Physics 102

Lecture 11. Friday. Oct. 1. 2004

- Kirchoff's laws.

For any junction : $\Sigma I_i = 0$. in (+) out (-).

For any Loop : $\Sigma V_i = 0$ up (+) down (-).

- Applications.

(e.g. 21-2 ..)

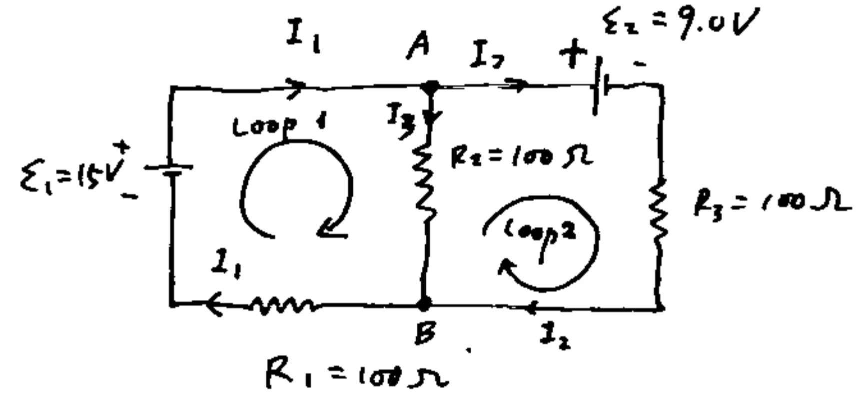
List all the equations of junctions and loops.

(delete the dependent ones) .

Solve the system of $\underset{\text{linear}}{\underbrace{\text{equations}}}$ algebraically.

Need excercies .

e.g. 21-2. (p.697).



Not a simple parallel + series connection.

It's a network.

use Kirchoff's Rules.

define Loops. — To cover all the elements.

(3 loops, but only 2 is needed)

find. junctions (nodes): A, B.

① $I_1 - I_2 - I_3 = 0$. $\left(I_3 + I_2 - I_1 = 0 \right)$

same, only one of them is useful.

② : loop 1. $\varepsilon_1 - I_3 R_2 - I_1 R_1 = 0$.

③ loop 2. $I_3 R_2 - \varepsilon_2 - I_2 R_3 = 0$

loop 3

3 unknowns: I_1, I_2 I_3.

$$\begin{cases} I_1 - I_2 - I_3 = 0 \\ -I_1 R_1 \qquad - I_3 R_3 = -\varepsilon_1 \\ \qquad -I_2 R_3 + I_3 R_2 = \varepsilon_2 . \end{cases}$$

Solve for I_1, I_2, I_3 :

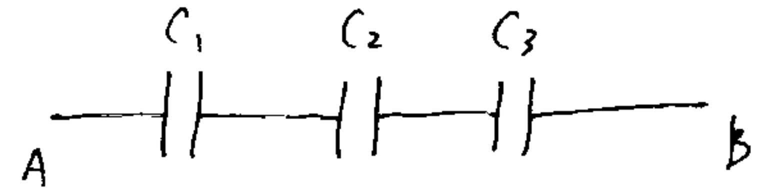
$I_1 = 0.070$ A,

$I_2 = -0.010$ A. (actual direction is opposite to the assumed direction)

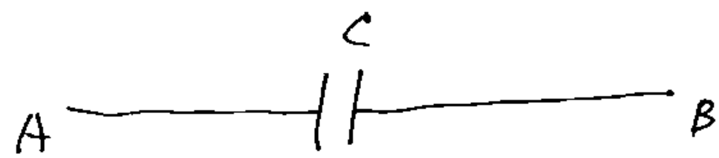
$I_3 = 0.080$ A.

- Circuits containing capacitors

1. Series.



equivalent to



$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}.$$

easy to understand:

$C < C_i$.

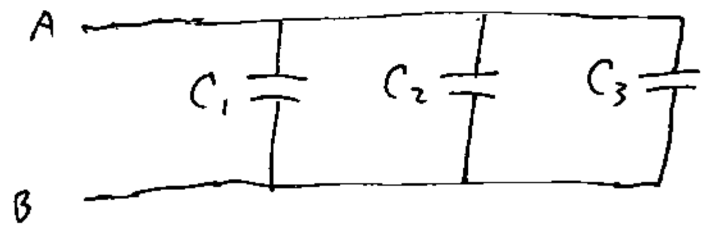
Imagine: 3 parallel-plate capacitors are connected this way.

The gaps add. but $C \propto \frac{1}{d}$.

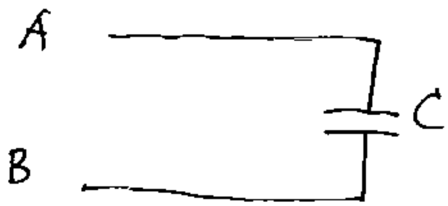
$$C = \frac{\varepsilon_0 A}{d}.$$

e.g.: $d = d_1 + d_2 + d_3$.
$A_1 = A_2 = A_3$

2. Parallel.



equivalent to :



$$C = C_1 + C_2 + C_3$$

$$C > C_i.$$

easy to understand.

Imagine, the areas add.

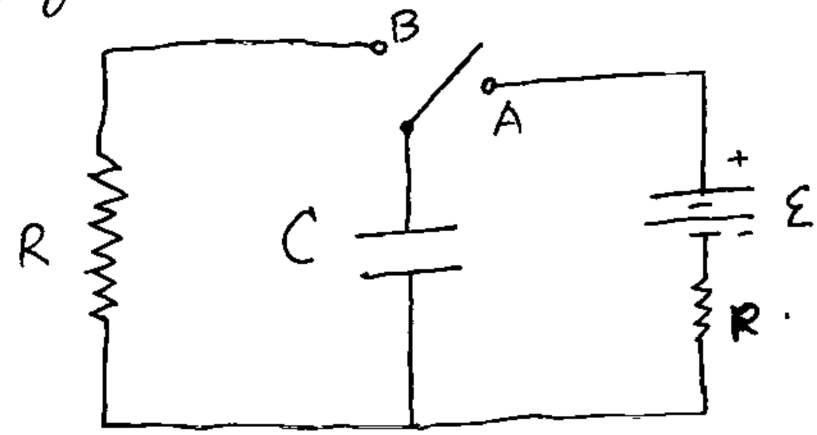
and $C = \frac{\varepsilon_0 A}{d}$.

$C \propto A$.

e.g.: $A = A_1 + A_2 + A_3$.

$d_1 = d_2 = d_3$.

- charging and discharging a capacitor



— charging.

switch at A:

Build up charge on C.

— discharging.

switch at B: release charge from C.

Roughly speaking: The larger the C, the more charge it can hold, the longer time it takes to charge (and discharge).

The larger the R, the smaller the current, the longer time it takes to charge (and discharge).

$\therefore$ charging / discharge time $\propto RC$.

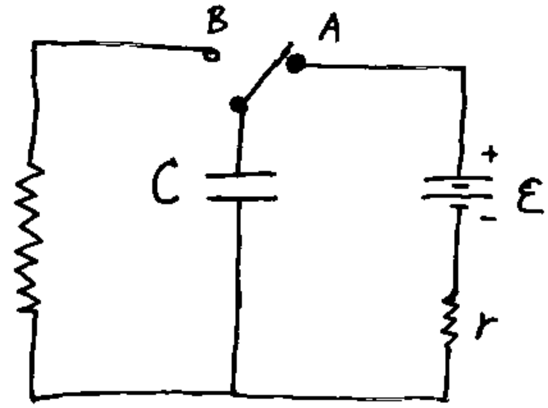
[illegible]

- charging and discharging a capacitor.

A — charging (build up charge on C)

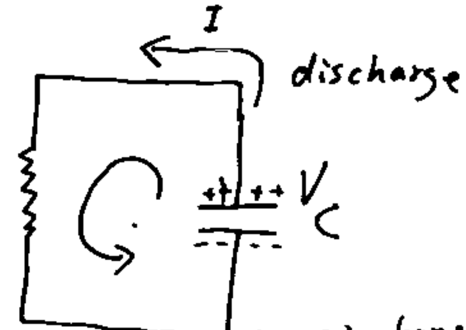
Then.

B — discharging. release charge from C.



- time-dependent behaviour of discharging. (charging is similar).

switch at B.



Use Kirchoff's Loop rule:

at any time:

$$V_c - IR = 0.$$

$$V_c = IR.$$

$$V_c = -RC \cdot \frac{dV}{dt}.$$

$$V_c = -RC\frac{dV}{dt}.$$

$$V_c = V_c(t).$$

$(-\Delta Q)$ charge flows in Δt.

but $I = I(t) = -\frac{\Delta Q}{\Delta t} = -\frac{dQ}{dt}.$

$$Q = CV_c.$$

$$I = -C \cdot \frac{dV_c}{dt}.$$

separate variables:

$$-\frac{dt}{RC} = \frac{dV_c}{V_c}.$$

$$\int_0^t -\frac{1}{RC}\,dt = \int_{V_0}^{V} \frac{1}{V_c}\,dV_c.$$

$$-\frac{t}{RC} = \ln V - \ln V_0 =$$

$$-\frac{t}{RC} = \ln\frac{V}{V_0}.$$

$$e^{-t/RC} = \frac{V}{V_0}$$

$$V_c(t) = V_0\, e^{-t/RC}.$$