CAPACITOR

$Q = CV$ $\quad \boxed{\frac{C}{\text{Volt}} = \text{farad}}$

- Depends on size, shape and medium b/w them – Slope of Q/V graph
- Dimension - $[M^{-1}L^{-2}T^4A^2]$
- 2 spherical capacitor :-

$$\boxed{C = \frac{QR}{KQ} = 4\pi\varepsilon_0 R}$$

special case :-

$C' = n^{1/3}C \quad V' = n^{5/3}V$

$V' = n^{2/3}V \quad R = n^{1/3}r$

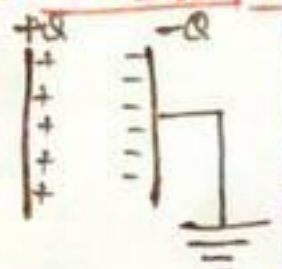
- Combination of spherical capacitors :-

$$\boxed{C = 4\pi\varepsilon_0\left[\frac{ab}{a-b}\right]}$$

$b = \infty$

$C = 4\pi\varepsilon_0 a$

Parallel Plate Capacitors :-



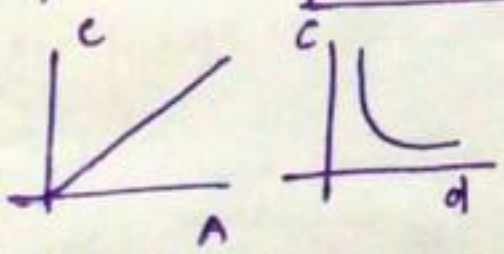
$$\boxed{E_{net} = \frac{\sigma}{\varepsilon_0} = \frac{Q}{A\varepsilon_0}}$$

$$\boxed{\Delta V = \frac{\sigma d}{\varepsilon_0} = \frac{Qd}{A\varepsilon_0}}$$

E (due to 1 plate) $= \frac{\sigma}{2\varepsilon_0} = \frac{Q}{2A\varepsilon_0}$

$$\boxed{C_0 = \frac{Q}{\Delta V} = \frac{A\varepsilon_0}{d}} \qquad \boxed{C' = K\frac{A\varepsilon_0}{d}}$$

Dielectric induced b/w plates :- $\boxed{C' = KC_0}$



- Force b/w the plates :-

$$\boxed{F = \frac{Q^2}{2A\varepsilon_0} = \frac{\sigma^2 A}{2\varepsilon_0}} \quad \because F = qE$$

- Pressure on the plates :-

$$\boxed{P = \frac{Q^2}{2A^2\varepsilon_0} = \frac{\sigma^2}{2\varepsilon_0}}$$ ← same as energy density

- Energy density :-

$$\boxed{E = \frac{\sigma^2}{2\varepsilon_0} = \frac{Q^2}{2\varepsilon A}}$$ Total Energy stored

- Energy on capacitor :-

$$\boxed{E = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}QV}$$

$$\boxed{V_A - V_B = Q/C}$$ + ase - Q jayega to - Q/C aayega

- self energy :- for spherical capacitor = $\boxed{U = \frac{Q^2}{8\pi\varepsilon_0 R}}$

$U = \left(\frac{KQ^2}{2R}\right)$

- Cylindrical capacitor :- $C = \frac{2\pi\varepsilon_0 L}{\log_e\left(\frac{b}{a}\right)}$

Charging of capacitor :-

- WD by battery in charging capacitor $= CV^2$
- WD in charging capacitor $= \frac{1}{2}CV^2$
- $U_{loss} = \frac{1}{2}CV^2$ (Heat)
- MR* for calculating loss :-

$$\boxed{U_i + W_{Battery} = U_f + U_{loss}}$$

$\frac{1}{2}CV_i^2 \quad Q\Delta V \quad \frac{1}{2}CV_f^2$

→ Connection of 2 capacitors :-

- Same terminal connection

$$\boxed{V_c = \frac{C_1V_1 + C_2V_2}{C_1 + C_2} = \frac{q_1 + q_2}{C_1 + C_2}}$$

Loss in Energy $\Delta U = \frac{1}{2}\frac{C_1C_2}{C_1+C_2}(V_1 - V_2)^2$

Final charge $q_1' = C_1V_c$ $\quad q_2' = C_2V_c$

Transfer = $[q - q_1']$

- Reverse polarity connection :-

$V_c = \frac{C_1V_1 - C_2V_2}{C_1 + C_2}$ $\quad \Delta U = \frac{1}{2}\frac{C_1C_2}{C_1+C_2}[V_1 + V_2]^2$

$$\boxed{V_c = \frac{V}{1+K}}$$ → 1 Air capacitor with other filled with dielectric

Combination of capacitor :-

- Series :- Q = same $\quad Q = CV$

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \dots \qquad \boxed{C \propto \frac{1}{V}}$$

Jisme C ↑ usme V ↓

- Parallel :- V = same

$$C_{eq} = C_1 + C_2 + \dots \qquad \boxed{q \propto C}$$

Jisme C ↑ uska q ↑

- If n-identical (connected in series and parallel :-

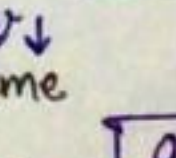
1) series	2) Parallel
$C_{eq} = \frac{C}{n}$	$C_{eq} = nC$
C_{eq} is smaller than the smallest C	C_{eq} is larger than the largest C.

- Breakdown Voltage :-

V max that can be applied across a C.

- series - $\boxed{V_B = V_1 + V_2 + V_3 + \dots}$
- Parallel - $\boxed{V_B = V}$

• Special case



No of gap = No of C

- Wheatstone :- $\frac{C_1}{C_4} = \frac{C_2}{C_3}$

- Cube capacitance :-

(side) (face D) (Body D)

$C_{AB} = \frac{12}{7}$, $C_{AC} = \frac{4}{3}$, $C_{AD} = \frac{6}{5}$

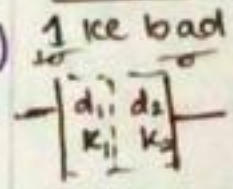
★ Dielectric Medium in an External Electric field :-

$$\boxed{E_{net} = \frac{E_0}{K}}$$

Jaise coulomb F ↓ 'K' times, similarly E.field ↓ 'K' times.

A) SERIES COMBINATION :-

1 ke bad 1 dalte hai.

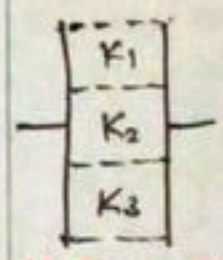


$$\boxed{C = \frac{A\varepsilon_0}{\left[\frac{d_1}{K_1} + \frac{d_2}{K_2}\right]}}$$

$$\boxed{K_{eq} = \frac{d}{\frac{d_1}{K_1} + \frac{d_2}{K_2}}}$$

B) PARALLEL COMBINATION :-

(sare dielectric ka 1 terminal +ve and dusra -ve)



$$\boxed{C_{eq} = \frac{\varepsilon_0}{d}[K_1A_1 + K_2A_2 + K_3A_3]}$$

$$\boxed{K_{eq} = \frac{K_1A_1 + K_2A_2 + \dots}{A_1 + A_2 + \dots}}$$

Introduction of dielectric b/w plates of capacitor :-

- Battery is connected :-

	Initially	Finally
Capacitance	C_0	KC_0
Potential	V_0	V_0 ★
Charge	$Q_0 = C_0V_0$	KQ_0
Electric field	$E_0 = V_0/d$	E_0
U_0 (energy)	$U_0 = \frac{Q_0^2}{2C_0}$	KU_0
F_0 (Force on plate)	$F_0 = qE$	KF_0

- Battery zidd hai V same rkhegi.

→ Battery is removed then dielectric placed.

	Initially	Finally
Capacitance	C_0	KC
Potential	$V_0 = Q_0/C_0$	V_0/K
Charge	$Q_0 = C_0V_0$	Q_0 ★
E. Field	$E_0 = V_0/d$	E_0/K
U_0 (Energy)	$U_0 = Q_0^2/2C_0$	U_0/K
F_0 (Force on plate)	$F_0 = qE$	F_0/K

Plate isolate hai to charge conserve rhega

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