CALCULUS BASED PHYSICS EXAM II

SHAN DENEEN

1) $\tau = RC$] EXPRESSION TO DETERMINE TIME CONSTANT OF RC CIRCUIT — SUB IN $\tau < 100\mu s$ & $1k\Omega$ FOR R!

$$(1k\Omega) \times \frac{1000\Omega}{1k\Omega} C < 100\mu s \times \frac{10^{-6}s}{1\mu s} \longrightarrow 1\cdot 10^{3}\Omega C < 1\cdot 10^{-4}s$$

$$C < \frac{1\cdot 10^{-4}s}{1\cdot 10^{3}\Omega} \longrightarrow C < 1\cdot 10^{-7}F \longrightarrow C < 1\cdot 10^{-7}F \times \frac{1nF}{1\cdot 10^{-9}F} = \boxed{100nF}$$ MAXIMUM CAPACITANCE.

b) NO, IT WOULD NOT BE HARD IN PRACTICE TO LIMIT THE CAPACITANCE TO $< 100nF$. THIS IS BECAUSE THE VALUE OF THE TIME CONSTANT (τ) $< 100\mu s$ ∴, CAN BE USED CAPACITOR WITH LESS CAPACITANCE.

c) $R = 10^{3}\Omega$
$V_0 = 60mV$
$V = 30mV$

$$V = V_0(1 - e^{-t/RC})$$

$$30 = 60(1 - e^{-t/1\cdot 10^{-6}}) \xrightarrow{\text{SOLVE}} \boxed{t = 6.93\cdot 10^{-5}s}$$

2. a. THE VOLTAGE AT A TIME (t) IS GIVEN BY:

$V(t) = V_0 \sin(2\pi f t + \phi)$ PLUG IN GIVENS ($V_0 = 120V$, $\phi = 0$)

$V(t) = 120\sin(2\pi f t)$

$V(t) = 0$ WHEN $\sin(2\pi f t) = \sin(2\pi n)$ $n = 0, 1, 2 \ldots$

SO, $2\pi f t = 2\pi n$

$$\therefore \boxed{t = \frac{n}{f}}$$

b. THE MAXIMUM POWER DELIVERED IS GIVEN BY:

$$P_{MAX} = V_{MAX} \cdot I_{MAX}$$
$$= V_{MAX} \cdot \frac{I_{MAX}}{R}$$
$$= \frac{1}{R} V_{MAX}^{2}$$

HERE, $R = 1k\Omega$, $V_{MAX} = V_0 = 120V$

$$\therefore P_{MAX} = \frac{1}{10^3} \times (120)^2 = \frac{14400}{10^3} = \boxed{14.4W}$$

c. $$\frac{1}{2\pi}\int_0^{2\pi} \sin^2(2\pi f t + \phi)\,dt$$
$$= \frac{1}{2\pi}\cdot\frac{1}{2}\int_0^{2\pi} (1 - \cos^2(2\pi f t + \phi)\,dt$$
$$= \frac{1}{2\pi}\cdot\frac{1}{2}\left(t\Big|_0^{2\pi} - \frac{\sin(4\pi f t + \phi)}{4\pi}\right.$$
$$= \frac{1}{2\pi}\cdot\frac{1}{2}\cdot 2\pi = \frac{1}{2}$$

AV. POWER DELIVERED -

$$P = \langle I\, V(t) \rangle$$
$$= \left\langle \frac{V(t)}{R} \cdot V(t) \right\rangle$$
$$= \frac{1}{R}\langle V_0^2 \sin^2(2\pi f t + \phi) \rangle$$
$$= \frac{V_0^2}{R}\langle \sin^2(2\pi f t + \phi) \rangle = \frac{1}{2}\cdot\frac{V_0^2}{R} = \frac{1}{2}\times 14.4$$
$$\boxed{= 7.2W}$$

3. P = POWER CONSUMPTION OF REFRIDGERATOR

$\left.\begin{array}{l} I = 3A \\ V = 110V \end{array}\right]$ $P = V \cdot I = (110V)(3A) = 330\text{ WATT}$

$\left.\begin{array}{l} \text{LAMP CONSUMES 100W POWER} \\ \text{OVERHEAD LIGHT} = 60\text{W POWER} \\ \text{THE OTHER DEVICES} = 3\text{W POWER} \end{array}\right]$ TOTAL POWER CONSUMED/HR $= 100 + 60 + 3 + 330 = 493\text{W}$

PER DAY POWER CONSUMPTION $= 493(12) = 5916\text{ WHR} \times \frac{1\text{KW}}{1000\text{W}} = 5.916\text{ KWATT HR}$

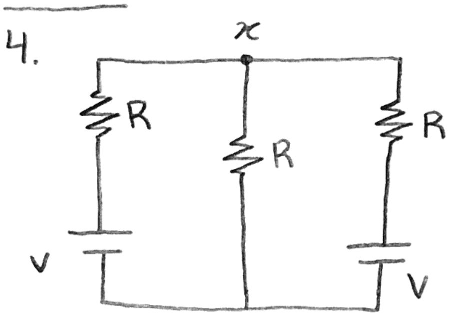
COST PER KWATT HOUR = 0.2 DOLLARS

$\therefore$ COST/DAY = 0.2 (5.916 KW HR) DOLLARS

MONEY SPENT FOR 1 MONTH = (30)(0.2)(5.916 kW HR)

$\boxed{= 35.496\text{ DOLLARS}}$

4.



APPLY KCL AT x

$$\frac{x-12}{1000} + \frac{x}{1000} + \frac{x-12}{1000} = 0 \longrightarrow \begin{array}{l} 3x = 24 \\ x = 8V \end{array}$$

$i_1 = \frac{8}{1000} = 8mA$ $\quad i_2 = \frac{12-8}{1000} = 4mA$ $\quad i_3 = \frac{12-8}{1000} = 4mA$ $\quad \boxed{\begin{array}{l} i_1 = 8mA \\ i_2 = 4mA \\ i_3 = 4mA \end{array}}$

SUM OF POWER CONSUMED IN
RESISTOR $= (i_1^2 + i_2^2 + i_3^2)R = (8^2 + 4^2 + 4^2)(10^{-6})(1000) = \boxed{0.096W}$

---

5. BY USING KVL IN LOOP abcfa,

$I_1 r_1 - I_2 r_2 + E2 - E1 = 0$

$0.25 I_1 - 0.25 I_2 + \cancel{1.5} - \cancel{1.5} = 0$

$I_1 = I_2 \; \ldots (1)$

USING KVL LOOP IN fcdef

$I_2 r_2 + (I_1 + I_2)R - E_2 = 0$

$I_2 r_2 + (I_2 + I_2)R - E_2 = 0$ (BY EQ. 1)

$0.25 I_2 + (I_2 + I_2)(50) - 1.5 = 0$

$I_2 = 0.015A$

CURRENT FLOW $= I = I_1 + I_2 = I_2 + I_2 = 2I_2 = 2(0.015A)$
$= \boxed{0.030A}$

b) $q = 2.5A\text{ HR}$

CURRENT: $I = \frac{2q}{t} \longrightarrow t = \frac{2q}{I} \longrightarrow t = \frac{2(2.5)}{.030} = \boxed{166.7\text{ HR}}$

---

6) a. THE PARTICLE MOVES UPWARD. MAGNETIC FIELD GOES INTO THE PAGE AND EXPERIENCES A LEFTWARD FORCE.

$\hookrightarrow$ FLEMING LEFT HAND RULE - FORCE TO THE LEFT & INWARD MAGNETIC FIELD.

UPWARD MOTION = POSITIVE CHARGE

$\therefore$ SIGN OF CHARGE = $\boxed{\text{POSITIVE}}$

b. $m = 9.1 \cdot 10^{-31}\,kg$

THIS WOULD BE STRANGE BECAUSE ITS MASS = MASS OF AN e^-, BUT IT HAS A POSITIVE CHARGE RATHER THAN (-).

$\therefore$ MUST BE SOME KIND OF ANTIPARTICLE OF e^- (CHARGE $q = +1.6 \cdot 10^{-19} C$) !

c. $\theta = 90°$

$F = qvB\sin\theta$

$= (1.6 \cdot 10^{-19})(10^6)(0.05)$

$= \boxed{8.0 \cdot 10^{-15} N}$ DIRECTION OF FORCE = $\boxed{\text{LEFWARD}}$ (VIA FLEMING'S LEFTHAND RULE).