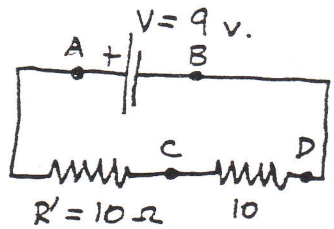
Physics 8B (Sec 2) <u>Solutions to First Exam</u> Oct. 10, 1986

(1) (a) We see that the total potential difference $V \equiv V_A - V_B$ is given by $V \equiv V_A - V_B = V_1 - V_2 + V_3 = 6 - 3 + 6 = 9$ volts. Then the resistance R' of the parallel combination is

$$\frac{1}{R'} = \frac{1}{30} + \frac{1}{30} + \frac{1}{30} = \frac{3}{30} \Rightarrow 3R' = 30 \text{ ohms} \Rightarrow R' = 10 \text{ ohms}$$

The circuit therefore reduces to



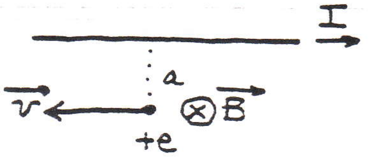
The current at point C is $\boxed{I = (V/20) = (9/20) = 0.45 \text{ amperes}}$

(b) Since $V_A - V_B > 0$, $V_A > V_B$, meaning point A is at a higher potential than point B. Since positive charge moves "naturally" from higher to lower potential, the conventional current flows counterclockwise around the circuit, or <u>to the right at point C.</u>

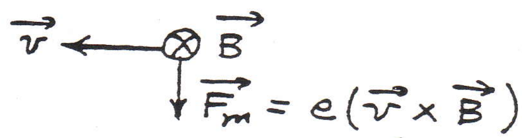
(c) Since $V = IR$, $(V_C - V_D) = I(10) = (0.45)(10) = \underline{4.5 \text{ volts}}$ and is <u>positive</u> since the potential at A is higher than the potential at B, so the potential at C is higher than the potential at D.

(d) Since $V_2 \equiv V_F - V_G = 3$ volts, and $V_1 \equiv V_A - V_G = 6$ volts, we have

$$\left.\begin{aligned} V_F - V_G &= 3 \\ -V_A + V_G &= -6 \end{aligned}\right\} \Rightarrow \underline{(V_F - V_A) = -6 \text{ volts}}$$

2. 

From the right hand rule, the magnetic field $\vec{B}$ at the position of the proton is <u>into</u> [$\otimes$] the paper and has a magnitude $B = (\mu_0 I/2\pi a)$. Since the magnetic force $\vec{F}_m = Q(\vec{v} \times \vec{B}) = (+e)(\vec{v} \times \vec{B})$, the direction of $\vec{F}_m$ is given by:



so $\vec{F}_m$ is directed normally <u>away from the wire</u>. (b) The magnitude $F_m = evB\sin\theta$ (where θ is the angle between $\vec{v}$ and $\vec{B}$ and is 90°) so $\boxed{F_m = ev(\mu_0 I/2\pi a) = (ev\mu_0 I/2\pi a)}$.

+Q,

3. <u>To find</u>: $V(r) - V_a = -\int_a^r E\cos\theta\, dr = -\int_a^r E\, dr$ $\left[\text{since } E \text{ is radial, } \theta = 0,\ \cos\theta = 1\right]$

We use Gauss' law to find $E(r)$ in the dielectric between the shells. The electric field in the dielectric will be the electric field without the dielectric, divided by the dielectric cofficient K. The Gaussian surface is a sphere of radius r $(a<r<b)$, so Gauss' Law says

$$EA = \frac{Q}{\epsilon_0} \Rightarrow E(r)[4\pi r^2] = \frac{Q}{\epsilon_0} \Rightarrow E(r) = \frac{Q}{4\pi\epsilon_0 r^2} \text{ (with no dielectric)}$$

so $\boxed{E(r) = \frac{Q}{4\pi\epsilon_0 K}\left(\frac{1}{r^2}\right)}$ with the dielectric present.

$$\text{Then} \quad V(r) - V_a = -\int_a^r E\, dr = -\frac{Q}{4\pi\epsilon_0 K}\int_a^r \frac{dr}{r^2} = -\frac{Q}{4\pi\epsilon_0 K}\left[-\frac{1}{r}\right]_a^r$$

3. (continued)

$$V(r) - V_a = \frac{Q}{4\pi\epsilon_0 K}\left[\frac{1}{r} - \frac{1}{a}\right] \Rightarrow \boxed{V(r) = \left[V_a - \frac{Q}{4\pi\epsilon_0 K a}\right] + \frac{Q}{4\pi\epsilon_0 K r}}$$

is the electrostatic potential at a distance r (where $a \leq r \leq b$) from the common center of the spheres.

To check, if $r = a$, $V(a) = V_a$, the potential on the inner shell, as it should.

(b) For $r > a$, $\left|\frac{Q}{4\pi\epsilon_0 K r}\right| < \left|\frac{Q}{4\pi\epsilon_0 K a}\right|$

$$\Rightarrow \left(-\frac{Q}{4\pi\epsilon_0 K a} + \frac{Q}{4\pi\epsilon_0 K r}\right) < 0$$

$$V_a - \frac{Q}{4\pi\epsilon_0 K a} + \frac{Q}{4\pi\epsilon_0 K r} < V_a$$

$$V(r) < V_a \quad \text{for } r > a$$

so V decreases as one moves away from inner shell.