Behaviour of conductors in electrostatic fields

Electrostatic properties of a conductor:

(i) Net electrostatic field is zero, inside a conductor:

Explanation: When a conductor is placed in an electric field, its free electrons begin to move in the opposite direction of external force. Negative charges are induced on the left side and positive charges are induced on the right end of the conductor.

The process continues till the electric field set up by the induced charges becomes equal and opposite to the external field.

Electrostatic properties of a conductor:

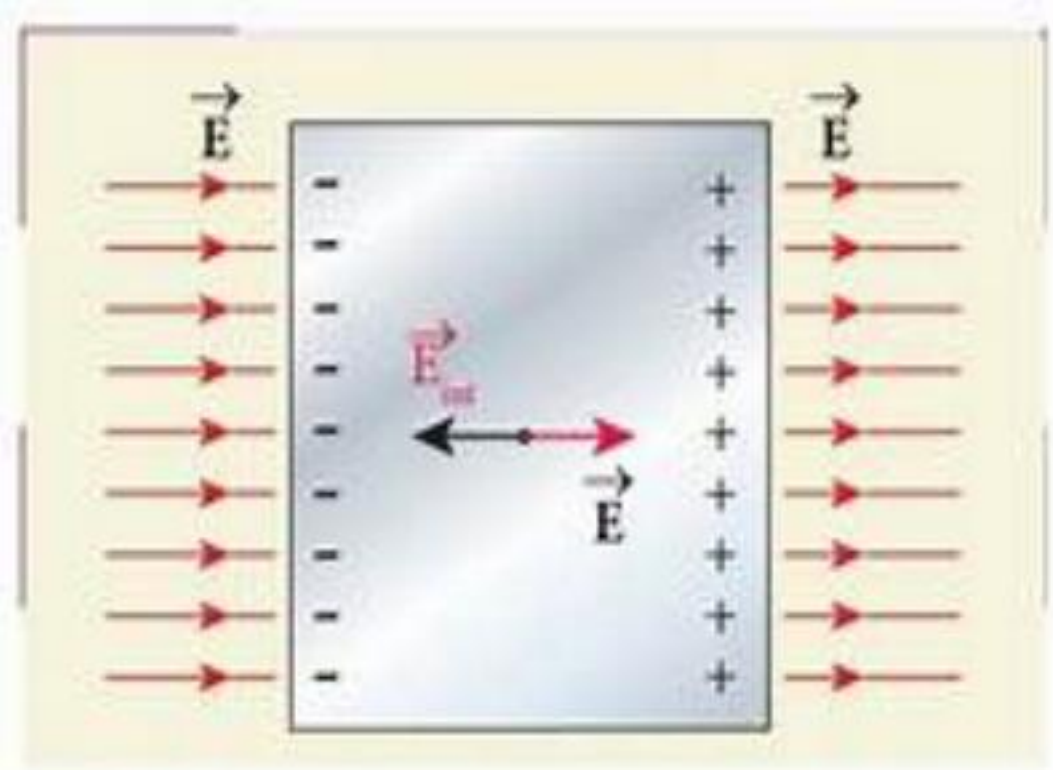


Figure 1.44 Electric field of conductors

Electrostatic properties of a conductor:

(ii) At the surface of a charged conductor, electrostatic field must be normal to the surface at any point.

Explanation: If the electric field is not normal to the surface, it will have a component tangential to the surface which will immediately cause the flow of charges, producing surface currents. But, no such current can exist under static conditions. Hence, electric field is normal to the surface of the conductor at every point.

Electrostatic properties of a conductor:

(iii) Net charge in the interior of a conductor is zero and any excess charge resides at its surface:

Explanation:

Interior electric field is zero.

Excess charge resides on outer surface

Useful for shielding(Faraday cage concept)

Confirmed by Gauss's law

Electrostatic properties of a conductor:

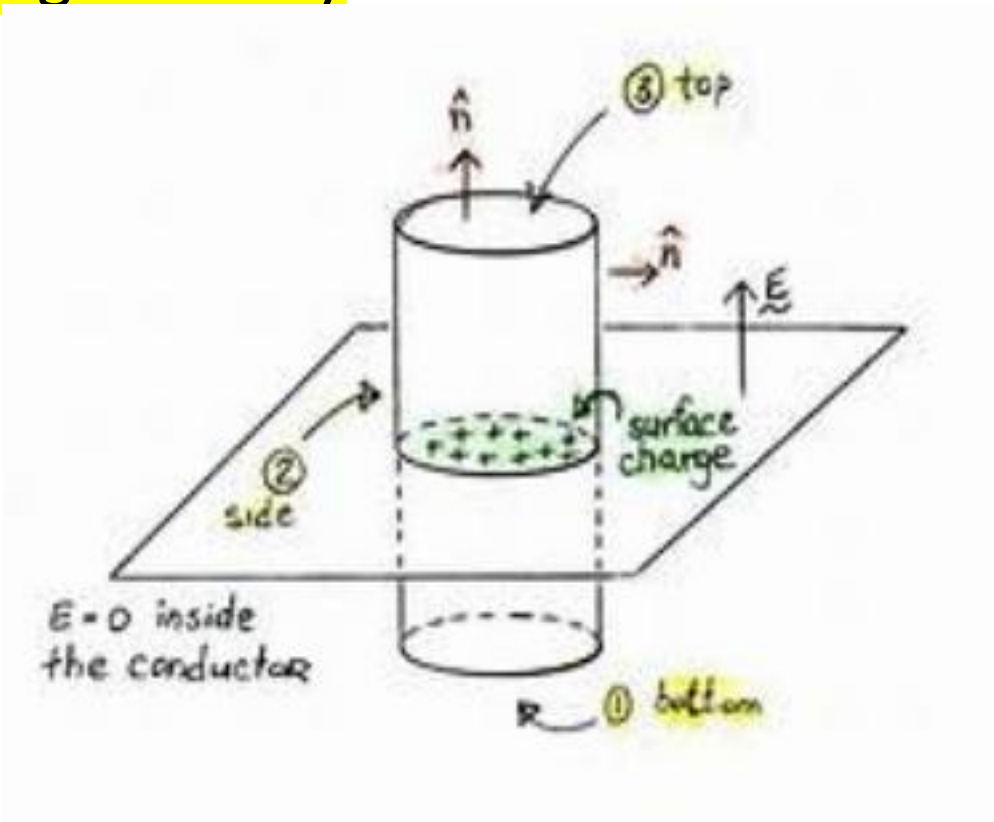
(iv) Potential is constant within and on the surface of a conductor.

Explanation: Throughout the surface, potential remains the same in an same equipotential surface. Therefore, work done is zero.

- Since electric field $\vec{E} = -\nabla V$ (i.e., it's the **negative gradient of potential**),
  if E=0, then: $\nabla V = 0$, V=constant
- If you move a charge inside a conductor (or along the surface), there's **no electric field to do any work** on it.
- Work done $W = q(V_B - V_A) = 0$; VB = VA

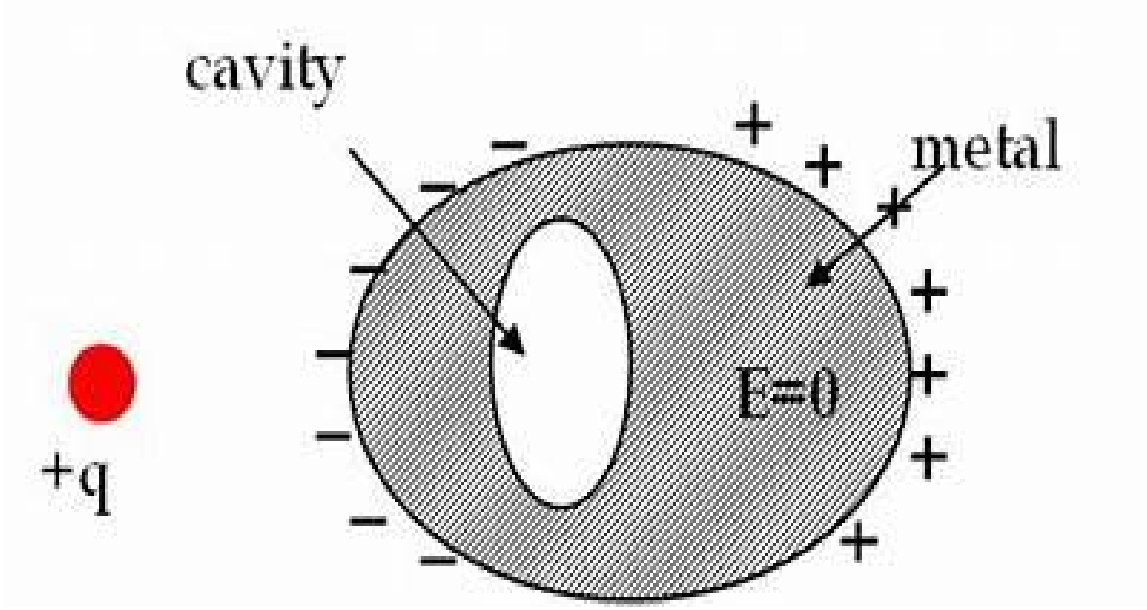
Electrostatic properties of a conductor:

- Electric field at the surface of a charged conductor is proportional to the surface charge density.



Electrostatic properties of a conductor:

- Electric field is zero in the cavity of a hollow charged conductor:



Electrostatic properties of a conductor:

Electrostatic shielding:

The phenomenon of making a region free from any electric field is called electrostatic shielding. It is based on the fact that electric field vanishes inside the cavity of a hollow conductor.

Application:

1. In a thunderstorm accompanied by lightning, it is safest to sit inside a car, rather than near a tree or on the open ground. The metallic body of the car becomes an electrostatic shielding from lightning.

Electrostatic properties of a conductor:

2. Sensitive components of electronic devices are protected or shielded from external electric disturbances by placing metal shields around them.

3. In a coaxial cable, the outer conductor connected to ground provides an electric shield to the signals carried by the central conductor.