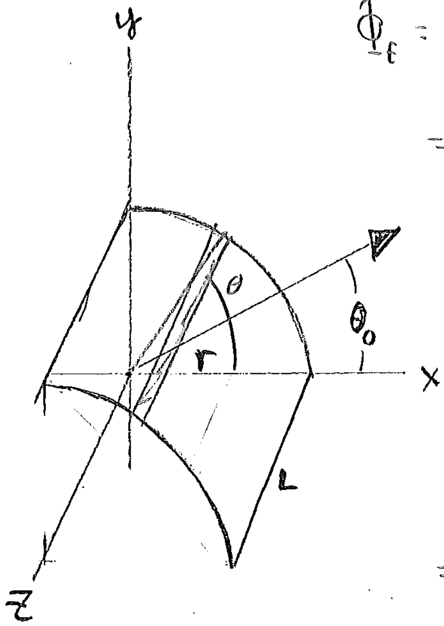
Physics 161 Fall 2010 Exam 4

1&2] What is the flux of a uniform electric field of 3320 N/C directed at an angle of 26° above the x-axis, parallel to the xy plane, through the quarter-pipe shown, with L=10 m and r=2 m (in Nm^2/C)?



$$\Phi_E = \int \vec{E} \cdot d\vec{A}$$

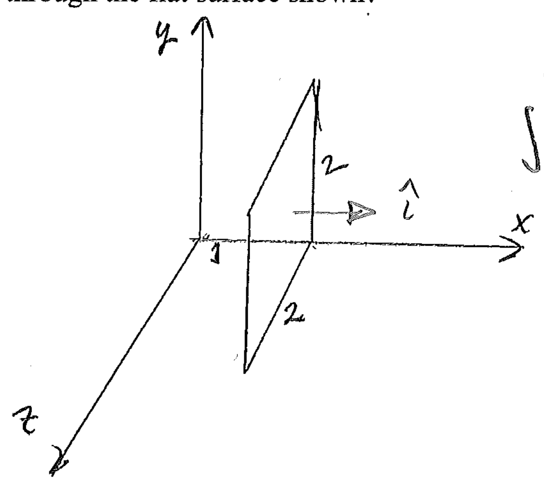
$$= \int E(L\,r\,d\theta)\cos(\theta - \theta_0) \qquad \text{let } \alpha = \theta - \theta_0,\ d\alpha = d\theta$$

$$= \int_{-\theta_0}^{90^\circ - \theta_0} ELr \cos\alpha \, d\alpha$$

$$= ELr \sin\alpha \Big|_{-\theta_0}^{90^\circ - \theta_0}$$

$$= ELr \cdot (0.90 + 0.44) = 1.34 \cdot ELr = 9 \times 10^4 \ \frac{Nm^2}{C}$$

3&4] What is the flux of the electric field E=(30z+x)$\hat{\imath}$ + (40y+z)$\hat{\jmath}$ + 35x$\hat{k}$ (in N/C) through the flat surface shown?



$$d\vec{A} = dy\,dz\,\hat{\imath}$$

$$\int \vec{E} \cdot d\vec{A} = \iint (30z + x)\,dy\,dz$$

$$= 30 \frac{z^2}{2}\Big|_0^2 \, y\Big|_0^2 + x \underbrace{\int dy\,dz}_{A}$$

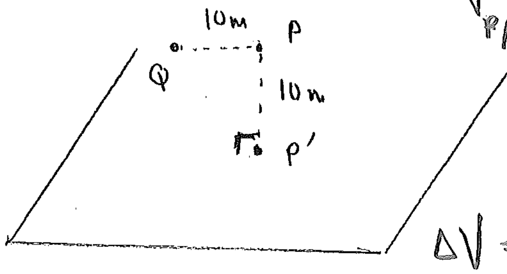
$$= 60 \cdot 2 + 1 \cdot 4$$

$$= 128 \ \frac{Nm^2}{C}$$

5&6] Consider an infinite insulating sheet of charge of charge density 0.003 C/m^2. What is the difference in electrical potential (in Volts) between a point in the sheet, P' and a point 10 m above the sheet, P?

$\Delta V = -\int \vec{E} \cdot d\vec{l} \quad E = \frac{\sigma}{2\epsilon_0} \quad \text{so } \Delta V = \frac{\sigma L}{2\epsilon_0} = \frac{2\pi\sigma L}{4\pi\epsilon_0} = 1.7\times10^9 \text{ V.}$

7&8] Suppose now that a point charge of Q=0.001 C is placed 10 m to the left of point P. Now, what is the difference in potential of these two points?



$V_{P/Q} = \frac{kQ}{r} = \frac{9\times10^9 \cdot 0.001}{10} = 9\times10^5$

$V_{P'Q} = \frac{kQ}{r} = \frac{9\times10^9 \cdot 0.001}{\sqrt{2}\ 10} = 6.4\times10^5$

$\Delta V = 2.6\times10^5$ V.

$\Delta V = 1.7\times10^9 - 2.6\times10^5$ V

On the real exam, the sheet might be a line of charge. (note sign here!)

9&10] An electric field is given by E = 40xî. (in N/C) What is the difference in potential between x=0 and x=3, in V?

$\Delta V = -\int \vec{E} \cdot d\vec{l} = \int 40x \cdot dx = 20x^2 \Big|_0^3 = 180\text{V.}$

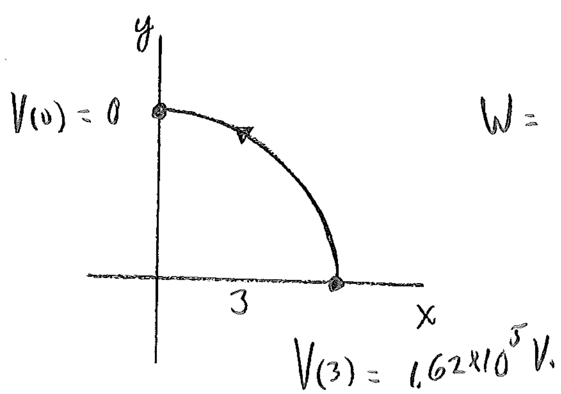
11] An electric potential is given by V=6000x^3 in volts, x in meters. What is the electric field direction at x=-3 m?

A] + B] - C] E=0.

$E_x = -\frac{dV}{dx} = -3 \cdot 6000\, x^2 = -1.62\times10^5$

12&13] What is the magnitude of the electric field in problem 7? (in N/C)

14&15] A charge is moved along the quarter circle path shown, from x = 3 m to y=3 m. How much work (in J) does the electric field do on the charge, Q=6 C?



$W = Q\Delta V = 9.7\times10^5$ Joules