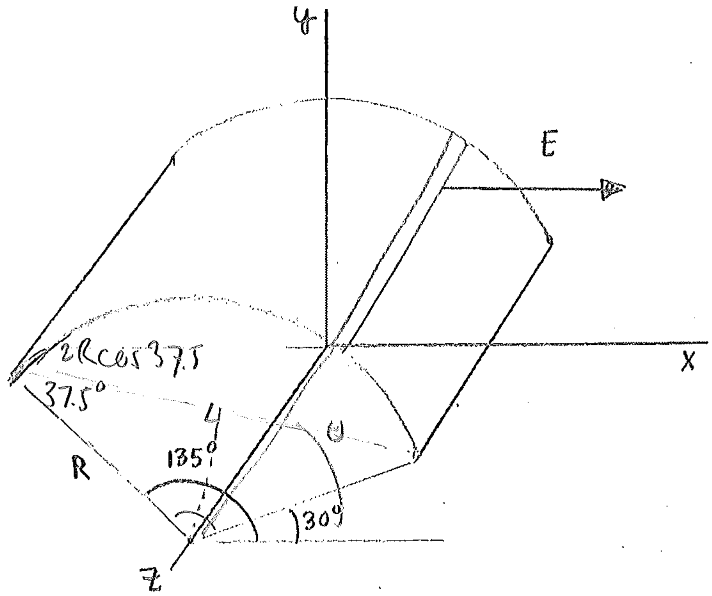
Solutions

Physics 161 Fall 2010 Exam 4



$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\hat{r}$$

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

$$\oint \vec{E}\cdot d\vec{A} = \frac{q_{enc}}{\varepsilon_0}$$

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

$$E_x = -\frac{\partial V}{\partial x}$$

$$W = -q\Delta V$$

$$\frac{1}{4\pi\varepsilon_0} = 9\times 10^9\ \frac{\text{Nm}^2}{\text{C}^2}$$

$$\varepsilon_0 = 8.85\times 10^{-12}\ \frac{\text{C}^2}{\text{Nm}^2}$$

1&2] What is the flux of a uniform electric field of 6600 N/C in the +x direction, through the section of pipe shown above. The radius and length of the pipe section are 12 m, and the pipe begins at an angle of 30° to the x-axis and ends at 135° to the x-axis. Answer in Nm^2/C.

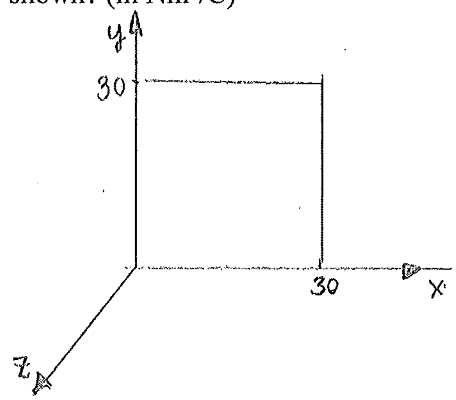
$$\Phi = \int \vec{E}\cdot d\vec{A} = E\int_{30}^{135} LR\,d\theta\cos\theta = ELR\sin\theta\Big|_{30}^{135} = 0.207\,ELR$$

$$= 2\times 10^5\ \text{Nm}^2/\text{C}$$

(OR) Note Φ is same as flat surface at 82.5°

$A = 2R\cos 37.5\cdot L$ $\quad \vec{E}\cdot\vec{A} = E\cdot 2RL\cos 37.5°\cdot\cos 82.5° = 2\times 10^5\ \text{Nm}^2/\text{C}$

3&4] What is the flux of the electric field $\vec{E} = 5\hat{\imath} + 7y\hat{\jmath} + 4x\hat{k}$ through the flat 30 m x 30 m surface shown? (in Nm^2/C)



$$\int \vec{E}\cdot d\vec{A} = \int_0^{30}\int_0^{30} 4x\,dx\,dy$$

$$= 2x^2y\Big|_0^{30}\Big|_0^{30} = 5.4\times 10^4\ \frac{\text{Nm}^2}{\text{C}}$$

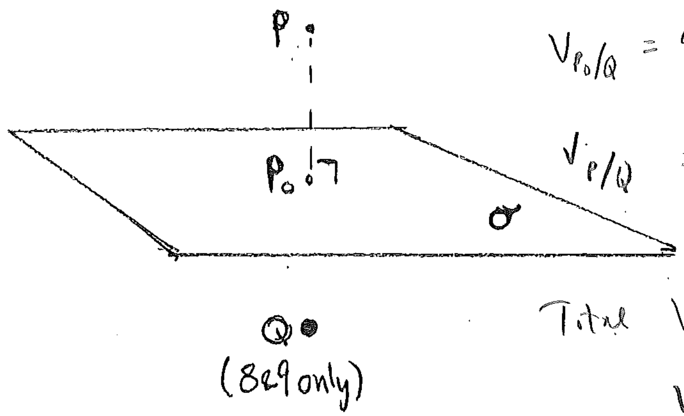
5&6] Consider an infinite insulating sheet of uniform **negative** charge density -0.04 C/m^2. What is the magnitude of the potential difference (in V) between a point in the sheet, P_0, and a point 0.5 m above the sheet, P?

$E = \frac{\sigma}{2\varepsilon_0} = 2.26\times10^9$ $\Delta V = E\cdot\Delta x = 1.1\times10^9$ V.

7] Moving from point P_0 to point P, does the potential go up or down? A] up B] down C] stays the same.

8&9] Now, a point charge Q = +0.1 C is placed 0.5 m below the sheet, directly below P_0 and P. What is the magnitude of the potential difference between P and P_0 now? (in V)

Take $V_s = 0$ at P_0. $V_{P/S} = 1.1\times10^9$ V



$V_{P_0/Q} = \frac{9\times10^9\cdot 0.1}{0.5} = 1.8\times10^9$ V

$V_{P/Q} = 0.9\times10^9$ V.

Total $V_P = 0.9 + 1.1 = 2.0\times10^9$ V

$V_{P_0} = 1.8 + 0 = 1.8\times10^9$ V

$\Delta V = 0.2\times10^9$ V $= 2\times10^8$ V.

10&11] An electric field is given by $\vec{E} = (80x + 20)\hat{i}$. What is the magnitude of the potential difference between x=0 and x=5 m (in V)?

$\Delta V = -\int \vec{E}\cdot d\vec{l} = -\int_0^5 (80x+20)\,dx = -(40x^2+20x)\Big|_0^5 = -1.1\times10^3$ V.

12] An electric potential is given by V = 2000x^2, with x in meters and V in volts. What is the direction of the electric field at x = -5 m?

A] +x B] –x C] There is no field at x=-5 m.

$E_x = -\frac{\partial V}{\partial x} = -4000x$

at $x=-5$ $E_x = 20{,}000$

13&14] What is the magnitude of the electric field in Q12 in N/C?

2×10^4 N/C

15&16] In Q12, a charge of +8 C is released from x=-5. What is its kinetic energy when it reaches x=0? (If it never reaches x=0, enter [0,0])

4×10^5 J $= -q\Delta V$