(1) Parallel plate capacitor: It consists of two parallel metallic plates (may be circular, rectangular, square) separated by a small distance. If A = Effective overlapping area of each plate.

(i) Electric field between the plates:

$$E=\sigma\varepsilon_0=QA\varepsilon_0$$

(ii) Potential difference between the plates:

$$V=E\times d=\sigma d\varepsilon_0$$

(iii) Capacitance:

$$C=\varepsilon_0 Ad$$

. In C.G.S. :

$$C=A4\pi d$$

(iv) If a dielectric medium of dielectric constant K is filled completely between the plates then capacitance increases by K times i.e.

$C'=K\varepsilon_0 Ad$

$\Rightarrow C'=KC$

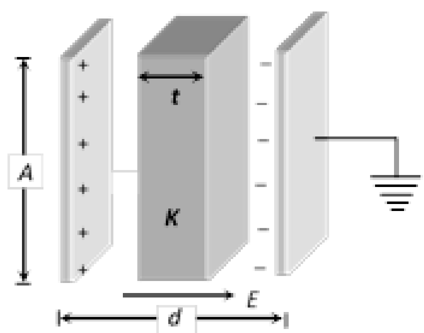
(v) The capacitance of parallel plate capacitor depends on

$$A(C\propto A) \quad \text{and} \quad (C\propto 1d)$$

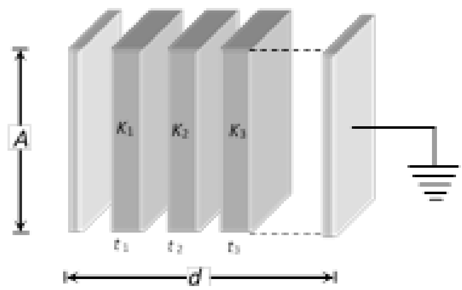
. It does not depend on the charge on the plates or the potential difference between the plates.
(vi) If a dielectric slab is partially filled between the plates

$$\Rightarrow$$

$$C'=\varepsilon_0 Ad-t+tK$$



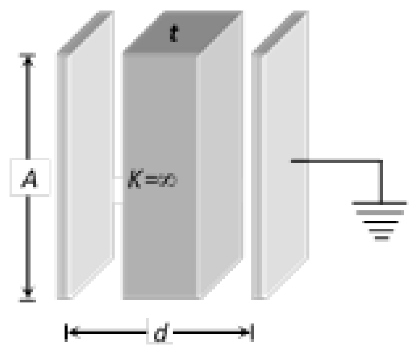
(vii) If a number of dielectric slabs are inserted between the plate as shown



$$C' = \varepsilon_0 A d - (t_1 + t_2 + t_3 + ...) + (t_1 K_1 + t_2 K_2 + t_3 K_3 + ...)$$

(viii) When a metallic slab is inserted between the plates

$$C' = \varepsilon_0 A (d - t)$$



If metallic slab fills the complete space between the plates (i.e. $t = d$) or both plates are joined through a metallic wire, then capacitance becomes infinite.

(ix) Force between the plates of a parallel plate capacitor.

$$|F| = \sigma^2 A 2 \varepsilon_0 = Q^2 2 \varepsilon_0 A = C V^2 2 d$$

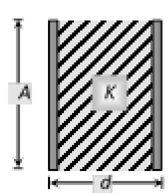
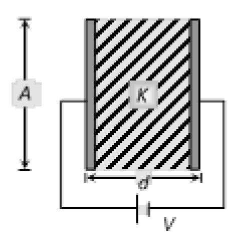
(x) Energy density between the plates of a parallel plate capacitor.

Energy density

$$= \text{Energy Volume}$$

$$= 12 \varepsilon_0 E^2.$$

Variation of different variable (Q, C, V, E and U) of parallel plate capacitor

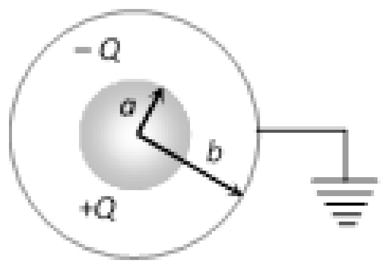
Quantity	**Battery is Removed**	**Battery Remains connected**
		

Capacity	$C' = KC$	$C' = KC$
Charge	$Q' = Q$	$Q' = KQ$
Potential	$V' = V/K$	$V' = V$
Intensity	$E' = E/K$	$E' = E$
Energy	$U' = U/K$	$U' = KU$

(2) Spherical capacitor : It consists of two concentric conducting spheres of radii a and b; $(a<b)$

Inner sphere is given charge $+Q$, while outer sphere is earthed

(i) Potential difference: Between the spheres is



$$V = \frac{Q}{4\pi\varepsilon_0 a} - \frac{Q}{4\pi\varepsilon_0 b}$$

(ii) Capacitance:

$$C = 4\pi\varepsilon_0 . \frac{ab}{b-a}$$

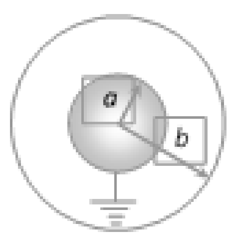
In C.G.S. $C = \frac{ab}{b-a}$

In the presence of dielectric medium (dielectric constant K) between the spheres

$$C' = \frac{4\pi\varepsilon_0 K ab}{b-a}$$

(iii) If outer sphere is given a charge $+Q$ while inner sphere is earthed.

Induced charge on the inner sphere



$$Q' = -\frac{a}{b} . Q$$

and capacitance of the system

$$C' = 4\pi\varepsilon_0 . \frac{b^2}{b-a}$$

This arrangement is not a capacitor. But it’s capacitance is equivalent to the sum of capacitance of spherical capacitor and spherical conductor i.e.

$$4\pi\varepsilon_0 . \frac{b^2}{b-a} = \frac{4\pi\varepsilon_0 ab}{b-a} + 4\pi\varepsilon_0 b$$

(3) Cylindrical capacitor: It consists of two concentric cylinders of radii a and b ; $(a<b)$

, inner cylinder is given charge $+Q$ while outer cylinder is earthed. Common length of the cylinders is l then

$$C = \frac{2\pi\varepsilon_0 l}{\log_e\left(\frac{b}{a}\right)}$$