EXERCIZES-8

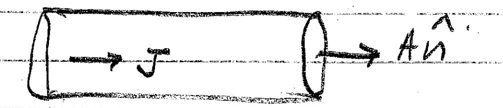
FORMULAE :

CURRENT $\quad I = \lim_{\Delta t \to 0} \left(\frac{\Delta Q}{\Delta t}\right)$

$I = n_e \, e \, A \, v_D$

$n_e = \frac{6.02 \times 10^{23}}{\text{molar mass}} \times \text{density}$

$I = \vec{J} \cdot \vec{A}$



$R = \frac{V}{I}$ $\qquad R = \frac{\rho l}{A}$ $\qquad R_S = \sum R_i$

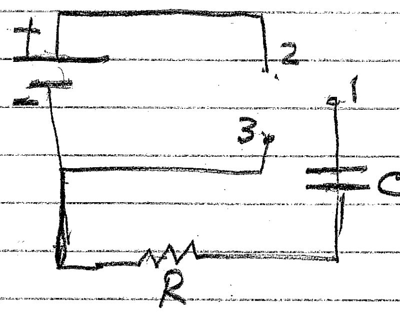
$\frac{1}{R_P} = \sum \frac{1}{R_i}$

$P_W = I^2 R = \frac{V^2}{R}$

$1 \to 2$ charging

$$i = \frac{\varepsilon}{R} e^{-t/RC}$$

$$V_C = \varepsilon \left[1 - e^{-t/RC}\right]$$



$1 \to 3$ Discharging

$$i = -\frac{\varepsilon}{R} e^{-t/RC}$$

$$V_C = \varepsilon e^{-t/RC}$$

NO CURRENT ISIDE C AT ANY TIME!

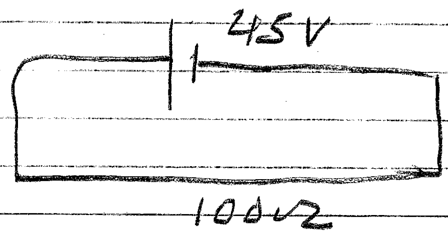
KIRCHHOFF'S RULES

JUNCTION RULE $\quad \sum I_{out} = \sum I_{in}$.

LOOP RULE

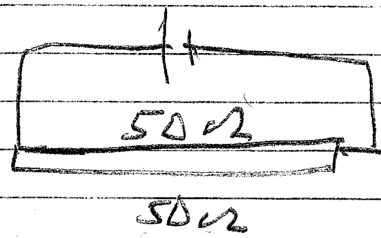
$$\sum_{Loop} \Delta V = 0.$$

E8-1 You are given a length of wire whose resistance 100Ω. Given a source of EMF = 45V will you get more power from it if you use the wire as is or split it in two halves and connect them across the source in parallel?



Single wire

$$P_W = \frac{V^2}{R} = \frac{45^2}{100} \text{ Watts}$$
$$= 20.25\ W$$



$$\frac{1}{R_P} = \sum \frac{1}{R_i}$$
$$= \left(\frac{1}{50} + \frac{1}{50}\right) \Omega^{-1}$$
$$R_P = 25\Omega$$

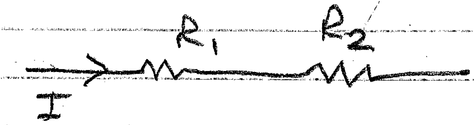
$$P_W = \frac{V^2}{25} = \frac{45^2}{25} = 81\ W$$

FOUR TIMES MORE

E8-2 Two light bulbs one of resistance R_1 and the other of resistance $R_2 < R_1$ are connected either in (i) series or (ii) parallel. Which bulb is brighter in either case?

Brightness depends on power absorbed in bulb.

(i) Series

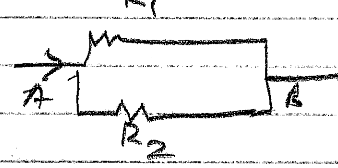


Both bulbs have same current so

$I^2 R_1 > I^2 R_2$

↙ Brighter

(ii) In parallel



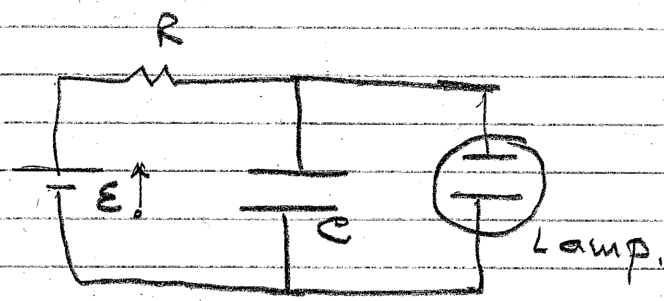
$I_1 R_1 = I_2 R_2 = V$

$P_W = \frac{V}{R^2}$

So $\frac{V}{R_2^2} > \frac{V}{R_1^2}$

↙ Brighter

E8-3 The circuit of a flashing lamp is shown. $\mathcal{E} = 95V$, $C = 0.15 \mu F$. You want the lamp to flash every 0.5 sec and it needs 72V to flash. What value of R would you use?



Once the lamp flashes, C is discharged

immediately, to cause the next flash

C must charge upto 72V so

$$72V = 95V\left[1 - e^{-t/RC}\right]$$

where

$t = 0.5 sec$

$C = 0.15\,\mu F$

$$72 = 95\left[1 - e^{-\frac{0.5}{RC}}\right]$$

$$23 = 95\, e^{-\frac{0.5}{RC}}$$

$$\frac{23}{95} = e^{-\frac{0.5}{RC}}$$

$$\ln\left(\frac{23}{95}\right) = -\frac{0.5}{RC}$$

$$-1.418 = -\frac{0.5}{RC}$$

$$R = \frac{0.5}{1.418 \times 0.15 \times 10^{-6}}\,\Omega$$

$$= 2.35 \times 10^{6}\,\Omega$$

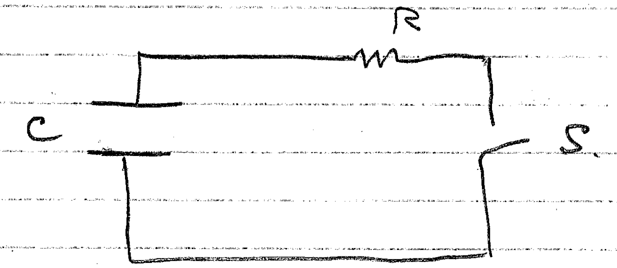
E8-4 Arguably, the resistance of a cell wall is $0.5 \times 10^{9}\,\Omega$. Considering that the potential difference can be 0.75 mV how many sodium ions cross the wall per sec. Na^{+} has a charge of 1.6×10^{-19} C.

$$I = \frac{V}{R} = \frac{0.75 \times 10^{-3}}{0.5 \times 10^{9}} = 1.5 \times 10^{-12}\ \text{amp}$$

# of ions = $\frac{1.5\times10^{-12}\ c/s}{1.6\times10^{-19}} \simeq 10^{7}$ ions/sec.

E8-5 Consider the circuit, $C = 60\,\mu F$

$R = 2\times10^{5}\,\Omega$. The initial stored energy in



C is 60 mJ when S is closed at t=0. At what time will the stored energy be 32 mJ?

The energy stored is

$$U_E = \frac{1}{2} C V_c^2.$$

and V_c varies as

$$V_c = V_c(0)\, e^{-t/RC}.$$

We need

$$\frac{V_c(t)}{V_c(0)} = \sqrt{\frac{32}{60}} = 0.73$$

and

$$0.73 = e^{-t/RC}.$$

So

$$-0.31 = -t/RC$$

$$t = 0.31 \times 6\times10^{-5} \times 2\times10^{5}$$

$$= 3.77 \text{ secs.}$$