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7. A surface element of area  $dA = 4.8 \times 10^{-6} \text{ m}^2$  has normal  $\hat{n}$  along  $(-3, 1, 4)$ . For this element,  $\vec{E} = (250, 180, -80) \text{ V/m}$ .

a. (5 pts) Find  $\hat{n}$ .

$$\hat{n} = \frac{(-3, 1, 4)}{\sqrt{9+1+16}} = \frac{(-3, 1, 4)}{5.10} = (-0.588, 0.196, 0.784)$$

c. (5 pts) Find the flux  $d\Phi_E$  through  $dA$ . ( $\frac{V}{m}$ )

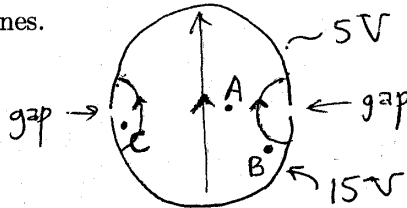
$$d\Phi_E = \vec{E} \cdot \hat{n} dA = (-147 + 35.3 - 62.7) \cdot 4.8 \times 10^{-6} \text{ m}^2 = (-174.4) \frac{V}{m} \cdot 4.8 \times 10^{-6} \text{ m}^2 = -8.37 \times 10^{-4} \text{ V}\cdot\text{m}$$

d. (5 pts) Find how much charge  $dQ_S$  will produce this  $d\Phi_E$ .

$$d\Phi_E = 4\pi k dQ, \quad dQ = \frac{d\Phi_E}{4\pi k} = -7.41 \times 10^{-15} \text{ C}$$

8. The figure gives the cross-section of a conductor that is infinitely long perpendicular to the page.

a. (5 pts) Sketch the field lines.

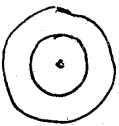


b. (5 pts) At which of the labeled points is the field the largest? the smallest?

C. A.

9. A charge  $Q$  at the origin is surrounded by two concentric spherical conducting shells. The one at radius  $b$  has charge  $-3Q$  and that at radius  $2b$  has charge  $4Q$ .

a. (5 pts) In terms of  $Q$  and  $b$ , find the charge per unit area on the shell at  $r = b$ .



$$\sigma = \frac{-3Q}{4\pi b^2}$$

b. (5 pts) In terms of  $Q$  and  $b$ , and using Gauss's Law and symmetry, find the magnitude and direction of the field for  $b < r < 2b$ .

$$\text{Use } E_r = \frac{k Q_{enc}}{r^2}, \quad \text{where } Q_{enc} = Q - 3Q = -2Q$$

$$\text{So } E_r = \frac{-2kQ}{r^2} \quad \text{radially inward}$$

c. (5 pts) Repeat for  $r > 2b$ .

$$\text{Use } E_r = \frac{k Q_{enc}}{r^2}, \quad \text{where } Q_{enc} = Q - 3Q + 4Q = 2Q$$

$$\text{So } E_r = \frac{2kQ}{r^2} \quad \text{radially outward}$$