Ministry of Education and Science of Ukraine
National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute"

GENERAL PHYSICS

Part 1

Practical tasks

Recommended by the Methodical Council of Igor Sikorsky Kyiv PolytechnicInstitute as a tutorialfor foreign students of higher technical educational institutions of all forms of education

Kyiv
Igor Sikorsky Kyiv Polytechnic Institute
2019

Reviewer: *Reshetniak Sergiy, Dr. Sc. (Physico-mathematical Sciences), Professor*

Responsible editor: *KotovskyiVitalii, Dr. Sc. (Engineering Sciences), Professor*

*Approval stamp is provided by the Methodical Council of Igor Sikorsky Kyiv Polytechnic Institute (protocol № 9 from 30.05.2019 р.)
on the submission of the Academic Councilof Faculty of Physics and Mathematicsof Igor Sikorsky Kyiv Polytechnic Institute(protocol № 5 from 29.05.2019 р.)*

Electronic online educational edition

ChijskaTatiana
KulieznovaSvitlana
ShtofelOlha

GENERAL PHYSICS
Part 1
Practical tasks

GENERAL PHYSICS: Part 1:Practical tasks: практикумдлястудентівтехнічнихспеціальностей/ *T.Chijska, S. Kulieznova, O. Shtofel*; *Igor Sikorsky Kyiv Polytechnic Institute*. – Kyiv :Igor Sikorsky Kyiv Polytechnic Institute, 2019. – 21 p.

The first module of the basic course of general physics. The manual includes the number of problemsto be solved. They are grouped into the topics of the first module. This manual is written for foreign students of higher educational institutions. It contains Chapter 1. Physical basis of mechanics;Chapter 2. Molecular physics and thermodynamics; and Chapter 3. Electrostatic field (practical materials from module “Physics-1”). Physics-1 also includes these tree sections.

Contents

Introduction

The main tasks of the cycle of practical lessons are the following: students after mastering the cycle of practical lessons should be able to apply the theoretical basistothesolutionofpracticalproblems, developlogicalandalgorithmicthinking, independentlydistributetheirknowledgeandconductanalysisofappliedproblems. Thestudent'sacquiredknowledgeshouldbeusedinstudyingothersectionsofthecoursein physics, aswellasinmasteringthecoursesoftheoreticalmechanics, theoreticalbasicsofelectricalengineering, specialdisciplinesandengineeringcalculations.

Thesubjectsofpracticallessonscoverthemainpartofthetheoreticalcourseandinvolvesconsolidatingtheoreticalknowledgeandacquiringtheskillsoftheirpracticaluseinquantitativestudiesofcertainphysicalphenomena.

Topics of classes

№	The subject of practical lessons and the list of the main issues (list of didactics, references to literature and tasks for individual work)
1	**Practice 1.** Kinematics of translational and rotational movements.
2	**Practice 2.** The dynamics of the translational motion.
3	**Practice 3.**Dynamics of rotational motion of a solid body around a fixed axis.
4	**Practice 4.**Mechanical vibrations
5	**Practice 5.**Molecular structure of matter. Laws of ideal gases. Molecular-kinetic theory of gases.
6	**Practice 6.** Physical bases of thermodynamics.
7	**Practice 7.** Electrostatics. Coulomb's law. Interaction of charged bodies. Field tension.
8	**Practice 8.** Potential. Energy system of electric charges. Work on moving the charge in the field.
9	**Practice 9.** Electric capacity. Capacitors. The energy of a charged conductor. Energy of the electric field**.**

Theoretical material for practice 1 to 4 you can find in the Lecture notes of GENERAL PHYSICS: Physical fundamentals of mechanics [1].

Practical lesson 1. Kinematics of translational and rotational movements

Problems to solve in the classroom:

1.1. Three quarters of its way the car drove at the velocity $\upsilon_1 = 60\ km/hour$, the other part of the way - at the velocity $\upsilon_2 = 80\ km/hour$. What is the average velocity $\langle\upsilon\rangle$ of a car?

1.2. The equation of rectilinear motion is described by equation $x = At + Bt^2$, where $A = 3\ m/s,\ B = -0.25\ m/s^2$. Construct graphs of coordinate and path of movement for a given time.

1.3 There is a man near the train in line with the front engine buffers. At the moment, when the train began to move with acceleration $a = 0.1\ m/s^2$, the person began to go in the same direction with velocity $\upsilon = 1.5\ m/s$. After what time does the train overtake a person? Determine the velocity υ_1 of the train at this point and the path passed by that time by the man.

1.4. The motion of a material point is given by the equation $r(t) = A(\boldsymbol{i}cos\omega t - \boldsymbol{j}sin\omega t)$, where $A = 0.5\ m$, $\omega = 5\ rad/s$. Draw the graph of a point trajectory. Determine the speed module $|\upsilon|$ and a normal acceleration module $|a_n|$.

1.5. Disc with radius $r = 10\ sm$ was in a rest, then it began to rotate with constant angular acceleration $\varepsilon = 0.5\ rad/s^2$. Find tangential a_τ, normal a_n and complete acceleration a at the points on the disk circle at the end of the 2nd second after the beginning of the rotation.

Problems for independent study:

1.6. During the first half of the way the body moved at the velocity $\upsilon_1 = 2\ m/s$, during the second half of the way - at the velocity $\upsilon_2 = 8\ m/s$. Determine the average path velocity $\langle\upsilon\rangle$.

1.7. The motion of a material point is given by the equation $x = At + Bt^2$, where $A = 4\ m/s$, B $= -0{,}05\ m/s^2$. Determine the moment of time when the velocity υ of the point is zero. Find the coordinate and acceleration at this point. Construct graphs of coordinate, path, velocity and acceleration of this motion depending on time.

1.8. Two points began to move equally accelerated from one place in one direction, and the second point began its movement in 2 seconds after the first one. The first point was moving at an initial velocity $\upsilon_1 = 1\ m/s$ and acceleration $a_1 = 2\ m/s^2$, the second - with the initial velocity $\upsilon_2 = 10\ m/s$ and acceleration $a_2 =$

$1\ m/s^2$. When (time) and where (distance) from the initial position willthe second point overtake the first one?

1.9. The motion of a material point is given by the equation$r(t) = \boldsymbol{i}(A + Bt^2) + \boldsymbol{j}Ct$, де $A = 10\ m$, $B = -5\ m/s^2$, $C = 10\ m/s$. Draw the point trajectory. Find the equation$v(t)$and$a(t)$. For the moment of time$t = 1\ s$calculate: 1) velocity module$|v|$; 2) acceleration module$|a|$; 3) tangential acceleration module$|a_\tau|$; 4) normal acceleration module$|a_n|$.

1.10. A cylinder that can rotate around a horizontal axis is reeled up with a thread. Some burden is tied to the end of thread and it is allowed to fall. Moving evenly accelerated, the burdenin $t = 3\ s$got down in $h = 1{,}5\ m$. Determine the angular acceleration of the cylinder, if its radius$r = 4\ sm$.

Practical lesson 2. The dynamics of the translational motion

Problems to solve in the classroom:

2.1. The block is hangedon spring balance. The cord is passed over the block,the loads with masses$m_1 = 1{,}5\ kg$ i $m_2 = 3\ kg$ are tied to the ends of the cord.What indicators will be displayed on the scales during the movement of theloads? Weights of the block and the cord are neglected.

2.2. The material point withthe mass$m = 1\ kg$ moves uniformlyand passes a quarter of a circle with the radius$r = 1{,}2\ m$during thetime$t = 2\ s$. Find the change of Δp momentum of the point.

2.3. The ball with the weight$m_1 = 10\ kg$moves at the velocity$v_1 = 4\ m/s$, collides withthe ballhaving the weight$m_2 = 4\ kg$, whose velocity is$v_2 = 12\ m/s$.Providing that the collision is direct, non-elastic find the speed of the balls after the collision in two cases: 1) the small ball catches up with the big one that moves in the same direction; 2) balls are moving towards each other.

2.4. Some weight is suspended to the cord.The weight was taken aside so that the cord took a horizontal position, and then it was released.Find the force of the tension of the cord at the moment when the weight passes the equilibrium position. What is the angle with the vertical the cord has at the moment when the force of the tension of the cord is equal to the force of gravity of the weight?

2.5. The body with mass$m = 1\ kg$is thrown from a height in a horizontal direction at the velocity$v_0 = 20\ m/s$, after$t = 3\ s$it falls down. Find the kinetic energy$E_k$at the moment when the body collided with the ground. Air resistance is neglected.

Problems for independent study:

2.6. There is a brick with mass$m = 4\ kg$ on a smooth table. Two cords are tied to the brick, passed overthe fixed blocks andattached to the opposite sides of the table. The weights with masses $m_1 = 1\ kg$ and $m_2 = 2\ kg$ are suspended to the ends of the cords. Find acceleration a f the moving brick, and the force of tension T of each of the cords.The mass of blocks and friction are neglected.

2.7. Ball with mass $m = 100\ g$ fell from the height $h = 2{,}5\ m$ on a horizontal plate, the mass of which is much larger than the mass of the ball, and jumped up from it.Assuming the the collision is absolutely elastic, determine the momentum p received by the plate.

2.8. On the railway platform some armament is installed. The platformmass with the weapon is $m = 15\ ton$. The weapon shoots up at the angle of $60°$ to the horizon in the direction of the movement.What speed v_1 will get the platform due to the impact if the mass of the projectile is $m = 20\ kg$ and it emerges at the velocity $v_2 = 600\ m/s$?

2.9.The plane flies Nesterov's loop with the radius $R = 200\ m$ (fig.1). How many times the force F with which the pilot presses the seat at the lower point is greater than the gravity force of the pilot P, if the speed of the plane $v = 100\ m/s$?

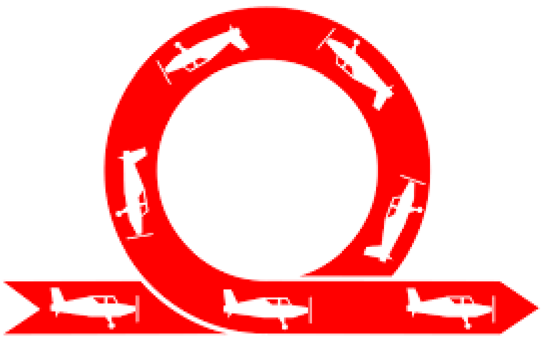


Fig. 1

2.10. The stone was thrown up at the angle 60° to the horizon. The kinetic energy E_{k0} of the stone at the initial time moment is equal to $20\ J$. Determine the kinetic E_k and potential E_p energy of the stone at the highest point of its trajectory. Air resistance is neglected.

Practical lesson 3. Dynamics of rotational motion of a solid body around a fixed axis

Problems to solve in the classroom:

3.1.There are two small balls with masses $m = 10\ g$ both. They are connected by a thin weightless rod with the length $l = 20\ sm$. Determine the moment of inertia J of the system relative to the axis, which is the perpendicular to the rod and passes through the center of its mass.

3.2.Diameter of the disk is $d = 20\, sm$, its mass is$m = 800$ g. Determine the moment of inertia $J$of thedisk relative to the axis thatpasses through the middle of one of the radii perpendicular to the area of the disk.

3.3.The flywheel and the light pulley with radius$R = 5\, sm$ are set on the horizontal axis. The pulley is reeled up with the cord and the cord is tied with the load having the weight $m = 0{,}4\, kg$. Having the accelerated downward movement, the load passed the distance$s = 1{,}8\, m$during thetime $t = 3\, s$.Determine the moment of inertia of the flywheel. Mass of the pulley is neglected.

3.4.A man is standing on Zhukovsky's bench and catching a ball with mass$m = 0{,}4\, kg$, which is flying in the horizontal direction at the velocity$v = 20\, m/s$ (fig.2). The trajectory of the ball passes at the distance$r = 0{,}8\, m$from the vertical axis of the rotation of the bench. Find the angular velocity of rotation of Zhukovsky's bench with the man who caught the ball if the total moment of inertia J of person and bench is equal to $6\, кг \cdot м^2$?

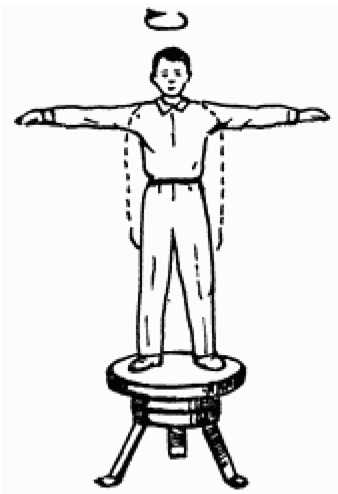


Fig. 2

3.5.The ball rolls without sliding on a horizontal surface. Total kinetic energy$E_k$of the ball is equal to$14\, J$. Determine the kinetic energy of the translational E_{k1} and rotational E_{k2}motion of the ball.

Problems for independent study:

3.6.Determine the moment of inertia J of a thin, homogeneous rod with length $l = 30\, sm$and mass$m = 100\, g$ relative to the axis perpendicular to the rod and passes through: 1) its end; 2) its middle; 3) point, remote from the end of the rod for 1/3 of its length.

3.7.Two small balls with masses m i $2m$ are attached to the ends of a thin, uniform rod with the length$l$and mass $3m$. Determine the moment of inertia $J$of such system relative to the axis perpendicular to the rod and passing through the point$O$which is on the axis of the rod. The calculations have to be done for casesa, b, c, d, e in fig.3. While calculatingtake $l = 1\,m$,$m = 0{,}1\,kg$. Balls are considered to be material points.

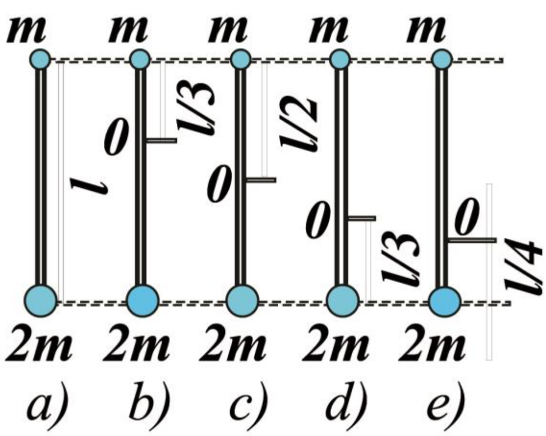


Fig. 3

3.8.Through a block that has the shape of a disc, the cord is thrown over.To the ends of the cord the weights with masses $m_1 = 100\,g$ and $m_2 = 110\,g$were strapped. Find the acceleration of the movement of the weights, ifthe block mass s$m$is$400\,g$.The friction during the block rotation is neglected.

3.9.Platform in the form of a disk with radius$R = 1\,m$with inertia in frequency$\nu = 6$ мин$^{-1}$ is rotating. At the edge of the platform there is a man with mass$m$equal to$80\,kg$. What frequency ν will the platform rotate, if the man moves into its center? The moment of inertia of the platform J is equalto$120\,kg$. The moment of inertia of a man is to be calculated as for a material point.

3.10.Determine the linear velocity v of the center of a ball that slid down without slipping from an inclined plane with the height $h = 1$ м.

Practical lesson 4. Mechanical vibrations

Problems to solve in the classroom:

4.1.The point is oscillating by law$x = Acos(\omega t + t)$, де$A = 2\,sm$; $\omega = \pi\,s^{-1}$; $\varphi = \frac{\pi}{4}rad$. Build time dependency graphics of: 1) displacement $x(t)$; 2)velocity $\dot{x}(t)$; 3) acceleration $\ddot{x}\,(t)$.

4.2.Determine the maximum velocity values $\dot{x}_{max}$and acceleration $\ddot{x}_{max}$of the point, which carries out harmonic oscillations with amplitude$A = 3\,sm$andangular frequency $\omega = \frac{\pi}{2}s^{-1}$.

4.3.Determine the amplitude $A$and the initial phase $\varphi$of the resulting oscillation that arises when compiling two oscillations of the same direction and period:$x_1 = A_1\sin(\omega t)$and $x_2 = A_2\sin(\omega\,(t + \tau))$, where$A_1 = A_2 = 1\ sm$;$\omega = \pi\ s^{-1}$;$t = 0{,}5\ s$. Find the resultant oscillation equation.

4.4.The material point of mass $m = 50\ g$carries oscillations whose equations have the form $x = \mathrm{A}\cdot\cos(\omega t)$, where$A = 10\ sm$,$\omega = 5\ s^{-1}$. Find force$F$, acting on the point in two cases: 1) at the moment when the phase is $\omega t = \pi/3$; 2) in the position of the largest displacement of the point.

4.5.The physical pendulum is a thin, homogeneous rod of mass$m$ with a small ball with mass m on it. The pendulum makes oscillations near the horizontal axis passing through the point$O$in the rod. Determine the period T of the harmonic oscillations of the pendulum for casesa, b, c, d, in fig.4.The rod length$l$ is equal to1 m. The ball is considered as a material point.

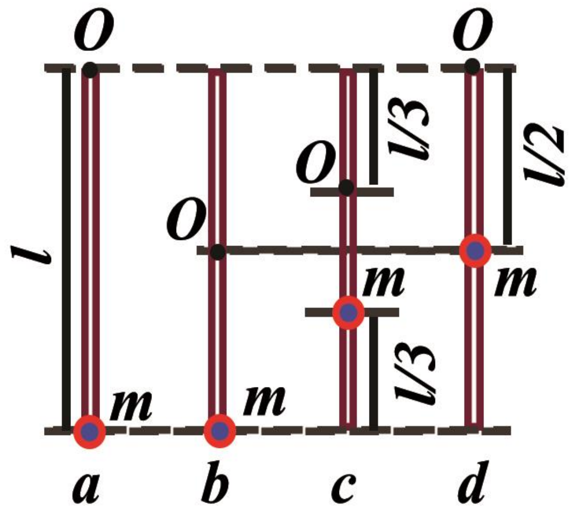


Fig. 4

Problems for independent study:

4.6.The point is oscillating by law$x = A\cdot\cos(\omega t)$, where$A = 5\ sm$; $\omega = 2\ s^{-1}$. Determine the acceleration $|\ddot{x}|$at the time point when its speed$\dot{x} = 8\ sm/s$.

4.7.The point is oscillating by law $x = A\cdot\sin(\omega t)$. At some point in displacement time $x_1$of the point is equal to5 sm. When the phase of oscillation has doubled, the displacement$x_2$became equal8 sm. Find the amplitude A of the oscillation.

4.8.The point appears in two equally directed oscillations: $x_1 = A_1\cdot\sin(\omega t)$and $x_2 = A_2\cos(\omega t)$, де $A_1 = 1\ sm$; $A_2 = 2sm$;$\omega = 1\ s^{-1}$. Determine the amplitude A of the resulting oscillation, its frequencyν and initial phase φ. Find the equation of this movement.

4.9.Find therestoring force$F$in time$t = 1$ s and total energy$E$of the material pointthat is oscillating by law $x = \mathrm{A}\cdot cos(\omega t)$, where$A = 20\ sm$; $\omega = {}^{2\pi}/_{3}\ \mathrm{c}^{-1}$. Mass of material point is equal to$m = 10\ g$.

4.10.The physical pendulum is a thin, homogeneous rod of mass m with two small balls on it with masses $m$and $2m$. The pendulum makes oscillations near the horizontal axis passing through the point Oonthe rod. Determine the period T of the harmonic oscillations of the pendulum for cases a, b, c, d, in fig.5. Length of rod l is equal to 1 m. The ball is considered as a material point.

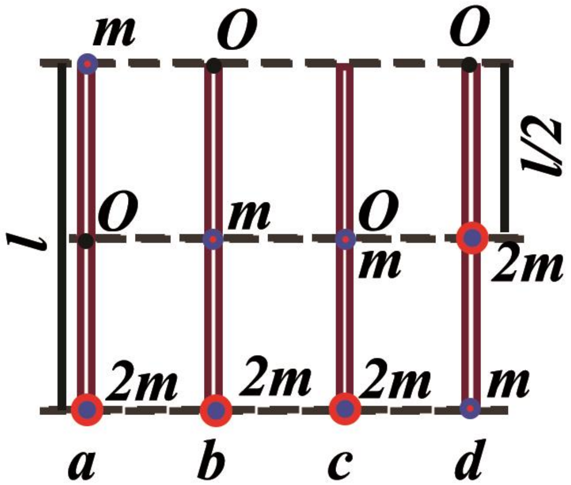


Fig. 5

Theoretical material for practical lessons 5 and 6 you can find in the Lecture notes of GENERAL PHYSICS: Physical fundamentals of fluid mechanics, molecular physics and thermodynamics.

Practical lesson 5.Molecular structure of matter.Laws of ideal gases.Molecular-kinetic theory of gases.

Problems to solve in the classroom:

5.1.Oxygen, under normal conditions, fills the vessel with volume$V = 11{,}2\ l$. Determine the amount of substance ν of the gas and its mass m.

5.2.In the cylinder with length$l = 1{,}6\ m$filled with air at normal atmospheric pressure p_0, theybegan to slowly insert the piston with area $S = 200\ sm^2$. Determine the force Fthat will act on the piston if it is stopped at distance$l_1 = 10\ sm$from the bottom of the cylinder.

5.3.Heating the ideal gas by$\Delta T = 1\ K$at the constant pressure its volume increased by $1/350$of the initial volume. Find the initial temperatureT_1 of gas.

5.4.Find the densityρ of gas mixture of hydrogen and oxygen, if their mass fractions$w_1$and$w_2$are equal relatively1/9 and 8/9.The mixture pressureis $p = 100\ kPa$, temperature - $T = 300\ K$.

5.5.The gas pressure is equal to 1 mPa, the concentration n of its molecules is equal to$10^{10} sm^{-3}$. Determine: 1)gas temperature T; 2)the average kinetic energy of the translational motion of gas molecules.

Problems for independent study:

5.6.Determine the amount of substance ν of hydrogen filling the vessel with volume $V = 3\ l$, if the density of the gas is $\rho = 6{,}65 \cdot 10^{-3}\ kg/mol$.

5.7.The cylinder contains gas at the temperature $t_1 = 100\ °C$. What temperature t_2 is it necessary to heat the gas to increase its pressure twice?

5.8.The container with volume $V = 12\ l$ contains carbon dioxide. The pressure p of gas is equal to $1\ MPa$, the temperature is $T = 300\ K$. Find the mass m of the gas in the container.

5.9.The container with volume $V = 30\ l$ contains the mixture of hydrogen and helium at the temperature $T = 300\ K$ and pressure $p = 828\ kPa$. Mass of the mixture m is equal to $24\ g$ .Determine the mass m_1 of hydrogen and the mass m_2 of helium.

5.10.Determine the average of the total kinetic energy of one molecule of helium, oxygen and water vapor at temperature $T = 400\ K$.

Practical lesson 6. Physical bases of thermodynamics

Problems to solve in the classroom:

6.1.Find the adiabatic index γ for a mixture of gases containing helium with mass $m_1 = 10\ g$ and hydrogen with mass $m_2 = 4\ g$.

6.2.Which work W is happening at the isothermal expansion of hydrogen with mass $m = 5\ g$ taken at temperature $T = 290\ K$, if the volume of gas is increased three times?

6.3.Hydrogen occupies the volume $V_1 = 10\ m^3$ under the pressure $p_1 = 100\ kPa$. Gas has been heated at constant volume up to the pressure $p_2 = 300\ kPa$. Determine: 1) the change ΔU of internal gas energy; 2) the work W, done by gas; 3) the amount of heat Q transferred to gas.

6.4.Perfect diatomic gas ($i = 5$) containing the amount of matter $\nu = 1\ mol$ carries out a cycle consisting of two isochores and two isobars. The smallest volume is $V_{min} = 10\ l$, the largest one is $V_{max} = 20\ l$, the smallest pressure is $p_{min} = 246\ kPa$, the largest one is $p_{max} = 410\ kPa$. Construct a cycle graph.Determine the temperature T of the gas for the characteristic points of the cycle and its thermal efficiency η.

6.5.Find the change ΔS of the entropy at the isobaric expansion for nitrogen with mass $m = 4\ g$ from volume $V_1 = 5\ l$ to $V_2 = 9\ l$.

Problems for independent study:

6.6.The mixture of gases consists of argon and nitrogen, taken under the same conditions and in the same volumes. Determine the adiabatic indexγ of the mixture.

6.7.Nitrogen with mass$m = 2\ g$at thetemperature$T_1 = 300\ K,$ was adiabatically compressedso that its volume decreased in$n = 10\ times$. Determine the final temperatureT_2gas and compression work W.

6.8.Oxygen at constant pressure$p = 80\ kPa$ heats up. Its volume increases from$V_1 = 1\ m^3$to$V_2 = 3\ m^3$. Determine: 1) the change ΔU of internal energy of oxygen; 2) the work W done at the expansion; 3) the amount of heat Q transferred to gas.

6.9.The ideal polyatomic gas carries out a cycle consisting of two isovolumetrics and two isobars, and the largest gas pressure is bigger than the smallest one in two times, and the largest volume is bigger than the smallest one in four times. Determine the thermal efficiency of the η cycle.

6.10.Oxygen with mass$m = 2\ kg$has increased its volume in$n = 5$ timesonce in isothermal way, the other one in adiabatic way. Find entropy changes in each of these processes.

Theoretical material for practical lessons 7 to 9 you can find in the Lecture notes of GENERAL PHYSICS: ELECTROSTATIC FIELD.

Practical lesson 7.Coulomb's law.Interaction of charged bodies.Field tension.

Problems to solve in the classroom:

7.1.Determine the interaction force of two point charges$Q_1 = Q_2 = 1\ C$in the vacuum at the distance$r = 1\ m$from each other.

7.2.Three identical charges$Q = 1\ nC$each of them is located at the vertices of the equilateral triangle. What negative charge Q_1 should be placed in the center of the triangleso that its gravity forces have balanced mutual repulsion of charges? Will this equilibrium be stable?

7.3.The thin rod with length$l = 10\ sm$is uniformly charged. The linear charge density ρequalsto$1 mkC/m$. At the distance from the axis of the rod$a = 20\ sm$ from the nearest end there is the point charge$Q = 100\ nC$. Determine the force F of the interaction of the charged rod and point charge.

7.4.On the metal sphere with the radius$R = 10\ sm$there is the charge$Q = 1\ nC$. Determine the electric field strength E at the following points: 1) at the distance$r_1 = 8\ sm$from the center of the sphere; 2) on its surface; 3) at the distance$r_2 = 15\ sm$ from the center of the sphere. Construct the graph $E(r)$.

7.5.The thin rod with length$l = 12\,sm$is uniformly charged with linear charge density$\tau = 200\,nC/m$. Find the electric field strength E at the point at distance$r = 5\,sm$ from the rod against its middle.

Problems for independent study:

7.6.The distance between two point charges$Q_1 = 1\,mkC$and $Q_2 = -Q_1$, is equal to$10\,sm$. Determine the force F acting on the point charge$Q = 0{,}1\,mkC$, distant on$r_1 = 6\,sm$from the first point chargeand on$r_2 = 8\,sm$ from the second one.

7.7.The same charges $Q = 0{,}3\,nC$ are in the vertices of the square. What negative charge Q_1 should be placed in the center of thesquare so that its gravity forces have balanced mutual repulsion of charges?

7.8.Thin long rod is uniformly charged with linear densityτthat is equal to$10\,mkC/m$. At the distance from the axis of the rod$a = 20\,sm$from the nearest end there is the point charge$Q = 10nC$. Determine the force F of the interaction of the charged rod and point charge.

7.9.Two concentric metal charged sphere withthe radii$R_1 = 6\,sm$and$R_2 = 10\,sm$correspondingly carry the charges $Q_1 = 1\,nC$and$Q_2 = -0{,}5\,nC$. Determine the electric field strength E at the distances from the center of the sphere $r_1 = 5\,sm$, $r_2 = 9\,sm$, $r_3 = 15\,sm$. Construct a graph of $E(r)$.

7.10.A thin rod with thelength $l = 10\,sm$ is charged with a linear density $\tau = 400\,nC/m$. Find the electric field strength E at the point located at the perpendicular to the rod, conducted through one of its ends, at the distance $r = 8\,sm$from this end.

Practical lesson 8.Potential.Energy system of electric charges. Work of moving the charge in the field.

Problems to solve in the classroom:

8.1.Determine the potential φ of the electric field at the point far from charges$Q_1 = -0{,}2\,mkC$and$Q_2 = 0{,}5\,mkC$respectively at distances$r_1 = 15\,sm$and$r_2 = 25\,sm$. Determine the minimum and maximum distance between the charges.

8.2.The metal sphere with the diameter$d = 2\,sm$charged negatively to the potential$\varphi = 150\,V$. How many electrons are on the surface of the sphere?

8.3.The electric field $E$of a homogeneous electric field at some point is equal to$600\,V/m$. Calculate the potential difference$U$ between this point and the otherone which lies on the straight component of the angle$\alpha = 60°$with the direction of the vector of electric field.The distance between points is equalto2 mm.

8.4.Determine the work$W_{1,2}$by moving the charge$Q_1 = 50\,nC$from point 1 to point 2 (fig.6) in the field created by two point charges, the module$|Q|$which is equal to$1\,mkC$and$a = 0{,}1\,m$.

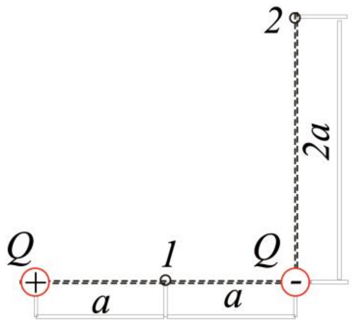


Fig. 6

8.5.The potentialdifference$U$ between the cathode and the anode of the electronic lamp is $90\,V$with the distance $r = 1\,mm$. Find the acceleration of the motion of the electron from the cathode to the anode.What is the electron velocity at the moment of collision with the anode?What time does the electron fly away from the cathode to the anode? The field is considered to be homogeneous.

Problems for independent study:

8.6.Charges$Q_1 = 1\,mkC$and$Q_2 = -1mkC$are at thedistance$d = 10\,sm$. Determinethe electric field$E$ andpotentialφfields at the pointremote from the distance$r = 10\,sm$from the first chargeand lies on the line passing through the first charge perpendicular to the direction from$Q_1$to Q_2.

8.7.One hundred identical drops of mercury, charged to the potential$\varphi = 20\,V$merge into one drop. What is the potential $\varphi_1$of the formed drop?

8.8.The electric field$E$of a homogeneous electric field is equal to$120\,V/m$. Calculate the potential difference$U$between this point and the one which lies on the same power line and remote from the first on$r = 1\,mm$.

8.9.On a straight line segment, there is a uniformly distributed charge withthe linear density$t = 1mkC/m$. Determine the work W of the field by moving the charge $Q = 1\,nC$ from point B to point C (fig.7).

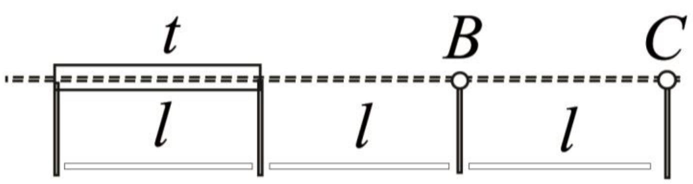


Fig. 7

8.10.A proton moves along the power line of a homogeneous electric field. At the point of the field with potential$\varphi_1$proton had thespeed$v_1 = 0{,}1\ Mm/s$. Determine the potential$\varphi_2$of the point of the fieldin which the proton velocity increases in$n = 2$ times. The ratio of the charge of the proton to its massis$\frac{e}{m} = 96\ mC/kg$.

Practical lesson 9.Electric capacity.Capacitors.The energy of a charged conductor. Energy of the electric field

Problems to solve in the classroom:

9.1.Between theparallel-plate capacitor there are two parallel conductingplates charged to the potential difference$U = 600V$. There are two layers of dielectrics with glass thickness$d_1 = 7\ mm$and ebonite thickness$d_2 = 3\ mm$.The area$S$of the plate capacitor is equal to $200\ sm^2$. Find: 1) The capacitance C of the capacitor; 2) the displacement$D$, the electric field$E$andpotential drop $\Delta\varphi$ in each layer.

9.2.Two capacitors has capacitances$C_1 = 3\ mkF$ i $C_2 = 6\ mkF$and areconnected to each other and connected to the battery with electromotive force$\varepsilon = 120\ V$. Determine the charges$Q_1$and$Q_2$of thecapacitors and potential differenceU_1andU_2between their covers, if the capacitors are connected: 1) in parallel; 2) sequentially.

9.3.Condensers with thecapacity$C_1 = 10\ nF$, $C_2 = 40\ nF$, $C_3 = 2\ nF$and$C_4 = 30\ nF$are connected as shown in fig.8. Determine the capacitance of the condenser connection.

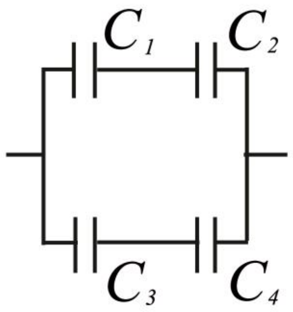


Fig. 8

9.4.The flat air condenser consists of two circular plates with the radius$r = 10\ sm$each. Distance$d_1$between the plates is equal to$1\ sm$. The capacitor is charged to the potential difference$U = 1{,}2\ kV$and disconnected from the current source. What work W should be done so that while removing the plates from each other, we can increase the distance between them to $d_2 = 3{,}5\ sm$?

9.5.Condensers with the capacities $C_1 = 1\,mkF$, $C_2 = 2\,mkF$, $C_3 = 3\,mkF$ are included in the circuit with voltage $U = 1{,}1\,kV$. Determine the energy of each condenser in the following cases: 1) their sequential inclusion; 2) parallel switching.

Problems for independent study:

9.6.The capacity of a flat capacitor is equal to $1{,}5\,mkF$. Distance d between theplates is equal to $5\,mm$. What will be the capacity C of the capacitor, if you put a sheet of ebonite with the thickness of $d_1 = 3mm$ on the bottom plate?

9.7.The condenser with the capacity $C_1 = 0{,}2\,mkF$ was charged to the potential difference $U_1 = 320\,V$. When it has been connected in parallel with the second capacitor, charged to the potential difference $U_2 = 450\,V$, the voltage U on it has changedto $400\,V$. What will be the capacity C_2 of the second capacitor?

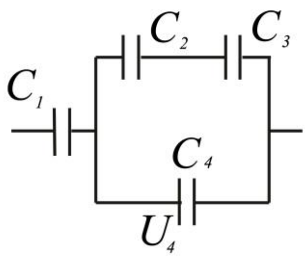


Fig. 9

9.8.The condensers with the capacities $C_1 = 2\,mkF$, $C_2 = 2\,mkF$, $C_3 = 3\,mkF$ and $C_4 = 1\,mkF$ are connected as shown in fig.9.The difference in potentials on the plates of the fourth capacitoris $U_4 = 100\,V$. Find the charges and potential difference on the plates of each capacitor, as well as the total charge and the difference in capacitors of the capacitors.

9.9.The condenser with the capacity $C_1 = 600\,pF$ has been charged to the potential difference $U = 1{,}5\,kV$ and then disconnected from the current source. Then another unloaded capacitor was connected to the condenser in parallel $C_2 = 400\,pF$. Determine the energy spent on the formation of a spark that slipped when the condensers are connected.

9.10.The ebonite plate with thickness $d = 2\,mm$ and area $S = 300 sm^2$ was placed in a homogeneous electric field $E = 1\,kV/m$, positioned so that the power lines are perpendicular to its flat surface. Find: 1) the density of charges on the surface of the plate; 2) the energy E of the electric field, concentrated in the plate.

Additional information (APPENDIXIS)

standard temperature and pressure (abbreviated as STP) [7]:

temperature of 273.15 K (0 °C, 32 °F)

absolute pressure of exactly 105 Pa (100 kPa, 1 bar)

normal temperature and pressure (abbreviated as NTP):

temperature of 20 °C (293.15 K, 68 °F)

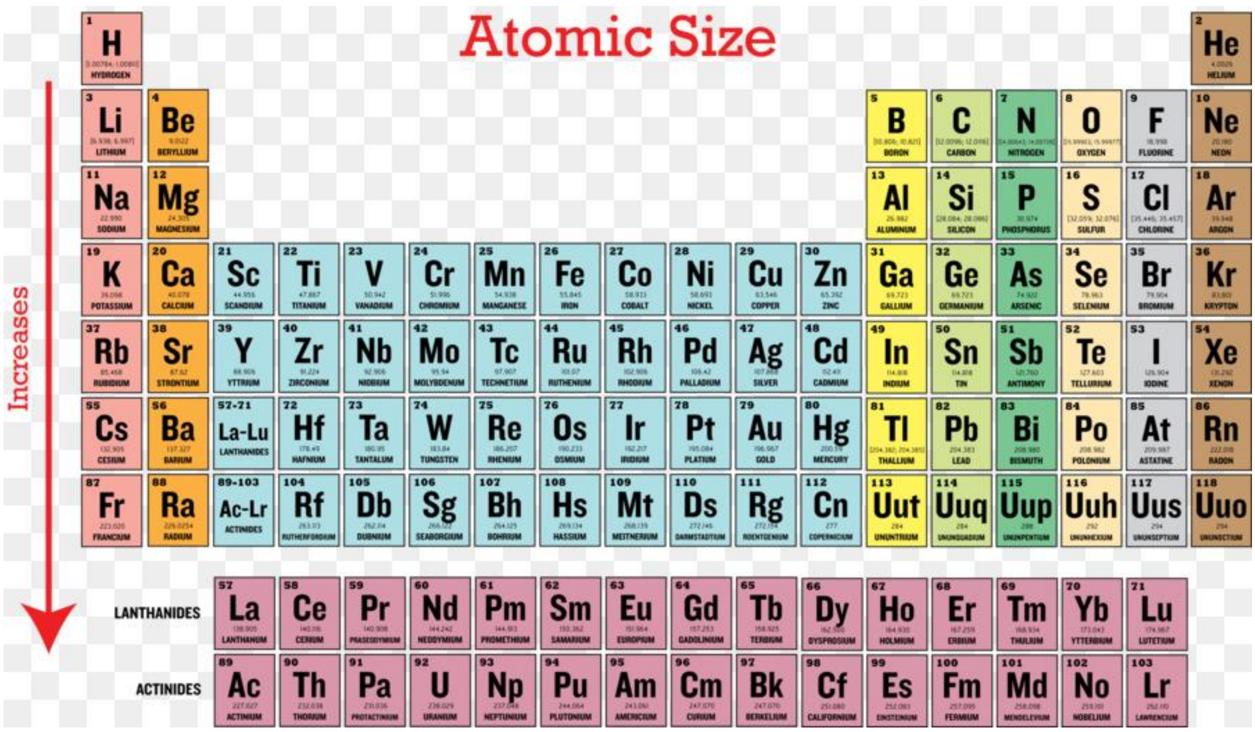
absolute pressure of 1 atm (14.696 psi, 101.325 kPa)

The molar volume of gases around STP [8]:

Vm = 8.3145 × 273.15 / 100.000 = 22.711 dm3/mol at 0 °C and 100 kPa

Vm = 8.3145 × 298.15 / 100.000 = 24.790 dm3/mol at 25 °C and 100 kPa

Periodictableofelements



Answers

1	1	2	3	4	5
	$64 km/h$	graph	$30s$, $3m/s$, $45m$	$2.5m/s$ $12.5m/s^2$	$5\ sm/s^2$
	6	7	8	9	10
	$3.2\ m/s$	$40s$, $80m$, $-0.1\ m/s^2$ graph	$3.4\ s, 15\ m$ $10.6\ s, 123\ m$	1)14.1 m/s 2) -10 m/s^2 3) 7.07 m/s^2 4) 7.07 m/s^2	$8.33\ rad/s^2$
2	1	2	3	4	5
	$39.2\ N$	$1.33\ kg \cdot m/s$	1) $6.3\ m/s$ 2) $-0.57\ m/s$	$3mg$ 70°30’	$633\ J$
	6	7	8	9	10
	$2\ m/s^2$	$1.4\ N \cdot m$	$0.4\ m/s$	*In* 6.1 *times*	$5\ J$ $15\ J$
3	1	2	3	4	5
	$2 \cdot 10^{-4}\ kg \cdot m^2$	$6 \cdot 10^{-3} kg \cdot m^2$	$0.0235\ \mathrm{kg \cdot m^2}$	$1.02\ rad/s$	$10\ J, 4\ J$
	6	7	8	9	10
	1) 3 10^{-3} kg m^2 2) 0.75 10^{-3} kg m^2 3) 10^{-3} kg m^2	a) 0.3kg m^2 b) 0.122kg m^2 c) 0.0833kg m^2 d) 0.0777kg m^2 e) 0.3kg m^2	$0.24\ m/s^2$	10 min^{-1}	3.74 m/s
4	1	2	3	4	5
	graph	4.71 sm/s, 7.40 sm/s	1.41sm, π/4 rad, π s^{-1}	1)-62.5 mN 2) -125 mN	a)1.89 s b) 1.64 s c) 1.34 s d) 1.53 s
	6	7	8	9	10
	12 sm/s^2	8.33 sm	2.24 sm, 0.159 Gz, 0.353π, 1 s^{-1}	4.39 mN, 877 mkJ	a) 0.386 Gz b) 0.537 Gz c) 0.652 Gz d) 0.582 Gz
5	1	2	3	4	5
	0.5 mol, 16 g	32.3 kN	350K	$0.481 \frac{kg}{m^3}$	1)7.25 kK, 2)$1.5 \cdot 10^{-19} J$
	6	7	8	9	10
	$9.97 \cdot 10^{-3} mol$	473°C	0.212 kg	16 g, 8 g	$8.28 \cdot 10^{-21} J$, $13.8 \cdot 10^{-21} J$, $16.6 \cdot 10^{-21} J$
6	1	2	3	4	5
	1.51	6.62 kJ	1)5MJ 2)0 3) 5MJ	296K, 493 K, 986 K, 592 K, 8,9%	2.43J/K
	6	7	8	9	10
	1.50	754 K, 674 J	1)0.4 MJ 2)160kJ	0.11	836 J/K, 0

			3)560kJ		
7	1	2	3	4	5
	9 GN	-0.577nC, no	1.5mN	1) 0 2)900 V/m 3) 400 V/m graph	55.7 kV/m
	6	7	8	9	10
	287 mN	-287nC	4.5mN	0, 1.11 kV/m, 200 V/m graph	35.6 kV/m
8	1	2	3	4	5
	6kV, 10sm, 40sm	$1.04 \cdot 10^9$	0.6 V	659 mkJ	$1.58 \cdot 10^{16}\ m/s^2$
	6	7	8	9	10
	664kV/m 26.4 kV	432 V	0.12 V	2.62 mkJ	289 V
9	1	2	3	4	5
	1)885 2)2.66 mkC/m^2, 42.8 kV/m, 100 kV/m, 300V	1) 360mkC, 720 mkC, 120V 2) 240 mkC, 80 V, 40 V	20 pF	50 kJ	1)0.18 J, 0.09 J, 0.06 J 2)0.605 J, 1.121 J, 1.82 J
	6	7	8	9	10
	2.5 mkF	0.32 mkF	200mkC, 120mkC, 120mkC, 100 mkC	0.27 mJ	1) 5.9 nC/m^2 2) 88.5pJ

Literature

1. GENERAL PHYSICS: Physical fundamentals of mechanics:Lecture notes: навч. посібдлястудентівтехнічнихспеціальностей/ *T.Chijska, S. Kulieznova, O. Shtofel*; *Igor Sikorsky Kyiv Polytechnic Institute*. – Kyiv :Igor Sikorsky Kyiv Polytechnic Institute, 2018. – 60 p. Electronic resources:

http://zfftt.kpi.ua/images/Shtofel/1LectureMechanics.PDF

2. Physicsfor Scientists and Engineerswith Modern Physics,eighth edition, 2010 Raymond A. Serway, John W. Jewett, Jr., ISBN-13: 978-1-4390-4844-3.
3. Mechanics and Oscillations: University Physics I: Notes and exercises, first edition, 2015, Daniel Gebreselasie, ISBN: 978-87-403-1164-8.
4. Modern Introductory Mechanics, second edition, 2015, Walter Wilcox, ISBN: 978-98-403-0855-6.
5. Курсфізики: У 2-х т. Т.1: Фізичніосновимеханіки. Молекулярнафізика і термодинаміка. Електростатика. Постійнийструм. Електромагнетизм: Навчальнийпосібникдлястудентівінженерно-технічнихспеціальностейвищихнавчальнихзакладів. – Донецьк: ДонНТУ, 2009. – 224 с.
6. Sýkora S. Stan's Library, Vol 1, DOI: 10.3247/SL1Phys06.002
7. IUPAC. Compendium of Chemical Terminology, 2nd ed. (the "Gold Book"). Compiled by A. D. McNaught and A. Wilkinson. Blackwell Scientific Publications, Oxford (1997). XML on-line corrected version: http://goldbook.iupac.org (2006-) created by M. Nic, J. Jirat, B. Kosata; updates compiled by A. Jenkins. ISBN 0-9678550-9-8. https://doi.org/10.1351/goldbook.
8. Fundamental Physical Properties: Molar Volumes (CODATA values for ideal gases)". NIST.

Electronic resources: http://zfftt.kpi.ua/en/education/online-library