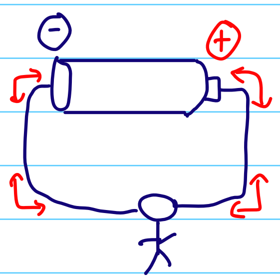
Electrical Circuit review

1. Electric current (I)
   - caused by electric potential V
   - rate of flow of electrical charges

$$I = \frac{Q}{t} \quad [A] \text{ for amperes}$$

$$= \frac{[C]}{[S]}$$



Conventional current
→ flow of positive ⊕ → ⊖

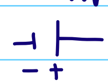
Electron current
→ flow of negative ⊖ → ⊕

2. Ohm's law $V = IR$ $I = \frac{V}{R}$

   current depends on potential and resistance in the conductor

3. circuit conventions

   negative terminals – blue or black
   positive terminals – red

   resistor 
   voltage 

④ Electrical power

$P = \frac{W}{t} = \frac{qV}{t}$ $\quad$ $P = IV$

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

apply to resistors

⑤ Electrical energy

$E = Pt$

Different unit of energy

$E_p = qV$ = electron (1 volt) = 1 electrol volt

= 1 eV

= 1.6×10^{-19} J

Work = Pt → work = kW(h) = kilowatthours

1kWh = (1000)(3600)

= 3.6×10^6 J

Assignment Giancoli 551 #7-9, 29-35 odd

APR 8 Capacitance

Capacitors store electrical charges and consist of two plates near but not touching

ex. backup energy in computers/phones while battery charges; large pulses of current (camera flash)

Capacitance describes the amount of separated electric charge that is stored on it per change in electric potential

$C = \dfrac{q}{V}$ units: $\dfrac{[\text{coulomb}]}{[\text{voltage}]}$

$= 1$ farad [F]

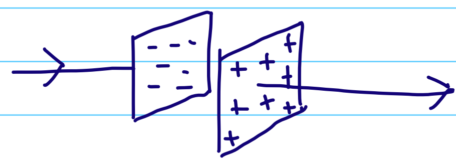
often we use pF (pico farad 10^{-12} F)

or μF (microfarad 10^{-6} F)

Symbol: 

capacitance depends on structure and dimensions

$C = \dfrac{\varepsilon_0 A}{d}$

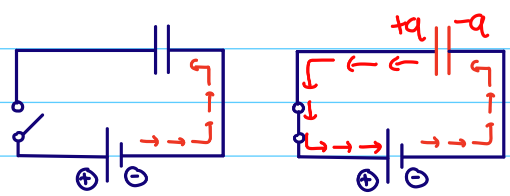


ε_0 = permittivity of free space = $8.85 \times 10^{-12} \dfrac{C^2}{Nm^2}$

A = area of plates

d = distance between plates

Large distance = less attraction = few charges



It takes work to move charges onto the capacitors.

$W = qV$

Initially the voltge across the cap is 0 so no work is needed to put the first charge

When the capacitor is at pull charge. It has the same voltage as the battery

The final charge placed has to overcome full V

Average work $W = \dfrac{qV}{2}$

if $C = \frac{q}{V} \rightarrow q = CV$

$$W = \frac{1}{2}CV^2$$

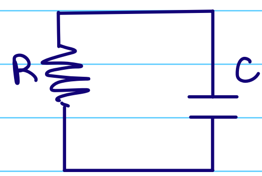
Ex① A homemade capacitor is assembled by placing 2 9 inch (22.86 cm) pizza pans, 10 cm apart and connecting to a 9 V battery. Calculate the capacitance and work it can do at full charge

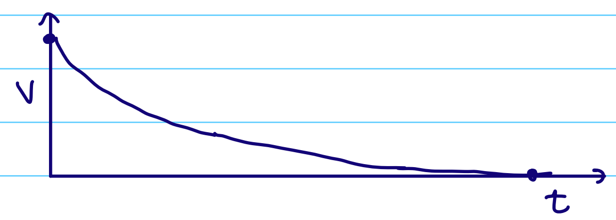
$$C = \varepsilon_0 \frac{A}{d} = 8.85\times10^{-12}\left(\frac{\pi(0.1143)^2}{0.10}\right)$$

$$= 3.63\times10^{-12}\ F$$

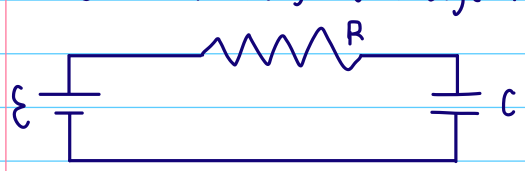
$$\text{Work} = \frac{1}{2}CV^2$$
$$= \frac{1}{2}(3.63\times10^{-12})(9)^2$$
$$= 1.471\times10^{-10}\ J$$

APR12 Discharing capacitors





Use kirchaff's voltage rule



$$\varepsilon - V_R - V_C = 0$$
$$\varepsilon - IR - \frac{q}{C} = 0$$

$$\varepsilon - \left(\frac{\Delta q}{\Delta t}\right)R - \frac{q}{C} = 0$$

$\downarrow$

after some integration

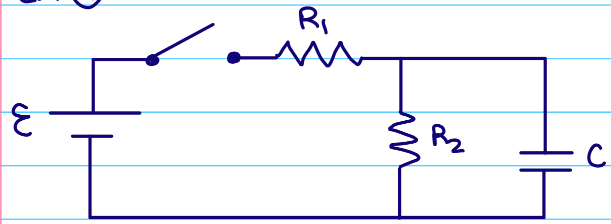
let $\tau = RC$

$e = 2.71828\ldots$

$$\boxed{\begin{aligned} q &= q_0 e^{-\frac{t}{\tau}} \\ V &= V_0 e^{-\frac{t}{\tau}} \\ I &= I_0 e^{-\frac{t}{\tau}} \end{aligned}}$$

after some time, q V I go $\downarrow$

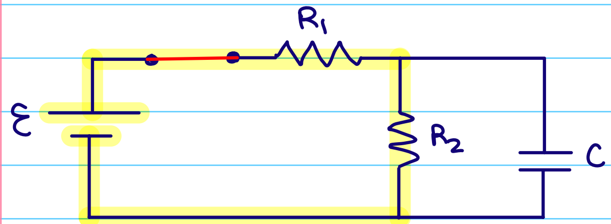
Ex ①



$R_1 = 12.0\ k\Omega$
$R_2 = 18.0\ k\Omega$
$V = 12.0\ V$
$C = 2.00\ \mu F$

The switch is closed for a long time (⊣⊢ at full charge)
Now the switch is open. Find the current in mA
through resistor R_2 after 5.00 ms

At full voltage, current is only through the first loop

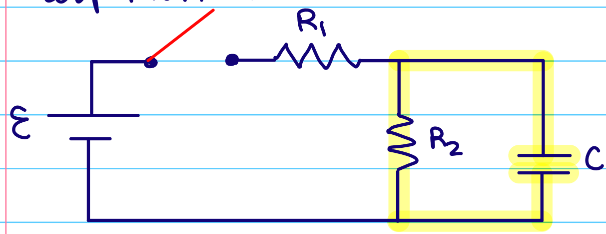


$I = \frac{V}{R_1 + R_2} = \frac{12.0}{12+18} = 0.400 \times 10^{-3} A$

$V_2 = IR_2 = I(18\ k\Omega) = 7.20\ V$

The ⊣⊢ is only
7.20 V across of full charge

When switch opens, only the second loop matters



$$\tau = RC$$
$$= [18\ k\Omega][2\ \mu F]$$
$$= 3.6\times10^{-2}\ s$$

$$I_0 = \frac{V_0}{R_2}$$
$$= \frac{7.20\ V}{18\ k\Omega}$$
$$= 0.400\times10^{-3}\ A$$

$$I = I_0 e^{-\frac{t}{\tau}}$$
$$= (0.400\times10^{-3})\, e^{-\frac{5ms}{3.6\times10^{-2}s}}$$
$$= 0.3480\ mA$$

Assignment: Tsokos p. 472 # 28-32 (even)