Electromagnetism I – Problem sheet 2

Problem 1.

1. Two identical spheres of mass m, each carrying a charge q are suspended from the ceiling with a flexible wire of length l. The electrostatic repulsion keeps the two spheres apart as shown in the figure.

   (a) At equilibrium, which of the following statements is true?

   (a) $\theta_1 = \theta_2$;
   (b) $\theta_1 > \theta_2$;
   (c) $\theta_1 < \theta_2$.

   Justify your answer. **[1]**

   (b) Derive an expression that relates the angles θ_1, θ_2 q, l and m. **[1]**

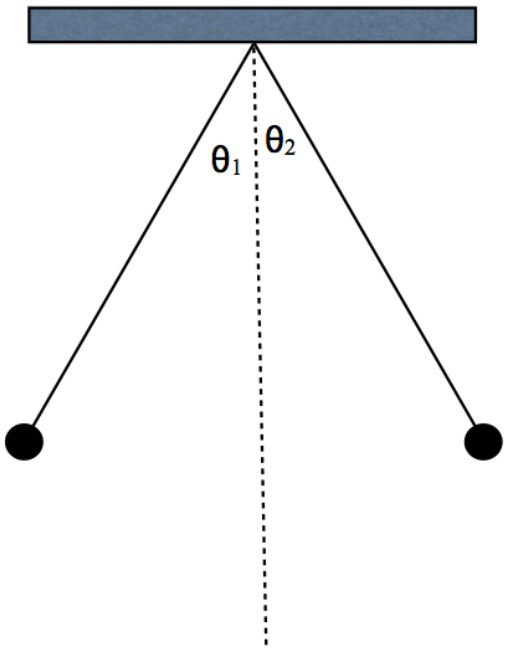
2. We now replace the sphere on the right hand side with a sphere twice as heavy.

   (a) Draw a diagram that includes all the forces. **[1]**

   (b) At equilibrium, which of the following statements is true?

   (a) $\theta_1 = \theta_2$;
   (b) $\theta_1 > \theta_2$;
   (c) $\theta_1 < \theta_2$.

   Justify your answer. **[1]**



Problem 2.

Consider a "linear quadrupole" (see figure below) consisting of two adjacent dipoles oriented oppositely and placed end to end. This linear quadrupole is along the y axis. There is effectively a point charge $-2q$ at the centre, which is located at the origin of the (x, y) plane. The two positive charges $+q$ are at a distance a from the centre. By adding up the electric fields of the charges, find the x and y components of the electric field at:

1. Point A along the y axis, **[3]**
2. Point B along the x axis, **[3]**

if both A and B are at a distance $r \gg a$ from the origin. Express the results as a function of a^n/r^m (where n and m are integer numbers), keeping the leading order contribution in a in the expansion of the electric field.