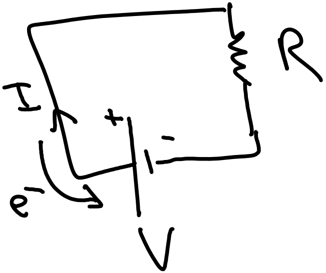
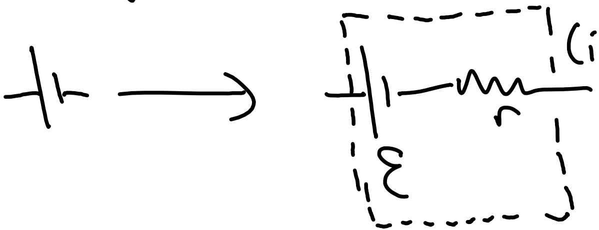
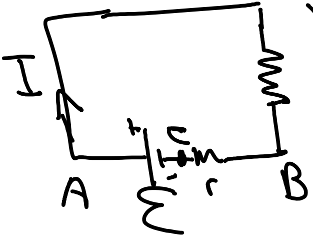
April 2, 2015



$V = IR$

$\mathcal{E}$: emf = electro motive force (it is not a force)





C

$$V_A - V_B \equiv V_{AB} = IR$$
$$= \mathcal{E} - Ir$$

$$V_A - V_B = \underbrace{(V_A - V_C)} + \underbrace{(V_C - V_B)}$$
$$= \mathcal{E} + (-Ir)$$

$$V_{AB} = \mathcal{E} - Ir = IR$$
$$I = \frac{\mathcal{E}}{R + r}$$

$$\Delta W = \Delta q (IR)$$

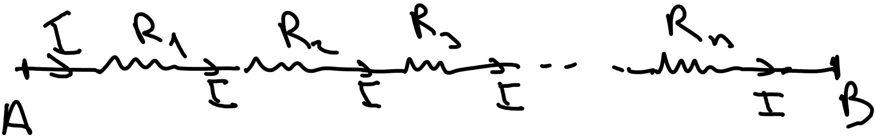
$$\frac{\Delta W}{\Delta t} = \underbrace{\frac{\Delta q}{\Delta t}}_{I} IR = I^2 R$$

ΔW by an emf source

$$\frac{\Delta W}{\Delta t} = \frac{\Delta q \mathcal{E}}{\Delta t} \Rightarrow \boxed{P = I \mathcal{E}}$$

Connecting Resistors

Series Connection



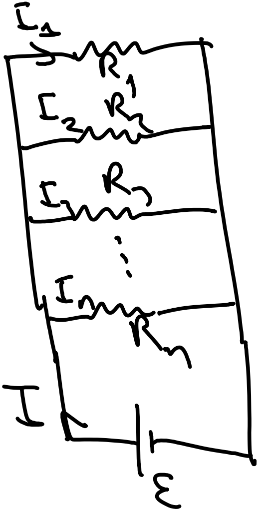
$$V_A - V_B \equiv V = V_1 + V_2 + \dots + V_n$$

$$= IR_1 + IR_2 + \dots IR_n$$

$$IR_{eq} = I(R_1 + R_2 + \dots + R_n)$$

$$R_{eq} = R_1 + R_2 + \dots + R_n$$

Parrallel Connection



$$I = I_1 + I_2 + I_3 + \dots + I_n$$

$$= \frac{\varepsilon}{R_1} + \frac{\varepsilon}{R_2} + \dots + \frac{\varepsilon}{R_n}$$

$$I = \varepsilon \left(\frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_n} \right)$$

$$= \frac{\varepsilon}{R_{eq}}$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_n}$$

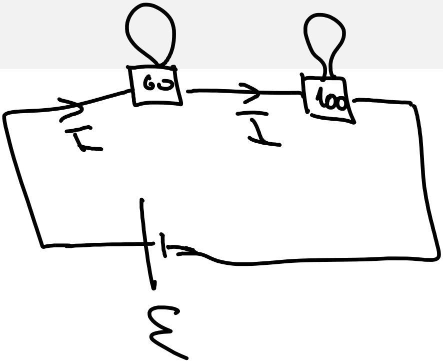
Example 60W, 100W

at 240 Volts.

$$P = IV = \frac{V^2}{R} \Rightarrow R = \frac{V^2}{P}$$

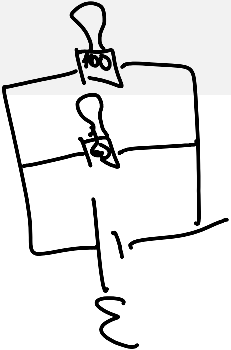
$$R_{60} = \frac{(240V)^2}{60W} \qquad R_{100} = \frac{(240V)^2}{100W}$$

$$\boxed{R_{60} > R_{100}}$$



$$P = VI = \frac{V^2}{R} = I^2 R$$

$$P_{60} > P_{100}$$

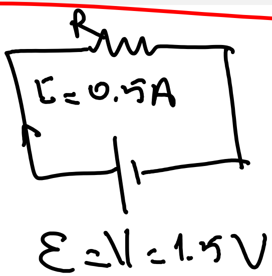


$$P = \frac{V^2}{R}$$

$$P_{60} = \frac{\varepsilon^2}{R_{60}} \qquad P_{100} = \frac{\varepsilon^2}{R_{100}}$$

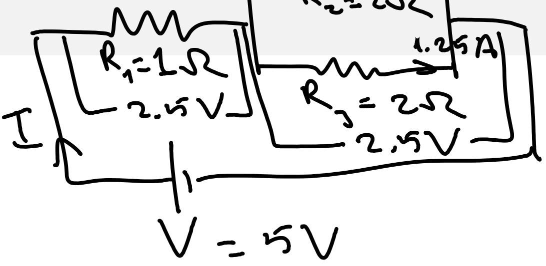
$$P_{100} > P_{60}$$

QUIZ 3



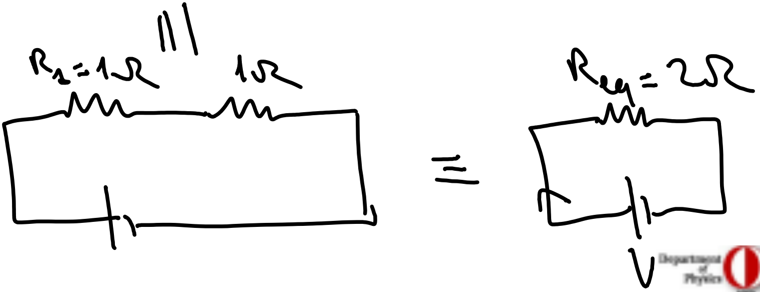
R is how many ohms?

Example



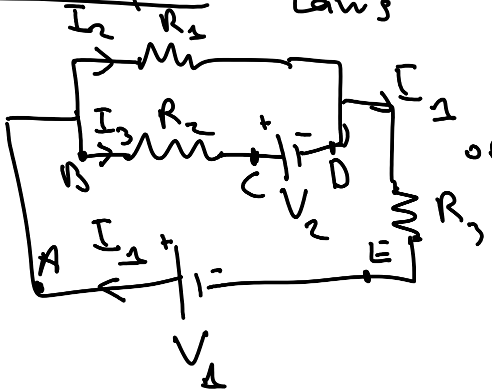
$I = ?$

$I = \frac{5V}{2\Omega} = 2.5 A$



Example - Kirchoff's Laws

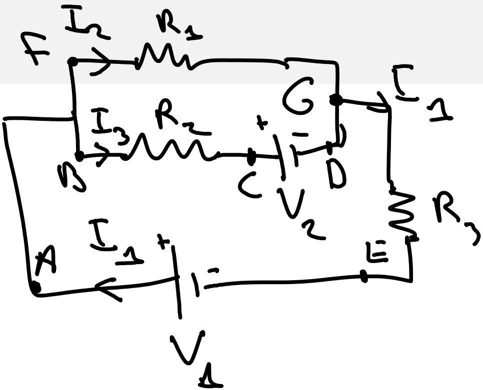
$$I_1 = I_2 + I_3$$
$$I_1 = I_5 + I_6$$



or

$$I_3 = I_4 + I_6$$

$$V_{AA} = 0 = V_{AB} + V_{BC} + V_{CD} + V_{DE} + V_{EA}$$
$$= 0 + I_3 R_2 + V_2 + I_1 R_3 - V_1 \quad (1)$$

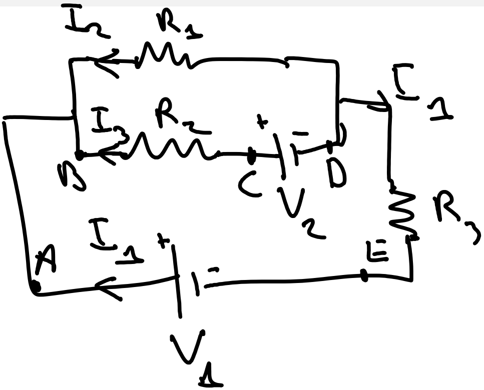


$$I_1 = I_2 + I_3 \quad (3)$$

$$V_{AA} = 0 = V_{AF} + F_{FG} + V_{GE} + V_{EA}$$

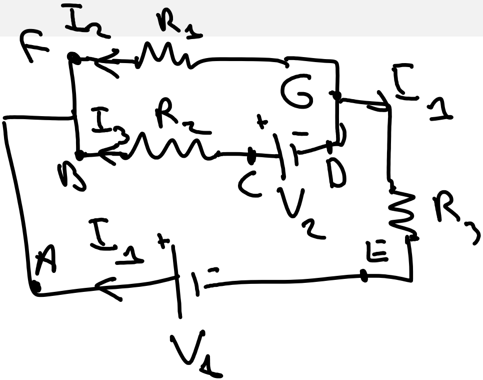
$$= 0 + I_2 R_1 + I_1 R_3 - V_1 \quad (2)$$

Alternative choice of directions of currents.



$$V_{AA} = V_{AB} + V_{BC} + V_{CD} + V_{DE} + V_{EA}$$

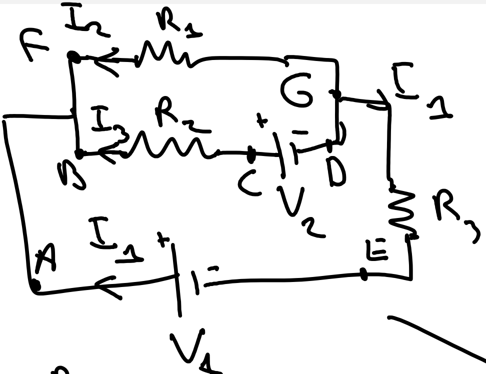
$$= 0 - I_3 R_2 + V_2 + I_1 R_3 - V_1 \quad (1')$$



$$I_1 + I_2 + I_3 = 0 \quad (3)$$

$$V_{AA} = 0 = V_{AF} + V_{FG} + V_{GE} + V_{EA}$$
$$= 0 - I_2 R_1 + I_1 R_3 - V_1 \quad (2)$$

Certain Limits



$R_1 \to \infty \Rightarrow I_2 = 0$

if $V_2 > V_1$

$I_3 > 0, \; I_1 < 0$

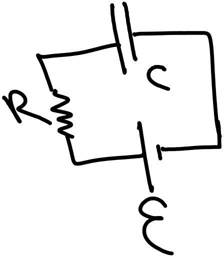
if $V_2 < V_1$

$I_3 < 0, \; I_1 > 0$

if $R_2 \to \infty \Rightarrow I_3 = 0$

$I_1 = -I_2 > 0 \qquad I_1 = \dfrac{V_1}{R_1 + R_3}$

Capacitors In a Circuit



$Q_{max} = C\mathcal{E}$

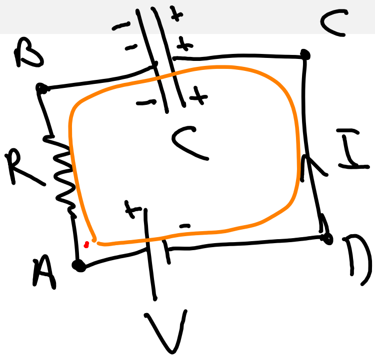
reached $t \to \infty$

at this time $I = 0$

at $t = 0$, $Q = 0$

$$I = \frac{\mathcal{E}}{R}$$

$Q(t)$



$$Q = CV$$

$$V_{AA} = V_{AB} + V_{BC} + V_{CD} + V_{DA}$$

$$= -IR - \frac{Q}{C} - 0 - V$$

I runs for a duration dt

$$dQ = I\,dt \Rightarrow I = \frac{dQ}{dt}$$

$$-\frac{dQ}{dt}R - \frac{Q}{C} - V = 0$$

$$-\frac{dQ}{dt}R-\frac{Q}{C}-V=0$$

$$\frac{dQ}{dt}+\frac{Q}{RC}=-\frac{V}{R}$$

$$Q(t)=Ae^{-t/RC}-VC$$

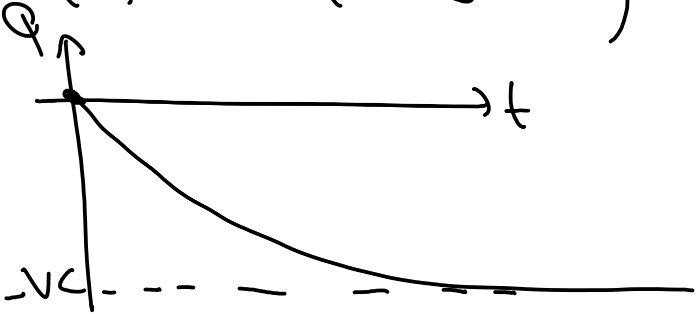
$$Q(t=0)=A-VC=0 \quad \text{(initial cond.)}$$

$$\boxed{Q(t)=-VC\left(1-e^{-t/RC}\right)}$$

$$Q(t) = -VC\left(1 - e^{-t/RC}\right)$$

$\ln e = 1$

$e \simeq 2.7\ldots$

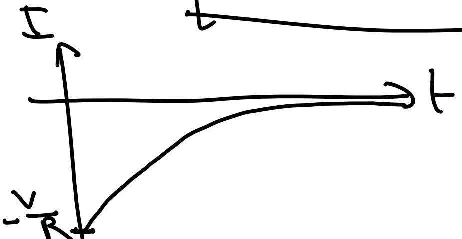


$t \to \infty \Rightarrow t \gg RC$

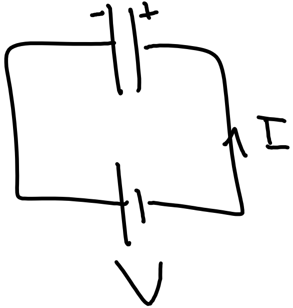
$$I = \frac{dQ}{dt} = \frac{d}{dt}(-VC)\left(1 - e^{-t/RC}\right)$$

$$= (-VC)\left(\frac{1}{RC}\right)e^{-t/RC}$$

$$\boxed{I(t) = -\frac{V}{R}e^{-t/RC}}$$



Example



$$Q(t=0) = VC$$