PHYSICS 2B | QUIZ 1 | WINTER QUARTER 2010
PROF. HIRSCH | | JANUARY 11, 2010

Formulas:

$\sin 30^\circ = \cos 60^\circ = 1/2, \quad \cos 30^\circ = \sin 60^\circ = \sqrt{3}/2, \quad \sin 45^\circ = \cos 45^\circ = \sqrt{2}/2$

$F = k\frac{q_1 q_2}{r^2}$ Coulomb's law ; $k = 9\times 10^9 \mathrm{N\cdot m^2/C^2}$; $\vec{F}_{12} = \frac{kq_1q_2}{|\vec{r}_2 - \vec{r}_1|^3}(\vec{r}_2 - \vec{r}_1)$

Electric field due to charge q at distance r: $\vec{E} = \frac{kq}{r^2}\hat{r}$; Force on charge Q: $\vec{F} = Q\vec{E}$

Electric field of dipole, along dipole axis: $E = \frac{2kp}{x^3}$ (p=qd)

Electric field of dipole, along direction perpendicular to dipole axis: $E = \frac{kp}{y^3}$

Energy of and torque on dipole in E-field: $U = -\vec{p}\cdot\vec{E}$, $\vec{\tau} = \vec{p}\times\vec{E}$

Linear, surface, volume charge density : $dq = \lambda\, ds$, $dq = \sigma\, dA$, $dq = \rho\, dV$

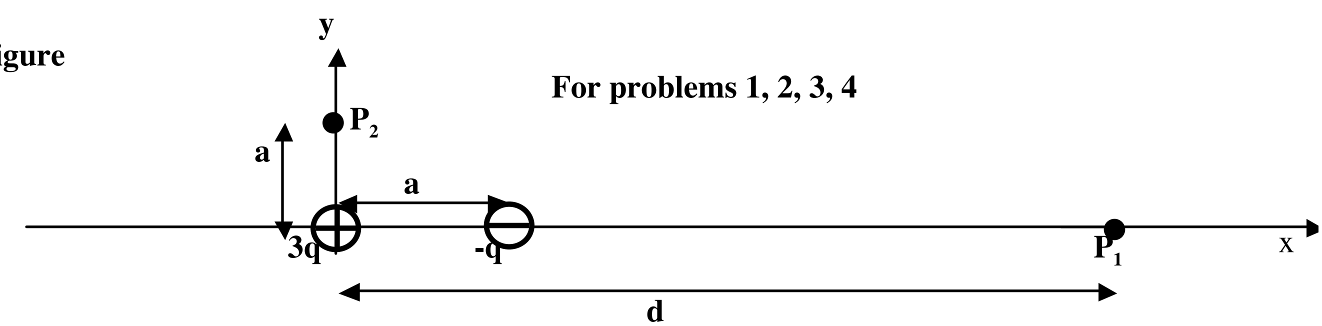
Electric field of infinite : line of charge : $E = \frac{2k\lambda}{r}$; sheet of charge : $E = 2\pi k\sigma$

Solutions are in bold

There are 7 problems in this quiz, all are worth the same. Mark the answer closest to yours. This is Test Form A

Figure

For problems 1, 2, 3, 4



The charge 3q is at the origin (x,y)=(0,0), the charge -q is at (a,0). Point P_1 is at (d,0), point P_2 is at (0,a). q > 0. Problems 1 to 4 refer to this figure.

Problem 1
A point on the x-axis where the electric field is 0 is (x_0,0), with x_0=
(a) 1.8a ; (b) 2.4a ; (c) 4a ; (d) 2.8a ; (e) -2a

On the x axis, to the right of the charge -q, set $3q/x^2=q/(x-a)^2$, solve for x: $x^2=3(x-a)^2$ ==> x=sqrt(3) (x-a) , solve, gives x=sqrt(3)/(sqrt(3)-1)) times a

Problem 2
The point on the positive x-axis to the right of the charge -q where the force on a positive test charge points to the right and its maximum is at
(a) 3.3a ; (b) 3.5a ; (c) 3.7a ; (d) 3.9a ; (e) 4.1a

E-field is $3q/x^2 - q/(x-a)^2$, take derivative, set it =0 to locate maximum, solve for x. Equation is $6(x-a)^3=2x^3$ ==> $x=3^{1/3}(x-a)$, etc.

Problem 3

The electric field at point P_1 (see figure) at a distance d>>a is approximately:

$$E_{P_1} = \frac{kq\alpha}{d^2} + \frac{kqa\beta}{d^3}$$

with

(a) α=2, β=2; (b) α=2, β=1 ; (c) α=3, β=-2 ; (d) α=3, β=-1 ; (e) α=2, β=-2

Hint: use superposition

$1/d^2$ dependence comes from net charge, $1/d^3$ from dipole. At a large distance, this charge arrangement looks like a dipole (q, -q) with dipole moment p=qd pointing in the negative x direction, plus a charge 2q. Use formulas for field of charge and field of dipole.

Problem 4

The electric field at point P_2 (see figure) has components

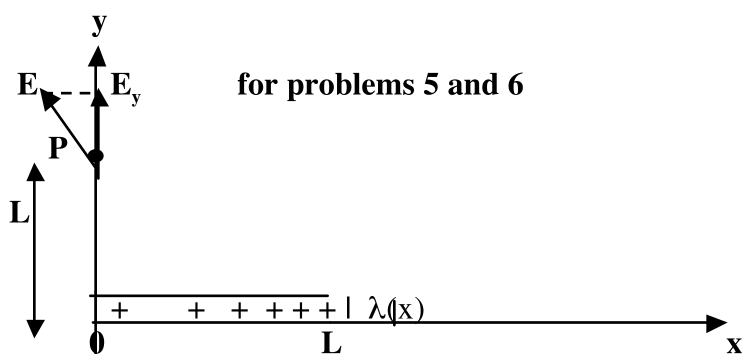
$$E_x = \frac{kq}{a^2}\alpha, \quad E_y = \frac{kq}{a^2}\beta$$

with

(a) α=0.5, β=2.5; (b) α=1, β=2 ; (c) α=1.5, β=-2.5 ; (d) α=0.5, β=3 ; (e) α=1, β=2.5

Charge 3q gives a positive y-component only, charge -q gives a positive x-component and a negative y-component that are equal in magnitude since the angle is 45 degrees. Add y-components from both contributions (with their sign).

Figure



for problems 5 and 6

A charged rod of length L on the x-axis has a nonuniform linear charge distribution $\lambda(x) = \lambda_0 \frac{x}{L}$, where x is measured from the left end. At the point P shown in the figure, at distance L from the left end of the rod in the vertical direction, the electric field points approximately in the direction shown, and it's y-component, E_y, is positive. It can be calculated by doing an easy integral.

Problem 5

The magnitude of E_y shown in the figure is $\frac{\lambda_0}{L}\alpha$, with

(a) α=0.1; (b) α=0.2 ; (c) α=0.3 ; (d) α=0.4 ; (e) α=0.5

It is like the integral discussed in class in connection with example 23-9 in the book, except that the charge density is x-dependent. That makes the integral a lot easier, since it involves $x/(x^2+L^2)^{3/2}$ and can be done simply by substitution.

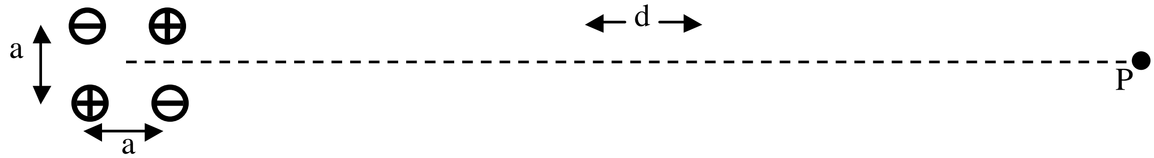
Problem 6

At another point very far away from this rod, at distance d>>L, the magnitude of the electric field is $E = \frac{\lambda_0 L}{d^2}\beta$, with

(a) β=0.25; (b) β=0.5 ; (c) β=1 ; (d) β=1.5 ; (e) β=2

Far from the rod, the electric field is kq/d^2 with q the total charge of the rod, which is obtained by integrating the linear charge density from 0 to L, giving $\lambda_0 L/2$.

Problem 7



The charges in the square arrangement in the figure with side a have all magnitude q, and their sign is shown. At the point P shown, very far away from this charge arrangement (at a distance d >> a), the electric field:

(a) points to the right ; (b) points to the left ; (c) points up ; (d) points down ; (e) is exactly zero

This can be seen as 2 dipoles, one pointing in the + y direction and the other in the -y direction, the latter one is a little further away (a further away). The first one gives an E-field pointing down, the second pointing up but a little smaller, so the net E-field points down.