Phys 4

Midterm Exam Solutions

S11

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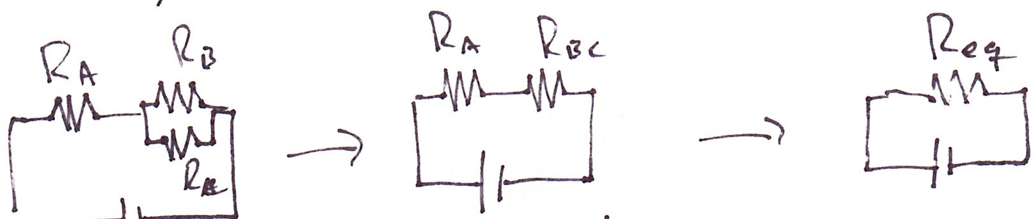
1 From the bulb ratings we can find their respective resistances:

$$R_A = \frac{P}{I^2} = \frac{85\,W}{(5.0\,A)^2} = 3.4\,\Omega$$

$$R_B = \frac{V^2}{P} = \frac{(80\,V)^2}{205\,W} = 31\,\Omega$$

$$R_c = \frac{V}{I} = \frac{120\,V}{0.6\,A} = 200\,\Omega$$

Now, since the bulbs are essentially resistors, apply the rules for resistors in series and parallel to find the equivalent resistance:



$$\frac{1}{R_{BC}} = \frac{1}{R_B} + \frac{1}{R_A}$$

$$R_{BC} = \frac{R_B R_c}{R_B + R_c}$$

$$R_{eq} = R_A + R_{BC}$$

$$R_{eq} = R_A + \frac{R_B R_c}{R_B + R_c}$$

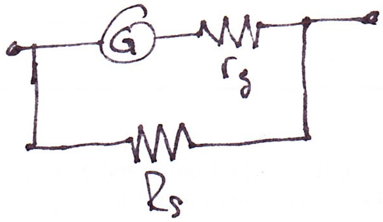
Plugging in the numbers, we find

$$R_{eq} = 3.4\,\Omega + \frac{(31\,\Omega)(200\,\Omega)}{31\,\Omega + 200\,\Omega}$$

$$R_{eq} = 30\,\Omega$$

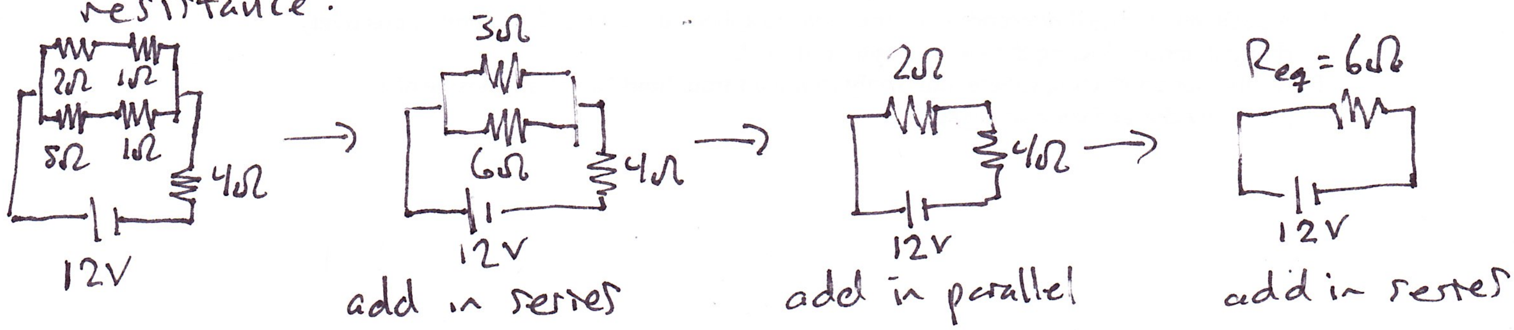
B

2 In Ch. 27 see the section on electrical measuring instruments. Applying a "shunt resistor" in parallel with the internal resistance of the galvanometer. Adjusting R_s allows us to set the full scale current measurement on the galvanometer. The correct diagram for this is the following



D

3 First, let's break the ciruit down and find an equivalent resistance:



Thus we can determine the current of this reduced circuit as

$$I = \frac{V}{R} = \frac{12V}{6\Omega} = 2A$$

With this current, the voltage drop over the 4Ω resistor will be

$$V = IR = (2A)(4\Omega) = 8V$$

and $12V - 8V = 4V$ will be distributed to the parallel resistors each. The current through the lower parallel resistors is then $I = \frac{V}{R} = \frac{4V}{6\Omega} = 0.67A$, which leaves $2A - 0.67A = 1.33\ A$ to pass through the upper parallel resistors. The power dissipated by the 2Ω resistor is thus

$$P = I^2 R = (1.33\ A)^2 (2\Omega) = 3.54\ W$$

E

4 For charging a capacitor, we will use the following

$$I = I_0 e^{-t/RC}$$

The time constant is $RC = (10^5 \Omega)(8\times10^{-5} F) = 8s$. The $I_0 = \frac{V}{R} = \frac{40V}{10^5\Omega} = 0.0004\ A = 0.4 mA$. Thus the current after 20s will be

$$I = (0.4 mA) e^{-20s/8s}$$

$$I = 3.2\times10^{-5} A = 32 \mu A$$

The potential difference across the resistor then becomes

$$V = IR = (3.2\times10^{-5} A)(10^5 \Omega)$$

$$V = 3.2 V$$

C

5 The force on the particle is found by

$$F = |q| \cancel{v} B = m\frac{v^{\cancel{2}}}{R}$$

and the velocity can be expressed in terms of the period

$$v = \frac{2\pi R}{\tau}$$

Thus

$$|q|B = \frac{2\pi \cancel{R} m}{\cancel{R}\tau}$$

$$\tau = \frac{2\pi m}{|q| B}$$

Plugging in the known values, we find $\tau = 1.3\times10^{-6} s = 1.3 \mu s$

A

6 The electric potential is found by

$$\frac{1}{2}mv^2 = qV$$

$$V = \frac{mv^2}{2q}$$

Plugging in the ~~results~~ numbers we find

$$V \approx 7\,kV$$

D

The sign is negative on account of the direction of the magnetic field.

7 The torque exerted on the loop can be found by

$$\tau = IBA\sin\varphi$$

Since $\mu = IA$ and $\varphi = \frac{\pi}{2}$, we have:

$$\tau = \mu B \cancel{\sin\frac{\pi}{2}}^{\,1}$$

$$= (0.75\ Am^2)(0.2\,T)$$

$$\tau = 0.15\ N\cdot m$$

B

8 $v = 330\,m/s$. $B = -20\hat{k}\,\mu T$.

$$= (-20\hat{k}) \times 10^{-6}\,T.$$

$d = +80\,mm$

~~0.08m~~

$= 0.08\,m$.

$$B = \frac{\mu_0 I}{2\pi d}$$

$$I = \frac{(2\pi d)B}{\mu_0}$$

$$= \frac{2\pi(0.08\,m)(-20\times10^{-6}\,T)}{4\pi\times10^{-7}}$$

$I = -0.08\,A = 80\,mA$, negative

A

$\boxed{9}$ Gauss's Law tells us that the magnetic field at point P will not change if the loop is merely distorted.

D

$\boxed{10}$ A solenoid with length l and N windings will have a ~~magnetic~~ current given by

$$Bl = \mu_0 N I$$

$$I = \frac{Bl}{\mu_0 N}$$

Plug in the numbers and find that

$$I \approx 2.8 A$$

D