Special Problems

Honors Physics – Week 3

©*Alex R. Dzierba*

Honors Physics P222 - Spring, 2004

Problem 3.1

Four identical charges of magnitude q are at the corners of a square of side a. A fifth charge Q is at the center of the square. What is the relationship of Q to q such that the net force on any one of the five charges is zero?

If the force on each particle is zero the system is in equilibrium. Is the equilibrium stable or unstable? Explain your answer.

Problem 3.2

A charge q is at the origin of coordinates. A charge $-2q$ is located on the x axis at $x = 1\ m$.

(a) Find the point on the x axis where the electric field is zero.

(b) Find a point on the y axis where the field is parallel to the x axis.

Problem 3.3

We have three charges: $+q$, $+q$ and $-q$. They are fixed on the corners of an equilateral triangle of side a where $a = 1$. At what points will the electric field vanish? To actually get a numerical answer you will need to use an iterative technique once you come up with an equation.

Problem 3.4

Figure 1 shows two charges of equal magnitude and opposite sign located a distance d above and below the origin of coordinates. Such an arrangement of charges is called an electric dipole and it is represented by a vector that points from the negative charge to the positive charge and it has magnitude $p = 2qd$. For a point on the vertical axis (point A) a distance r from the origin, where $r >> d$, show that the electric is given by:

$$\vec{E} = +\frac{p_0}{2\pi\epsilon_0 r^3}\hat{\mathbf{j}} \qquad (1)$$

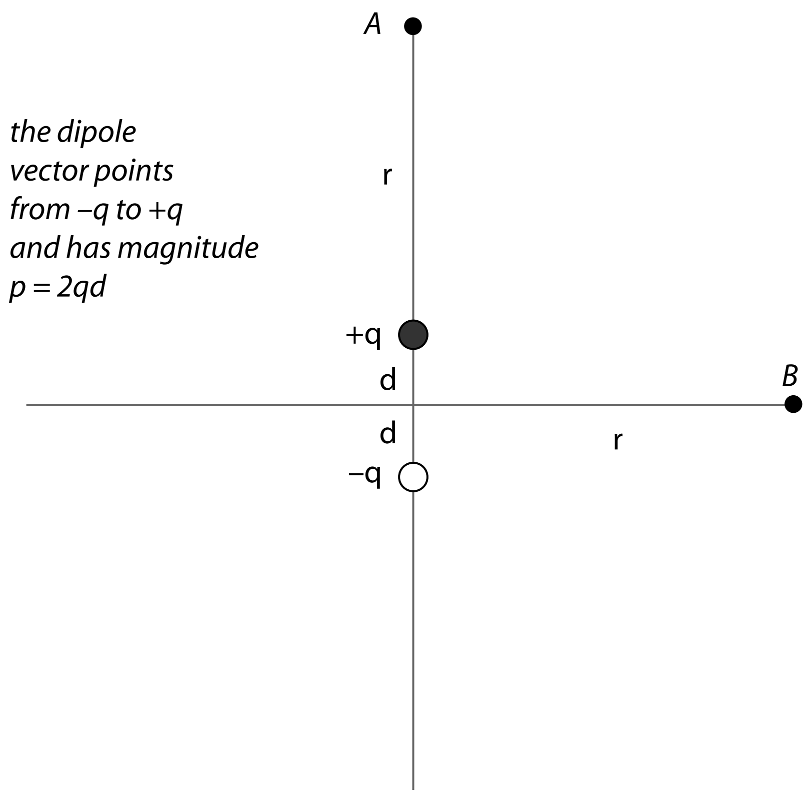

Figure 1: Problem 3.4

You will need to make use of an approximation which uses the binomial expansion, namely that if $z << 1$ then $(1+z)^n \approx 1 + nz$.

Also show that the electric field for a point on the horizontal axis (point B) a distance r from the origin, where $r >> d$, show that the electric is given by:

$$\vec{E} = -\frac{p_0}{4\pi\epsilon_0 r^3}\hat{\mathbf{j}} \tag{2}$$

Obviously the drawing is not to scale but we make the assumption that $r >> d$.

Problem 3.5

Figure 2 summarizes the results of the previous problem – it shows a dipole located at the origin of coordinates and the electric field at four points above and below and to either side of the dipole.

Find an expression for the electric $\vec{E}$ at some arbitrary point (x, y) where $r = \sqrt{x^2 + y^2}$ in the following notation: $\vec{E} = E_x(x, y)\hat{\mathbf{i}} + E_y(x, y)\hat{\mathbf{j}}$ where it is understood that both the x and y components are each functions of x and y.

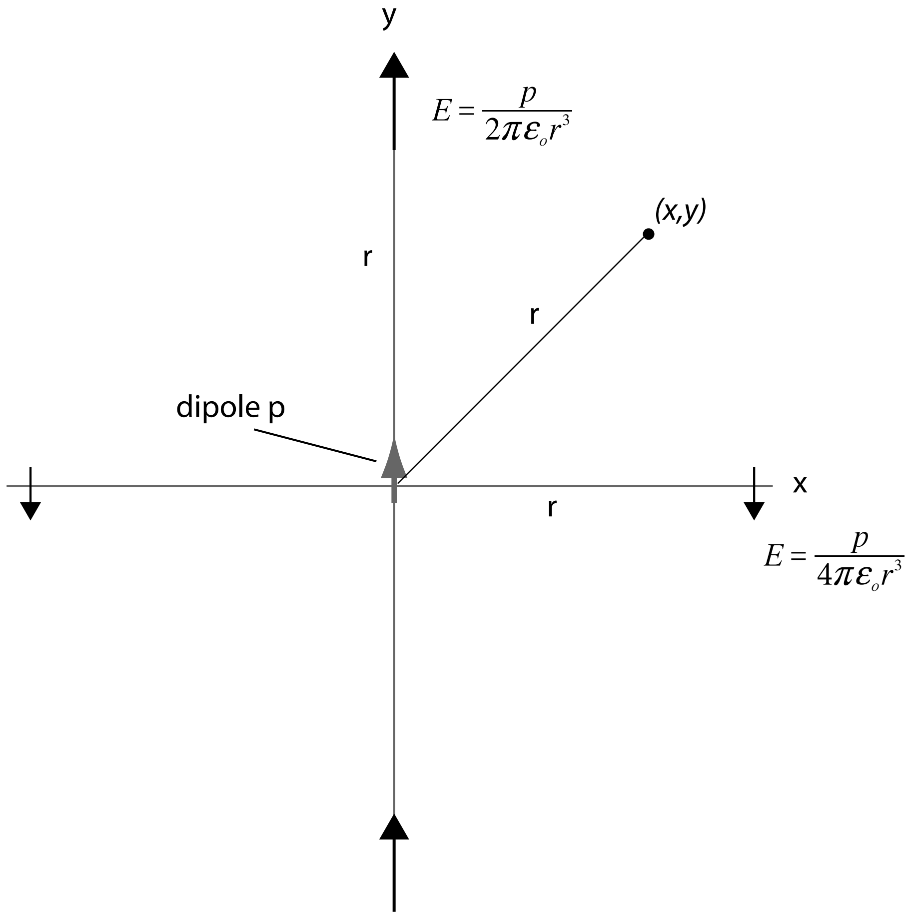

Figure 2: An electric dipole vector is located at the origin of coordinates. The electric field is shown for points on the x and y axes a distance r from the center of the dipole where r is much larger than the dimensions of the dipole.

Hint: Draw a line from the origin to the point (x, y). Find the projection of the dipole vector along and perpendicular to this line. For each of these you know the corresponding $\vec{E}$ field. Now use superposition.