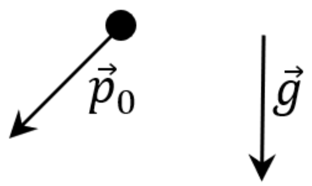
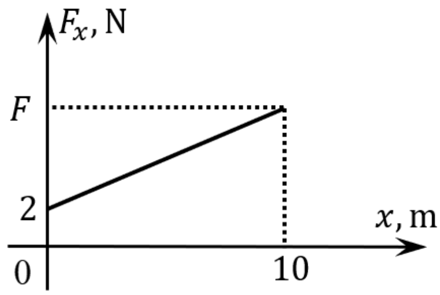
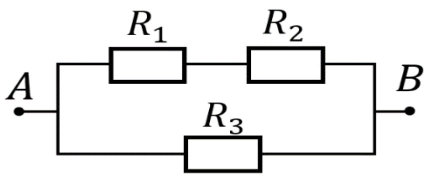
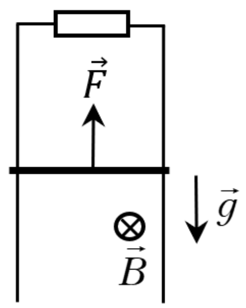
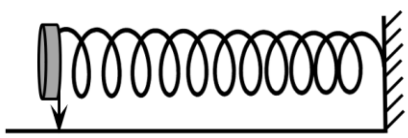
No.	Item	Score	
	I. FOR ITEMS 1-3 PROVIDE SHORT ANSWERS ACCORDING TO THE GIVEN REQUIREMENTS		
1	**Complete the following sentences as to make true statements:** **a)** In a uniform circular motion of a mass point the acceleration vector is ……………………………to its velocity. **b)** The return force acting on the body of an oscillator is directed towards the ………………………position of the body. **c)** Among the thermodynamic parameters, the internal energy of the ideal gas is a function of the gas……………………………………. **d)** Of the powers dissipated by the electric current on two resistors connected in series, the power dissipated on the resistor with the ……………………….. resistance is greater. **e)** When a photon is absorbed by an atom, the energy of the atom ………………………..	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:** Acceleration K Momentum m/s^2 Inductance kg·m/s Radiation frequency mH Absolute temperature Ω s^{-1}	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)** In non-uniform rectilinear motion of a material point the velocity and acceleration vectors are parallel. **T F** **b)** An isobarically cooled ideal gas has constant internal energy. **T F** **c)** If wires of constant cross-section used to carry electrical energy are longer, energy losses are smaller. **T F** **d)** By diffraction, light penetrates the shadow zone of an object which has a size comparable to the wavelength of light. **T F** **e)** The binding energy of a nucleus depends on its nucleon number. **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	On a mass point in a gravitational field, a horizontal force $\vec{F}_0$ additionally acts. Show on an arbitrary scale the forces acting on the material point, the resultant force $\vec{F}$ and the acceleration vector of the body if the body is moving rectilinearly uniformly accelerated with initial momentum $\vec{p}_0$, oriented as shown in the figure. 	L 0 1 2 3 4	L 0 1 2 3 4
5	Determine the maximum kinetic energy of the photoelectron extracted by the 200 nm wavelength radiation from the cathode whose threshold frequency is equal to $1{,}0 \cdot 10^{15}$ Hz. SOLUTION	L 0 1 2 3 4 5 6	L 0 1 2 3 4 5 6

6	Two bodies with masses equal to 1,0 kg and 2,0 kg move in a straight line towards each other. After the plastic collision they continue their motion coupled together. The kinetic energy after the collision is equal to 6,0 J. Determine the initial speed of the first body before the collision, if the second body had a speed of 5,0 m/s and its momentum was less than that of the first body. SOLUTION	L 0 1 2 3 4 5	L 0 1 2 3 4 5
7	A body of mass 4,0 kg, initially at rest at the origin of the *Ox* axis, is acted upon by a net force parallel to the *Ox* axis, the projection of which varies with the coordinate of the body, as shown in the figure below. Determine the value of the force when the distance travelled by the body becomes equal to 10 m, if its speed at this point becomes equal to 4,0 m/s. SOLUTION 	L 0 1 2 3 4 5 6 7	L 0 1 2 3 4 5 6 7

8	One mole of a monoatomic ideal gas is heated in isochoric form, so the temperature increases twofold. Determine: a) how many times the pressure of the gas has changed; b) the change in the internal energy of the ideal gas if the initial temperature is 200 K. SOLUTION	a) L 0 1 2 3 b) L 0 1 2 3 4 5 6	a) L 0 1 2 3 b) L 0 1 2 3 4 5 6
9	In the circuit shown in the figure, the electrical resistances of resistors R_1, R_2 are equal to 5,0 Ω and 10 Ω. The voltage on the resistor R_2 is equal to 4,0 V. The current from A to B is equal to 1,0 A. Determine the resistance of resistor R_3. 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	In a vertical cylinder, with a movable piston that can move without friction, provided with a heater of electrical resistance R_0=2,0 Ω, connected to a voltage equal to $u = 2{,}0$ V, there is one mole of Helium. Of the heat energy released by the heater, 70% is transferred to the gas. Determine the temperature change of the gas in τ=830 s after the heater is turned on, if the pressure outside the cylinder is constant and the universal gas constant is *R*=8,3 J/(mol K). 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
11	A horizontal rod moves downwards without friction on two vertical, plane-parallel rails in a homogeneous gravitational and magnetic field of induction 0,5 T, with velocity equal to 4,0 m/s, under the action of a force $\vec{F}$ equal to 5,0 N, acting vertically upwards. A resistor with a resistance of 0,5 Ω is connected to the ends of the rails. The mass of the rod is 0,55 kg. The free fall acceleration is 10 m/s^2. The rod and rails have negligible electrical resistance and the rod permanently closes the circuit. a) Indicate the direction of the induction current through the rod. b) State the other forces acting on the rod. c) Determine the length of the rod. SOLUTION  	a) L 0 1 b) L 0 1 2	a) L 0 1 b) L 0 1 2

		c) L 0 1 2 3 4 5 6 7 8 9	c) L 0 1 2 3 4 5 6 7 8 9
12	You have a spring with known spring constant, which can be both stretched and compressed, fixed at one end to a support, tennis ball with known mass, tennis ball launcher, ruler. A device is attached to the end of the spring to record the deformation of the spring. The device and the spring have negligible mass. You need to determine the speed at which the tennis ball is launched from the launcher. Requirements: a) describe how to determine the speed; b) derive the formula for the calculation. SOLUTION 	a) L 0 1 b) L 0 1 2 3 4 5 6	a) L 0 1 b) L 0 1 2 3 4 5 6

ANNEX
Physical constants

Elementary charge $e = 1,60\cdot10^{-19}\,\mathrm{C}$	Avogadro's constant $N_A = 6,02\cdot10^{23}\ \mathrm{mol}^{-1}$
Electron rest mass $m_e = 9,11\cdot10^{-31}\,\mathrm{kg}$	Boltzmann's constant $k = 1,38\cdot10^{-23}\ \mathrm{J/K}$
Light speed in vacuum $c = 3,00\cdot10^{8}\,\mathrm{m/s}$	Ideal gas constant $R = 8,31\,\mathrm{J/(mol\cdot K)}$
Gravitational constant $K = 6,67\cdot10^{-11}\ \mathrm{N\cdot m^2/kg^2}$	Planck's constant $h = 6,63\cdot10^{-34}\,\mathrm{J\cdot s}$
Electric constant $\varepsilon_0 = 8,85\cdot10^{-12}\,\mathrm{F/m}$	Coulomb's force constant $k_e = 9,00\cdot10^{9}\,\mathrm{N\cdot m^2/C^2}$

MECHANICS

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

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

$$\vec{p} = m\vec{\upsilon};\ \Delta\vec{p} = \vec{F}\Delta t;\ L_{mec.} = Fs\cos\alpha;\ P = \frac{L}{t};\ E_c = \frac{m\upsilon^2}{2};\ L_{12} = E_{c2} - E_{c1};\ E_p = mgh;\ E_p = \frac{kx^2}{2};\ L_{12} = -\left(E_{p2} - E_{p1}\right);$$

$$x = A\sin\left(\omega t + \varphi_0\right);\ T = 2\pi\sqrt{\frac{l}{g}};\ T = 2\pi\sqrt{\frac{m}{k}};\ \lambda = \upsilon T;$$

MOLECULAR PHYSICS AND THERMODYNAMICS

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

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

$$U = \frac{3}{2}\frac{m}{M}RT;\ L = p\Delta V;\ Q = cm\Delta T;\ Q = C_M\nu\Delta T;\ c_p - c_V = \frac{R}{M};\ Q_V = \lambda_V m;\ Q = qm;\ Q = \Delta U + L;\ \eta = \frac{Q_1 - |Q_2|}{Q_1};$$

$$\eta_{\max.} = \frac{T_1 - T_2}{T_1};\ \varphi = \frac{\rho_a}{\rho_s} = \frac{p_a}{p_s};\ \sigma = \frac{F_s}{l};\ h = \frac{4\sigma}{\rho g d};\ \frac{F}{S} = E\frac{\Delta l}{l};\ l = l_0\left(1 + \alpha t\right);$$

ELECTRODYNAMICS

$$F = \frac{k_e}{\varepsilon_r}\frac{|q_1 q_2|}{r^2};\ E = \frac{k_e}{\varepsilon_r}\frac{|q|}{r^2};\ k_e = \frac{1}{4\pi\varepsilon_0};\ \vec{E} = \frac{\vec{F}}{q_0};\ E = \frac{U}{d};\ \varphi = \frac{W}{q_0};\ \varphi = \frac{kq}{r};\ U = \frac{L}{q_0};$$

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

$$I = \frac{\Delta q}{\Delta t};\ I = \frac{U}{R};\ I = \frac{\varepsilon}{R + r};\ I_{s.c.} = \frac{\varepsilon}{r};\ R = \rho\frac{l}{S};\ R_s = \sum_{i=1}^{n} R_i;\ \frac{1}{R_P} = \sum_{i=1}^{n}\frac{1}{R_i};\ L = IUt;\ Q = I^2Rt;\ P = IU;\ \eta = \frac{L_u}{L_t};$$

$$F_m = IBl\sin\alpha;\ F_L = q\upsilon B\sin\alpha;$$

$$\Phi = BS\cos\alpha;\ \varepsilon_i = -\frac{\Delta\Phi}{\Delta t};\ \Phi = Li;\ \varepsilon_{ai} = -L\frac{\Delta i}{\Delta t};\ W_m = \frac{LI^2}{2};\ q = q_m\cos\left(\omega t + \varphi_0\right);\ I = \frac{I_m}{\sqrt{2}};\ U = \frac{U_m}{\sqrt{2}};$$

$$\frac{I_2}{I_1} \approx K = \frac{N_1}{N_2} = \frac{U_1}{U_2};\ X_C = \frac{1}{\omega C};\ X_L = \omega L;\ T = 2\pi\sqrt{LC};$$

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

MODERN PHYSICS

$$\tau = \frac{\tau_0}{\sqrt{1 - \upsilon^2/c^2}};\ l = l_0\sqrt{1 - \upsilon^2/c^2};\ m = \frac{m_0}{\sqrt{1 - \upsilon^2/c^2}};\ \vec{p} = \frac{m_0\vec{\upsilon}}{\sqrt{1 - \upsilon^2/c^2}} = \frac{E}{c^2}\vec{\upsilon};\ E = mc^2;\ E_c = (m - m_0)c^2;$$

$$\varepsilon_{ph} = \frac{hc}{\lambda};\ p_{ph} = \frac{h}{\lambda};\ h\nu = L_e + \frac{m\upsilon_{\max}^2}{2};\ \nu = \frac{c}{\lambda};\ h\nu = E_n - E_m;\ N = N_0 e^{-\lambda t};\ \lambda = \frac{\ln 2}{T_{1/2}};\ N = N_0 2^{-\frac{t}{T_{1/2}}}$$

$${}_Z^AX \to {}_{Z-2}^{A-4}Y + {}_2^4He;\ {}_Z^AX \to {}_{Z+1}^{A}Y + {}_{-1}^{0}e;\ 1\ \mathrm{eV} = 1,60\cdot10^{-19}\ \mathrm{J};\ 1\ \mathrm{u} = 1,66\cdot10^{-27}\ \mathrm{kg}.$$