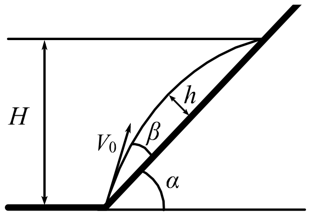
1. A motorboat of mass 150 kg moves in a straight line along the lake with a speed V_0 = 3 m/s. The drag is proportional to the speed of the boat in the form $\vec{F} = -B\vec{V}$, where is B = 7,5 kg/c.

Find the initial acceleration of the boat immediately after turning off the engine if the boat continues straight motion. Give your answer in [m/s^2] to the nearest hundredth.
Find the distance that the boat has traveled by the time the speed is halved if the boat continues straight motion. Give your answer in [m] to the nearest integer.
Find the speed of the boat when it passes one-third of the distance traveled to a complete stop, if the boat continues straight motion. Give your answer in [m/s] up to integers.

2. A shooter standing at the foot of a high mountain with an angle of inclination to the horizon α = 30 degrees shoots from an air rifle at an angle β = 10 degrees to the slope. The initial speed of the bullet V_0 = 100 m/s. Take the acceleration of gravity equal to 10 m/s^2.

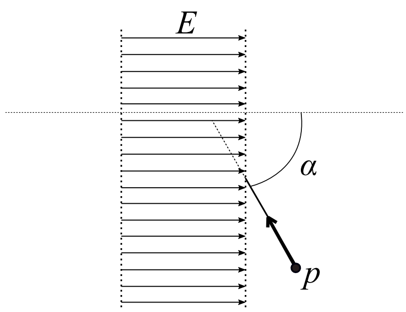


Find the time of the bullet flight before falling on the slope assuming that there is no air resistance. Give your answer in [s] and round it up to integers.
Find the maximum distance from the surface of the slope h, on which the bullet is during flight assuming that there is no air resistance. Give your answer in [m] and round it to integers.
Find the maximum height from the horizontal surface at the foot of Mount H, to which the bullet rises during flight assuming that there is no air resistance. Give your answer in [m] and round it up to integers.

3. 2 moles of an ideal monoatomic gas, with an initial temperature of T_0 = 200K expands in the process where gas pressure directly proportional to its volume. The initial temperature of the gas is T_0 = 200K. Take the universal gas constant equal to 8,31 J/(mol·K).

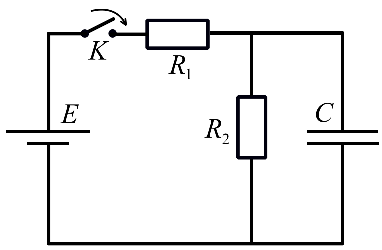
Find the final temperature of the gas if its volume has increased by 1.5 times in this process. Give your answer in [K] up to integers.
Find the work done by the gas if gas volume in this process is increased by 1.5 times. Give your answer in [J] and round it up to integers.
Find the ratio of the molar heat capacity of a monatomic ideal gas in an isochoric process to the molar heat capacity of the gas in this process. Give your answer to the nearest hundredths.

4. A proton moving with a speed of 50 km/s enters a wide region of 1 m depth in which the electric field of 100 V/m magnitude is uniform at an angle of 30 degrees to electric field lines. Take the ratio of the proton charge to its mass equal to 9,6·10^7 Kl/kg and neglect gravity.



Find the minimum proton speed in the region. Give your answer in [km/s] to the nearest integer.
Find the maximum penetration depth for the proton into the region. Give your answer in [cm] and round to tenths.
Find the time interval required proton to travel to the point of its minimum speed in the region. Give your answer in [μs] and round to tenths.

5. In the electrical circuit shown in the figure, all elements are ideal: The EMF is equal to 12 V, the resistors are respectively equal to R_1= 10 ohms and R_2 = 5 ohms. The capacitor capacity is 100 μF.



Find the current through the resistance R_1 immediately after the key is closed. Give your answer in [A] to the nearest tenths.
Find the current through the resistance R_2 at the time when the energy on the capacitor is two times less than the energy of the full charge of the capacitor. Give your answer in [A] and round to tenths.
Find the rate of current change through the resistor R_2 at a time when the energy on the capacitor is two times less than the energy of the full charge. Give your answer in [kA/s] and round to tenths.

Solution of Problem Set No. 1

1. 1.1 $ma = -BV_0;$ $|a| = \frac{BV_0}{m} = \frac{7{,}5\cdot 3}{150} = 0{,}15$ m/s^2.

1.2 $m\frac{\Delta V}{\Delta t} = -B\frac{\Delta x}{\Delta t};$ $m(V_k - V_0) = -Bx;$ $x = \frac{mV_0}{2B} = \frac{150\cdot 3}{2\cdot 7{,}5} = 30$ m.

1.3 $m(V_k - V_0) = -B\frac{mV_0}{3B};$ $V_k = \frac{2}{3}V_0 = \frac{2}{3}\cdot 3 = 2$ m/s.

2. 2.1 $t_F = \frac{2V_0\cdot\sin\beta}{g\cdot\cos\alpha} = \frac{2\cdot 100\cdot\sin 10^0}{10\cdot\cos 30^0} \approx 4$ s.

2.2 $h = y(t_F) = \frac{V_0^2\sin^2\beta}{2g\cos\alpha} = \frac{100^2\cdot sin^2\cdot 10^0}{2\cdot 10\cos 30^0} \approx 17{,}4$ m.

2.3 $V_y(t_F) = V_0\left(\sin(\alpha+\beta) - \frac{2\sin\beta}{\cos\alpha}\right) = 100\left(\sin(30^0+10^0) - \frac{2\cdot\sin 10^0}{\cos 30^0}\right) \approx 24{,}2 > 0 \Rightarrow$

$H = L\cdot\sin\alpha;$

$L = V_0\cdot\cos\beta\cdot t_F - \frac{g\sin\alpha\cdot t_F^2}{2} = 100\cdot\cos 10^0\cdot 4 - \frac{10\sin 30^0\cdot 4^2}{2} = 354{,}7$ m.

$H \approx 177$ m.

3. 3.1 $T_\mathrm{F} = T_\mathrm{I}\left(\frac{V_\mathrm{F}}{V_\mathrm{I}}\right)^2 = 200\cdot 1{,}5^2 = 450$ K

3.2 $A = \frac{\nu R(T_2 - T_1)}{2} = \frac{2\cdot 8{,}31\cdot(450-200)}{2} \approx 2078$ J.

3.3 $C = C_V + \frac{R}{2} = \frac{3}{2}R + \frac{R}{2} = 2R;$ $\frac{C_V}{C} = \frac{\frac{3}{2}R}{2R} = \frac{3}{4} = 0{,}75.$

4. 4.1 $V_{min} = 25$ km/s.

4.2 $h = \frac{V_0^2\cos^2\alpha}{2\gamma E} = \frac{(50000)^2\cos^2(30^0)}{2\cdot 9{,}6\cdot 10^7\cdot 100} \approx 9{,}8$ sm.

4.3 $t = \frac{V_0\cos\alpha}{\gamma E} = \frac{50000\cdot\cos 30^0}{9{,}6\cdot 10^7\cdot 100} \approx 4{,}5$ µs.

5. 5.1 $I_0 = \frac{E}{R_1} = 1{,}2$ A.

5.2 $I_2 = \frac{U'}{R_2} = \frac{1}{\sqrt{2}}\frac{E}{(R_1+R_2)} = \frac{1}{\sqrt{2}}\frac{12}{15} \approx 0{,}6$ A.

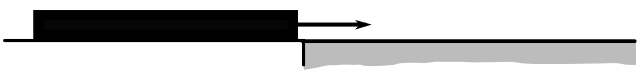
5.3 $I_1R_1 + I_2R_2 = E;$ $\Delta I_1R_1 + I_2R_2 = 0;$

$(I - I_0)R_1 + I_2R_2 = 0 \Rightarrow I = I_0 - I_2\frac{R_2}{R_1} = 1{,}2 - 0{,}6\cdot\frac{5}{10} = 0{,}9$ A;

$\frac{\Delta I_2}{\Delta t} = \frac{I - I_2}{R_2C} = \frac{0{,}9-0{,}6}{5\cdot 100\cdot 10^{-6}} = 600\,\frac{\mathrm{A}}{\mathrm{s}} = 0{,}6\,\frac{\mathrm{kA}}{\mathrm{s}}.$

1. A ball of mass 0.5 kg is dropped from rest at a great height. The drag is proportional to the speed of the boat in the form $\vec{F} = -B\vec{V}$, where is B = 1 kg/s. Take the acceleration of gravity equal to 10 m/s^2.
Find the magnitude of the ball acceleration when the drag force is four times less than gravity. Give your answer in [m/s^2] to the nearest tenths.
Find the ball's terminal speed magnitude. Give your answer in [m/s] up to integers.
Find the ball speed magnitude when its acceleration is four times less than the initial one. Give your answer in [m/s] to the nearest tenths.

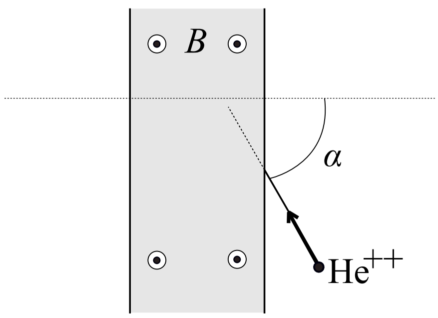
2. A long homogeneous rod of mass 2 kg slides, moving translationally with initial speed of 1 m/s on horizontal frictionless ice surface of the hockey field by inertia beyond the boundary of this field to a rough horizontal surface with a coefficient of friction 0.5 and stops when a third of its length is on this surface.



Find the amount of heat that is released when the rod stops completely. Give your answer in [J] up to integers.
Find the acceleration magnitude of the rod when a quarter of its length on the surface with friction.
Give your answer in [m/s^2] with an accuracy of hundredths.
Find the length of the rod. Give your answer in [m] to the nearest tenths.

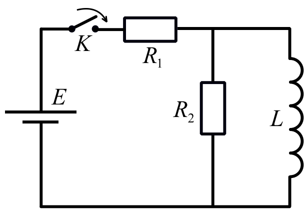
3. A monatomic ideal gas undergoes a process PV^2 = const with a constant heat capacity.
Find the ratio of the final gas pressure to the initial one in the process if the volume is halved. Give your answer to the nearest integers.
Find the ratio of the final gas temperature to the initial one in the process if the volume is halved. Give your answer to the nearest integers.
Find the ratio of the molar heat capacity of a monatomic ideal gas in an isochoric process to the molar heat capacity of the gas in this process. Give your answer to the nearest integers.

4. An alpha particle moving with a speed of 100 km/s enters a wide region of 1 m depth in which the magnetic field of 0.1 mT magnitude is uniform at an angle of 30 degrees, as shown in the figure. The direction of the alpha particle speed is perpendicular to the magnetic field induction lines. Take the ratio of the charge of the alpha particle to its mass equal to 4,8·10^7 Kl/kg and neglect gravity.



Find the speed of the alpha particle when it leaves the region. Give your answer in [km/s] to the nearest integer.
Find the maximum penetration depth for alpha particle into the region. Give your answer in [cm] and round to tenths.
Find the time interval required alpha particle to travel the maximum depth in the region. Give your answer in [µs] and round it up to integers.

5. In the electrical circuit shown in the figure, all elements are ideal: The EMF is equal to 12 V, the resistors are respectively equal to R_1= 10 ohms and R_2 = 5 ohms. The inductance of the coil is 50 mH.



Find the current through the resistor R_2 immediately after the key is closed. Give your answer in [A] to the nearest tenths.
Find the current through the resistance R_2 when the voltage across the coil is half the voltage across the coil immediately after the key is closed. Give your answer in [A] to the nearest tenths.
Find the charge flowed through the resistor R_2 after closing the key until the current through the coil is two times less maximum current. Give your answer in [mC] with an accuracy of integers.

Solution of Problem Set No. 2

1\. 1.1 $a = \frac{3g}{4} = 7{,}5$ m/s^2.

1.2 $V = \frac{mg}{B} = \frac{0{,}5\cdot 10}{1} = 5$ m/s.

1.3 $m\frac{\Delta a}{\Delta t} = -B\frac{\Delta V}{\Delta t}$; $(a_\mathrm{F} - a_\mathrm{I}) = -\frac{B}{m}V_\mathrm{F}$; $\frac{3a_\mathrm{I}}{4} = \frac{B}{m}V$; $V = \frac{3a_\mathrm{I}m}{4B} = \frac{3gm}{gB}$;

$V = \frac{3\cdot 10\cdot 0{,}5}{4\cdot 1} \approx 3{,}8$ m/s.

2\. 2.1 $\frac{mV^2}{2} = Q \Rightarrow Q = \frac{2\cdot 1}{2} = 1$ J.

2.2 $ma = -\mu\frac{m}{4}g$; $|a| = \frac{\mu g}{4} = \frac{5}{4} = 1{,}25$ m/s^2.

2.3 $Q = \frac{\mu mg(L/3)^2}{2L} = \frac{\mu mgL}{18}$; $L = \frac{18Q}{\mu mg} = \frac{18\cdot 1}{0{,}5\cdot 2\cdot 10} = 1{,}8$ N.

3\. 3.1 $\frac{P}{P_0} = \left(\frac{V_0}{V}\right)^2 = 4$.

3.2 $\frac{T}{T_0} = \frac{V_0}{V} = 2$.

3.3 $C = \frac{1}{2}R$; $\frac{C_V}{C} = 3$.

4\. 4.1 100 km/s.

4.2 $h = R(1-\sin\alpha) = \frac{mV}{qB}(1-\sin\alpha)$;

$h = \frac{V}{\gamma B}(1-\sin\alpha) = \frac{100\cdot 10^3}{4{,}8\cdot 10^7\cdot 0{,}1\cdot 10^{-3}}\cdot 0{,}5 = 10{,}4$ m.

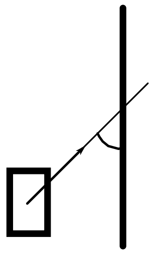
4.3 $t = \frac{R\left(\frac{\pi}{2}-\alpha\right)}{V} = \frac{mV}{qB}\frac{\left(\frac{\pi}{2}-\alpha\right)}{V}$; $t = \frac{1}{\gamma B}\left(\frac{\pi}{2}-\alpha\right) = \frac{\pi/3}{4{,}8\cdot 10^7\cdot 0{,}1\cdot 10^{-3}}$; $t \approx 218$ µs.

5\. 5.1 $I_0 = \frac{E}{R_1+R_2} = \frac{12}{15} = 0{,}8$ A.

5.2 $U_2 = \frac{1}{2}\frac{E}{(R_1+R_2)}R_2$; $I = \frac{E}{2(R_1+R_2)} = 0{,}4$ A.

5.3 $L\frac{\Delta I}{\Delta t} = IR_2$; $L\frac{\Delta I}{\Delta t} = \frac{\Delta q}{\Delta t}R_2$; $\Delta q = \frac{LI}{R_2} = \frac{LE}{2R_1R_2} = \frac{50\cdot 10^{-3}\cdot 12}{2\cdot 10\cdot 5} = 6$ mC

1. A bar of mass 2 kg slides translationally on the frictionless horizontal ice surface of a hockey field with a speed of $V = 0{,}5$ m/s and collides with a vertical wall with a coefficient of friction of 0.5 at an angle of 60 degrees to the wall so that one of its facets is parallel to the wall. Consider that the component of the bar speed perpendicular to the wall does not change in magnitude because of the collision.



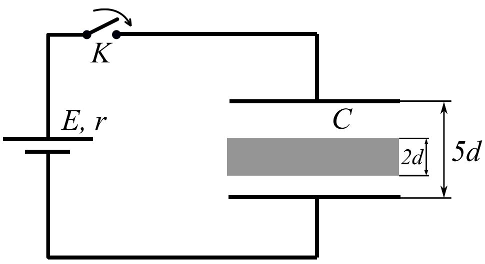
Find the magnitude of component of bar momentum perpendicular to the wall after the collision. Give your answer in [kg·m/s] and round to hundredths.
Find the magnitude of component of bar momentum parallel to the wall after the collision. Give your answer in [kg·m/s] to the nearest tenths.
Find the amount of heat released during the collision. Give your answer in [mJ] and round to hundredths.

2. A small bar is hanging on a long massless spring of constant k = 100 N/m. The change in spring length at equilibrium position is x = 1 cm in comparison to unloaded spring. Take the acceleration of gravity equal to 10 m/s^2.
Find the mass of the bar. Give your answer in [kg] to the nearest tenths.
Find the minimum work needed to enlarge spring length triple from the equilibrium position applying vertical force to the bar. Give your answer in [mJ] up to integers.
Find the bar speed when it passes the equilibrium position if it is released from a position in which spring length triple enlarged in comparison with the equilibrium position. Give your answer in [m/s] and round to tenths.

3. A horizontally positioned sealed cylindric vessel is divided into two parts by a movable piston that can move along the cylinder with no friction. There are two moles of helium in one part of the vessel, and a vacuum in the other. The piston is connected to the vertical wall of the vessel by an elastic massless spring, which is in the vacuumed part of vessel. The spring is selected so if it is undeformed than the piston is located at the opposite wall of the vessel. The gas temperature in the cylinder is slowly increased so that the helium volume increases by 1.1 times.
Find the ratio of the final helium pressure to the initial helium pressure in this process. Give your answer to the nearest tenths.
Find the ratio of the final helium temperature to the initial helium temperature in this process. Give your answer to the nearest hundredths.
Find the ratio of the molar heat capacity of helium in an isochoric process to the molar heat capacity of helium in this process. Give your answer to the nearest hundredths.

4. A conducting sphere of radius R with a charge of $2Q$ is surrounded by a concentric uncharged conducting sphere of radius $4R$.
Find the ratio of the magnitude of the electric field at $3R$ to the magnitude of the electric field at $6R$ from the center of spheres. Give your answer to the nearest integers.
Find the ratio of the electrostatic potential of the center of spheres to the electrostatic potential of a point located at $5R$ from the center of spheres, considering the electrostatic potential at infinity equal to zero. Give your answer to the nearest integers.
Find the ratio of the electrostatic potential of the center of spheres to the electrostatic potential of a point located at $5R$ from the center of spheres, after the closure and subsequent disconnection both spheres to each other by the conductor, considering the electrostatic potential at infinity equal to zero. Give your answer to the nearest hundredths.

5. A solid metal plate is inserted into a flat capacitor parallel to its plates. The area of each capacitor plate and each of the two largest sides of the plate is equal to S = 3 m^2. The thickness of the plate is $2d$, the distance between capacitor plates is $5d$, d = 1 mm. EMF is E = 100 V. Take the electrical constant equal to $8{,}85 \cdot 10^{-12}$ F/m.



Find the capacitance of the capacitor. Give your answer in [nF] with an accuracy of hundredths.
Find the amount of charge on the capacitor plates after a long time after the key is closed. Give your answer in [nCl] up to integers.
Find the heat released across the circuit after the key is closed until the voltage across the capacitor is two times less than the maximum. Give your answer in [μJ] to the nearest tenths.

Solution of Problem Set No. 3

1. 1.1 $p = mV \cdot \sin\alpha = 2 \cdot 0{,}5 \cdot \frac{\sqrt{3}}{2} \approx 0{,}87$ kg·m/s.

   1.2 $P_y = 0$ kg·m/s.

   1.3 $Q = \frac{\Delta P_y^2}{2m} = \frac{0{,}5^2}{2\cdot 2} = \frac{0{,}25}{4} = 0{,}0625$ J, $Q = 6{,}25$ mJ.

2. 2.1 $mg = kx$; $m = \frac{kx}{g} = \frac{100\cdot 0{,}01}{10} = 0{,}1$ kg.

   2.2 $A = 2kx^2 = 2 \cdot 100 \cdot 0{,}01^2 = 0{,}02$ J = 20 mJ.

   2.3 $\frac{kx^2}{2} + \frac{mV^2}{2} = \frac{k(3x)^2}{2} - mg \cdot 2x$;

   $V = \sqrt{\frac{8kx^2}{m} - 4gx} = \sqrt{\frac{8\cdot 100\cdot 0{,}01^2}{0{,}1} - 4 \cdot 10 \cdot 0{,}01} \approx 0{,}6$ m/s.

3. 3.1 $P = \alpha V$; $\frac{P_k}{P_N} = \frac{V_k}{V_N} = 1{,}1.$

   3.2 $PV = \alpha V^2$; $\nu RT = \alpha V^2$; $\frac{T_k}{T_N} = \left(\frac{V_k}{V_N}\right)^2 = 1{,}1^2 = 1{,}21.$

   3.3 $C = 2R$; $\frac{C_V}{C} = \frac{3}{2}\frac{R}{2R} = 0{,}75.$

4. 4.1 $\alpha = \frac{6^2}{3^2} = \frac{36}{9} = 4.$

   4.2 $\beta = \frac{5R}{R} = 5.$

   4.3 $\gamma = \frac{5R}{4R} = 1{,}25.$

5. 5.1 $C = \frac{\varepsilon_0 S}{3d} = \frac{8{,}85\cdot 10^{-12}\cdot 3}{3\cdot 1\cdot 10^{-3}} = 8{,}85 \cdot 10^{-9} = 8{,}85$ nF.

   5.2 $q = CE = 8{,}85 \cdot 100 = 885$ nC.

   5.3 $q = C\frac{E}{2}$; $A_{\text{EMF}} = qE = \frac{CE^2}{2}$; $A_{\text{EMF}} = Q + \frac{C\left(E/2\right)^2}{2}$;

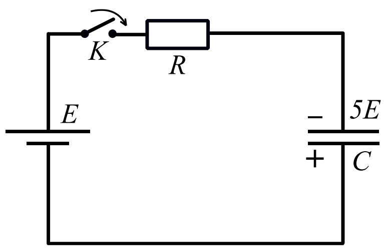
   $Q = \frac{CE^2}{2} - \frac{CE^2}{8} = \frac{3}{8}CE^2 = \frac{3}{8} \cdot 8{,}85 \cdot 10^{-9} \cdot 100^2 \approx 33{,}2 \cdot 10^{-6}$ J = 33,2 μJ.

1. At the ends of a massless rod with a length of l = 1 m identical balls with a mass of m = 500 g are fixed. The rod is placed almost vertically (the angle of deviation of the rod from the vertical is much less than 1 degree) on a frictionless horizontal surface and released from the rest. Take the acceleration of gravity equal to 10 m/s^2.
Find the absolute value of lower ball displacement from initial point when the rod takes a horizontal position. Give your answer in meters with an accuracy of tenths.
Find the speed of the lower ball when the upper ball collides the horizontal surface. Give your answer in [m/s] up to integers.
Find the speed of the upper ball when it collides the horizontal surface. Give your answer in [m/s] and round to integers.

2. A long homogeneous bar with a length of L = 1 m and a mass of M = 2 kg lies on a horizontal surface with a coefficient of friction of 0.1. Take the acceleration of gravity equal to 10 m/s^2.
Find the minimal force needed to lift the bar by one of its ends. Give your answer in Newtons and round it up to integers.
Find the speed of the bar 8 seconds after a horizontal time dependent force $F=\alpha t$ (where α = 1 N/s) was applied to the bar, the line of action of which passes through the center of mass of the bar. Give your answer in [m/s] up to integers.
Find the minimal work needed to rotate the bar in a horizontal plane relative to its center of mass at an angle of 30 degrees by applying a horizontal force to one of the ends of the bar, having previously fixed the bar with a vertical frictionless rod to the horizontal surface passing through the center of mass of the bar so that the bar can rotate around this rod. Give your answer in [J] with an accuracy of hundredths.

3. A vertical sealed heat-conducting cylindrical vessel is divided into two parts by a piston of mass 20 kg, which can move along the axis of the cylindrical surfaces of the vessel without friction. The radius of the inner cylindrical surface of the vessel is 5 cm. There is 0.1 mol of helium in the lower part of the vessel, and 0.2 mol of saturated water vapor in the upper part. The contents of the vessel are maintained at a temperature of 100 C. Take atmospheric pressure equal to 10^5 Pa. Take the acceleration of gravity equal to 10 m/s^2. Take the molar mass of water equal to 18 g/mol.
Find the difference between the initial pressure of saturated water vapor and the initial pressure of helium. Give your answer in [kPa] and round it to integers.
Find the pressure of helium if the vessel is upending so that the part filled with helium is at the top. Give your answer in [kPa] and round it to integers.
Find the mass of condensed vapor after the vessel is upending. Give your answer in [g] and round to hundredths.

4. Two conducting spheres of radius R and 3R with charges 2Q and 3Q respectively, are located at a large (r>>R) distance from each other.
Find the ratio of the electrostatic potential of the sphere of radius R to the electrostatic potential of a sphere of radius 3R, considering the electrostatic potential at infinity equal to zero. Give your answer to the nearest integers.
Find the ratio of the overflowed charge from R sphere to 3R to the initial charge of a sphere of radius R, after the closure and subsequent disconnection of spheres by a conductor with low resistance, considering the electrostatic potential at infinity equal to zero. Round your answer to hundredths. During the time of connection, the stationary distribution of charges is established.
Find the ratio of the current immediately after the closure of the spheres by a conductor with a low resistance to the current, at the time when the charge on the sphere of radius R decreased by half the value of the overflowed charge. Give your answer to the nearest integers.



5. A capacitor with a capacity of C = 100 μF, charged to a voltage of 5E, is connected to a battery with EMF E (see Fig.). EMF is E = 12 V. Resistance is R = 30 ohms. Neglect the internal resistance of the battery.
Find the current in the circuit immediately after the key is closed. Give your answer in [A] to the nearest tenths.
Find the heat released across the circuit after a long time after closing the key. Give your answer in [J] and round to hundredths.
Find the value of the rate of current change in the circuit immediately after the key is closed. Give your answer in [kA/s] with an accuracy of tenths.

Solution of Problem Set No. 4

1. 1.1 S = 0,5 m.

 1.2 $V = 0$.

 1.3 $\frac{mV^2}{2} = mgh$; $V = \sqrt{2gh} = \sqrt{2gl} = \sqrt{2 \cdot 10 \cdot 1} \approx 4{,}5$ m/s.

2. 2.1 $F = \frac{Mg}{2} = 10$ N.

 2.2 $V = \frac{\alpha t^2}{2M} - \mu g t = \frac{1 \cdot 8^2}{2 \cdot 2} - 0{,}1 \cdot 10 \cdot 8 = 8$ m/s.

 2.3 $A = \mu g \beta \frac{ML}{4} \approx 0{,}1 \cdot 10 \cdot 0{,}524 \cdot \frac{2 \cdot 1}{4} \approx 0{,}26$ J.

3. 3.1 $\Delta P = \frac{Mg}{S} = \frac{20 \cdot 10}{\pi \cdot 0{,}05^2} \approx 25$ kPa.

 3.2 $P = P_0 - \frac{Mg}{S} \approx 75$ kPa.

 3.3 $\Delta m = m_0 - m = \frac{\mu P_0}{RT} \Delta V_V$; $\Delta V_V = \Delta V_{He}$;

 $\Delta V_{He} = \frac{\nu_{He} RT}{P} - \frac{\nu_{He} RT}{P_{He}} = \nu_{He} RT \left(\frac{P_{He} - P}{P_{He} P} \right)$;

 $\Delta m = \mu P_0 \nu_{He} \left(\frac{P_{He} - P}{P_{He} P} \right) \approx 18 \cdot 10^{-3} \cdot 10^5 \cdot 0{,}1 \left(\frac{125 - 75}{125 \cdot 75} \right) \approx 0{,}98$ g.

4. 4.1 $\alpha = \frac{2Q}{R} \frac{3R}{3Q} = 2$.

 4.2 $\varphi_1' = \varphi_2'$; $k \frac{Q_1'}{R} = k \frac{Q_2'}{3R}$; $Q_1' = \frac{Q_2'}{3}$; $Q_1' + Q_2' = 2Q + 3Q = 5Q$;

 $\frac{Q_2'}{3} + Q_2' = 5Q \Rightarrow Q_2' = \frac{15}{4} Q$; $Q_1' = \frac{5}{4} Q$;

 Overflowed charge $\Delta q = 2Q - \frac{5}{4} Q = \frac{3}{4} Q$; $\frac{\Delta q}{2Q} = \frac{3Q}{8Q} = \frac{3}{8} = 0{,}375 \approx 0{,}38$.

 4.3 current immediately after the closure:

 $I = \frac{\Delta \varphi}{r} = \frac{1}{r} \left(k \frac{2Q}{R} - k \frac{3Q}{3R} \right) = k \frac{Q}{rR}$

 A half of overflowed charge $\frac{3}{8} Q$.

 $Q_1' = 2Q - \frac{3}{8} Q = \frac{13}{8} Q$; $Q_2' = 3Q + \frac{3}{8} Q = \frac{27}{8} Q$;

 $\varphi_1' = k \frac{13Q}{8R}$; $\varphi_2' = k \frac{27Q}{3 \cdot 8R} = k \frac{9Q}{8R}$; $I' = \frac{\Delta \varphi'}{r} = \frac{1}{r} \left(k \frac{13Q}{8R} - k \frac{9Q}{8R} \right) = k \frac{Q}{2Rr}$; $\frac{I}{I'} = 2$.

5. 5.1 $I = \frac{6E}{R} = \frac{6 \cdot 12}{30} = 2{,}4$ A.

 5.2 $A_{EMF} + W_0 = Q + W$; $Q = A_{EMF} + W_0 - W$;

 $Q = 6CE^2 + \frac{C(5E)^2}{2} - \frac{CE^2}{2} = 6CE^2 + \frac{25CE^2}{2} - \frac{CE^2}{2} = 18CE^2 = 18 \cdot 100 \cdot 10^{-6} \cdot 12^2 \approx 0{,}26$ J.

 5.3 $\left| \frac{\Delta I}{\Delta t} \right| = \frac{I}{RC} = \frac{2{,}4}{30 \cdot 100 \cdot 10^{-6}} = 800 = 0{,}8$ kA/s.