Physics Midterm #2, Calc-based — Alfonso Gonzalez

2: Chapter 9: Current & Resistance

#1 a: $R_{C\,max} = 100\,\mu s$ $\quad C = \frac{\tau}{R}$ $\quad \tau = R \times C$

$$C_{max} = \frac{100 \times 10^{-6}\,s}{1.0 \times 10^{3}} = \boxed{1 \times 10^{-7}\,F}$$

b: No, it is not difficult to make a capacitor w/capacitance less than 100 nF, b/c an ECG monitor can measure at a time constant (C) less than 100 μs.

c. $V = V_0\left(1 - e^{-t/RC}\right)$

$\rightarrow 30 = 60\left(1 - e^{-t/(100 \times 10^{-6})}\right) \rightarrow \frac{30}{60} = e^{-t/100 \times 10^{-6}}$

$\rightarrow 0.5 = e^{-t/100 \times 10^{-6}} \rightarrow 0.693 = \frac{t}{100 \times 10^{-6}}$

$\boxed{\rightarrow t = 6.93 \times 10^{-5}\ \text{seconds}}$

#2 a.) $V(t) = V_0 \sin\left(2\pi f t + \phi\right)$

$0 = V_0 \sin(2\pi f t + 0)$

$\sin(2\pi f t) = 0 = \sin \pi$

$2\pi f t = \pi$ or $t = \frac{\pi}{(2\pi \times 60)}$

$\boxed{t = 8.33 \times 10^{-3}\ \text{sec} \simeq 8.33\,ms}$

b.) Max power delivered

$$P_{max} = \frac{V_0^2}{R} = \frac{(120)^2}{10^3} = \boxed{14.4\,W}$$

c.) Average power delivered

$$P_{avg.} = \frac{1}{2}\frac{V_0^2}{R} = \frac{1}{2} P_{max} = \frac{1}{2} \times 14.4$$

$\boxed{P_{avg.} = 7.2\,W}$

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#3 Total Watts $= VI + W_{bulb_1} + W_{light} + W_{misc}$

$= (110 \times 3) + 100 + 60 + 3 = 330 + 100 + 60 + 3$

$= 493$ watt

Total hours $= 12 \times 1 \times 30 = 360$ hours (30 days in a month)

Total Watt-hours $= 493 \times 360$

$= 177.48$ Kw hours

Expenditure $= 177.48 \times 0.2$

$\boxed{= \$35.496}$

3: Chapter 10: Direct Current (DC) circuits

#1 Junction Rule

$I_2 + I_3 = I_1 \rightarrow (1)$

Loop 1

$I_2 - I_2 R - I_1 R = 0$

$\rightarrow I_2 = 1000 I_1 + 1000 I_2 \rightarrow (2)$

Loop 2

$I_2 - 1000 I_3 - 1000 I_1 = 0$

$I_2 = 1000 I_1 + 1000 I_3 \rightarrow (3)$

Solving

$I_3 = I_1 - I_2$

$\rightarrow 12 = 1000 I_1 + 1000(I_1 - I_2)$

$12 = 2000 I_1 - 1000 I_2 \rightarrow (4)$

$12 = 1000 I_1 + 1000 I_2$

$12 = 2000 I_1 - 1000 I_2$

$+$

$24 = 3000 I_1$

$I_1 = \frac{24}{3000} A = \boxed{I_1 = 8mA}$

$1000 I_2 = 2000 I_1 - 12$

$1000 I_2 = 2000 \times 8 \times 10^{-3} - 12$

$\boxed{I_2 = 4mA}$

$I_3 = (8-4) mA = \boxed{4mA}$

$I_1 = 8mA, I_2 = 4mA, I_3 = 4mA$

$P = I_1^2 R + I_2^2 R + I_3^2 R$

$P = [(8 \times 10^{-3})^2 \times 1000 + (4 \times 10^{-3})^2 \times 1000 + (4 \times 10^{-3})^2 \times 1000] W$

$P = (84 + 16 + 16) mW \Rightarrow \boxed{P = 96 mW}$

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#2 a.) $\varepsilon - I_1 r - (I_1 + I_2) R = 0$

$\rightarrow 1.5 = 0.25 I_1 + 50 I + 50 I_2$

Also $\cancel{\varepsilon} - I_1 \cancel{r} + I_2 \cancel{r} - \cancel{\varepsilon} = 0$

$\Rightarrow I_1 = I_2$

let $I_1 = I_2 = I$

then, $1.5 = 0.25 I + 100 I$

$\rightarrow I = \dfrac{1.5}{(100 X 0.25)}$

Current through each battery $I_1 = I_2 = 0.014963\,A$

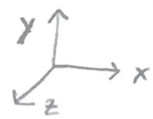
I_R = Current through $R = 2I = 0.02993\,A \approx \boxed{0.03\,A}$

b.) $2q = It$

$t = \dfrac{2q}{I} \rightarrow t = \dfrac{5}{0.03\,A} = \boxed{167\ hrs}$

4: Chapter 11: Magnetic forces and Fields

#1 a.) $\vec{F} = q(\vec{v} \times \vec{B})$, The velocity $\vec{v}$ of the particle must point vertically upward $\vec{B}$ after passing the Lead plate. according to the Lorentz force equation, the charge q of the particle must be positive b/c $\vec{F}$ must point leftward. So the charge of the particle is positive.



b.) The strangeness comes from the particle having the mass of an electron, although the charge of the electron is negative. So it's strange b/c the particle has a mass equal to an electron but is positively charged. This also causes the particle to the right when entering the magnetic field.

c.) $\vec{F} = qvB$, $B = 0.05T$, $v = 10^6\,m/s$, $q = e^-$

$= 1.6 \times 10^{-19} \times 10^6 \times 0.05$

$\boxed{= 8 \times 10^{15}\ N}$

So, from a.) it is clear that the magnetic field is along the $-z$ axis and the velocity of the particle is along the y axis and the force $\vec{F} = q(\vec{v} \times \vec{B})$ will be along the $-x$ axis is horizontally left.