chapter 29

Magnetic Fields

29.1 particle in a magnetic Field
29.2 Motion of charged particle in a Uniform Magnetic Field.
29.3 Applications Involving charged particles Moving in a Magnetic Field
29.4 Magnetic Force Acting on a Current - carrying Conductor
29.5 Tourque on a Current Loop in a Uniform Magnetic Field
29.6 The Hall Effect.

Magnetism المغناطيسية

Recall : تذكر
electric (Coulomb) force between electric charges

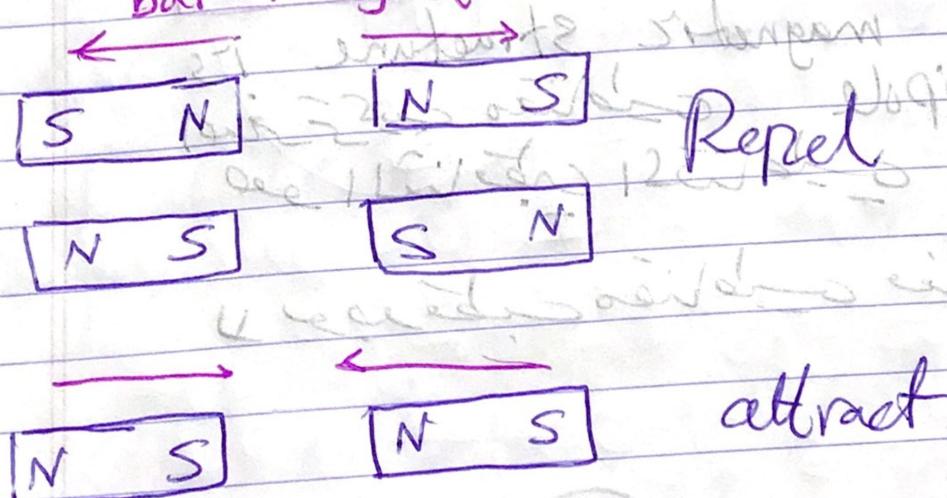
(+q , +q) Repel like charges
(+q , −q) attract . opposite charges

* In this chapter we have two kinds of magnetic poles (north ; N) and (south ; S)

Like poles repel الاقطاب المتشابهة تتنافر
(N , N) , (S , S)

opposite poles attract الاقطاب المختلفة تتجاذب
(N , S)

bar magnet



Important difference between Electricity and Magnetisim

— isolated + or − electric charges exist.

— isolated N and S poles are not exist.

(−) (+) exist

(N) (S) not exist

<u>Note</u>

Every magnet has both N and S pole. [N S]

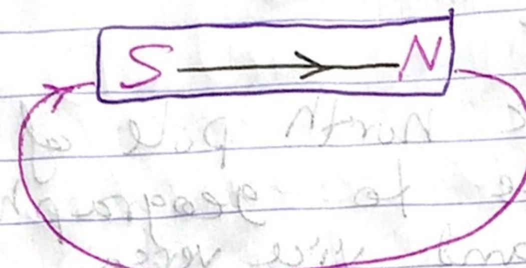
Basic magnetic structure is a dipole اصغر تركيب مغناطيسي

[N S] هو الثنائي المغناطيسي

لا يوجد قطب مغناطيسي مفرد

Magnetic Fields

Magnetic dipoles create magnetic Fields ينشأ المجال المغ من الثناقطبي



Magnetic Field Lines

outside starts from N ⟶ S

inside from S ⟶ N

Symbol for magnetic field $\vec{B}$

$\vec{B}$: vector quantity

SI unit for magnetic field is

T (Tesla)

$$1\,T = 1\,\frac{Kg}{C.S}$$

Gauss (G)

$$1\,G = 10^{-4}\,T$$

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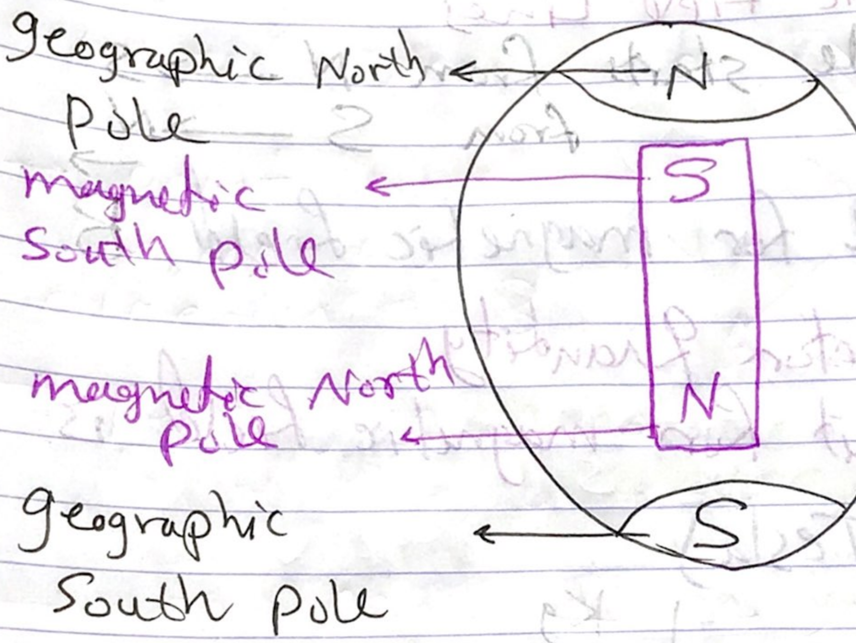
(B_e) Earth Magnetic Field

المجال المغناطيسي الارضي

Earth has magnetic field with poles near the geographic poles

Magnetic north pole of earth is close to geographic south pole and vice versa



$$B_e \simeq 0.5\ G \text{ or}$$

$$B_e \simeq 5 \times 10^{-5}\ T$$

in Headphones $B \simeq 0.1\ T$

Superconducting magnets $B = 10\ T$

ix (Magnetic Force on Moving charged particles)

القوة المغناطيسية المؤثرة على شحنة كهربائية متحركة في مجال مغناطيسي

Magnetic Force $\vec{F_B}$

→ F_B : The magnetic force is directly proportional the charge q of the particle

→ F_B on negative charge is opposite to F_B on positive charge

→ F_B is proportional to B

→ F_B is " to the speed (v)

→ F_B is " to angle θ between B, v

→ when q is moving parallel to B → $F_B = 0$

→ when $(0 < \theta < 180)$ → $F_B \perp$ on B, V

→ $F_B = q\, v B \sin\theta$ or

$$\vec{F_B} = q\, \vec{v} \times \vec{B}$$

$F_B = q\,VB\sin\theta$

F_B: magnetic Force (N)

q: charge (C)

V: speed (m/s)

B: magnetic Field (T)

θ: angle between (B, V)

right hand Rule (+ve charge) to find Direction of F_B

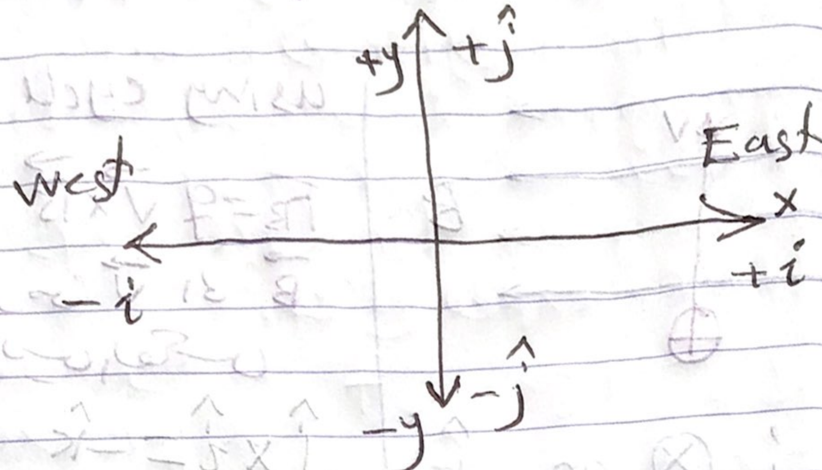
→ point your fingers the direction of B

→ point your thumb to the direction of V

→ F_B points ⊥ on your hand

For negative charge use your left hand Rule.

vector notation conventions
نظام المحاور والاتجاهات

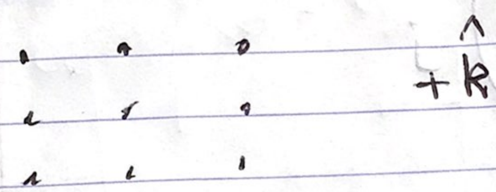


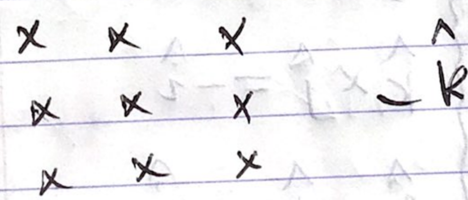
⊙ : $\hat{k}$ vector pointing out of paper

للخارج / مقترب من الناظر

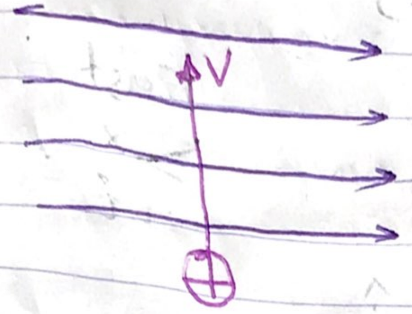
(⊗ : $-\hat{k}$) ; vector pointing into paper

مبتعد عن الناظر





Examples on Directions



F_B : ⊗ or $-\hat{k}$

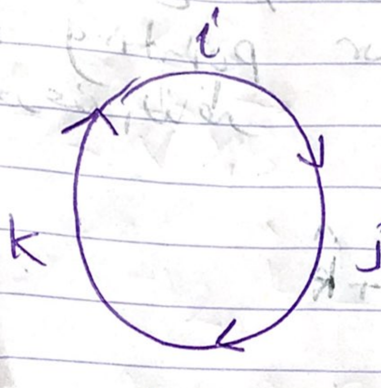
using cycle Rule

$\vec{F_B} = q\, \vec{V} \times \vec{B}$

ندور من $\vec{V}$ الى $\vec{B}$
وليس بالعكس

$\hat{j} \times \hat{i} = -\hat{k}$

cycle Rule



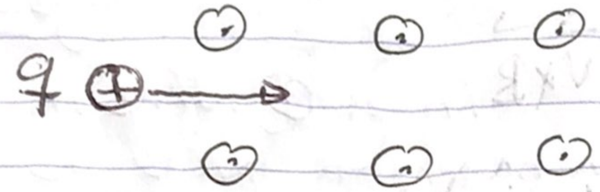
$\hat{i} \times \hat{j} = \hat{k}$ | $\hat{j} \times \hat{i} = -\hat{k}$

$\hat{j} \times \hat{k} = \hat{i}$ | $\hat{k} \times \hat{j} = -\hat{i}$

$\hat{k} \times \hat{i} = \hat{j}$ | $\hat{i} \times \hat{k} = -\hat{j}$

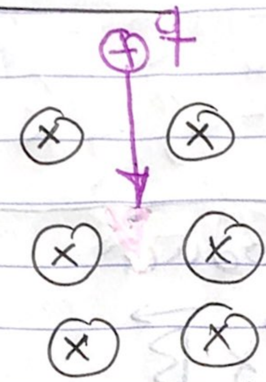
$\hat{i} \times \hat{i} = \hat{j} \times \hat{j} = \hat{k} \times \hat{k} = 0$

Ex 2



Fingers $\hat{k}$
thumb : $\hat{i}$ **or** $\hat{i} \times \hat{k} = -\hat{j}$
F_B : $-\hat{j}$

Ex 3

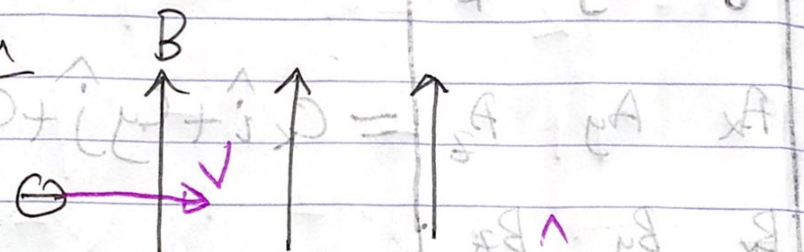


V : $-\hat{j}$
B : $-\hat{k}$

$-\hat{j} \times -\hat{k}$
$= \hat{j} \times \hat{k} = \hat{i}$

Fingers : $-\hat{k}$
thumb : $-\hat{j}$
F_B : $\hat{i}$

Ex 4



$F_B = q\, \vec{V} \times \vec{B}$
$= -(\hat{i} \times \hat{j})$
$= -K$

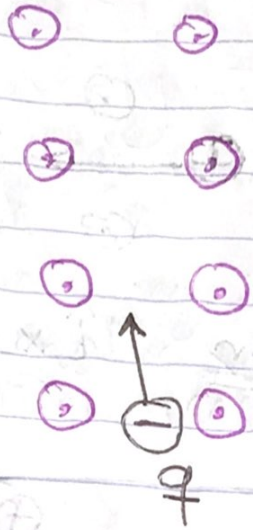
الاصابع $\hat{j}$
الابهام $\hat{i}$
سالب، يسرى
F_B : $-\hat{k}$

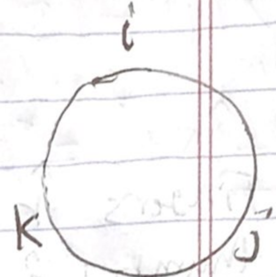
(11)

$$\vec{F}_B = q\,\vec{v} \times \vec{B}$$

$$= -(\hat{j} \times \hat{k})$$

$$= -\hat{i}$$





اليد اليسرى

الاصابع : +k

الابهام +j

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cross product

طريقة المصفوفات

$$\vec{C} = \vec{A} \times \vec{B}$$

$$\vec{F}_B = q\,\vec{v} \times \vec{B}$$

$$\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k}$$

$$\vec{B} = B_x\hat{i} + B_y\hat{j} + B_z\hat{k}$$

$$\vec{C} = \begin{vmatrix} \hat{i} & -\hat{j} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix} = C_x\hat{i} + C_y\hat{j} + C_z\hat{k}$$

$$\vec{C} = \hat{i}(A_yB_z - A_zB_y) \leftarrow C_x$$

$$-\hat{j}(A_xB_z - A_zB_x) \leftarrow C_y$$

$$+\hat{k}(A_xB_y - A_yB_x) \leftarrow C_z$$

problem 6
page 895

A proton moving at 4×10^6 m/s through a magnetic Field of 1.7T experiences a magnetic force of magnitude 8.2×10^{-13} N. What is the angle between the proton's velocity and the field?

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

$B = 1.7$ T

$F_B = 8.2 \times 10^{-13}$ N

$v = 4 \times 10^6$ m/s

$\theta = ??$

$F = qVB\sin\theta$

$8.2 \times 10^{-13} = 1.6 \times 10^{-19} \times 4 \times 10^6 \times 1.7 \times \sin\theta$

$\sin\theta = 0.754$

$\rightarrow \theta = 48.9°$

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Problem 8
895

A proton moves with velocity $\vec{v} = 2\hat{i} - 4\hat{j} + \hat{k}$ m/s in a region in which the magnetic field is $\vec{B} = \hat{i} + 2\hat{j} - \hat{k}$ T. What is the magnitude of the magnetic force this particle experiences?

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

$\vec{v} = 2\hat{i} - 4\hat{j} + \hat{k}$

$\vec{B} = \hat{i} + 2\hat{j} - \hat{k}$

$|\vec{F_B}| = ?$

$\vec{F_B} = q\, \vec{v} \times \vec{B}$

$$\vec{F_B} = 1.6 \times 10^{-19} \begin{vmatrix} \hat{i} & -\hat{j} & +\hat{k} \\ 2 & -4 & 1 \\ 1 & 2 & -1 \end{vmatrix}$$

$$\vec{v} \times \vec{B} = i \begin{vmatrix} -4 & 1 \\ 2 & -1 \end{vmatrix} - j \begin{vmatrix} 2 & 1 \\ 1 & -1 \end{vmatrix} + k \begin{vmatrix} 2 & -4 \\ 1 & 2 \end{vmatrix}$$

$= i(-4 \times -1 - 1 \times 2) - j(2 \times -1 - 1 \times 1) + k(2 \times 2 - -4 \times 1)$

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$= 2\hat{i} + 3\hat{j} + 8K$

$\vec{F_B} = 1.6\times10^{-19} (2\hat{i} + 3\hat{j} + 8\hat{K})$

$|F_B| = 1.6\times10^{-19} \sqrt{(2)^2 + (3)^2 + (8)^2}$

$= 14 \times 10^{-19}\ N$

11/895 A proton moves perpendicular to a uniform magnetic field $\vec{B}$ at speed of 1×10^{7} m/s and experiences acceleration of 2×10^{13} m/s^2 in the positive x direction when it velocity to (+z). Determine magnitude and direction of $\vec{B}$.

$q = 1.6\times10^{-19} C$ $\quad m = 1.67 \times 10^{-27}$ kg

$v = 1\times10^{7}$ m/s $+\hat{K}$

$a = 2\times10^{13}$ m/s^2 $(+\hat{i})$

$\vec{B} = ?$

$F = ma$

$= 1.67\times10^{-27} \times 2\times10^{13}$

$= 3.34 \times 10^{-14} N (+\hat{i})$

$F = qVB\sin\theta$

$3.34\times10^{-14} = 1.6\times10^{-19} \times 1\times10^{7} \times B \times 1$

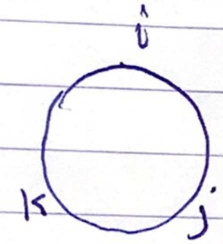
$B = 20.9 \times 10^{-3}\ T$

direction

$V: \hat{K}$

$F: +i$

$B: -\hat{j}$



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