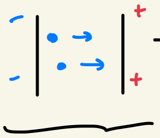
24.1 Capacitors and Capacitance

Any two conductors seperated by an insulator form a capacitor.

Charging the capacitor

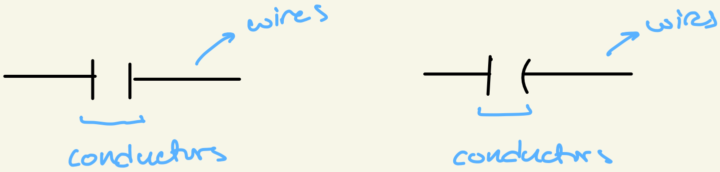


→ each conductor has initially a net 0 charge

both conductors opposite in charge equal magnitude

net charge as a whole remains 0

In circuit diagrams a capacitor is represented by these symbols



- Capacitance of a capacitor → $C = \dfrac{Q}{V_{ab}}$

  Q → magnitude of charge on each conductor

  V_{ab} → potential difference between conductors

- The larger the capacitance of a capacitor, greater the magnitude Q of charge on either conductor for a given potential difference and hence greater the amt of stored energy.

Capacitance only depends on the shapes and sizes, and position of conductors.

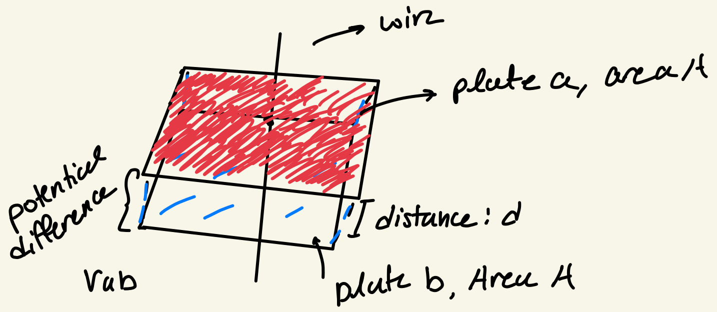
lets say we wanted to store the same charge on a number of capacitors of different capacitance.

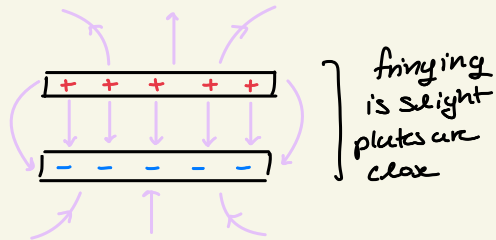
The smaller the capacitance the larger potential difference we would need.

Important formulas in this Section

Calculating Capacitance

- We can calculate capacitance C of a given capacitor by finding the potential difference V_{ab} between the conductors for a given magnitude of charge q





finding electric field $\vec{E}$ between the conductors is $\frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0}$

$\vec{E} = \frac{\sigma}{\varepsilon_0}$; σ magnitude of surface charge density (each plate)

Since $\sigma = \frac{Q}{A}$ E can be expressed as:

$$\boxed{\frac{\sigma}{\varepsilon_0} = \frac{Q}{\varepsilon_0 A}}$$

$$V_{ab} = \vec{E}d = \frac{Q}{\varepsilon_0 A} \cdot d = \frac{1}{\varepsilon_0} \cdot \frac{Qd}{A}$$

Thm.

$$C = \frac{Q}{V_{ab}} = \varepsilon_0 \frac{A}{d}$$

mag of charge

area of each plate

distance between plates

Capacitance of a parallel plate capacitor in vacuum

Potential diff

electric Constant

24.2 Capacitors in Series and Parallel

Capacitors are manufactured with certain standard capacitances and working voltages

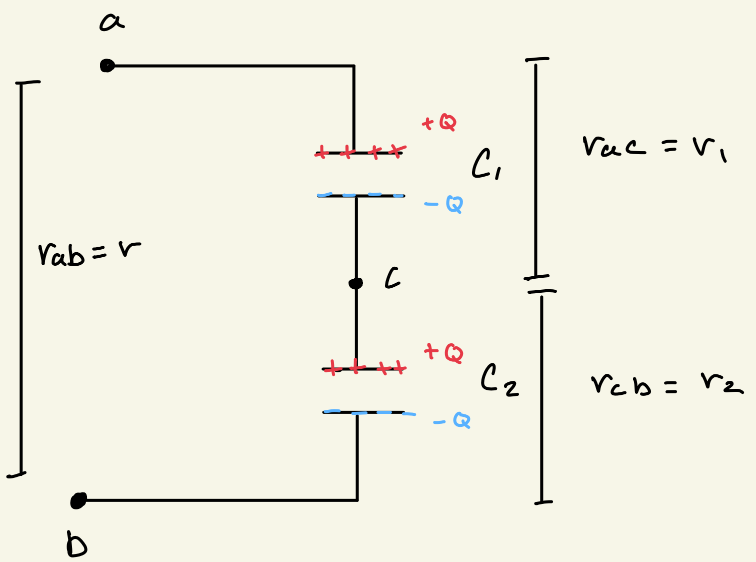
Capacitors in series.

Two capacitors are connected in series by conducting wires betweens points a and b.

initially unchanged when a potential difference is applied The capacitors become charged.

Capacitors in series:

- The capacitors have the same charge Q
- Their potential differences add : $V_{ac} + V_{cb} = V_{ab}$



Equivalent Capacitance is less than individual capacitances.

$$C_{eq} = \frac{Q}{V}$$

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

Def. Capacitors in Series

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

Capacitance of individual capacitors

charge of the capacitors are the same voltage is not

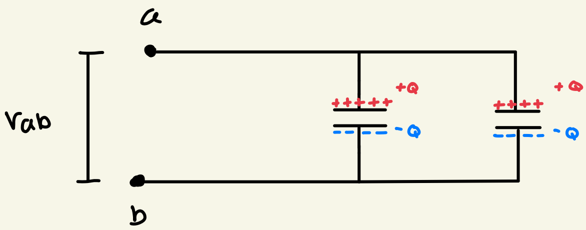
$$V = \frac{Q}{C}$$

$$V = Q\left(\frac{1}{C} + \frac{1}{C_n}\right)$$

Capacitors in parallel

- The capacitors have the same potential V
- The charge on each capacitor depends on its Capacitance

$$Q_1 = C_1 V \quad , \quad Q_2 = C_2 V$$



$$Q = Q_1 + Q_2$$

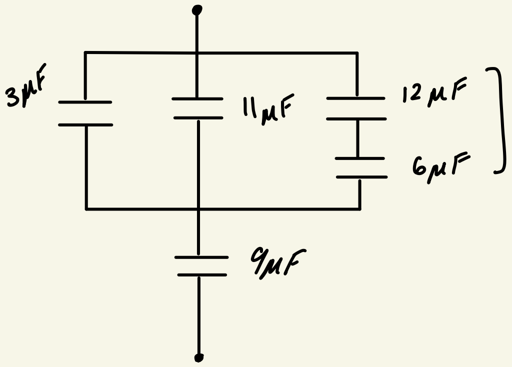
$$C_{eq} = C_1 + C_2$$

voltage is the same in parallel so,

$$\left.\begin{aligned} Q_1 &= C_1 V \\ + \quad Q_2 &= C_2 V \end{aligned}\right\} \quad \underline{Q_1 + Q_2} = V\underline{(C_1 + C_2)}$$

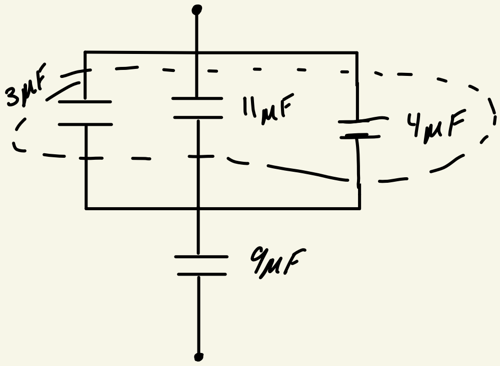
Also important note Capacitance is in $\underline{\underline{\text{Farads}}}$.

Ex Problem:



Series => $\frac{1}{12} + \frac{1}{6}$ $\quad \frac{3}{12} = \frac{1}{4} = 4\mu F$

Step 2



parallel

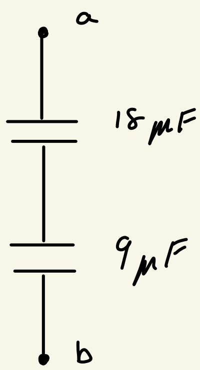
constant voltage.

$\uparrow$

$Q = CV$

$= 3 + 11 + 4 = 18\mu F$

Step 3.)



$\frac{1}{18} + \frac{1}{9}$ $\quad \left(\frac{3}{18}\right)^{-1} = 6\mu F$

now we know capacitance if the potential diff $V_{ab} = 9.0V$, net charge is $Q = C_{eq} V_{ab}$ => $Q = (6\mu F)(9.0V) = 54\mu C$