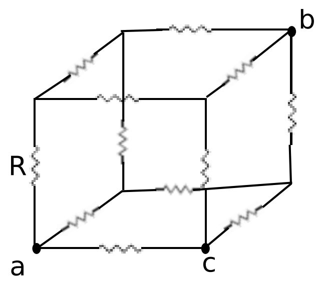
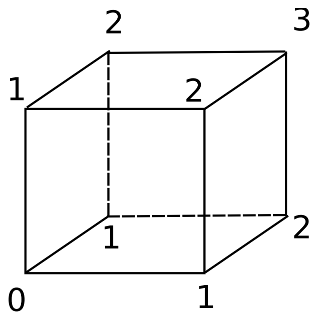
8.022 Lecture Notes Class 32 - 11/14/2006



$$R_{eq} = \begin{cases} \frac{5}{6}R & a \rightarrow b \\ \frac{7}{12}R & a \rightarrow c \end{cases}$$

Same #'s have same potential, so dotted line wires have no current thru them.



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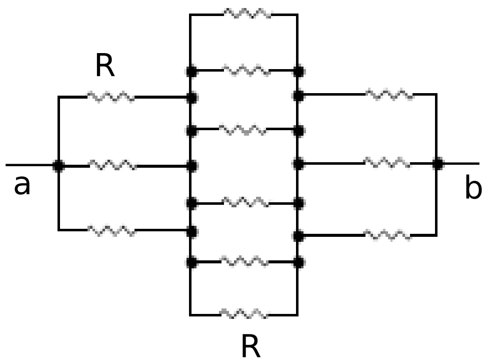


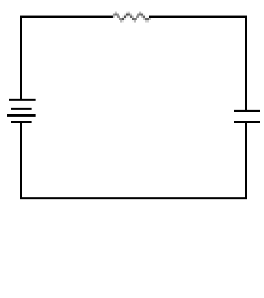
Work to move charge :

$$dW = V dq$$

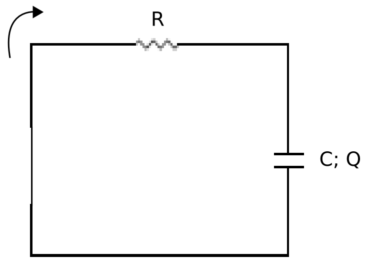
Power :

$$P = \frac{dW}{dt} = V\frac{dq}{dt} = VI$$

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



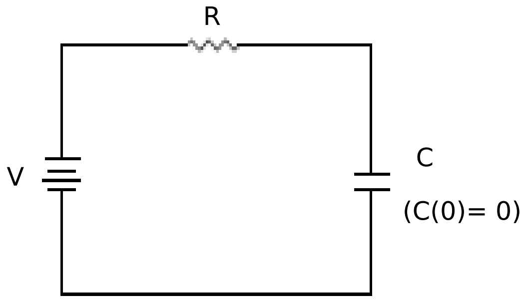
RC Circuits



• Steady State is boring !

If capacitor is charged , $V = \frac{Q}{C}$ (voltage charge)

If not, $V = 0$ (like wire)

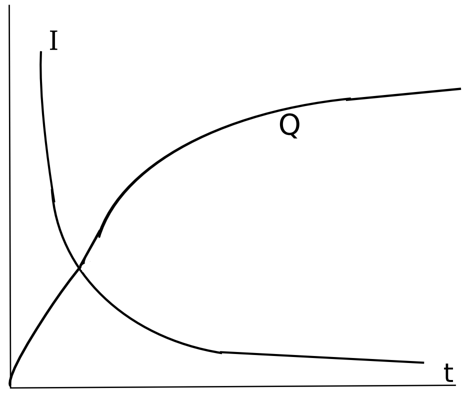


$$\Sigma \Delta V = \frac{Q}{C} - IR = 0 \qquad I = -\frac{dQ}{dt}$$

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

Separate:

$$
\begin{aligned}
\int_{Q_0}^{Q} \frac{dQ}{Q} &= \int_0^t -\tfrac{dt}{RC} \\
ln\frac{Q}{Q_0} &= -\tfrac{t}{RC} \\
Q &= Q_0 e^{-\frac{t}{RC}} \qquad \text{time constant } \tau = RC \\
I &= -\tfrac{dQ}{dt} \\
&= -Q_0 \cdot -\tfrac{1}{RC} e^{-\frac{t}{RC}} \\
&= \tfrac{Q_0}{RC} e^{-\frac{t}{RC}}
\end{aligned}
$$



$$
\begin{aligned}
V - \frac{Q}{C} - IR = & \quad 0 \\
I = & \quad -\tfrac{dQ}{dt} \\
V - \frac{Q}{C} = & \quad R\tfrac{dQ}{dt} \\
dt\frac{V - \frac{Q}{C}}{R} = & \quad CQ \\
\int_0^t \frac{dt}{RC} = & \quad \textstyle\int_0^Q \frac{dQ}{VC-Q} \\
ln(\frac{CV - Q}{CV}) = & \quad -\tfrac{t}{RC} \\
Q(t) = & \; CV(1 - e^{-\frac{t}{RC}}) \\
I(t) = \frac{V}{R}e^{-\frac{t}{RC}}
\end{aligned}
$$

- What about multiple V's and R's?

Thevenin's Theorem (Helmholtz)

Any combination of batteries and resistors with two terminals is equivalent to a battery and resistor in series

$$
\text{from galvanometer} \begin{cases} \text{A - series (yes I) (low R)} \\ \text{V - parallel (no I) (high R)} \end{cases}
$$