Problems: Week 4

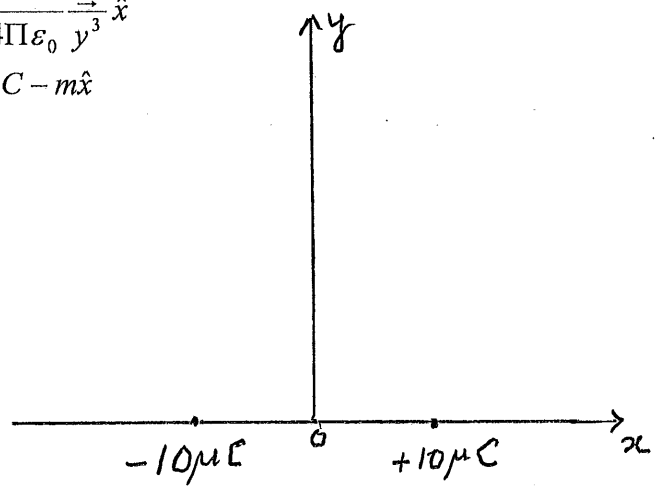
4-1. You are given a charge q and a device to measure force. How would you discover presence of an $\underrightarrow{E}$ - field.

4-2. A point charge is located at r = 0 and produces an $\underrightarrow{E}$ - field. of $-100N/C\hat{r}$ at $\underrightarrow{r} = 2m\hat{r}$. (i) What is the charge? (ii) What is the magnitude and direction of $\underrightarrow{E}$ at $\underrightarrow{r} = 4m\hat{x}$?

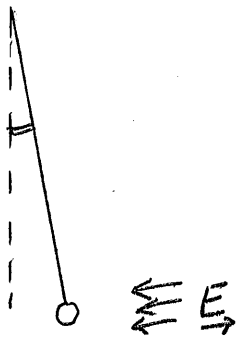
4-3. A dipole is located on the x-axis as shown. Charges of $\mp\ 10\mu C$ fixed at $\mp 0.01m$. Show that at y very large (y >> 0.1m) the $\underrightarrow{E}$ field is

$$\underrightarrow{E} = -\frac{1}{4\Pi\varepsilon_0}\frac{\underrightarrow{p}}{y^3}\hat{x}$$

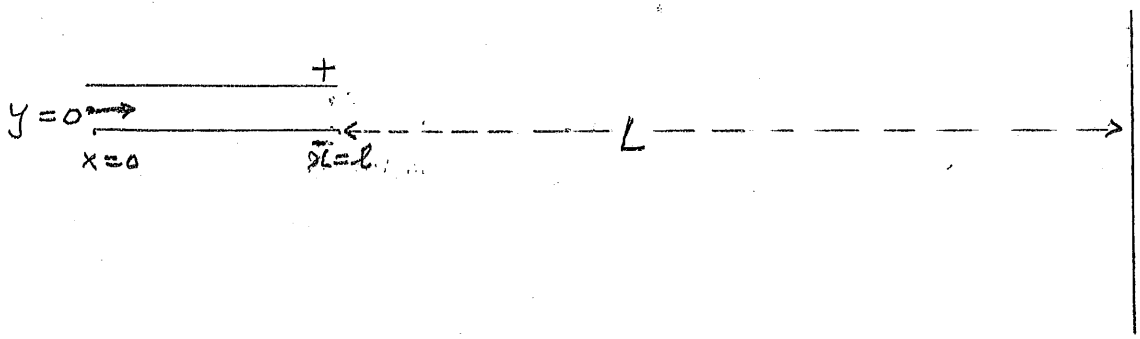
Where $\underrightarrow{p} = 2\times10^{-7}C - m\hat{x}$



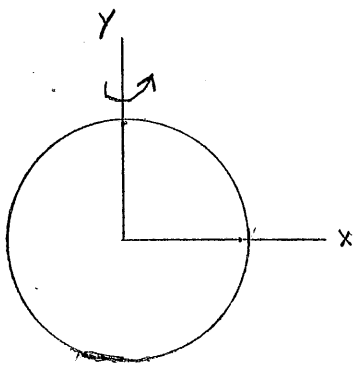
4-4. A small sphere of mass 0.001kg and charge q is hanging at an angle of 10° with respect to the vertical in a constant $\underrightarrow{E}$ field of $-100N/C\hat{x}$.
(i) Is q positive or negative? Why? (ii) What is the magnitude of q?



4-5. Shown are two parallel plates which produce a constant $\underrightarrow{E} = -50N/C\hat{y}$, for $0 \le x \le 0.15m$. At x = 0, y = 0 an electron with velocity $\underrightarrow{v} = 10^7 m/\text{sec}\ \hat{x}$ is introduced between the plates.
(i) What is the acceleration of the electron? (ii) What is the velocity when $x = l$? (iii) What is its position when $x = l$? (iv) Where will it go and hit a screen which is located at $L = 1m$? (incidentally, this device is used to move electrons across the screen of an oscilloscope/TV) *Neglect gravity*



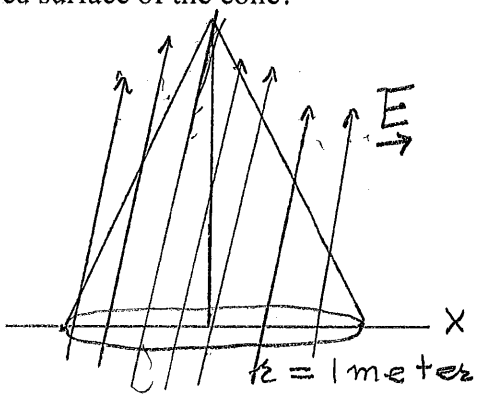
4-6. A flat disk of radius 1m is rotated about the y-axis in a region where a constant $\underrightarrow{E} = 60N/C\ \hat{x}$ is present. Calculate the maximum and minimum flux of $\underrightarrow{E}$ through the disk.



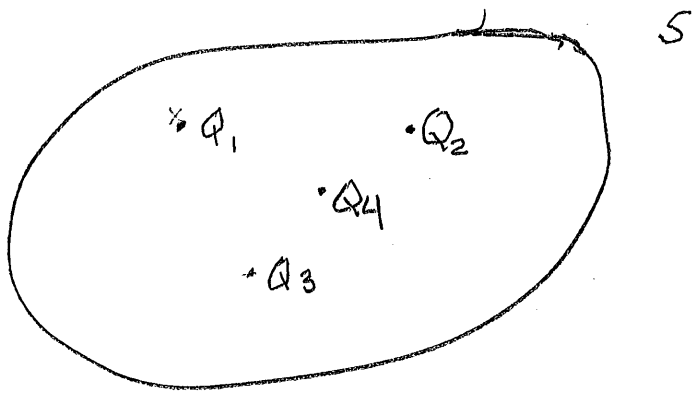
4-7. A point charge Q is located at the origin (r = 0). Knowing that $\underrightarrow{E}$ - field lines can only stop/start at a charge, show that the total flux of $\underrightarrow{E}$ through any closed surface enclosing Q is

$$\Sigma_c \underrightarrow{E} \cdot \underrightarrow{\Delta A} \equiv \frac{Q}{\varepsilon_0}$$

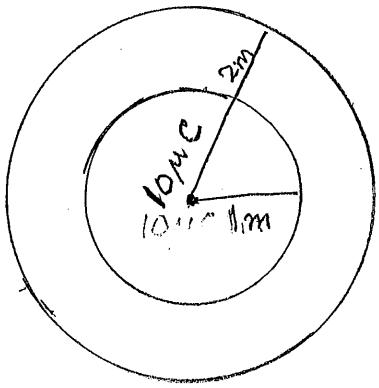
4-8. Shown is a cone lying in a uniform $\underrightarrow{E}$ field of magnitude 30N/C directed at an angle of 30° with respect to the cone axis (y-axis).
(i) Are there any sources/sinks of $\underrightarrow{E}$ inside the cone? Why? (ii) What is the flux of $\underrightarrow{E}$ through the curved surface of the cone?



4-9. Inside a closed shell S the following charges are located
$Q_1 = 10\mu C$, $Q_2 = 20\mu C$
$Q_3 = 30\mu C$, $Q_4 = -60\mu C$
(i) What is the total flux of $\underrightarrow{E}$ through S? Why? (ii) What is the $\underrightarrow{E}$ - field at any point on S? Why?



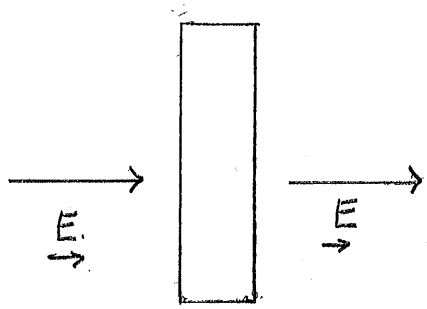
4-10. Shown is a conducting sphere with internal radius 1m and external radius 2m. If there is a charge of $10\mu C$ located at the center of the sphere (r = 0) what charges will appear on its surfaces and what are the $\underrightarrow{E}$ fields at r < 1m and r > 2m?



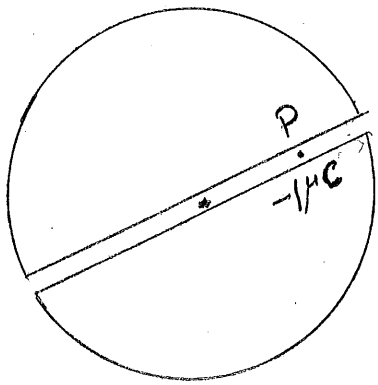
4-11. A conducting sphere of diameter $1m$ carries a charge of $100\mu C$. Under stationary conditions, where would this charge be located? Why?

4-12. In problem 4-11, what would be the force experienced by a point charge of $1\mu C$ if it was located at
(i) $0.49m$ (ii) $0.51m$ from the center of the conducting sphere? Why?

4-13. A conductor of thickness d is placed in a uniform $\underrightarrow{E}$-field, $\underrightarrow{E}$=100N/C $\hat{x}$ as shown. Under stationary conditions what are the charge densities that appear on its surface? Why?



4-14. An insulating sphere of radius 1m has a small diametric hole in it as shown. It carries a charge of 50 μC uniformly distributed over its volume. If we release a charge q=-1 μC at the point P what will be the motion of q? Why?



4-15. What is a conservative force? Give one example.