Physics Entrance Exam

Part I. – Solving exercises or problems:

1.) Two small size balls are falling off in free fall as Figure 1. shows it. Initial heights of $h = 30\ m$ and masses of the balls are the same in both cases. Balls start their movement at the same time moment. Left-side ball collides with a slope surface at its half route between the initial height and the ground surface (see in Figure 1.). The collision is completely elastic collision. Angle of the slope surface to the horizontal line is $45°$. After the collision, the ball continues its route to the ground surface. Right-hand ball is falling off in free fall without any collision. It finishes its movement at the ground surface.

   a. Please, determine – or in other words – calculate the sum (or net) falling off times for the left-side and the right-side balls!
   b. Whether left-side or right-side ball reaches the ground surface earlier?

   Acceleration of gravity is: $g = 10\frac{m}{s^2}$.

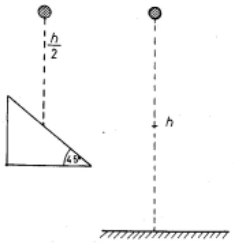

Figure 1. (Belongs to problem 1.)

2.) A sandbag full of sand is hanging on the plafond on a rope as it is shown in Figure 2. Mass of the sandbag is $M = 3\ kg$. During the experiment a bullet is penetrating the sandbag. Direction of the flying velocity of the bullet is horizontal. Mass of the bullet is $m = 5\ g$. The bullet is decelerated and finally it stops itself inside the sandbag. During the interaction between the bullet and the sandbag the bag is swinging out from the equilibrium position, and the center of mass of the sandbag is lifting with $5\ cm$. Length of the rope is $1\ m$. What was the value of the velocity (speed) of the bullet before it penetrated the sandbag? Acceleration of gravity is: $g = 10\frac{m}{s^2}$.

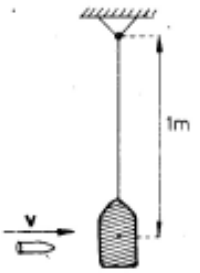

Figure 2. (Belongs to problem 2.)

3.) A U-shape tube is given as it is shown in Figure 3. Firstly, we pour Mercury (Hg) into the tube. As next step, we pour alcohol into one of the stem of the U-shape tube to the top of the Mercury level. Height of the alcohol column is $25\ cm$ measured from the top of Mercury level (surface) to the top level (surface) of alcohol column. Into the other stem of the U-shape tube water was poured. The top surfaces of the water column and the alcohol column are set in the same height (see it in Figure 3.). Mass density of the water is: $1000\ \frac{kg}{m^3}$, mass density of the Mercury is $13600\ \frac{kg}{m^3}$, and the mass density of the alcohol is $700\ \frac{kg}{m^3}$. Acceleration of gravity is: $g = 10\frac{m}{s^2}$.

a. If you look at in Figure 3, please, answer the question: In what stem of the U-shape is filled with alcohol? On the left-side or on the right-side of the U-shape tube?
b. What is the distance between the two Mercury levels? (What is x in the Figure 3?)

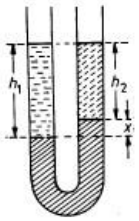

Figure 3. (Belongs to problem 3.)

4.) We warm up a piece of Aluminum bulk with mass of $2\ kg$ during $5\ minutes$ from 20 ℃ to 70 ℃ on the top of an electric hot plate.

a. What is the efficient power ("useful" power)?
b. What is the efficiency of the warming, if the power of the electric hot plate is $500\ W$?

Specific heat of the Aluminum is $c_{Al} = 900\frac{J}{kg \cdot K}$.

5.) A battery with $U_0 = 10\ V$ of electromotive force (inner voltage of the battery) and with $R_{in} = 0.5\ \Omega$ of inner resistance is placed in an electric circuit as it is shown in Figure 4. Value of the outer resistance is $R_{out} = 2\ \Omega$, and the value of the capacitor is $C = 0.5\ \mu F$.

a. What is the voltage between the capacitor plates?
b. What is the charge on the capacitor?

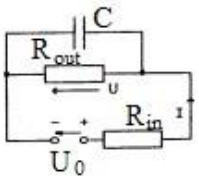

Figure 4. (Belongs to problem 5.)

Part II. – Simple choice test:

1.) What is the correct sentence?
   a. $13600\ \frac{kg}{m^3} = 1360\ \frac{kg}{dm^3}$.
   b. $13600\ \frac{kg}{m^3} = 13.6\ \frac{g}{cm^3}$.
   c. $2.7\ \frac{g}{cm^3} = 27\ \frac{kg}{m^3}$.
   d. $1\ \frac{g}{cm^3} = 1000\ \frac{kg}{dm^3}$.

2.) Temperature of $2\ kg$ of alcohol has been increased from $10\ ℃$ to $50\ ℃$. What is the change of energy of the alcohol if the specific heat of the alcohol is $c_{alcohol} = 2.4\ \frac{kJ}{kg \cdot ℃}$?
   a. $192\ kJ$.
   b. $19.2\ kJ$.
   c. $1920\ J$.
   d. $19200\ J$.

   Please, choose the correct answer!

3.) Please, see Figure 5! In case of $m_1 = m_2 = m$, what is the acceleration of the system, if we leave the whole system alone. Acceleration of gravity is: g.
   a. $\sqrt{\frac{g}{2}}$.
   b. $\frac{g}{2}$.
   c. zero
   d. $g \cdot \sqrt{2}$.
   e. $\frac{g}{\sqrt{2}}$.

   Please, choose the correct answer!

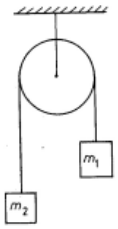

Figure 5. (Belongs to Test # 3., Part II.)

4.) Length of a mathematical pendulum is $L = 0.5\ m$. Initial position of the pendulum is shown in Figure 6 with dashed line (so the pendulum stays in horizontal position). We let off the pendulum now. What is the speed of the mass object (mass of it is: m) at the end of the pendulum, while it moves through its equilibrium position? (Drag of air can be neglected.) Acceleration of gravity is: g.

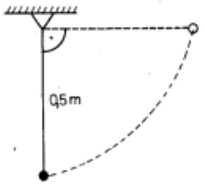

Figure 6. (Belongs to Problem #4., Part II.)

a. $v = \sqrt{0.5 \cdot m \cdot g}$.
b. $v = \sqrt{1 \cdot m \cdot g}$.
c. $v = \sqrt{1.5 \cdot m \cdot g}$.
d. $v = \sqrt{2 \cdot m \cdot g}$
e. $v = \sqrt{3 \cdot m \cdot g}$.

Meaning of m is: $meter$. Please, choose the correct answer!

5.) All drawings in Figure 7. shows scattering of alpha particles (alpha particle is: nucleus of Helium atom) on Gold atoms. Alpha particles have same energies. What is the correct drawing? Please, choose the correct answer!

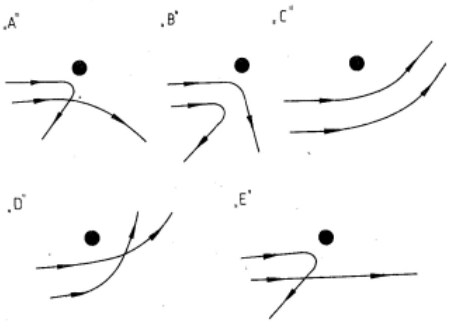

Figure 7. (Belongs to Problem #5., Part II.)

a. Only drawing “A” is the correct.
b. Only drawing “B” is the correct.
c. Only drawing “C” is the correct.
d. Only drawing “D” is the correct.
e. Only drawing “E” is the correct.
f. Drawing “A” and “B” are correct.
g. Drawing “C” and “D” are correct.

6.) Figure 8 shows acceleration versus time diagrams of different movements. What diagram can describe acceleration-time diagram of a harmonic oscillation of a mass object? Please, choose the correct answer!

a. Diagram a.) and b.).
b. Diagram c.) and d.).
c. Diagram b.) and c.).
d. Diagram a.) and d.).

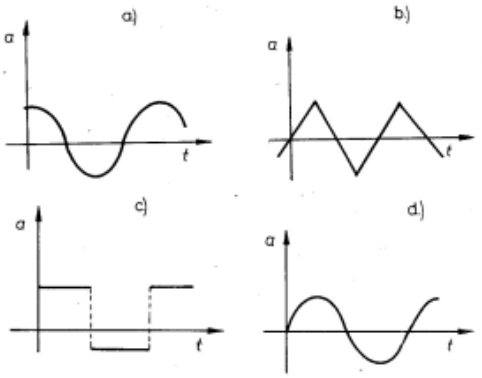

Figure 8. (Belongs to Problem #6., Part II.)

7.) Two objects are hanging on the two-arm scale as Figure 9. shows it. The scale is covered by an air tight glass cover. The two-arm scale with the objects shows equilibrium under air (see Figure 9.). We know that object "A" is a wooden sphere and object "K" is a metal cylinder. What will happen, if we pump down the air from the glass cover and the two-arm scale will stay under vacuum condition?

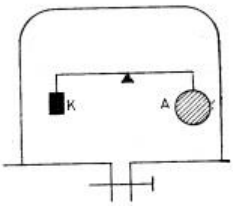

Figure 9. (Belongs to Problem #7., Part II.)

a. The wooden sphere will move downward.
b. The metal cylinder will more downward.
c. The equilibrium position will remain, or in other words none of the objects will move.

Please, choose the correct answer!

8.) A scientific expedition landed with a spacecraft on the surface of the Moon. Members of the expedition team take space-walking on the surface of the Moon and they want to communicate with each other. How does the communication work?

a. They can communicate only with sound signals, where the sound is generated on the surface of the Moon.
b. They can communicate with sound and light signals, where the sound is generated on the surface of Moon.
c. They can communicate only with light signals.
d. Neither sound signals nor light signal will work for communication.

Please, choose the correct answer!

9.) Water is filled in a glass measuring cylinder. We decant the water into another plastic cylinder, which has greater diameter then the first one (glass cylinder) has. How does the hydrostatic pressure at the bottom of the new plastic measuring cylinder change?
   a. The answer cannot be said, because the given data are not enough to answer the question.
   b. The hydrostatic pressure does not change, because the amount of the water is the same.
   c. The hydrostatic pressure has been increased.
   d. The hydrostatic pressure has been decreased.

10.) Please, consider in the previous test question (in test #9) described problem. Now the question is: How does the force acting on the bottom of the plastic measuring cylinder change? Please, choose the correct answer!
   a. The mentioned force does not change.
   b. The mentioned force is increasing.
   c. The mentioned force is decreasing.
   d. The answer cannot be said, because the given data are not enough to answer the question.

11.) What is the correct sentence? Please, choose the correct answer!
   a. We necessarily need to use direct electric current in case of using electric heater.
   b. We necessarily need to use direct electric current in case of electrolysis.
   c. We necessarily need to use direct electric current in case of using electric bell.
   d. We necessarily need to use direct electric current in case of electric cooling.

12.) Is it possible to build airship (balloon), that we use only air as working gas to fill up the balloon?
   a. Not, it is not possible.
   b. Yes, if we open the valve and deflate the balloon. (Decreasing the amount of air in the balloon.)
   c. Yes, it is possible, for example with heating or warming up the air as working gas.
   d. Balloon can be built only using Helium as working gas.

   Please, choose the correct answer!

13.) Two electric conductors (electric wires) with same material are given. Length of the first conductor (first wire) is $L_1 = 10\ m$ and the cross section of it is $A_1 = 1\ mm^2$. Length of the second conductor (second wire) is $L_2 = 20\ m$ and the cross section of it is $A_2 = 2\ mm^2$. What wire has higher electric resistance?
   a. The given data are not enough to say the answer correctly. Giving of more data are needed to answer the question correctly.
   b. The first wire has higher resistance.
   c. The second wire has higher resistance.
   d. The first and the second wire has the same electric resistance.

   Please, choose the correct answer!

14.) What is the order of magnitude of the size of an atomic nucleus?

a. $\sim 10^{-8}\, m.$
b. $\sim 10^{-10}\, m.$
c. $\sim 10^{-14}\, m.$
d. $\sim 10^{-15}\, m.$

Please, choose the correct answer!

15.) What is the approximate wavelength of a green color light wave?

a. Approximate wavelength of a green color light wave is: $\lambda \approx 550\ micrometer.$
b. Approximate wavelength of a green color light wave is: $\lambda \approx 550\ nanometer.$
c. Approximate wavelength of a green color light wave is: $\lambda \approx 550\ picometer.$
d. Approximate wavelength of a green color light wave is: $\lambda \approx 550\ femtometer.$

Please, choose the correct answer!