

Physics Exam
for Entrance to the MIPT Bachelor's Degree Program

Summer 2020

Test #1

You are expected to complete a distance assignment of ten single-operation tasks. Each answer should be given as a number in SI units unless otherwise requested. A numerical answer is considered correct if it differs from the official answer by no more than 10%. You may use a calculator. You will be allowed to access the next test only if at least half of the tasks in this test have been correctly solved.

1. A metal ball falls without initial speed. How long does it take for the ball to travel the path of 45 m? Neglect air resistance. Acceleration of free fall is equal to 10 m/s^2 .
2. When weighing a puck on a spring scale on the Moon, the spring scale shows weight of 1 N. Find the mass of this puck when it is weighing on Earth. Free fall acceleration on the Moon is 6 times less than on Earth.
3. The kinetic energy of a translationally moving ball of 0.1 kg mass is equal to 20 J. Find the translational momentum of the ball.
4. The volume of a certain amount of an ideal gas increases by 2 times, and the temperature (on the Kelvin scale) decreases by 1.5 times. How many times has the gas pressure decreases?
5. Small balls with charges q_1 , q_2 and $q_3 = 2 \cdot 10^{-8} \text{ Cl}$ are in the three vertices of the square. A ball with a charge q_3 is acted upon by a force of $50 \mu\text{N}$ from other balls. Find the magnitude of the electric field strength, created by the balls with charges q_1 and q_2 at the location of the ball with a charge q_3 .
6. A $20 \mu\text{F}$ capacitor has a charge of $500 \mu\text{C}$. Find the voltage across the capacitor.
7. Three resistors with a resistance of 12 ohms each are connected in parallel and connected to a battery with an EMF of 12 V and an internal resistance of 2 ohms. Find the current through the battery.
8. A proton moves perpendicular to the lines of force of a uniform magnetic field with an induction of 0.5 T. A force of $6,4 \cdot 10^{-14} \text{ N}$ acts on the proton. The proton charge module is $1,6 \cdot 10^{-19} \text{ Cl}$. Find the speed of the proton. Give your answer in kilometers per second (km / s).
9. A ray of light falls from air onto a glass plate with a refractive index of 1.6. The angle of refraction is 30 degrees. Find the value of the sine of the angle of incidence.
10. The red border of the photoelectric effect for a metal is 275 nm. Find the binding energy of the metal. Give your answer in electron volts (eV). Planck's constant is $6,6 \cdot 10^{-34} \text{ J}\cdot\text{s}$. The speed of light in a vacuum is $3 \cdot 10^8 \text{ m / s}$. $1 \text{ eV} = 1,6 \cdot 10^{-19} \text{ J}$.

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Test #2

You are expected to complete a distance assignment of 10 tasks each requiring 2-3 operations. Each answer should be given as a number in SI units unless otherwise requested. A numerical answer is considered correct if it differs from the official answer by no more than 10%. You may use a calculator. You will be allowed to access the next test only if at least half of the tasks in this test have been correctly solved.

1. An aluminum ball placed to the bottom of a vessel filled with water. The ball is completely submerged in the water. The volume of the ball is 27 cm^3 . The density of water is 1 g / cm^3 . The density of aluminum is 2.7 g / cm^3 . Find the magnitude of the force exerted on the bottom by the ball. Acceleration of free fall is equal to 10 m/s^2 .

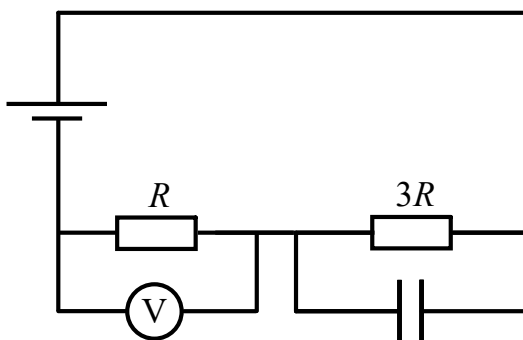
2. A small puck of mass 100 g slides off the top of the fixed frictionless hemisphere without initial speed. Find the magnitude of the force exerted on the hemisphere by the puck at the moment of time when the line drawn from the center of the spherical surface of the hemisphere to the puck makes an angle with the vertical $\alpha \left(\cos \alpha = \frac{3}{4} \right)$. Acceleration of free fall is equal to 10 m/s^2 .

3. A dog with a mass of m sits on a cart with a mass of 4 m . The cart moves along a horizontal road at a speed of V . The dog jumps off the cart in the direction of the cart moves and gets a horizontal speed of $11V / 3$ relative to the road. How many times has the total kinetic energy of the dog-cart system increased as a result of the dog jump? The wheels of the cart are considered light.

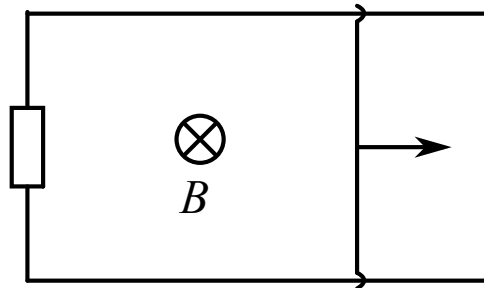
4. In isobaric heating of hydrogen from 20° C to 50° C , work done by gas is 2 kJ . Find the mass of hydrogen. Consider hydrogen as an ideal gas with a molar mass of 2 g / mol . Give your answer in grams (g).

5. The relative humidity of the air inside the cylinder under the piston is 40% . The air is isothermally compressed, its volume decreased by 1.5 times. Find the relative humidity after compressing. Give your answer as a percentage.

6. In the circuit shown in the figure, an ideal voltmeter reads 6 V . Find the voltage across the capacitor.



7. A conductive jumper is moved along two parallel metal guides at a speed of 1 m/s . The guides are connected with a 10 ohm resistor as shown in the figure. The distance between the guides is 10 cm . The circuit is in a uniform magnetic field with an induction of 0.3 T , directed perpendicular to the plane of the circuit. Find the current in the resistor. Neglect guides and jumper resistance. Give your answer in milliamperes (mA).



8. An object suspended from an elastic spring vibrates along the vertical with an amplitude of 8 cm , having a maximum speed of 1 m/s . Find the oscillation period of the object.

9. Using a converging lens with a focal length of 20 cm , an image of a pencil is obtained on the screen, located at 60 cm from the lens perpendicular to the main optical axis of the lens. How many times is the pencil image smaller than the pencil itself?

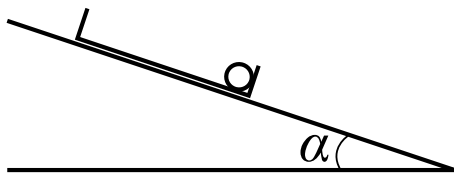
10. Find the fraction of the atoms of a radioactive element decay in a time equal to two half-lives.

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Test #3

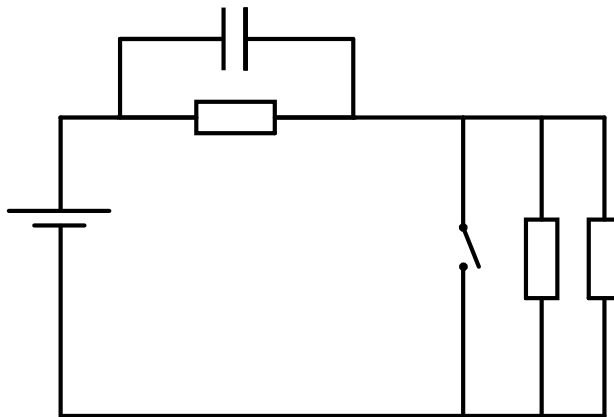
You are expected to complete a distance assignment of five tasks. It is necessary to provide not only an answer, but also a detailed solution. You may use a calculator.

1. A rectangular box with a ball is held on a rough inclined plane with an angle of inclination to the horizon as shown in the figure. The box is released and together with the ball it slides with acceleration. Ball mass is 3 kg. Find the magnitude of the force exerted on the front (right) wall of the box by the ball when sliding the box. Acceleration of free fall is equal to 10 m/s^2 .

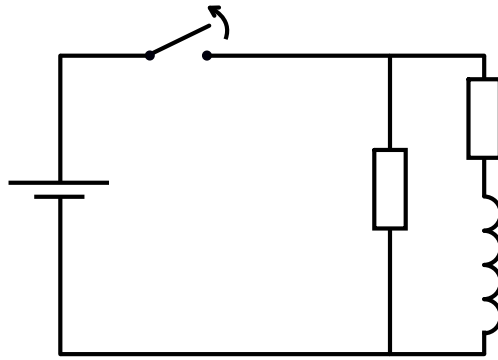


2. A thermally insulated vessel contains a monoatomic ideal gas in an amount of 3 mol at a temperature of 300 K and a pressure of 100 kPa. Find the gas pressure after switching on for 120 s a 25 W electric heater placed in the vessel. Give your answer in kilopascals (kPa).

3. Find the ration between stored charge in the capacitor after the switch is closed to stored charge in the capacitor before the switch is closed in the circuit shown in the figure. All resistors have the same value. Consider the current source as ideal.



4. In the circuit shown in the figure, the switch is closed, and equilibrium is established. EMF of an ideal current source is 24 V, the resistance of each resistor is 12 Ohm, the inductance of an ideal coil is 20 mH. Find heat produced across the circuit on opening the switch?



5. A small object is located at some distance from the main optical axis of a thin converging lens with a focal length of 25 cm at a distance of 35 cm from the lens. An image of the object is obtained on the screen. Find the distance that the lens is moved in the plane perpendicular to the main optical axis, if the image is displaced by 7 cm when the object and the screen are stationary? Give your answer in centimeters.