SECTION I (One hour)

Answer all questions in this section.

1. (a) Explain what is meant by the homogeneity of a physical equation.

(b) Show that the expression $c^2\mu_o\varepsilon_o = 1$ is homogenous, where μ_o is the permeability of free space, and ε_o is the permittivity of free space, and c is the speed of light.

(c) Given that $\mu_o = 4\pi \times 10^{-7}$ H m^{-1}, calculate a value for ε_o.

(7 marks)

2. Figure 1 shows a graph of the square of the frequency against the inverse of the length for a simple pendulum.

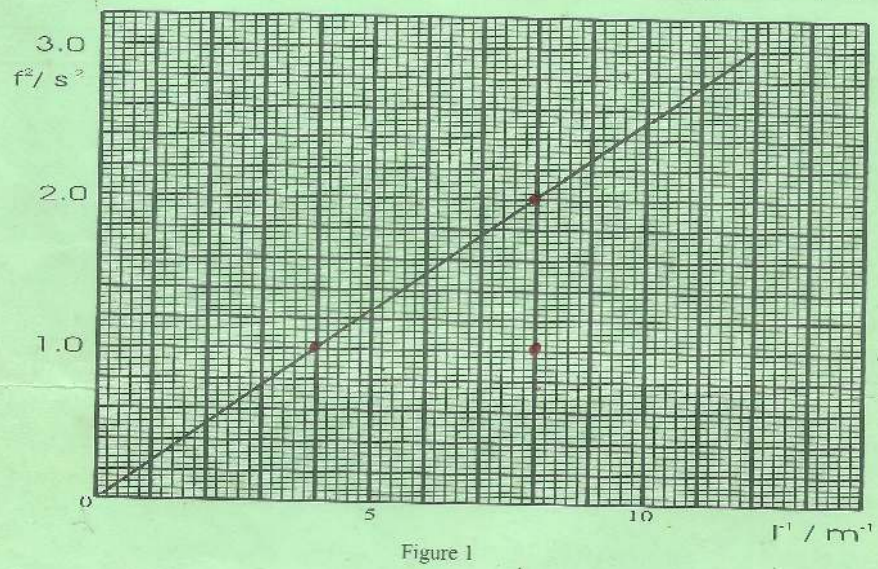

Figure 1

(i) Use the graph to determine a value for the acceleration due to gravity.
(ii) Calculate a length for which the pendulum would have a frequency of 20.0 Hz.

(7 marks)

3.

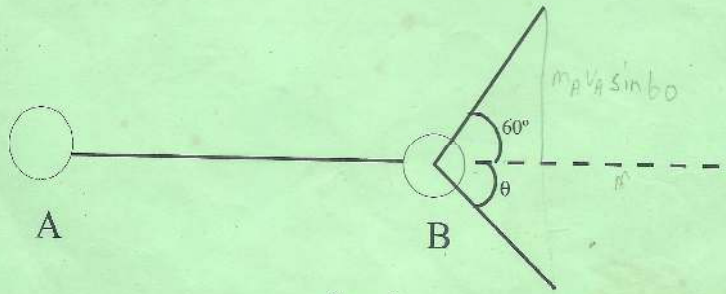

Figure 2

Figure 2 shows a snooker ball A moving with a velocity of 5.5 m s^{-1}, which hits a stationary snooker ball B. After collision A moves with a velocity of 2.5 m s^{-1} at 60° to its original path.
Calculate:-
(i) the velocity of B after collision. **(6 marks)**

4. Figure 3 shows two light beams X and Y of wavelength 450 nm travelling in air and incident on a composite crystal of thickness 20 μm. The refractive index of P is 1.40 and that of Q is 1.45.

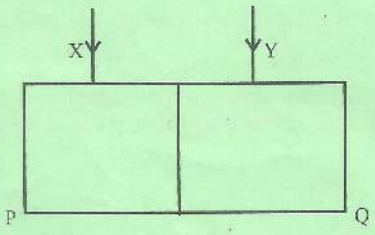

Figure 3

(a) Determine which beam will first emerge from the crystal.

(b) If X and Y are in phase as they enter the crystal, calculate their phase difference as they leave the crystal. **(7 marks)**

5. A converging lens of focal length 20.0 cm is placed 25.0 cm away from a screen on which an image is formed. A biconcave lens of focal length 30.0 cm is now placed between the converging lens and screen so that it is 10.0 cm from the converging lens. Calculate how far the screen has to be moved to focus the new image.

(5 marks)

6. Figure 4 shows an electrical circuit.

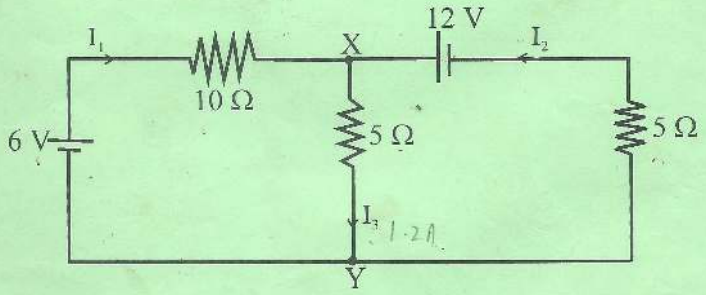

Figure 4

Determine the
(i) currents I_1, I_2 and I_3.
(ii) pd between X and Y.

(8 marks)

7.

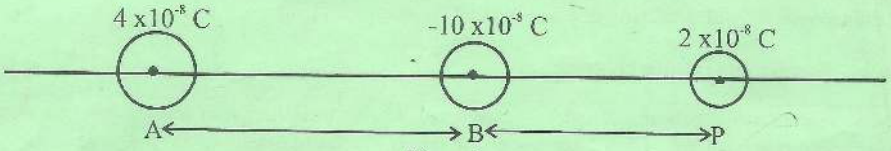

Figure 5

Figure 5 shows three charges A, B and P placed in a straight line. The charge at A is 4×10^{-8} C, that at B is -10×10^{-8} C and that at P is 2×10^{-8} C.

(a) Calculate the force on the charge at the point, P due to charges A and B.
(b) Show that the resultant force on P cannot be zero, if the charge at P is placed between A and B.

(5 marks)

SECTION II (one and a half hours)

Answer all questions

Answer either 8 (a), (b) and (c) or 8 (d), (e), and (f).

EITHER 8 (a), (b) and (c)

8. (a) (i) State Newton's laws of motion. **(6 marks)**

(ii) Show how the principle of conservation of linear momentum could be derived from the second and third laws of motion. **(3 marks)**

(b) Describe an experiment to verify the principle of conservation of linear momentum. **(7 marks)**

(c) Distinguish between *conservative* and *non-conservative* forces giving one example of each. **(4 marks)**

OR 8 (d), (e,) and (f)

(d) (i) State Kirchhoff's laws. **(4 marks)**

(ii) Explain how each of the laws is essentially a statement of either the conservation of energy or the conservation of electric charge. **(4 marks)**

(e) Describe an experiment to investigate how the p.d. across a wire filament varies with current through it at constant temperature. **(6 marks)**

(f) Given the circuit in figure 6.

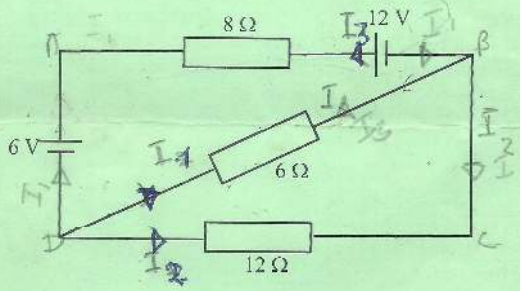

Figure 6

Calculate

(a) the current in the 6 Ω resistor.

(b) the p.d. across the 6 Ω resistor.

(6 marks)

Answer either 9 (a) and (b) or 9(c) and (d)

EITHER 9 (a),(b)

9. (a) (i) State the assumptions used in deriving the kinetic theory for an ideal gas. **(4 marks)**

(ii) From these assumptions derive the kinetic theory equation,

$$P = \frac{1}{3}\rho\overline{c^2}$$

Where P = pressure of the ideal gas,

ρ = the density of the gas,

c = the velocity of a gas molecule.

(4 marks)

(b) Figure 7 shows how the pressure of oxygen gas at temperatures T and 300 K varies with density, ρ.

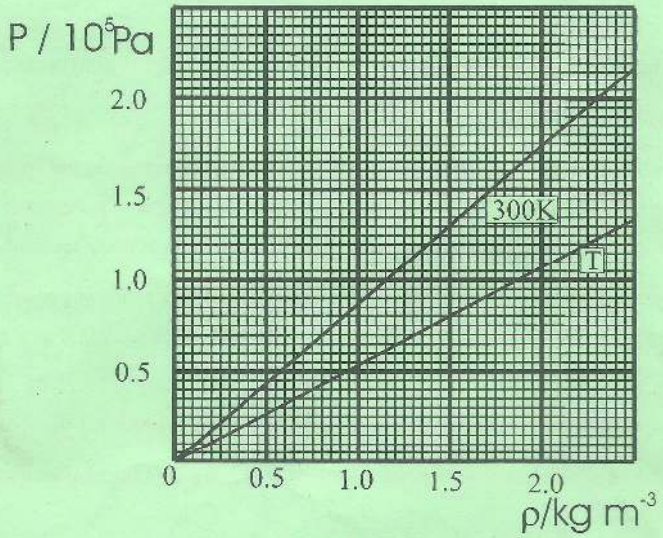

Figure 7

Use the graphs to

(i) Calculate a value for the r.m.s. speed of oxygen molecules at 300 K. **(4 marks)**

(ii) Explain whether T is higher or lower than 300 K. **(3 marks)**

(c) (i) On the same axes sketch labelled graphs to show how the speeds of the molecules in an ideal gas are distributed at temperatures of 300 K and 600 K. **(2 marks)**

(ii) On one of the graphs show the position of average velocity, r.m.s. speed and most probable velocity. **(3 marks)**

OR 9 (c) and (d)

(d) Materials could be classified as *crystalline*, *amorphous* or *polymmeric*. Define the terms in italics. Give one example for each of the terms. **(9 marks)**

(e) An aluminium wire and a glass thread are subjected to linear stress until they break. On the same axes, sketch labelled graphs of stress-strain to show the behaviour of each material. **(4 marks)**

(f) Figure 8 shows a graph of extension, e, against force, F, for a certain nylon climbing rope.

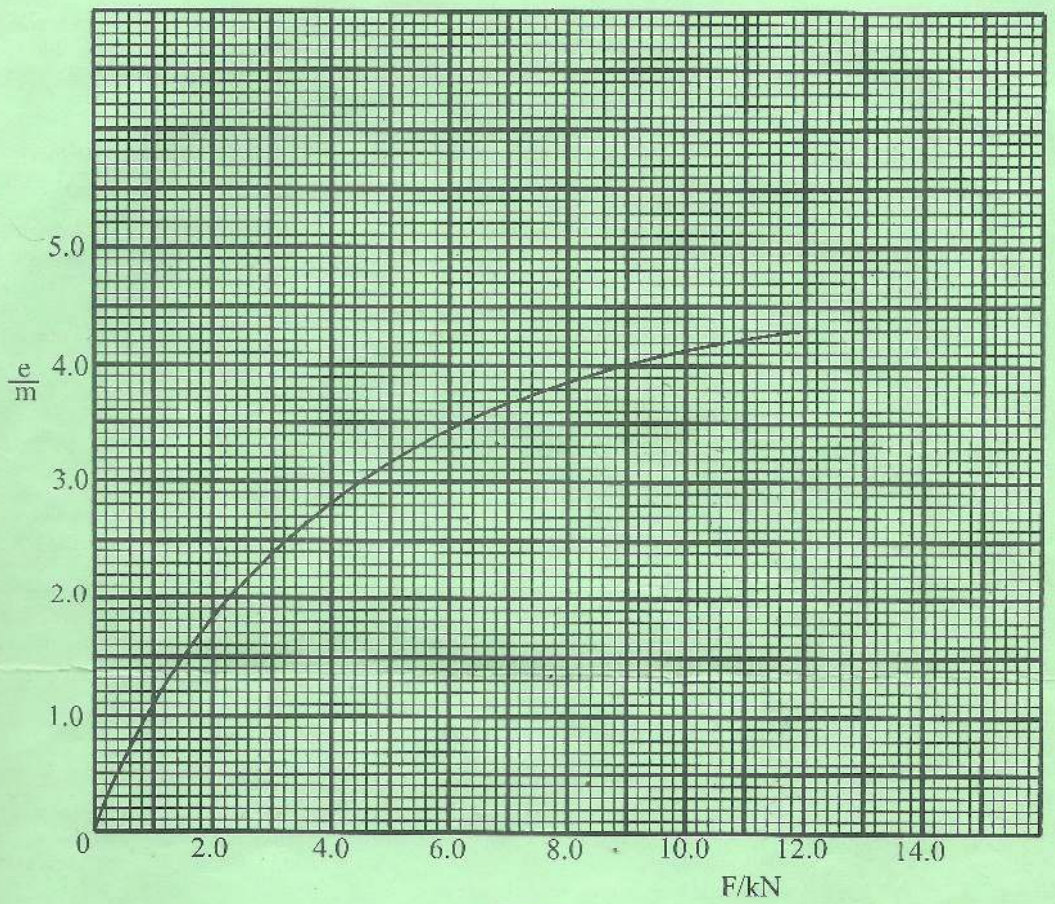

Figure 8

A climber of mass 80 kg, attached to a 10 m length of this rope, can withstand a force from the rope of not more than 7.5 kN without the risk of serious injury.

Use the graph to

(i) estimate the maximum energy stored in the rope when the climber is not at risk. **(4 marks)**

(ii) explain how you would determine a value for Young's Modulus for a given extension. **(3 marks)**

Answer Either 10 (a), (b) and (c) or 10 (d) , (e), (f)

EITHER 10 (a), (b) and (c)

10. (a) Differentiate between *interference* and *diffraction* of light. **(4 marks)**

(b) A parallel beam of light of wavelength 5.5×10^{-7} m in air is incident on the slits in Young's double slit experiment. A thin film of transparent plastic of refractive index 1.48 and thickness 5.2×10^{-6} m is placed over one of the slits.

(i) Determine the increase in the optical path of the light passing through the thin film. Hence determine the number of fringes by which the central fringe is displaced. **(6 marks)**

(ii) Explain how the fringe spacing would change if

- the slit separation were increased
- the slit-screen distance were increased. **(4 marks)**

(c) Light of wavelength 5.5×10^{-7} m falls on a single slit of width 0.15 mm. A screen is placed 1.2 m beyond the slit.

(i) Sketch a graph showing the light pattern observed on the screen.

(ii) Calculate the width of the central fringe. **(6 marks)**

OR 10 (d),(e) and (f)

10 (d) State the following laws.

(i) Newton's gravitational law.

(ii) Coulomb's law. **(4 marks)**

(e) Explain in what ways the Coulomb force between two charged particles is

(i) different.

(ii) similar, to the gravitational force between two masses.

(4 marks)

(f) The gravitational potential energy, U, of a mass, m, a distance, h, above the surface of the earth is

$$U = \frac{-GMm}{(R+h)}$$

where M is the mass of the earth, R the radius of the earth, and G, the gravitational constant. ($R = 6.4 \times 10^{6}$ m)

(i) Show that this expression is equivalent to U = mgh usually quoted in elementary physics courses where g is the gravitational force per unit mass near the surface of the earth. **(4 marks)**

(ii) How much kinetic energy must a 100 kg spacecraft have at the surface of the earth to be able to leave the earth completely. **(6 marks)**

(iii) Explain what would happen if the space craft had

- less energy
- more energy

(2 marks)
