JUNE 2008

1. One condition for an equation to be physically correct is that the equation should be homogeneous
   i. What is the meaning homogeneous as used in the above statement?
   ii. Show that the equation $\eta\pi av = \frac{4}{3}\pi a^3(\rho - \rho')g$ is homogeneous, where ρ is the density of a sphere of radius a falling steadily through a liquid of density ρ' with speed v. η is the coefficient of viscosity of the liquid with units $kgm^{-1}s^{-1}$
2. (a) Figure 1 shows a graph of image distance, v, versus magnification, m, for a convex lens.
   (i) Use the graph to find a value for the focal length of the lens.

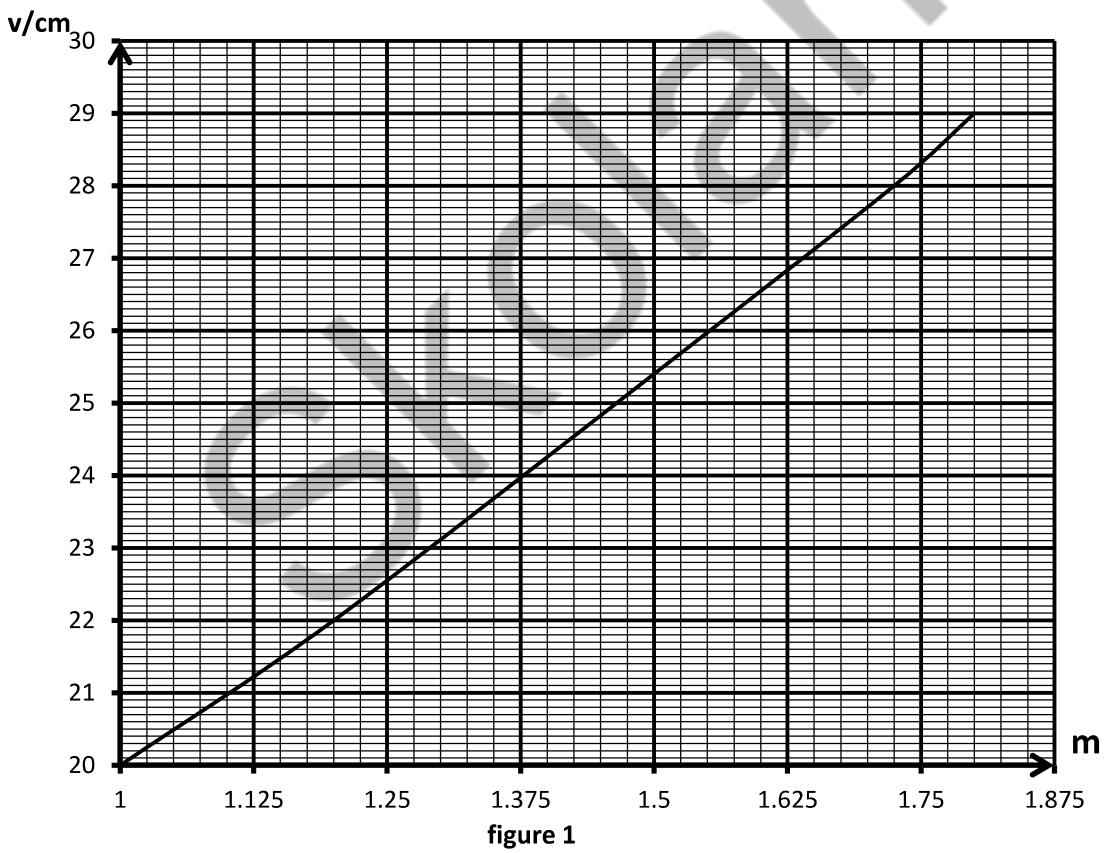

figure 1

   (b) List two advantages which optical fibres have over copper cables when used in telecommunication
3. A charged capacitor of capacitance, C, can be discharged through a resistor R. At a time t after the start of discharge, the charge, Q, remaining on the capacitor can be given by the expression $Q = Q_0 e^{-\frac{t}{RC}}$, where Q_o is the initial charge on the capacitor.
   i. Use the above equation to obtain an expression for the half – life, $T_{\frac{1}{2}}$ of the discharge process.

ii. Use the equation to define the time constant, τ, of the discharge.

iii. Compare the values of $T_{\frac{1}{2}}$ and τ.

4. Define simple harmonic motion (SHM).
   For a body executing SHM, the displacement y, is given by the equation $y = rsin\omega t$. What do r, ω and t represent in the above equation?
5. Light is incident normally on a diffraction grating of 500 lines per centimeter and a second order image is obtained at an angle of 36^0.
   (a) Calculate the wavelength of the light used
   (b) Determine whether a third order image can be obtained with light of the same wavelength.
   (c) State and explain a way in which the number of orders could be increased.
6. (a) Sketch the stress – strain curve for a specimen of rubber when it is loaded within the elastic limit and then unloaded.
   (b) Explain in molecular terms the shape of the graph during loading and unloading process, state clearly the energy changes involved.
7. (i) Draw a block diagram for a radio transmitter and receiver.
   (ii) Differentiate between FM and AM transmissions.
8. (a) State Coulomb's law.
   (b) In an experiment to determine the permittivity, ε, of a medium, a series of values of force, F, and corresponding separation, r, between similar charges Q each of value 3.8 x 10^{-3} C were obtained. A graph of $\frac{1}{r^2}$ versus F was plotted as shown in figure 2.

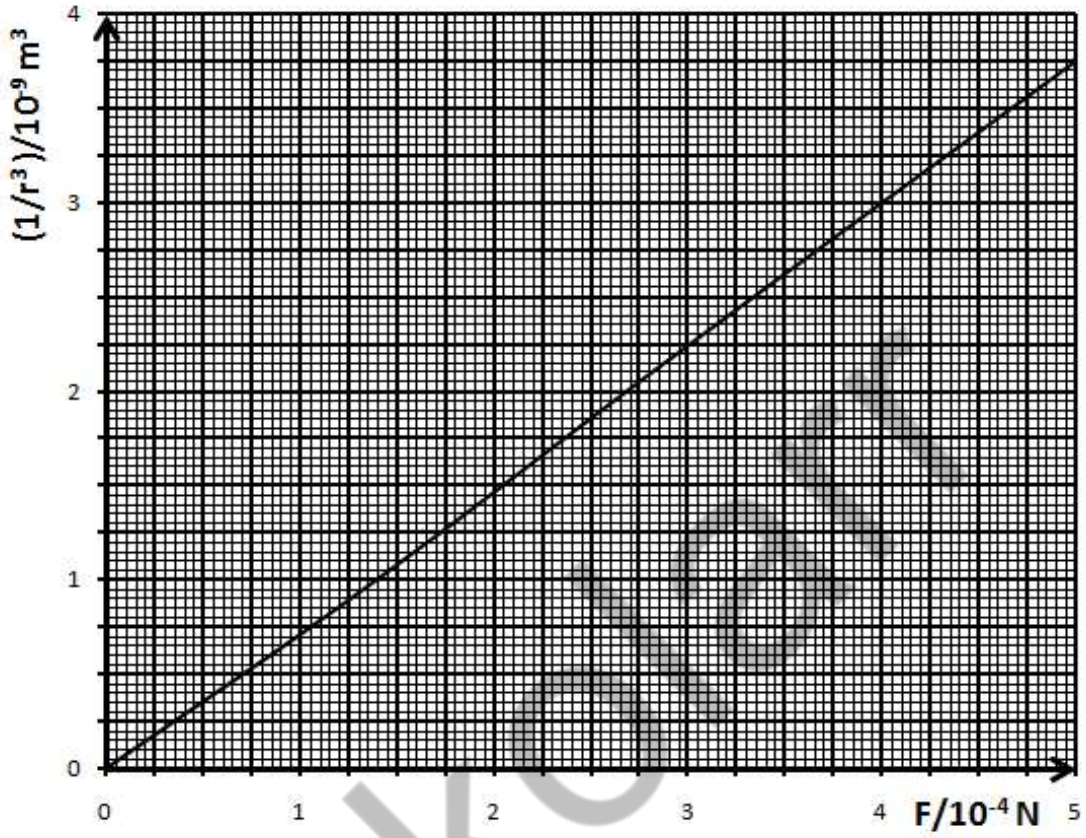

Figure 2

(i) From the graph obtain a value for the permittivity of the medium

(ii) From the value of the permittivity obtained from the graph, in what type of medium do you think the charges were placed.

(b) Lighting occurred in a forest and a tree standing vertically in the forest provided path along which the lightning passed.

Suppose 600 x 10^{-3} C of charge is conducted through the tree in 1.0 μs

(i) Calculate the average current

(ii) Sketch the temporal magnetic fields created by this current.

(iii) What will the magnetic field strength be 10 cm from the tree.

(d) (i) State Newton's law of gravitation

(ii) Suppose a planet of mass m is moving in a circular orbit of radius r above the sun of mass M. prove that the periodic time, T, of the planet round the sun is given by the expression.

$$T^2 = 4\pi^2 \frac{r^3}{GM}$$

(iii) If the universal gravitational constant is 6.67 x 10^{-11} Nm^2kg^{-2}, the radius of the moon's orbit is 3.5 x 10^8 m and the mass of the earth is 6.0 x 10^{24} kg, calculate the period of rotation of the moon round the earth.

(e) Figure 3 shows how r^3 varies with T^2 for a planet of mass m. Use the graph in figure 3 to obtain the mass, m of the planet given that G = 6.67 x 10^{-11} Nm^2kg^{-2}.

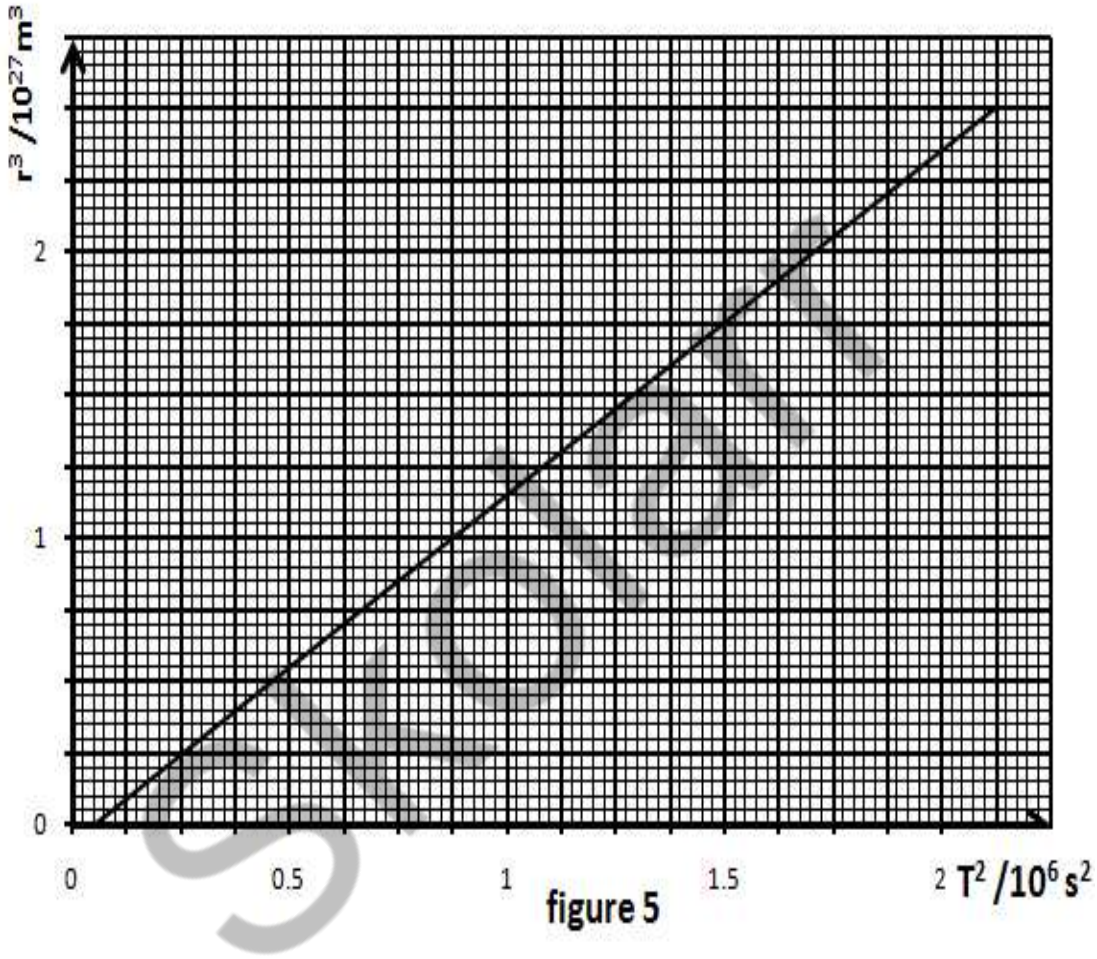

figure 5

(f) Sketch a graph to show how the field strength, g, varies with distance from the centre of the earth to some distance outside the earth assuming that the density of the earth is uniform.

9. A bullet is projected horizontally at a height above the ground with a velocity u of magnitude 5 ms^{-1}.
(i) What is the trajectory of the ball?
(ii) Find the position and velocity of the ball after 0.5 s.
(iii) State how the velocity and acceleration of the ball vary with time.
(b) Figure 4 shows a framed picture of a body held up by two strings OP and OQ each at an angle of 60^0 to the vertical.
Calculate the weight of the framed picture.

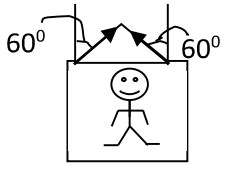

Figure 4

(c) What is a collision?
Distinguish between elastic and inelastic collisions
(d) (i) State the principle of conservation energy. Give a mathematical form of this law, stating clearly each term of the equation. (First law of thermodynamics may be used).
(ii) Give an example of a situation in which the principle of conservation of energy applies.

(e) (i) Differentiate between renewable and non renewable energy sources giving an example of each.
(ii) To harness tidal power a dam is built across the tidal region of water. Water is trapped at high tides and released at low tides. Suppose the water trapped during high tides is in a basin of area 40 x 10^6 m^2. If the maximum height of water is 10 m.
(ii) (a) Calculate the gravitational potential energy change from high tides to low tides given that density of water is 1000 kgm^{-3}.
(ii)(b) Calculate the average power obtained if the flow from high to low tide took 6 hours
(f) How can
(i) Wind (ii) Oil, as energy sources be derived from the sun.

10. (a) Describe an experiment to measure the specific charge, e/m of an electron
(b) The element uranium $^{238}_{92}U$ undergoes radioactivity to give an alpha particle and the particle thorium (Th)
(i) Explain the meaning of the underlined words
(ii) Write the equation of the decay
(c) A certain radioactive material contains 10^{10} atoms. The half life of the radioactive material is 20 days
(i) Calculate the number of disintegrations after one second
(ii) After how long will the material take to reduce to 10^4 radioactive atoms?
(d) (i) Define temperature coefficient of resistance
(ii) Describe an experiment to determine the temperature coefficient of resistance of a conductor.
(e) Distinguish between the following
(i) Ohmic and non – ohmic conductors
(ii) Potential difference and electromotive force

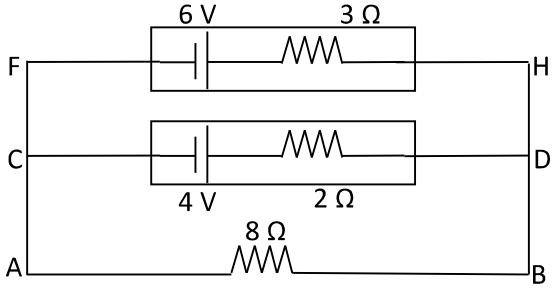

Figure 5

Figure 5 shows a load of resistance R = 8Ω connected across two cells in parallel. The cells have internal resistances as shown in figure 5.
(i) Determine the values of I_1 and I_2
(ii) Comment on the values obtained