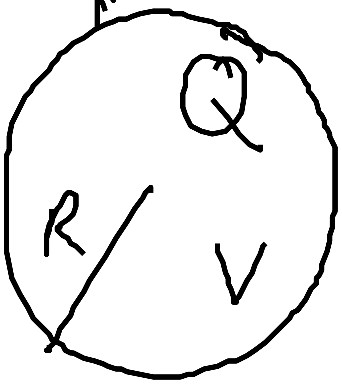
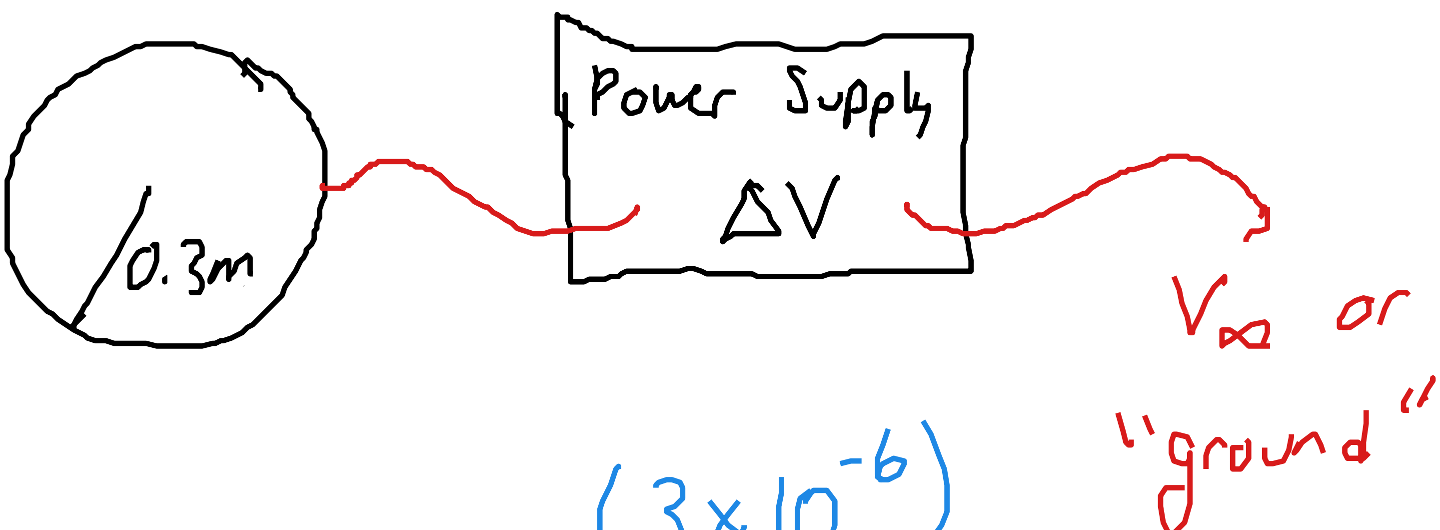
metal: has same V everywhere in the metal



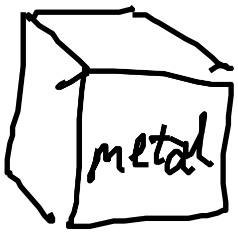
$$\Delta V = V - V_\infty = k\frac{Q}{R}$$

Suppose I want to put $3\mu C$ of charge on this sphere



$$\Delta V = (9\times10^9)\frac{(3\times10^{-6})}{(0.3)}$$

$$= 9\times10^4\,V = 90\,kV$$



the exact relationship between Q & ΔV is less pretty, but

$$\Delta V \sim Q$$

$$Q = C \Delta V$$

capacitance of the conductor

For sphere

$$\cancel{Q} = C \frac{k\cancel{Q}}{R}$$

$$\boxed{C_{sphere} = \frac{R}{k}}$$

bigger R, bigger C

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

Units C : $\frac{\text{Coulomb}}{\text{Volt}}$ = Farad

1 F

1 Farad is a huge capacitance

μF, nF, pF $(p = 10^{-12})$

Careful: $C = 5\mu F$

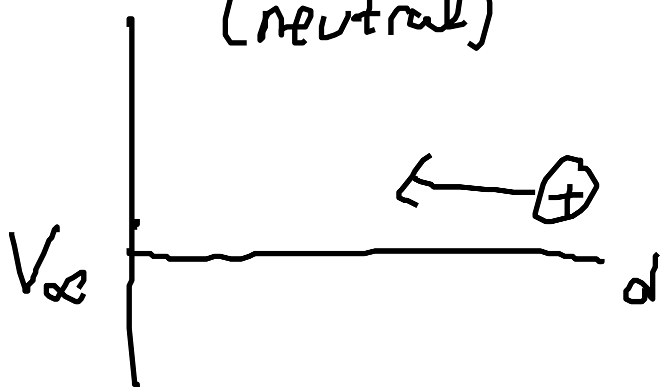
$Q = 5\mu C$

Capacitance is a property of the metal - it's shape, size, etc.

Capacitor is a device designed to have a specific capacitance.

Capacitors store charge <u>and</u> potential energy

empty capacitor (neutral)



later

Work is required to add charge to a charged capacitor

For every charge you add,

change in capacitor's energy $\rightarrow \Delta PE = q \, \Delta V \leftarrow$ how "high" the capacitor is already

tiny charges

$$dPE = dq \, \Delta V(q)$$

total

$$PE = \int dPE = \int_0^Q \Delta V(q) \, dq$$

$Q \leftarrow$ final charge on capacitor

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

$$\Delta V = Q/C$$

$$= \int_0^Q q/C \, dq$$

$$= \frac{1}{C}\int_0^Q q \, dq = \frac{1}{C}\left[\frac{1}{2}q^2\right]_0^Q$$

$$= \frac{1}{C}\left[\frac{1}{2}Q^2 - 0\right]$$

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

$$Q = C\Delta V$$

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

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

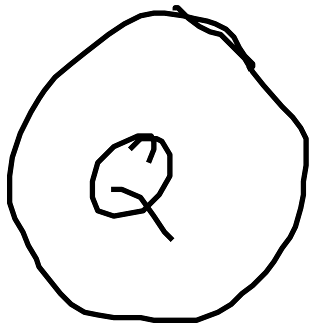
$$PE = \frac{1}{2}C(\Delta V)^2$$

if ΔV ~~changes~~ increases when you change C, then you don't know what happens to PE

If Q is constant

(e.g isolated capacitor)

and C increases



$$\underset{\text{const}}{Q} = \underset{\uparrow}{C}\,\underset{\downarrow}{\Delta V}$$

$$\underset{\downarrow}{PE} = \frac{Q^2 \ \text{const}}{2C\uparrow}$$

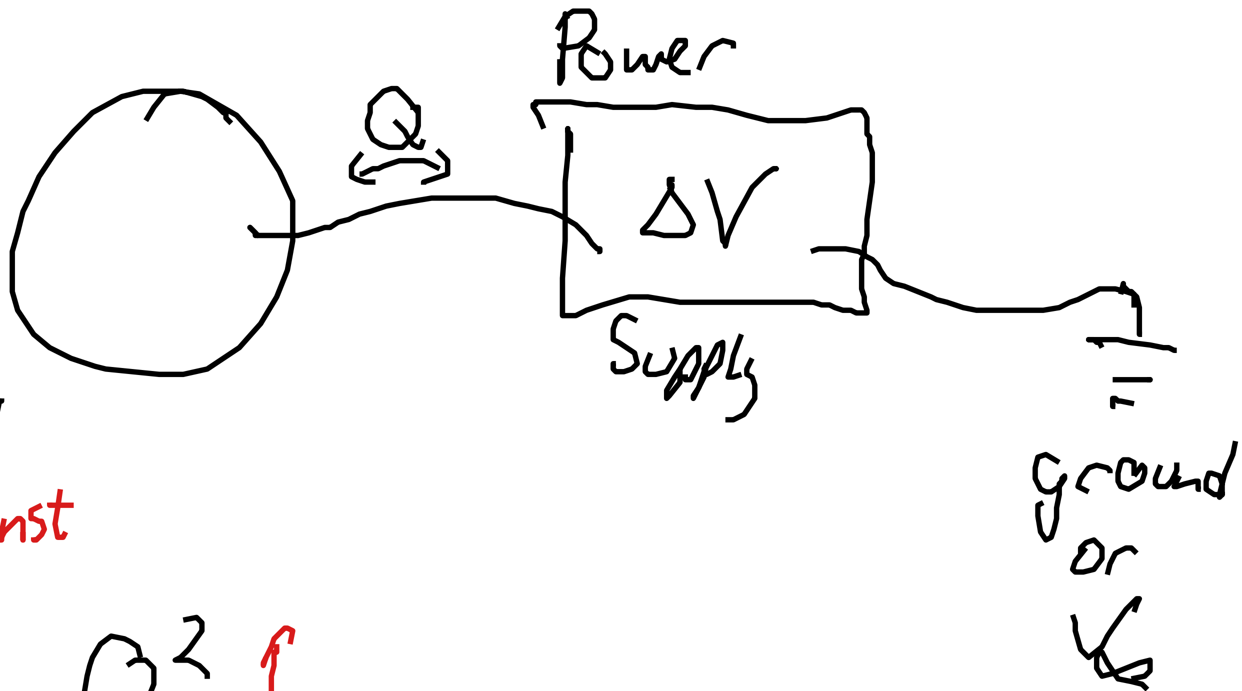
$$\underset{?}{PE} = \frac{1}{2}\underset{\uparrow}{C}(\underset{\downarrow}{\Delta V})^2$$

For isolated capacitor,

larger capacitance $\rightarrow$

less energy

If ΔV is constant



$$\underset{\uparrow}{Q} = \underset{\uparrow}{C}\,\underset{\text{const}}{\Delta V}$$

$$\underset{?}{PE} = \frac{Q^2 \uparrow}{2C \uparrow} \qquad \underset{\uparrow}{PE} = \frac{1}{2}\underset{\uparrow}{C}\,\underset{\text{const}}{(\Delta V)}^2$$

For capacitor at constant potential,

larger capacitance $\longrightarrow$ more energy