Conductor properties

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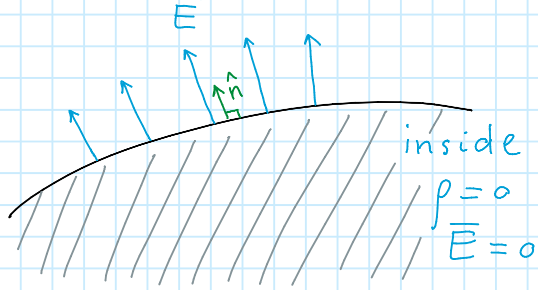
An electrical conductor is an object, substance or material allowing the flow of an electric charge. In particular, metals are conductors since some of the electrons of the metal atoms are free to move in the metal. In an electrostatic situation, conductors have the following properties

1) $\bar{E} = 0$: The electric field inside a conductor must be zero. If that was not the case, the free charges in the conductor would feel a force due to the electric field and would move, bringing us out of an electrostatic situation.
2) $\varphi = const$: Since the electric field inside a conductor is zero, the potential inside a conductor is constant.
3) $\rho = 0$: The charge density inside a conductor is zero, because E = 0 and $\nabla \cdot \bar{E} = \frac{\rho}{\varepsilon_0}$
4) Conducting objects can either be neutral (carrying therefore the same amount of positive and negative charges) or charged. In the latter case the charge should be distributed on the surface of the conductor.
5) The surface of the conducting object is an equipotential surface, since all points of the conductor are at the same potential. Consequently, the electric field on the surface of the conductor is perpendicular to the surface of the conductor. This satisfies automatically the condition that the component of E parallel to the surface is continuous across the surface of the conductor: That component is zero inside the conductor and it must be zero just outside the conductor.
6) If there is a surface charge density somewhere on the surface of the conductor, the fact that E = 0 inside the conductor and that E is perpendicular to the surface of the conductor, in combination with the boundary conditions which we already mentioned imply that

$$\bar{E} = \frac{\sigma}{\varepsilon_0} \hat{n}$$

$\hat{n}$ = unit vector $\perp$ to the surface of the conductor



Electrostatic problems involving conductors are characterized by the fact that electric fields due to sources other than the conductor will induce a rearrangement of the free charges in the conductor which results in the fact that at equilibrium E = 0 inside the conductor.

Faraday's cage

A Faraday's cage is a region of space where there are no charges which is furthermore enclosed by a conducting surface. The electric field in a conducting cage is zero, because the free charges in the conductor will react to any external field by repositioning themselves in such a way that the electric field in the cage is zero.

This can be seen in a more formal way as follows: The conducting surface is an equipotential surface, $\varphi = \varphi_0$ for all points on the surface. In addition, since there are no charges inside the cage, all points inside the cage satisfy Laplace equation

$$\triangle \varphi = 0$$

The potential is then an harmonic function inside the cage. An important mathematical theorem says that an harmonic function defined on a connected domain cannot have local maxima or minima. Therefore the potential inside the cage should be the same as the potential on the border of the cage. Consequently, the electric field is zero inside the cage.