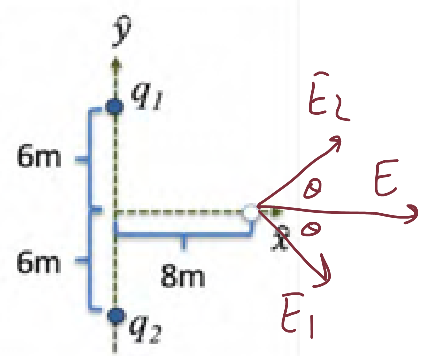
Exam 1 (Questions only):

1) A charge q_1 = 10nC is placed on the positive y-axis at $\vec{r}_1$=(0,6m,0), and another charge q_2 = 10nC is placed on the negative y-axis at $\vec{r}_2$=(0,-6m,0). The x-component of the electric field at $\vec{r}$=(8m,0,0) is :



$|E_1| = |E_2| = \frac{kq}{r^2} = \frac{9\times10^9 \cdot 10^{-8}}{100} \frac{N}{C} = 0{,}9\ N/C$ (r^2: 10 m)

$E_x = |E| = 2|E_1|\cos\theta \cong 1{,}4\ N/C$ ($\cos\theta$: 8/10)

2) A fully ionized Pb nucleus (mass m = 3.5 * 10^{-25} kg, charge +82 e) is released from rest in a uniform electric field (ignore gravity). After 5 seconds, the nucleus is moving at a speed of 2 * 10^6 m/s. The magnitude of the electric field is :

$82e = 1{,}3\times10^{-17}\,C$

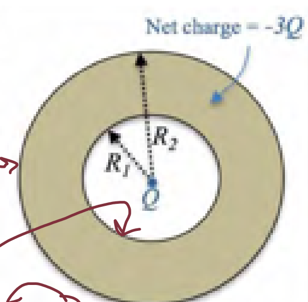
$v = at = qEt/m \rightarrow E = \frac{mv}{qt} = 0.011\ V/m$

3) You hold a plate of area A inside a uniform electric field such that the normal vector of its plane makes an angle of 30 degrees with the field lines. You measure an electric flux of 25 Vm through the plate. You then rotate the plate such that it is still fully immersed in the field but its normal vector is parallel to the field lines. The new flux is :

Flux= 25 Vm　　after rotation Flux = ?

$\Phi_1 = EA\cos 30°,\ \Phi_2 = EA \Rightarrow \Phi_2 = \frac{25\,Vm}{\cos 30°} = 29\,Vm$

4) A point charge Q is placed at the center of a conducting spherical shell with inner radius R_1 and outer radius R_2. The total charge on the shell is -3Q. The charge on the outer surface of the shell (at r= R_2) is equal to :



$-2Q$

$-2Q$

$-Q$

5) A solid insulating sphere of radius R is uniformly charged with total charge Q and placed at the origin. Use Gauss' law to determine the electric field for a radius r < R. The answer is :

6) A thin circular ring of radius R and uniformly distributed charge Q is placed in the x-y-plane, with its center at the origin. The electric potential of the ring along the z-axis is given by $V(z) = kQ/\sqrt{z^2 + R^2}$. The electric field on the z-axis is given by :

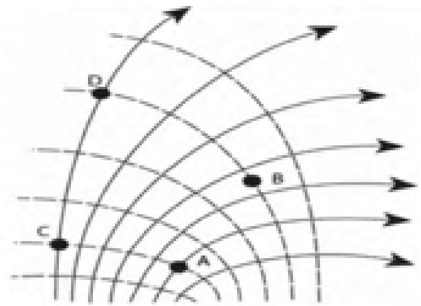
$E = -\nabla V \Rightarrow E_z = \frac{-\partial V}{\partial z} = \frac{kQ}{2}\frac{2z}{(z^2+R^2)^{3/2}} = \frac{kQz}{(z^2+R^2)^{3/2}}$

$Q_{in} = \rho \cdot \frac{4}{3}\pi r^3 = Q\, r^3/R^3$

$E \cdot \underbrace{A}_{4\pi r^2} = Q_{in}/\epsilon_0$

so $E = \frac{Qr}{4\pi\epsilon_0 R^3} = \frac{kQr}{R^3}$

7) A configuration of electric field lines (solid lines) and corresponding equipotential surfaces (dashed lines) is shown on the right.

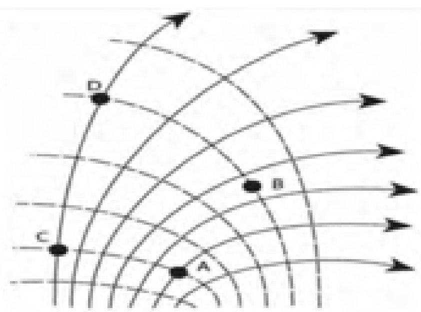


The work done by the electric force when a positive charge q is moved from A to B, W_{AB}, is related to the work done for the same charge to move from C to D, W_{CD}, as :

- $W_{AB} > W_{CD}$
- $W_{AB} = W_{CD}$
- $W_{AB} < W_{CD}$
- not uniquely determined.

ΔV = same for same two equipotentials

8) A configuration of electric field lines (solid lines) and corresponding equipotential surfaces (dashed lines) is shown on the right.



Comparing the potentials at points C and D, one has :

- $V_D > V_C$
- $V_D = V_C$
- $V_D < V_C$
- not uniquely determined.

$\Delta V = -\int \vec{E} \cdot d\vec{s}$ so

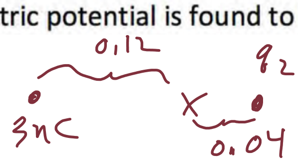
V slopes downhill along $\vec{E}$ direction

9) In electrostatic equilibrium, the electric potential inside a conductor is :

- always zero.
- always a constant.
- increases from the negatively charged surface to the positively charged surface.
- decreases from the negatively charged surface to the positively charged surface.

$E = 0$ so $\Delta V = -\int E \cdot ds = 0$

10) A positive charge q_1=3nC is located at the origin, and an unknown charge q_2 at x_2= 0.16m. The electric potential is found to be zero at x=0.12m. The value of q_2 is :

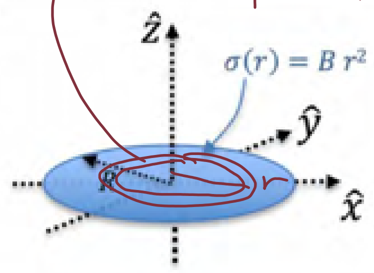


$V = \sum \frac{kQ}{r} \Rightarrow \frac{\cancel{k}(3nC)}{0{,}12m} + \frac{\cancel{k}(q_2)}{0{,}04m} = 0$

$q_2 = -3nC\left(\frac{0.04}{0{,}12}\right) = -1nC$

$$dq = \sigma dA = \sigma 2\pi r dr = B \cdot 2\pi r^3 dr$$

11) A thin circular disk of radius R has a surface charge density of sigma = B r^2 with B given. The potential of the disk at its center (that is, at the origin) is given by :



$$V = \sum \frac{kq}{r} = \int \frac{k\,dq}{r} = \int_0^R \frac{k \cdot 2\pi B r^3 dr}{r}$$

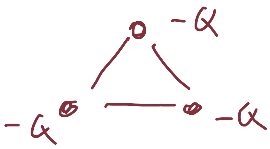
$$= 2\pi k B \, R^3/3$$

$K_0 = 0$

12) An electron (charge q = -e) is placed in a static electric field at a point P_0 where the electric potential is +12 V. The electron is released from rest. It then reaches a point P_1 where it is observed to have a kinetic energy of $4.2*10^{-18}$ J. Calculate the electric potential at P_1.

$$\Delta U + \Delta K = 0 \rightarrow \Delta U = -\Delta K = -4.2\times10^{-18}\,J = (-e)\Delta V$$

13) Three equal negative point charges, -Q, are placed on the corners of an equilateral triangle with sides of equal length D. The electric potential energy stored in this system is :



$$U = k\sum \frac{Q_i Q_j}{R_{ij}}$$

$$= 3\times k(-Q)^2/D$$

$$= 3kQ^2/D$$

$$\text{so } \Delta V = \frac{-4.2\times10^{-18}\,J}{-1.6\times10^{-19}\,C} \cong 26\,V$$

$$V_F = V_0 + \Delta V = 12V + 26V$$

$$= 38\,V$$