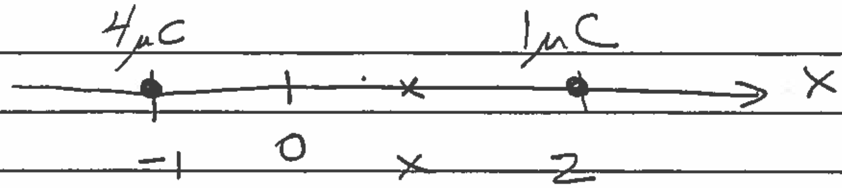
Test 1 S17 PHY 2005

Solutions ①

1)



region I   II   III

In regions I and III, any test charge will experience a nonzero force because the field from both charges will point in same direction, i.e. can't cancel. So put the test charge in region II. E-field is

$$E_{tot} = E_4 + E_1 = \frac{kQ_4}{(x+1)^2} - \frac{kQ_1}{(2-x)^2} = 0$$

$Q_4 = 4\mu C$; $Q_1 = 1\mu C$

$$4(2-x)^2 = (x+1)^2 \Rightarrow 2(2-x) = \pm(x+1)$$

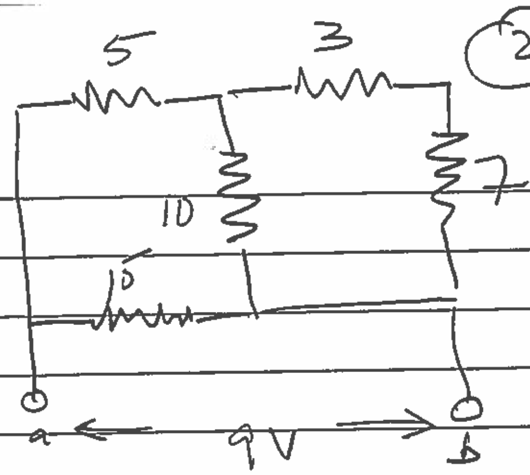
2 solns:
i) $2(2-x) = x+1 \Rightarrow x = 1$ ✓
ii) $2(2-x) = -x-1 \Rightarrow x = 5$ ✗ (outside region II)

$\Rightarrow x = 1$ is correct

2) $\text{current} = \frac{\Delta Q}{\Delta t} = \frac{\text{charge}}{\text{time}}$

$$\frac{\Delta Q}{60\,s} = 6\text{ Amp} \Rightarrow \Delta Q = 360\text{ C}$$

3)



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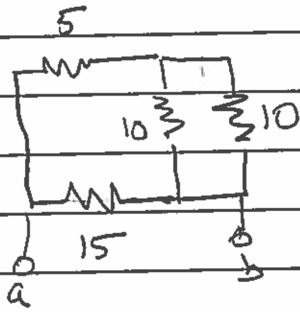

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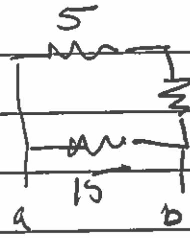

$R_{eq} = 6\Omega$

$\left(\frac{1}{10} + \frac{1}{10} = \frac{1}{R_{eq}}\right)$

$10 = 5 + 5$

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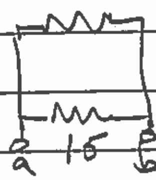
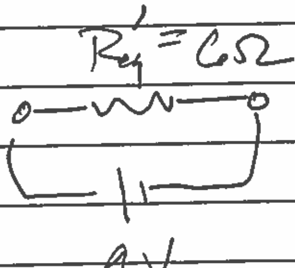


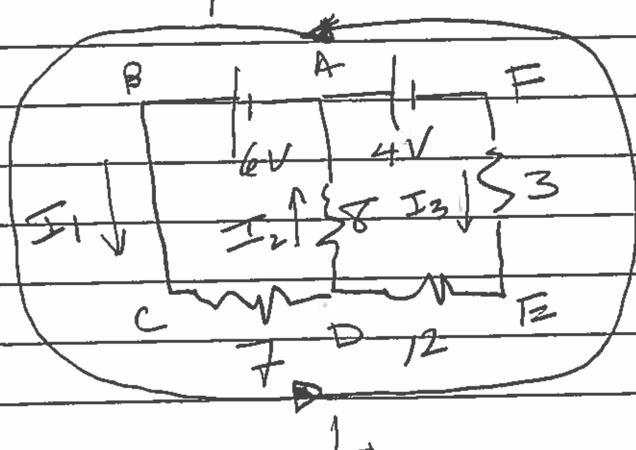
$\frac{1}{R'_{eq}} = \frac{1}{10} + \frac{1}{15} = \frac{5}{30}$

$R'_{eq} = 6\Omega$



$\Rightarrow I = \frac{V}{R} = \frac{9}{6} = 1.5A$

4)



L:

$6 - 7I_1 + 12I_3 + 3I_3 + 4 = 0$

$\Rightarrow 10 - 7I_1 + 15I_3 = 0$

5) E-field pts to left, so a −3 mC charge feels a force to the right regardless of where it is. Thus the statement

"If the charge is placed at D, it will move to the left" is wrong

6) Initially q_1 • ← 5m → • q_2 force $F = 4N$

$$= \frac{k q_1 q_2}{5^2}$$

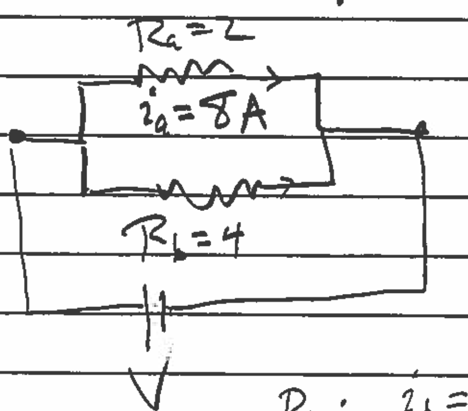
at new separation r, force is

$$F' = 100 N = \frac{k q_1 q_2}{r^2}$$

From initial configuration, we know $k q_1 q_2 = 4 \cdot 25^2 = 100$

So $F' = 100 = \frac{100}{r^2} \Rightarrow \underline{r = 1m}$

7)



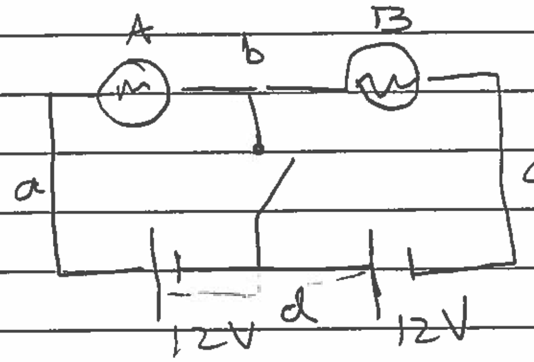
Potential drop across R_a:

$$V = i_a R_a = 8 \cdot 2 = 16V$$

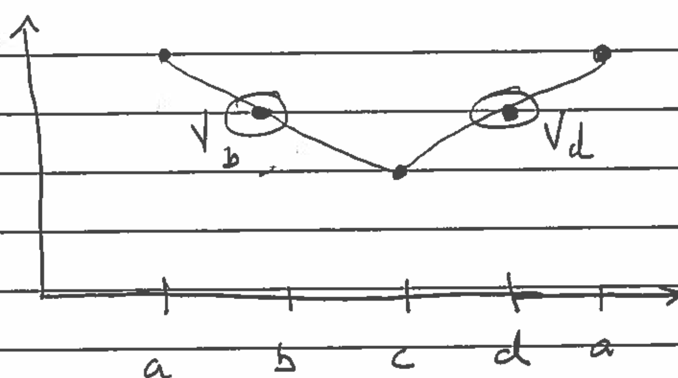
R_b: $i_b = V/R_b = \frac{16V}{4} = 4A$

since V is the same across both.

8) Since bulbs are identical, the voltage drop across both must be the same, 12 V. This means the voltage around the circuit

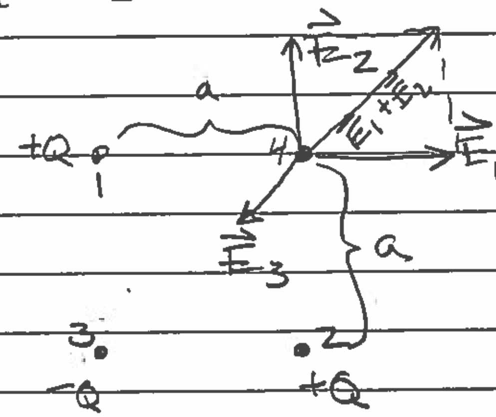


looks like



V_b and V_d are the same; therefore closing the switch doesn't lead to any current flow

9) E-field on charge 4 is the sum of the 3 fields $\vec{E}_1$, $\vec{E}_2$, $\vec{E}_3$.



$\vec{E}_1 + \vec{E}_2$ have magnitude $\frac{kQ}{a^2}$ but they add up to

$$|\vec{E}_1 + \vec{E}_2| = \frac{kQ}{a^2} \cdot \sqrt{2}$$ up and to right (Pythagorean thm)

They are opposed by $\vec{E}_3$ with magnitude $\frac{kQ}{(\sqrt{2}a)^2} = \frac{kQ}{2a^2}$

which pts down and to left

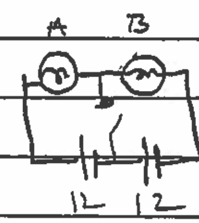
$\vec{E_1} + \vec{E_2}$ wins since $\frac{kQ}{a^2} \cdot \sqrt{2} > \frac{kQ}{a^2} \cdot \frac{1}{2}$

So C is correct

10) when spheres touch they share $1.3\,\mu C + (-0.5\,\mu C) = 0.8\,\mu C$ equally charge because they are identical, So each has $0.4\,\mu C$, At 5 m separation the force is

$$F = \frac{kQ^2}{r^2} = \frac{(9 \times 10^9)(0.4)^2}{5^2}$$

$$= 5.75 \times 10^{-5}\, N$$



11) Total voltage 24 V, total resistance 2R in series circuit

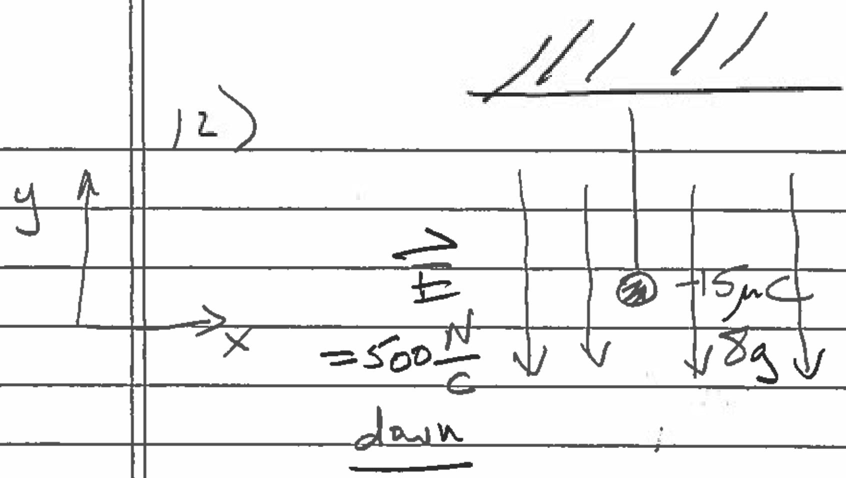
$$\Rightarrow I = \frac{24}{2R} = \frac{12}{R}$$

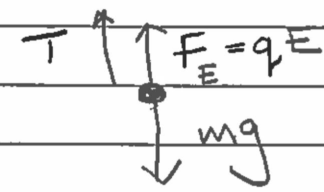
2 bulbs

$$\text{total power} = \frac{12 \cdot 24}{R} = \frac{2 \cdot 144}{R} = 2 \cdot 14.4$$

$$\Rightarrow R = 10\,\Omega$$

12)





free-body diagram!

T = tension in string

Forces balance ⟹

y-forces: $T + (-15\mu C)(-500) = (0.008\,kg)(9.8\,\frac{m}{s^2})$

$\Rightarrow T = -(15\times10^{-6})(500) + (0.008)(9.8)$

$= 7.09\times10^{-2}\,N$