Capacitance

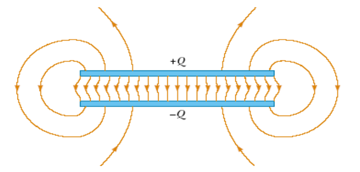
03/12/2023 3:50 PM

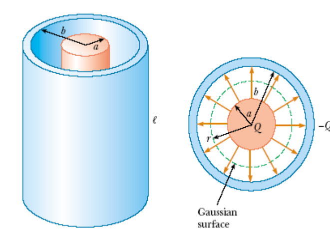
CAPACITORS:- devices that store electric charge. Two conductors carrying equal magnitude of opposite charges cause a p.d to exist between them

CAPACITANCE:-
- charge per unit volt
- $C = \frac{Q}{V}$

USES:-
- used to tune the frequency of radio receivers
- as filters in power supplies
- to eliminate sparking in automobile ignition systems
- as energy storing devices in electronic flash units

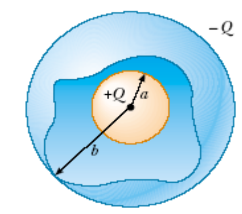
PARALLEL PLATE CAPACITORS:-
- parallel metallic plates of equal area A are separated by a distance d
- capacitance of a parallel plate capacitor is proportional to A and inversely proportional to d
- electric field between the plates $\longrightarrow E = \frac{\sigma}{\varepsilon_0} = \frac{Q}{\varepsilon_0 A}$
- $\Delta V = Ed = \frac{Qd}{\varepsilon_0 A}$
- $C = \frac{Q}{\Delta V} = \frac{\varepsilon_0 A}{d}$





CYLINDRICAL CAPACITOR:-
- a solid cylindrical conductor of radius a and charge Q is coaxial with a cylindrical shell of negligible thickness, radius b>a and charge −Q.
- $C = \frac{\ell}{2k_e \ln\left(\frac{b}{a}\right)}$ where $k_e = 9\times10^9$

SPHERICAL CAPACITOR:-
- a spherical capacitor consists of a spherical conducting shell of radius b and charge −Q concentric with a smaller conducting sphere of radius a and charge Q.
- $C = \frac{ab}{k_e(b-a)}$



PARALLEL COMBINATION OF CAPACITORS:-
- V remains same
- Q and I divided
- $Q = Q_1 + Q_2$
- $CV = C_1V_1 + C_2V_2$
- $C_T = C_1 + C_2$

SERIES COMBINATION OF CAPACITORS:-
- Q and I remain same
- V divided
- $V_T = V_1 + V_2$
- $\frac{Q}{C} = \frac{Q}{C_1} + \frac{Q}{C_2}$

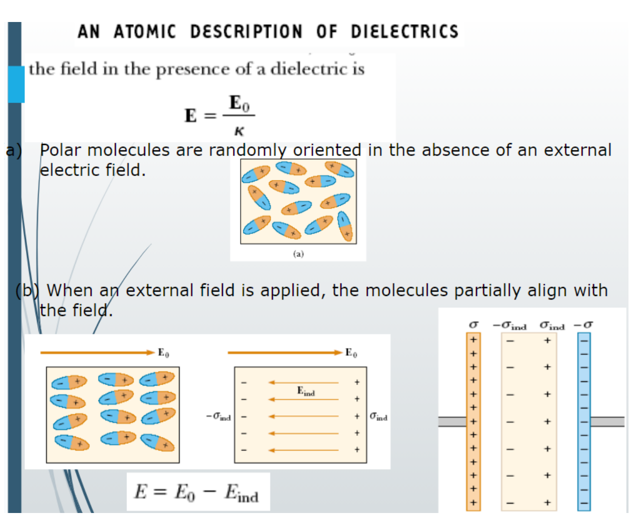
$= \frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2}$

ENERGY STORED IN A CHARGED CAPACITOR:-
- $U = \frac{1}{2}(\varepsilon_0 Ad)E^2 \longrightarrow U = \frac{1}{2}CV^2$ OR $\frac{1}{2}QV$ OR $\frac{Q^2}{2C}$
- energy density $\longrightarrow u_E = \frac{1}{2}\varepsilon_0 E^2$

$u_E \propto E^2$ in any electric field at a given point

CAPACITORS WITH DIELECTRICS:-
- a dielectric is a non-conducting material such as rubber, glass or waxed paper inserted between the plates of a capacitor, this causes the capacitance to increase
- if the dielectric completely fills the space between the plates, the capacitance increases by a dimensionless factor κ called the dielectric constant
- $C = \kappa C_0 \longrightarrow C = \frac{\kappa\varepsilon_0 A}{d}$

ADVANTAGES:-
- increase in capacitance
- increase in maximum operating voltage
- possible mechanical support between the plates, which allows the plates to be close together without touching, thereby decreasing d and increasing C



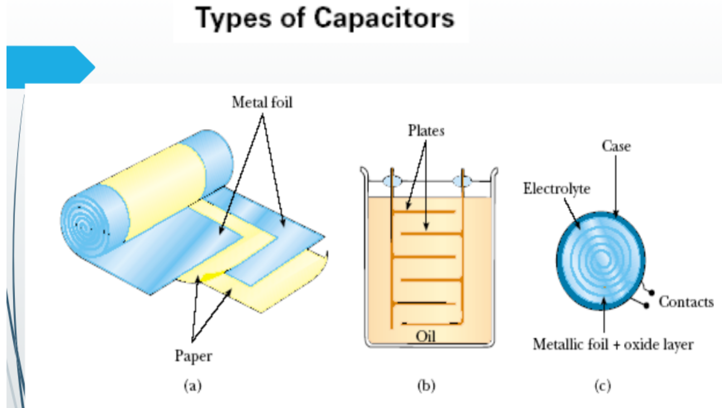


Figure 26.15 Three commercial capacitor designs. (a) A tubular capacitor, whose plates are separated by paper and then rolled into a cylinder. (b) A high-voltage capacitor consisting of many parallel plates separated by insulating oil. (c) An electrolytic capacitor.