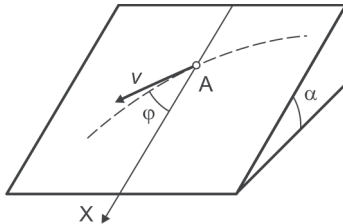
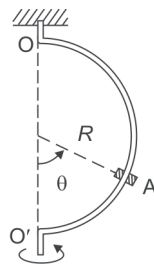


- 1.104. A particle of mass  $m$  moves in the plane  $P$  under the action of the force  $F$  of a constant modulus, which rotates in this plane with a constant angular velocity  $\omega$ . At time  $t = 0$ , the particle was at rest. Find the:
- modulus of its velocity as a function of time;
  - path travelled by the particle between two successive stops, and the mean velocity on this path.
- 1.105. A small washer is placed on an inclined plane that makes an angle  $\alpha$  with the horizontal (Fig. 1.18), with an initial velocity  $v_0$ . Find the dependence of velocity of the washer on angle  $\varphi$ , if the friction coefficient  $k = \tan \alpha$  and at the initial moment  $\varphi_0 = \pi/2$ .



**Fig. 1.18**

- 1.106. A chain of length  $l$  was placed on a smooth spherical surface of radius  $R$ , such that its one end is secured on top of the sphere. With what acceleration  $a$  will each element of the chain move, if the upper end is released? Chain length  $l < \pi R/2$ .
- 1.107. A small body was placed on top of a smooth sphere of radius  $R$ . Then the sphere is imparted a constant acceleration  $a_0$  in the horizontal direction, and the body began to slide down. Find the velocity of the body relative to the sphere at the moment of break-off. Compare with the solution of 1.95.
- 1.108. A sleeve  $A$  can freely slide along a rod, bent in the form of a semi-circle of radius  $R$  (Fig. 1.19). The system is led into rotation with constant angular



**Fig. 1.19**

velocity  $v$ . To what height (relative to the initial level) will the disc rise after breaking off the body  $M$ ? The friction is assumed to be absent.

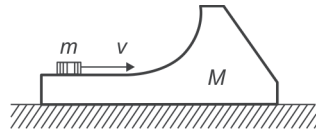


Fig. 1.37

- 1.196. A small disc of mass  $m$  slides down a smooth hill of height  $h$  without initial velocity and gets onto a plank of mass  $M$  lying on the horizontal plane at the base of the hill (Fig. 1.38). Due to friction between the disc and plank the disc slows down and beginning with a certain moment, moves as one piece with the plank. Find the total work performed by the friction forces in this process.

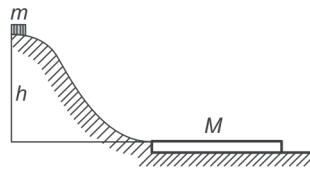


Fig. 1.38

- 1.197. A plank AB of length  $l = 100$  cm lies on a smooth horizontal plane, a small disk lies on its end A. The mass of plank is  $\eta = 10$  times greater than the mass of the disk, friction coefficient between both of them is  $k = 0.15$ . What initial velocity needs to be imparted to the disk in direction from A to B, so that it can slide off the plank?
- 1.198. Find the increment of the kinetic energy of the system of two spheres of masses  $m_1$  and  $m_2$ , during their perfect inelastic collision. The velocities of the spheres before collision were  $v_1$  and  $v_2$ .
- 1.199. A particle A of mass  $m$  flying near another stationary particle B, deviated at an angle  $\alpha$ . Momentum of the particle A before the interaction was equal to  $p_0$  and after the interaction it was  $p$ . Find the mass of the particle B, if this is a closed system.
- 1.200. At a certain point two identical particles, forming a close system, are at a distance  $l_0$  from each other and have velocity  $v$ , whose direction form an angle  $\alpha$  with the connecting line (Fig. 1.39). Mass of each particle

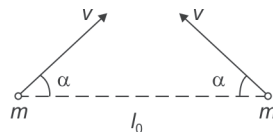


Fig. 1.39

- (b) a uniform solid cone relative to its symmetry axis, if the mass of the cone is equal to  $m$  and radius of its base to  $R$ .
- 1.281. Find the moment of inertia of a thin wire ring of radius  $a$  and mass  $m$  relative to the axis, coinciding with its diameter.
- 1.282. Demonstrate that in the case of a thin plate of arbitrary shape there is the following relationship between the moments of inertia:  $I_1 + I_2 = I_3$ , where sub-indices 1, 2, and 3 are three mutually perpendicular axes passing through one point, with axes 1 and 2 lying in the plane of the plate. Using this relationship, find the moment of inertia of a thin uniform round disc of radius  $R$  and mass  $m$  relative to the axis coinciding with one of its diameters.
- 1.283. The moment of inertia of the body relative to the mutually parallel axes 1 and 2 is equal to  $I_1 = 1.00 \text{ g} \cdot \text{m}^2$  and  $I_2 = 3.0 \text{ g} \cdot \text{m}^3$  respectively. Axes 1 and 2 are situated at distances  $x_1 = 100 \text{ mm}$  and  $x_2 = 300 \text{ mm}$  from the center of mass  $C$  of the body. Find the moment of inertia of this body relative to the axis, passing through point  $C$  and parallel to the axes 1 and 2.
- 1.284. A uniform disc of radius  $R$  has a round cut out (Fig. 1.53). The mass of the remaining (shaded) portion of the disc is equal to  $m$ . Find the moment of inertia of such a disc relative to the axis perpendicular to the plane of the disc and passing through:
- the point  $O$ ;
  - its center of mass.
- 1.285. Using the formula for the moment of inertia of a uniform sphere, find the moment of inertia of a thin spherical layer of mass  $m$  and radius  $R$  relative to the axis passing through its center.
- 1.286. Two threads are wound on a step pulley in opposite directions (Fig. 1.54).

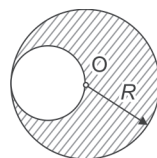


Fig. 1.53

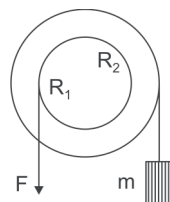


Fig. 1.54

tube and flask equals  $r = 25$  cm and the wall thickness is equal to  $\Delta r = 1.0$  mm?

- 1.349. A horizontally oriented copper rod of length  $l = 1.0$  m is rotated about a vertical axis passing through its center. What is the number of rps at which this rod ruptures?
- 1.350. A ring of radius  $r = 25$  cm made of lead wire is rotated about a stationary vertical axis passing through its centre and perpendicular to the plane of the ring. What is the number of rps  $n$  at which the given ring can rupture?
- 1.351. A steel wire of diameter  $d = 1.0$  mm is stretched horizontally between two clamps located at the distance  $l = 2.0$  m from each other. A weight of mass  $m = 0.25$  kg is suspended from the midpoint O of the wire. What will the resulting descent of the point O?
- 1.352. A uniform elastic plank moves over a smooth horizontal plane due to a constant force  $F_0$  distributed uniformly over the end face. The surface area of the end face is equal to  $S$ , and Young's modulus of the material is  $E$ . Find the compressive strain of the plank in the direction of the acting force.
- 1.353. A thin uniform copper rod of length  $l$  and mass  $m$  rotates uniformly with an angular velocity  $\omega$  in a horizontal plane about a vertical axis passing through one of its ends. Determine the tension in the rod as a function of the distance  $r$  from the rotation axis as well as the elongation of the rod.
- 1.354. A solid copper cylinder of length  $l = 65$  cm is placed on a horizontal surface and subjected to a vertical compressive force  $F = 1000$  N directed downward and distributed uniformly over the end face. What will be the resulting change of the volume of the cylinder in cubic millimeters?
- 1.355. A copper rod of length  $l$  is suspended from the ceiling by one of its ends. Find the:
- (a) elongation of the rod due to its own weight;
  - (b) relative increment of its volume  $\Delta V/V$ .

# Contents

<i>Preface</i>	<i>v</i>
<i>Advice for Solving the Problems</i>	<i>vii</i>
<b>Part 1. Physical Principles of Mechanics</b>	<b>1</b>
1.1. Kinematics	1
1.2. The Fundamental Equation of Dynamics	12
1.3. Laws of Conservation of Energy, Momentum, and Angular Momentum	23
1.4. Universal Gravitation	47
1.5. Dynamics of a Solid Body	52
1.6. Elastic Deformation of Solid Bodies	69
1.7. Mechanics of Incompressible Liquids	72
1.8. Relativistic Mechanics	78
<b>Part 2. Electromagnetism</b>	<b>88</b>
2.1. Constant Electrical Field in Vacuum	88
2.2. Conductors and Dielectrics in Electrical Field	97
2.3. Electrocapacity: Energy of an Electric Field	107
2.4. Electric Current	115
2.5. Constant Magnetic Field: Magnetics	130
2.6. Electromagnetic Induction: Maxwell's Equations	148
2.7. Movement of Charged Particles in Electrical and Magnetic Fields	165
<b>Part 3. Oscillations and Waves</b>	<b>174</b>
3.1. Mechanical Oscillations	174
3.2. Electrical Oscillations	193
3.3. Elastic Waves: Acoustics	206
3.4. Electromagnetic Waves: Radiation	217

<b>Part 4. Optics</b>	<b>227</b>
4.1. Photometry and Geometrical Optics	227
4.2. Interference of Light	242
4.3. Diffraction of Light	250
4.4. Polarization of Light	265
4.5. Dispersion and Absorption of Light	277
<b>Part 5. Quantum Physics</b>	<b>282</b>
5.1. Corpuscular Properties of Electromagnetic Radiation	282
5.2. Scattering of Particles: Rutherford–Bohr Atom	287
5.3. Wave Properties of Particles	294
5.4. Atoms and Molecules	306
5.5. Nucleus of an Atom: Radioactivity	317
5.6. Nuclear Reactions	322
5.7. Elementary Particles	328
<b>Part 6. Physics of the Macrosystems</b>	<b>333</b>
6.1. Equation of the Gas State: Processes	333
6.2. First Law of Thermodynamics: Heat Capacity	337
6.3. Molecular Kinetic Theory	344
6.4. Second Law of Thermodynamics: Entropy	354
6.5. Transport Phenomena	362
6.6. Thermal Radiation	368
6.7. Solid Body	371
6.8. Liquids: Capillary Phenomena	379
6.9. Phase Transformations	383
<b>Answers and Solutions</b>	<b>390</b>
<b>Appendix</b>	<b>515</b>
1. Basic Algebraic and Trigonometrical Formulas	515
2. Derivatives and Integrals	516
3. Some Numerical Constants and Approximations	517
4. Some Data on Vectors	517
5. Greek Alphabets	517
6. Trigonometric Function Values	518
7. Exponential Functions	519
8. Astronomical Data	520

9. Density of Substances	521
10. Elastic Constants: Tensile Strength	522
11. Dielectric Permittivity	522
12. Resistivity of Conductors	522
13. Magnetic Susceptibilities of Para and Diamagnetics	523
14. Refractive Indices	523
15. Rotation of the Plane of Polarization	524
16. Work Function of Various Metals	524
17. <i>K</i> -Band Absorption Edge	525
18. Mass Absorption Coefficients (X-ray radiation, narrow beam)	525
19. Constants of Diatomic Molecules	525
20. Half-Life Values of Radionuclides	526
21. Mass of Light Atoms	526
22. Gas Constants	526
23. Specific Heat Capacities	527
24. Certain Liquid Constants	527
25. Saturated Vapour Pressure of Water	527
26. Fundamental Quantities and SI Units	528
27. Units of Physical Quantities	529
28. Some Miscellaneous Units	531
29. Basic Formulas of Electrodynamics in the SI and Gaussian Systems	532
30. Formulas of Certain Atomic Quantities in SI and Gaussian Systems	535
31. Fundamental Physical Constants	536