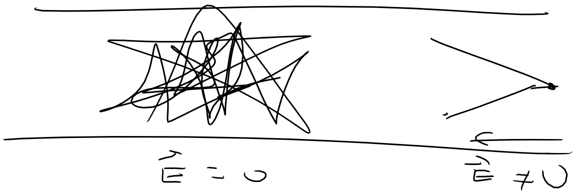
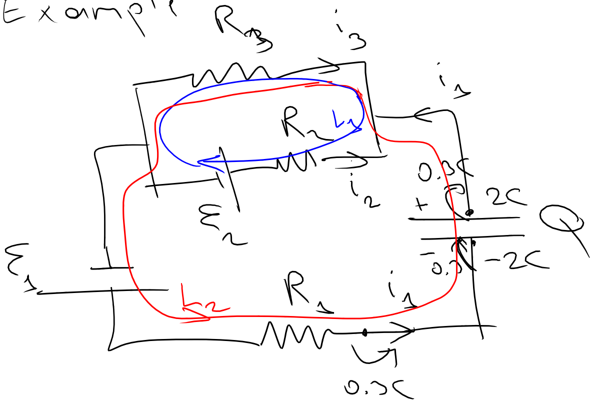



$v_d = \text{const}$

Example




$i_1 + i_2 + i_3 = 0$

$$i_1 = \frac{dq}{dt} = -\frac{dQ}{dt}$$

example $dt = 1$ sec

$Q = 2C$

$dq = 0.3\,C$

$$i_1 = \frac{0.3\,C}{1\text{ sec}} = 0.3A$$

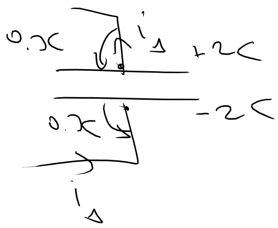
$(-2C) + (0.3C) = -1.7C$

$(2C) - (0.3C) = 1.7C$

$dQ = -0.3C = -dq$

example

$dt = 1$ sec ; $Q = 2C$, $dq = -0.3C$, $i_1 = -0.3A$

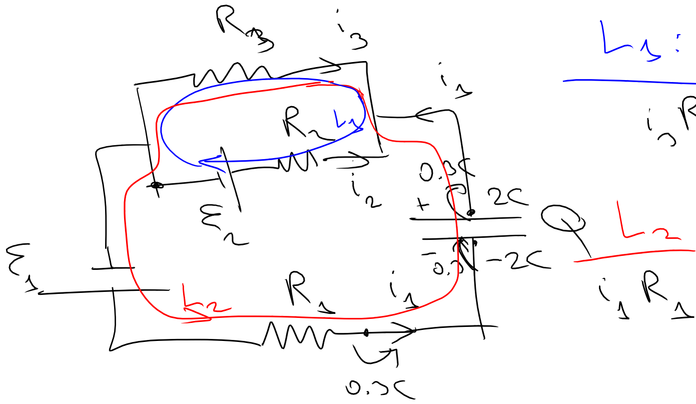



$2C + 0.3C = 2.3C$

$(-2C) - (0.3C) = -2.3C$

$dQ = (+2.3C) - (2C) = 0.3C$

$dQ = 0.3C = -dq$

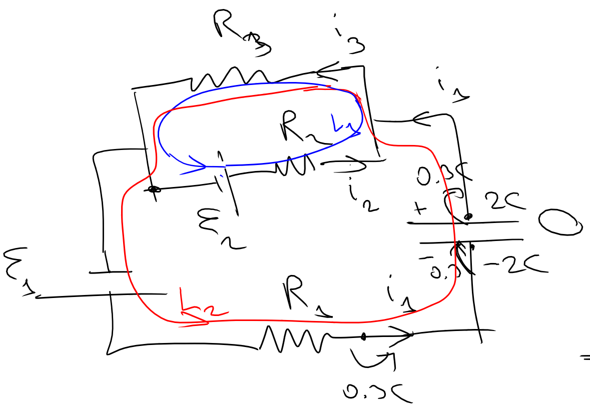



$L_1$:

$i_3R_3 + (-i_2R_2) + \mathcal{E}_2 = 0$

$L_2$

$$i_1R_1 + \left(-\frac{Q}{C}\right) - i_3R_3 + (-\mathcal{E}_1) = 0$$



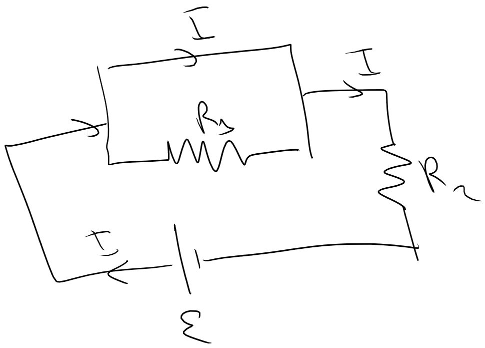

$$i_1 = -\frac{dQ}{dt}$$

$$i_1 + i_2 = i_3 \Rightarrow i_1 + i_2 + (-i_3) = 0$$

$L_1$

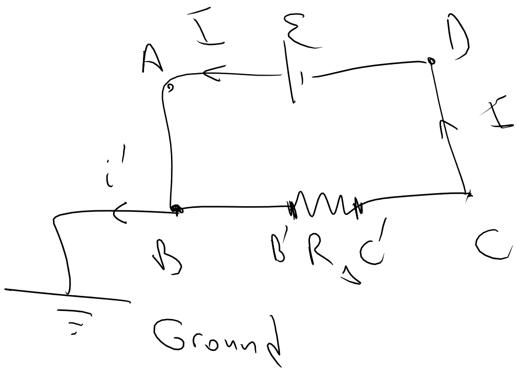
$$-\mathcal{E}_2 + i_2 R_2 + i_3 R_3 = 0$$

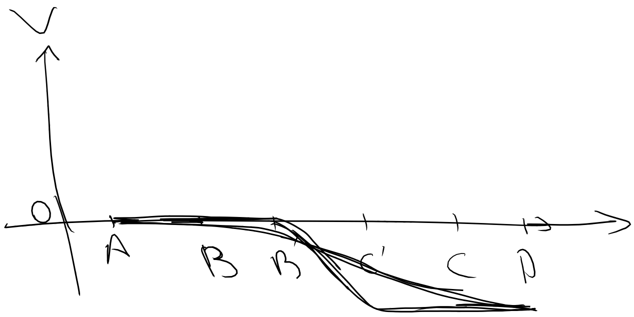
$$\Rightarrow \mathcal{E}_2 - i_2 R_2 + (-i_3) R_3 = 0$$




$$I = \frac{\mathcal{E}}{R_2}$$

## Example

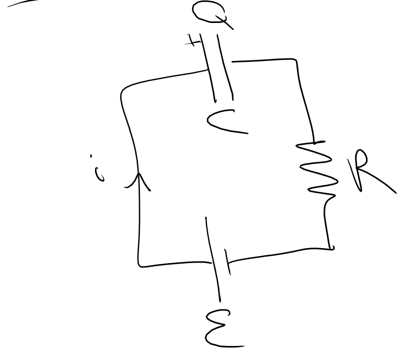



$$I = \frac{\mathcal{E}}{R_1}$$

$$I = I + i' \Rightarrow i' = 0$$

Example




$$\frac{Q}{C} + iR - \mathcal{E} = 0$$

$$i = \frac{dQ}{dt}$$

$$\boxed{\frac{Q}{C} + \frac{dQ}{dt}R - \mathcal{E} = 0}$$

$$\frac{dQ}{dt} + \frac{1}{RC}Q = \frac{\mathcal{E}}{R}$$

$$dQ = \left(\frac{\mathcal{E}}{R} - \frac{Q}{RC}\right)dt$$

$$\int_{Q_0}^{Q(t)} \frac{dQ}{\mathcal{E} - \frac{Q}{RC}} = \int_0^t dt$$

$$\left.\frac{\ln\left(\frac{\mathcal{E}}{R} - \frac{Q}{RC}\right)}{-\frac{1}{RC}}\right|_{Q=Q_0}^{Q=Q(t)} = t$$

$$\underbrace{\ln\left(\frac{\mathcal{E}}{R} - \frac{Q(t)}{RC}\right) - \ln\left(\frac{\mathcal{E}}{R} - \frac{Q_0}{RC}\right)}_{} = -\frac{t}{RC}$$

$$\ln\left(\frac{\frac{\mathcal{E}}{R} - \frac{Q(t)}{RC}}{\mathcal{E}/R - \frac{Q_0}{RC}}\right) = -\frac{t}{RC} \quad ; RC \equiv \tau$$

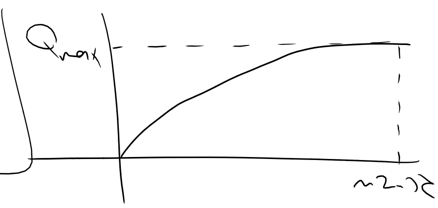
$$\frac{\mathcal{E}/R - \frac{Q(t)}{\tau}}{\mathcal{E}/R - \frac{Q_0}{\tau}} = e^{-\frac{t}{\tau}}$$

$$\frac{Q(t)}{\tau} = \left(\frac{Q_0}{\tau} - \frac{\mathcal{E}}{R}\right)e^{-t/\tau} + \mathcal{E}/R$$

$$\boxed{Q(t) = Q_0 e^{-t/\tau} + \frac{\mathcal{E}}{R}\tau\left(1 - e^{-t/\tau}\right)}$$

$Q_0 = 0$ (initially, the capacitor is not charged

$$Q(t) = \frac{\varepsilon\tau}{R}\left(1 - e^{-t/\tau}\right)$$

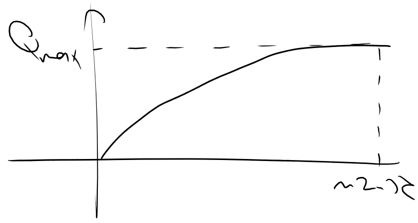


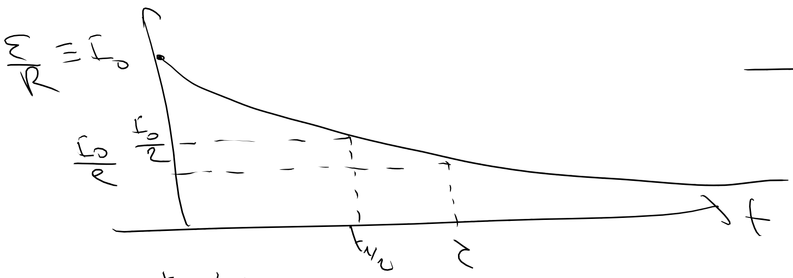

$$Q(t=0) = 0$$

$$Q(t \to \infty) = \frac{\varepsilon\tau}{R} = \frac{\varepsilon RC}{R} = \varepsilon C$$

$$i = \frac{dQ}{dt} = \frac{\varepsilon\tau}{R}\left(0 + \left(+\frac{1}{\tau}\right)e^{-t/\tau}\right)$$

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




$$\ln\left(e^{-t_{1/2}/\tau}\right) = \ln\left(\frac{1}{2}\right) \Rightarrow -\frac{t_{1/2}}{\tau} = \ln\left(\frac{1}{2}\right) = -\ln 2$$

$$t_{1/2} = \tau \ln 2$$

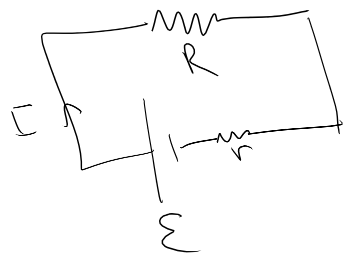
$$R \to \frac{R}{2} \Rightarrow I = \frac{V}{R} \Rightarrow 2I$$

$$P = IV = I^2 R_b \Rightarrow (2I)^2\left(\frac{R}{2}\right)$$

Power of the battery $P = I\varepsilon$

Power dissipated by a resistor $P = IV = I(IR) = \frac{V}{R}\cdot V$

# Quiz




$I = 0.1\ mA$  $r = 0.01\ \Omega$

$R = 2.0\ \Omega$

$P_R = ?$ (in watts)