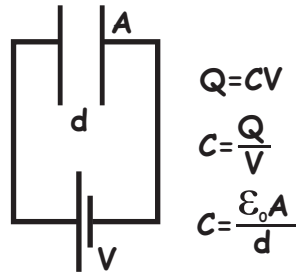


CAPACITANCE

CAPACITANCE



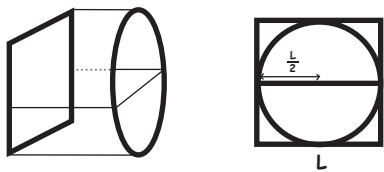
Capacitance Depends on

1. Distance between plates
2. Area of plates
3. Medium b/w plates

Capacitance is Independent of

1. Charge
2. Potential difference

Unit Of Capacitance = Farad



$$A_{\text{eff}} = \pi \left(\frac{L}{2} \right)^2 = \pi \frac{L^2}{4}$$

$$C = \frac{\epsilon_0 A_{\text{eff}}}{d} = \frac{\pi \epsilon_0 L^2}{4d}$$

ENERGY STORED

Work done by battery = QV (100%)

50% Energy stored in capacitor
 $= \frac{1}{2} QV = \frac{CV^2}{2}$
 $= \frac{Q^2}{2C}$

50% Energy dissipated
 $= \frac{1}{2} QV = \frac{CV^2}{2}$
 $= \frac{Q^2}{2C}$

Variation with plate separation

1. $Q = CV = \frac{\epsilon_0 AV}{d}$
2. $C = \frac{\epsilon_0 A}{d}$ $C \propto \frac{1}{d}$
3. $V = \frac{Q}{C} = \frac{Qd}{\epsilon_0 A}$
4. $E = \frac{Q}{A\epsilon_0} = \frac{V}{d}$
5. $F = \frac{Q^2}{2A\epsilon_0} = \frac{CV^2}{2d}$
6. $U = \frac{CV^2}{2}$ OR $U = \frac{Q^2}{2C} = \frac{Q^2 d}{2\epsilon_0 A}$
 $= \frac{\epsilon_0 AV^2}{2d}$

DIELECTRIC IN CAPACITOR

$C' = \frac{k\epsilon_0 A}{d}$
 $C' = KC$

$C' = \frac{\epsilon_0 A}{d - t + \frac{t}{K}}$

$C' = \frac{\epsilon_0 A}{\frac{t_1}{K_1} + \frac{t_2}{K_2} + \frac{t_3}{K_3}}$

Dielectric inserted in capacitor

Battery removed

1. $C = KC'$
2. $Q' = Q$
3. $V' = \frac{V}{K}$
4. $E' = \frac{E}{K}$
5. $U' = \frac{U}{K}$

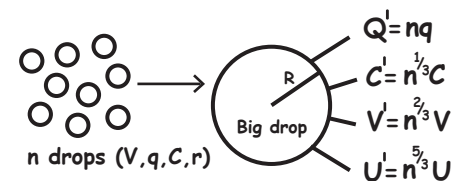
Battery remains connected

1. $C' = KC$
2. $Q' = KQ$
3. $V' = V$
4. $E' = E$
5. $U' = KU$

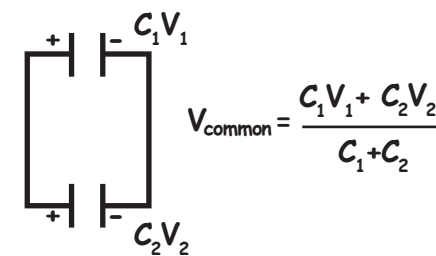
SPHERICAL CAPACITOR

$C = 4\pi\epsilon_0 R$ $C = 4\pi\epsilon_0 \left[\frac{R_1 R_2}{R_2 - R_1} \right]$

REDISTRIBUTION OF CHARGE



Connecting two charged capacitors - Case 1



Initial Energy

$$U_i = \frac{C_1 V_1^2}{2} + \frac{C_2 V_2^2}{2}$$

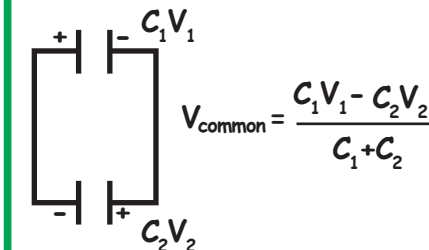
Heat loss

Final Energy

$$U_f = \frac{1}{2} (C_1 + C_2) \left(\frac{C_1 V_1 + C_2 V_2}{C_1 + C_2} \right)^2$$

$$\text{Energy loss} = \frac{C_1 C_2}{2(C_1 + C_2)} (V_1 - V_2)^2$$

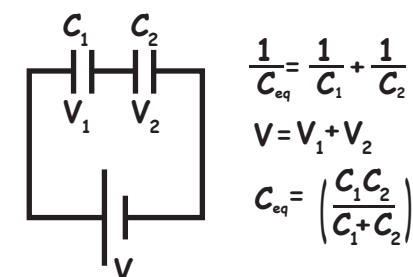
Connecting two charged capacitors - Case 2



$$\text{Energy loss} = \frac{C_1 C_2}{2(C_1 + C_2)} (V_1 + V_2)^2$$

Grouping of capacitors

1. Series combination

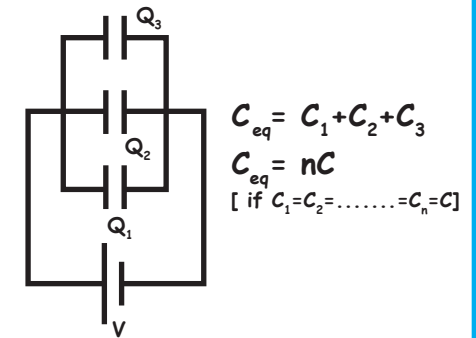


Voltage divider rule

$$V \propto \frac{1}{C}$$

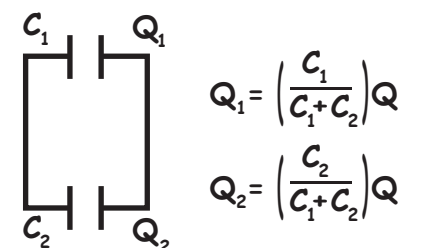
$$V_1 = \left(\frac{C_2}{C_1 + C_2} \right) V \quad V_2 = \left(\frac{C_1}{C_1 + C_2} \right) V$$

2. Parallel combination

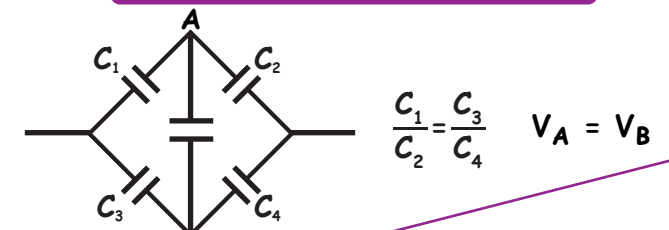


Charge divider rule

$$Q \propto C$$

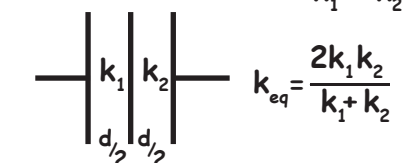
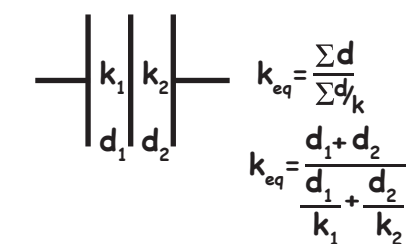


WHEATSTONE'S BRIDGE



MULTIPLE DIELECTRICS

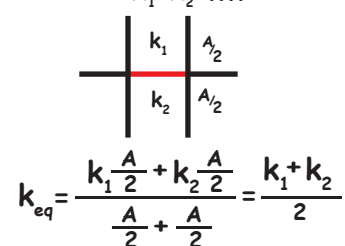
1. Series combination



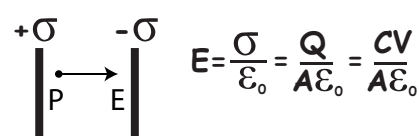
2. Parallel combination

$$k_{\text{eq}} = \frac{\sum kA}{\sum A}$$

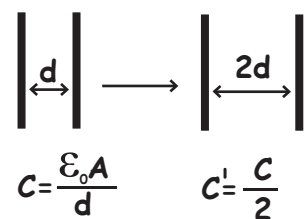
$$k_{\text{eq}} = \frac{k_1 A_1 + k_2 A_2 + \dots}{A_1 + A_2 + \dots}$$



ELECTRIC FIELD



when plate separation doubled



POTENTIAL

$$V = Ed = \frac{Qd}{A\epsilon_0}$$

Force b/w plates of a parallel plate capacitor

$F = Q \times E$ (Due to one plate)
 $= Q \times \frac{\sigma}{2\epsilon_0} = Q \times \frac{Q}{2A\epsilon_0}$
 $= \frac{Q^2}{2A\epsilon_0} = \frac{C^2 V^2}{2A\epsilon_0} = \frac{\epsilon_0 A}{d} \times \frac{CV^2}{2A\epsilon_0}$
 $= \frac{CV^2}{2d}$

Battery connected

$d \rightarrow 2d$

1. $V = \text{Constant}$
2. $C' = \frac{C}{2}$
3. $Q = CV$, $Q' = \frac{Q}{2}$
4. $E = \frac{V}{d}$, $E' = \frac{E}{2}$
5. $F = \frac{CV^2}{2d}$, $F' = \frac{F}{4}$
6. $U = \frac{CV^2}{2}$, $U' = \frac{U}{2}$

Battery Disconnected

$d \rightarrow 2d$

1. $Q = \text{Constant}$
2. $C' = \frac{C}{2}$
3. $V = \frac{Q}{C}$, $V' = 2V$
4. $E = \frac{Q}{A\epsilon_0} = \text{Constant}$
5. $F = \frac{Q^2}{2A\epsilon_0} = \text{Constant}$
6. $U = \frac{Q^2}{2C}$, $U' = 2U$