# The Open University of Sri Lanka
## B.Sc. Degree Programme - Level 03
## Final Examination - 2006/2007
## Physics for Biology Students - PSU 1244 / PSE 1244

**Duration: Three Hours (3 Hrs.)**

**Date:- 27.11.2006** **Time :- 09.30 a.m. to 12.30 p.m.**

**Answer <u>SIX</u> Questions ONLY.**

1. (a) (i) Define linear momentum.
   (ii) State the principle of conservation of linear momentum.
   (iii) How is linear momentum related to force?

   (b) A truck of mass 6000 kg traveling at high speed collides with a stationary car of mass 1200 kg. The two vehicles lock together on impact and slide a distance of 100 m before coming to rest. Assuming frictional force in the slide as 0.20 × total weight of the vehicles, calculate,
   (i) the deceleration of the two vehicles after the impact.
   (ii) the speed of the two vehicles immediately after the impact.
   (iii) the speed of the 6000 kg truck just before the impact.

2. (a) State and discuss the Fourier's law of heat conduction.

   (b) Show that in the case of heating a solid sphere, which is immersed in a liquid, the Fourier's law could be simplified to a form $J = \kappa \Delta T / R$, where $J$ is heat flow per unit area, $\Delta T$ is the temperature difference between the outer surface and centre of the sphere, $\kappa$ is the thermal conductivity of the material and $R$ is the radius of the sphere.

   (c) An egg, assumed to be spherical in shape, taken directly from the fridge at temperature $T_0 = 4$°C, is transferred into a pot with water that is kept boiling at temperature $T_1$.
   (i) Find the amount of energy $U$ that is needed to get the egg coagulated?
   (ii) Calculate the largest heat flow $J$ that is flowing into the egg?
   (iii) Find the largest heat power $P$ transferred to the egg?
   (iv) For how long do you need to cook the egg so that it is hard-boiled?

Useful Data:

Mass density of the egg: $\mu = 10^3\ \text{kg m}^{-3}$

Specific heat capacity of the egg: $C = 4.2\ \text{J K}^{-1}\ \text{g}^{-1}$

Radius of the egg: $R = 2.5$ cm

Coagulation temperature of albumen (egg protein): $T_c = 65°\text{C}$

Thermal conductivity of both the liquid & the solid albumen, $\kappa = 0.64\ \text{W K}^{-1}\ \text{m}^{-1}$

3. (a) Define the terms *magnetic field strength* and *ampere*.

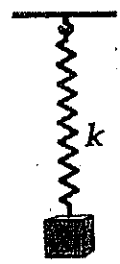
(b) Write an expression for the force $F$ acting on a current *(I)* carrying conductor of length $L$ placed in a magnetic field strength $B$.

(c) The Earth's magnetic field strength at a certain position $P$ on its surface has a horizontal component of 18 μT due north and a downward vertical component of 55 μT. Calculate,

(I) the magnitude and direction of Earth's magnetic field strength at $P$.

(II) the force on a 0.5 m length of a straight wire carrying a steady current of 4.0 A when the wire is (i) vertical with the current passing downwards, (ii) horizontal with the current passing from east to west.

4. (a) A light spring of force constant $k$ is attached to a solid support and a mass $m$ is fixed to its lower end as shown in the figure.




Prove that when displaced through a small distance vertically and released, the mass moves with simple harmonic motion of period,

$$T = 2\pi\sqrt{\frac{m}{k}}$$

(b) A spring of natural length 300 mm is suspended vertically from a fixed point with its upper end fixed. A mass of 0.15 kg is suspended at rest from the lower end of the spring to increase its length to 355 mm. The mass is then pulled down a further distance of 30 mm and released from rest so it oscillates about its equilibrium position. Calculate,

(i) the spring constant $k$ of the spring.

(ii) the time period $T$ of oscillations.

(iii) the maximum speed and the maximum kinetic energy of the mass.

(iv) the maximum and minimum tension in the spring.

5. (a) With the aid of labeled diagram, show that the magnifying power of a compound microscope is equal to its linear magnification when the final image is at viewer's near point.

(b) A compound microscope consists of two convex lenses of focal lengths 8.0 mm and 50 mm. A small object is placed on the microscope axis at a distance of 10 mm from the objective. The distance between the two lenses is then adjusted so that a magnified virtual image is seen at a distance of 250 mm from the eyepiece. Calculate,

(i) the distance from the image formed by the objective to each lens.

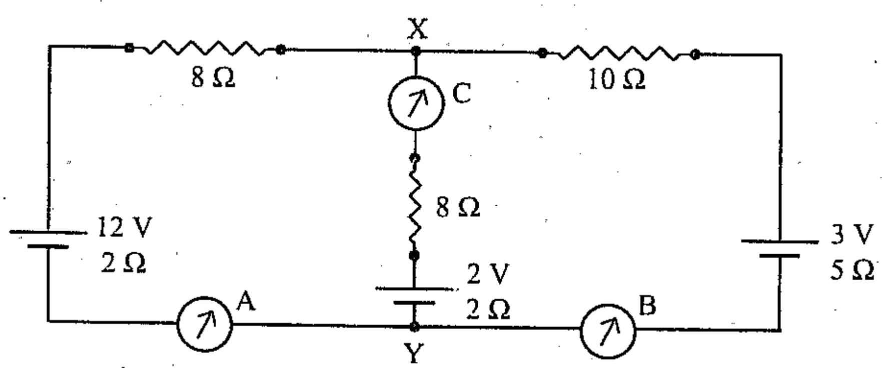
(ii) the distance between the two lenses.

(iii) the magnifying power of the compound microscope.

6. (a) Explain clearly the difference between e.m.f. and potential difference.

(b) State the Kirchchoff's network laws, and point out that each is essentially a statement of a conservation law.

(c)




Find, for the above circuit,

(i) the readings on the ammeters A, B, and C (of negligible resistances).

(ii) the potential difference between X and Y.

(iii) the power dissipated as heat in the circuit.

(iv) the power delivered by the 12 V cell.

7. (a) Draw the circuit symbol and give the truth table for each of the following:

(i) a 2-input AND gate

(ii) a 2-input NOR gate

(iii) a 2-input Ex-OR gate

(iv) a 3-input OR gate

(b) Draw a circuit to show how three NAND gates may be connected together to form a 2-input OR gate. Indicate the logic states at the input and output lines of each NAND gate when one input of the circuit drawn is high and the other input is low.

(c) Write down the truth table for an Ex-OR gate and show how an Ex-OR gate may be constructed from four NAND gates.

**8.** (a) Explain the terms *half-life* and *activity* in radioactivity.

(b) (i) Show that the activity $A$ of a radioactive isotope at a given time $t$ can be denoted by $A = A_o e^{-\lambda t}$, where $\lambda$ is decay constant and $A_o$ is activity at $t = 0$.

(ii) Hence, deduce the equation $t_{1/2} = \frac{\ln 2}{\lambda}$ for the half-life of a radioactive isotope.

(c) A freshly prepared sample of a radioactive isotope X contains $10^{20}$ atoms. The half-life of the isotope is 12 hours. Calculate,

(i) the initial activity of the radioactive isotope.

(ii) the number radioactive atoms of X remaining after 1 hour

(iii) the number radioactive atoms of X remaining after 24 hours.



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