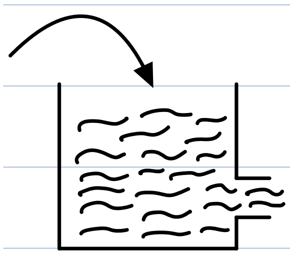
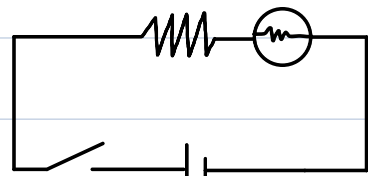
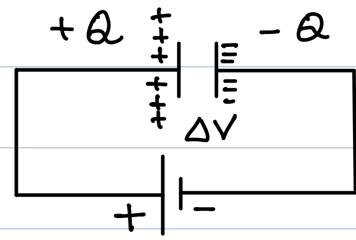
Capacitor

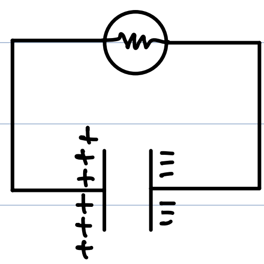
↳ Store charges







Potential differences



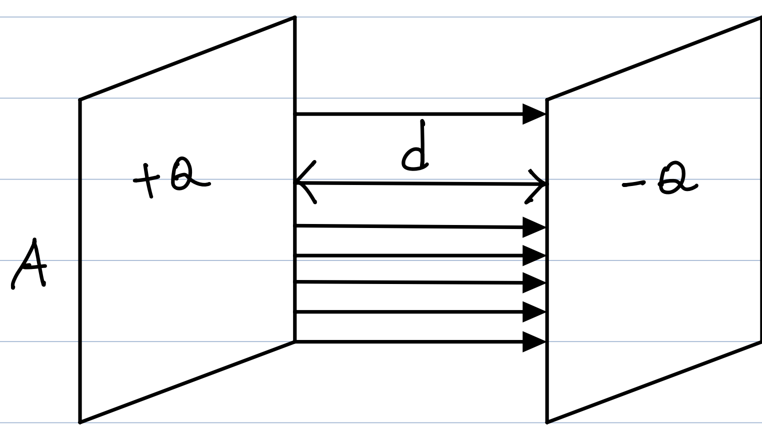
$Q \propto \Delta V$

$\Rightarrow Q = C\Delta V$

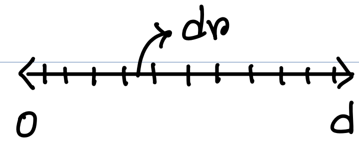
↳ (constant) Capacitance

$C = f(\text{material, shape})$

$Q = C\Delta V$



$$\Delta V = -\int_{-}^{+} \vec{E} \cdot d\vec{r}$$



$$\Delta V = V_{+} - V_{-} = -\int_{-}^{+} \vec{E} \cdot d\vec{r}$$

$$E = \frac{\sigma}{2\varepsilon_0} \text{ [non-conducting]}$$

$$E = \frac{\sigma}{\varepsilon_0} \text{ [conducting]}$$

$$\Delta V = V_{+} - V_{-} = -\int_{-}^{+} \vec{E} \cdot d\vec{r}$$

$$= \int_{+}^{-} \vec{E} \cdot d\vec{r}$$

$$= \int_{+}^{-} E\,dr \cos 0^{\circ}$$

$$= \int_{+}^{-} E\,dr$$

$$= \int_{0}^{d} \frac{\sigma}{\varepsilon_0}\,dr$$

$$= \frac{\sigma}{\varepsilon_0} \int_{0}^{d} dr$$

$$= \frac{\sigma}{\varepsilon_0} r \Big|_0^d$$

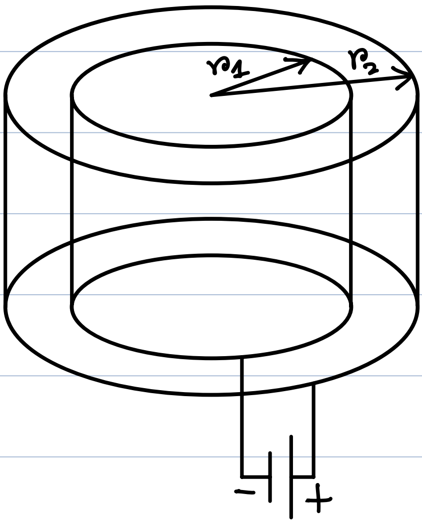
$$\therefore \Delta V = \frac{\sigma d}{\varepsilon_0}$$

$$= \frac{Qd}{A\varepsilon_0}$$

$$\Rightarrow Q = C\,\Delta V$$

$$\Rightarrow Q = C \frac{Qd}{A\varepsilon_0}$$

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



$$\Delta V = \int_{+}^{-} \vec{E} \cdot d\vec{r}$$

$$E = \frac{1}{2\pi\epsilon_0} \frac{\lambda}{r}$$

$$\Rightarrow E \cdot A = \frac{q}{\epsilon_0}$$

$$\Rightarrow E \cdot 2\pi r l = \frac{q}{\epsilon_0}$$

$$\Rightarrow E = \frac{q}{2\pi r l \epsilon_0}$$

$$= \frac{\lambda}{2\pi r \epsilon_0}$$

$$\Delta V = \int_{+}^{-} \vec{E}\, d\vec{r}$$

$$= \int_{r_1}^{r_2} \frac{\lambda}{2\pi\epsilon_0 r}\, dr$$

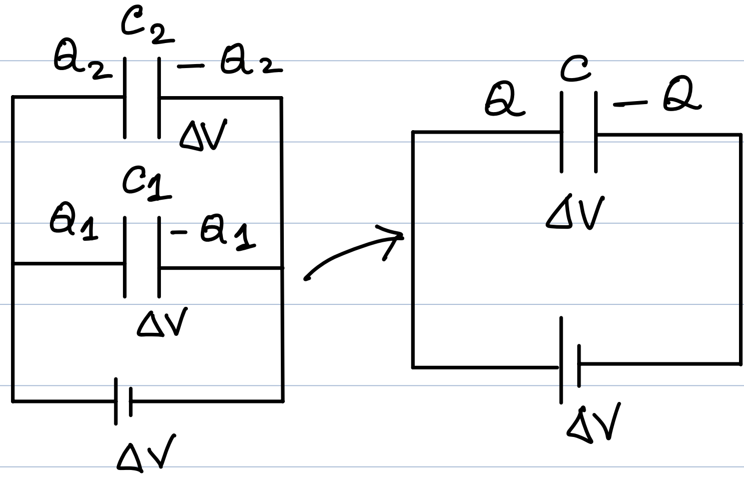
$$= \frac{\lambda}{2\pi\epsilon_0} \int_{r_1}^{r_2} \frac{1}{r}\, dr$$

$$\Delta V = \frac{Q}{2\pi\epsilon_0 l} \ln\left|\frac{r_2}{r_1}\right|$$

$$Q = C\,\Delta V$$

$$\Delta V = \frac{C\,\Delta V}{2\pi\epsilon_0 l} \ln\left|\frac{r_2}{r_1}\right|$$

$$C = \frac{2\pi l \epsilon_0}{\ln\left|\frac{r_2}{r_1}\right|}$$

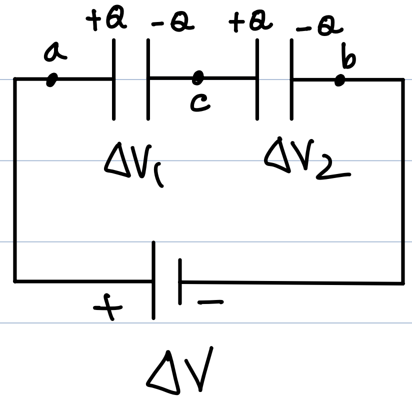


$$Q = Q_1 + Q_2$$

$$\Rightarrow C\,\Delta V = C_1\,\Delta V + C_2\,\Delta V$$

$$\Rightarrow C = C_1 + C_2$$

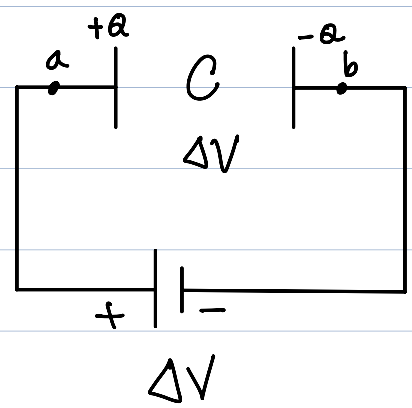
[Parallel combination]



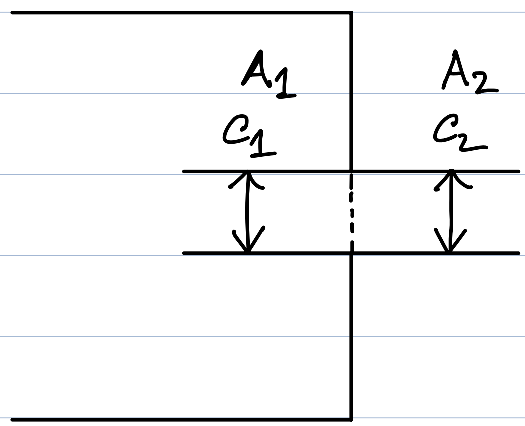
$$\Delta V = V_a - V_b$$
$$= V_a - V_c + V_c - V_b$$
$$= \Delta V_1 + \Delta V_2$$

$$Q = C_1 \Delta V_1 \Rightarrow \Delta V_1 = \frac{Q}{C_1}$$
$$Q = C_2 \Delta V_2 \Rightarrow \Delta V_2 = \frac{Q}{C_2}$$

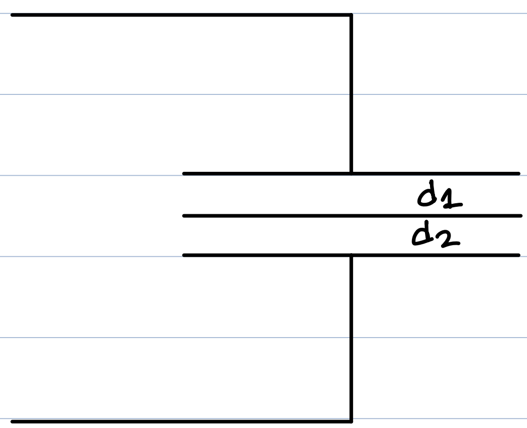
$$\Delta V = \Delta V_1 + \Delta V_2$$
$$= \frac{Q}{C_1} + \frac{Q}{C_2}$$

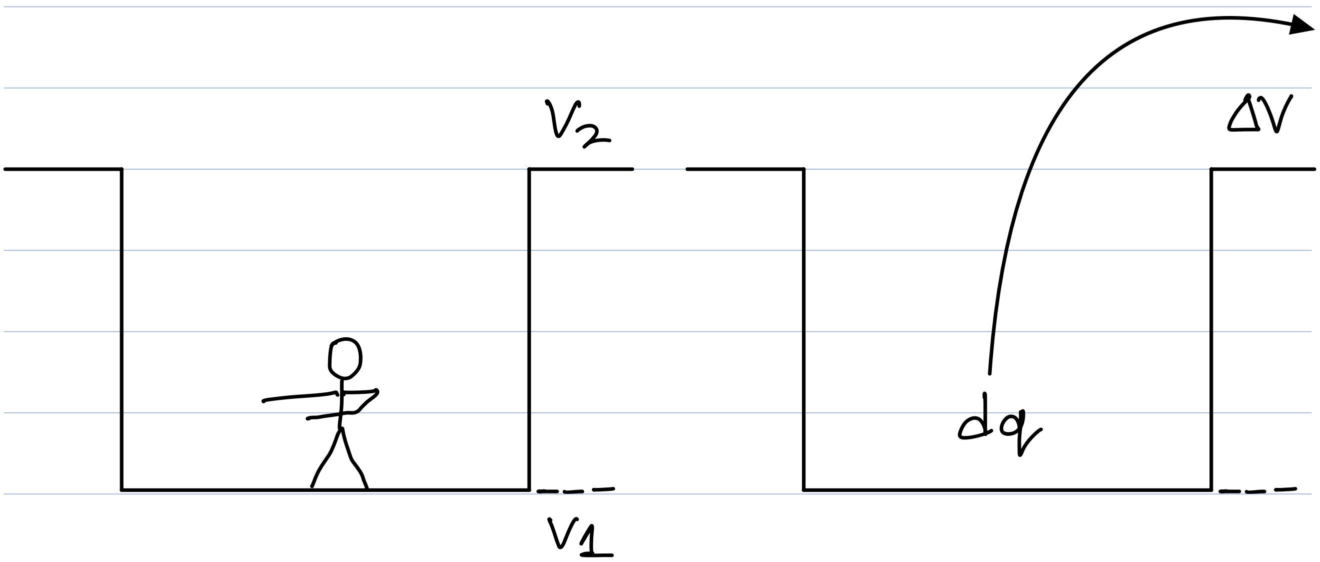


$$\frac{Q}{C_s} = \frac{Q}{C_1} + \frac{Q}{C_2}$$
$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2}$$

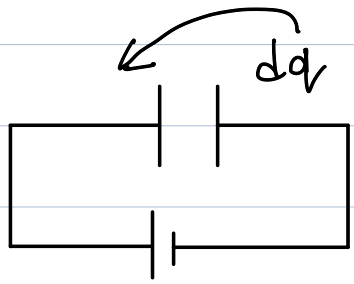


$$C = \frac{\epsilon_0 A}{d}$$





$du = dq\,\Delta V \qquad Q = C\Delta V$



$$U = \int_0^Q dq\,\Delta V$$

$$= \int_0^Q dq\,\frac{q}{C}$$

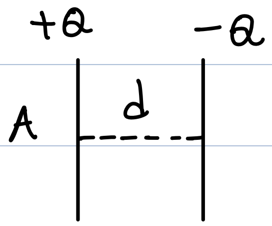
$$= \frac{1}{C}\int_0^Q q\,dq$$

$$= \frac{1}{C}\,\frac{q^2}{2}\Big|_0^Q$$

$$= \frac{Q^2}{2C}$$

$$= \frac{1}{2C}(C\Delta V)^2$$

$$= \frac{1}{2}C\Delta V^2$$



$V = Ad \longrightarrow U$

$1 \longrightarrow \frac{U}{Ad} = u$

$$\Rightarrow u = \frac{U}{Ad}$$

$$\Rightarrow u = \frac{\frac{1}{2}C\Delta V^2}{Ad} = \frac{1}{2}\,\frac{\epsilon_0 A}{d}\,(Ed)^2 \cdot \frac{1}{Ad}$$

$$= \frac{1}{2}E^2\epsilon_0$$