ELECTRIC AND MAGNETIC FIELDS

ASSIGNMENT 2

Questions 1 - 4 count for 95% of the marks and Question 5 for 5%

Q1 In the Bohr model of the hydrogen atom (one electron in a circular orbit around one proton), the electron orbits the proton at a distance of 5.29 x 10^{-11} m.

(a) What is the magnitude of the proton's electric field at this radius?

(b) What is the orbital speed of the electron? (**Hints:** Look for things beginning with "Bohr" in the index of *Young & Freedman* or any similar book. You will also need to use the mass of the electron, which is given in *Young & Freedman* and similar books.)

Q2 The earth has a net electric charge which results in an electric field near its surface of magnitude E = 150 N C^{-1}, and direction vertically downwards.

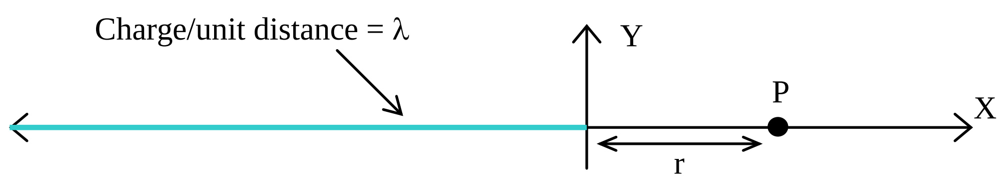
(a) What magnitude and sign of charge would a person weighing 50 kg need to have to overcome the pull of gravity?

(b) If two 50-kg people, separated by a horizontal distance of 500 m, acquire the charge calculated in part (a), what would be the force of repulsion between them? What acceleration would they experience? (Express this in terms of the acceleration due to gravity, g = 9.81 m s^2.)

(c) Explain why this method of flight would not be practical. (**Hint:** The maximum acceleration that the human body can withstand without damage is around 50g).

Q3 A point charge of -3 C lies at co-ordinates (2, 2) in the x-y plane, and another point charge of -3 C lies at co-ordinates (0, -2), where the distances are in metres. What is the resultant force exerted by these two charges on a charge of 1 C at the origin? (**Hint:** The method for this question is the same as for Assignment 1, Q2. Your answer should start with a clearly labelled diagram showing the positions of the charges and the forces acting on the 1 C charge.)

Q4 A very long thin rod carries a uniform charge density λ (charge per unit length). It lies on the x-axis with one end at the origin. The other end may be regarded as being at - ∞.



(a) Explain how the Principle of Superposition can be used to find the electric field at a point P, which lies at position (r, 0) as shown.

(b) Show that the electric field at P is given by $\overline{\mathbf{E}} = \dfrac{\lambda}{4\pi\varepsilon_o r}\hat{\mathbf{i}}$.

Q5 Two infinite threads with uniform charge density 4 C m^{-1} lie along the x and y axes, respectively. A point P has co-ordinates (2, 2, 2). Show that the electric field at P is given by

$$\overline{\mathbf{E}} = \frac{1}{2\pi\varepsilon_0}\left[\hat{\mathbf{i}} + \hat{\mathbf{j}} + 2\hat{\mathbf{k}}\right].$$

Hint: Recall that the electric field at a perpendicular distance r from an infinite straight lin carrying charge density λ per unit length is given by

$$E = \frac{\lambda}{2\pi\varepsilon_0 r} .$$