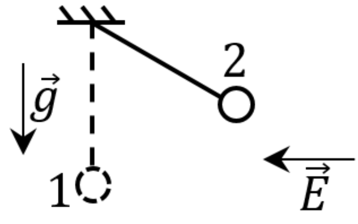
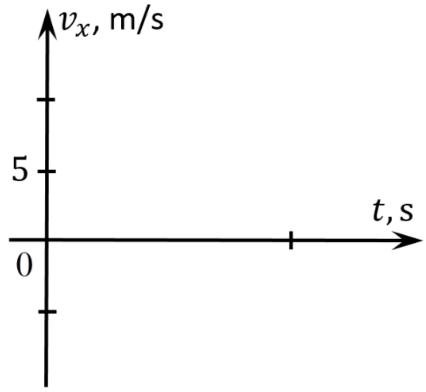
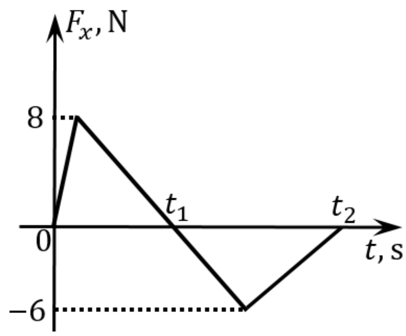
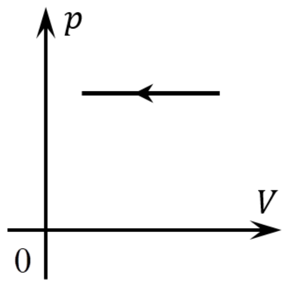
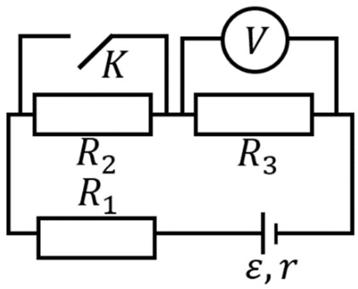
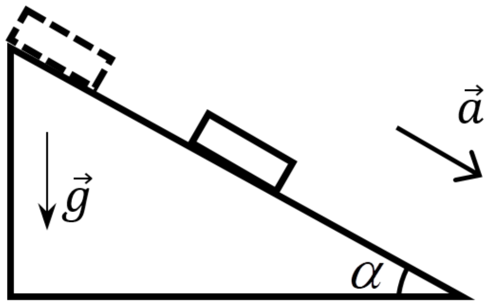
No.	Item	Score	
	I. FOR ITEMS 1-3 PROVIDE SHORT ANSWERS ACCORDING TO THE GIVEN REQUIREMENTS		
1	**Complete the following sentences as to make true statements:** **a)** In uniformly accelerated rectilinear motion, the acceleration of the body is ……………………. **b)** If the work done by the net external force acting on a body is positive, then the variation of its kinetic energy will be …………………. than zero. **c)** During the adiabatic expansion of a gas, the internal energy of the ideal gas…………………. . **d)** Of two capacitors connected in parallel, the one with the ……………………….. electrical capacitance will accumulate a larger electric charge. **e)** As a result of the disintegration of the nucleus of a radioactive element accompanied by the emission of an electron from the nucleus, the number of protons in the nucleus will ……………………by one unit.	L 0 2 4 6 8 10	L 0 2 4 6 8 10
2	**Indicate (by using arrows) the correspondence between the following physical quantities and the physical units they represent:** Force — kg Mechanical work — N Electromotive force — nm Photon wavelength — mol Amount of substance — kJ V	L 0 2 4 6 8 10	L 0 2 4 6 8 10
3	**State whether the following statements are true or false and circle the right answer:** **a)** The vectors of a body's momentum change and the net force acting upon it are parallel and point in the same direction. **T F** **b)** During the isobaric expansion of an ideal gas, its temperature increases. **T F** **c)** Of two resistors connected in parallel to a current source, the resistor with the lower electrical resistance will carry a higher current. **T F** **d)** The energy of a photon changes when it passes from one transparent medium to another with a different refractive index. **T F** **e)** . As a result of the emission of a gamma photon by a radioactive nucleus, the number of protons and neutrons in the nucleus remains unchanged. **T F**	L 0 2 4 6 8 10	L 0 2 4 6 8 10
	II. IN EXERCISES 4-9 ANSWER THE QUESTIONS OR SOLVE THE TASKS, AND PROVIDE ARGUMENTS IN THE SPACES BELOW:		
4	A charged body, suspended from an insulated thread, is deflected from the vertical, from position 1 to position 2, by a horizontal electric field, as shown in the adjacent figure. Indicate, in position 2, the forces acting on the body and determine the sign of its charge. 	L 0 1 2 3 4	L 0 1 2 3 4
5	By emitting a photon with a frequency of 2.46×10^{15} Hz, an electron transitions from level 2 to level 1 of an atom. By emitting a photon with a frequency of 6.91×10^{14} Hz, an electron in the same atom transitions from level 5 to level 2. What is the frequency of the photon absorbed when an electron transitions from level 1 to level 5? SOLUTION	L 0 1 2 3 4 5 6	L 0 1 2 3 4 5 6

6	A body, with the initial velocity projection equal to 5 m/s, moves rectilinearly uniformly accelerated for 5 s. Draw the graph of the velocity projection as a function of time and determine the projection of the body's acceleration, if the magnitude of the final velocity is 10 m/s. SOLUTION  	L 0 1 2 3 4 5	L 0 1 2 3 4 5
7	A force acts on a body initially at rest, along the *Ox* axis, with its projection varying over time as shown in the figure. What is the time moment t_2 when the body stops, given that force changes sense at time t_1 = 3 s? The scale may not be accurate. SOLUTION  	L 0 1 2 3 4 5 6 7	L 0 1 2 3 4 5 6 7

8	One mole of an ideal monoatomic gas is cooled so that its volume decreases according to the diagram. Indicate the type of process and determine the amount of heat released by the gas if the change in the gas's volume is equal to -0.20 L and its initial pressure is 1.0×10^5Pa. SOLUTION  	L 0 1 2 3 4 5 6 7 8 9	L 0 1 2 3 4 5 6 7 8 9
9	In the circuit shown in the adjacent figure, the resistances of the resistors are $R_1 = 15{,}0\ \Omega$, $R_3 = 8{,}0\ \Omega$ and $r = 1{,}0\ \Omega$. When the switch K is closed, the voltage indicated by the ideal voltmeter becomes $n = 1{,}5$ times greater than the voltage indicated by the same voltmeter when the switch is open. Determine the resistance of the resistor R_2. SOLUTION  	L 0 1 2 3 4 5 6 7 8 9	L 0 1 2 3 4 5 6 7 8 9

III. FOR ITEMS 10-12 PROVIDE FULL SOLUTION TO THE GIVEN PROBLEMS			
10	A body with no initial velocity is released from the top of an inclined plane. The angle formed by the inclined plane with the horizontal is 30°, and the coefficient of kinetic friction between the body and the plane is 0.40. The free fall acceleration is 10 m/s², sin(30°) = 0.50, and cos(30°) = 0.87. a) Represent in the figure the forces acting on the body as it moves downward along the inclined plane. b) Determine how much time after release the body will have reached a velocity of 7.6 m/s.  SOLUTION	a) L 0 1 2 3 b) L 0 1 2 3 4 5 6 7 8	a) L 0 1 2 3 b) L 0 1 2 3 4 5 6 7 8
11	Inside a vertical cylinder, placed in a vacuum, closed at the bottom and fitted with a movable piston at the top, there is an ideal monoatomic gas. Inside the cylinder there is a resistor connected to a capacitor with an electric capacitance of 30 μF, initially charged with an electric charge equal to 6.0 mC. The heat released by this resistor caused the piston to move upward. Neglecting friction forces, energy losses, and the heat capacities of the cylinder and of the resistor, determine: the amount of heat released by the resistor, and the mass of the piston, if the height to which the piston has risen from its initial position is 12 cm. All the energy stored in the capacitor is dissipated through the resistor. The free fall acceleration is 10 m/s².		

	SOLUTION	L 0 1 2 3 4 5 6 7 8 9 10 11	L 0 1 2 3 4 5 6 7 8 9 10 11
12	You have at your disposal a diffraction grating with an unknown period, a laser with a known frequency, a screen, and a measuring tape. Your task is to determine the diffraction grating period. a) Describe the method used to determine the diffraction grating period and draw an explanatory diagram indicating the measured quantities; b) Derive the calculation formula. SOLUTION	a) L 0 1 2 3 4 b) L 0 1 2 3 4	a) L 0 1 2 3 4 b) L 0 1 2 3 4

ANNEX

Physical constants

Elementary charge $e = 1{,}60 \cdot 10^{-19}\mathrm{C}$	Avogadro's constant $N_A = 6{,}02 \cdot 10^{23}\mathrm{mol}^{-1}$
Electron rest mass $m_e = 9{,}11 \cdot 10^{-31}\mathrm{kg}$	Boltzmann's constant $k = 1{,}38 \cdot 10^{-23}\ \mathrm{J/K}$
Light speed in vacuum $c = 3{,}00 \cdot 10^{8}\mathrm{m/s}$	Ideal gas constant $R = 8{,}31\ \mathrm{J/(mol \cdot K)}$
Gravitational constant $K = 6{,}67 \cdot 10^{-11}\mathrm{N \cdot m^2/kg^2}$	Planck's constant $h = 6{,}63 \cdot 10^{-34}\ \mathrm{J \cdot s}$
Electric constant $\varepsilon_0 = 8{,}85 \cdot 10^{-12}\mathrm{F/m}$	Coulomb's force constant $k_e = 9{,}0 \cdot 10^{9}\mathrm{N \cdot m^2/C^2}$

MECHANICS

$$x = x_0 + v_x t;\ \ x = x_0 + v_{0x}t + \frac{a_x t^2}{2};\ v_x = v_{0x} + a_x t;\ v_x^2 - v_{0x}^2 = 2a_x s_x; \nu = \frac{1}{T};\ \omega = \frac{2\pi}{T};\ v = \omega r;\ a_c = \frac{v^2}{r}.$$

$$\vec{F} = m\vec{a};\ \vec{F}_{12} = -\vec{F}_{21}; F = K\frac{m_1 m_2}{r^2}; \Gamma = K\frac{m}{r^2}; G = mg; \vec{F}_e = -k\Delta\vec{l};\ F_f = \mu N;\ F_A = \rho_0 V g; p = \frac{F}{S}; p = \rho g h;$$

$$M = Fd;\ \vec{p} = m\vec{v};\ \Delta\vec{p} = \vec{F}\Delta t;\ L = Fs\cos\alpha;\ P = \frac{L}{t};$$

$$E_c = \frac{mv^2}{2};\ L_{12} = E_{c2} - E_{c1};\ E_p = mgh;\ E_p = \frac{kx^2}{2};\ L_{12} = -\left(E_{p2} - E_{p1}\right);$$

$$\nu = \frac{N}{t};\ T = \frac{t}{N}; T = 2\pi\sqrt{\frac{l}{g}};\ T = 2\pi\sqrt{\frac{m}{k}}; v = \lambda\nu; \lambda = vT; x = A\sin(\omega t + \varphi_0);\ v_m = A\omega;\ a_m = A\omega^2$$

MOLECULAR PHYSICS AND THERMODYNAMICS

$$p = \frac{1}{3}m_0 n\overline{v^2} = \frac{2}{3}n\bar{\varepsilon}_{tr}; \bar{\varepsilon}_{tr} = \frac{3}{2}kT; p = nkT;\ v_T = \sqrt{\frac{3RT}{M}}; pV = \nu RT; \nu = \frac{m}{M} = \frac{N}{N_A}; R = kN_A; M = m_0 N_A;$$

$$pV = const, T = const;\ \frac{p}{T} = const, V = const;\ \frac{V}{T} = const, p = const;\ \frac{pV}{T} = const, m = const.$$

$$Q = \Delta U + L;\ U = \frac{3}{2}\frac{m}{M}RT;\ L = p\Delta V;\ Q = cm\Delta T = C_M \nu\Delta T;\ Q = \lambda m;\ Q = qm;\ c_p - c_V = \frac{R}{M};$$

$$\eta = \frac{Q_1 - |Q_2|}{Q_1};\ \eta_{max} = \frac{T_1 - T_2}{T_1};\ \varphi = \frac{\rho_a}{\rho_s} = \frac{p_a}{p_s}; \sigma = \frac{F_s}{l}; h = \frac{4\sigma}{\rho g d}; \frac{F}{S} = E\frac{\Delta l}{l_0}; l = l_0(1 + \alpha t); V = V_0(1 + \beta t)$$

ELECTRODYNAMICS

$$q = \pm Ne; F = \frac{k_e}{\varepsilon_r}\frac{|q_1 q_2|}{r^2}; E = \frac{k_e}{\varepsilon_r}\frac{q}{r^2}; k_e = \frac{1}{4\pi\varepsilon_0}; \vec{E} = \frac{\vec{F}}{q};\ E = \frac{U}{d}; \varphi = \frac{kQ}{r}; W = \varphi q; U = \varphi_1 - \varphi_2;\ U = \frac{L}{q};$$

$$C = \frac{q}{U}; C = \frac{\varepsilon_0\varepsilon_r S}{d};\ C_p = \sum_{i=1}^{n} C_i; \frac{1}{C_s} = \sum_{i=1}^{n}\frac{1}{C_i}; W_e = \frac{CU^2}{2}$$

$$I = \frac{\Delta q}{\Delta t}; I = \frac{U}{R}; I = \frac{\varepsilon}{R + r}; I_{sc} = \frac{\varepsilon}{r}; R = \rho\frac{l}{S};\ R_S = \sum_{i=1}^{n} R_i; \frac{1}{R_p} = \sum_{i=1}^{n}\frac{1}{R_i}; L = UIt; Q = I^2 Rt; P = UI; \eta = \frac{L_u}{L_t};$$

$$F = IBl\sin\alpha; F_L = qvB\sin\alpha;$$

$$\Phi = BS\cos\alpha; \varepsilon_i = -\frac{\Delta\Phi}{\Delta t}; \Phi = Li; \varepsilon_{ai} = -L\frac{\Delta i}{\Delta t}; W_m = \frac{LI^2}{2};$$

$$I = \frac{I_m}{\sqrt{2}}; U = \frac{U_m}{\sqrt{2}};\ X_L = \omega L; X_C = \frac{1}{\omega C};\ \frac{I_2}{I_1} \approx K = \frac{N_1}{N_2} = \frac{U_1}{U_2};\ P = UI\cos\varphi;\ T = 2\pi\sqrt{LC}; q = q_m\cos(\omega t + \varphi_0)$$

$$\Delta_{\max} = \pm 2k\frac{\lambda}{2};\ \Delta_{\min} = \pm(2k + 1)\frac{\lambda}{2};\ d\sin\varphi = \pm k\lambda;\ d = \frac{l}{N} = \frac{1}{n}$$

MODERN PHYSICS

$$m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}};\ \vec{p} = \frac{m_0\vec{v}}{\sqrt{1 - \frac{v^2}{c^2}}};\ E = mc^2; E_0 = m_0 c^2;\ E_c = E - E_0;$$

$$\varepsilon_f = \frac{hc}{\lambda};\ p_f = \frac{h}{\lambda};\ m_f = \frac{h}{\lambda c};\ h\nu = L_e + \frac{mv_{max}^2}{2};\ \nu = \frac{c}{\lambda};\ h\nu = E_n - E_m;$$

$$N = N_0 e^{-\lambda t};\ \lambda = \frac{ln2}{T_{1/2}};\ N = N_0 2^{-\frac{t}{T_{1/2}}};\ {}_{Z}^{A}X \to {}_{Z-2}^{A-4}Y + {}_{2}^{4}He;\ {}_{Z}^{A}X \to {}_{Z+1}^{A}Y + {}_{-1}^{0}e$$

$$1\ \mathrm{eV} = 1{,}6 \cdot 10^{-19}\ \mathrm{J};\quad 1\ \mathrm{u} = 1{,}66 \cdot 10^{-27}\ \mathrm{kg}$$