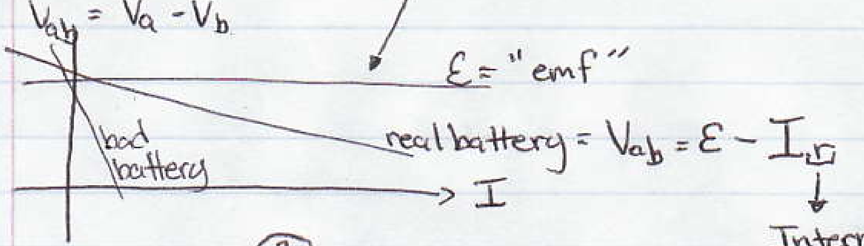
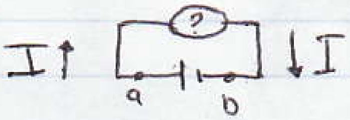
Alfredo Morales

Idealized battery



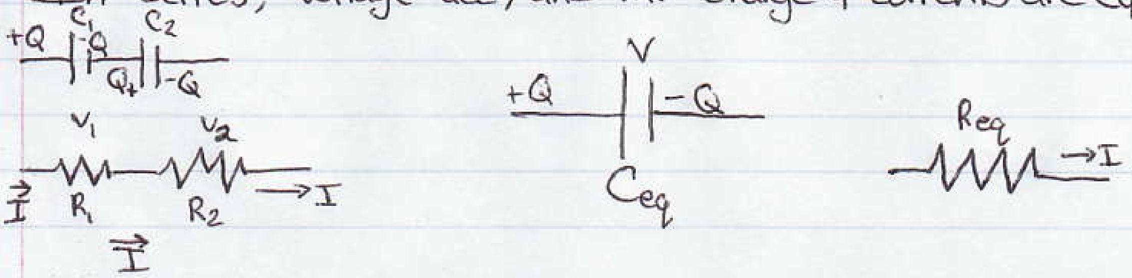


when circuit is open, $I = 0$, so $V_{ab} = \mathcal{E}$

good battery: r small

bad battery: r big

In series, voltage add, and the charge & currents are equal.



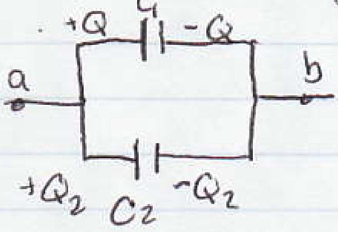
$$\frac{1}{C_{eq}} = \frac{V}{Q} = \frac{V_1}{Q} + \frac{V_2}{Q} = \frac{1}{C_1} + \frac{1}{C_2}$$

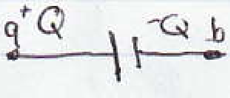
$$R_{eq} = \frac{V}{I} = \frac{V_1}{I} + \frac{V_2}{I} = R_1 + R_2$$

$$\frac{1}{R_{eq}} = \frac{I}{V} = \frac{I_1}{V} + \frac{I_2}{V} = \frac{1}{R_1} + \frac{1}{R_2}$$

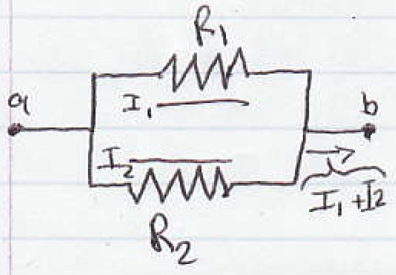
In parallel, currents & charges add, and the Voltage are equal

$$C_{eq} = \frac{Q}{V} = \frac{Q_1}{V} + \frac{Q_2}{V} = C_1 + C_2$$

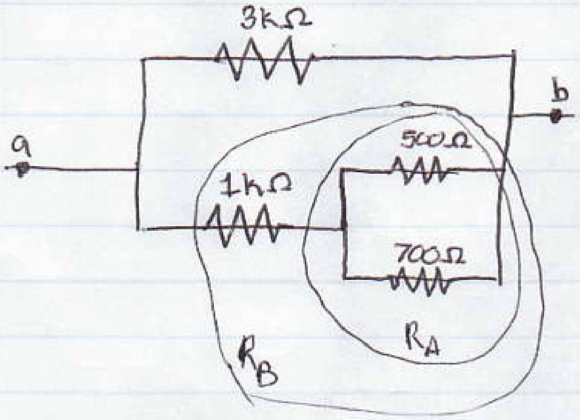


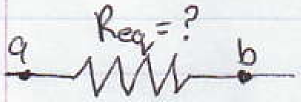


$V = V_{ab}$



$I = I_1 + I_2$

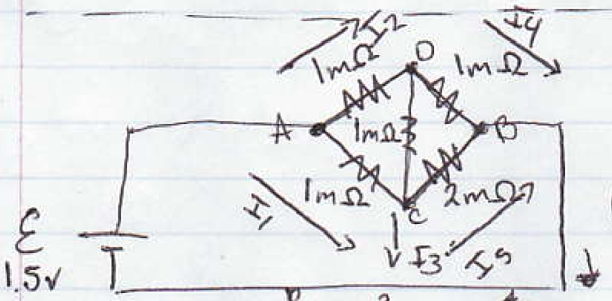




① $\frac{1}{R_A} = \frac{1}{500\Omega} + \frac{1}{700\Omega}$

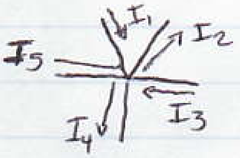
② $R_B = 1k\Omega + R_A$

③ $\frac{1}{R_{eq}} = \frac{1}{3k\Omega} + \frac{1}{R_B}$



Use Kirchoff's Rules:

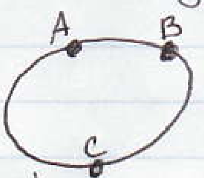
Junction:
(wire)



$I_1 + I_3 = I_2 + I_4 + I$

total incoming current
equals total outgoing current

Loop:
The voltage
add to 0. (zero)



$(V_a - V_B) + (V_B - V_c) + (V_c - V$

$V_{ab} + V_{bc} + V_{ca} = 0$

Junction:

ⓐ $I = I_1 + I_2$

ⓑ $I_4 + I_5 = I$

ⓒ $I_1 + I_3 = I_5$

ⓓ $I_2 = I_3 + I_4$

one more loop:

(acb) $0 = \underbrace{(1m\Omega)I_1}_{V_{ac}} + \underbrace{(2m\Omega)I_5}_{V_{cb}} + \underbrace{(-1.5V)}_{V_{ba}}$

(adc) $0 = (1m\Omega)I_2 + (1m\Omega)I_3 + (1m\Omega)(-I_1)$

(bcd) $0 = (2m\Omega)(-I_5) + (1m\Omega)(-I_3) + (1m\Omega)I_4$

Equivalently: $\underbrace{V_{ab}}_{\underbrace{V_a - V_b}_{\int_b^a -\vec{E}\cdot\vec{dl}}} = V_{ac} + V_{cb}$

7 Equations, 6 variables

$R_{eq} = \frac{V}{I} = \frac{\mathcal{E}}{I} = \frac{1.5V}{I} = \frac{5}{6} m\Omega$

$I = 1.8kA$

$I_1 = \frac{13}{24} \cdot 1.8kA$

$I_3 = \frac{1}{12} \cdot 1.8kA$

$I_4 = \frac{3}{8} \cdot 1.8kA$

$I_2 = \frac{11}{24} \cdot 1.8kA$

$I_5 = \frac{15}{24} \cdot 1.8kA$

I Divide all the equations by I & used variables

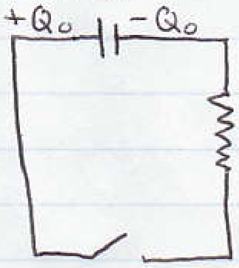
$x_1 = \frac{I_1}{I} \quad x_2 = \frac{I_2}{I} \ldots \quad x_5 = \frac{I_5}{I}$

and then found

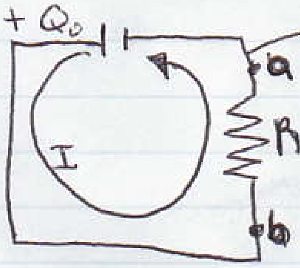
$R_{eq} = (1m\Omega)x_1 + (2m\Omega)x_5$ I found I's last.

$I = \frac{\mathcal{E}}{R_{eq}}, \quad I_1 = Ix_1, \quad I_5 = Ix_5$

Discharging RC circuit



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



close circuit at time t=0

$V = V_{ba} = V_b - V_a$

$\frac{dQ}{dt} = -I$ ④ $= \frac{-Q}{RC}$

express in terms of Q and constant

② $C = \frac{Q}{V}$ $V = \frac{Q}{C}$

① $R = \frac{V}{I}$ $I = \frac{V}{R}$

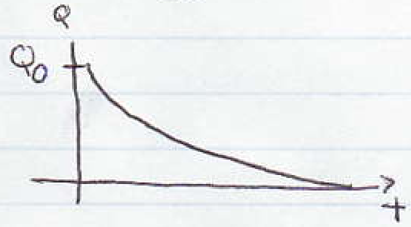
③ $\frac{Q/C}{R}$ $\frac{Q}{RC}$

V & I are not constant

⑤ $\frac{dQ}{dt} = \frac{-Q}{RC} \Rightarrow \int_{Q_0}^{Q} \frac{dQ}{Q} = \int_0^t \frac{-dt}{RC} =$

$\ln\left(\frac{Q}{Q_0}\right) = \frac{-t}{RC}$

$Q = Q_0 e^{-t/(RC)}$



$I = \frac{-dQ}{dt} = \frac{Q_0}{RC} e^{-t/(RC)}$, where $\frac{Q_0}{RC} = I_0$

$V = IR = \frac{Q_0}{C} e^{-t/(RC)}$, where $\frac{Q_0}{C} = V_c$