ElCoM
ELECTRICAL COMPUTER MECHATRONICS

تقدم لجنة ElCoM الاكاديمية

دفتر الفاينل لمادة:

فيزياء عامة (2)

من شرح:

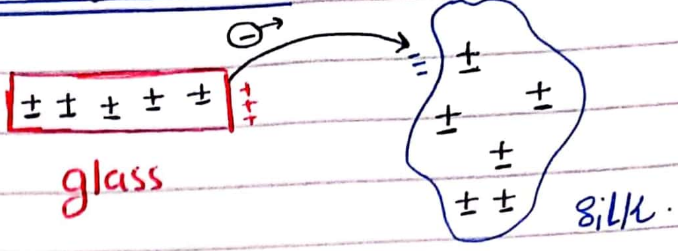
د. غسان النعواشي

جزيل الشكر للطالبة:

تولين آسامة

Ch-23- Electric fields

- Glass rod rubbed with silk.



* مواد بتختلف طاقة الربط فيها منها بتكون طاقة الربط عالية ومنها تكون طاقة الربط قليلة

* بعضها يميل للكسب للالكترونات وبعضها يميل لخسارة الالكترونات.

تجربة (1)

⇒ Electrons are transferrd from glass to silk.

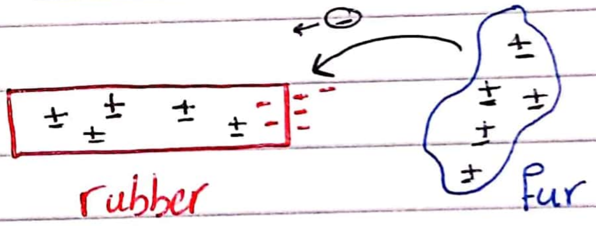
⇒ glass is positively charged.

silk is negatively charged.

* تنتقل من ال glass لأنه قابل للفقد الى ال silk لأنه قابل للكسب.

* عملية الدلك عبارة عن احتكاك و الاحتكاك هو طاقة

- Rubber rod rubbed with fur.



قابل للفقد

⇒ Electrons are transferrd from fur to rubber

⇒ fur is positively charged

⇒ Rubber is negatively charged.

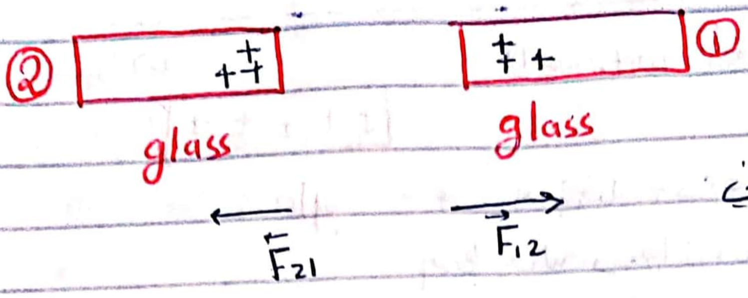
Conclusion : There are two kinds of charges.

1) positive (+) : Like protons.

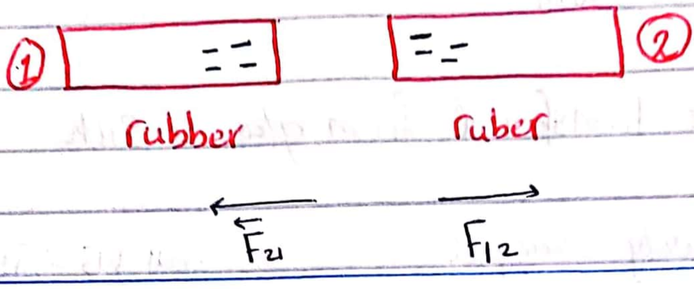
2) negative (-) : Like electron.

حسب قانون نيوتن الثالث ← متساويتان في المقدار متعاكستان في الاتجاه

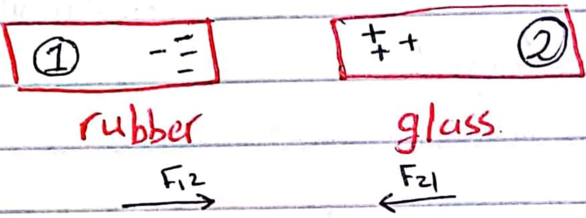
(تنافر)



(تنافر)



(تجاذب)



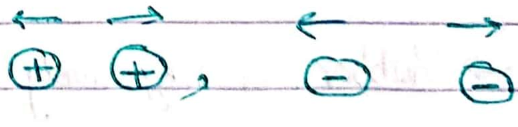
$$\vec{F}_{12} = -\vec{F}_{21}$$

Newton's 3rd Law

* سواء تجاذب أو تنافر (متساويتان في المقدار متعاكستان في الاتجاه) في التجربة (١) (٢) (٣)

Conclusion

* Like charges repel



* unlike charges attract

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* Conservation of charges (حفظ الشحنة)

* Electric charge is always Conserved. on an isolated system

EX ⇒ Charge is not created in the process of rubbing two objects together but transfered from one object to another

* Quantization of charge :

Electric charge is said to quantized : (تكممية)

ie Electric charge exist as discrete packets.

• يعني يتم نقلها (لا يمكن ان ننقل جزء من الالكترون)

$q = \pm ne$	شحنة = N x شحنة e

* $e = 1.6 \times 10^{-19}$ C | C : Coulomb

Electron ; $q_e = -e = -1.6 \times 10^{-19}$ C.

proton : $q_p = +e = 1.6 \times 10^{-19}$ C.

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* Classification of materials. :

• materials are classefied interms of the ability of electrons to move through info.

1) Conductors. (الموصلات) : Some of the electrons are free (unbound) → (غير مقيدة)

e.g. Aluminum , Silver , Copper (النحاس)

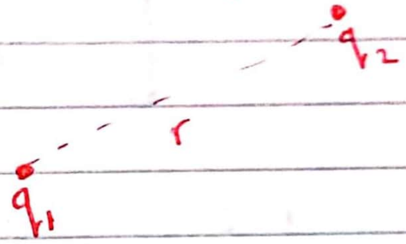
2) Insulators (العازلات) : All the electrons are bound
لا يوجد نقل الالكترونات لأنها (مقيدة)
مقيدة.

Example ⇒ glass, rubber, wood, plastic.

3) Semiconductors (أشباه موصلات) : Electric properties are some when between those of conductors and insulators.

EX ⇒ Silicon, germanium

(شحنتين)



* Coulomb's law :

افتراض
Assumption : we have point charges
(ما إلها حجم) (charge of zero ~~z~~ size)
* بعد النقطة أكبر تأثير من الحجم إلي بتشكلها أي شحنة

$F_e = k_e \dfrac{\lvert q_1 \rvert \lvert q_2 \rvert}{r^2}$	ق = م × م١ م٢ / ف²

F = electric force.

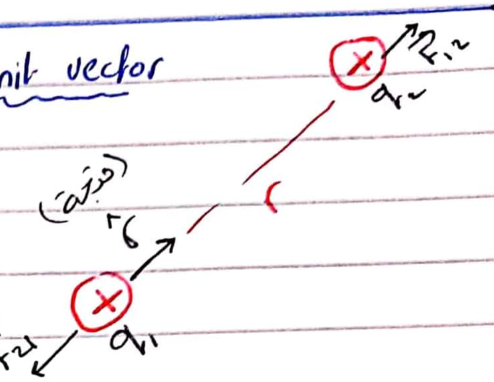
K = Colamb's Constant $= \dfrac{1}{4\pi\epsilon_0} = 8.99 \times 10^{9}\ N.m^2/C^2 \approx 9 \times 10^{9}$

$\epsilon_0 = 8.85 \times 10^{-12}\ C^2/N.m^2$ = pemitivity of free space.

F_e is attractive if charges are of ~~the~~ opposite sign.

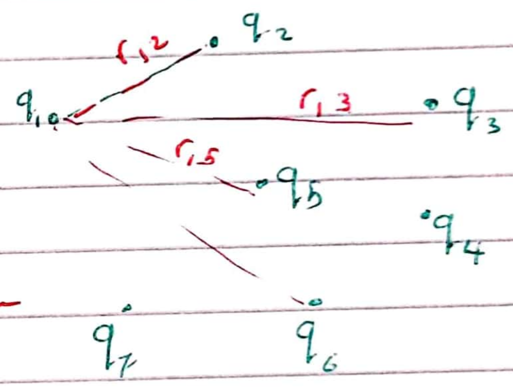
F_e is negative if charges are of the same sign

$$\vec{F}_{12} = -\vec{F}_{21} = \frac{k\,|q_1||q_2|}{r^2}\,\hat{r} \rightarrow \text{unit vector}$$



اتجاههم دائمًا بينهم سواء كان تنافر او تجاذب

Superposition principle:
محصلة القوى



The resultant force on q_j is the vector sum of all the forces exerted on it by other charges

$$\boxed{\vec{F}_1 = \vec{F}_{21} + \vec{F}_{31} + \vec{F}_{41} + \cdots}$$

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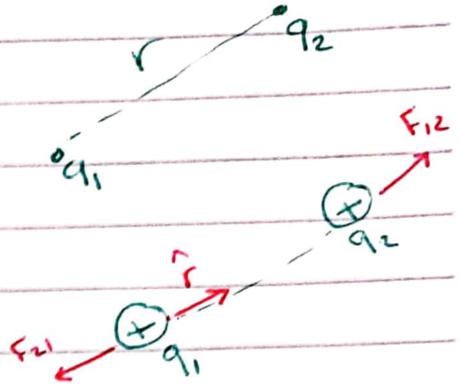
Coulomb's law

$$F_e = k_e \frac{|q_1||q_2|}{r^2}$$



$$\vec{F}_{12} = -\vec{F}_{21} = k \frac{|q_1||q_2|}{r^2} \hat{r}$$

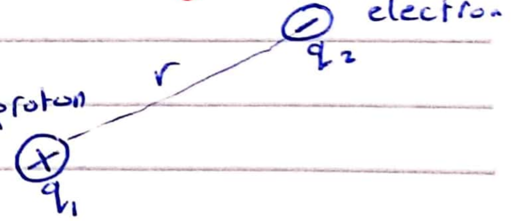
---

* superposition principle.

$$\vec{F}_1 = \vec{F}_{21} + \vec{F}_{31} + \vec{F}_{41}$$

EX ⇒ 23.1

The electron and proton of a hydrogen atom are separated (on the average) by a distance of approximately 5.3×10^{-11} m find the magnitudes of the electric force and the gravitational force between the two particles.



$q_1 = +e = 1.6 \times 10^{-19}$ C

$q_2 = -e = -1.6 \times 10^{-19}$ C.

$r = 5.3 \times 10^{-11}$ m

$m_1 = 1.67 \times 10^{-27}$ kg.

$m_2 = 9.11 \times 10^{-31}$ kg.

$$F_e = k \frac{|q_1||q_2|}{r^2} = (9 \times 10^9) \frac{(1.6 \times 10^{-19})(1.6 \times 10^{-19})}{(5.3 \times 10^{-11})^2}$$

قوة الجذب الكهربائي ← $= 8.2 \times 10^{-8}$ N

قانون الجذب الكتلي

$$F_G = G\frac{m_1 m_2}{r^2}$$

$$= (6.67\times10^{-11})\frac{(1.67\times10^{-27})(9.11\times10^{-31})}{(5.3\times10^{-11})^2}$$

$$= 3.6\times10^{-47}\ N$$

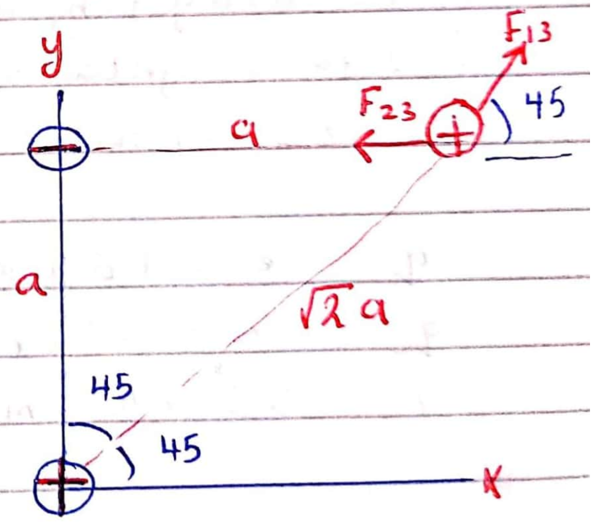
* قوة الجذب الكتلي صغيرة جداً

$$\frac{F_e}{F_G} \approx 2.3\times10^{39} \Rightarrow F_G \text{ is negligible}$$

(مهملة)

EX. 23.2 → Consider three point charges located at the corners of a right triangle as shown in figure where $q_1 = q_3 = 5.00\ \mu C$, $q_2 = -2.00\ \mu$ and $a = 0.100\ m$
find the resultant force exerted on q_3

$q_1 = q_3 = 5\ \mu C$
$q_2 = -2\ \mu C$
$a = 0.1\ m$



$$F_{13} = k\frac{|q_1||q_3|}{(\sqrt{2}a)^2}$$

$$= (9\times10^9)\frac{(5\times10^{-6})(5\times10^{-6})}{(2)(0.1)^2}$$

$$F_{13} = 11.2\ N.$$

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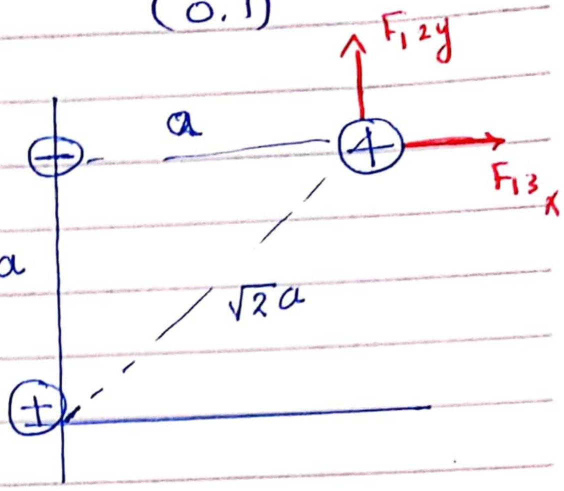
$$F_{23} = k\frac{|q_2||q_3|}{a^2} = (9\times10^9)\frac{(2\times10^{-6})(5\times10^{-6})}{(0.1)^2}$$

$$F_{23} = 9\ N.$$



$$F_{13x} = F_{13}\cos 45 = (11)(0.71)$$
$$= 7.9\ N$$

$$F_{13y} = F_{13}\sin 45 =$$
$$(11.2)(0.71) = 7.9\ N$$

$$F_{23x} = F_{23}\cos 180 = (9)(-1) = -9\ N.$$

$$F_{23y} = F_{23}\sin 180 = 0$$

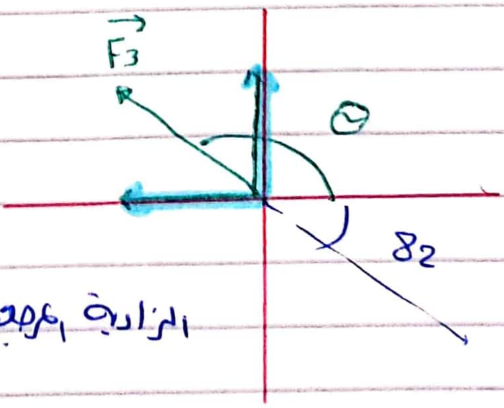
$$F_{3x} = F_{13x} + F_{23x} = -1.1\ N.$$

$$F_{3y} = F_{13y} + F_{23y} = 7.9\ N.$$

$$\vec{F_3} = (-1.1\,\hat{i} + 7.9\,\hat{j})\ N.$$

$$F_3 = \sqrt{(-1.1)^2 + (7.9)^2} \approx 8\ N.$$

$$\theta = \tan^{-1}\left(\frac{F_{3y}}{F_{3x}}\right) = \tan^{-1}\left(\frac{7.9}{-1.1}\right)$$
$$= -82^\circ + 180$$
$$= 98^\circ$$



الزاوية مرجعه ⇐ الالة الحاسبة بتطلع يا بالربيع الاول
او الرابع

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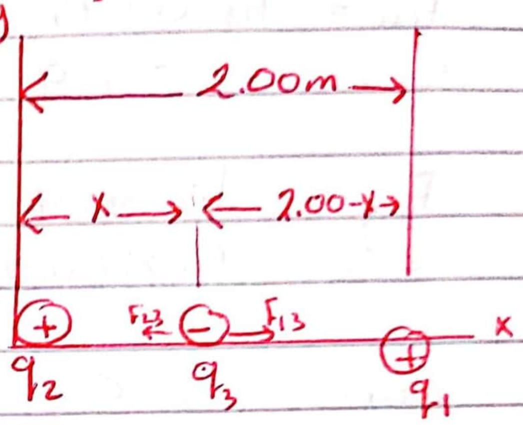
ex. 23.3 ⇒ Three point charges lie along the X axis as shown in Figure. The positive charge $q_1 = 15.0\ \mu C$ is at $X = 2.00$ m, the positive charge $q_2 = 6.00\ \mu C$ is at the origin, and the net force acting on q_3 is zero. what is the X coordinate of q_3?

$q_1 = 15$ mc
$q_2 = 6$ mc



$\Sigma F_{3_x} = 0$

$F_{13} - F_{23} = 0$

$F_{13} = F_{23}$

$$\cancel{k} \frac{|q_1||\cancel{q_3}|}{(2-X)^2} = \cancel{k} \frac{|q_2||\cancel{q_3}|}{X^2}$$

$$\frac{|q_1|}{(2-X)^2} = \frac{|q_2|}{X^2}$$

$$\frac{5\ \cancel{15 \times 10^{-6}}}{(2-X)^2} = \frac{2\ \cancel{6 \times 10^{-6}}}{X^2}$$

$$\Rightarrow \frac{5}{(2-X)^2} = \frac{2}{X^2} \Rightarrow \frac{5}{4-4X+X^2} = \frac{2}{X^2}$$

$5X^2 = 8 - 8X + 2X^2$

$3X^2 + 8X + 8 = 0$

$$X = \frac{-8 \pm \sqrt{8^2-(4)(3)(-8)}}{6}$$

$X = 0.775$ m ✓

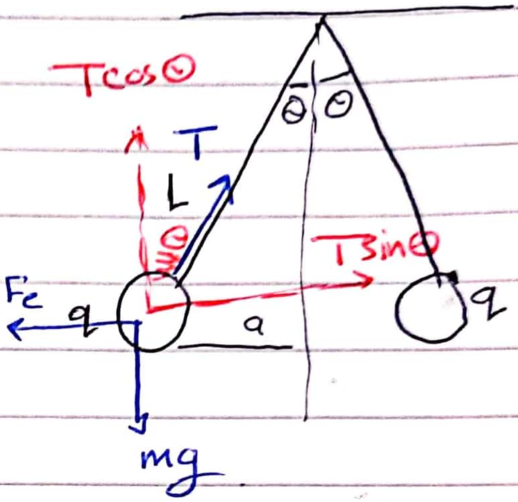
$X = -3.44$ ✗

متماثلات

Ex 23.4 ⇒ Two identical small charged spheres, each having a mass of 3.00×10^{-2} kg, hang in equilibram as shown in figure. The length L of each string is 0.150 m and the angle θ is 5.00. Find the magnitude of the charge on each sphere.

$m = 3 \times 10^{-2}$ kg , $L = 0.15$ m

$\theta = 5°$



$$F_e = k \frac{|q|^2}{(2a)^2} = \frac{k|q|^2}{4a^2}$$

$$\cancel{T} \sin\theta = F_e$$

$$\cancel{T} \cos\theta = mg$$

Divide

$$\sin\theta = \frac{a}{L}$$

$$a = L \sin\theta$$

$$\frac{\sin\theta}{\cos\theta} = \frac{F_e}{mg}.$$

$$\tan\theta = \frac{F_e}{mg}.$$

$$|q| = \sqrt{\frac{4L^2 mg \sin^2\theta \tan\theta}{k}}$$

$$F_e = mg \tan\theta$$

$$|q| = 4.4 \times 10^{-8} \text{ C}.$$

$$\frac{k|q|^2}{4a^2} = mg \tan\theta$$

$$|q| = \sqrt{\frac{4a^2 mg \tan\theta}{k}}$$

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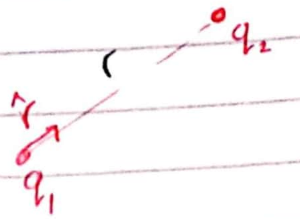
* The Electric field *

$$\vec{F} = k\,\frac{q_1 q_2}{r^2}\,\hat{r}$$



* The electric force is a field force
(Can act through space with no phisical contact)

* اي شحنة تنشئ حولها مجال
* دائما المجال الكهربائي يوجد اكثر في المنطقة حول الشحنة

* Electric field exisist in a region of space around charged objects.

* when a charge enters the electric field, an electric force acts on it.

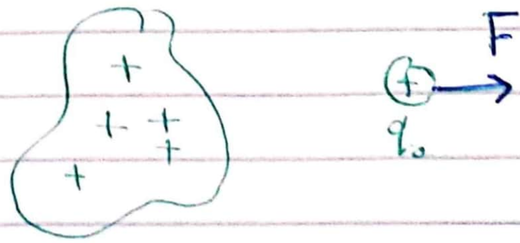
* The electric field is defined as the electric force acting on a positive per unit charge.

* The electric field $(\vec{E})$ at a point is defined as the electric force $(\vec{F})$ acting on a positive test charge (q_0) placed at that point devided by the test charge.

$\vec{E} = \dfrac{\vec{F}}{q_0}$	م = ق / ش.

definition of $\vec{E}$

* اي نقطة بدي احسب شدها المجال أضع شحنة اختبار موجبة



$[\vec{F} = q\vec{E}]$

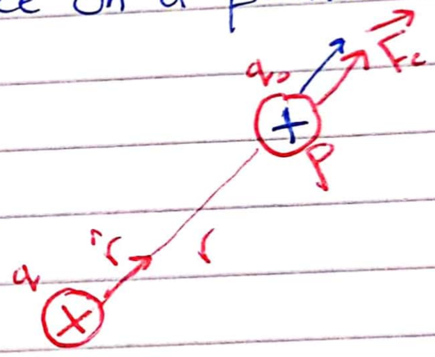
↳ The electric force $\vec{F}$ on a charge q placed on an electric field

SI unit of $\vec{E}$ is N/C

$$[E] = \frac{[F]}{|q|} = \frac{N}{C}$$

Comments

1) Direction of $\vec{E}$ is that of the force on a positive charge.

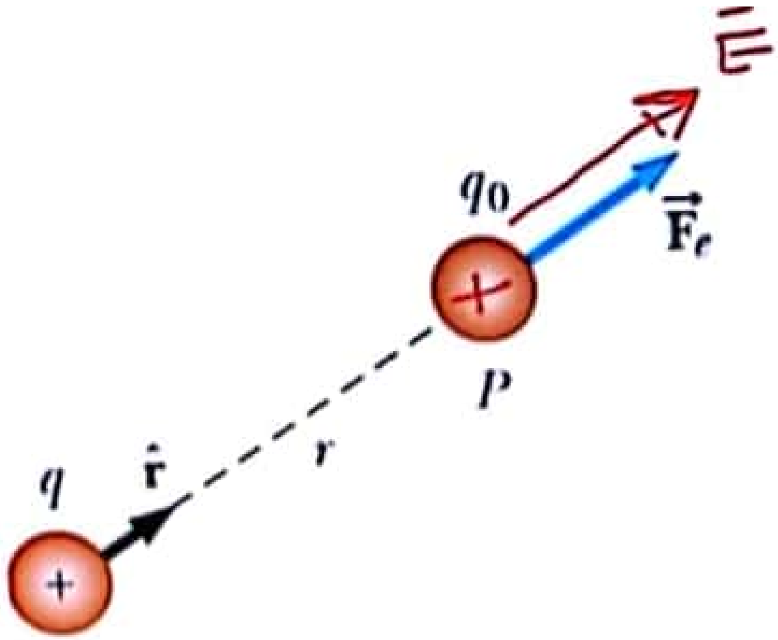


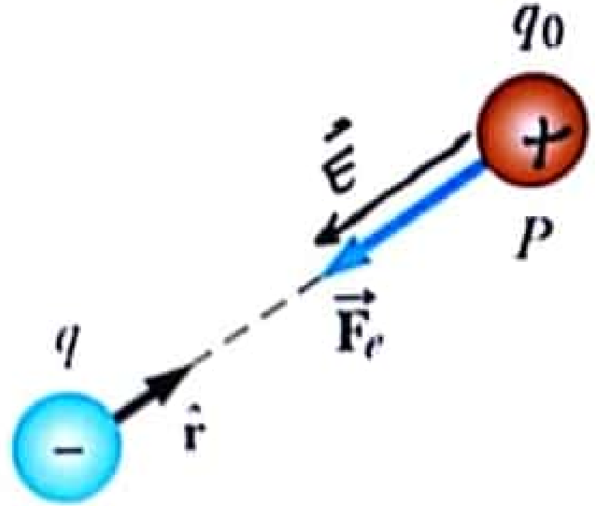
2) SI unit of E is N/C

3) $\vec{F} = q\vec{E}$ is valid for point charges.

4) $\vec{E}$ is directed away from a positive charge.

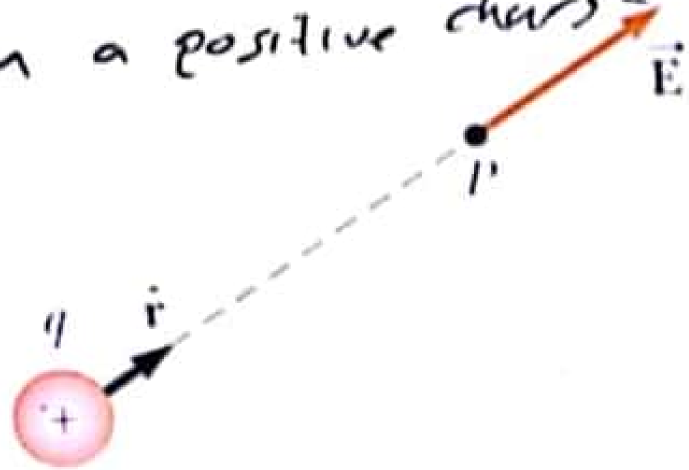
5) E is directed toward a negative.

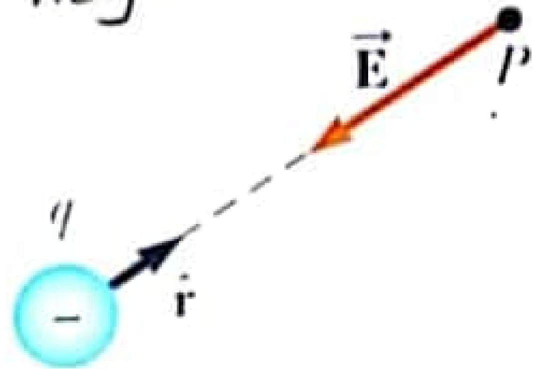




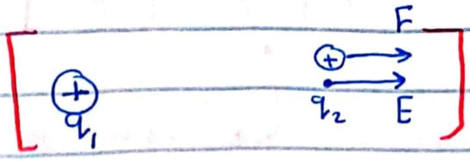
$\vec{E}$ is directey away from a positive charge

$\vec{E}$ is directed toward a negative charge.

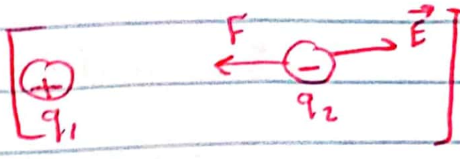


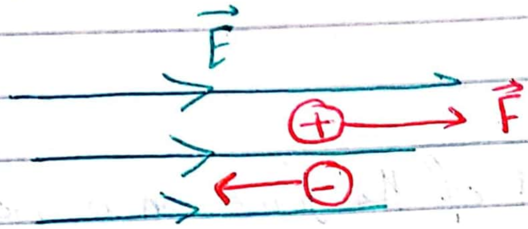


6) The force on a positive charge is in the same direction of $\vec{E}$



7) The force on a negative charge is opposite to $\vec{E}$





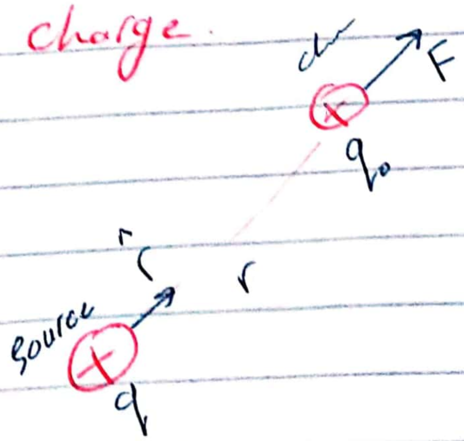
The force between the source and the test charge is

$$F = k \frac{q q_0}{r^2} \hat{r}$$

The electric field is then $\vec{E} = \frac{\vec{F}}{q_0} = \frac{kq}{r^2} r$

$$\boxed{E = \frac{kq}{r^2} \hat{r}}$$

$\vec{E}$ due ~~to~~ r from a point charge.

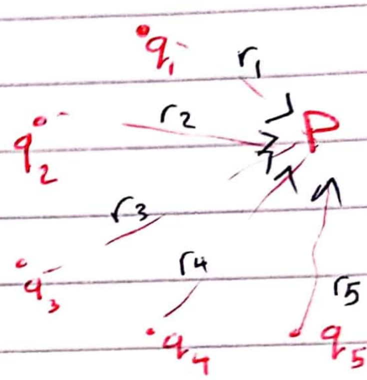


The total electric field at a point P due to a group of charges is the vector sum of the electric fields of all the charges.

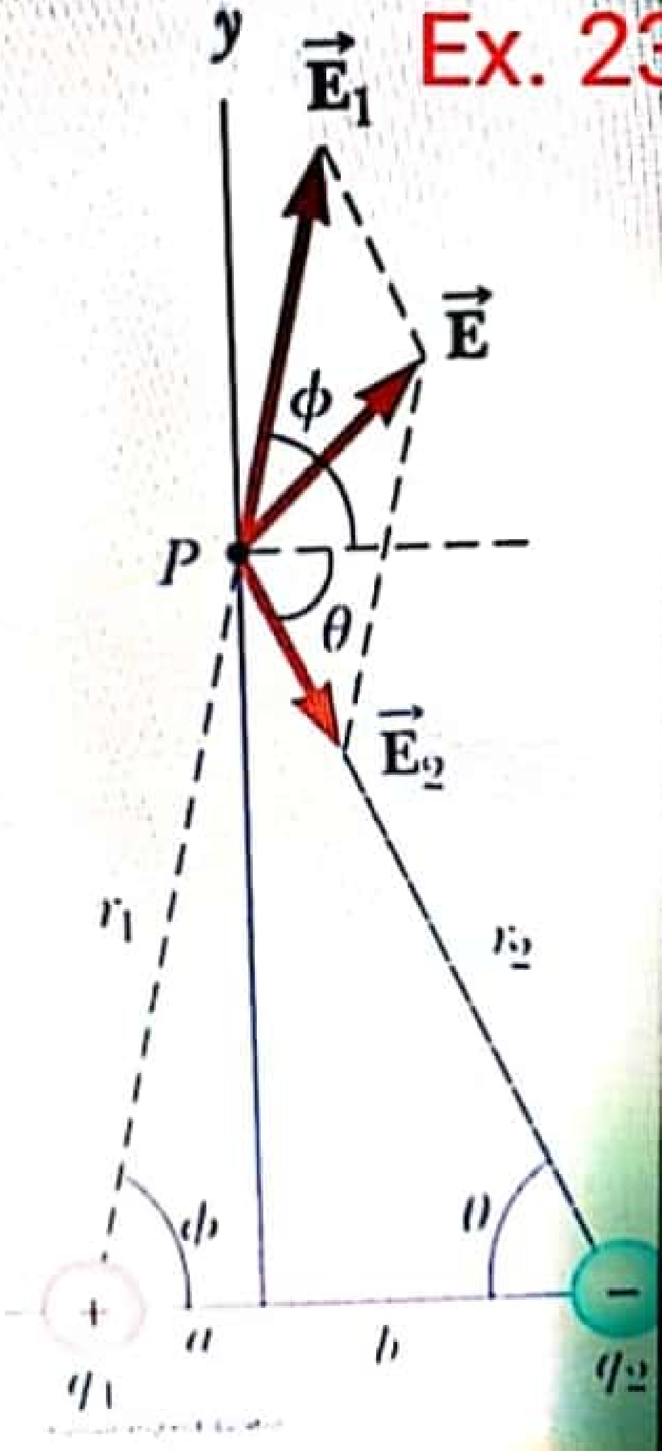
$$\vec{E}_p = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + \cdots$$

$$= \frac{k q_1}{r_1^2}\hat{r}_1 + k\frac{q_2}{r_2^2}\hat{r}_2 + \cdots$$

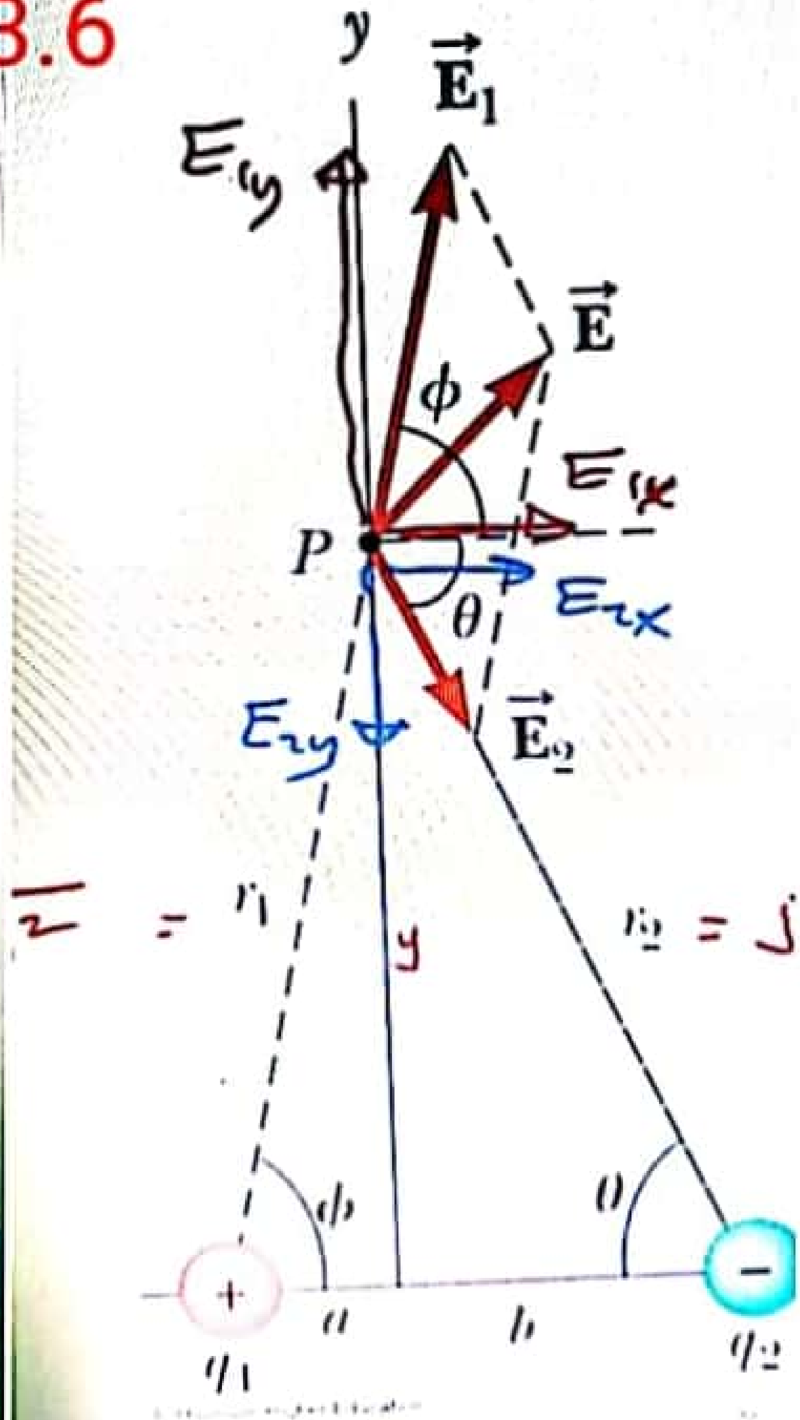
$$= \sum k \frac{q_i}{r_i^2}\hat{r}_i$$



Ex. 23.6



y
$\vec{E}_1$
$\vec{E}$
ϕ
P
θ
$\vec{E}_2$
r_1
r_2
a
b
q_1
q_2



y
$\vec{E}_1$
E_{1y}
$\vec{E}$
ϕ
E_{1x}
P
E_{2x}
θ
E_{2y}
$\vec{E}_2$
r_1
y
$r_2 = \sqrt{}$
a
b
q_1
q_2

EX. 23.6 p. 702

Charges q_1 and q_2 are located on the X axis, at distances a and b, respectively, from the origin, as shown in the figure

(A) find the components of the net electric field at the point p, which is at position.

A) $E_1 = \frac{k|q_1|}{r_1^2} = k\frac{|q_1|}{a^2+y^2}$

$E_2 = \frac{k|q_2|}{r_2^2} = \frac{k|q_2|}{b^2+y^2}$

$E_{1x} = E_1 \cos\theta = \frac{k|q_1|\cos\phi}{a^2+y^2}.$

$E_{1y} = E_1 \sin\phi = \frac{k|q_1| \sin\phi}{a^2+y^2}.$

$E_{2x} = E_2 \cos\theta = \frac{k|q_2|\cos\theta}{b^2+y^2}$

$E_{2y} = -E_2 \sin\theta = \frac{-k|q_2|\sin\theta}{b^2+y^2}$

$E_x = E_{1x} + E_{2x} = k\left[\frac{|q_1|\cos\phi}{a^2+y^2} + \frac{|q_2|\cos\theta}{b^2+y^2}\right]$

$E_y = E_{1y} + E_{2y} = k\left[\frac{|q_1|\sin\phi}{a^2+y^2} - \frac{|q_2|\sin\theta}{b^2+y^2}\right].$

$\vec{E} = E_x\hat{i} + E_y\hat{j}$ $\quad E = \sqrt{}$

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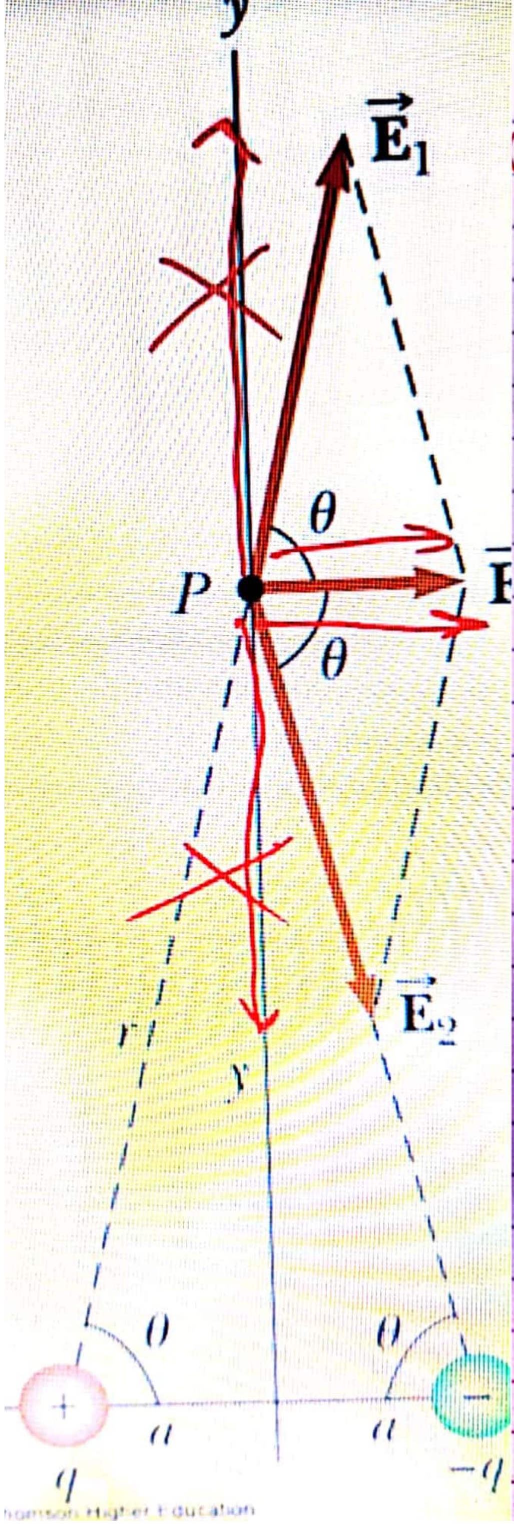


(B) Evaluate the electric field of point (p) in the special case that $|q_1| = |q_2|$ and $a = b$.

$$|q_1| = |q_2| = q$$

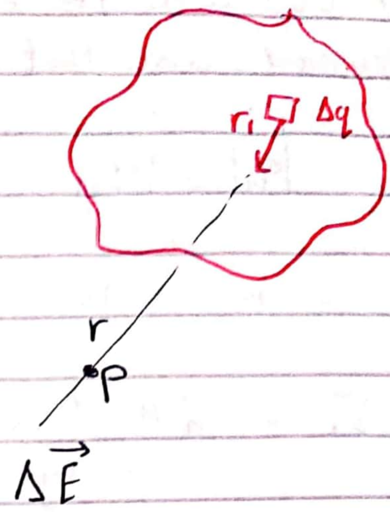
$$a = b \implies \theta = \phi$$

$$E_x = \frac{2kq\cos\theta}{a^2+y^2}$$

$$E_y = 0$$

* Electric field of a continuous charge distribution

The electric field due to the charge element Δq_1 is ΔE_i



$$\vec{\Delta E_i} = k \frac{\Delta q_i}{r_i^2} \hat{r_i}$$

The total electric field $\vec{E}$ at the point p is the vector of electric field of all charge elements.

$$\vec{E} = \vec{\Delta E_1} + \vec{\Delta E_2} + \text{———}$$

$$= k \frac{\Delta q_1}{r_1^2} \hat{r}_1 + k \frac{\Delta q_2}{r_2^2} \hat{r}_2 + \text{——} \ldots$$

$$= k \sum_n \frac{\Delta q_n}{r_n^2} \hat{r}_n$$

If we make the elements very small $(\Delta q \to 0)$

then

$$\vec{E} = k \lim_{\Delta q_n \to 0} \sum_n \frac{\Delta q_n}{r_n^2} \hat{r}_n = k \int \frac{dq}{r^2} \hat{r}$$

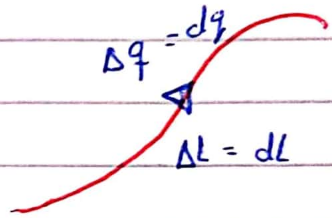
The electric field due to a Continuous charge distributions.

$$\boxed{\vec{E} = k \int \frac{dq}{r^2}\hat{r}} = \vec{E} \text{ due to a Continous charge.}$$

** There are three kinds of charge distributions.

1) Linear charge distribution. (كثافة شحنة خطية)
we define the linear charge density (λ)

* مقدار الشحنة الموجودة في طول ΔL
الشحنة لكل وحدة طول



(charge per unit ~~length~~ Length).

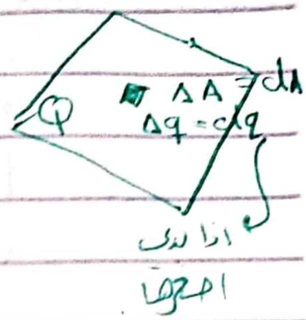
$$\left[\lambda = \frac{\Delta q}{\Delta L} = \frac{dq}{dL}\right]; \quad [\lambda] \equiv C/m.$$

If the total charge Q is uniformly distributed along line then

$$\left[\lambda = \frac{dq}{dL} = \frac{Q}{L} = \text{Const}\right]$$

$$\boxed{dq = \lambda\, dL.}$$

2) Surface charge distribution



we define the surface charge density (σ)

(charge per unit area)

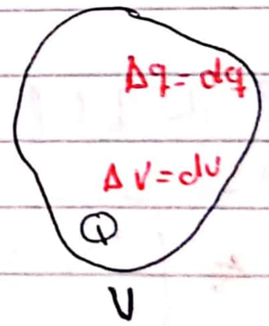
$$\sigma = \frac{\Delta q}{\Delta A} = \frac{dq}{dA} \; ; \; [\sigma] = C/m^2$$

If the charge is uniformly distributed through the surface, then

$$\sigma = \frac{dq}{dA} = \frac{Q}{A} = \text{Const}$$

$$\boxed{dq = \sigma \, dA}$$

3) Volume charge distribution



we define the volume charge density (ρ)

(charge per a unit volume)

$$\rho = \frac{\Delta q}{\Delta V} = \frac{dq}{dV} \; ; \; [\rho] = C/m^3$$

If the charge is uniformly distributed (موزعة بانتظام) through the volume then

$$\rho = \frac{\Delta q}{\Delta V} = \frac{Q}{V} = \text{Const}$$

$$\boxed{dq = \rho \, dV}$$

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$$E = k \int \frac{dq}{r^2} \hat{r}$$

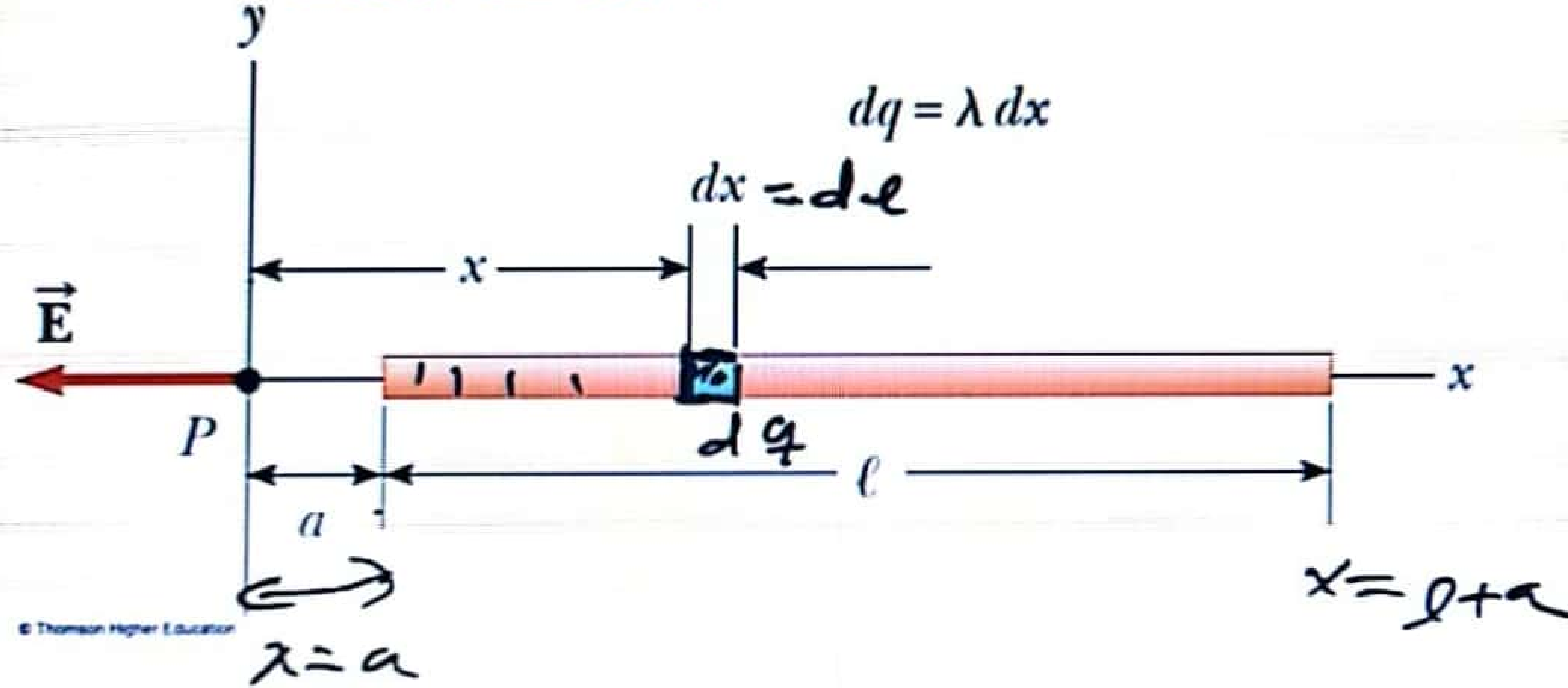
$dq = \lambda \, dl \equiv$ Linear charge. (نشرحها بعدين)

$dq = \sigma \, dA \equiv$ Surface charge.

$dq = \rho \, \underline{dV} \equiv$ Volume charge.

(حجم)

Ex. 23. 7



y
$dq = \lambda\, dx$
$dx = dl$
x
$\vec{E}$
x
P
dq
ℓ
a
$x = a$
$x = l + a$
© Thomson Higher Education

EX ⇒ 23.7

A rod of length L has a uniform positive charge per unit length λ and a total charge Q. Calculate the electric field at a point P that is located along the long axis of the rod and a distance a from one end

$$\lambda = \frac{Q}{L} = \text{Const}$$

$$E = k \int \frac{dq}{r^2}$$

ثابت

$$dq = \lambda\, dl = \lambda\, dx = \frac{Q}{L} \cdot dx$$

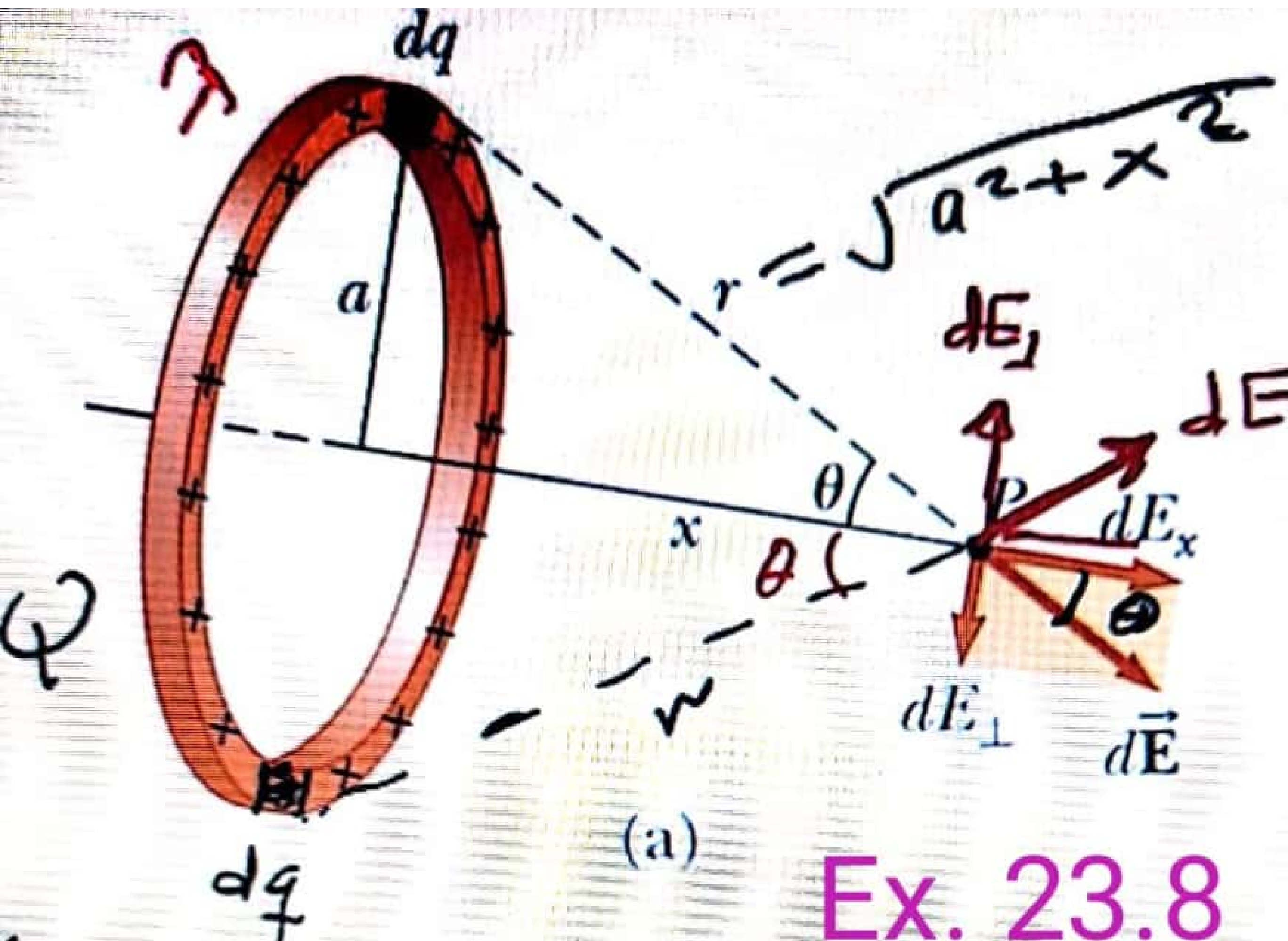
$$r = X$$

ال r هي البعد بين dq
وبين النقطة التي نحسب عندها
المجال.

$$E = k \int \frac{dq}{r^2} = k \int_a^{L+a} \frac{\frac{Q}{L}\, d.x}{X^2}$$

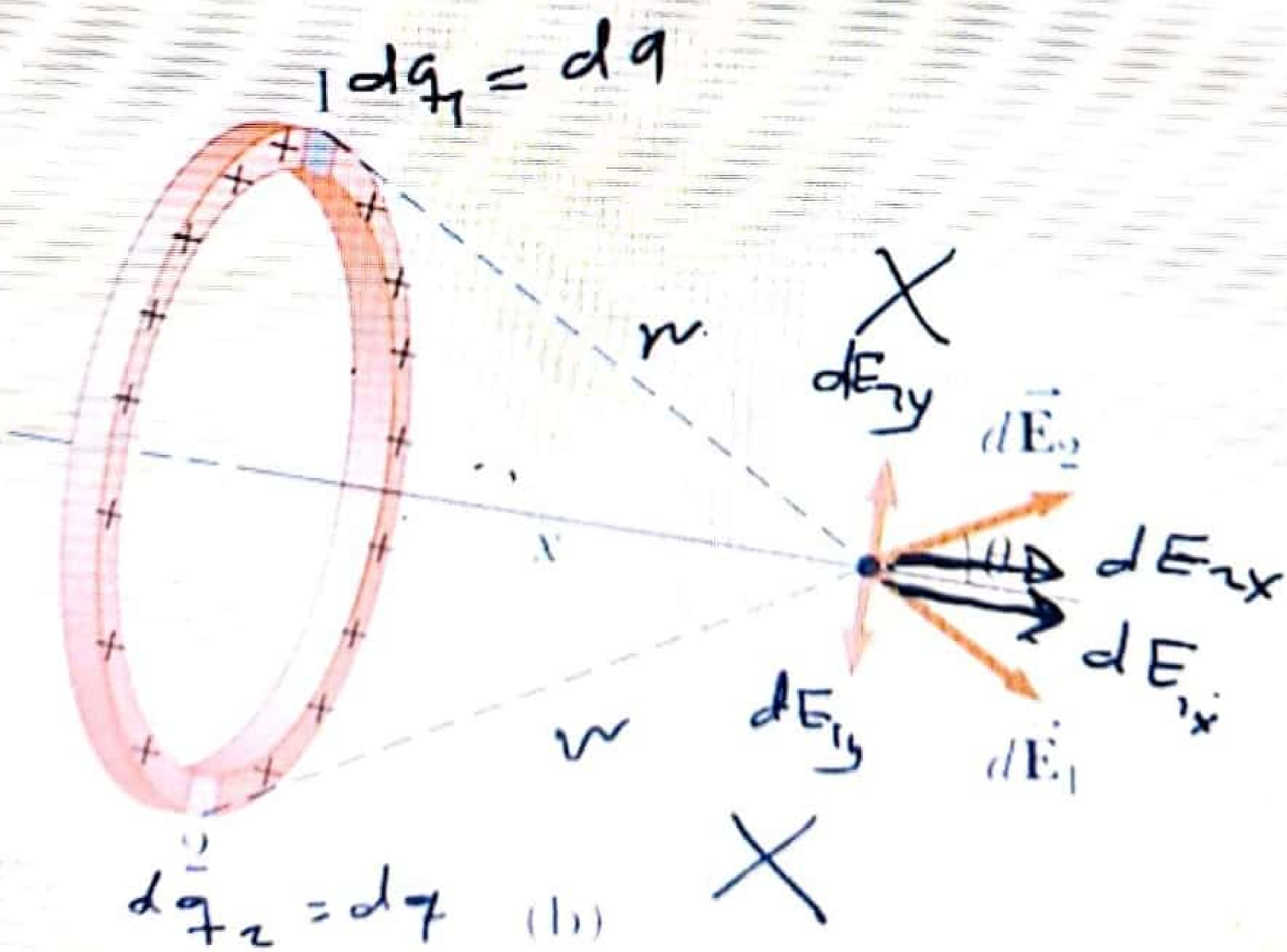
$$= \frac{kQ}{L} \int_a^{a+L} \frac{dx}{X^2} = \frac{kQ}{L} \left[\frac{-1}{X} \right]_a^{L+a}$$

$$\boxed{E = \frac{kQ}{L} \left[\frac{1}{a} - \frac{1}{L+a} \right]}$$


dq
a
$r = \sqrt{a^2+x^2}$
$dE_\perp$
dE
θ
P
dE_x
x
θ
Q
$dE_\perp$
$d\vec{E}$
dq

(a)

Ex. 23.8


$dq_1 = dq$
r
dE_{1y}
$d\vec{E}_2$
x
θ
dE_{2x}
dE_{1x}
dE_{1y}
$d\vec{E}_1$
r
$dq_2 = dq$

(b)

EX ⇒ 23.8

A ring of radius a carries a uniformly distributed positive total charge Q. Calculate the electric field due to the ring at a point ~~physics~~ (P) lying a distance x from its center along the central axis perpendicular to the plane of the ring.

λ : uniform

$$\lambda = \frac{Q}{2\pi a}$$

$$dE_1 = dE_2$$

vertical components, $dE_{\perp}$, cancel. (each other)

$$dE_{\perp} = 0$$

normal

$$dE_{1x} = dE_{2x} = dE \cos\theta$$

$$dE = K\frac{dq}{r^2} = k\frac{dq}{a^2+x^2}$$

$$dE_x = dE\cos\theta = \frac{k\,dq}{a^2+x^2} = \frac{x}{\sqrt{a^2+x^2}}$$

$$\int dE_x = \int \frac{kx\,dq}{(a^2+x^2)^{\frac{3}{2}}}$$

$$E_x = k\int \frac{x\,dq}{(a^2+x^2)^{\frac{3}{2}}} \rightarrow \frac{kx}{(a^2+x^2)^{\frac{3}{2}}}\int \underbrace{dq}_{=Q}$$

(لأنه نصف القطر ثابت)

* كلهم ثوابت

$$\boxed{E_x = \frac{kQx}{(a^2+x^2)^{\frac{3}{2}}}} \rightarrow$$

$\vec{E}$ a distance x from the center of a ring of radius a along the perpendicular axis.

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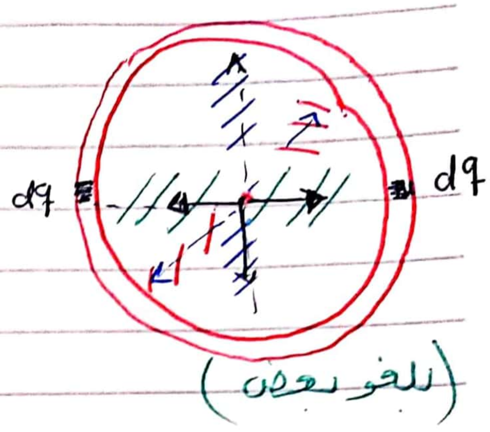
* The electric field at the center of the ring is zero ①

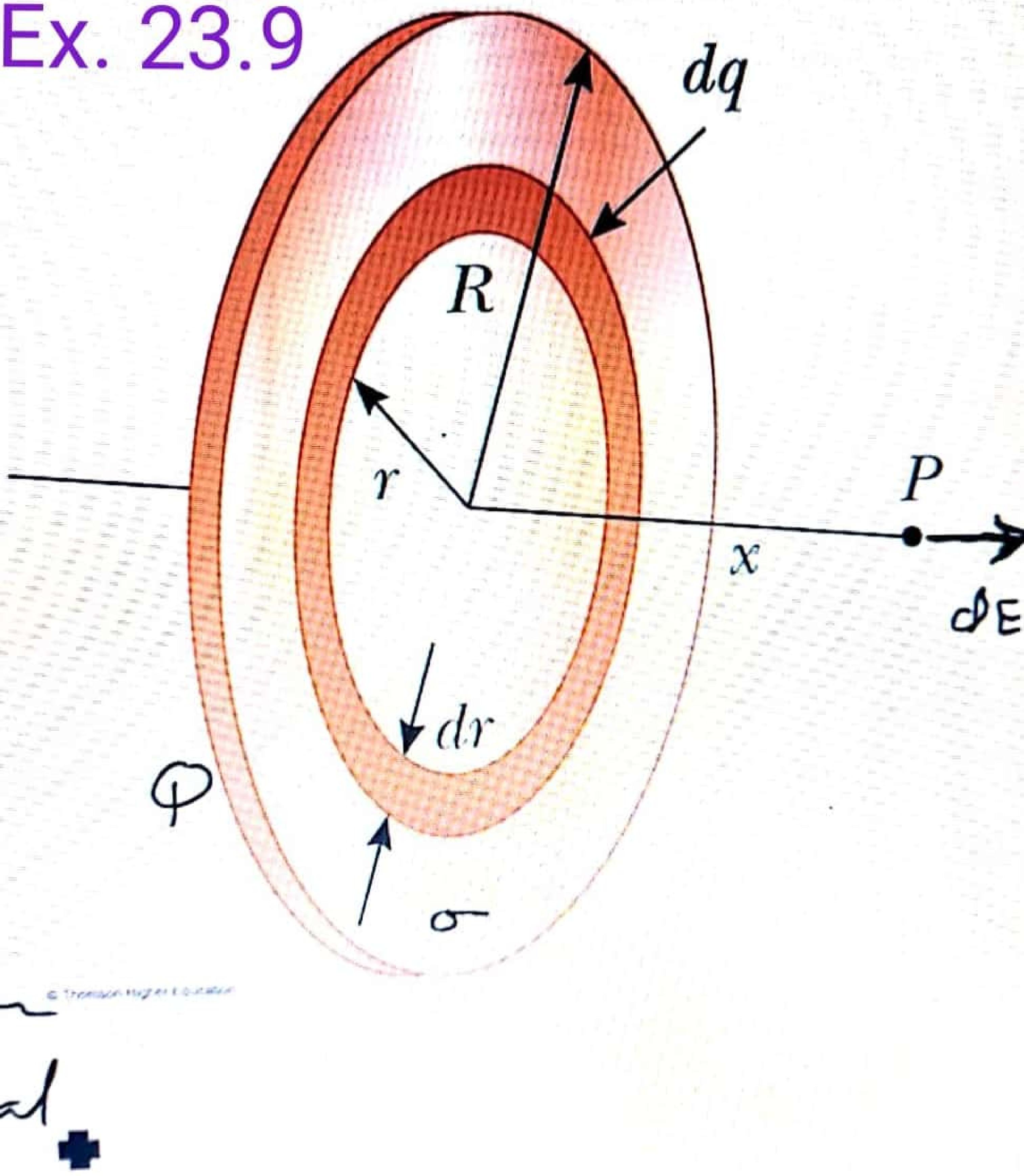
* At the center of the ring ②

(X = 0)

$$E = \frac{kQ \overset{\text{zero}}{X}}{(a^2+X^2)^{\frac{3}{2}}} = 0$$



Ex. 23.9



[EX. 23.9]

A disk of radius R has a uniform surface charge density σ. Calculate the electric field at a point (P) that lies along the central perpendicular axis of the disk a distance x from the center of the disk.

σ is uniform

⇒ Go back to EX. 23.8 ⇐

$$E = \frac{kQx}{(a^2+x^2)^{\frac{3}{2}}}$$

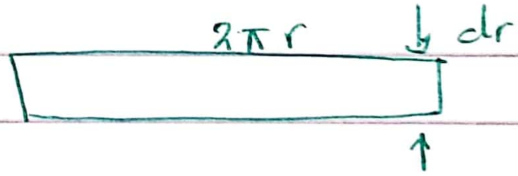
with replacing

$Q \equiv dq$ and $a \equiv r$ و [$E_x \overset{\text{استبدال}}{\equiv} dE$]

The electric field dE due to the charge element dq distribution along a ring of radius r is

$$\int dE = \int \frac{k\,dq\,x}{(x^2+r^2)^{\frac{3}{2}}}$$

(مساحة شريحة مستطيلة)



$dq = \sigma\,dA = \sigma(2\pi r\,dr)$

$dA = (2\pi r)\cdot dr$ مساحة

$$\int dE = \int \frac{kx\,dq}{(x^2+r^2)^{\frac{3}{2}}}$$

$$E_x = \int_0^R \frac{kx\sigma(2\pi r\,dr)}{(x^2+r^2)^{\frac{3}{2}}}$$

$$= \pi k\sigma x \int \frac{2r\,dr}{(x^2+r^2)^{\frac{3}{2}}}$$

(integration by substitution) تكامل بالتعويض

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$$E_x = \pi k \sigma x \left[\frac{(x^2+r^2)^{-\frac{1}{2}}}{-\frac{1}{2}} \right]_0^R$$

$$E_x = 2\pi k \sigma x \left[\frac{1}{x} - \frac{1}{\sqrt{x^2+R^2}} \right]$$

$$\boxed{E_x = 2\pi k \sigma \left[1 - \frac{x}{\sqrt{x^2+R^2}} \right]}$$

The electric field due to a disk

$$E_x = \pi k \sigma x \left[\frac{(x^2+r^2)^{-\frac{1}{2}}}{-\frac{1}{2}} \right]_0^R$$

$$E_x = 2\pi k \sigma x \left[\frac{1}{x} - \frac{1}{\sqrt{x^2+R^2}} \right]$$

$$\boxed{E_x = 2\pi k \sigma \left[1 - \frac{x}{\sqrt{x^2+R^2}} \right]}$$

The electric field due to uniformly charged disk of radius (R) a distance x from the center along the perpenicular axis.

* If x is very small $(x \longrightarrow 0)$

$$E_x = 2\pi k \sigma$$

$$= \cancel{2\pi} \frac{1}{{}_2\cancel{4\pi} \epsilon_\circ} \sigma$$

$$\boxed{E_x = \frac{\sigma}{2\epsilon_\circ}} \longrightarrow$$ very close the surface of the disk

* Electric field lines *

خطوط المجال الكهربائي

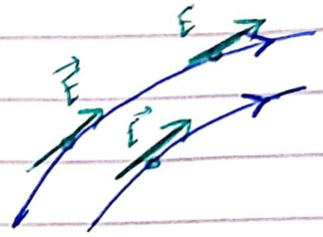
⇒ Graphical representation of the electric field. (تمثيل صوري)

* proporties of the electric field lines :

خصائص خطوط المجال

[1] The electric field $\vec{E}$ is tangent to the field Lines.

(اتجاه المجال الكهربائي هو المماس)



[2] number of field Lines per unit area through a surface perpendicular to the Lines is proportional to the magnetude of E

تناسب

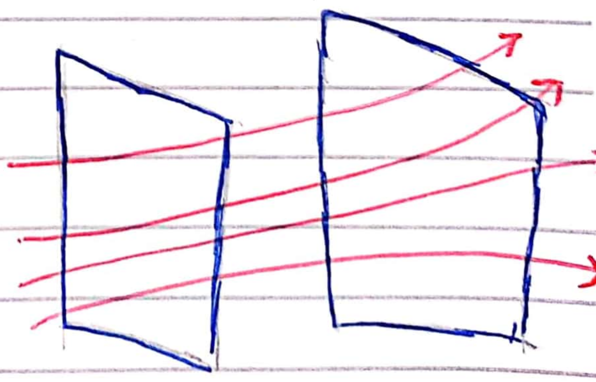
Density of Lines at (A) > density of Lines at (B) (كثافة الخطوط)

$E_A > E_B$

* قيمة (شدة) المجال ← ترتبط مع الكثافة
- الكثافة بعدد الخطوط التي تخترق المساحة عمودياً.
- كلما زادت كثافة الخطوط في منطقة ما زاد المجال.

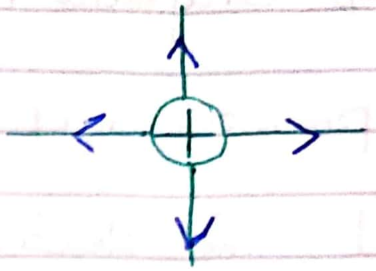
المجال (مركبة عامودية) (المركبة موازية للمساحة

← المركبة العامودية على المساحة (السطح)

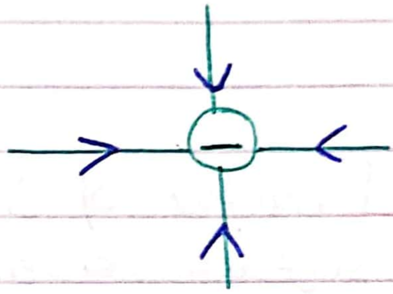


3. Field lines are directed away from a positive charge.

خطوط المجال متجهة من شحنة (+)

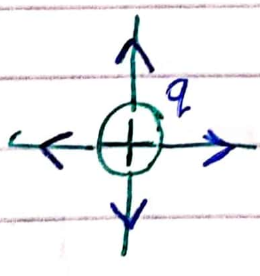


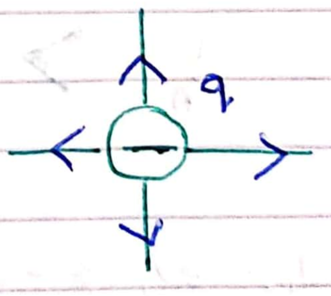
4. field lines are directed toward a negative charge.

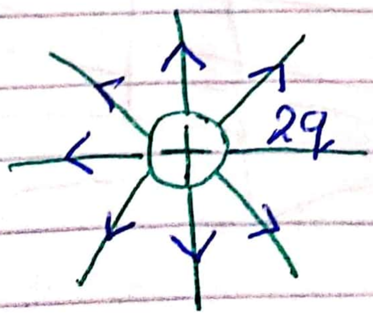


5. Number of field lines leaving a positive charge or approaching a negative charge is proportional to the magnetude of charge.

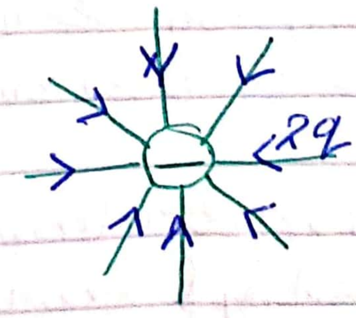
المجال عند النقطة
2q تضاعف





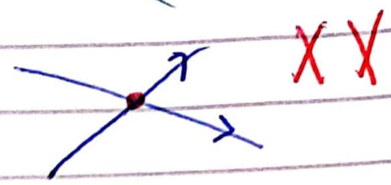


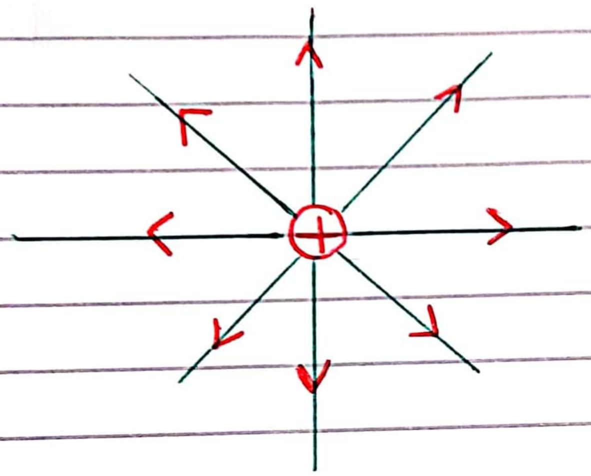
(الخطوط متضاعفة)

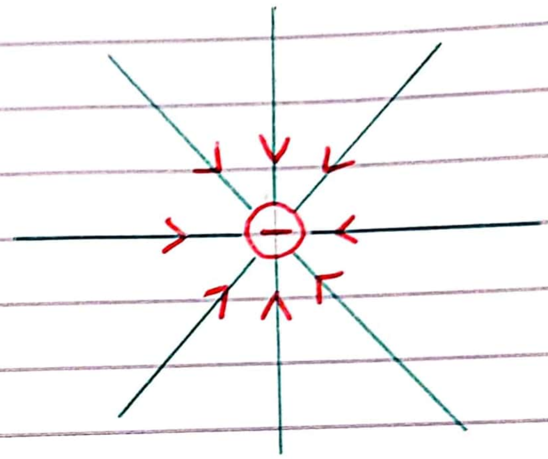


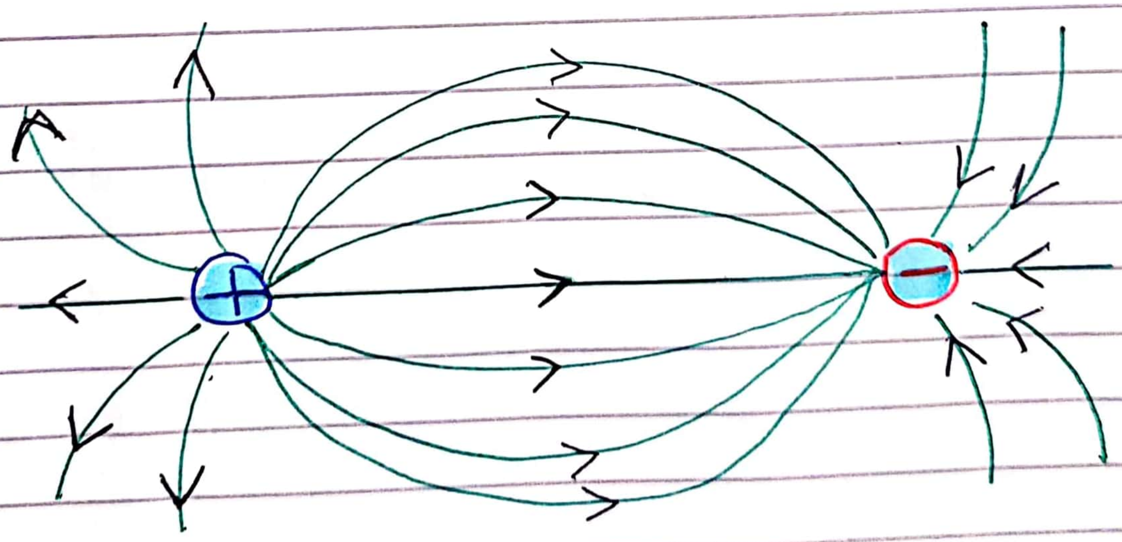
$\boxed{6}$ No two field lines can cross. (لا يمكن أن يتقاطعا)

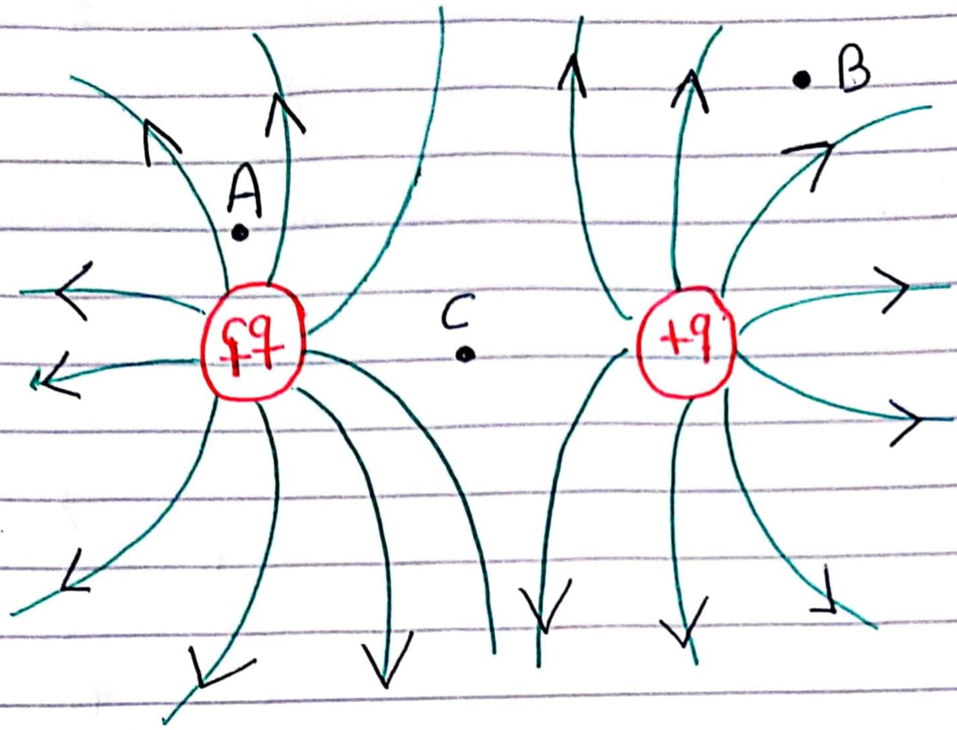
لأصبح أكثر من اتجاه للمجال ~~هنا~~ وهذا مستحيل.





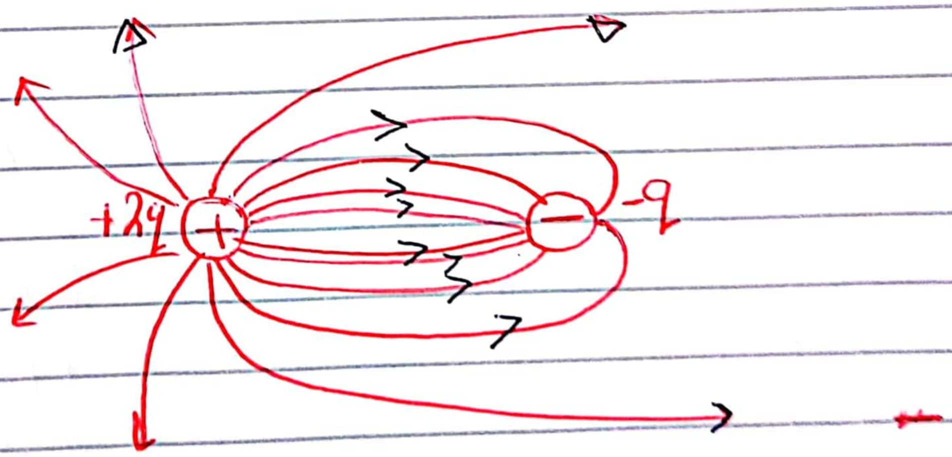






$E_A > E_B$ (لأن كثافة خطوط عند A أكبر من عند B)

$E_C = 0$ (zero) none line. (لا يوجد مجال)



$$\frac{\text{Number of lines leaving } (2q)}{\text{Number of lines approaching } (-q)} = \frac{16}{8} = (2)$$

* Motion of charged particle in a uniform electric field

حركة جسم مشحون داخل مجال كهربائي

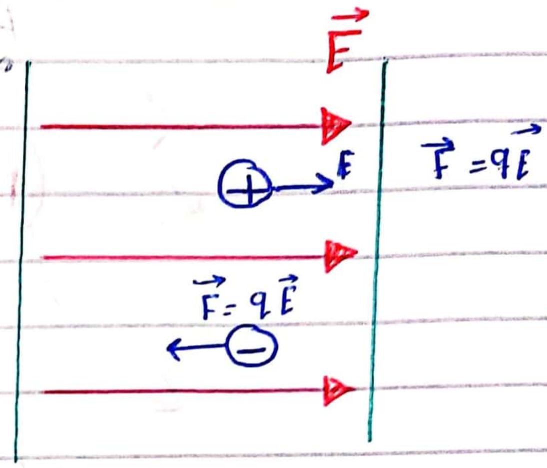
$$\vec{F} = q\vec{E}$$

ق = ش مـ

$$\vec{F} = m\vec{a}$$

ق = ك ت

$$q\vec{E} = m\vec{a}$$



(acceleration)

$$\boxed{a = \frac{qE}{m}}$$

التسارع الذي يكتسبه الجسم.

* اذا كان المجال منتظم ، ثابت المقدار والاتجاه

← اذا التسارع ثابت.

* تقتصر الدراسة في هذا الفصل على حركة جسم مشحون داخل مجال منتظم. (ثابت)

If $\vec{E}$ is uniform then $\vec{a}$ = constant

مجال ثابت

وبما ان التسارع ثابت نستخدم معادلات التسارع في حركة ثابتة

[Comments]

1) If $\vec{E}$ = Constant ($\vec{E}$ is uniform) then

$$\vec{a} = \frac{qE}{m} = \text{Constant}$$

⇒ Kinematic equations Can Be used.

1. $U_{xf} = U_{xi} + a_x t$
2. $X_f - X_i = U_{xi} t + \frac{1}{2} a_x t^2$
3. $U_{xf}^2 = U_{xi}^2 + 2 a_x (X_f - X_i)$

Same for y.

2) If q is positive ⇒ $\vec{a}$ is in the direction of $\vec{E}$

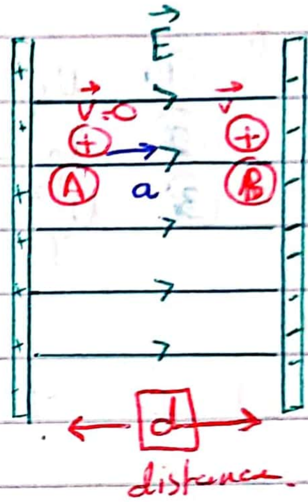
3) If q is negative ⇒ $\vec{a}$ is opposite to $\vec{E}$

* دائماً الشحنة الموجبة تتأثر بقوة مع المجال اذا التسارع مع المجال.
(لأن القوة بنفس اتجاه المجال).

P. 711 صفحتين متوازيتين

EX . 23.10

⇒ A uniform electric field $\vec{E}$ is directed along the x axis between parallel plates of charge seperated by a distance d as shown in figure. A positive point charge q of mass m is released from rest at a point Ⓐ next to the positive plate and accelerates to a point Ⓑ next to the negative plate.



$\vec{E}$ = Constant (uniform)

$E_x = E$, $E_y = 0$

$X_i = X_A = 0$

$X_F = X_B = d$

q , m.

$U_i = U_A = 0$

$U_B = ??$

(A) find the speed of the partical at Ⓑ by modeling it as a particle under constant acceleration.

$$\vec{a} = \frac{q\vec{E}}{m}$$

$$a_y = \frac{qE_y}{m} = 0$$

$$a_x = \frac{qE_x}{m} = \frac{qE}{m}$$

$$U_{x_f}^2 = U_{x_i}^2 + 2a_x(X_f - X_i)$$

$$U_B^2 = \cancel{U_A^2}^{\,0} + 2\frac{qE}{m}(d-0)$$

$$U_B = \sqrt{\frac{2qEd}{m}}$$

Scanned with CamScanner

(B) find the speed of the particle at (B) by modeling it as a nonisolated system in terms of energy.

* نستخدم نظرية الشغل والطاقة الحركية

Non-isolated system. $\xrightarrow{\text{التعريف}}$ * (ما بتأثر عليه قوة خارجية)

System ≡ charge.

[chapter 7 Phisics(1)]

Rev

$$W_{ext} = K_B - K_A$$

$$F \Delta X \cos\theta = \frac{1}{2} m v_B^2 - \cancel{\frac{1}{2} m v_A^2}_{\text{zero}}$$

$$F d \underbrace{\cos\overset{\text{zero}}{\theta}}_{(1)} = \frac{1}{2} m v_B^2$$

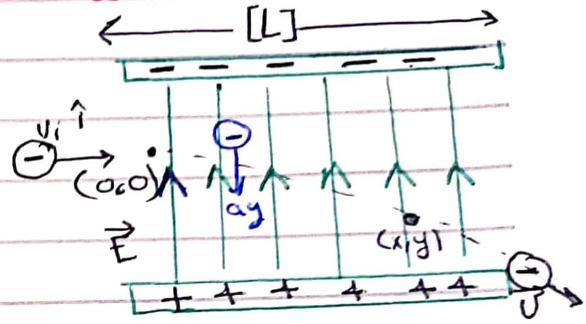
$$qEd = \frac{1}{2} m v_B^2$$

$$v_B = \sqrt{\frac{2qEd}{m}}$$

EX. 23.11 p. 712.

⇒ An electron enters the region of a uniform electric field as shown, with $v_i = 3.00 \times 10^6$ m/s and $E = 200$ N/C. The horizontal length of the plates is $l = 0.100$ m.

A) find the acceleration of the electron while It is in the electric field



$q = -1.6 \times 10^{-19}$ C

mass ← $m = 9.11 \times 10^{-31}$ kg.

$v_i = 3 \times 10^6$ m/s

$E = (200\,\hat{j})$

$E_x = 0$ $\quad E_y = 200$, $L = 0.1$ m (طول الصفيحة)

الشارع في (X) تساوي صفر.

$F = q\vec{E} = ma$

$\vec{a} = \dfrac{q\vec{E}}{m}$

$a_x = \dfrac{qE_x}{m} = 0$

$a_y = \dfrac{qE_y}{m} = -\dfrac{(1.6 \times 10^{-19})(200)}{9.11 \times 10^{-31}} \Rightarrow a_y = -3.15 \times 10^{13}$ m/s^2.

$\vec{a} = (-3.51 \times 10^{13}\,\hat{j})$ m/s^2.

(B) Assuming the electron enters the field at time $t=0$, find the time at which it leaves the field.

(الزمن الذي يحتاجه حتى يخرج من منطقة المجال) ؟؟!
المعنى يقطع افقيا الطول L)

$[x_i = 0]$ $[x_f = L]$

$$U_x = V_i \overset{(1)}{(\cos 0)} = V_i = 3 \times 10^{6} \text{ m/s}$$

$$U_{y_i} = V_i \sin 0 = 0.$$

$$\underset{=}{\overset{L}{X_f}} - \overset{0}{\cancel{X_i}} = U_x t + \overset{\text{zero}}{\cancel{\tfrac{1}{2} a_x t}}$$

$$L = U_x t$$

$$t = \frac{L}{U_x} = \frac{0.1 \text{ m}}{3 \times 10^{6} \text{ m/s}} = 3.33 \times 10^{-8} \text{ s}.$$

C) Assuming the vertical position of the electron as it enters the field is $y_i = 0$, what is its vertical position when it leaves the field?

كم نزل من مستوى لي كان في
$\Delta y = ?$

$y_i = 0$ $y_i = 0$ $y_f = ?$

$$y_f - \overset{\text{zero}}{\cancel{y_i}} = \overset{\text{zero}}{\cancel{U_{y_i} t}} + \frac{1}{2} a_y t^2$$

$$y_f = \frac{1}{2} a_y t^2 = \frac{1}{2} (-3.51 \times 10^{13} \text{ m/s}^2)(3.33 \times 10^{-8} \text{ s})^2$$

$$y_f = -1.59 \times 10^{-2} \text{ m} = -1.59 \text{ cm}$$

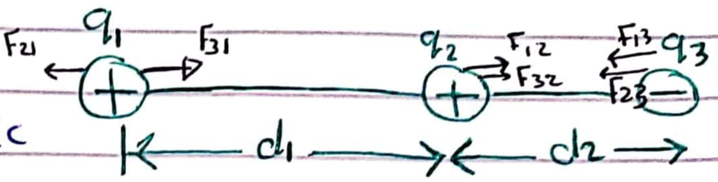
prob 12 #

Three point charges lie along a straight line as shown in figure, where $q_1 = 6.00\ \mu C$, $q_2 = 1.50\ \mu C$, and $q_3 = -2.00\ \mu C$. The separation distance are $d_1 = 3.00$ cm and $d_2 = 2.00$ cm. Calculate the magnitude and direction of the net electric force on (a) q_1 (b) q_2 and (c) q_3

$q_1 = 6\ \mu C$

$q_2 = 1.5\ \mu C$ $\quad q_3 = -2\ \mu C$

$d_1 = 3$ cm , $d_2 = 2$ cm



$$F_{12} = F_{21} = \frac{k\,|q_1|\,|q_2|}{d_1^2} = \frac{(9\times10^{9})(6\times10^{-6})(1.5\times10^{-6})}{(0.03)^2} = \boxed{89.5\ N}$$

$$F_{13} = F_{31} = \frac{k\,|q_1|\,|q_3|}{(d_1+d_2)^2} = \boxed{43.2\ N.}$$

(لا نعوض لإشارة السالبة)

$$F_{23} = F_{32} = \frac{k\,|q_2|\,|q_3|}{d_2^2} = \frac{(9\times10^{9})(1.5\times10^{-6})(2\times10^{-6})}{(2\times10^{-2})^2} = \boxed{67.4\ N.}$$

لأنها بالاتجاه السالب

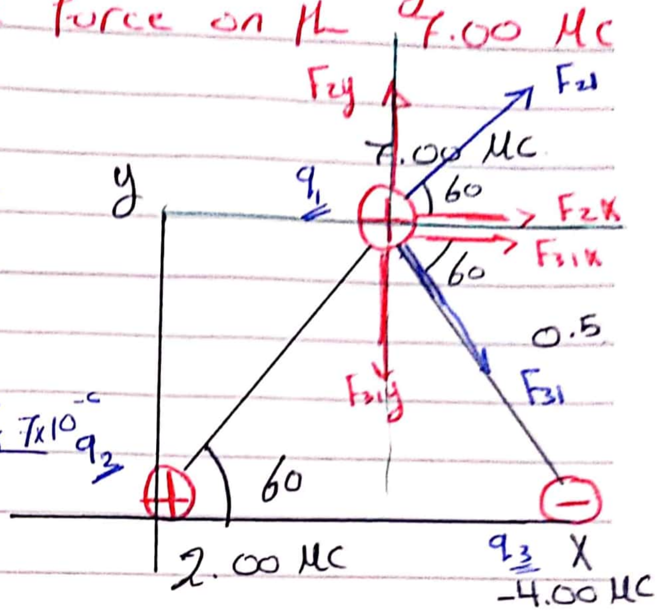
A) $\vec{F_1} = (F_{31} - F_{21})\,\hat{i} = (-46.3\,\hat{i})\ N$

B) $\vec{F_2} = (F_{12} + F_{32})\,\hat{i} = (157\,\hat{i})\ N.$

C) $\vec{F_3} = -(F_{13} + F_{23})\,\hat{i} = (-111\,\hat{i})\ N.$

[prob. 15] #

Three charged particles are located at the corners of an equilateral triangle as shown in figure. Calculate the total electric force on the 7.00 μC charge.



$q_1 = 7\ \mu C$, $q_3 = -4\ \mu C$

$q_2 = 2\ \mu C$ $d = 0.5\ m$

$$F_{21} = k\frac{|q_2||q_1|}{d^2} = \frac{9\times10^{9}\times 2\times10^{-6}\times 7\times10^{-6}}{(0.5)^2}$$

$$= \boxed{0.504\ N}$$

$$F_{31} = k\frac{|q_3||q_1|}{d^2} = \frac{9\times10^{9}\times4\times10^{-6}\times7\times10^{-6}}{(0.5)^2} = \boxed{1.008\ N}$$

⇒ $F_{21x} = F_{21}\cos 60 = 0.252\ N$

$F_{2y} = F_{21}\sin 60 = 0.436\ N$

⇒ $F_{31x} = F_{31}\cos 60 = 0.504\ N$

$F_{31y} = - F_{31}\sin 60 = -0.872\ N$

$F_{1x} = F_{21x} + F_{31x} = 0.776\ N.$

$F_{1y} = F_{21y} + F_{31y} = -0.436\ N.$ → الربع الرابع

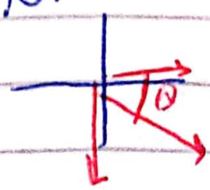
(+) (−)

$$\vec{F_1} = F_{1x}\hat{i} + F_{1y}\hat{j} = \vec{F_1} = (0.776\hat{i} - 0.436\hat{j})\ N.$$

$$F_1 = \sqrt{0.776^2 + (-0.436)^2} = 0.89\ N.$$

$$\theta = \tan^{-1}\left(\frac{-0.436}{0.776}\right) = -30^\circ$$

or 330°



Prob 23.16 p. 717

Two small metallic spheres, each of mass $m = 0.200g$ are suspended as pendulums by light strings of length L as shown in Figure. the spheres are given the same electric charge of 7.2 nC, and they come to equilibrum when each string is at an angle of $\theta = 5.00$ with the vertical. How long are the strings?

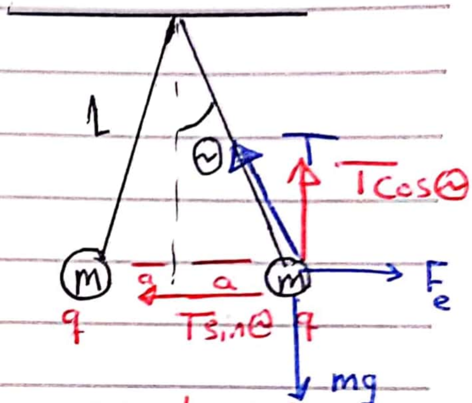
$m = 0.2\ kg$, $\theta = 5°$

$q = 7.2\ nC$

$a = L\sin\theta$

$F_e = T\sin\theta$

$mg = T\cos\theta$



$a = L\sin\theta$

$$\frac{F_e}{mg} = \tan\theta \longrightarrow F_e = mg\tan\theta$$

$$k\frac{|q|^2}{(2a)^2} = mg\tan\theta$$

$$\frac{k|q|^2}{4L^2\sin^2\theta} = mg\tan\theta$$

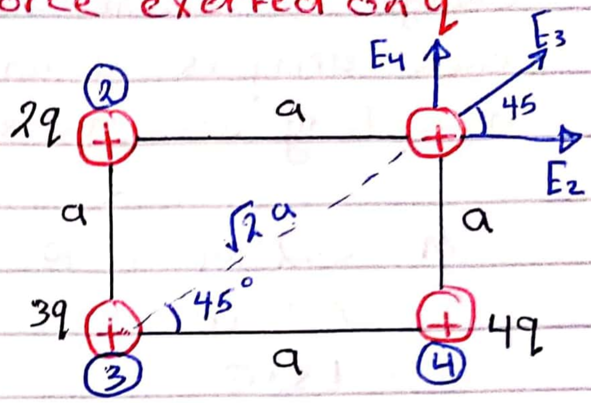
$$L = \sqrt{\frac{k|q|^2}{4mg\tan\theta\sin^2\theta}} = \sqrt{\frac{9\times10^9 \times |7.2\times10^{-9}|^2}{4(0.2)(10)\tan(5)\sin^2(5)}}$$

$= 0.299\ m$

$= 29.9\ cm.$

prob. 25 p. 718

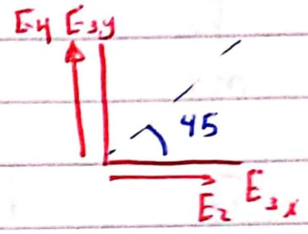
Four charged particles are at the corners of a square of side a as shown in figure. Determine (a) the electric field at the location of charge q and (b) the total electric force exerted on q



A) $E_2 = \dfrac{k(2q)}{a^2}$

$E_3 = \dfrac{k(3q)}{2a^2}$

$E_4 = k\dfrac{4q}{a^2}$



$E_{2x} = E_2 \cos 0 = \dfrac{k(2q)}{a^2}$

$E_{2y} = E_2 \sin 0 = 0$

$E_{3x} = E_3 \cos 45 = \dfrac{k(3q)}{2a^2}\cos 45$

$E_{3y} = E_3 \sin 45 = \dfrac{k(3q)}{2a^2}\sin 45$

$E_{4x} = E_4 \cos 90 = 0$

$E_{4y} = E_4 \sin 90 = \dfrac{k(4q)}{a^2}$

غلط مني

محصلة ← $E_x = E_{2x} + E_3 + E_{4x} = \dfrac{kq}{a^2}\left(2 + \frac{3}{2}\cos 45 + 0\right)$

$E_x = 3.06\,\dfrac{kq}{a^2}$

$$E_y = E_{2y} + E_{3y} + E_{4y} = \frac{kq}{a^2}\left(0 + \frac{3}{2}\sin 45 + 4\right)$$

$$E_y = 5.06\ \frac{kq}{a^2}$$

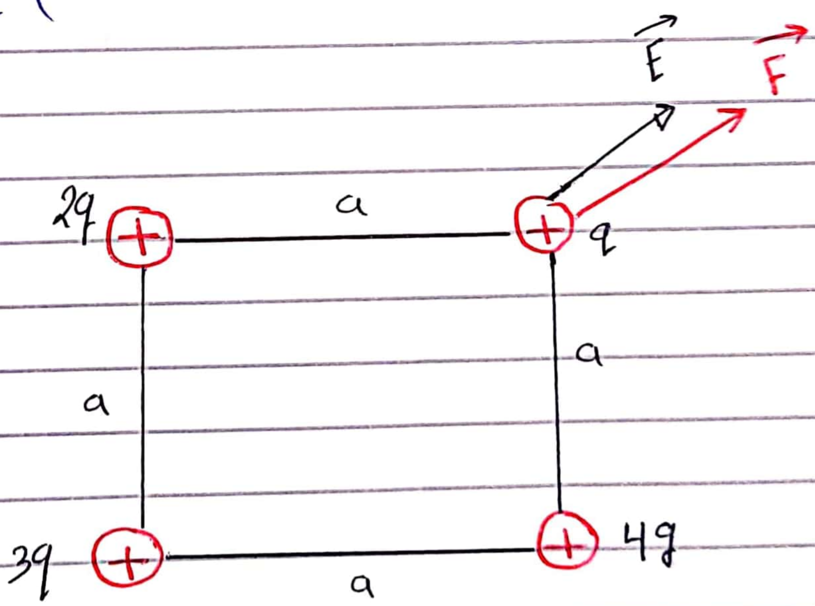
$$\vec{E} = E_x\,\hat{i} + E_y\,\hat{j}$$

$$= \frac{kq}{a^2}\left(3.06\hat{i} + 5.06\hat{j}\right)$$

B)

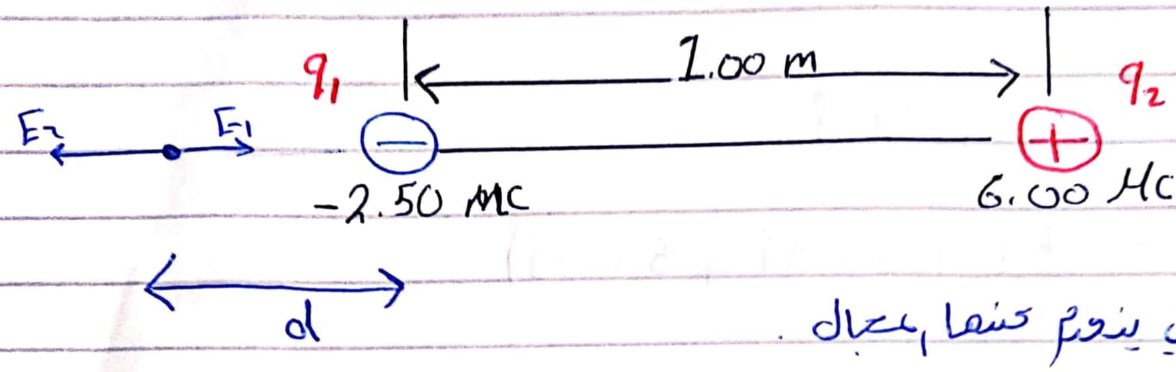
$$\vec{F} = q\vec{E}$$

$$= \frac{kq^2}{a^2}\left(3.06\hat{i} + 5.06\hat{j}\right)$$



prob 29 . P. 718

In figure , determine the point (other than infinity) at which the electric field is zero



النقطة التي ينعدم عندها المجال .

نقطة التعادل في الصفحة التالية

$$\Sigma E_x = 0$$

$$E_1 - E_2 = 0$$

$$E_1 = E_2$$

$$\frac{k\,|q_1|}{d^2} = \frac{k\,|q_2|}{(1+d)^2}$$

$$\frac{2.5 \cancel{\times 10^{-6}}}{d^2} = \frac{6 \cancel{\times 10^{-6}}}{d^2 + 2d + 1}$$

$$6d^2 = 2.5d^2 + 5d + 2.5$$

$$3.5d^2 - 5d - 2.5 = 0$$

$$d = \frac{+5 \pm \sqrt{25 - 5(3.5)(-2.5)}}{2(3.5)}$$

$d = 1.82$ m ✓

$= -0.392$ m ✗

* في السؤال السابق حتى نعرف اين ينعدم المجال .

الحالات ① الشحنتان متشابهتان في الاشارة .

أ- متساويتان في المقدار :- تقع نقطة التعادل بينهما في منتصف المسافة

(هـ نقطة التعادل)

ب- مختلفتان بالمقدار :- تقع نقطة التعادل بينهما اقرب للشحنة الصغرى .

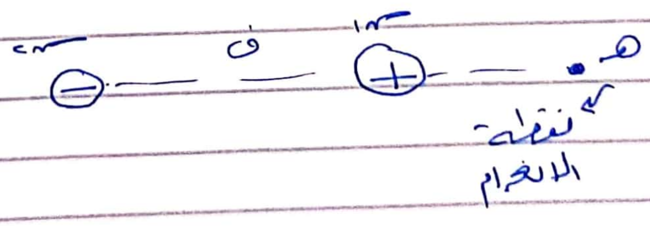
(ش١ > ش٢)

② الشحنتان مختلفتان في الاشارة .

أ- متساويتان بالمقدار ⟸ لا يوجد نقطة تعادل .

ب- مختلفتان بالمقدار :- تقع نقطة التعادل خارجهما اقرب للشحنة الصغرى .

ش١ > ش٢



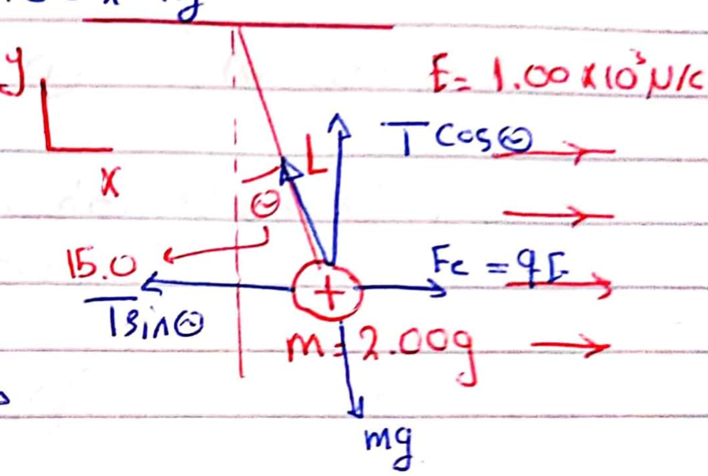
prob. 33

A small, 2.00-g ~~th~~ plastic ball is suspended by a 20.0-cm-long string in a uniform electric field as shown. If the ball is in equilibrium when the string makes a 15.0 angle with the vertical, what is the net charge on the ball?

q is positive. , $m = 2g = 0.002\ kg$

$E = 1 \times 10^3\ N/C$

$\theta = 15°$



$$\frac{qE = T \sin\theta}{mg = T\cos\theta}$$ Divide

قسمة الطرفين

$$\frac{qE}{mg} = \tan\theta$$

$$q = \frac{mg \tan\theta}{E}$$

$$= \frac{(0.002)\times(10)(\tan 15)}{1\times10^3} =$$

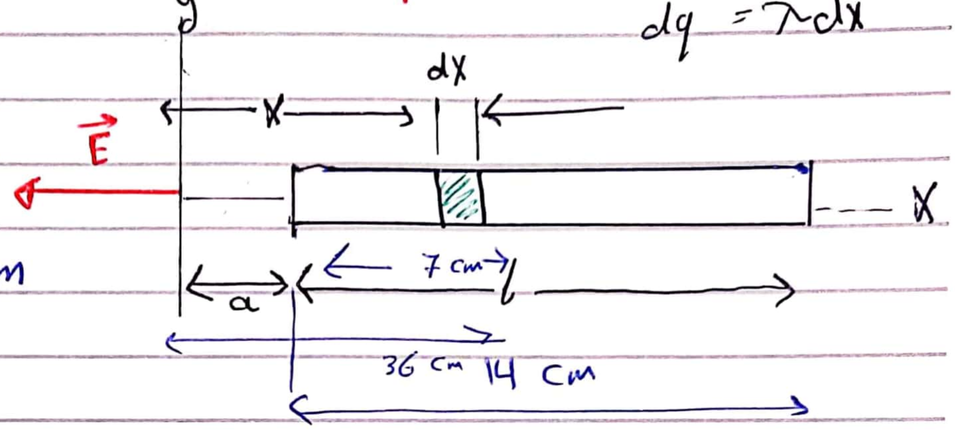
$$5.25 \times 10^{-6}\ C$$

$$= 5.25\ \mu C$$

prob 37

A rod 14.0 cm long is uniformly charged and has a total charge of $-22.0\ \mu C$. Determine (a) the magnitude and (b) the direction of the electric field along the axis of the rod at a point 36.0 cm from its center.

$dq = \lambda dx$



$L = 14\ cm = 0.14\ m$

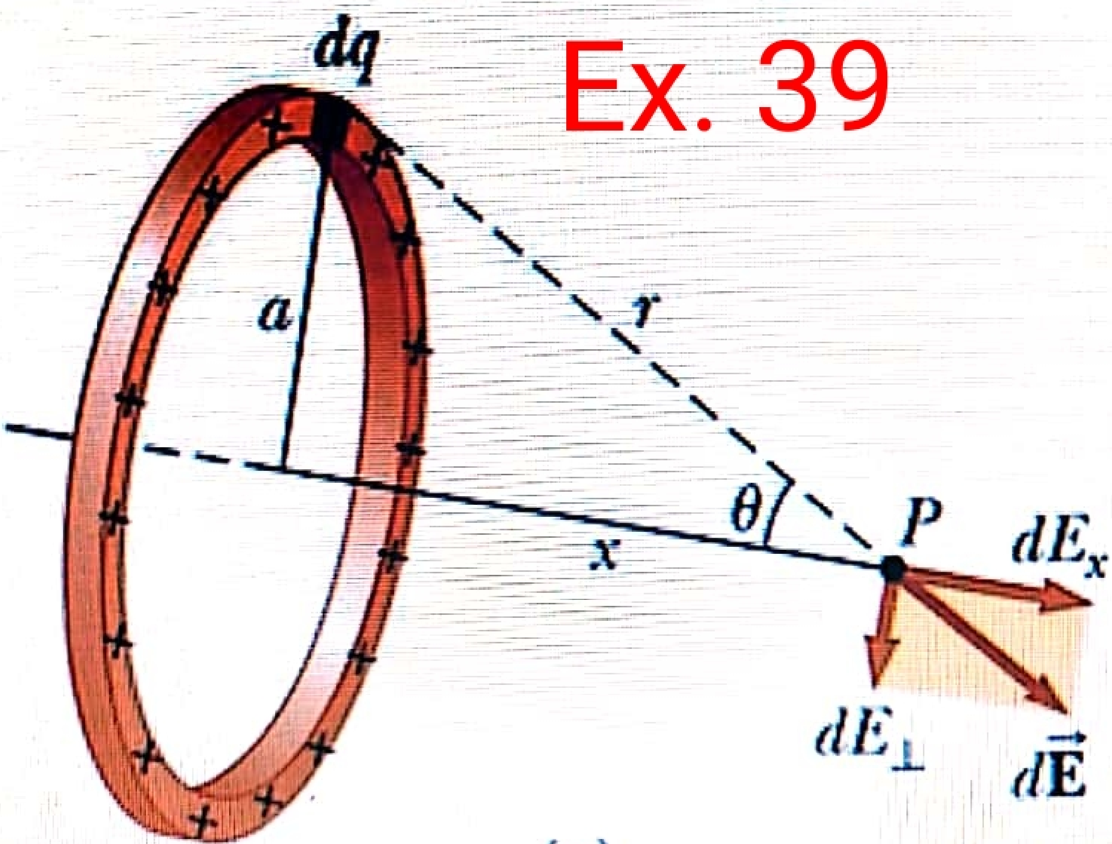
$Q = -22\ \mu C$

$a = 36\ cm - 7\ cm = 29\ cm$

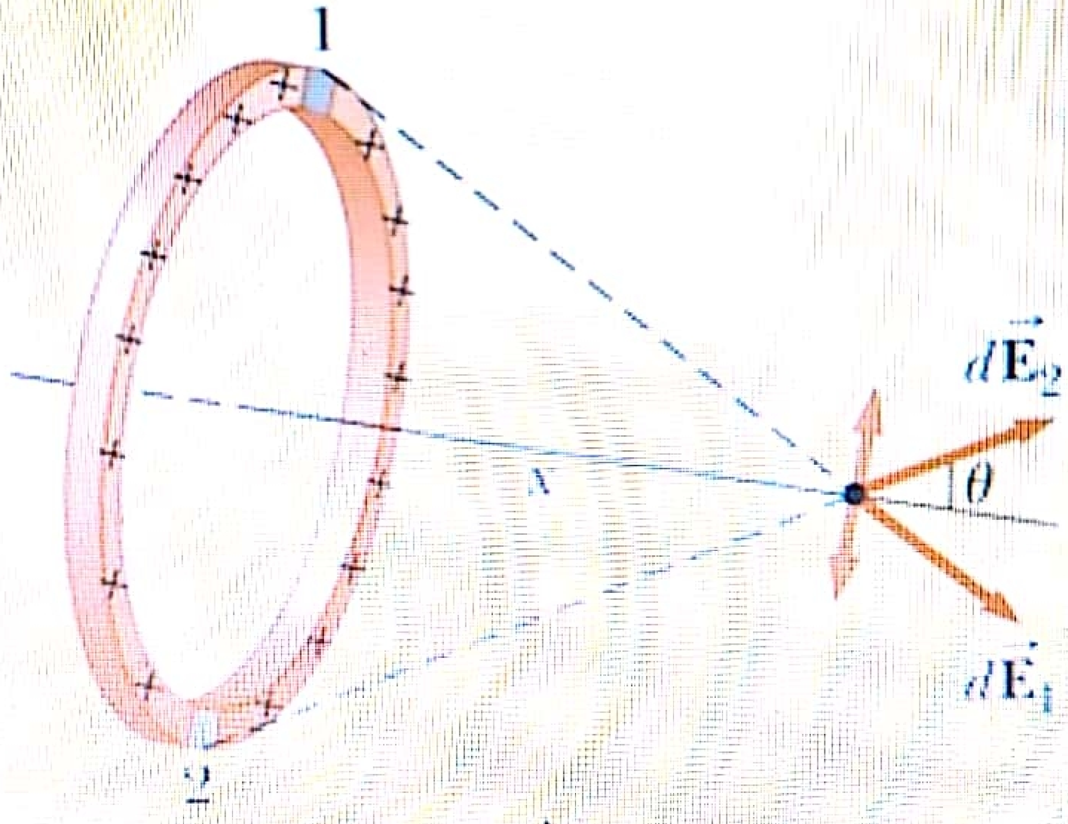
$$E = \frac{kQ}{a(L+a)}$$

$$= \frac{(9\times10^{9})(22\times10^{-6})}{(0.29)(0.41+0.29)} = 1.59\times10^{6}\ N/C$$

Ex. 39



(a)



(b)

Prob 39 -

A uniformly charged ring of radius 10.0 cm has a total charge of 75.0 μC. Find the electric field on the axis of the ring at (a) 1.00 cm (b) 5. cm (c) 30.0 cm and (d) 100 cm from the center of the ring

$a = 10 \text{ cm} = 0.1 \text{ m}$

$q = 75 \ \mu C = 75 \times 10^{-6} \text{ C}$

$$E_y = \frac{k q x}{(x^2 + a^2)^{\frac{3}{2}}}$$

A) $x = 1 \text{ cm} = 0.01 \text{ m}$

$$E_x = \frac{(9 \times 10^9)(75 \times 10^{-6})(0.01)}{(0.01^2 + 0.1^2)^{\frac{3}{2}}}$$

$E_x = 6.64 \times 10^6 \text{ N/C}$

$\Rightarrow \vec{E} = (6.64 \times 10^6 \hat{i}) \text{ N/C}$

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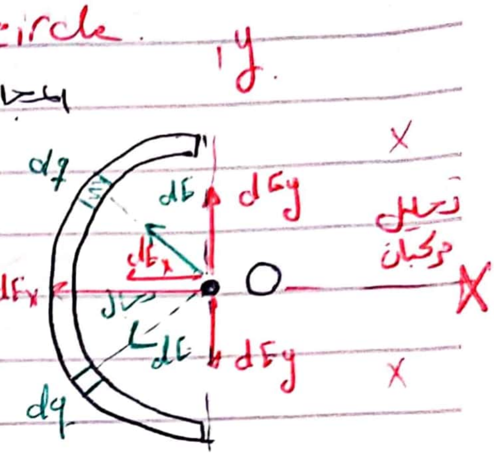
P. 45 . P. 720

A uniformly charged insulating rod of length 14.0 cm is bent into the shape of a semicircle as shown. The rod has a total charge of $-7.50\ \mu C$. Find (a) the magnitude and (b) the direction of the electric field at O, the center of the semicircle.

المجال في مركز القضيب



$L = 14\ cm = 0.14\ m$

$q = -7.5\ \mu C \equiv$ uniform

$\Rightarrow E_y$ Cancle. , $dE = k\dfrac{dq}{r^2}$

$dE_x = dE \sin\theta$

$dE_x = \dfrac{k\,dq \sin\theta}{r^2}$ تكامل الطرفين

$E_x = \dfrac{k}{r^2}\int dq \sin\theta$

$dL = r\,d\theta$ | $\lambda = \dfrac{q}{L}$

$dq = \lambda\, dL$

$= \lambda r\, d\theta$ | $L = \pi r$

$E_x = \dfrac{k}{r^2}\int dq \sin\theta$ | $r = \dfrac{L}{\pi}$

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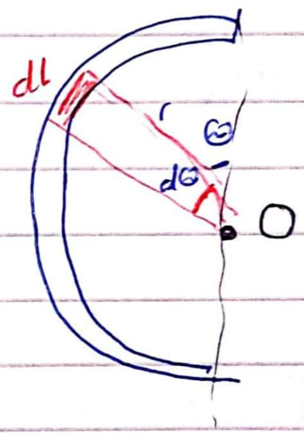
$$E_x = \frac{k}{r^2}\int dq \sin\theta$$

$$= \frac{k}{r^2}\int_0^{\pi} \lambda r \, d\theta \sin\theta$$

$$= \frac{k\lambda r}{r^2}\int \sin\theta \, d\theta$$

$$= \frac{k\lambda}{r}\left(-\cos\theta\right)\Big]_0^{\pi}$$



$$E_x = \frac{2k\lambda}{r}$$

$$= \frac{2k\left(\frac{q}{L}\right)}{\frac{L}{\pi}}$$

$$E_x = \frac{2\pi k q}{L^2}$$

$$= \frac{(2\pi)(9\times10^9)(7.5\times10^{-6})}{(0.14)^2}$$

$$E_x = 2.16\times10^7 \ N/C$$

لأنه الاتجاه لليسار. $\leftarrow \vec{E} = \left(-2.16\times10^7\,\hat{i}\right) N/C$

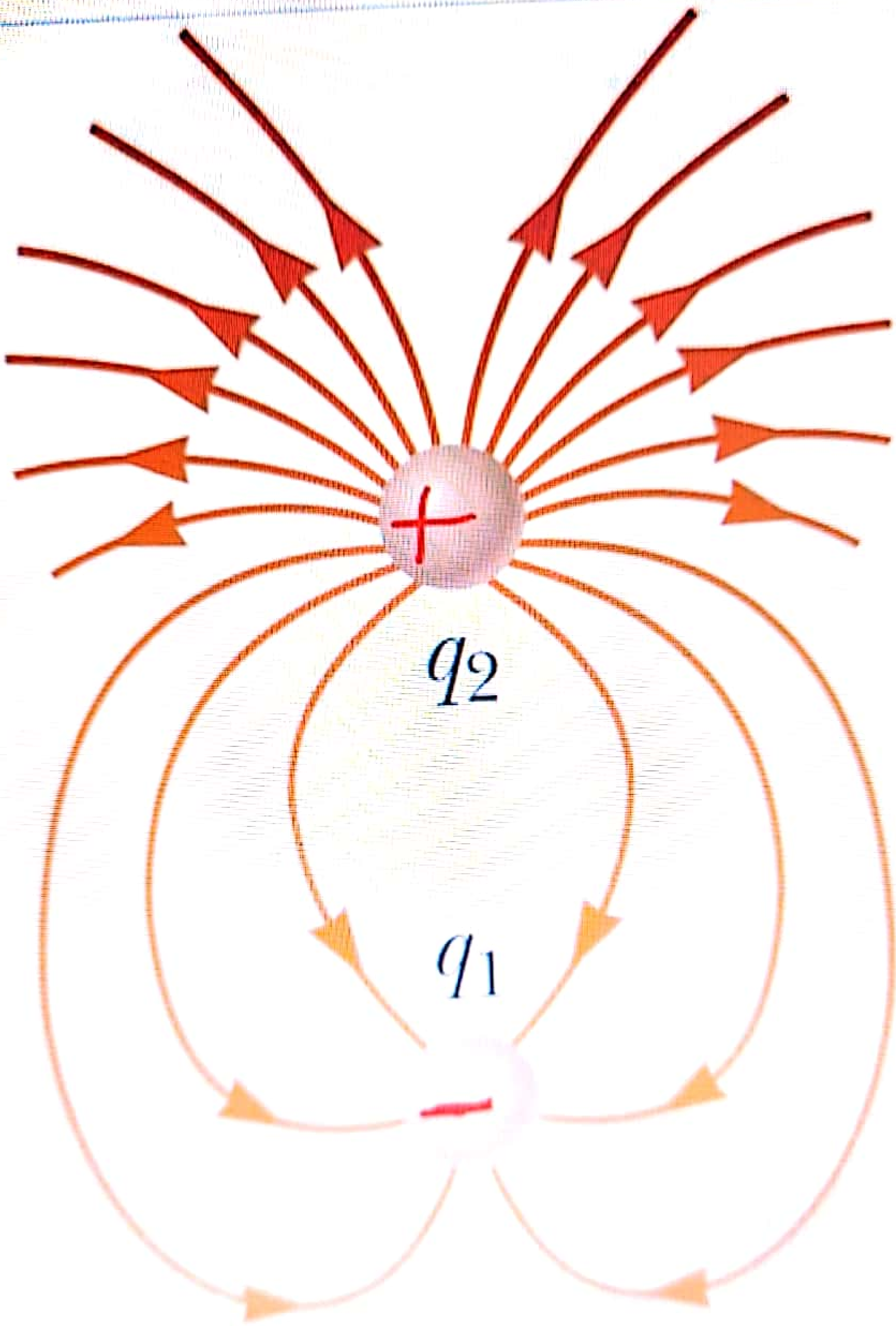

+
q_2
q_1
−

Figure shows the electric field lines for two charged particles seperated by a small distance (a) determine the ratio q_1/q_2 (b) what are the signs of q_1 and q_2

$$\left|\frac{q_1}{q_2}\right| = \frac{6}{18} = \frac{1}{3}$$

$$\frac{q_1}{q_2} = -\frac{1}{3}$$

$q_2 \longrightarrow (+)$

$q_1 \longrightarrow (-)$

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prob. 52

A proton is projected in the positive x direction into a region of a uniform electric field $\vec{E} = (-6.00 \times 10^5)\hat{i}$ N/C at $t=0$. The proton travels 7.00 cm as it comes to rest. Determine (a) the acceleration of the proton, (b) its initial speed, and (c) the time interval over which the proton comes to rest

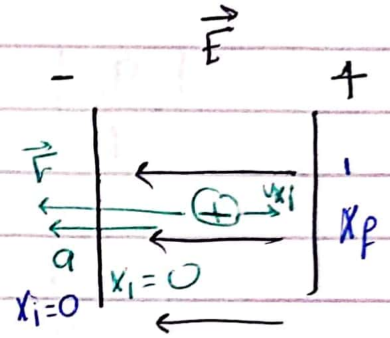
$q = 1.6 \times 10^{-19}$ C

$m = 1.67 \times 10^{-27}$ kg.

$E = (-6 \times 10^5 \hat{i})$ N/C

$X_f = 7m$

$V_{xf} = 0$



$E_x = -6 \times 10^5$ N/C , $E_y = 0$

(A) $q\vec{E} = m\vec{a} \Rightarrow \vec{a} = \frac{qE}{m}$

$a_x = \frac{qE_x}{m} = -5.76 \times 10^{13}$ m/s²

$a_y = \frac{qE_y}{m} = 0$

(B) $V_{x_f}^2 = V_{x_i}^2 + 2a_x(X_f - X_i)$

$0 = V_{x_i}^2 + 2(-5.76 \times 10^{13})(0.07 - 0)$

$V_{x_i} = 2.84 \times 10^6$ m/s.

(C) $V_{xf} = V_{xi} + a_x t$

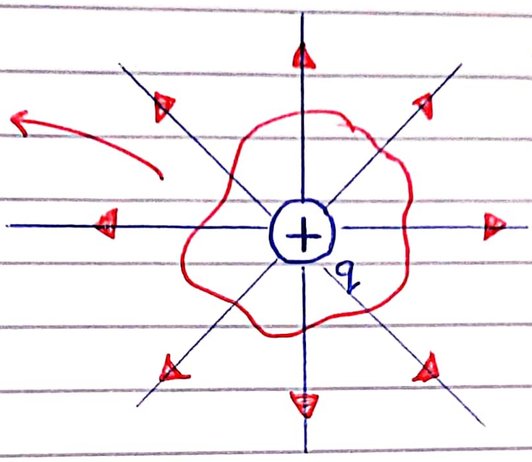
$0 = 2.84 \times 10^6 + (-5.76 \times 10^{13})t$

$t = 4.93 \times 10^{-8}$ s

- chapter 24 -

Gauss's Law

عدد الخطوط التي تخترق السطح تعبر عن التدفق



في الشكل سواء الشحنة موجبة او سالبة (عدد الخطوط الخارجة والداخلة من الشحنة تتناسب طرديًا مع مقدار الشحنة.

لازم يكون في سطح

* **Electrical flux** → is a measure of the number of field lines penerating some surface.

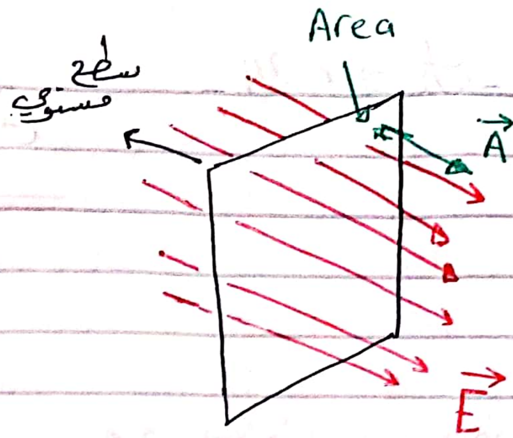
تخترق

* مقياس لعدد الخطوط التي تخترق سطح معين

* بما ان التدفق الكهربائي يتناسب مع عدد الخطوط وعدد الخطوط يتناسب مع الشحنة
اذا التدفق يتناسب مع الشحنة ← اي شحنة ؟!
الشحنة التي في داخل السطح

* If the surface is closed and encloses some net charge, then the net number of lines that go through the surface (electric flux) is proportional to the net charge within the surface

* اذا كان السطح مغلق ويغلف شحنة معينة فإن عدد الخطوط التي تخترق هذا السطح يتناسب مع الشحنة التي في الداخل



* Area is a vector, normal to the Surface الاتجاه

الـ (A) متجه ودائماً اتجاهها عمودية على السطح. (العامة)

* The electric flux (Φ) of a uniform electric field ($\vec{E}$) normal to the surface

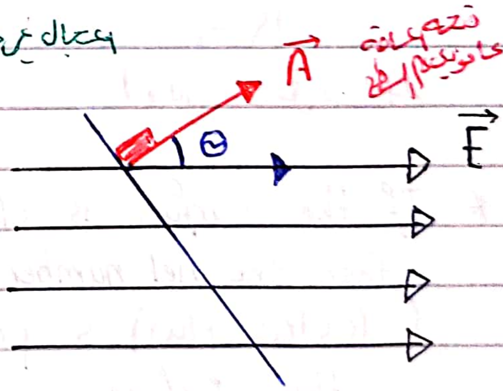
($\vec{E} \parallel \vec{A}$) parallel (موازي)

If $E \perp$ surface ($\vec{E} \parallel \vec{A}$)
normal
then

$$\boxed{\Phi = EA}$$

---

* If $\vec{E}$ is not paralle to $\vec{A}$ ($\vec{E}$ is not normal to the surface) المجال غير عادي على السطح



الزاوية Θ بين المجال E ومتجه مساحة.

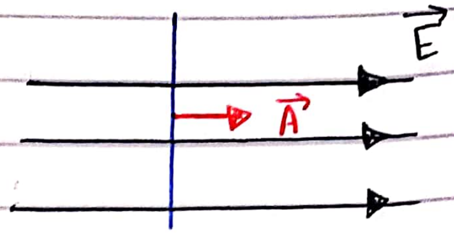
$$\Phi = EA\cos\Theta = \vec{E}\cdot\vec{A}$$

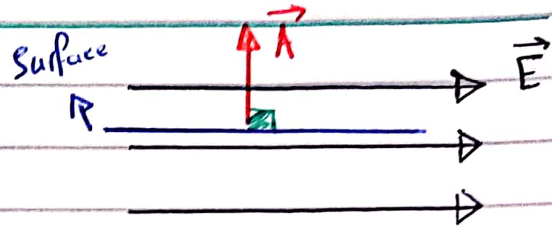
تعريف
Dot product
ضرب المتجهات

If $\theta = 0$

$\Rightarrow \Phi = EA\cos 0$

$\Phi = EA$



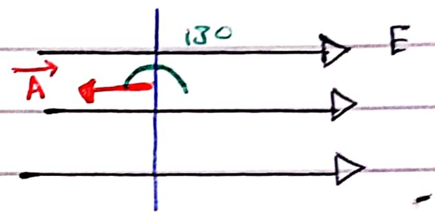


If $\theta = \frac{\pi}{2}$

$\Rightarrow \Phi = EA\cos\frac{\pi}{2}$

$\Phi = 0$

If $\theta = \pi$



$\Rightarrow \Phi = EA\cos\pi$

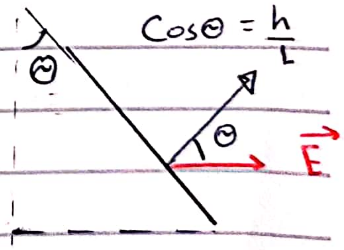
$\Phi = -EA$

<next page>

In the figure $\Rightarrow$

$|\Phi_A| = |\Phi_{A_\perp}|$

$|\Phi_{A\perp}| = EA_\perp = Ewh$



$A_\perp = wh \quad , \quad A = wL$

$= wL\cos\theta$

$A_\perp = A\cos\theta$

$|\Phi_A| = |\Phi_{A\perp}| = EA_\perp = EA\cos\theta$

$$\boxed{\Phi_A = EA\cos\theta = \vec{E}\cdot\vec{A}}$$

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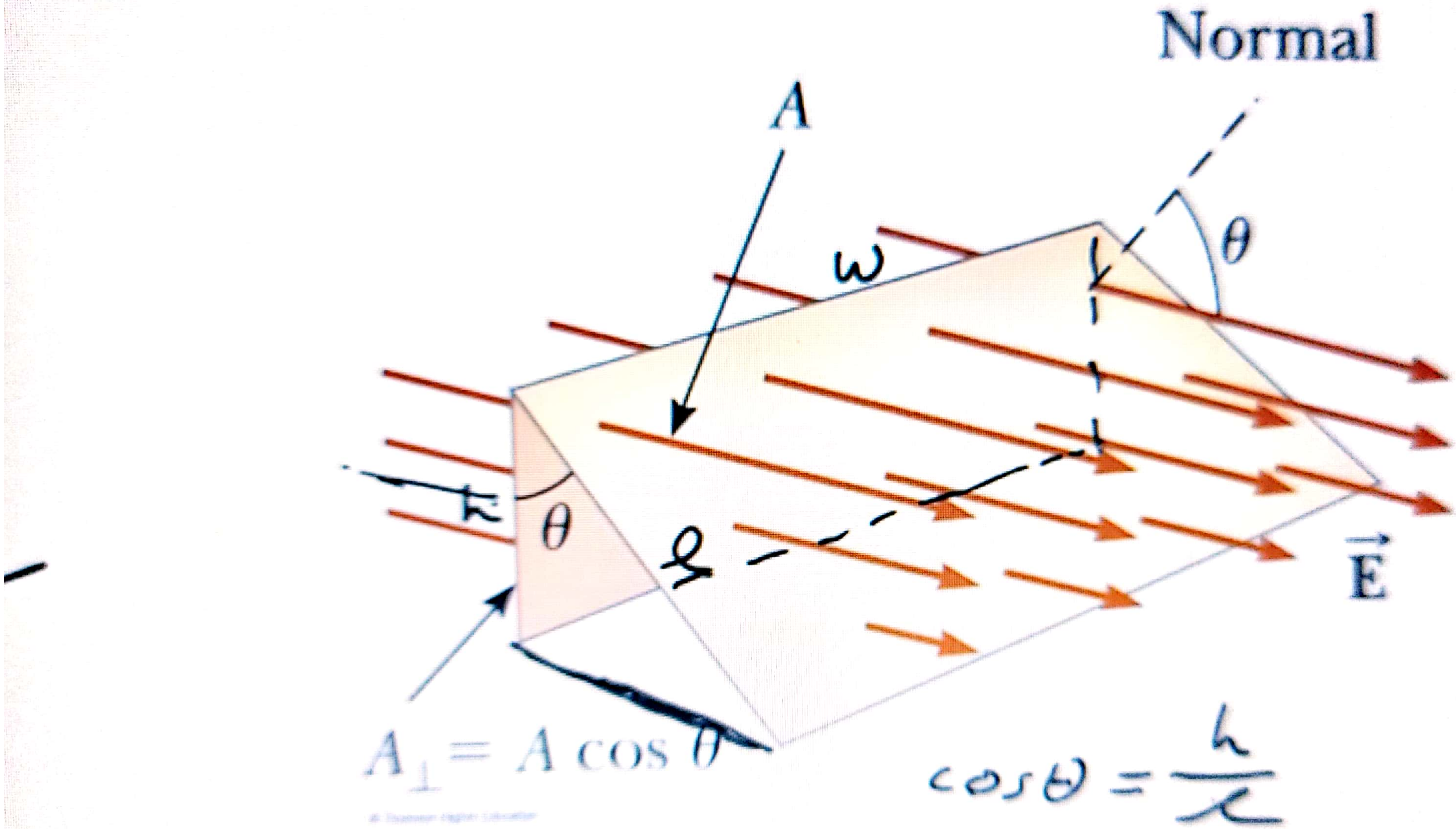
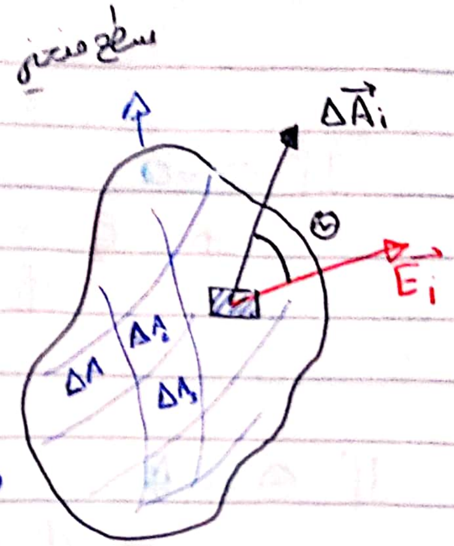

Normal
A
θ
w
h
θ
ℓ
E
A⊥ = A cos θ
cos θ = h/ℓ

For the most case:
$\vec{E}$ is not uniform and
$\vec{A}$ is curved (not plane)



* The electric flux, $\Delta\Phi$, of the electric field through the area element ΔA_i is

مساحة الكلية هي مجموع كل المساحات الصغيرة

$$\Delta\Phi_i = \vec{E}_i \cdot \Delta\vec{A}_i$$

Summing the contributions of all area elements
(نجمع كل المساحات)

$$\Phi = \sum_i \Delta\Phi_i = \sum_i \vec{E}_i \cdot \Delta\vec{A}_i$$

$$\Phi = \lim_{\Delta A_i \to 0} \sum_i \vec{E}_i \cdot \Delta\vec{A}_i = \int_s \vec{E} \cdot dA$$

$$\boxed{\Phi = \int \vec{E} \cdot d\vec{A}}$$ Most general case

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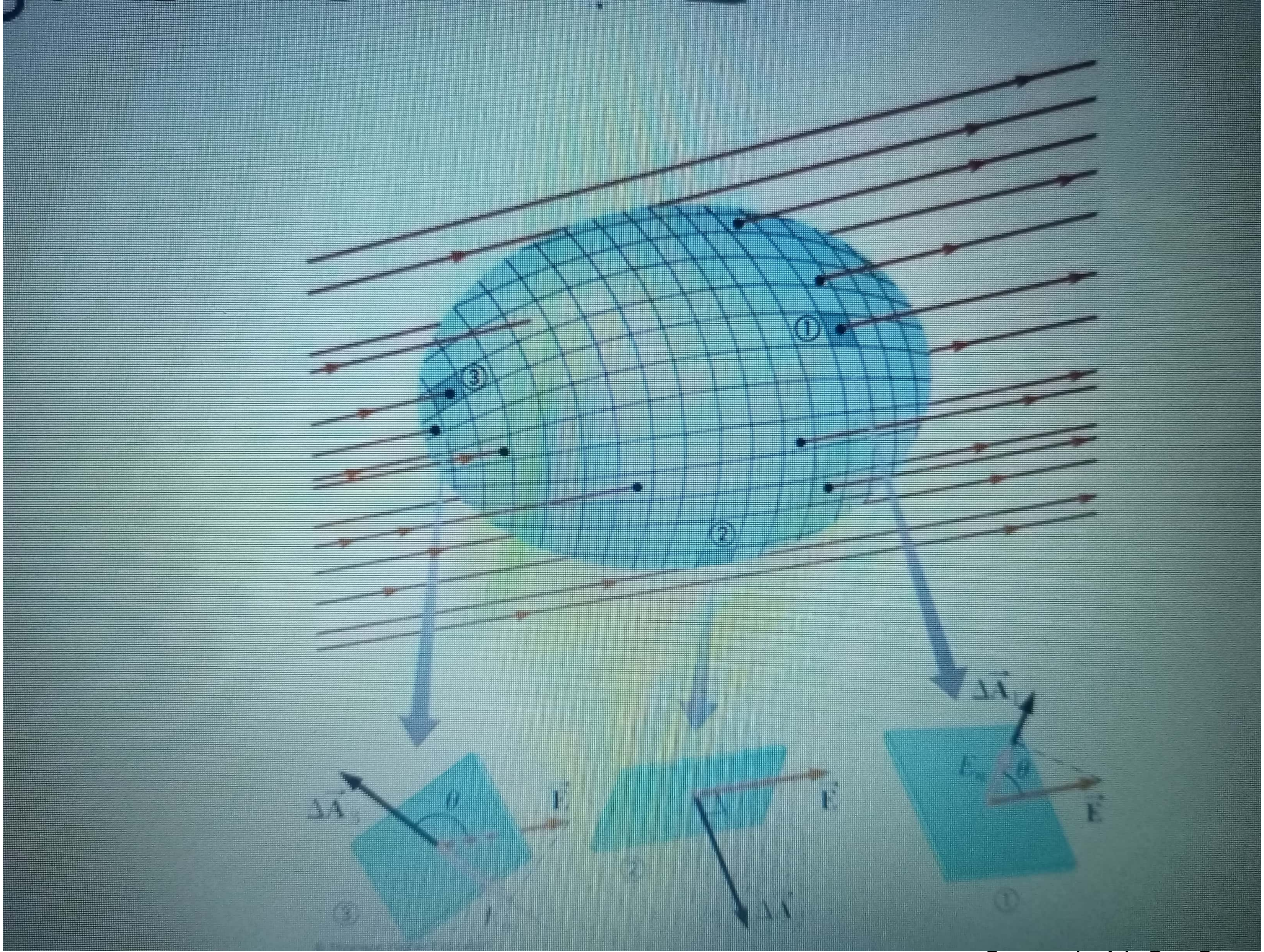

①
②
③
θ
E

* في هذه الرسمة السطح مغلق

If the surface closed

$$\Phi_c = \oint \vec{E} \cdot d\vec{A}$$

$\oint$ ← الدائرة تعني ان التكامل على سطح مغلق.

رسمة ①

$$0 \leq \Theta_1 \leq \frac{\pi}{2}$$

$(+)$ Cos ال تعني لـ

$$\Delta\Phi_1 = \vec{E} \cdot \Delta A_1 = E \Delta A_1 \underbrace{\cos\Theta}_{>0}$$

رسمة ②

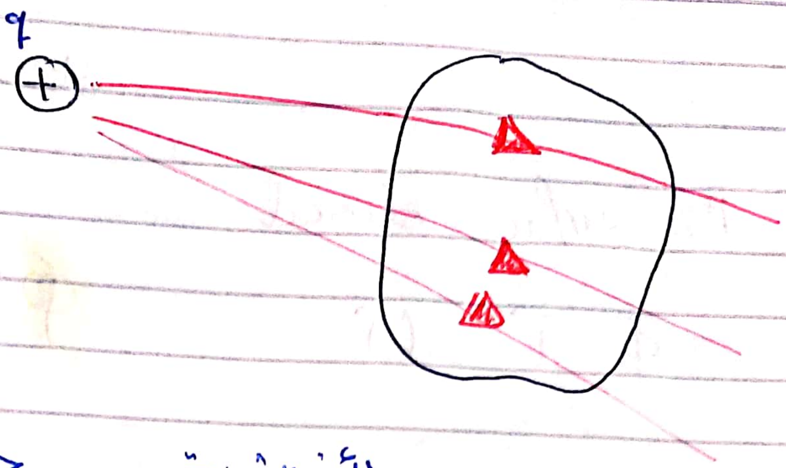
$$\Theta_2 = \frac{\pi}{2}$$

$$\Delta\Phi_2 = \vec{E} \cdot \Delta A_2 = E(\Delta \cdot A_2)\cos\frac{\pi}{2} = 0$$

رسمة ③

$$\frac{\pi}{2} \leq \Theta_3 \leq \pi$$

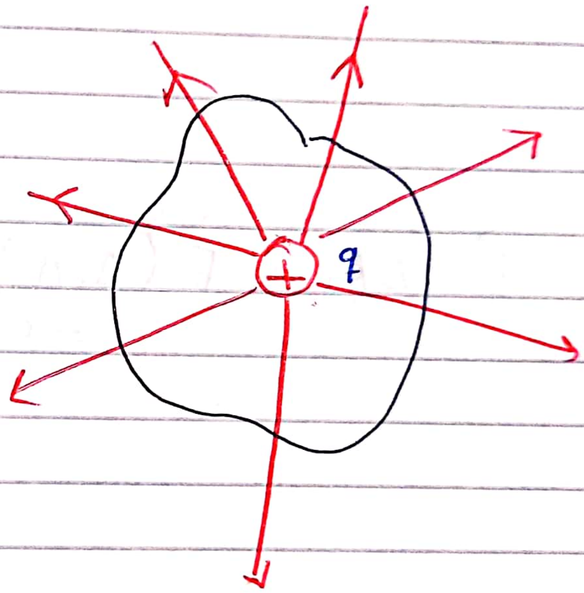
$$\Delta\Phi_3 = E \cdot \Delta\vec{A}_3 = E(\Delta A_3)\underbrace{\cos\Theta_3}_{<0}$$



$\Phi = 0$ → لأن الشحنة ليست بالداخل.

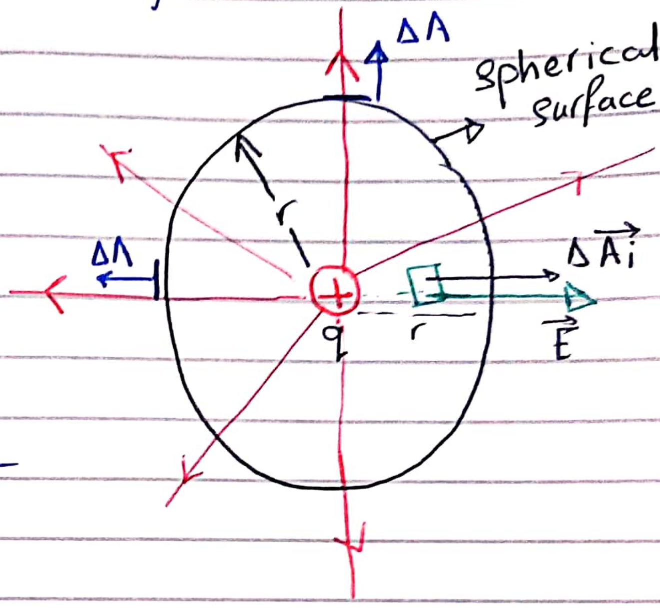
الكلي

$\Phi \neq 0$ → ويتناسب مع الشحنة q



* Gauss's law relates the net electric flux through a chosed surface and the net charged enclosed by the surface.

اتجاه ال (E) , (A) عمودية
على السطح



* The electric field of the surface is

$$\vec{E} = \frac{kq}{r^2}\hat{r}$$

$\theta = 0$ between $\vec{E}$ and $\Delta \vec{A}_i$

$$\Phi = \oint \vec{E} \cdot dA$$

$$= \oint E\, dA = \oint \frac{kq}{r^2}\, dA$$

$$= \frac{kq}{r^2} \underbrace{\oint dA}_{\text{مساحة}} = \frac{kq}{\cancel{r^2}} A = \frac{kq}{r^2}(4\pi \cancel{r^2})$$

ثوابت

$$4\pi kq = \cancel{4\pi} \frac{1}{\cancel{4\pi}\epsilon} q = \frac{q}{\epsilon}$$

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$$\boxed{\Phi = \oint \vec{E} \cdot dA = \frac{q_{in}}{\epsilon_\circ}}$$

in → inside the Surface (داخل محيط)

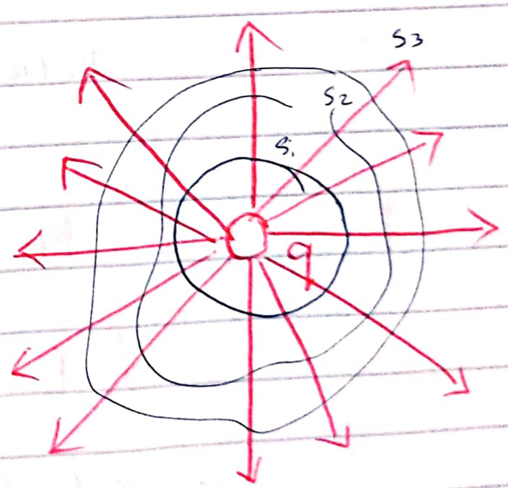
Gausse's Law

$\epsilon_\circ = 8.85 \times 10^{-12} \ C/N.m^2$

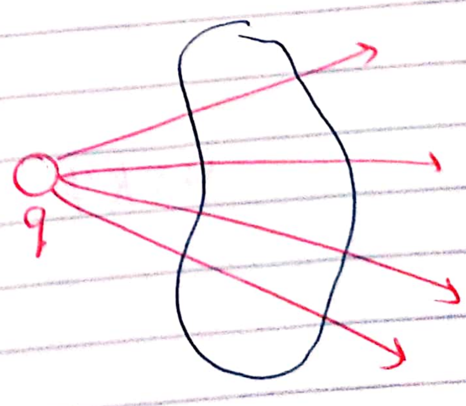
Gauss's Law ⇒ The net electric flux through a closed surface is equal to the net charge inside the surface divided By $\epsilon_\circ$

Comments

⇒ The net electric flux through each closed surface surrounding the same charge is the same regardless the shape and size.



⇒ The net electric flux through any closed surface is zero if there is no charge inside.



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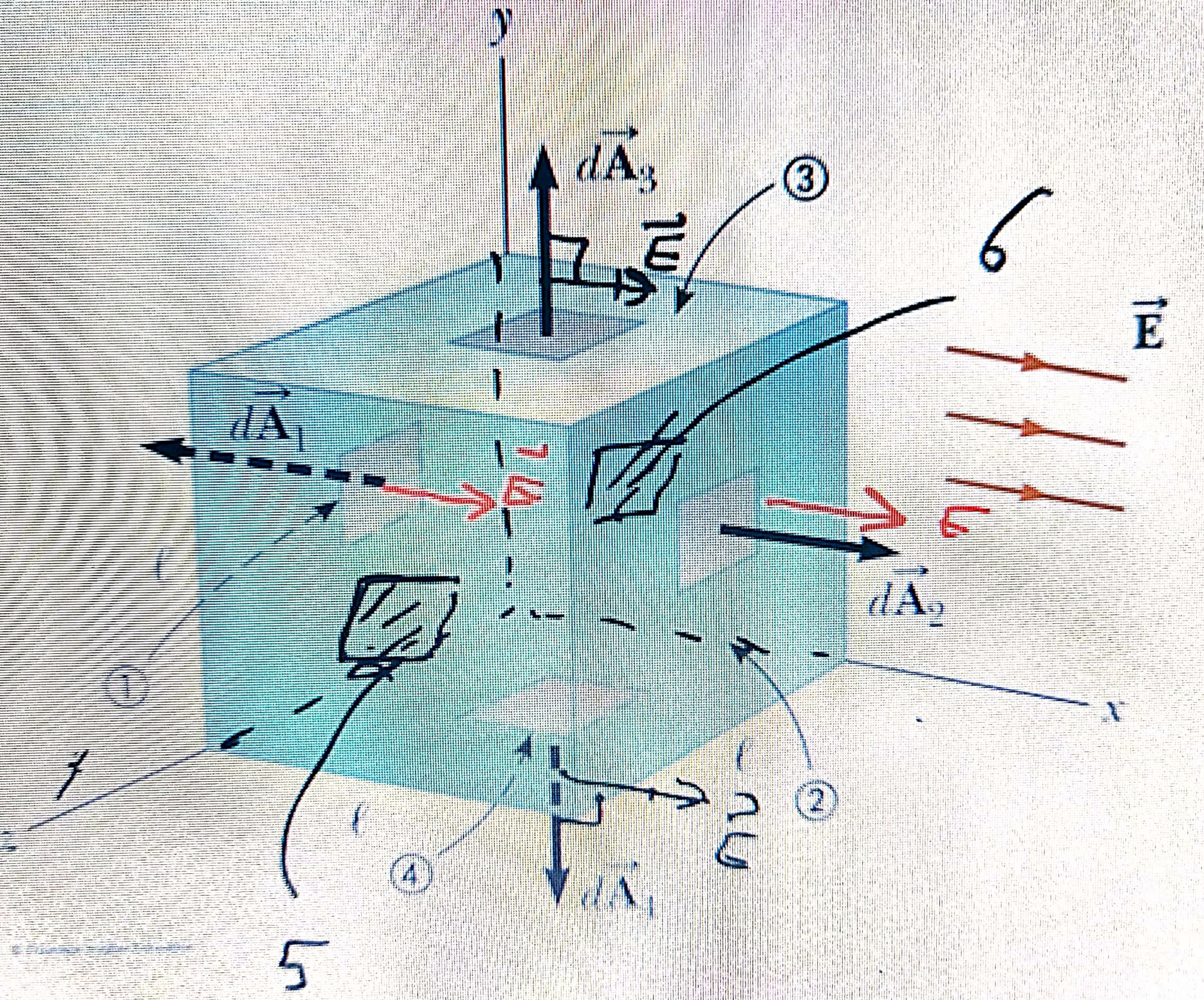
Ex. 24.1



Gauss's Law

$$\boxed{\Phi_c = \oint \vec{E} \cdot d\vec{A} = \frac{q_{in}}{\epsilon_0}}$$

لو كان مافي شحنة يعني q_{in} zero ← والتدفق (zero)

Ex. 24.1

Consider a uniform electric field $\vec{E}$ oriented in the x direction in empty space. A cupe of edge length L is placed in the field, oriented as shown in figure. Find the net electric flux through the surface of the cube.

$$\Phi_1 = EA_1 \cos 180 = -EL^2$$

$$\Phi_2 = EA_2 \cos 0 = EL^2$$

for A_3, A_4, A_5, and A_6

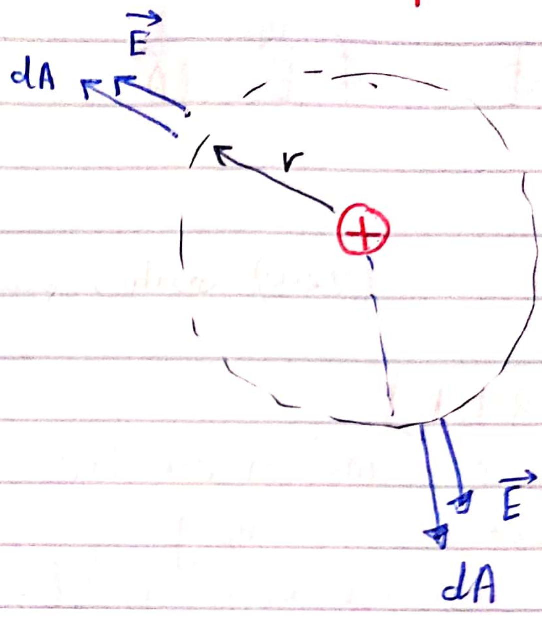
we have $\theta = \frac{\pi}{2}$ between the area vector and $\vec{E}$

$$\Rightarrow \Phi_3 = \Phi_4 = \Phi_5 = \Phi_6 = 0$$

The total flux

$$\Phi_{total} = \Phi_1 + \Phi_2 + \Phi_3 + \cdots + \Phi_6 = 0$$

EX) Electric field due a distance r from a point charge q



$$\vec{E}\cdot d\vec{A} = E\,dA \quad , \; \theta = 0$$

$$\oint \vec{E}\cdot d\vec{A} = \frac{q_{in}}{\epsilon}$$

$$\oint E\,dA = \frac{q_{in}}{\epsilon}$$

ثابت

$$E \underbrace{\oint d.A}_{=A} = \frac{q}{\epsilon}$$

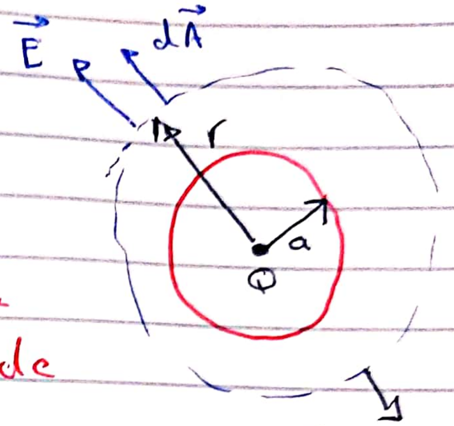
$$EA = \frac{q}{\epsilon}$$

$$E(4\pi r^2) = \frac{q}{\epsilon} \rightsquigarrow E = \frac{1}{4\pi\epsilon}\,\frac{q}{r^2}$$

$$\boxed{E = \frac{kq}{r^2}}$$

EX.24.3 ⇒ An insulating soild ~~sh~~ sphere of radius a has a uniform volume charge density ρ and and Carries a total positive charge Q

كرة مصمتة عازلة



Gaussian sphere.

Q : total charge (uniform)

$$\rho = \frac{Q}{\frac{4}{3}\pi a^3}$$

A) Calculate the magnitude of the electric field at a point outside the sphere. $(r > a)$

$$\oint \vec{E}_{out} \cdot d\vec{A} = \frac{q_{in}}{\epsilon}$$

$$\oint_{out} E\, dA = \frac{q_{in}}{\epsilon}$$

$$E_{out} \oint \underline{dA} = \frac{Q}{\epsilon} \nearrow$$

$$EA = \frac{Q}{\epsilon}$$

$$E(4\pi r^2) = \frac{Q}{\epsilon}$$

$$E_{out}(4\pi r^2) = \frac{Q}{\epsilon_\circ}$$

$$E_{out} = \frac{1}{4\pi\epsilon_\circ}\,\frac{Q}{r^2}$$

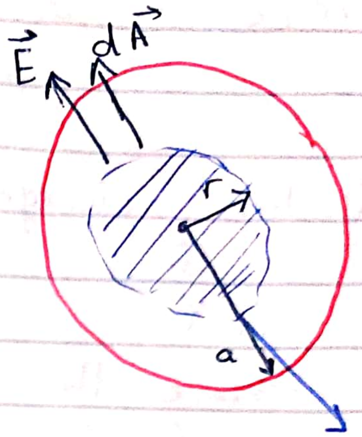
حالها كرة مشحونة بانتظام ←

$$\boxed{E_{out} = k\,\frac{Q}{r^2}}$$

$\vec{E}$ out side the sphere.

B Find the magnitude of the electric field at a point inside the sphere. $(r < a)$

$$\oint \vec{E}_{in} \cdot d\vec{A} = \frac{q_{in}}{\epsilon}$$



Gaussian sphere

$$\oint E_{in}\, dA = \frac{q_{in}}{\epsilon}$$

$$E_{in} \oint dA = \frac{q_{in}}{\epsilon}$$

$$E_{in}(4\pi r^2) = \frac{q_{in}}{\epsilon}$$

$$E_{in} = \frac{1}{4\pi\epsilon}\,\frac{q_{in}}{r^2} = k\frac{q_{in}}{r^2} = k\frac{q_{in}}{r^2}$$

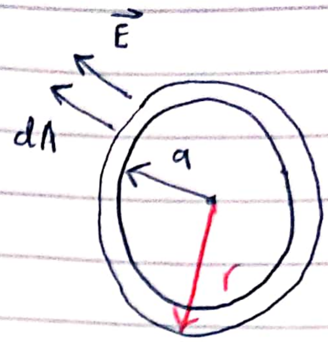
$$\Rightarrow \rho = \frac{Q}{\cancel{\tfrac{4}{3}\pi}\, a^3} = \frac{q_{in}}{\cancel{\tfrac{4}{3}\pi}\, r^3}$$

$$q_{in} = \frac{Q r^3}{a^3}$$

$$\boxed{E_{in} = k\frac{Qr}{a^3}}$$

$\vec{E}$ inside the sphere.

Example find the electric field inside and out-side a thin spherical shell of ~~[illegible]~~ radius a and uniform charge Q



A) out side $(r>a)$

$$\oint \vec{E}_{out} \cdot d\vec{A} = \frac{q_{in}}{\epsilon_0}$$

$$E_{out}\,(4\pi r^2) = \frac{Q}{\epsilon_0}$$

$$\boxed{E_{out} = \frac{1}{4\pi\epsilon_0}\,\frac{Q}{r^2}}$$

لو الشحنة سالبة
بيكون سالب في القانون
للدلالة أن المجال
للداخل

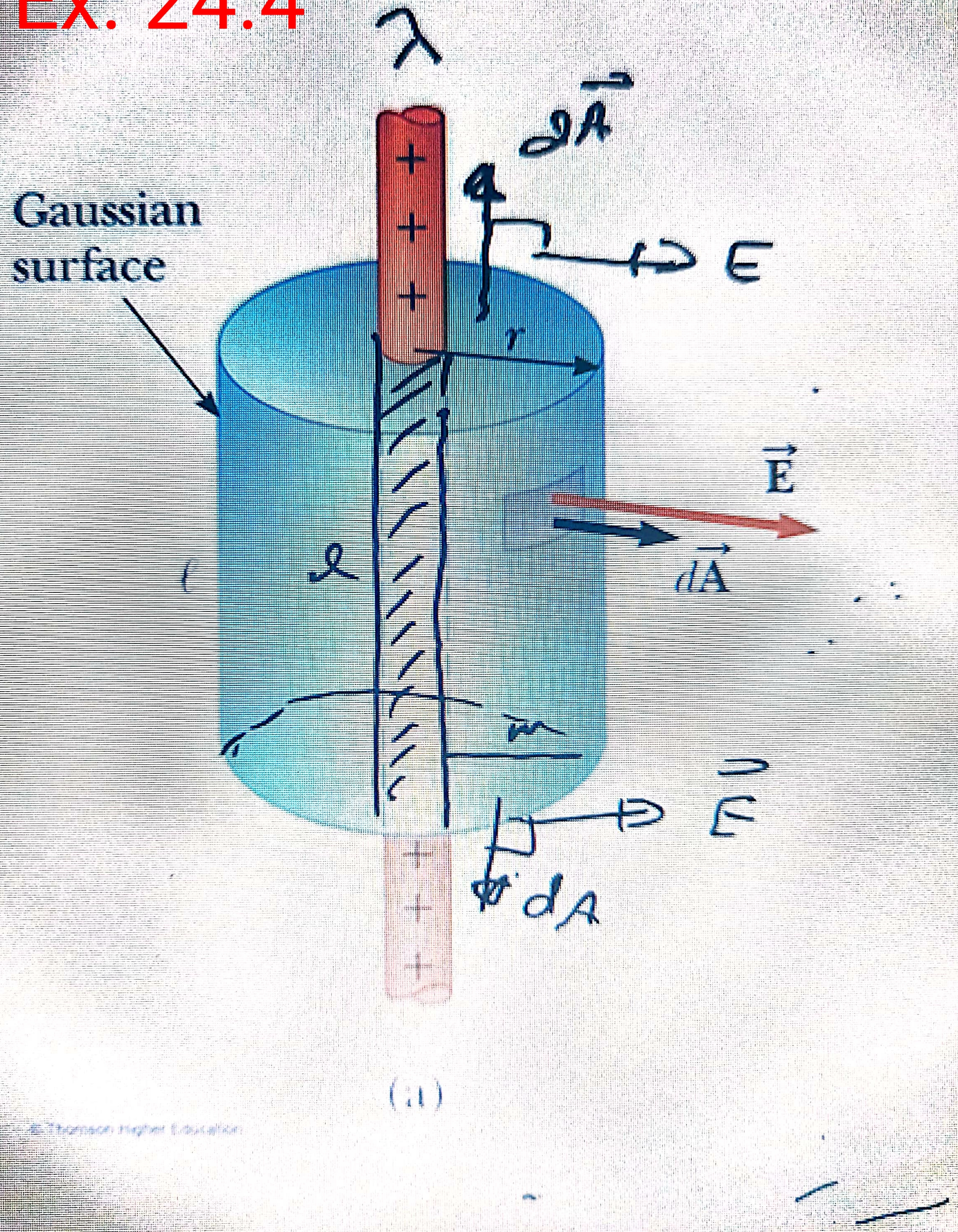
B) Inside $(r<a)$

$$\oint \vec{E}_{in} \cdot d\vec{A} = \frac{q_{in}}{\epsilon_0} = \frac{0}{\epsilon_0}$$

$$\oint \vec{E}_{in} \cdot d\vec{A} = 0$$

$$\boxed{E_{in} = 0}$$

Ex. 24.4



EX. 24.4)

find the electric field a distance r from a line of positive charge of infinite length and constant charge perunit length λ

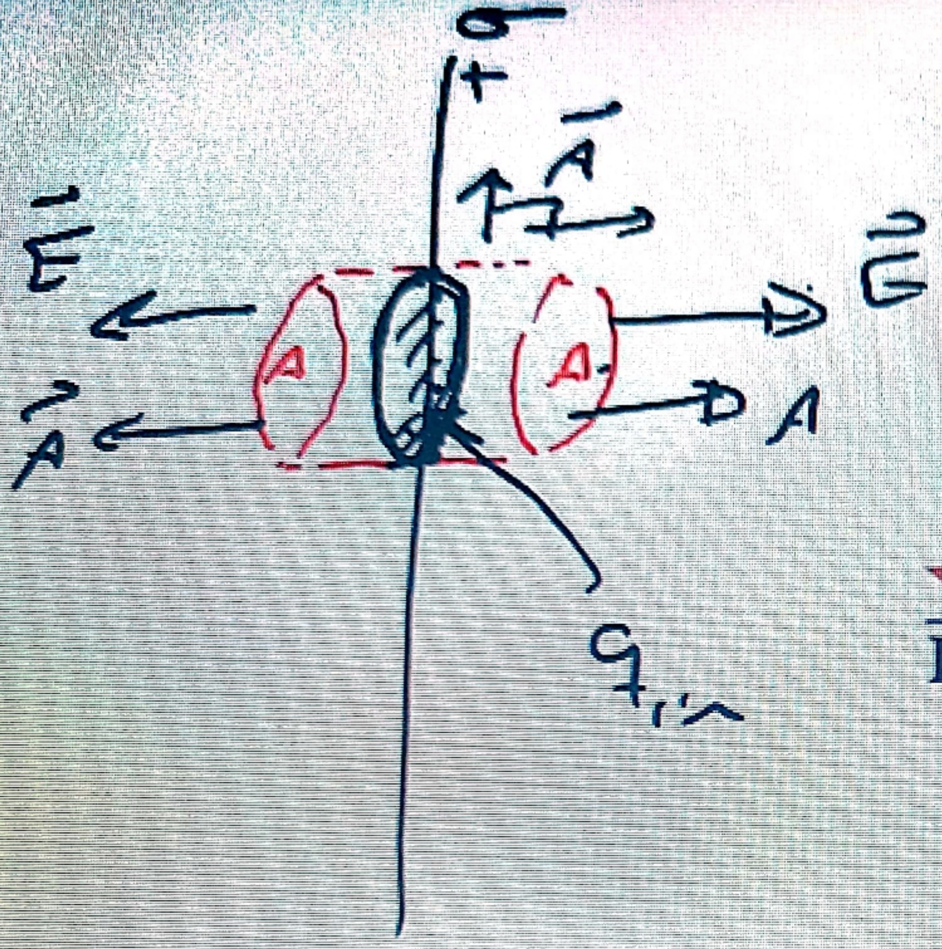
$$\oint \vec{E} \cdot d\vec{A} = \frac{q_{in}}{\epsilon}$$

$$E(2\pi r \cancel{L}) = \frac{\lambda \cancel{L}}{\epsilon}$$

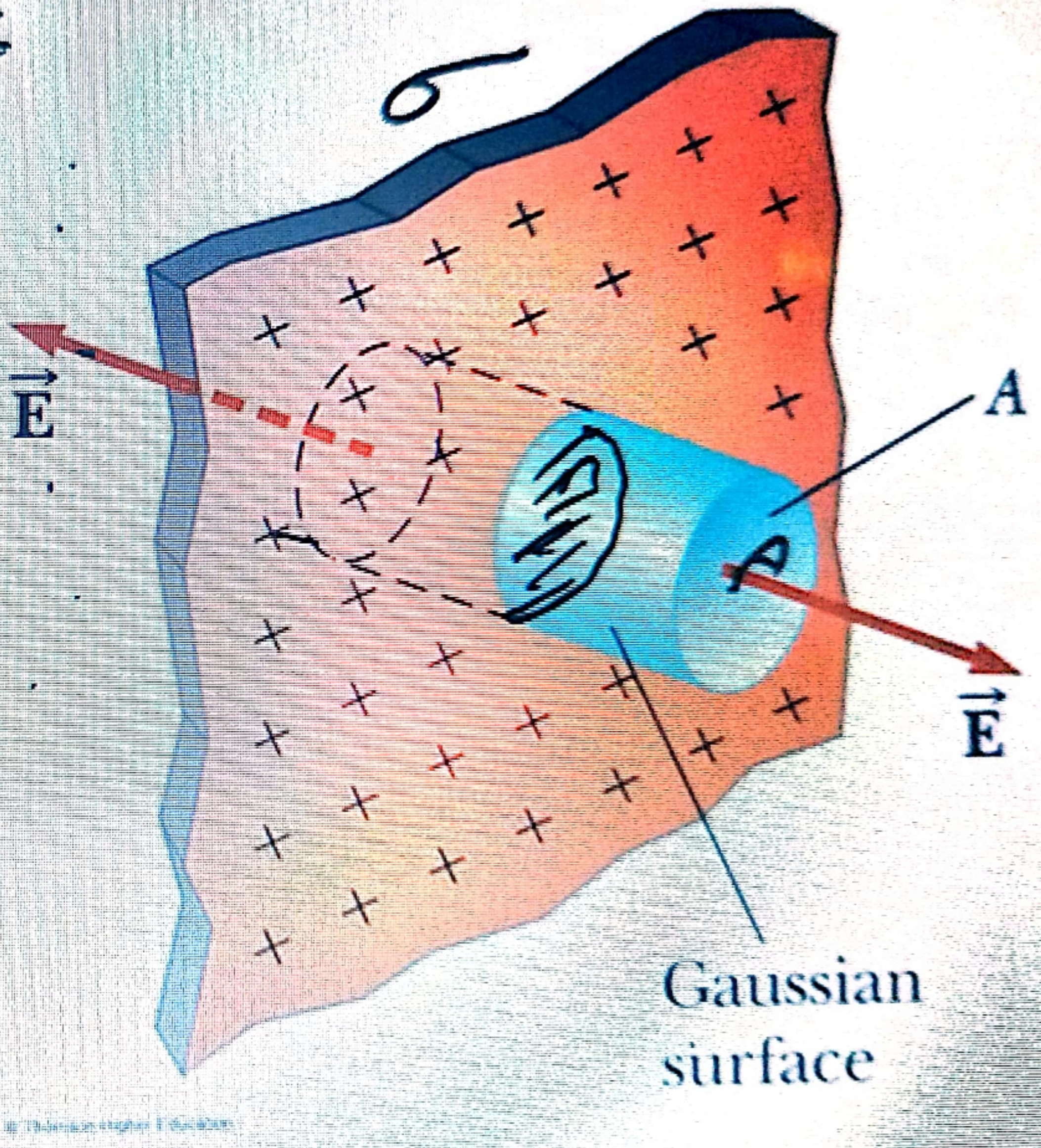
$$= E\left(\frac{1}{2\pi\epsilon} \frac{\lambda}{r}\right) * \frac{2}{2}$$

$$= \frac{1}{4\pi\epsilon} \frac{2\lambda}{r}$$

$$\boxed{\vec{E} = \frac{2k\lambda}{r}}$$ → $\vec{E}$ due to a line charge λ of infinite length



Ex. 24.5



EX 24.5) Find the electric field due to an infinite plane of positive charge with uniform surface charge density σ.

$$\oint \vec{E} \cdot d\vec{A} = \frac{q_{in}}{\epsilon_0}$$

$$EA + EA = \frac{\sigma A}{\epsilon_0}$$

$$= 2EA = \frac{\sigma A}{\epsilon_0}$$

$$\boxed{E = \frac{\sigma}{2\epsilon_0}}$$

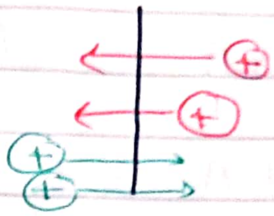
$\vec{E}$ of non conducting sheet of uniform charge density σ

الموصلات الموجودة في اتزان كهروستاتيكي

Conductors in electrostatic equilibrium

Electrostatic equilibrium ≡ no net motion of charge

الشحنة يلي رايحة لليمين = الشحنة يلي رايحة لليسار



دائماً محصلة الحركة = Zero

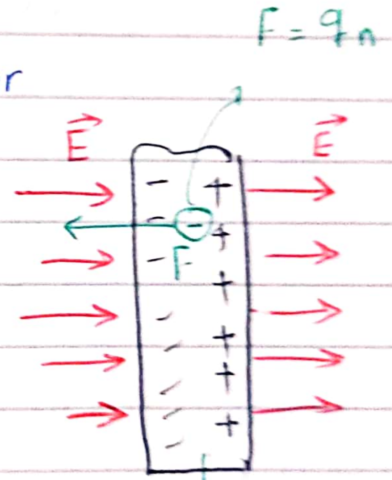
properties of Contuctors in electrotatic equilibrium

+ دائماً المجال الكهربائي داخل الموصل = Zero

1. $\vec{E}_{in} = 0$ inside the Conductor

$\vec{E}_{in} = \vec{E} - \vec{E}'$

$F = q E_{in}$ التي تؤثر على الشحنة بالداخل



شحنات حرة (موصل)

حتى ينشأ مجال آخر عكس المجال الذي في الخارج

The process (redistribution) of charge) Continue until

$\vec{F} = q E_{in} = 0$

حتى يتعادل المجال الخارجي مع الداخل

2 If an isolated conductor is charged then the charge resides on its surface.

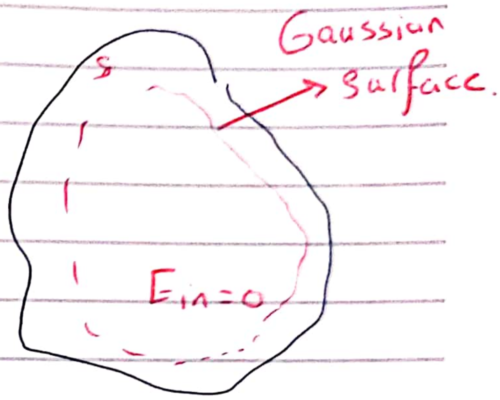
لو كان موصل مشحون ومعزول
الشحنه لا تتراكم في الداخل تتراكم ع السطح

$$\oint \vec{E}_{in} \cdot dA = \frac{q_{in}}{\epsilon}$$

$$0 = \frac{q_{in}}{\epsilon}$$

$$q_{in} = 0$$

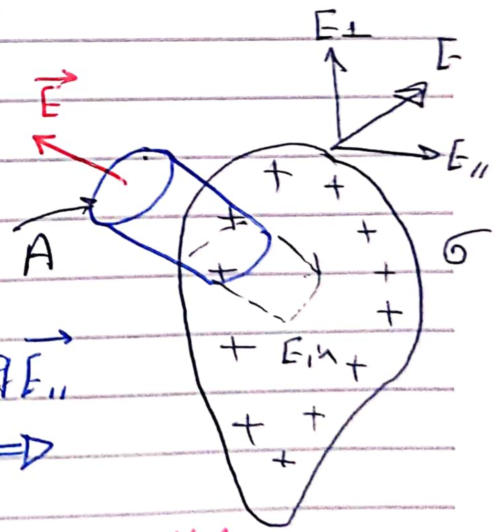
$\Rightarrow$ The charge resides on the surface.



3 Just outside the conductor

a) $\vec{E} \perp$ surface

b) $E_{surface} = \frac{\sigma}{\epsilon}$



Let $\vec{E}$ is not normal to the surface $\Rightarrow$

$E_{\parallel}$ affects before of $\vec{F}_{\parallel} = q\vec{E}_{\parallel}$ parallel to the surface $\Rightarrow$

parllel
موازي للسطح

There is a net motion of charge parallel to the surface $\Rightarrow$

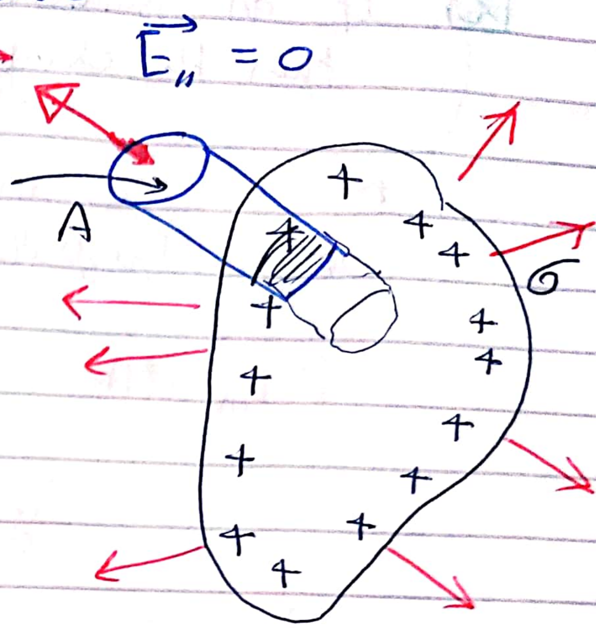
The ~~conductor is not~~ Conductor is not in electrostatic equilibrium

$\Rightarrow$ We must have $\vec{E}_{\parallel} = 0$

يجب ان يكون ال $E_{\parallel}$ zero

For a conductor to be in electrostatic equiliburum we must have

$\Rightarrow \vec{E} \perp$ surface



(B)

Apply Gauss's Law

$$\oint \vec{E} \cdot d\vec{A} = \frac{q_{in}}{\epsilon_0}$$

$$EA - \underbrace{\cancel{E_{in}}}_{\text{zero}} A = \frac{\sigma A}{\epsilon_0}$$

$$EA = \frac{\sigma A}{\epsilon_0}$$

$$\boxed{E = \frac{\sigma}{\epsilon_0}}$$

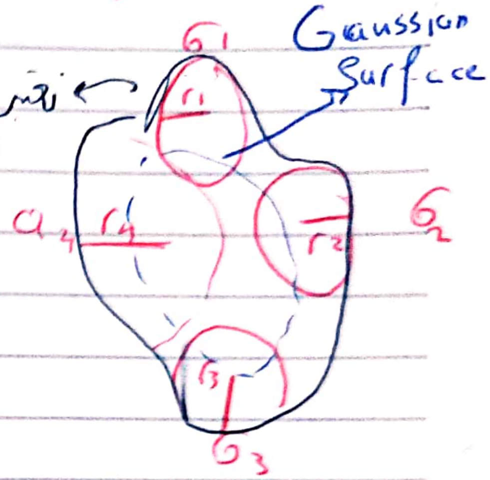
[illegible]
[illegible]

4. on an irregulary chaped conductor, σ and $\vec{E}$ are large where the surface radius of curvature is small

كل ما كان السطح مدبب σ ← عالية

E ← عالي.

نعتبر جزء من الكرة بالرأس المدبب

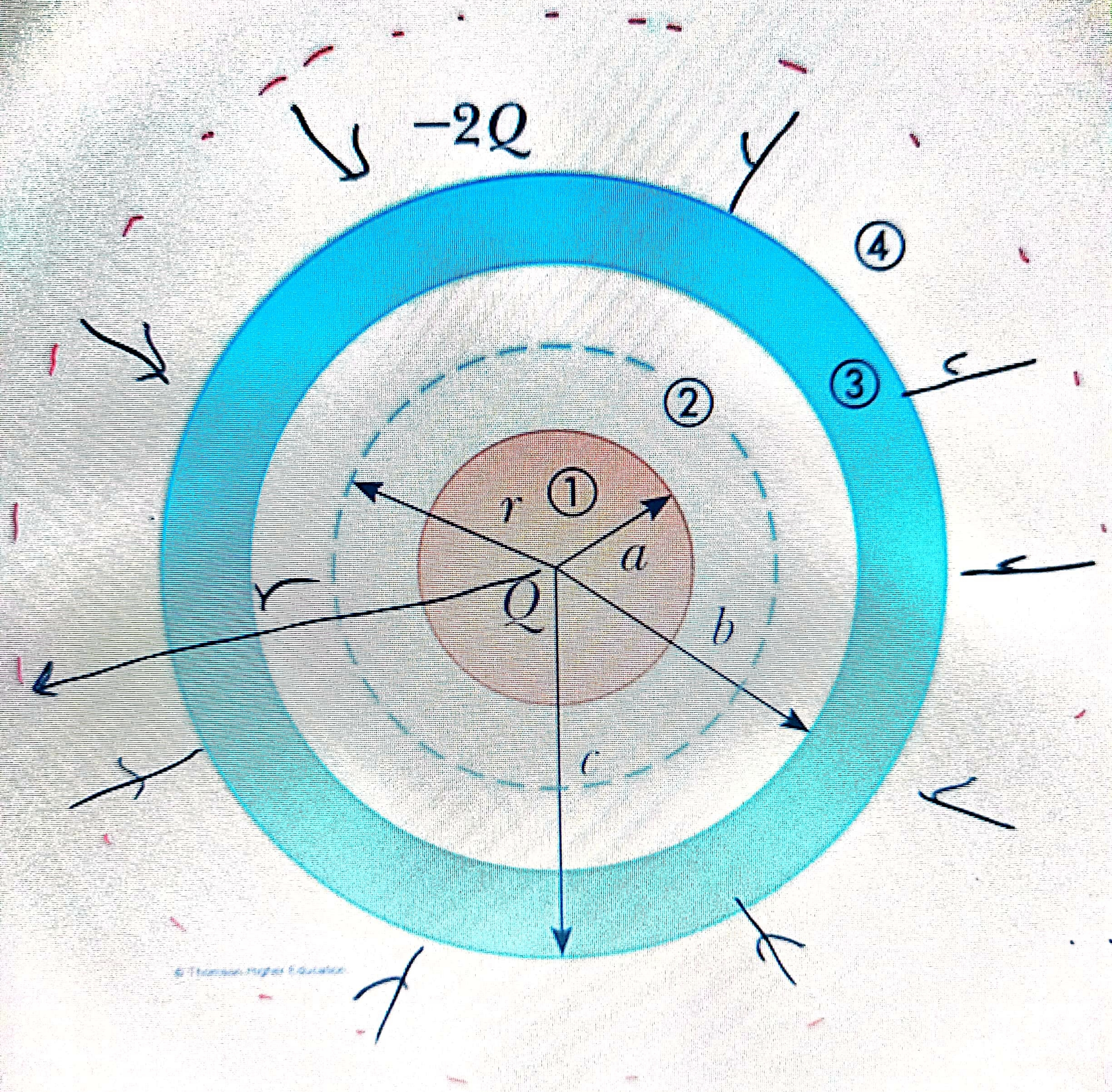


$r_1 < r_2 < r_3 < r_4$

$\sigma_1 > \sigma_2 > \sigma_3 > \sigma_4$

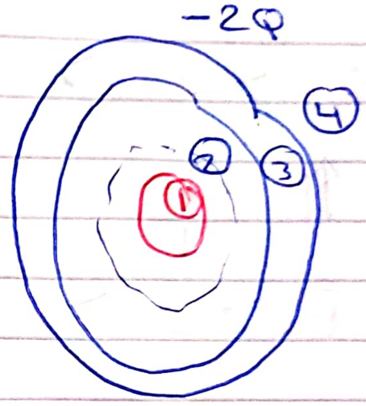
$\uparrow E = \dfrac{\uparrow \sigma}{\downarrow \epsilon}$

$E_1 > E_2 > E_3 > E_4$



Ex... 24.7

Ex. 24.7 A solid insulating ~~sth~~ sphere of radius a carries a net positive charge Q uniformly distributed throughout its volume. A conducting spherical shell of inner radius b and outer radius c is concentric with the solid sphere and carries a net charge −2Q using Gauss's law find the electric field in the regions labeled ①, ②, ③ and ④ in figure and the charge distribution on the shell when the entire system is in electrostatic equilibrium



$$\oint \vec{E} \cdot d\vec{A} = \frac{q_{in}}{\epsilon}$$

region ① $(r<a)$

$$\oint \vec{E_1} \cdot d\vec{A} = \frac{q_{in}}{\epsilon} \quad , \rho = \text{constant (uniform)}$$

$$E_1 (4\pi r^2) = \frac{q_{in}}{\epsilon}$$

$$E_1 = \frac{1}{4\pi\epsilon} \frac{q_{in}}{r^2} = k \frac{q_{in}}{r^2}$$

$$\rho = \frac{Q}{\cancel{\frac{4}{3}}\pi a^3} = \frac{q_{in}}{\cancel{\frac{4}{3}}\pi r^3}$$

$$q_{in} = \frac{Q r^3}{a^3}$$

$$E_{in} = k \frac{Q \cancel{r^3}/a^3}{\cancel{r^2}} = \frac{kQr}{a^3}$$

$$\Rightarrow \boxed{E_1 = \frac{kQr}{a^3}}$$

Region ② $a < r < b$

$$\oint \vec{E_2} \cdot d\vec{A} = \frac{q_{in}}{\epsilon_\circ}$$

$$E_2 (4\pi r^2) = \frac{Q}{\epsilon_\circ}$$

$$\boxed{E_2 = \frac{1}{4\pi\epsilon_\circ} \frac{Q}{r^2} = k\frac{Q}{r^2}}$$

Region ③ $b < r < c$

$\boxed{E_3 = 0}$ → inside the Conductor

Region ④

$$\oint \vec{E_4} \cdot dA = \frac{q_{in}}{\epsilon_\circ}$$

$$E_4 (4\pi r^2) = \frac{-2Q + Q}{\epsilon_\circ}$$

$$E_4 (4\pi r^2) = \frac{-Q}{\epsilon_\circ}$$

$$E_4 = \frac{-1}{4\pi\epsilon_\circ} \frac{Q}{r^2} = -\frac{kQ}{r^2}$$

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$$q' + q'' = -2Q$$

$$\oint \vec{E_3} \cdot dA = \frac{q_{in}}{\epsilon_0} \quad ; \quad E_3 = 0$$

$$0 = \frac{q_{in}}{\epsilon_0}$$

$$q_{in} = 0$$

$$q'' + Q = 0$$

$$\boxed{q'' = -Q}$$

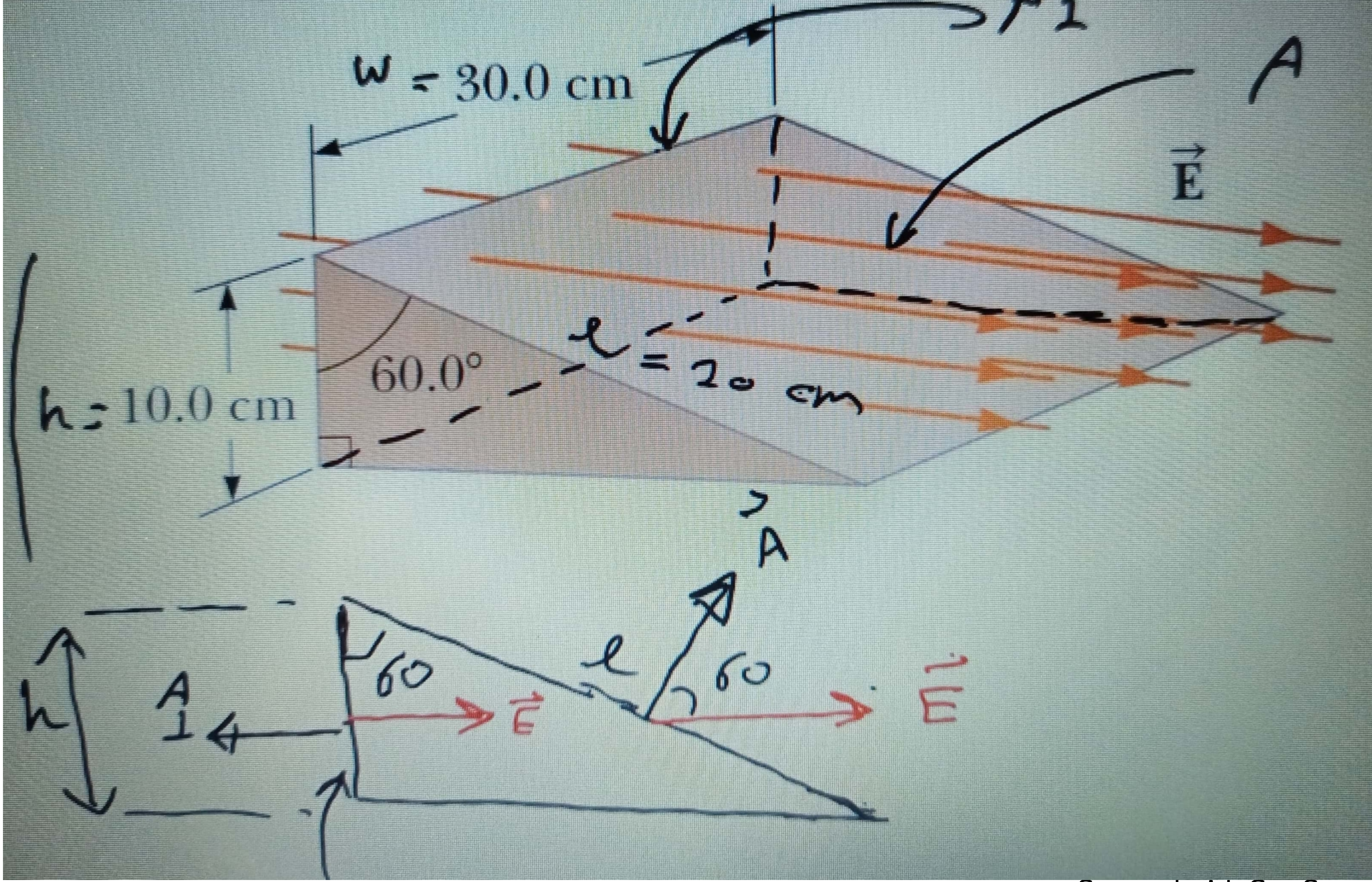
$$q' + q'' = -2Q \Rightarrow$$

$$q' = -2Q - q'' = -Q$$

$$\Rightarrow \boxed{q' = -Q}$$

دائماً على السطح الداخلي: ناقص الشحنة التي في المركز.

Ex. 24.4

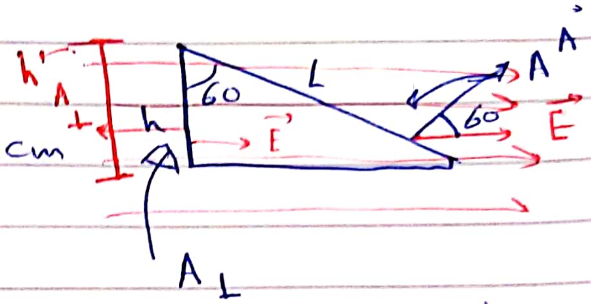


prob. 24.4 ⇒ Consider a closed triangle box resting within a horizontal electric field of magnitude $E = 7.80 \times 10^{4}$ N/C as shown. Calculate the electric flux through (a) the vertical rectangular surface, (b) the slanted surface, and (c) the entire surface of the Box

$E = 7.8 \times 10^{4}$ N/C

$h = 10$ cm , $w = 30$ cm

$L = \dfrac{h}{\cos 60} = \dfrac{10 \text{ cm}}{0.5} = 20$ cm



a) $\Phi_{A_\perp} = \vec{E} A_\perp \cos 180$

$= (7.8 \times 10^{4})(0.3 \times 0.1)(-1)$

$= -2.34 \times 10^{3}$ N.m²/C

$= -2.34$ KN.m²/C

التدفق من السطح المائل هو سالب التدفق من السطح العامودي لأنه خطوط المجال دخلت من السطح العامودي وخرجت من السطح المائل.

b) $\Phi_A = EA \cos \theta\ (60)$

$= (7.8 \times 10^{4})(0.3 \times 0.2)(\frac{1}{2})$

$= 2.34 \times 10$ N.m²/C.

$\Phi_{total} = \Phi_{A_\perp} + \Phi_A \xrightarrow{\text{مائل}} = 0$

لأنه لا يوجد شحنة في الداخل.

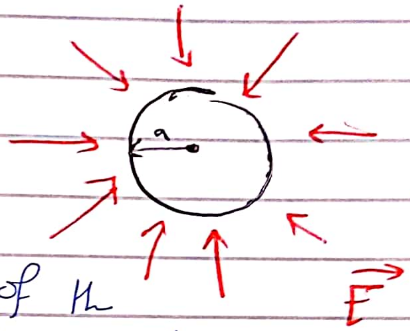
Prob - 24-10

The electric field everywhere on the surface of a thin, spherical shell of radius 0.750 m is of magnitude 890 N/C and points radially toward the center of the sphere.
(a) what is the net charge within the spheres' surface? (b) what is the distribution of the charge inside the spherical shell?

$a = 0.75$ m

$E = 890$ N/C at $r = a = 0.75$ m

E = point radially toward the center



b) Because $\vec{E}$ points radially toward the center
$\Rightarrow$ Q inside the spherical shell is negative
Because $|\vec{E}|$ = Consant at the surface of the spherial shell then the distribution of charge inside is uniform and concentric with the spherical shell

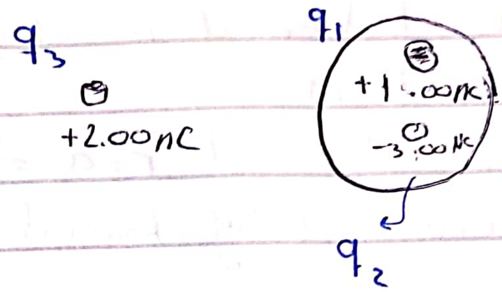
a) $$E = \frac{KQ}{a^2} \rightarrow Q = \frac{Ea^2}{K}$$

$$= \frac{(-890)(0.75)^2}{9 \times 10^9}$$

$$Q = -5.57 \times 10^{-8} \text{ C}$$
$$= -55.7 \text{ nC}$$

prob 24.8

Find the net electric flux through the spherical closed surface shown in figure. The two charges on the right are inside the spherical surface.



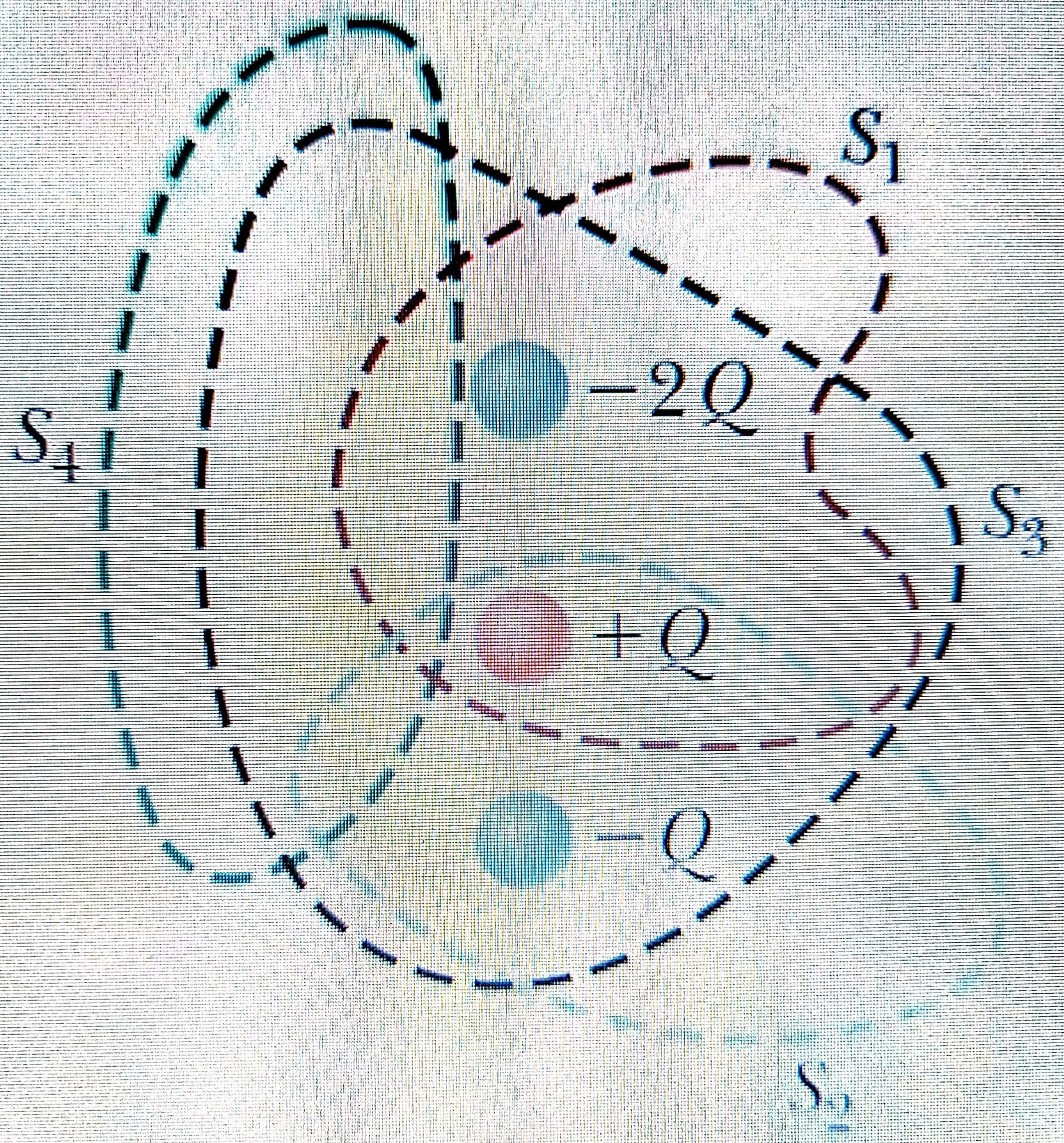
$$\Phi = \oint \vec{E} \cdot d\vec{A} = \frac{q_{in}}{\epsilon}$$

$$\Phi_{tot} = \frac{q_{in}}{\epsilon} = \frac{q_1 + q_2}{\epsilon}$$

$$\Phi_{total} = \frac{(1 \times 10^{-9}) + (-3 \times 10^{-9})}{8.85 \times 10^{-12}}$$

$$\Phi_{total} = -226 \ N.m^2/C$$

Ex. 24.11



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Prob 24.11

Four closed surfaces, S_1 through S_4, together with the charges $-2Q$, Q, and $-Q$ are sketched in figure (the colored lines are the intersections of the surfaces with the page) find the electric flux through each surface.

$$\Phi = \frac{q_{in}}{\epsilon}$$

$$S_1 = \Phi_1 = \frac{-2Q + Q}{\epsilon_0} = \frac{-Q}{\epsilon_0}$$

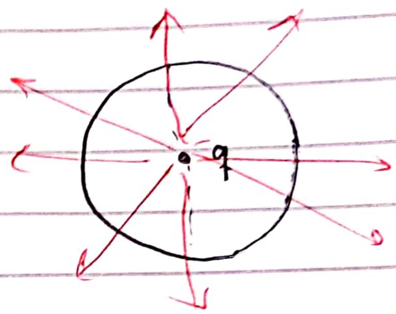
$$S_2 = \Phi_2 = \frac{+Q - Q}{\epsilon_0} = 0$$

$$S_3 = \Phi_3 = \frac{-2Q + Q - Q}{\epsilon_0} = \frac{-2Q}{\epsilon_0}$$

$S_4 = \Phi_4 = 0 \rightarrow$ لا يوجد شحنات في الداخل

prob → 24-14

A particle with charge of 12.0 μC is placed at the center of a spherical shell of radius 22.0 cm what is the total electric flux through (a) the surface of the shell and (B) any hemispherical surface of the shell? (c) Do the results depend on the radius? explain → لأ



$q = 12\ \mu C = 12 \times 10^{-6}\ C$

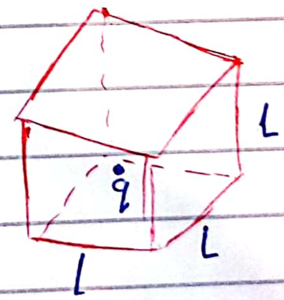
a) $\Phi_{shell} = \dfrac{q_{in}}{\epsilon_\circ} = \dfrac{q}{\epsilon_\circ} = \dfrac{12 \times 10^{-6}}{8.85 \times 10^{-12}}$

$\Phi_{shell} = 1.36 \times 10^{6}\ N.m^2/C$

b) $\Phi_{half\ shell} = \dfrac{1}{2} \Phi_{shell} = 6.78 \times 10^{5}\ N.m^2/C$

prob → عكس السؤال

لوكان بشكل Cube (مكعب)



q is at the center

$\Phi_{tot} = \dfrac{q}{\epsilon_\circ}$

$\Phi_{one-face} = \dfrac{\Phi_{tot}}{6} = \dfrac{q}{6\epsilon_\circ}$

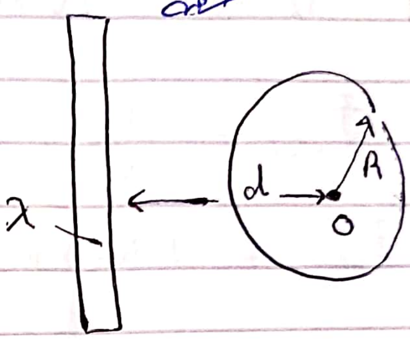
Prob. 24.17

An infinitely long line charge having a uniform charge per unit length λ lies a distance d from point O as shown. Determine the total electric flux through the surface of a sphere of radius R centered at O resulting from this line charge. Consider both cases, where (a) $R < d$ and (b) $R < d$

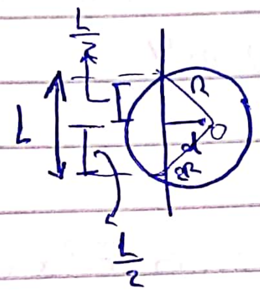
A) $R < d \Rightarrow \Phi = \frac{q_{in}}{\epsilon} = 0$

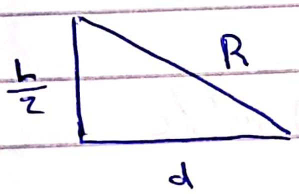
لأنه بره
ها برة

شحنة
خطية



B) $R > d$.





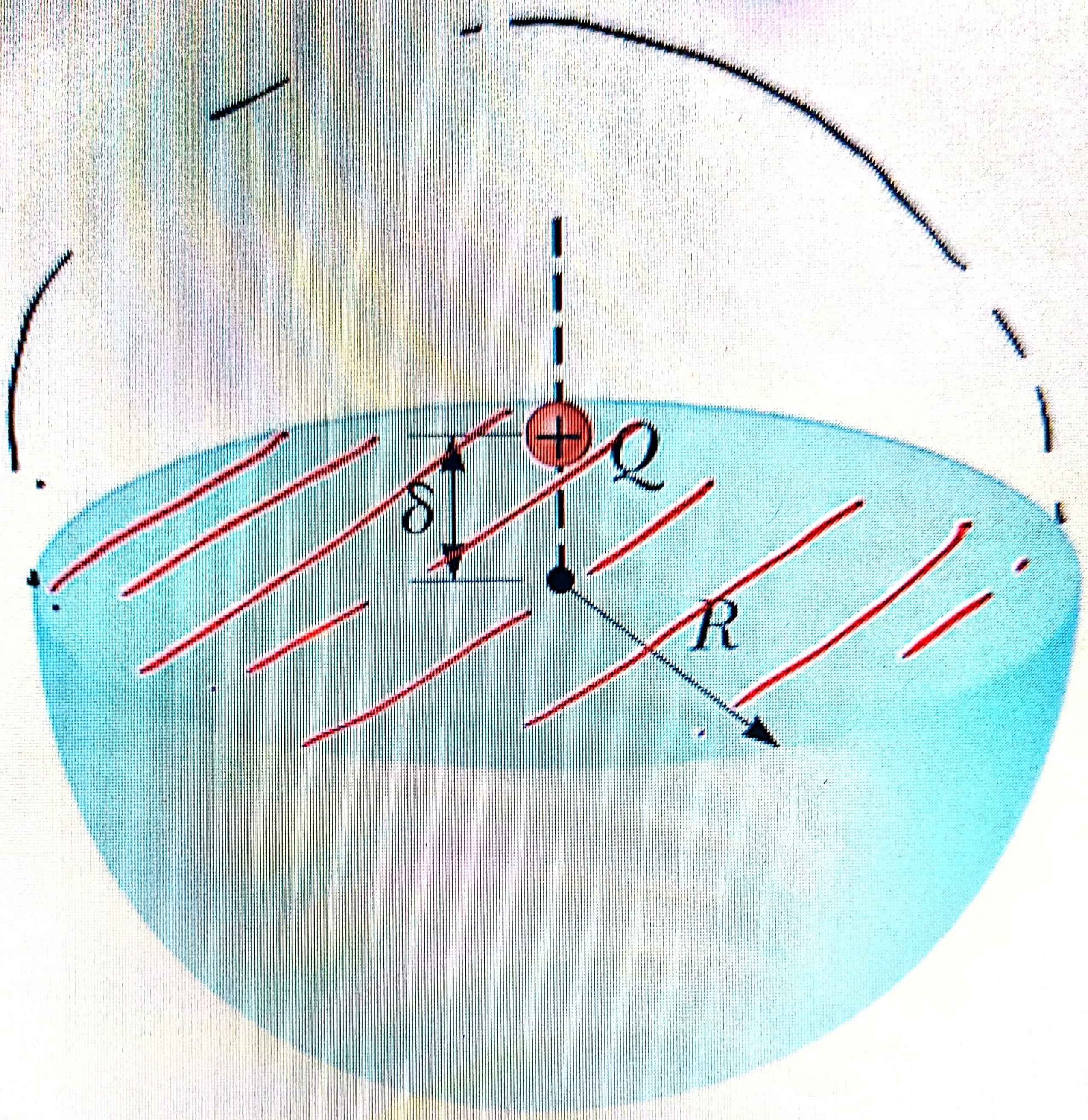
~~عملها~~
فيثاغورس

$$\frac{L}{2} = \sqrt{R^2 - d^2}$$

$$L = 2\sqrt{R^2 - d^2}$$

$$q_{in} = \lambda L = 2\lambda\sqrt{R^2 - d^2}$$

$$\Phi = \frac{q_{in}}{\epsilon} = \frac{2\lambda\sqrt{R^2 - d^2}}{\epsilon}$$



Ex... 24.21

Prob. 24.21

A partical with charge Q is located a small distance δ immedietly above the center of the flat face of a hemisphere of radius R as shown what is the electric flux (a) through the curved surface and (B) through the flat face as $\partial \to 0$?

$\delta \to 0$

A)

$$\Phi_{hemisphere} = \frac{1}{2} \Phi_{sphere}$$

$$= \frac{1}{2} \frac{Q}{\epsilon} = \frac{Q}{2\epsilon} = \frac{Q}{2\epsilon}.$$

B) $\Phi_{Flat} = -\Phi_{hemisphere} = \frac{-Q}{2\epsilon}$

prob. ~~The~~ 24.24 The charge perunit length on a long, straight filament is $-90.0\ \mu C/m$. Find the electric field (a) 10.0 cm, (b) 20.0 cm and (c) 100 cm from the filament where distance are measured perpendicular to the length of the filament

a) $r = 10\ cm = 0.1\ m$

$$E = \frac{2k\lambda}{r} = 16.2 \times 10^{6}\ N/C$$

$$= -16.2\ MN/C$$

$\lambda = -90\ \mu C$

$m = -90 \times 10^{-6}\ C/m$

$E = \frac{2k\lambda}{r}$

b) $r = 20\ cm$

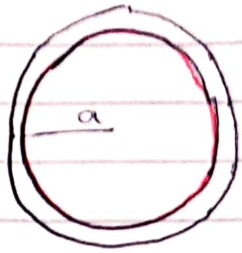
$$E = \frac{2k\lambda}{r} = 8.09\ MN/C.$$

Prob 29) Consider a thin spherical shell of radius 14.0 cm with a total charge of 32.0 μC distributed uniformly on its surface. Find the electric field (a) 10.0 cm and (b) 20.0 cm from the center of the charge distribution.

$a = 0.14\ m$

$Q = 32\ \mu C$

$E_{in} = 0$, $E_{out} = \frac{kQ}{r^2}$



shell

a) $r = 10\ cm < a$

$\Rightarrow E = E_{in} = 0$

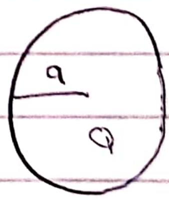
b) $r = 20\ cm = 0.2\ m > a$

$E = E_{out} = \frac{kQ}{r^2} = 7.19 \times 10^{16}\ N/C$

Prob 35) A solid sphere of radius 40.0 cm has a total positive charge of 26.0 μC uniformly distributed throughout is volume. Calculate the magnitude of the electric field (a) 0 cm (b) 10.0 cm (c) 40 cm, and (d) 60.0 cm from the center of the sphere.

$a = 40\ cm$, $Q = 26\ \mu C$

$E_{in} = \frac{kQr}{a^3}$, $E_{out} = \frac{kQ}{r^2}$



solid insulating

A) $r = 0$ $0 < a$ $\Rightarrow E = E_{in} = \frac{kQr}{a^3} = 0$

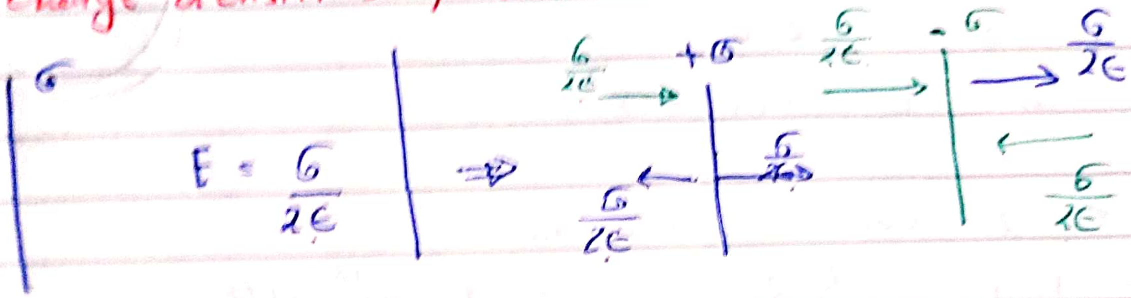
B) $r = 10\ cm$ (0.1 m) $= 10\ cm < a \Rightarrow E = E_{in} = \frac{kQr}{a^3} = 365\ kN/C$

c) $r = 40\ cm \Rightarrow E = E_{out} = \frac{kQ}{r^2} = 1.46\ MN/C$

d) $r = 60\ cm \Rightarrow E = E_{out} = \frac{kQ}{r^2} = 649\ kN/C$

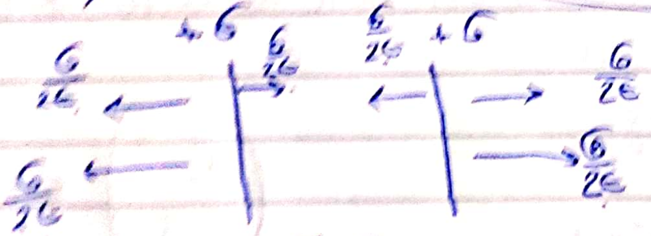
prob. 56)

Two infinite, nonconducting sheets of charge are parallel to each other as shown. The sheet on the left has a uniform surface of charge density σ, and the one on the right has a uniform charge density $-\sigma$. Calculate the electric field at points (a) to the left of, (b) in between and (c) to the right of the two sheets (d) what if? find the electric fields in all three regions if both sheets have positive, uniform surface charge densities of value σ.



$E = \frac{\sigma}{2\epsilon}$

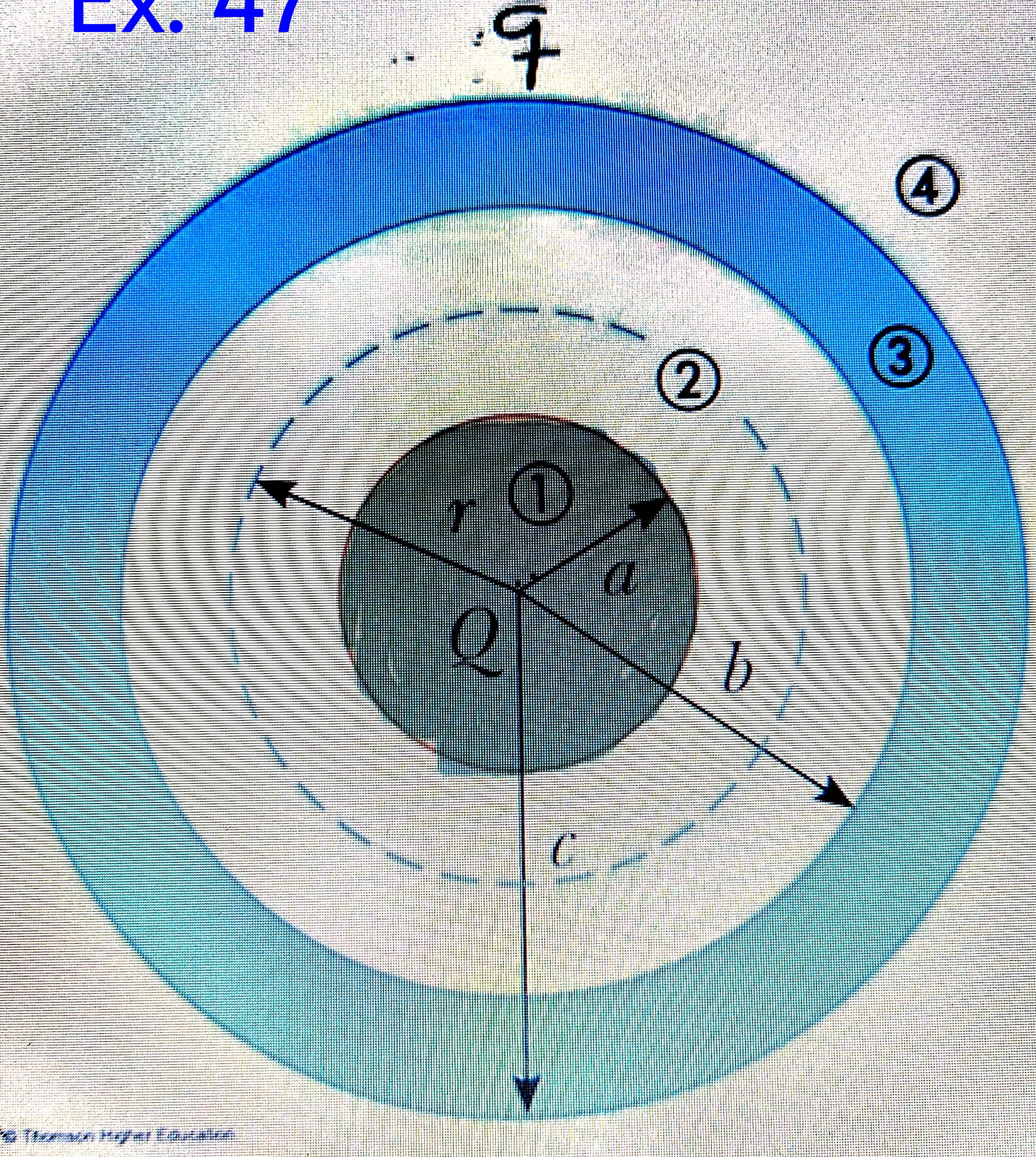
$E = \frac{\sigma}{2\epsilon} - \frac{\sigma}{2\epsilon}$	$E = \frac{\sigma}{2\epsilon} + \frac{\sigma}{2\epsilon}$	$E = \frac{\sigma}{2\epsilon} - \frac{\sigma}{2\epsilon}$
$= 0$	$= \frac{\sigma}{\epsilon}$	$= 0$



$E = 0$

$E = \frac{\sigma}{\epsilon}$ $\qquad$ $E = \frac{\sigma}{\epsilon}$

Ex. 47



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Prob. 47

A soild conducting sphere of radius 200 cm has a charge of 8.00 μc. A conducting spherical shell of inner radius 4.00 cm and outer radius 5.00 cm is concentric with the soild sphere and has a charge of -4.00 μc. Find the electric field at (a) r = 1.00 cm (b) r = 3.00 cm (c) r = 4.50 cm and (d) r = 7.00 cm from the center of this charge configuration

① $r < a$ ⇒ (inside the conductor)

$E_1 = 0$

② $a < r < b$

$E_2 = \frac{KQ}{r^2}$

③ $b < r < c$

$E_3 = 0$ (inside conductor)

④ $r > c$

$E_4 = \frac{k(q+Q)}{r^2}$

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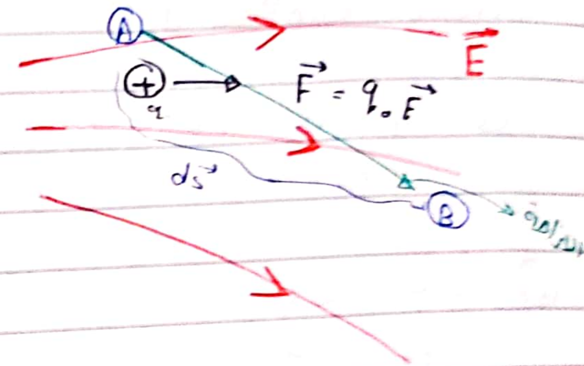
ch-25- Electric potential

Electric force ≡ conservative force قوة محافظة

(work done does not depend on the path)

الشغل لا يعتمد ع المسار ويعتمد ع النقطة الابتدائية والنهائية

$\vec{F} = q \cdot \vec{E}$



نريد ان ننقل الشحنة من (A) الى (B) عبر مسار

$$\underline{W} = \int_A^B \vec{F} \cdot d\vec{s}$$

عنصر الازاحة

The work done By the field on moving the charge from point A to B

$$W = \int_A^B \vec{F} \cdot d\vec{s} = q \int_A^B \vec{E} \cdot d\vec{s}$$

$\vec{F} = q\vec{E} \equiv$ Conservative $\Rightarrow W = -\Delta U$

$$= -(U_B - U_A)$$

$$= U_A - U_B$$

$$W = -\Delta U = q \int_A^B \vec{E} \cdot d\vec{s}$$

$$U_B - U_A = -q \int_A^B \vec{E} \cdot d\vec{s}$$

$$\frac{U_B}{q} - \frac{U_A}{q} = -\int_A^B \vec{E} \cdot d\vec{s}$$

Example 25.7

A rod of length L located along the x axis has a total charge Q and a uniform linear charge density λ. find the electric potential at a point p located on the y axis a distance a from the origin.

$$\lambda = \frac{Q}{L}$$

$$dq = \lambda\, dl = \frac{Q}{L}\, dx$$

$$r = \sqrt{x^2 + a^2}$$

$$V_p = k \int \frac{dq}{r}$$

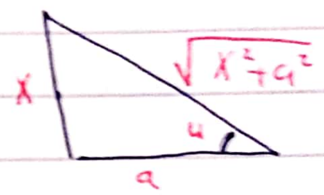
$$= k \int_0^L \frac{\frac{Q}{L}\, dx}{\sqrt{x^2+a^2}}$$

$$= \frac{kQ}{L} \int_0^L \frac{dx}{\sqrt{x^2+a^2}}$$

w:

$$x = a \tan u \Rightarrow \tan u = \frac{x}{a}$$

$$dx = a \sec^2 u \, .du$$



$$x^2 + a^2 = a^2 \tan^2 u + a^2$$

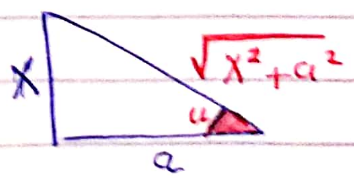
$$= a^2 (\tan^2 u + 1)$$

$$= a^2 \sec^2 u$$

$$V_p = \frac{kQ}{L} \int \frac{a \sec^2 u \, .du}{\sqrt{a^2 \sec^2 u}}$$

$$V_p = \frac{kQ}{L} \int \frac{\cancel{a}\, \sec^{\cancel{2}} u\, du}{\cancel{a}\, \cancel{\sec u}} \quad \sec u.$$

$$V_p = \frac{kQ}{L} \int_{x=0}^{x=L} \sec u \, .du$$



$$= \frac{kQ}{L} \ln \left[\sec u + \tan u \right]$$

$$= \frac{kQ}{L} \ln \left[\frac{\sqrt{x^2+a^2}}{a} + \frac{x}{a} \right] \Bigg|_0^L = \frac{kQ}{L} \ln \left[\frac{\sqrt{L^2+a^2} + L}{a} \right]$$

$$- \cancel{\ln(1)} \text{ zero}$$

$$V_p = \frac{kQ}{L} \ln \left[\frac{\sqrt{L^2+a^2} + L}{a} \right]$$

ch- 27 - Currents and resistance.

Electric currents is the rate of flow of charge through some region of space.

If ΔQ is the charge that passes the A in time Δt then the averge current is.

$$\boxed{I_{avg} = \frac{\Delta Q}{\Delta t}}$$ averge current

If the rate at which the charge flows varies then the instantaneous current is

$$I = \lim_{\Delta t \to 0} \frac{\Delta Q}{\Delta t} = \frac{dQ}{dt}$$

$$\boxed{I = \frac{dQ}{dt}}$$ instantaneous current

SI of current is Ampere (A)

$1\,A = 1\,c/s$

Current could be due to a flow of positive or negative charge.

⇒ Conventional current :- is the current due to the flow of positive charge

⇒ Direction of current is opposite to the direction of flow of electrons.

Microscopis Model of Current

* Consider a section of conductor of uniform cross sectional area A

n : number of charge carriers per unit volume

* V_d = drift speed (average speed of charges)

$\Delta x = V_d \, \Delta t \equiv$ distance the charge moves in time Δt

$$\text{Volume} = (\Delta x) A = V_d A \Delta t$$

Total number of charges in volume $= (n)$ volume

$= n V_d A \Delta t$

If q is the charge per charge carrier

$$\Delta Q = (q)(n V_d A \Delta t) = n q V_d A \Delta t$$

$$I = \frac{\Delta Q}{\Delta t} = \frac{n q V_d A \cancel{\Delta t}}{\cancel{\Delta t}}$$

$$\boxed{I = n q V_d A}$$

EX. 26.2) 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 find the Capacitance of this device.

the electric field between the plates
$(a < r < b)$

$$\oint \vec{E} \cdot d\vec{A} = \frac{q_{in}}{\epsilon}$$

$$E(4\pi r^2) = \frac{Q}{\epsilon}$$

$$E = \frac{1}{4\pi\epsilon} \frac{Q}{r^2} = \frac{KQ}{r^2}$$

$$\Delta V = V_+ - V_- = -\int_{(-)}^{(+)} \vec{E} \cdot \vec{ds}$$

$$= -\int_b^a \frac{KQ}{r^2} dr$$

$$= -KQ \int_b^a \frac{dr}{r^2}$$

$$= -KQ \int_b^a \frac{dr}{r^2}$$

$$= -KQ \left(\frac{-1}{r}\right) \Big|_b^a$$

$$\Delta V = KQ \left(\frac{1}{a} - \frac{1}{b}\right)$$

Ex. 27.1

Capper ($n = 8.48 \times 10^{28}$ electron $/m^3$)

$q = e = 1.6 \times 10^{-19}$ C

$I = 10$ A

$A = 3 \times 10^{-6}$ m^2

$I = nqV_d A$

$$V_d = \frac{I}{nqA} = \frac{10\ A}{(8.48 \times 10^{28})(1.6 \times 10^{-19})(3 \times 10^{-6})}$$

$V_d = 2.46 \times 10^{-4}$ m/s.

Summary

$$I_{avg} = \frac{\Delta Q}{\Delta t}$$

$$I = \frac{dQ}{dt}$$

$$J = \frac{I}{A}$$

$J = \sigma E$ = Ohms law

$\Delta V = RI$ ≡ ohm's law

$R = \frac{\rho l}{A}$; $\rho = \frac{1}{\sigma}$, $\frac{P}{\sigma}$

Electrical power

The energy gained when a charge ΔQ from point a to point b through a potential difference ΔV

$$\Delta U = (\Delta Q)\, \Delta V$$

The rate at which the charge ΔQ loses a potential energy in going through the resistor ex - 27.2

$w = 0.32 \ mm = 3.2 \times 10^{-4} \ m$

$\rho = 1 \times 10^{-8} \ \Omega . r$

A) $R = \frac{\rho L}{A}$

$\frac{R}{L} = \frac{\rho}{A} = \frac{\rho}{\pi r^2} = 3.1 \ \Omega / m$

B) $L = 1 m$, $\Delta V = 10 \ V$

$R = \frac{\rho L}{A} = \frac{\rho L}{\pi r^2} = 3.1 \ \Omega$

$I = \frac{\Delta V}{R}$

$= \frac{10 \ V}{3.1 \ \Omega} = 3.2 \ A$

Ex. 27.4

$\Delta V = 120\ V$, $R = 8\ \Omega$

$$I = \frac{\Delta V}{R} = \frac{120\ V}{8\ \Omega} = 15\ A$$

$$P = I\Delta V = 1.8\ kW$$

or

$$P = I^2 R = 1.8 \times 10^3\ W = 1.8\ kW$$

or

$$P = \frac{(\Delta V)^2}{R} = 1.8\ kW$$

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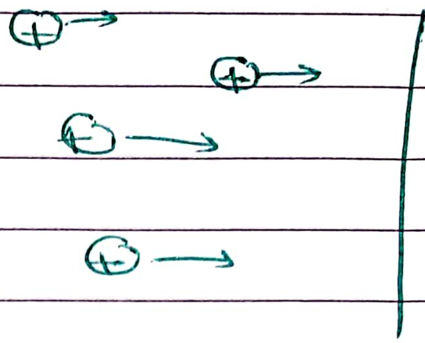
prob - 27.5



$q = e = 1.6 \times 10^{-19}\ C.$

$I = 125\ \mu A = 125 \times 10^{-6}\ A$

$\Delta t = 23\ s$

$$I = \frac{\Delta Q}{\Delta t}$$

$$\Delta Q = I(\Delta t)$$

$$N = \frac{\Delta Q}{q} = \frac{I\,\Delta t}{e} = \frac{(125 \times 10^{-6} A)(23\ s)}{(1.6 \times 10^{-19})C}$$

$N = 1.8 \times 10^{16}$ proton

ch-28-

Direct current circuits.

انواع التيار

* Direct current (DC) ≡ has a constant direction
* steady current ≡ has constant direction and constant magnitude
* Alternating current ≡ (AC) ≡ Alternate their direction

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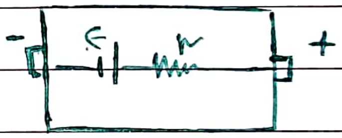
* The electromotive force (emf or ε) : is the maximum possible voltage (potential difference) that (اقصى فرق جهد) the battery can provide between its terminals



ε : electromotive force. (emf)
r : internal resistance
مقاومة داخلية

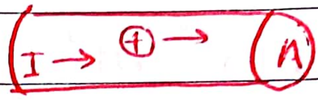
emf or ε is the potential difference between the terminals when the battery is in an open circuit

PRIMA

Resistance and ohm's law.

The current density J is defined as the current per unit area.

$$\boxed{J = \frac{I}{A}}$$



If $I = nqv_dA \Rightarrow J = \frac{I}{A} = nqv_d$

SI unit of J A/m^2.

J is a vector that has a direction of the flow of positive charge (conventional current)

ohm's law : The current density in a conductor is propotional the electric field

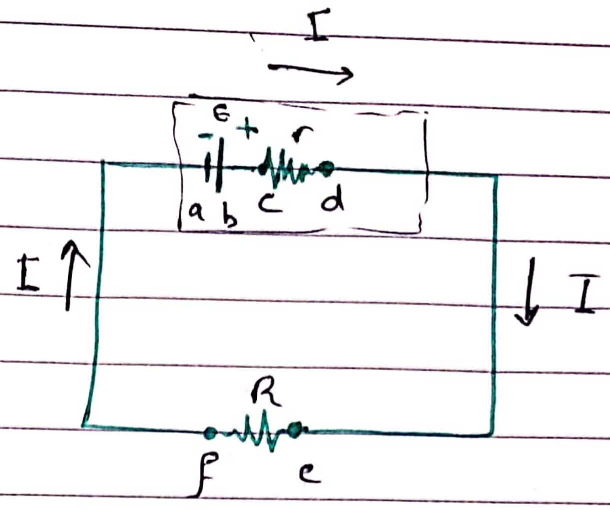
$$\vec{J} \propto \vec{E}$$

$$\boxed{\vec{J} = \sigma \vec{E}}$$ ohm's law

σ = electrical conducting of the material (depends on the material)

comments

- The currents flows from the higher to the lower potential
- The positive terminal at higher potential and the negative terminal is at lower potential
- we consider the wires to have no resistance.



$\epsilon \equiv$ emf (electromotive force)

$r \equiv$ internal vosistance.

R : load resistance

$V_d - V_a \equiv$ term

The terminal voltage is

$$\Delta V = V_d - V_a = \epsilon - Ir$$

$$\Delta V = V_d - V_a = \epsilon - Ir$$

$$\Delta V = V_d - V_a = IR$$

$$\varepsilon - Ir = IR \Rightarrow \varepsilon = I(r+R)$$

$$\boxed{I = \frac{\varepsilon}{r+R}}$$

[Power]

* The total power output of the battery is

$$P = I\mathcal{E}$$

تبدد

* The power disipdated in the internal resistance (P_r) and in the load resistance P_R are

$$P_r = I^2 r$$
$$P_R = I^2 R$$

$$P = P_r + P_R$$
$$I\mathcal{E} = I^2 R + I^2 r$$

EX . 28.1

$\varepsilon = 12\ V$, $r = 0.05\ \Omega$

$R = 3\ \Omega$

A) $I = \dfrac{\varepsilon}{r+R} = \dfrac{12}{0.05+3} = 3.93\ A$

$\Delta V = \varepsilon - Ir = 12 - (3.93)(0.05)$

$\Delta V = 11.8V$

or

$\Delta V = IR = (3.93\ A)(3\ \Omega) = 11.8V$

B) $P_r = I^2 r = (3.93\ A)^2 (0.05\ \Omega) = 0.772\ W$

$P_R = I^2 R = (3.93 A)^2 (3) = 46.3\ W$

$P = I\varepsilon = (3.93\ A)(12\ V) = 47.1\ W$

$P = P_r + P_R = 47.1\ W$

Consider a section of conductor at uniform cross section A

$$\Delta V = E L \quad , \quad J = \frac{I}{A}$$

$$J = \sigma E$$

$$\frac{I}{A} = \sigma \frac{\Delta V}{L}$$

$$\Delta V = \left(\frac{L}{\sigma A}\right) I$$

$\boxed{\Delta V = R I}$ ohm's law

$\boxed{R = \frac{L}{\sigma A} = \frac{\rho L}{A}}$, R : resistance.

ρ : resistivity

$$\boxed{\rho = \frac{1}{\sigma}}$$

ρ and σ depends on the material R depends on the material and the geometry (size and shape)

SI unit of R is Ohm (Ω)

$1\ \Omega = 1\ V/A$

$I = \left(\frac{1}{R}\right) \Delta V \equiv$ slope $= \frac{1}{R}$

I is linear with ΔV for ohmic material.

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Ex. 28.2

Find the load resistance R for which the maximum power is delivered to the load resistance in figure.

$$I = \frac{\mathcal{E}}{r+R}$$

$$P_R = I^2 R$$

$$P_R = \frac{\mathcal{E}^2 R}{(r+R)^2}$$

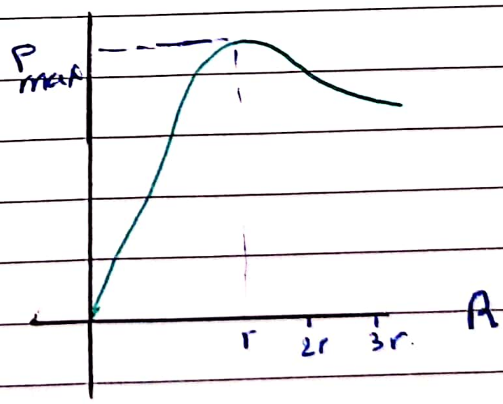
$$\frac{dP_R}{dR} = \mathcal{E}^2 \left[\frac{(r+R)^2 - 2R(r+R)}{(r+R)^4} \right] = 0$$

$$\Rightarrow (r+R)^{\cancel{2}} - 2R \cancel{(r+R)} = 0$$

$$r - R = 0$$

$\boxed{R = r}$ maximum.

$$P_{R\,max} = \frac{\mathcal{E}^2 r}{(r+r)^2} = \mathcal{E}^2/4r$$



Resistors in series and parallel

1) Resistors in series.

$I_1 = I_2 = I$ (Current is the same)

$$\Delta V = \Delta V_1 + \Delta V_2$$

$$\cancel{I}R_{eq} = \cancel{I}R_1 + \cancel{I}R_2$$

$$\boxed{R_{eq} = R_1 + R_2}$$

For more than two resistors connected in series.

$$\boxed{R_{eq} = R_1 + R_2 + R_3}$$

R_{eq} is grater than the greatest resistor in the group.

2) Resistors in parallel

$\Delta V = \Delta V_1 = \Delta V_2$

The current at the junction a

$I = I_1 + I_2$

$$\frac{\cancel{\Delta V}}{R_{eq}} = \frac{\cancel{\Delta V}}{R_1} + \frac{\cancel{\Delta V}}{R_2}$$

$$\boxed{\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}}$$

or $\boxed{R_{eq} = \frac{R_1 R_2}{R_1 + R_2}}$

For more than two resistors connected in parallel

$$\boxed{\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots}$$ resistors in parallel

R_{eq} in parallel is smaller than the smallest resistor in the group

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Ex. 28.4

Four resistors are connected as shown

A) find the equivalent resistance between points a and c.

A) R_1, R_2 , parallel

$$R_{12} = \frac{R_1 R_2}{R_1 + R_2} = 2\ \Omega$$

R_3, R_4 : series

$$\cancel{R_3 + R_4}\ R_{34} = R_3 + R_4 = 12\ \Omega$$

R_{12}, R_{34} : series

$$R_{eq} = R_{12} + R_{34} = 14\ \Omega$$

B) what is the current in each resistor if a potential difference of 42 V is maintained between a and c?

$$\Delta V = 42\ V$$

$$I = \frac{\Delta V}{R_{eq}} = \frac{42}{14}\ V = 3\ A$$

The current passing R_3 and R_4 is the same current ($I = 3A$)

$$I_3 = I_4 = 3A$$

$$\Delta V_{bc} = IR_{12} = (3A)(2\Omega) = 6\ V$$

$$I_1 = \frac{\Delta V_{bc}}{R_1} = \frac{6\ V}{6\ \Omega} = 1\ A$$

$$I_2 = \frac{\Delta V_{bc}}{R_2} = \frac{6V}{3\Omega} = 2\ A$$

$$I = I_1 + I_2 \Rightarrow 3A = 1A + 2A$$

Ex. 28.5) Three resistors are connected in parallel as shown. A potential difference of 18.0 V is maintained between points a ~~ab~~ and b

A) Calculate the equivalent resistance of the circuit

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R_{eq}} = \frac{1}{3} + \frac{1}{6} + \frac{1}{9} = \frac{11}{18}$$

$$R_{eq} = \frac{18}{11}\ \Omega = 1.64\ \Omega$$

B) Find the current in each resistor

$$I_1 = \frac{\Delta V}{R_1} = \frac{18V}{3\Omega} = 6A$$

$$I_2 = \frac{\Delta V}{R_2} = \frac{18V}{6\Omega} = 3A$$

$$I_3 = \frac{\Delta V}{R_3} = \frac{18V}{9\Omega} = 2A$$

$$I = I_1 + I_2 + I_3 = 11\ A$$

$$I = \frac{\Delta V}{R_{eq}} = \frac{18V}{(18/11)} = 11\ A$$

c) Calculate the power delivered to each resistor and the total power delivered to the combination of resistors

$P_1 = I_1^2 R_1 = 108\ W \qquad P_2 = I_2^2 R_2 = 54\ W$

$P_3 = I_3^2 R_3 = 36\ W$

$P = P_1 + P_2 + P_3 = 198\ W$

or $P = I\Delta V = (11\ A)(18V) = 198\ W.$

(Kirchhoff's Rules)

* In some circuits, resistors can not be reduced to a ~~single~~ single equivalent resistance.

* Therefore the Kirchhoff's rules can be applied

1) Junction Rule.
It is a consequence of conservation of charge

- The sum of the current at the junction must equal zero.

$$\sum_{\text{junction}} I = 0$$

convention : current entering the junction is positive (+) current leaving the junction is negative.

Comments

a) If the resistor is traversed in direction of Current

$$\Delta U = V_b - V_a = -IR$$

b) If the resistor is traversed opposite to the current I

$$\Delta U = V_b - V_a = IR$$

c) If the emf is traversed from the negative to the positive terminal

$$\Delta U = V_b - V_a = +\mathcal{E}$$

d) If the emf is traversed from(+) to (-)

$$\Delta U = V_b - V_a = -\mathcal{E}$$

RC - circuit

RC - circuit contains a series combination of a resistor and capacitor

I) charging a capacitor

$$\sum_{\text{obrda}} \Delta V = 0$$

$$\varepsilon - \frac{q}{c} - IR = 0 \quad \text{—— ①}$$

Two extreme cases :

1) At $t = 0$, $q = 0 \Rightarrow$

$$\varepsilon - IR = 0$$

$$\boxed{I_i = \frac{\varepsilon}{R}} \equiv \text{Initial (maximum) current}$$

In the intermediate case

$$\varepsilon - \frac{q}{c} - IR = 0 \quad ; \quad I = \frac{dq}{dt}$$

$$\varepsilon - \frac{q}{c} - R\frac{dq}{dt} = 0$$

$$\frac{dq}{dt} = - \frac{q - C\varepsilon}{RC}$$

$$\int_0^q \frac{dq}{q - C\mathcal{E}} = -\frac{1}{RC}\int_0^t dt$$

$$\ln\left(\frac{q - C\mathcal{E}}{-C\mathcal{E}}\right) = \frac{-t}{RC}$$

$$\frac{q - C\mathcal{E}}{-C\mathcal{E}} = e^{-t/RC}$$

$$q(t) = C\mathcal{E}\left(1 - e^{-t/RC}\right) = Q_{max}\left(1 - e^{-t/\tau}\right)$$

$$\boxed{\tau = RC}$$ = time constant of RC - Circuit

The current is

$$I = \frac{dq}{dt}$$

$$\boxed{I = \frac{\mathcal{E}}{R} e^{-t/RC} = I_i e^{-t/\tau}}$$

The voltage on the capacitor

$$\frac{q}{C} = \frac{C\mathcal{E}}{C}\left(1 - e^{-t/RC}\right)$$

$$\boxed{V_c = \mathcal{E}\left(1 - e^{-t/RC}\right) = \mathcal{E}\left(1 - e^{-t/\tau}\right)}$$

Prob 28.1) A ~~battry~~ battery has an emf of 15.0 V

The terminal voltage of the battery is 11.6 V when It is delivering 20.0 W of power to an external load resistor R (a) what is the value of R ? (b) what is the internal resistance of the battery?

$\varepsilon = 15 \text{ V}$

$\Delta V = V_d - V_a = 11.6 \text{ V}$ when $P_R = 20 \text{ W}$

A) $P_R = \dfrac{(\Delta V)^2}{R}$

$R = \dfrac{(\Delta V)^2}{P_R} = \dfrac{(11.6 \text{ V})^2}{20 \text{ W}} = 6.73 \ \Omega$

$I = \dfrac{\Delta V}{R} = \dfrac{11.6 \text{ V}}{6.73 \ \Omega} = 1.72 \text{ A}$

$\Delta V = \varepsilon - Ir$

$r = \dfrac{\varepsilon - \Delta V}{I} = \dfrac{15 \text{ V} - 11.6 \text{ V}}{1.72 \ \Omega} = 1.97 \ \Omega$

B)

$R_{12} = R_1 + R_2 = 9\,\Omega$ (series)

$R_{34} = R_3 + R_4 = 6\,\Omega$ (series)

$$R_{eq} = \frac{R_{12}\,R_{34}}{R_{12} + R_{34}} = 3.6\,\Omega$$

$$\frac{q}{C} = \frac{Q_i}{C}\,e^{-t/RC}$$

$$V_c = \Delta V_c\, e^{-t/RC_{eq}}$$

$$V_c = \frac{1}{10}\,\Delta V_c$$

$$\frac{1}{10}\,\cancel{\Delta V_i} = \cancel{\Delta V_i}\, e^{-t/RC}$$

$$= -\ln 10 = \frac{-t}{RC}$$

$$t = (RC_{eq}) \ln 10$$

$$= (3.6\,\Omega)(1\times10^{-6}\,F)\ln(10)$$

$$t = 8.29\ \mu s$$

Prob. 28.43 The circuit in figure has been connected for a long time (a) What is the potential difference across the capacitor? (b) If the battery is disconnected from the circuit, over what time interval does the capacitor discharge to one-tenth its initial voltage?

For long time ⇒ the current in the branch of the capacitor is zero because it is max charged

⇒ R_1, R_3 : series ⇒ $R_{13} = R_1 + R_3 = 5\,\Omega$

R_2, R_4 : series ⇒ $R_{24} = R_2 + R_4 = 10\,\Omega$

$$I_2 = \frac{\mathcal{E}}{R_{13}} = \frac{10\,V}{5\,\Omega} = 2A$$

$$I_3 = \frac{\mathcal{E}}{R_{24}} = \frac{10\,V}{10\,\Omega} = 1\,A$$

$$V_a - V_b = I_3 R_2 - I_2 R_1$$
$$= (1)(8) - (2)(1) =$$

$$\boxed{V_a - V_b = \Delta V_1 = 6V}$$

≡ potential across the capacitor

$\Delta V_1 = 6V$

Prob. 28.9 Consider the circuit shown in fig. find (a) the current in the 20-0 Ω resistor and (b) the potential difference between points a and b.

R_4, R_5 series

$$R_{45} = R_4 + R_5 = 20\ \Omega + 5\ \Omega = 25\ \Omega$$

R_2, R_3, R_{45} : parallel

$$\frac{1}{R_{2345}} = \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_{45}} = \frac{1}{10\ \Omega} + \frac{1}{5\ \Omega} + \frac{1}{25\ \Omega} = \frac{17}{50\ \Omega}$$

$$R_{2345} = \frac{50}{17}\ \Omega = 2.94\ \Omega$$

R_1, R_{2345} : series.

$$R_{eq} = R_1 + R_{2345} = 12.94\ \Omega$$

$$I = \frac{\mathcal{E}}{R_{eq}} = \frac{20\ V}{12.94} = 1.93\ A$$

$$\Delta V_{ab} = I R_{2345} = (1.93\ A)(2.94\ \Omega)$$

$$\Delta V_{ab} = 5.68\ V$$

$$I_4 = \frac{\Delta V_{ab}}{R_{45}} = \frac{5.68\ V}{25\ \Omega} = 0.227\ A = 227\ mA$$

$$I_2 = \frac{\Delta V_{ab}}{R_2} = \frac{5.68\ V}{10\ \Omega} = 0.568 A$$

$$I_3 = \frac{\Delta V_{ab}}{R_3} = \frac{5.68 V}{5} = 1.136\ A$$

Prob - 28.14

(a) when the switch S in the circuit of figure is closed, will the equivalent resistance between points a and b increase or decrease? State your reasoning.
(b) Assume the equivalent resistance drops by 50.0 % when the switch is closed. Determine the value of R

A) If S is ~~\$~~ closed

R_1, R_2 : parallel

$$R_{12} = \frac{R_1 R_2}{R_1 + R_2} = 9\ \Omega$$

R_3, R_4 : parallel

$$R_{34} = \frac{R_3 R_4}{R_3 + R_4} = 9\ \Omega$$

R, R_{12}, R_{34} : series

$$R_{eq} = R + R_{12} + R_{34}$$
$$= R + 9\ \Omega + 9\ \Omega$$
$$= R + 18\ \Omega$$

If S is open R_1, R_3 : series $R_{13} = R_1 + R_3 = 100\ \Omega$

R_2, R_4 : series.

$$R_{24} = R_2 + R_4 = 100\ \Omega$$

R_{13}, R_{24} : parallel

$$R_{1234} = \frac{R_{13} R_{24}}{R_{13} + R_{24}} = 50\ \Omega$$

$R, R_{12,3,4}$: series

$$R_{eqe} = R + R_{1234} = R + 50\ \Omega$$

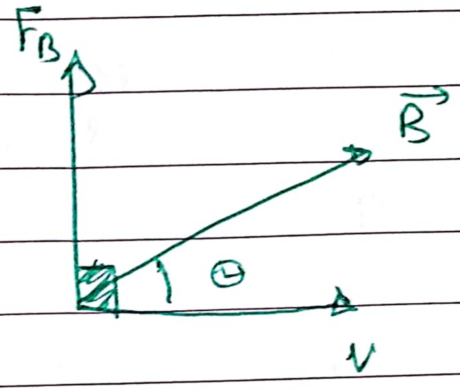
If S is closed the R_{eq} decreases

$$R_{eq}(\text{S closed}) = 0.5\,(R_{eq}(\text{S open}))$$
$$R + 18\ \Omega = 0.5\,(R + 50\ \Omega)$$
$$R + 18 = 0.5 R + 25$$
$$R = 14\ \Omega$$

The magnetic force on a moving charge q is

$$\vec{F_B} = q\vec{v} \times \vec{B}$$

$$F_B = qvB\sin\theta$$



EX. 29.1

$q = -e = -1.6 \times 10^{-19}$ C

$v = 8.10^{6}$ m/s

$B = 0.025$ T

$\Theta = 60^{\circ}$

$F_B = |q| v B \sin\Theta$

$= (1.6 \times 10^{-19})(8 \times 10^{6})(0.025) \sin 60$

$= 2.8 \times 10^{-4}$ N

Motion of a charged particle in a uniform magnitue field

$\vec{B}$ = Const (uniform)

$\vec{v} \perp \vec{B}$

It is clear that

1. The path followed by the particle is Circular.

2. The magnetic force ($\vec{F_B}$) is toword the center of the circle.

3. $\vec{F_B}$ Causes Centriepital acceleration ($a_c = \frac{v^2}{r}$)

4. $\vec{F_B}$ changes the direction of $\vec{v}$ only

$\Rightarrow$ $\vec{F_B}$ does not change the magnetude of $\vec{v}$

$\Rightarrow$ F_B does not change the kinetic energy.

$\Rightarrow$ magnetic fore ($\vec{F_B}$) does no work.

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$\vec{v} \perp \vec{B} \Rightarrow \theta = \frac{\pi}{2}$

$F_B = qvB \sin\left(\frac{\pi}{2}\right) = qvB$

$F_B = qvB = ma_c$

$q\cancel{v}B = \frac{m\cancel{v^2}}{r}$

$\boxed{r = \frac{mv}{qB}}$ The radius of the path.

Angular Speed (ω) :

$s = \theta r$

$\frac{ds}{dt} = \frac{d\theta}{dt} r$

$\boxed{v = \omega r}$, ω : angular speed

$\boxed{\omega = \frac{v}{r}}$

$\omega = \frac{v}{r} = \frac{\cancel{v}}{m\cancel{v}/qB} = \frac{qB}{m}$

$\boxed{\omega = \frac{v}{r} = \frac{qB}{m}}$ angular speed.

The period (T) : Time for one revolution

$\boxed{T = \frac{2\pi r}{v} = \frac{2\pi}{\omega} = \frac{2\pi m}{qB}}$ period of the motion.

The Frequency (f) : Number of revolutions in one seconed

$\boxed{f = \frac{1}{T} = \frac{v}{2\pi r} = \frac{\omega}{2\pi} = \frac{qB}{2\pi m}}$

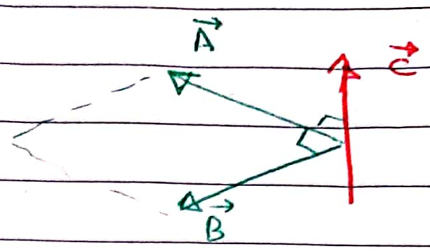
ch-29. magnetic fields.

Cross (vector) product

$\vec{C} = \vec{A} \times \vec{B}$

$|\vec{C}| = |\vec{A}|\,|\vec{B}| \sin\theta$

$C = AB \sin\theta$



Direction of $\vec{C}$ is determined by the right hand rule

$\vec{C} \perp \vec{A}$, and $\vec{C} \perp \vec{B}$

- $\vec{B} \times \vec{A} = -\vec{A} \times \vec{B}$ (not commutative)
- $\vec{A} \times (\vec{B} + \vec{C}) = \vec{A} \times \vec{B} + \vec{A} \times \vec{C}$
- $\dfrac{d}{dt}(\vec{A} \times \vec{B}) = \dfrac{d\vec{A}}{dt} \times \vec{B} + \vec{A} \times \dfrac{d\vec{B}}{dt}$

If $\theta = 0$ ($\longrightarrow \vec{A}$, $\longrightarrow B$) or π ($\longrightarrow \vec{A}$, $\longleftarrow B$) then

$\vec{A} \times \vec{B} = 0 \quad (\theta = 0, \pi)$

$\Rightarrow \vec{A} \times \vec{A} = 0$

If $\theta = \dfrac{\pi}{2}$ (B ↑, → A) $\Rightarrow |\vec{A} \times \vec{B}| = AB$

unit vectors

$|\hat{i}| = |\hat{j}| = |\hat{k}| = 1$

$\hat{i} \times \hat{i} = \hat{j} \times \hat{j} = \hat{k} \times \hat{k} = 0$

$|\hat{i} \times \hat{j}| = (1)(1) \sin\dfrac{\pi}{2} = 1$

$\hat{i} \times \hat{j} = k$

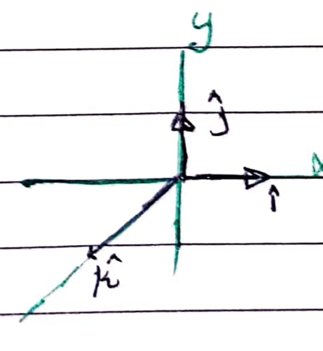
$\hat{j} \times \hat{k} = \hat{i}$

$\hat{k} \times \hat{i} = \hat{j}$

$\hat{j} \times \hat{i} = -\hat{k}$

$\hat{k} \times \hat{j} = -\hat{i}$

$\hat{i} \times \hat{k} = -\hat{j}$



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In terms of unit vectors

$$\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k}$$

$$\vec{B} = B_x\hat{i} + B_y\hat{j} + B_z\hat{k}$$

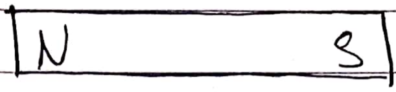
$$\vec{A} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

$$= (A_y B_z - A_z B_y)\hat{i} - (A_x B_z - A_z B_x)\hat{j} + (A_x B_y - A_y B_x)\hat{k}$$

ch - 29 - magnitude field

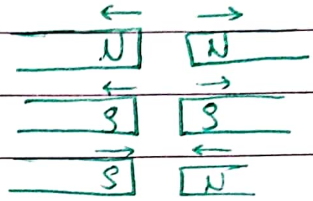
* Every magnet, regard less of its shape, has two poles

1) North pole (N)
2) South pole (S)



• magnetic poles exerts forces on one another

- Like poles repel each other
- unLike poles attract each other.



* If a bar magnt is suspended as it can move Freely, it will rotate such that the north pole points tward the north geographic pole.

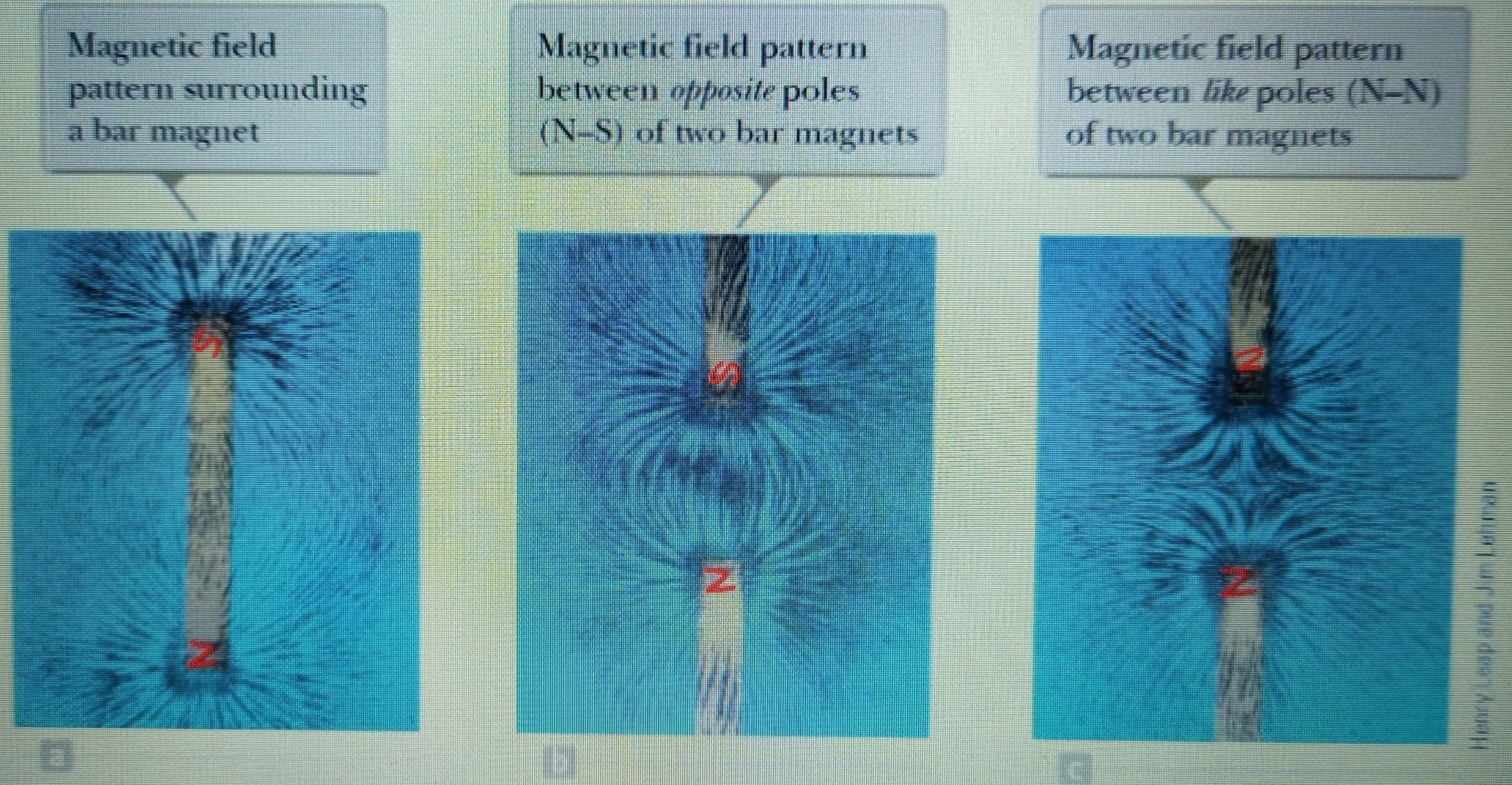
• magnetic poles are always found in pairs (N S)

* The region of space surrounding a moving charge (current) Containes a magnetic field.

* Region of space surrounding magnetic materials (make up permaent magnetic) Contains ~~mg~~ magnetic field

$\vec{B} \equiv$ magnetic field.

Magnetic field lines



Properties of field lines.

1. The lines outside the magnet point from the north pole (N) to the south pole (S)

2. The magnetic field ($\vec{B}$) is tangent to the field lines.

3. Number of field lines perunit (intasity of lines) is proportional to the magnetude of the field, $|\vec{B}|$.

4. The field lines form closed loops.

SI unit of $\vec{B}$ is Tesla (T)

$1\,T = 1\,wb/m^2 = 1\,N/A.s$

The cgs unit of $\vec{B}$ is Gause (G)

$1\,G = 10^{-4}\,T$

Magnetic force on a moving charge.

$\vec{F_B} \equiv$ magnet force.

It was found

- $F_B \propto q$
- $F_B \propto v$, ($F_B = 0$ if $v = 0$)
- $F_B \propto B$
- $F_B \propto \sin\theta$ (If $\theta = 0$ or π then $F_B = 0$)

  $\vec{F_B} \perp \vec{v}$, $\vec{F_B} \perp \vec{B}$

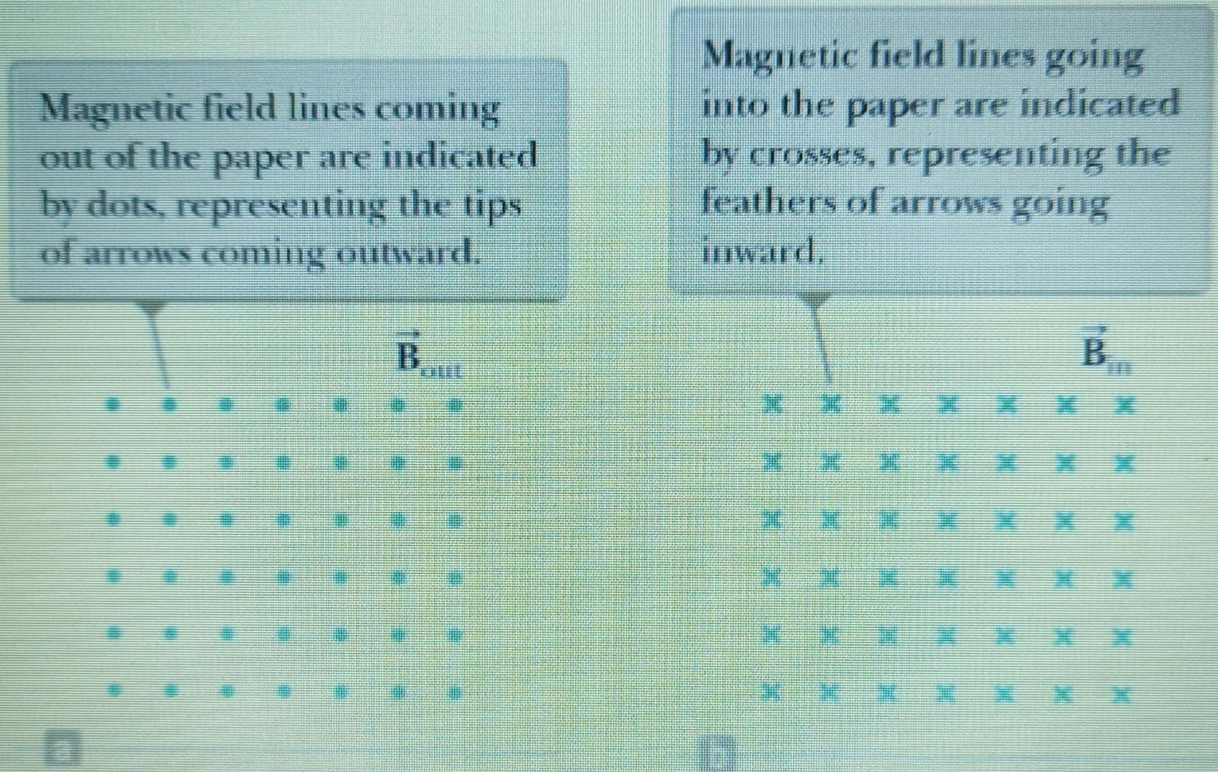
The properties are summeried in

$$\vec{F_B} = q\vec{v} \times \vec{B}$$
$$F_B = q v B \sin\theta$$

- The magnetic force on a negative charge is opposite to the magnetic force on a positive charge.

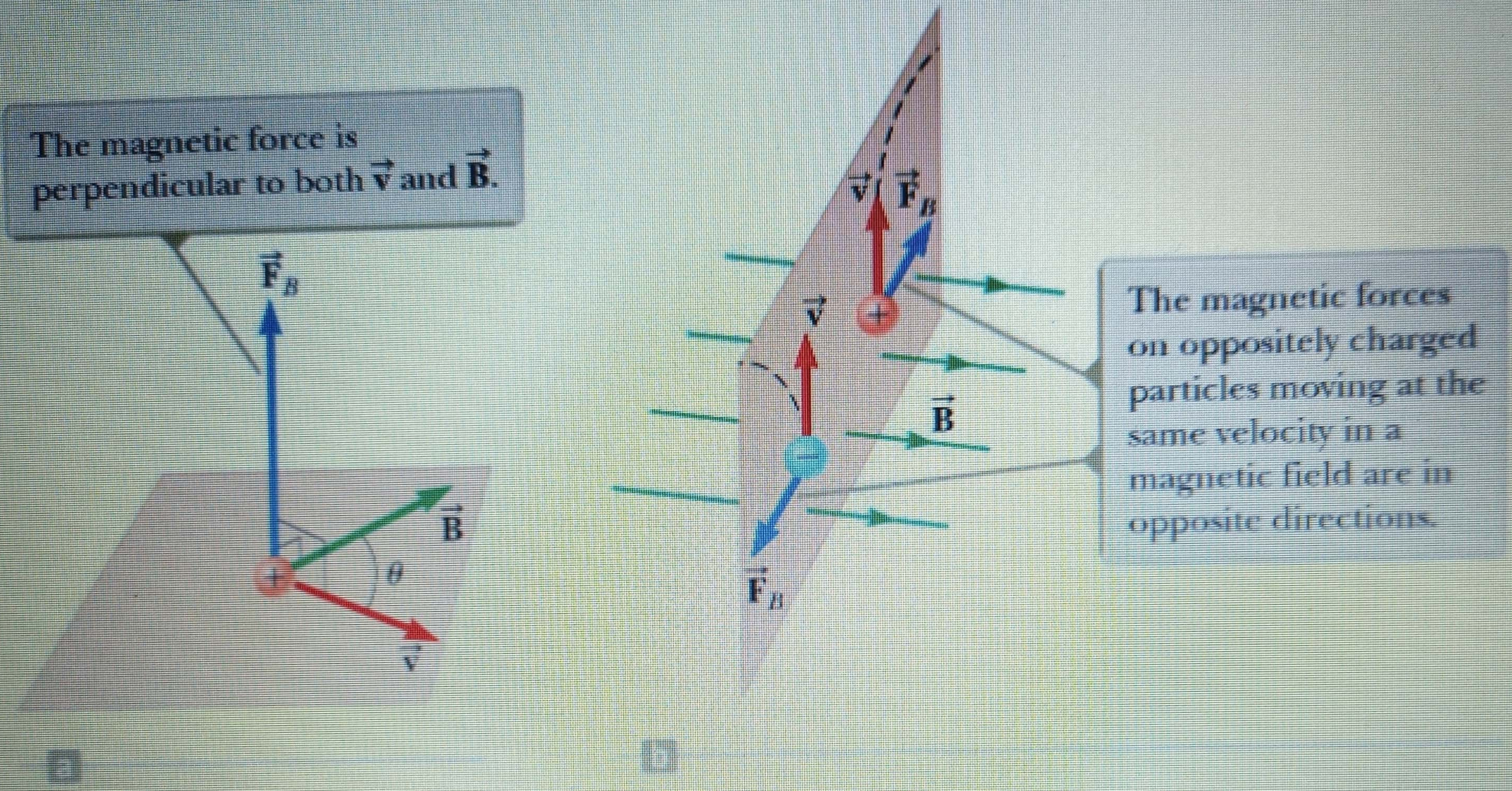
$$\vec{F_B} = q\vec{v} \times \vec{B}$$

Convention

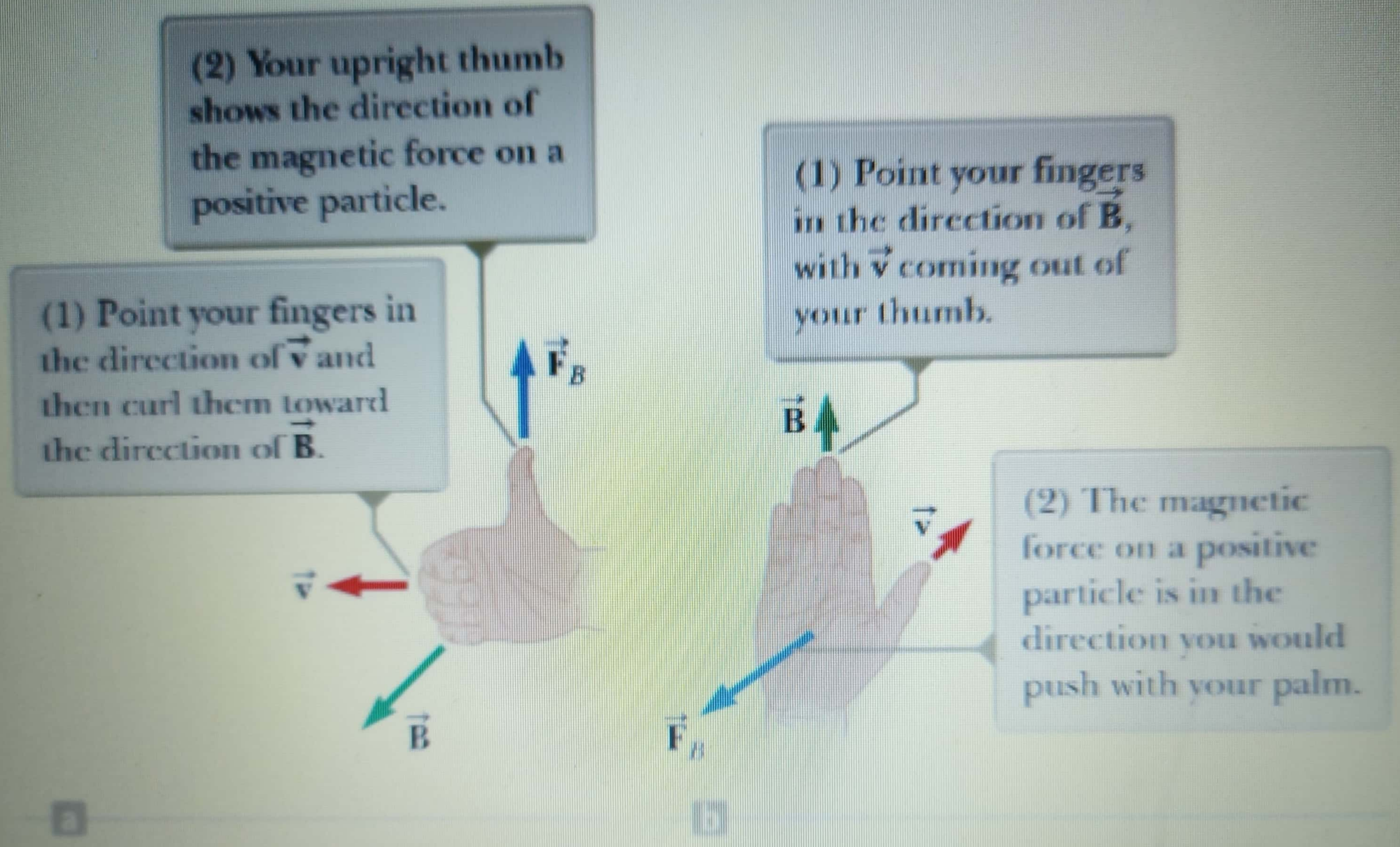


B_{out} (out of the page)

(B_{in} into the page)



The magnetic force is perpendicular to both $\vec{v}$ and $\vec{B}$.
$\vec{F}_B$
$\vec{B}$
θ
$\vec{v}$
a
$\vec{v}$
$\vec{F}_B$
$\vec{v}$
$\vec{B}$
$\vec{F}_B$
The magnetic forces on oppositely charged particles moving at the same velocity in a magnetic field are in opposite directions.
b

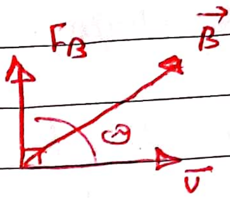


(2) Your upright thumb shows the direction of the magnetic force on a positive particle.
(1) Point your fingers in the direction of $\vec{v}$ and then curl them toward the direction of $\vec{B}$.
$\vec{F}_B$
$\vec{v}$
$\vec{B}$
(1) Point your fingers in the direction of $\vec{B}$, with $\vec{v}$ coming out of your thumb.
$\vec{B}$
$\vec{v}$
(2) The magnetic force on a positive particle is in the direction you would push with your palm.
$\vec{F}_B$
a
b

The magnetic force on a moving charge q is

$$\vec{F_B} = q\vec{v} \times \vec{B}$$

$$F_B = qvB\sin\theta$$



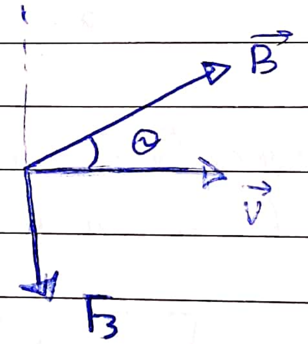
EX .29.1 ⇒ An electron in an old-style television picture tube moves toward the front of the tube with a speed of 8.0×10^6 m/s along the x axis. Surrounding the neck of the tube are coils of wire that creat a magnetic field of magnitude 0.025 T. directed at an angle of 60° ~~to~~ to the x-axis and lying in xy plan calculate the magnetic force on the electron

$q = -e = -1.6 \times 10^{-19}$ C

$v = 8 \times 10^6$ m/s

$B = 0.025$ T

$\theta = 60°$



$$F_B = |q| v B \sin\theta$$

$$= (1.6 \times 10^{-19})(8 \times 10^6)(0.025)\sin 60$$

$$= 2.8 \times 10^{-4} \text{ N}$$

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Motion of a charged particle in a uniform magnetic field

$\vec{B} = \text{const}$ (uniform)

$\vec{v} \perp \vec{B}$

It is clear that:

1. The path followed by the particle is circular

2. The magnetic force $(\vec{F}_B)$ is toward the center of the circle

3. $\vec{F}_B$ Causes Centrieited acceleration $\left(a_c = \frac{v^2}{r}\right)$

4. $\vec{F}_B$ changes the direction of $\vec{v}$ only.

$\Rightarrow \vec{F}_B$ does not change the magnetude of $\vec{v}$

$\Rightarrow \vec{F}_B$ does not change the kinetic energy

$\Rightarrow$ magnetic force $(\vec{F}_B)$ does no work.

$\vec{v} \perp \vec{B} \Rightarrow \theta = \frac{\pi}{2}$

$F_B = qvB \sin\left(\frac{\pi}{2}\right) = qvB$

$F_B = qvB = ma_c$

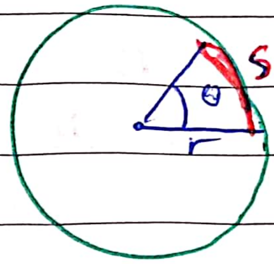
$q\cancel{v}B = m\frac{v^{\cancel{2}}}{r}$

$\boxed{r = \frac{mv}{qB}}$ The radius of the path.

Angular speed (ω)

$$S = \theta r$$

$$\frac{ds}{dt} = \frac{d\theta}{dt} r$$



$\boxed{v = \omega r}$; ω : angular speed

$$\boxed{\omega = \frac{v}{r}}$$

$$\omega = \frac{v}{r} = \frac{\cancel{v}}{m\cancel{v}/qB} = \frac{qB}{m}$$

$\boxed{\omega = \frac{v}{r} = \frac{qB}{m}}$ angular speed.

* The period (T) : Time for one revolution

$$v = \frac{2\pi r}{T}$$

$\boxed{T = \frac{2\pi r}{v} = \frac{2\pi}{\omega} = \frac{2\pi m}{qB}}$ period of the motion.

The Frequency (F) :- number of revolutions in one second.

$\boxed{F = \frac{1}{T} = \frac{v}{2\pi r} = \frac{\omega}{2\pi} = \frac{qB}{2\pi m}}$ Frequency ($Hz \equiv s^{-1}$)

Ex 29.2 A proton is moving in a circular orbit of radius 14 cm in a uniform 0.35 T magnetic field perpendicular to the velocity of the proton. Find the speed of the proton.

proton : $q = 1.6 \times 10^{-19}$ C, $m = 1.67 \times 10^{-27}$ Kg.

$r = 14$ cm $= 0.14$ m

$B = 0.35$ T (uniform)

$\vec{v} \perp \vec{B}$ $(\theta = \pi/2)$

Speed : $F_B = ma_c$

$$q\cancel{v}B = \frac{m v^{\cancel{2}}}{r}$$

$$v = \frac{qBr}{m} = 4.7 \times 10^{6} \text{ m/s}$$

Find the angular speed

$\omega = \frac{v}{r} = 3.36 \times 10^{7}$ rad/s. or

$\omega = \frac{qB}{m} = 3.36 \times 10^{7}$ rad/s

Find the perival of the motion

$T = \frac{2\pi r}{v} = 1.9 \times 10^{-7}$ s. or

$T = \frac{2\pi}{\omega} = 1.9 \times 10^{-7}$ s. or

$T = \frac{2\pi m}{qB} = 1.9 \times 10^{-7}$ s.

EX. 29.3

electron : $q = -1.6 \times 10^{-19}$ C.

$m = 9.11 \times 10^{-31}$ Kg.

$v_i = 0$, $v_f = v$

$\Delta V = 350$ V

$r = 7.5$ cm $= 0.075$ m.

A) $\Delta K + \Delta U = 0$

$$\left(\frac{1}{2}mv^2 - \frac{1}{2}mv_i^2\right) + q\Delta V = 0.$$

$$v = \sqrt{\frac{-2q\,\Delta V}{m}} = 1.11 \times 10^{7} \text{ m/s}.$$

$$F_B = ma_c$$

$$qvB = \frac{mv^2}{r}$$

$$B = \frac{mv}{qr} = 8.4 \times 10^{-4} \text{ T}$$

B) $\omega = \frac{v}{r} = 1.5 \times 10^{5}$ rad/s.

or $\omega = \frac{qB}{m} = 1.5 \times 10^{5}$ rad/s

Calculate the period (T)

$$T = \frac{2\pi}{\omega} = 4.18 \times 10^{-5} \text{ s}.$$

or

$$T = \frac{2\pi r}{v} = 4.18 \times 10^{-5} \text{ s}$$

or

$$T = \frac{2\pi m}{qB} = 4.18 \times 10^{-5} \text{ s}$$

Magnetic force on a current carrying conductor

- A magnetic force is exerted on a current carrying conductor when placed in a magnetic field.
- Direction of the magnetic force is determined by the right-hand-rule.
- The magnetic force on a single charge moving in the wire with the drift speed, v_d, in a magnetic $\vec{B}$ is

$$\vec{F}_{\text{single-charge}} = q\vec{v}_d \times \vec{B}$$

The total force is

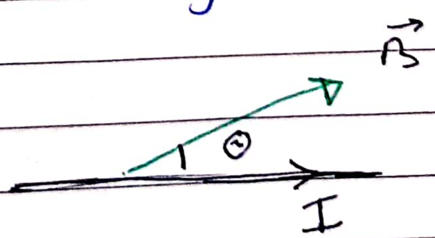
$$\vec{F}_B = (\vec{F}_{\text{single-charge}})(\text{number of charges})$$
$$= (q\vec{v}_d \times \vec{B})(nAL)$$

$$\vec{F}_B = [\underbrace{(nq\vec{v}_d A)}_{I} L] \times \vec{B}$$

$$\vec{F}_B = (\vec{I}L) \times \vec{B}$$

$\boxed{\vec{F}_B = I\vec{L} \times \vec{B}}$ The force on the straight wire.

$$\boxed{|\vec{F}_B| = ILB\sin\theta}$$

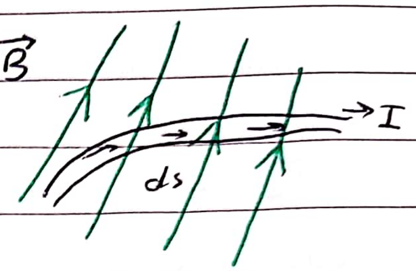


For an irregular shaped wire we consider a ~~s~~ segment $\vec{ds}$

$$d\vec{F}_B = I\,d\vec{s} \times \vec{B} \equiv \text{Force on segment } \vec{ds}$$

The total force is the sum over all segment.

$$\boxed{\vec{F}_B = I\int d\vec{s} \times \vec{B}}$$



Ex. 29.4 The Force on the straigh motion

$$\vec{F}_1 = I\vec{L} \times \vec{B}$$

$L = 2R$, $\theta = \frac{\pi}{2}$

F_B is out the page $(+\hat{k})$

$$F_1 = ILB\sin\theta\,\hat{k}$$
$$= I(2R)B\sin\frac{\pi}{2}\,\hat{k}$$

$$\boxed{F_1 = 2IRB\,\hat{k}}$$

The Force on the Current protion

$$\vec{F}_2 = I\int d\vec{s} \times \vec{B}$$

$$d\vec{s} \times \vec{B} = (ds)\,B\sin\theta\,(-\hat{k}) = -B(ds)\sin\theta\,\hat{k}$$

$$= -I\int B(ds)\sin\theta\,\hat{k}$$

$ds = R\,d\theta$

$$= -I\int_0^{\pi} B(R\,d\theta)\sin\theta\,\hat{k}$$

$$= -IRB\underbrace{\int_0^{\pi}\sin\theta\,d\theta}_{=2}\,\hat{k}$$

$$\boxed{F_2 = -2IRB\,\hat{k}}$$

The force on the current poation.

we have

$$\vec{F_1} = 2IRB \ \hat{k}$$
$$\vec{F_2} = -2IRB \ \hat{k}$$

Two Conclusions

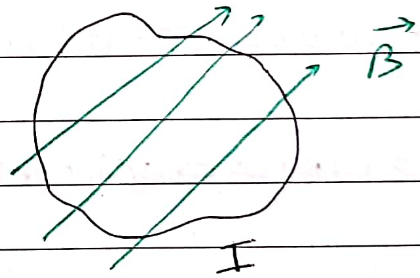
$$\vec{F_1} = -\vec{F_2} \Rightarrow \vec{F_1} + \vec{F_2} = 0.$$

[Conclusion]

The force on the curved portion is equal in magnetude and oppostim direction to the force on the straight portion.

The magnetic force on a closed current loop in a uniform magnetic field is zero.

$$\boxed{\sum F = 0}$$



$$\vec{F_1} + \vec{F_2} = 0$$

$$F_1 = -\vec{F_2} = -I\vec{l} \times \vec{B}$$

In general the force on the curved portion in a uniform magnetic field is equal to that on the straight porotion.

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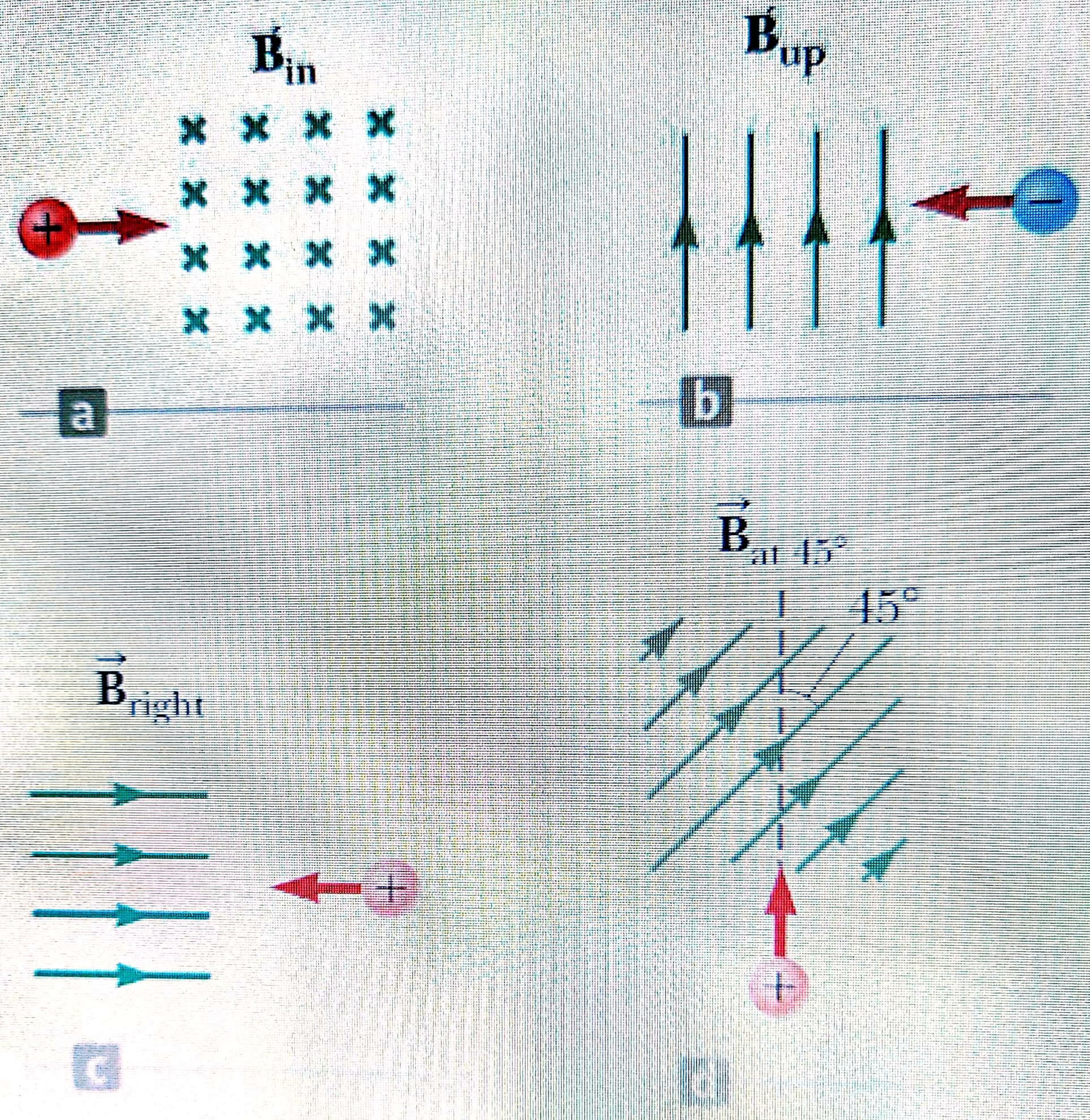
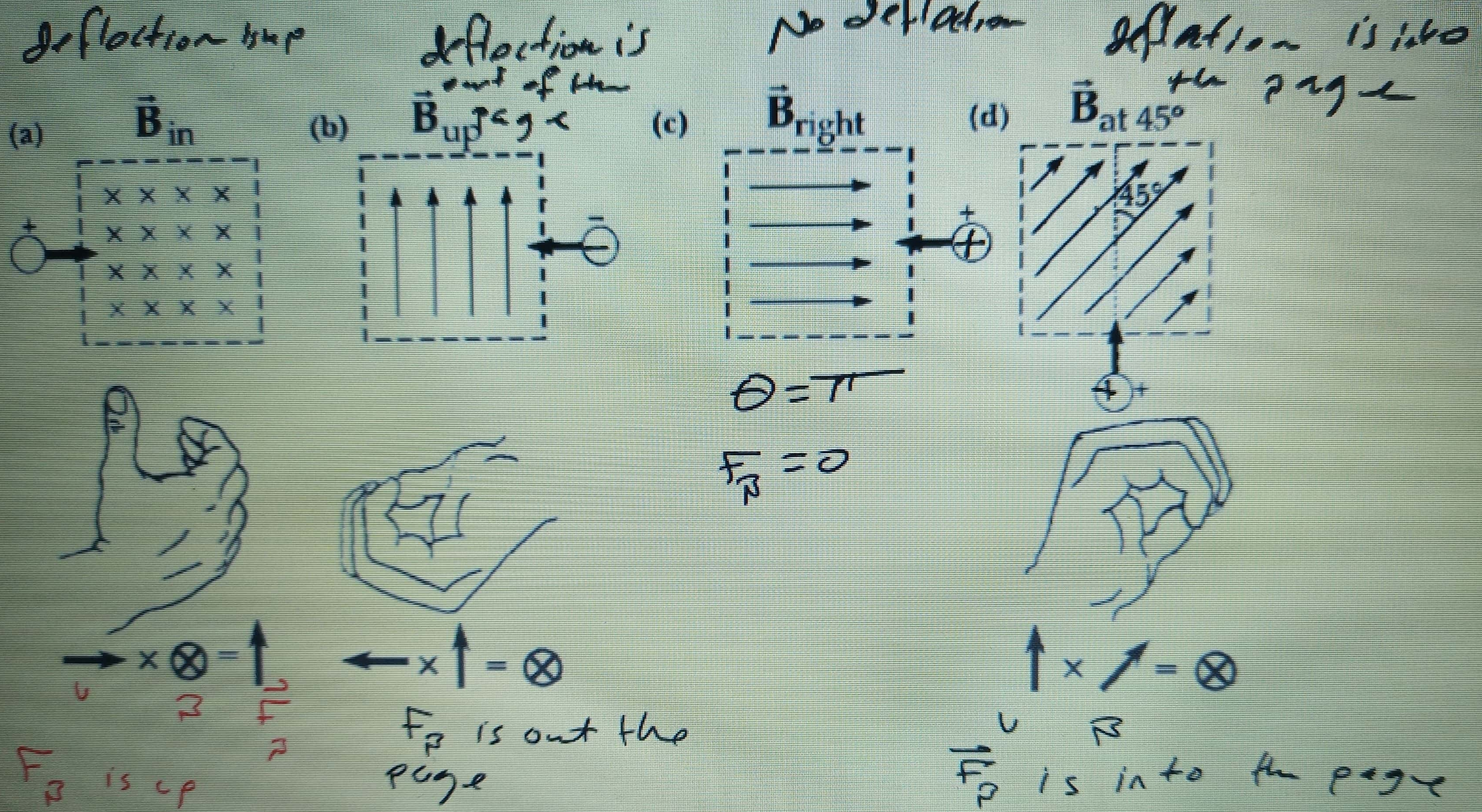
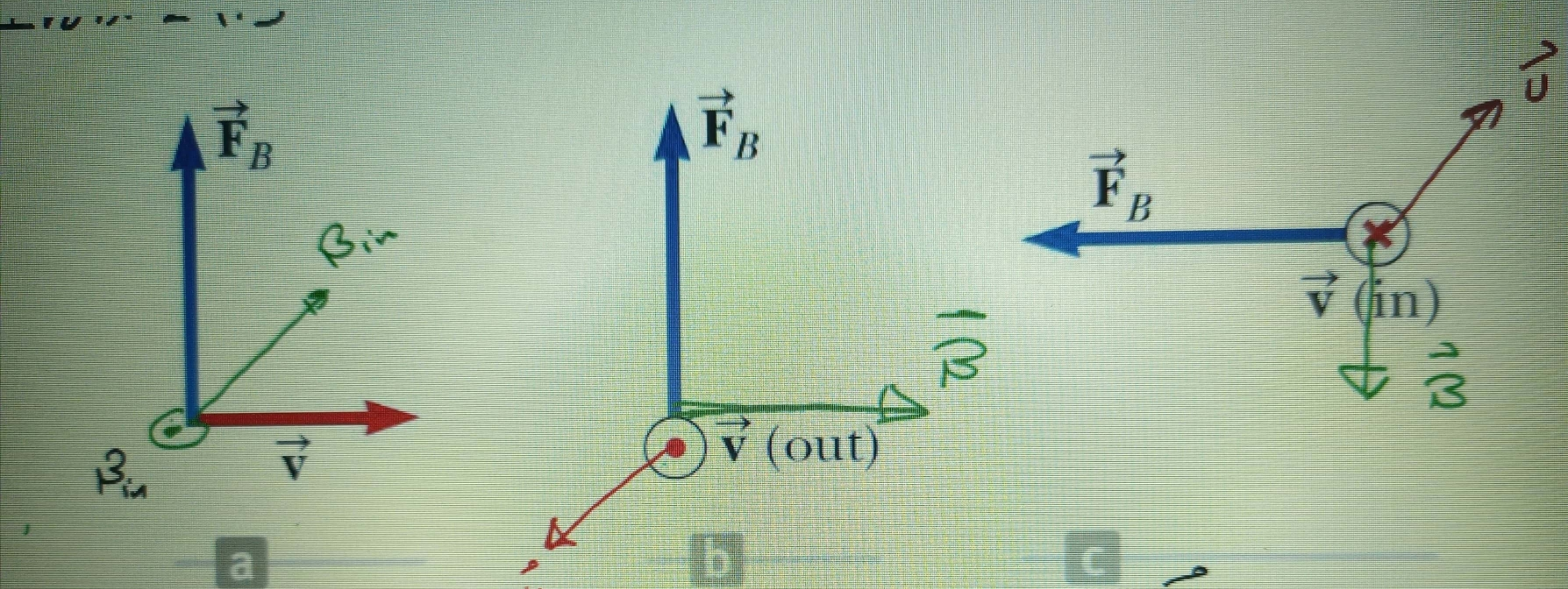
Prob. 29.2




deflection is up
(a) $\vec{B}_{in}$
deflection is out of the page
(b) $\vec{B}_{up}$
No deflation
(c) $\vec{B}_{right}$
$\theta = \pi$
$F_B = 0$
deflation is into the page
(d) $\vec{B}_{at\ 45°}$
45°
v
B
$\vec{F}_B$
F_B is up
F_B is out the page
v
B
$\vec{F}_B$ is into the page



$\vec{B}$ is into the page

$\vec{B}$ is to the right

$\vec{B}$ is to the bottom

Prob. 29.3

Prob. 29.8 ⇒ A proton moves with a velocity of $\vec{v} = (2\hat{i} - 4\hat{j} + \hat{k})$ m/s in a region in which the magnitude field is $\vec{B} = (\hat{i} + 2\hat{j} - \hat{k})$ T. What is the magnitude of the magnetic force this particle experience?

proton : $q = 1.6 \times 10^{-19}$, $m = 1.67 \times 10^{-27}$ Kg.

$\vec{v} = (2\hat{i} - 4\hat{j} + \hat{k})$ m/s.

$\vec{B} = (\hat{i} + 2\hat{j} - \hat{k})$ T

$$\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & -4 & 1 \\ 1 & 2 & -1 \end{vmatrix}$$

$\vec{F_B} = q\vec{v} \times \vec{B} = (1.6 \times 10^{-19})$

$\vec{F_B} = (1.6 \times 10^{-19}) \left[(4-2)\hat{i} - (-2-1)\hat{j} + (4--4)\hat{k} \right]$.

$\vec{F_B} = (3.2\,\hat{i} + 4.8\,\hat{j} + 12.8\,\hat{k}) \times 10^{-19}$ N

$|\vec{F_B}| = \sqrt{3.2^2 + 4.8^2 + 12.8^2} \times 10^{-19}$ N

$= 13.2 \times 10^{-19}$ N.

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prob. 29.13 An electron moves in a circular path perpendicular to a uniform magnetic field with a magnitude of 2.00 mT. If the speed of the electron is 1.50×10^{7} m/s determine (a) the radius of the circular path (b) the time interval required to complete one revolution.

$q = -e = -1.6 \times 10^{-19}$, $m = 9.11 \times 10^{-31}$ kg.

$B = 2mT = 2 \times 10^{-3}$ T

$v = 1.5 \times 10^{7}$

$\vec{v} \perp B$

A) $qvB = \frac{mv^2}{r} \Rightarrow r = \frac{mv}{qB} = 0.0427 \text{ m} = 4.27 \text{ cm}$

B) $T = \frac{2\pi r}{v} = 1.79 \times 10^{-8}$ s

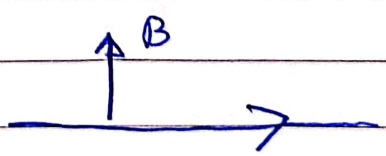
$T = \frac{2\pi m}{qB} = 1.79 \times 10^{-8}$ s.

prob. 29.32

$I = 3A$, $B = 0.28\,T$, $\theta = \frac{\pi}{2}$

A) $L = 14$ cm $= 0.14$ m.

$F_B = ILB \sin\theta$
$= 0.118$ N



chapter 30 - Sources of magnetic field.

There are two sources of magnetic field :
1) Electric Currents (moving charges)

2) magnetic materials.

* Biot and Savart conducted experiments to measure the magnetic fields and magnetic forces due to a current I.

The results are :-
The magnetic $d\vec{B}$ at point P due to a current I in the length segment $d\vec{s}$ is.

1) $d\vec{B} \perp d\vec{s}$

2) $d\vec{B} \perp \hat{r}$; ($\hat{r}$ is unit vector that points from $d\vec{s}$ to the point P)

3) $dB \propto \frac{1}{r^2}$; (r : r is the distance from $d\vec{s}$ to P)

4) $dB \propto I$

5) $dB \propto |d\vec{s}| = ds$

6) $dB \propto \sin\theta$, (θ : the angle between $d\vec{s}$ and $\hat{r}$)

The results can be summerized in the Biot - Sawart law.

$$\left[d\vec{B} = \frac{\mu_0 I}{4\pi} \frac{d\vec{s} \times \hat{r}}{r^2} \right]$$

$\mu_0 = 4\pi \times 10^{-7}$ T.m/A

μ_0 = magnetic permeability of free space.

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The total magnetic field can be found by summing up the contributions from all current elements(integral)

$$\left[\vec{B} = \frac{\mu_0 I}{4\pi} \int \frac{d\vec{s} \times \hat{r}}{r^2} \right]$$ Biot, Savart law

EX. 30. 2

$$\vec{B} = \frac{\mu_0 I}{4\pi} \int \frac{d\vec{s} \times \hat{r}}{r^2}$$

The magnetic fields due to the sections A A` and CC` is zero because.

$$d\vec{s} \times \hat{r} = 0$$

The sections A A` and CC` do not contribute to the magnetic field at O

The field at O is due to the section AC only

$$\Theta = \frac{\pi}{2}$$

$$|d\vec{s} \times \hat{r}| = |d\vec{s}| \underbrace{|\hat{r}|}_{=1} \underbrace{\sin\left(\frac{\pi}{2}\right)}_{=1} = ds$$

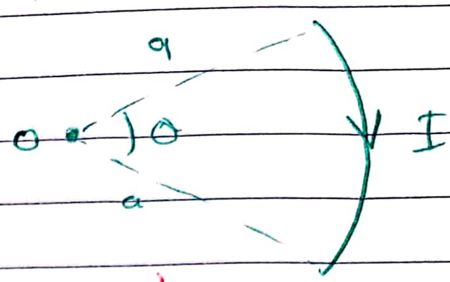
$r = a$

$$B = \frac{\mu_0 I}{4\pi} \int \frac{|d\vec{s} \times \hat{r}|}{r^2} = \frac{\mu_0 I}{4\pi} \int \frac{ds}{a^2} = \frac{\mu_0 I}{4\pi a^2} \underbrace{\int ds}_{= s = a\Theta}$$

$$B = \frac{\mu_0 I}{4\pi a^2} (a\,\Theta)$$

$$\boxed{B = \frac{\mu_0 I}{4\pi a} \Theta}$$

$$\boxed{B_o = \frac{\mu_o I}{4\pi a}\theta}$$

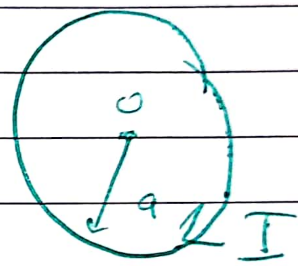


Special case :-

If $\theta = 2\pi$ (closed circular loop)

$$\boxed{B = \frac{\mu_o I}{2a}}$$

Magnetic field at the center of a closed circular current loop of radius a



$$\boxed{B_x = \frac{\mu_o I a^2}{2(x^2+a^2)^{\frac{3}{2}}}}$$

Special case. 1

If $x=0$

$$B = \frac{\mu_o I a^2}{2(0+a^2)^{\frac{3}{2}}} = \frac{\mu_o I}{2a}$$

$$\boxed{B = \frac{\mu_o I}{2a}}$$

Magnetic field at the center of a closed circular loop of current

EX - 30.6

take loop 2

$$\oint \vec{B}_{out} \cdot \vec{ds} = \mu_0 I_{in} = 0$$

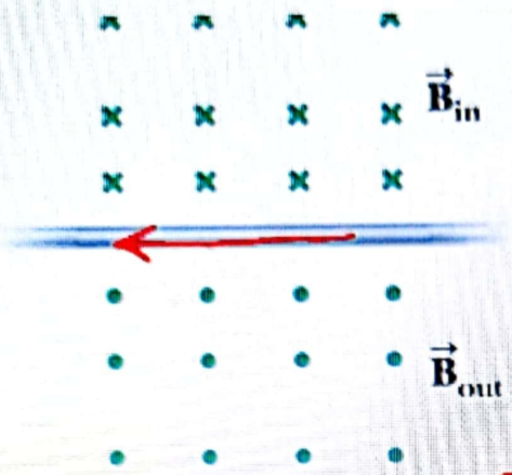
$\boxed{B_{out} = 0}$, $r < b$, $r > c$

Take loop 1 $(b < r < c)$

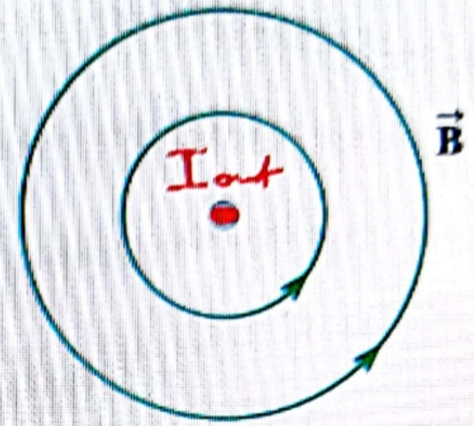
$$\oint \vec{B_{in}} \cdot \vec{ds} = \mu_0 I_{in}$$

$$B_{in}(2\pi r) = \mu_0 N I$$

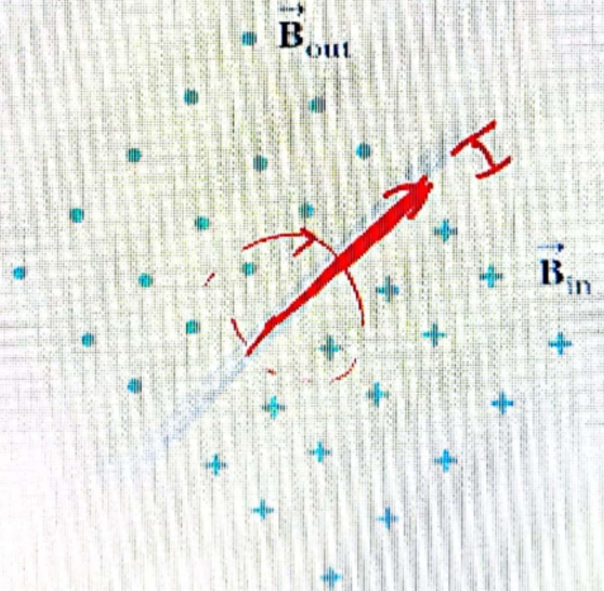
$\boxed{B_{in} = \frac{\mu_0 N I}{2\pi r}}$, $b < r < c$



a I to the left



b I is out of the page



I is up and right

Prob. 2

prob. 19

$I = 5A$, $d = 10$ cm $= 0.1$ m

a) At the point midway between the two wires

$B_1 = \frac{\mu_0 I}{2\pi(\frac{d}{2})}$ (into the page)

$B_2 = \frac{\mu_0 I}{2\pi(\frac{d}{2})}$ (into the page)

$B = B_1 + B_2 = \frac{\mu_0 I}{2\pi \frac{d}{2}} + \frac{\mu_0 I}{2\pi \frac{d}{2}} = \frac{2\mu_0 I}{\pi d} = 40 \times 10^{-6}$ T (into the page)

$= (-40 \times 10^{-6} \hat{k})$ T

b) at point P_1

$B_1 = \frac{\mu_0 I}{2\pi d}$ (out of the page)

$B_2 = \frac{\mu_0 I}{2\pi(2d)}$ (into the page)

$B_{P_1} = (B_1 - B_2)\hat{k} = \frac{\mu_0 I}{2\pi d}\left(1 - \frac{1}{2}\right)\hat{k}$

$B_{P_1} = (5 \times 10^{-6} \hat{k})$ T

$= 5 \times 10^{-6}$ T (out of the page)

c) At point P_2

$$B_1 = \frac{\mu_0 I}{2\pi(3d)} \quad \text{(into the page)}$$

$$B_2 = \frac{\mu_0 I}{2\pi(2d)} \quad \text{(out of the page)}$$

$$\vec{B}_{P_2} = \vec{B}_2 - \vec{B}_1$$

$$= \frac{\mu_0 I}{2\pi d}\left(\frac{1}{2} - \frac{1}{3}\right)\hat{k}$$

$$= (1.67 \times 10^{-6}\,\hat{k})\ T$$

$$= 1.67 \times 10^{-6}\ T \text{ (out of the page)}$$

prob. 31

$I_1 = 1A$, $I_2 = 3A$

$d = 1mm = 0.001\ m$

A) B at a (take loop 1)

$$\oint \vec{B_a} \cdot \vec{ds} = \mu_0 I_{in}$$

$$B_a (2\pi d) = \mu_0 I_1$$

$$B_a = \frac{\mu_0 I_1}{2\pi d} = 200 \times 10^{-6}\ T \text{ (counter clock wise)}$$

B) B at b (take loop 2)

$$\oint \vec{B_b} \cdot \vec{ds} = \mu_0 I_{in}$$

$$B_b (2\pi (3d)) = \mu_0 (I_1 - I_2)$$

$$B_b = \frac{\mu_0 (I_1 - I_2)}{6\pi d}$$

$$B = -133 \times 10^{-6}\ T$$

(-) = clock wise.

#

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