Hwk 3 Solutions PHYS 142 Summer '09 Dr. Jenkins

Problem 25.4

using

$$V_B - V_A = -\int_A^B \vec{E} \cdot d\vec{s}$$

split the path into its component parts; noting that:

$$\vec{E} \cdot d\vec{s} = \vec{E} \cdot (d\vec{x} + d\vec{y}) = -E \cancel{\cos 90}^{0} dx - E \cancel{\cos 180}^{-1} dy$$

$$\Rightarrow V_B - V_A = E \int_{-0.30}^{0.50} dy = 325\ V/m\ (0.80\ m) = 260\ V\ (+)$$

Problem 25.5

use energy conservation to find ΔU:

$$\Delta U = -\Delta K = -\frac{1}{2} m (v_f^2 - v_o^2) \quad \text{absorb (-) sign}$$

$$= -\frac{1}{2}(9.11 \times 10^{-31}\ kg)\left[(3.70 \times 10^6\ m/s)^2 - (1.40 \times 10^5\ m/s)^2\right]$$

$$= 6.23 \times 10^{-18}\ J$$

$$\Delta U = q\Delta V \Rightarrow \Delta V = \frac{\Delta U}{q} = \frac{6.23 \times 10^{-18}\ J}{-1.609 \times 10^{-19}\ C}$$

$$\Delta V = -38.9\ V$$

$x = 0$ is at higher potential

Problem 25.11

(a) $$V_1 = \frac{kq}{r} = \frac{(8.99 \times 10^9)(1.609 \times 10^{-19}\ C)}{0.01\ m} = 1.44 \times 10^{-7}\ V$$

(b) potential at 2 cm is ½ that at 1 cm b/c dependence on distance is inverse and linear

$$\Rightarrow V_2 = \frac{1}{2}(1.44 \times 10^{-7}\ V) = 7.19 \times 10^{-8}\ V$$

$$\Rightarrow \Delta V = V_2 - V_1 = -7.19 \times 10^{-8}\ V$$

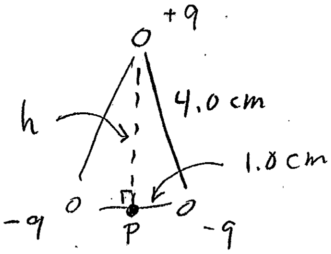
(Prob 25.11) cont.

(c) only the signs will change for an electron

$V_1 = -1.44\times10^{-7}\,V$; $V_2 = -7.19\times10^{-8}\,V$

$\Delta V = 7.19\times10^{-8}\,V$

Problem 25.15



$V = \frac{kq}{r}$

contribution from each charge depends only on value of q, sign of the charge, and the distance:

$h = \sqrt{4.0^2 - 1.0^2}\ cm = \sqrt{15}\ cm \simeq 3.87\ cm$

$\Rightarrow V_P = (8.99\times10^9)(7.00\times10^{-6}\,c)\left[2\left(\frac{-1}{0.01m}\right) + \frac{1}{0.0387m}\right]$

$V_P = -1.10\times10^7\,V$

Problem 25.30

(a) $V = \frac{kQ}{R}$ is a constant value with respect to r:

$E_r = -\frac{dV}{dr} = -\frac{d}{dr}\left(\frac{kQ}{R}\right) = 0$; good since field inside a conductor is always zero

(b) $E_r = -\frac{dV}{dr} = -\frac{d}{dr}\left(\frac{kQ}{r}\right)$

$E_r = \frac{kQ}{r^2}$ (negatives cancel)

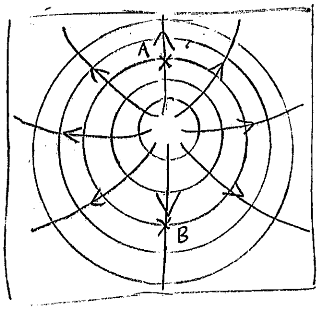
Problem 25.32

(a) the closer the equipotential lines are to each other, the steeper the potential gradient, ∇V. since $|E| = \nabla V$, then the field magnitude is larger at A b/c the gradient of V is greater at A.

(b) Since the spacing and scaling of the equipotential lines are constant at B and the values of all are known, we can calculate the value of the field at B. (use Δs along line between A and B):

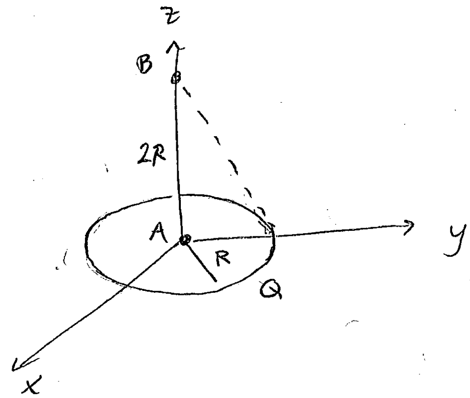
$$\vec{E}_B = -\frac{\Delta V}{\Delta s} = \frac{6V - 2V}{0.02m} = 200\ N/C \text{ downward}$$

(c)



Problem 25.34

I'll do this out the long way so you see all the tricks:



$$V = k\int \frac{dq}{r}$$

for A:

$$dq = \lambda ds = \lambda R\, d\theta \quad ; \quad \lambda = \frac{Q}{2\pi R}$$

$$V_A = k\lambda \cancel{R}\int_0^{2\pi} \frac{d\theta}{\cancel{R}} = k\lambda(2\pi) = k\left(\frac{Q}{2\pi R}\right)(2\pi)$$

$$V_A = \frac{kQ}{R}$$

notice, given uniform charge distribution and const distance from A, the total charge is just Q, as if it were all at one point.

for B:

$$r = \sqrt{R^2 + (2R)^2} = \sqrt{5}\,R \quad (\text{const value})$$

again $dq \rightarrow Q$

$$\Rightarrow V_B = \frac{kQ}{\sqrt{5}\,R}$$

$$\Rightarrow \Delta V = V_B - V_A = \frac{kQ}{R}\left(\frac{1}{\sqrt{5}} - 1\right) \simeq -0.553\,\frac{kQ}{R}$$

Problem 25.35

$$V_A = k \int \frac{dq}{r}$$

$$r = x + d$$

$$dq = \lambda\, dx = \alpha x\, dx$$

$$V_A = k\alpha \int_0^L \frac{x\, dx}{x+d}$$

here's the trick for this integral

$$\frac{x}{x+d} = \frac{x+d-d}{x+d} = \frac{x+d}{x+d} - \frac{d}{x+d} = 1 - \frac{d}{x+d}$$

$$\Rightarrow V_A = k\alpha \left[\int_0^L dx - d \int_0^L \frac{dx}{x+d} \right]$$

$$= k\alpha \left[L - d \ln(x+d) \Big|_0^L \right]$$

$$= k\alpha \left[L - d \ln(L+d) - d \ln d \right]$$

$$= k\alpha \left[L - d \ln\left(\frac{L+d}{d}\right) \right] \qquad \text{recall } \ln a - \ln b = \ln\left(\frac{a}{b}\right)$$

$$V_A = k\alpha \left[L - d \ln\left(1 + \frac{L}{d}\right) \right]$$

Problem 25.39

find fields first, then use $V = \vec{E} \cdot \vec{r}$ to find V.

(a) $r = 10\text{ cm}$ is inside the sphere $\Rightarrow E = 0$

potential inside conductor is constant, same value as surface.

$$V_{10} = \frac{kQ}{R} = \frac{(8.99\times10^9)(26.0\times10^{-6}\text{c})}{0.14\text{m}} = 1.67\times10^6\text{ V}$$

(b) $$\vec{E}_{20} = \frac{kQ}{r^2}\hat{r} = \frac{(8.99\times10^9)(26.0\times10^{-6}\text{c})}{(0.20\text{m})^2}\hat{r} = 5.84\times10^6\text{ N/C}\ \hat{r}$$

$$V_{20} = \vec{E}\cdot\vec{r} = (5.89\times10^6\text{ N/c})(0.20\text{m}) = 1.17\times10^6\text{ V}$$

(Prob 25.39) cont.

(c) field even just at or above surface is still like that of a point charge:

$$\vec{E}_{14} = \frac{(8.99\times10^{9})(26.0\times10^{-6}C)}{(0.14m)^2}\hat{r} = 1.19\times10^{7}\ N/C\ \hat{r}$$

$$V_{14} = V_{10} = 1.67\times10^{6}\ V \quad (\text{same as (a)})$$

Problem 25.40

first just find charge needed to create potential:

$$V = \frac{kq}{r} \Rightarrow q = \frac{Vr}{k} = \frac{(7.50\times10^{3}\ V)(0.30m)}{8.99\times10^{9}}$$

$$q = 2.50\times10^{-7}\ C$$

how many electrons? just divide by e (note need to create a positive charge, which is why we take away electrons)

$$\# = \frac{2.5\times10^{-7}C}{1.609\times10^{-19}\ C/e^-} = 1.56\times10^{12}\ e^-$$

Need over 1.5 trillion elections removed