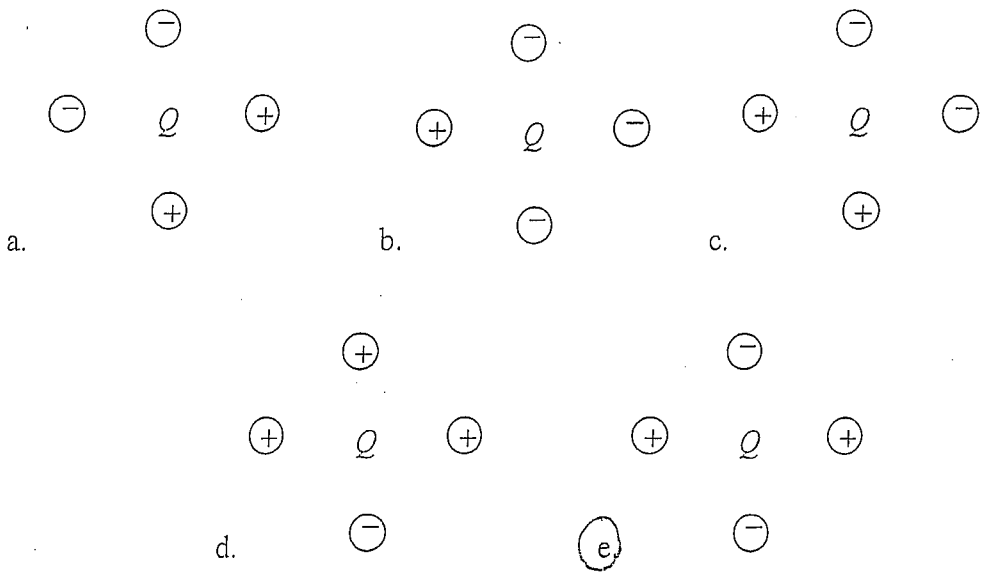
Multiple Choice:

(6 marks)

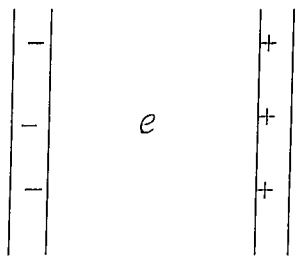
1. Q_1, Q_2, Q_3, and Q_4 are three identical spherical conductors. Q_1, Q_2 and Q_3 are neutral and Q_4 has a charge Q. If Q_4 touches Q_1 then Q_2 then Q_3, how much is the charge on Q_4?

   a. Q b. $\frac{Q}{2}$ c. $\frac{Q}{4}$ (d.) $\frac{Q}{8}$ e. other than that.

2. In the following figure, the surrounding charges to Q are of equal magnitude and are equidistant from Q. Which charge arrangement neutralizes the force on Q?



3. How much is the magnitude of the electric force on an electron sandwiched between two non-conducting plates having the same charge density, σ?



a. $\frac{3\sigma}{2\varepsilon_0}$N b. $\frac{e\sigma}{2\varepsilon_0}$N (c.) $\frac{e\sigma}{\varepsilon_0}$ N d. $\frac{5\sigma}{2\varepsilon_0}$ N e. $\frac{3e\sigma}{2\varepsilon_0}$N

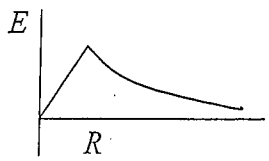
4. A point charge of 1.8 μC is at the center of a cubical Gaussian surface of edge 55 cm. What is the electric flux through each face?

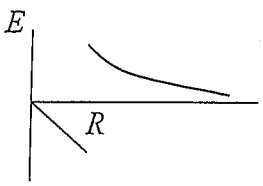
a. 5.7×10^5 N.m^2 C^{-1} b. 2.0×10^5 N.m^2 C^{-1} c. 7.9×10^5 N.m^2 C^{-1} NC^{-1}
d. 1.3×10^5 N.m^2 C^{-1} (e) 0.3×10^5 N.m^2 C^{-1}.

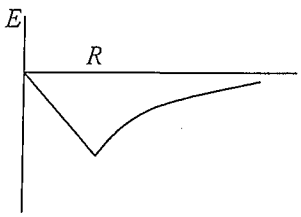
5. How much is the force on a proton 4 μm away from the center of a dipole whose dipole moment is 8×10^{-24} Cm.

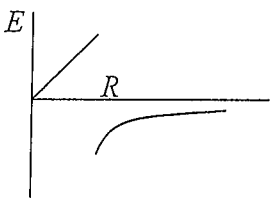
a. 9.0×10^{-13} N b. 2.2×10^3 N c. 1.2×10^3 N
(d) 3.6×10^{-16} N e. other than that

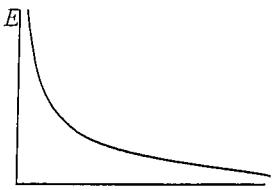
6. Which of the following figure describes the electric field inside and outside a solid spherical non-conducting ball with radius R and negative charge q distributed uniformly?

a.


b.


(c.)


d.


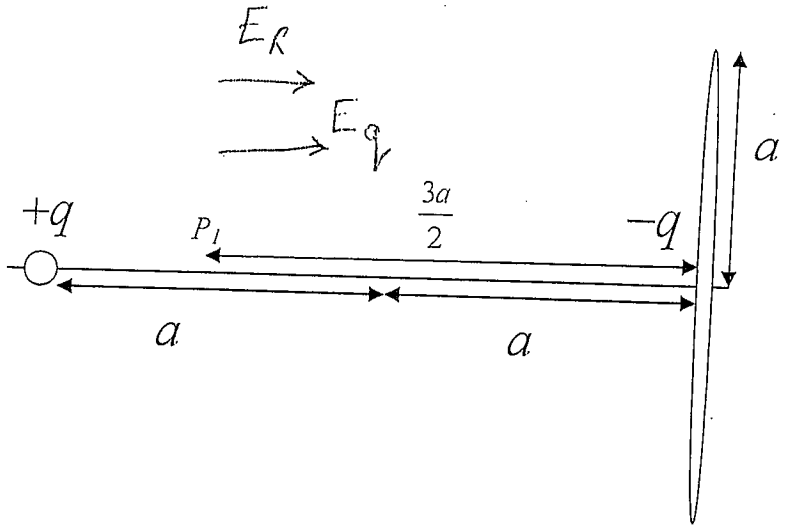
e.


Problems:

1. A ring with radius a of uniform negative charge $-q$ is at a distance $2a$ from a positive charge $+q$ laying along the axis of the ring. Find the net electric field due to the ring and the positive charge at point p_1 at distance $\frac{3a}{2}$ from the ring.

   Take $a = 3$ cm, $q = 3\mu C$.

   (4 marks)



$$E = E_R + E_q$$

$$= \frac{q \frac{3a}{2}}{4\pi\varepsilon_0\left(\frac{9a^2}{4} + a^2\right)^{3/2}} + \frac{1}{4\pi\varepsilon_0}\frac{4q}{a^2}$$

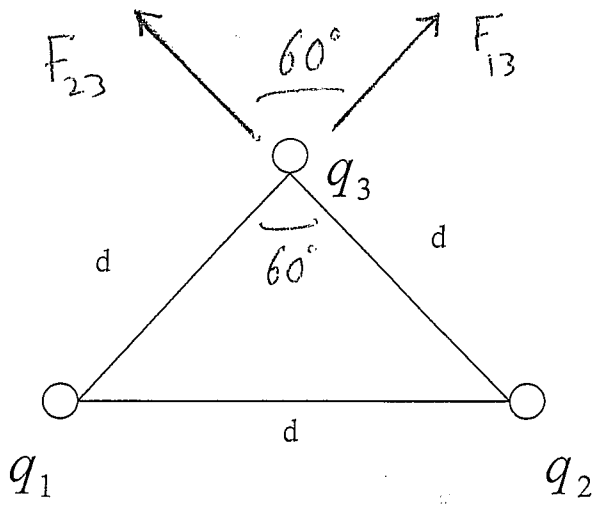
$$= K\frac{12qa}{(13a^2)^{3/2}} + K\frac{4q}{a^2}$$

$$= Kq\left(\frac{12a}{(13a^2)^{3/2}} + \frac{4}{a^2}\right)$$

$$= 128 \times 10^6 \, \hat{i} \; NC^{-1}$$

2. Three charges, $q_1 = q_2 = +5nC$ and $q_3 = +7nC$ are located at the corners of an equilateral (equal sided) triangle with edge length d=3 cm. What is the force on q_3?

(4 marks)



$$F_y = (F_{23} + F_{13}) \cos(30^\circ)$$

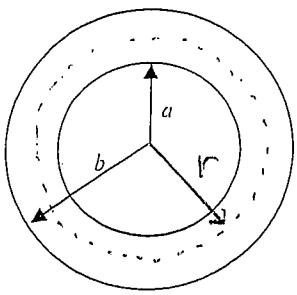
$$= 2K \frac{(5 \times 10^{-9})(7 \times 10^{-9})}{(3 \times 10^{-2})^2} \cos(30^\circ)$$

$$= 6.1 \times 10^{-4} \hat{j} \ N$$

3. **a.** What is the electric field inside a non-conducting spherical shell of an inner radius a and an outer radius b? The volume charge density through the shell is non-uniform with $\rho = \frac{(r^3 - a^3)}{r^3} c$, where c is a constant, in terms of C/m^3 and r is the distance from the center of the sphere.

b. What is the electric field at the surface of the sphere?
Express your results in terms of ε_0, a and b.

(6 marks)



a) $\varepsilon_0 \oint E \cdot dA = q_{enc}$

$$\varepsilon_0 E 4\pi r^2 = \oint \frac{r^3 - a^3}{r^3} c \; 4\pi r^2 dr$$

$$\varepsilon_0 E r^2 = c \int_a^r r^2 dr - c \int_a^r \frac{a^3 dr}{r}$$

$$= \frac{c}{3}(r^3 - a^3) - c a^3 (\ln r - \ln a)$$

$$\therefore E = \frac{c(r^3 - a^3)}{3\varepsilon_0 r^2} - \frac{c a^3}{\varepsilon_0 r^2} \ln\left(\frac{r}{a}\right) \text{ at } r$$

b) $$E_s = \frac{c(b^3 - a^3)}{3\varepsilon_0 b^2} - \frac{c a^3}{\varepsilon_0 b^2} \ln\left(\frac{b}{a}\right) \text{ at } b$$