University of Anbar

College of Science

Department of Applied Geology

Fourth Year

Electromagnetics

جامعة الانبار

كلية العلوم

قسم علوم الفيزياء

المرحلة الرابعة

الكهرومغناطيسية

Electrical Field in matter

Part One: Electrical Field in matter 1

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Part one in this chapter: Electrical Field in matter 1

Electrical field in matter

Conductors, Basic properties

in an insulator like glass, each electron is attached to a particular atom,
in conductor, one or more electrons per atom are free throught the material.

i) $E = 0$ inside conductor

ii) $\rho = 0$ inside a conductor

this Follows from Gauss law $\nabla \cdot E = \frac{\rho}{\epsilon_0}$

if $E = 0$ so also is $\rho = 0$

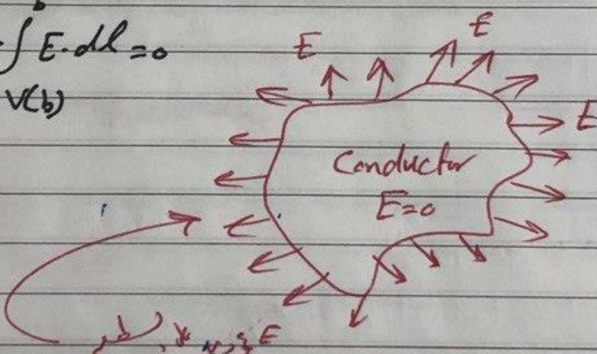
iii) Any net charge reside on The surface اي شحنة موجودة تستقر بالسطح

iv) A conductor is an equipotential الموصل متساوي الجهد

For if a & b are any Two points within OR at The surface of a conductor

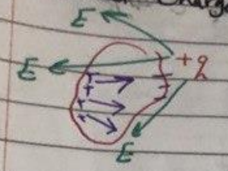
$$V(b) - V(a) = -\int_a^b E \cdot dl = 0$$

hence $V(a) = V(b)$



v) E is perpendicular to the surface

induced charges

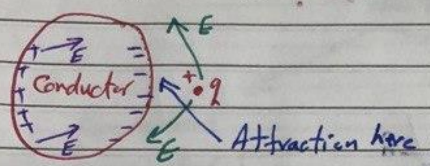


if you hold +q near uncharge conductor in figuer +q with Electric field line $\vec{E}$

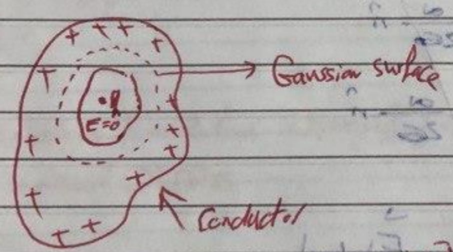
we must to build inside the Conductor $\vec{E}$ with apposite direction and the same magnitude

[illegible] مجال كهربائي داخل الموصل
[illegible]
[illegible]
[illegible] = Zero

Since the Negative charge is closer to q, There is a net force of attraction [illegible]



if there is some cavity in the Conductor, and within the Cavity there is some charge, then the field in the Cavity will not be Zero

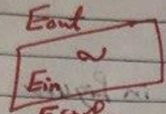


The total charge induced on the Cavity wall is equal and apposite to the charge inside, if we surounded the cavity with a Gaussian surface all the points which are in the Conductor $\oint \vec{E} \cdot da = 0$

the net enclosed charge must be Zero

But $q_{inclosed} = -q$

Electric Field on a Conductor, The Force on a surface charge



3 electric field in this surface

E_{out}, E_{inside}, $E_{surface}$

$E_{inside} = $ Zero (just inside)

$$\vec{E}_{out} = \frac{\sigma}{\epsilon_0}\hat{n}$$

Potential $-\nabla \cdot V = \vec{E}$

$$\frac{\partial V}{\partial n} = \frac{-\sigma}{\epsilon_0} \Rightarrow \sigma = -\epsilon_0 \frac{\partial V}{\partial n}$$ surface charge on the conductor

What is the force on this surface charge?

$$\vec{F} = \sigma \vec{E}_{(\text{at the surface})}$$

$$\vec{E}_{above} = \vec{E}_{ot} + \frac{\sigma}{2\epsilon_0}\hat{n}$$

$$\vec{E}_{below} = \vec{E}_{ot} - \frac{\sigma}{2\epsilon_0}\hat{n}$$

$$\vec{E}_{outside} = \vec{E}_{above} - \frac{\sigma}{2\epsilon_0}\hat{n}$$

$$= \vec{E}_{below} + \frac{\sigma}{2\epsilon_0}\hat{n}$$

add them and Divided to 2

$$\vec{E}_{out} = \frac{1}{2}\left(\vec{E}_{above} + \vec{E}_{below}\right)$$

↑ For Conductor E inside = Zero

[scribbled out] $= \frac{1}{2}\left(\frac{\sigma}{\epsilon_0}\right)$

$$= \frac{1}{2}\frac{\sigma}{\epsilon_0}\hat{n}$$

$\vec{F} = \sigma \vec{E}_{\text{at the surface}}$

$= \sigma \frac{1}{2} \frac{\sigma}{\epsilon_0} \hat{n}$ ← normal direction

$= \frac{1}{2} \frac{\sigma^2}{\epsilon_0} \hat{n}$

$= \vec{E}_{out}^{\,2} \hat{n}$

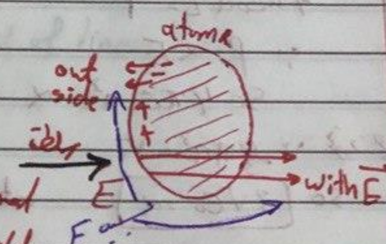
Polarization :-

matter

Conductors
contain an unlimited charges
that are free to move through
the material
تسري بشحناته حرة
(الجع، نحاس)

insulator (dielectrics)
all charges are attached
to specific atoms or
Moleculars.
تكون مقيدة لا تتحرك حيث بالذرة
او الجزيئة

Dielectrics Polarization الاستقطاب في المواد العازلة
induced Dipoles



inside any atoms or surface or shape...
There is Two charges (+, -)
between $+q$ and $-q$ there is r and this is called Dipole or

Electric Dipole

$(+q) \xrightarrow{r} (-q)$

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Reference:

1) INTRODUCTION to ELECTRODYNAMICS, Third Edition, David j.Griffths