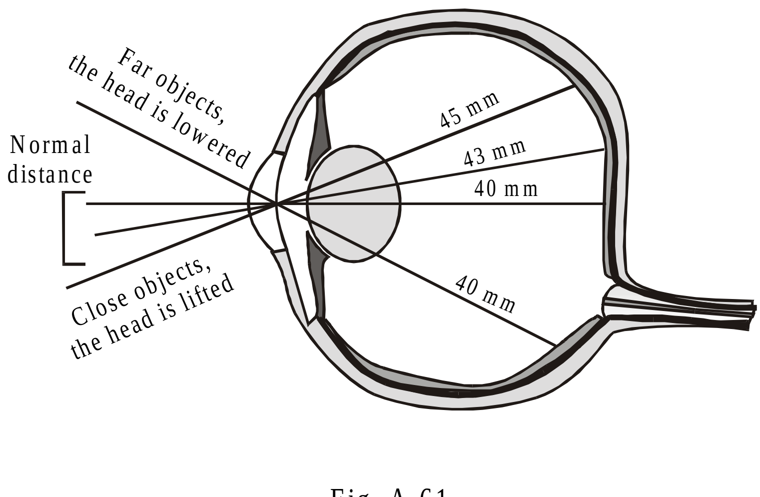


Fig. A.61.

VII.107. The power of the radiation of a heated body is proportional to the fourth power of the temperature. A stove has a greater heat emission than a lamp does, so it does not heat up to the temperature of the

filament of the lamp.
VII.108. Absorbing the energy, the cavity simultaneously radiates it. The power of the radiation quickly grows with rising temperature, which leads to establishing of an equilibrium: the cavity gets as more heat as it radiates.
VII.109. a) The common area of the interior surface of the container is $S = \pi d \cdot h + 2\pi d^2/4 = 0{,}102$ m^2, where d is its diameter, h is its height. The losses of the heat in the unit of time by virtue of radiation are $W = 0.1 \cdot S \cdot \sigma \cdot (T^4 - T_0^4) \approx 6{,}9$ Wt, where T is the temperature inside the container, T_0 is the temperature of the ambient. b) Denote by W_1 the flux of the heat from the internal wall of by W_2 that for the external wall. Then the general flux of the heat between the walls of the container without additional wall is $W_0 = W_1 - W_2$. If we set the additional wall, it will take an intermediary temperature and will radiate in the unit of time to the both sides the flux of heat W_3. The flux of heat in the internal interval will be $W_1 - W_3$, in the external interval it will be $W_3 - W_2$. These two fluxes must be similar by the condition of the thermodynamic equilibrium, i.e., $W_1 - W_3 = W_3 - W_2 = W'$. Hence $W_3 = (W_1 + W_2)/2$. This gives us $W' = W_1 - W_3 = (W_1 - W_2)/2 = W_0/2$. Consequently, in introduction of the intermediary wall the heat flux decrease by two times.
VII.110. Note: consider the answer to the previous problem.
VII.111. In the present case, two bodies possessing different temperatures are interchanging heat by means of heat radiation. In this situation, the more heated body (thermometer) radiates more heat than the cooled one. Respectively, the cooled body absorbs more heat than radiates. With the time the temperatures of the bodies become equal and the heat balance takes place. The mirrors are concentrating the flux of energy of the infrared radiation.
VII.112. Those with black soil.
VII.113. The air is heated mainly by expense of the radiation of the soil. The radiation of the soil increases with growth of its temperature. The largest temperature is reached by soil afternoon, therefore the air afternoon is heated greater.
VII.115. In the smoked.
VII.116. The sense of the light is related to the frequency of the wave of light. The frequency does not depend on the medium where the light is propagated, because with the change of the speed of light in a medium, by same times the length of its wave will change.
VII.117. Reflection of the ultraviolet radiation is different from the natural green leaves and those on disguise. Therefore the different is their action on the photographis film. The sensitivity of an eye and the film are different in various parts of the spectrum.
VII.118. The water absorbs the ultraviolet radiation .
VII.119. Almost black.
VII.121. In the spectrum of the radiation of the electric incandescent lamp the yellow and red rays prevail, which changes the intrinsic color of bodies.
VII.122. These umbrellas reflect well the orange, red, and infrared rays.
VII.123. The visible light will not pass through.
VII.124. The solar crown which is visible in a solar eclipse, is a gas external shell of the Sun, which is in heated state; it gives the linear spectrum. As for the dark lines of the usual solar spectrum, they are formed in absorption of the radiation leaving the interior part of the Sun by exterior more "cold" shell (solar crown).
VII.125. Here they deal with glowing vapors of the metals of electrodes which give a linear spectrum. By this spectrum they determine the substance which the electrode is made of.
VII.126. Infrared radiation penetrates the glass worse than the visible light. Due to this feature the heat supported in a house by heating is hold in a room. The infrared rays irradiated by heated bodies in the room are partially reflected by glasses of windows and poorly leave the room for the ambient. However, in the construction of modern buildings made of "glass and concrete" the losses of heat significantly increase by expense of the augmented size of windows. Therefore in the recent time they started to apply a special coating for glass. This coating allow the glass to reflect almost completely the infrared rays.
VII.127. Poorly; in this relation the usual glasses are not convenient because they do not allow penetration into a house of rays which kill bacterias and are necessary for normal development of human organism.
VII.129. The linen possesses rather yellowish tone; the blue color is additional to it and gives in a superposition with yellow the white color.
VII.130. Note: see the answer to the previous problem.
VII.131. As a result of quick deceleration of electrons, the braking X-rays arise.
VII.133. X-rays passing through a casting with cavities are absorbed in different places in a different degree. In passing through places with cavities they are less absorbed and thus an increased resulting radiation hits the screen or film with a greater force. Multiple scanning allows determine relative size,

position, and contours of the cavity.
VII.134. A man consume in the food both the products of agriculture and stock-breeding; animals also consume plants. The growth and development of the plants directly depend on the Sun (photosynthesis).
VII.135. Shorter (by the length of waves) is the radiation, greater is its influence upon a photo-sensitive b/w film. As for the red light, the molecules of the silver bromide almost do not react in ordinary black and white films. We should mention that in the present time they widely use materials sensitive in a wider spectral range, its development requires the complete darkness.
VII.136. Note: consider the answer to the previous problem.
VII.137. It is possible: in the infrared and ultraviolet rays.
VII.140. The white surface is subject to a stronger pressure.
VII.141. The alkaline metals possess an energy of output which is relatively small.
VII.142. Irradiation of the electromagnetic energy by the heated bodies.
VII.143. In the atoms of metals under an action of heat the electrons rather easily pass to higher energetic levels. In their afterward returning to a state with a less energy, they eject light quanta. In the glass the electrons are stronger connected to the nuclei and thus a greater energy is necessary for their excitation. Therefore the temperature must be higher.
VII.145. The quartz glasses must absorb heat (infrared) rays. In doing so, these glasses should not melt (i.e., they have to have a greater temperature of melting).
VII.146. The sunlight is poorly absorbed by the atmospheric air. These rays are absorbed by the Earth's surface and then the atmospheric air is heated by expense of the heat exchange with the ground and absorption of the infrared radiation of the ground. Passing through the glass, the sunlight heat the soil. For the infrared rays which are irradiated by the soil the glass is poorly permeable. The hotbed is a kind of trap for the heat. In addition, inside the hotbed the water vapor attains the saturation point, which prevents the evaporation of water from soil and thus works against a cooling of the soil by expense of the hidden heat of vaporization.
VII.147. The formation of a "bronze sunburn" covering of the skin is a kind of a self-defense of the human organism against the exaggerated action of the ultraviolet rays. The ultraviolet radiation is strongly absorbed by the pigment of sunburn, thus producing only a harmless heating. Therefore a well sunburn man is heated under the Sun more than that without sunburn and, in addition, the first does not experience the dangerous action of the ultraviolet rays.
VII.148. Blue ones.
VII.150. By the following phenomenon: in water drops the rays with a shorter length of wave are better diffused.
VII.152. The path of the rays in sundown is greater; in addition, the air and particles in the air (dust, vapors, etc.) diffuse mainly shorter waves.
VII.153. The most diffused by air are the deep-blue and blue rays.
VII.154. Passing through various mediums, the light is diffused on various non-homogeneous domains: fluctuations of the density, impurities. As the size of particles grows, the dependence of the intensity of the diffused light on its length changes. On large particles the light with a greater length will be well diffused. In shallow waters, the impurities in water grow (different microorganisms, the sand hoisted by waves, etc.) which determines the "green shift" of the water.
VII.155. On the Moon, there is not atmosphere which could diffuse the sunlight.
VII.156. In the atmosphere only the infrared rays of certain definite lengths of wave may be propagated with rather small diffusion. Since the lengths of the infrared rays are greater than those of the visible light, the intensity of their dissipation on the atmosphere will be significantly less.
VII.158. The rainbow arises as a consequence of the complete interior reflection and dispersion of the sunlight in raindrops. In this situation, the rays of different colors are reflected with the largest intensity in a direction which forms the angle 42^o with the direction of sunlight. The geometric place of the points which generate the rays directed at the angle 42^o to the line of an observer is an arc of circumference.
VII.159. The rainbow can be seen when the height of the noon Sun above the horizon does not exceed 42^o. But the height of the noon Sun at the geographic latitude of these cities exceeds 55^o.
VII.160. In 5 p.m.
VII.161. It is not possible. The eye of an observer is always in the plane passing through the center of the rainbow and the center of the disk of the Sun.
VII.162. In the western side.
VII.163. A brilliant (diamond) possesses a greater refractive index and thus a greater dispersion.
VII.166. Colored dots (the colors of iridescence or the oxide tint) is the result of interference of the light reflected by the thin film of the oxide.
VII.167. By the interference of the sunlight in a transparent film covering the wings of insects and possess-

ing different thickness in various places.
VII.168. The rays of light reflected by the front and rare surfaces of the film, interfere with and cancel each other (|the optical difference between their paths is $\lambda/4+\lambda/4=\lambda/2$).
VII.169. For a complete cancellation of waves reflected by the boundaries of a film, in addition to the phase difference equaling π, they must have the same amplitude. This is ensured by the corresponding selection of the thickness and refractive index of the film.
VII.170. It is practically impossible to make the lightening cover for the whole visible range. Therefore the lenses are lightened for the most intensive (yellow-green) domain of the spectrum. Obviously, namely these colors are absent in the reflected light.
VII.171. By the diffraction of light on the paths of a compact disk.
VII.174. Yes, it is possible if the ball covers a small quantity of the Fresnel zones.
VII.175. A bird feather represents a kind of diffraction lattice. By determining the angular distance between neighboring maximums, one can evaluate the size of cells.
VII.176. The holes are regularly disposed in a tissue and thus form a diffraction lattice for visible rays. Disposition of dots depend on the structure of this lattice. By extending and declining the tissue, we change the period of the lattice, which causes the variation of dots' displace.
VII.177. This phenomenon is explained by the diffraction of the light upon the tiny particles of water dust and crystals of ice which are always present in the air.

Answers to Chapter VIII

VIII.2. By realizing the nuclear reaction. In the nature, one stable isotope of the gold (Au^{197}) exists as well as seven isotopes of the mercury (Hg^{196}, Hg^{198}, Hg^{199}, Hg^{200}, Hg^{201}, Hg^{202}, Hg^{204}). Therefore in the process of a nuclear reaction, we must remove from the nucleus of the mercury one proton and either add one neutron or delete one, two, three, four, five neutrons.
VIII.3. It is possible; the γ-rays penetrate bodies, besides, even in a greater degree than the X-rays.
VIII.4. Quick neutrons are often emerged from the body of uranium, not having a time to initiate or participate in a nuclear reaction. Slow neutrons spend more time near a nucleus, therefore the probability of their arresting by a nucleus increases.
VIII.5. A neutron may arise by expense of a spontaneous fusion of uranium nuclei; each such fission gives 2–3 free neutrons.
VIII.6. Neutrons which result in a spontaneous fusion of uranium nuclei (see the previous answer), as a rule, are absorbed by nuclei of U^{238} without initiation of the chain reaction. But their collisions with nuclei of U^{235} take place very rarely due to small (0,7%) quantity of them in the uranium ore.
VIII.7. The reactor *1*, where the nuclear fusion chain reaction holds, heats a substance possessing high heat capacity up to a high temperature. The substance then passes to the heat exchanger *3*, where gives its heat to water which is transformed into a vapor; after cooling the heat carrier by the pump *5* is again returned into the reactor. The vapor goes to turbines *2*, which put into move the electric generators. In the condenser *4* the flowing water is heated by expense of the worked-out vapor; it is used for central heat supply.
VIII.8. In the β-fusion a nucleus undergoes some changes. This is explained by the transformation of one of the neutrons entering the nucleus into three particles (proton, electron, and antineutrino); besides the proton remains in the formed nucleus, while both the electron and antineutrino emerge from the nucleus. This makes to increase the charge of the nucleus by unit. The charge of the atom's nucleus determines the order number of the element in the Periodic Table by Mendeleev as well as all its chemical properties.
VIII.9. The lead is composed of heavy atoms, the graphite consists of light atoms (carbon). In an elastic collision with a heavy nucleus, the neutron changes it trajectory of motion, practically without changing its speed. In the collision with a nucleus of a carbon atom, which is closer by its mass, the neutron transfers to it the most part of its energy. Therefore, in the capacity of a moderator , they use substances which are composed by light molecules, for example, the water or the graphite. The substances mentioned above differ by a high concentration of molecules and possibility to conserve their features in absorption of large quantities of energy (the water possesses a high heat capacity, the graphite possesses a high temperature of melting).
VIII.10. A snail is a sensitive indicator of radioactive radiation. It is a kind of an alive Geiger counter.

Answers to Chapter IX

IX.1. a) The bar has the length of 1m in all orientations, because with respect to the observer on the board of spacecraft the bar is in the state of rest; b) the length of the bar varies from 1m in a position perpendicular to the motion to 0.6m in the position coinciding with the direction of the motion.
IX.2. Yes, he will se his reflection in the mirror. In his reference system, as in any other inertial reference system, the light possesses the same speed. The runner will see his image as if it is seen at any other speed of motion with respect to the track.
IX.3. This paradox can be resolved as follows. In the reference system of the runner the front end of the pole leaves the shed before the rare end will enter in the shed. Therefore, from the standpoint of the runner, the whole pole never is in the shed.
IX.4. The stumbling-block is in the concept of the simultaneity – "in the instant when". The points *A* and *B'* in their motions may occur to be in front of each other only in other place on the trajectory of the relative motion of thr rockets, but not at the point, where the shot has been made. Therefore the moment when the points *A* and *B'* are in front of each other can coincide with moment of the shot only in one of the two reference systems. By the condition of the problem, such a simultaneity tales place in the reference system *O*, so the Fig. IX.2 is correct by the definition. As for Fig. IX.3, it is not correct: to at the time when in the reference system *O'* the points *A* and *B'* will occur to be in front of each other, the shot will already have been made. The projectile will not hit the target with respect to the both reference systems.
IX.5. The interval of time, the length, and the mass were not change in passing from one inertial reference system to another.
IX.7. It would change by $\Delta m = Q/c^2$, where Q is the quantity of heat removed out from the stick. One can easily estimate that with the mass of 1kg and the difference between the temperatures being 1500K, the change of the mass is about 7×10^{-5}mg. In general, the Einstein formula $E = mc^2$ represents the complete energy of a body without regard for the potential energy of the body in external force fields.
IX.8. The mass of the compressed string if greater by the quantity $\Delta m = k\Delta x^2/2c^2$, where k and Δx are the coefficient of elasticity and its lengthening, respectively.
IX.11. The imaginary paradox can be explained within the framework of the special theory of relativity. For the explanation it is principally important that the complete electric charge remains same in a transition from one inertial reference system to other inertial reference system, while the size of the charges bodies changes, which results in the change of the density of the electric charge distribution. For the sake of simplicity we assume that the speed of an electron v in a laboratory reference system S equals the drift speed of the electrons forming the current in a conductor in the same reference system, i.e., in a reference system S', related to the external electron the electrons of the substance are moving only chaotically. In the reference system S' the length of the conductor is

$$L_{S'} = L_S\sqrt{1-\beta^2},$$

where $\beta = v/c$, c is the speed of light. Then the density of a positive charge of ions of the crystal lattice of the conductor in this reference system is

$$\rho^+_{S'} = Q\big/\left(L_{S'}\cdot A_{S'}\right) = \rho^+_S\Big/\sqrt{1-\beta^2},$$

where $A_{S'} = A_S$ is the are of section of the conductor. Let us note that, in the laboratory reference system, no electric field around the conductor exists, therefore

$$\rho^-_S = -\rho^+_S.$$

Then, as the electrons have in this reference the drift speed v, we get

$$\rho^-_{S'} = \rho^-_S\cdot\sqrt{1-\beta^2} = -\rho^+_S\cdot\sqrt{1-\beta^2}.$$

Therefore in the reference system S' the conductor possesses a charge per the unit of length, which is

$$\lambda_{S'} = \left(\rho^+_{S'} + \rho^-_{S'}\right)\cdot A_{S'} = \lambda_S\cdot\beta^2\Big/\sqrt{1-\beta^2}.$$

The electric force of the electric field of the straight conductor with the charge λ per a unit of length is known to equal

$$E = \frac{\lambda}{2\pi\varepsilon_0 r},$$

where r is the distance from the conductor to the point of observation. Taking into account that the induction of the magnetic field with a current in this reference system S is

$$B = \frac{\mu_0 I}{2\pi r} = \frac{\mu_0 v\rho^+_S A_S}{2\pi r}$$

and that

$$\mu_0 \varepsilon_0 = 1/c^2 \,,$$

for the force acting on the electron we find

$$F_{S'} = eE = F_S \Big/ \sqrt{1-\beta^2} \,.$$

Finally, taking into account the second Newton law $\Delta p = F\Delta t$ (Δp is the change of the impulse within the time Δt) and that

$$\Delta t_S \sqrt{1-\beta^2} = \Delta t_{S'},$$

we get

$$\frac{\Delta p_{S'}}{\Delta p_S} = \frac{F_{S'} \Delta t_{S'}}{F_S \Delta t_S} = 1.$$

This means that the forces acting on the electron in the reference systems *S* and *S'*, result in the same change of the impulse, but, if the force has in the reference system *S* the magnetic nature, in the reference system *S'* its origin is purely electric! This, in particular, testifies the necessity to consider the electric and magnetic fields in their unity, not dividing them from each other. The imaginary paradox has been resolved.