Topic: Magnetic Field Date:

Concept of Magnetic Field:

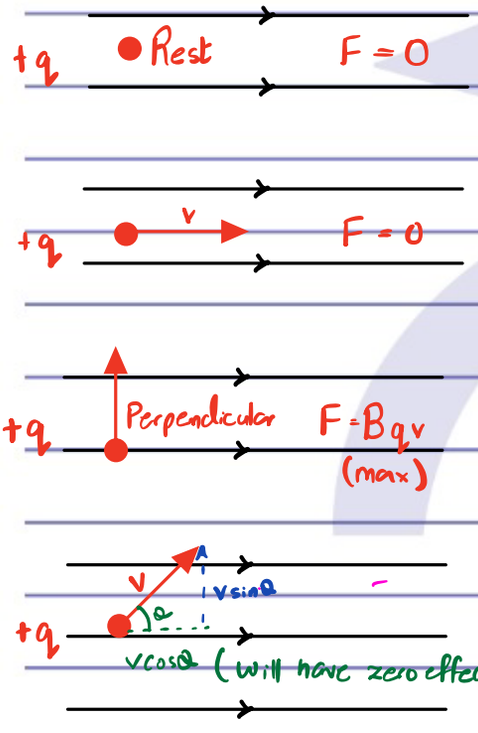
The stength of magnetic field is called "magnetic fidd strength" or "magnetic flux density."

Denoted by: B

measured in : T (Tesla)

It is vector quantity with direction from North to south.

→ Calculation of Force experienced by a charged particle as it enters a magnetic field.



$$F = Bqv$$

F = Force (N)

B = magnetic Flux density (T)

q = charge. (C)

v = velocity. (m/s)

$F = Bq(v \sin\theta)$

$F = Bqv \sin\theta$

Define Magnetic Field Strength: Region in which moving charge experiences a force provided that it is not moving parallel to the field lines.

Define 1 Tesla: If a Force of 1N acts on a charge of 1C which is moving at 1m/s in a direction perpendicular to the field, than the strength of the magnetic field is said to be equal to 1 Tesla.

Topic: _____ Date: _____

How to find the direction of this magnetic Force.

Fleming's left hand Rule:

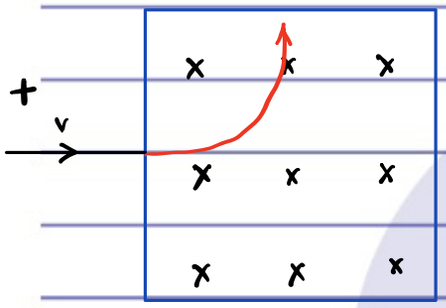
First finger = Direction of magnetic Field.

Second finger: Direction of Current / direction in which +ve charge is moving.

Thumb: direction of force.

* What if there is a negative charge:

Then second finger will point opposite to the direction in which negative charge is moving.



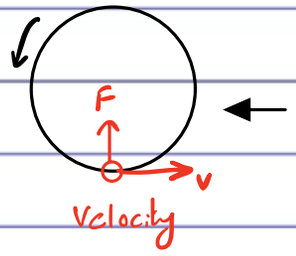
⊗ magnetic Field into the page.

Thumb of left hand provides direction of Force

In the upper case Force will be upwards.

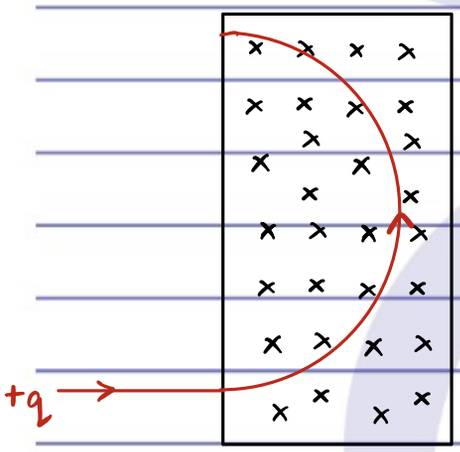
Topic: _____ Date: _____

Circular motion:



If Force and velocity are perpendicular, than we can expect object to perform "circular motion"

⇒ hence we can conclude that a charge particle in a magnetic field must also perform circular motion.



⊗ into the page

Find the Radius of this Arc

The magnetic Force is providing the centripetal Force

$$F_m = F_c$$

$$Bqv = \frac{mv^2}{R} \Rightarrow \boxed{R = \frac{mv}{Bq}}$$

m = mass

v = velocity

B = magnetic flux density

q = charge.

Topic: _____ Date: _____

2) Find angular velocity (ω)

$F_m = F_c$

$Bqv = mv\omega$

$$\omega = \frac{Bq}{m}$$

⇒ Derivations are very important.

2) Find "Time period"

$$T = \frac{2\pi}{\omega}$$

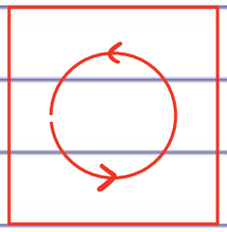
$$T = \frac{2\pi m}{Bq}$$

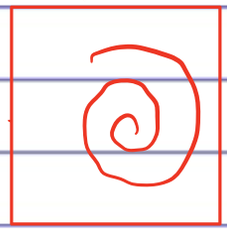
T and ω do not depend on radius if r increases or decreases it has no effect.

⇒ What if velocity of the charged particle decreases continuosly due to presence of some resistive Force.

$R \propto v$ so if velocity decreases continuosly then radius also decreases continuosly hence shape will be spiral

Spiral



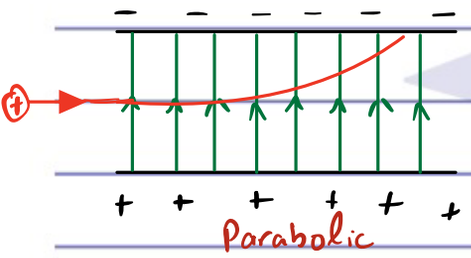


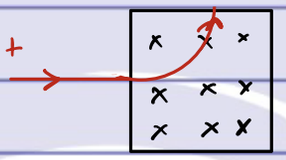
Topic: _____ Date: _____

What is the difference b/w Electrical Force and magnetic Force

① Electrical Force $F = Eq$ applies on stationary charges as well as on moving charges whereas magnetic force only applicable on moving charges.

② Electrical Force results in a parabolic Path where as magnetic Force results in a circular path



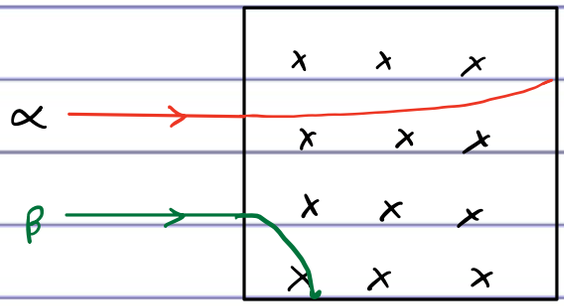


③ In Electric Field, the Electric Force is parallel to the field lines where as in magnetic field, force is perpendicular to the field lines.

Topic: _____ Date: _____

$$R = \frac{m v}{Bq}$$

Example:



$R\alpha : R\beta = ?$

$$\frac{R\alpha}{R\beta} = \frac{1}{1}$$

Is this path correct?

$$\frac{R\alpha}{R\beta} = \frac{\frac{m_\alpha v}{B q_\alpha}}{\frac{m_\beta v}{B q_\beta}}$$

$m\alpha = 4u$

$u = 1.66 \times 10^{-27}$

$q\alpha = 2e$

$1e = 1.6 \times 10^{-19}$

$m\beta = 9.11 \times 10^{-31}$

$q_B = 1e$

$$\frac{R\alpha}{R\beta} = \frac{m\alpha}{q\alpha} \times \frac{q\beta}{m\beta}$$

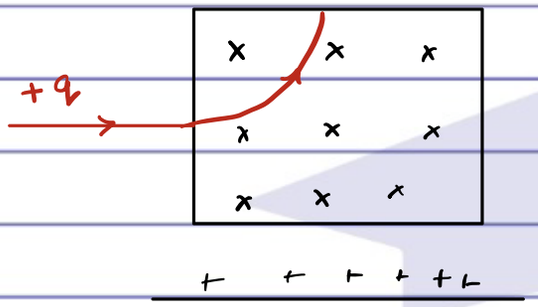
$$\frac{4u}{2e} \times \frac{e}{9.11 \times 10^{-31}} = \frac{3640}{1} = \frac{3600}{1}$$

Topic: _____ Date: _____

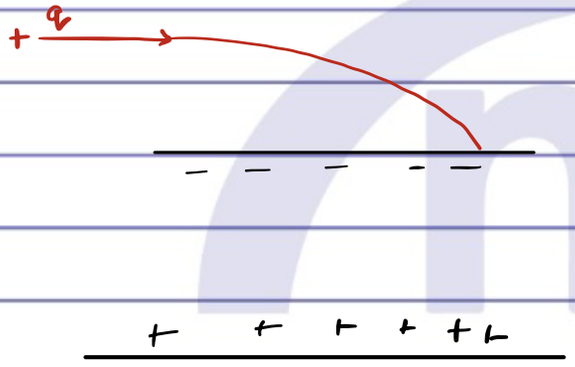
Behavior of a charged Particle in a "cross field"

What is cross field:

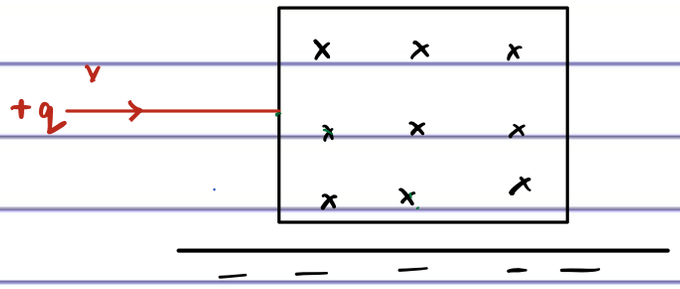
Cross field is a region in which both Electric field and magnetic Field are applied simultaneously such that they are perpendicular to one another.



F_m = upwards.



F_E = downward.



If the cross field is a setup as shown above such that F_m acts upwards & F_E acts downward than provided that $F_m = F_E$ (if they are numerically equal) than we can expect the charged particle to go "indeflected" as shown above i.e (it enters the crossfield on one side and Exits on the other side)

$$F_M = F_E$$

$$Bqv = Eq$$

$$\boxed{v = \frac{E}{B}}$$

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Q) What is the significance of this answer?

Ans) Let suppose in a question if they give you $E = 1 \times 10^{3}\ Vm^{-1}$ and $B = 1.0 \times 10^{-3}\ T$

$$V = \frac{E}{B} = \frac{1.0 \times 10^{3}}{1.0 \times 10^{-3}}$$

$$v = 1.0 \times 10^{6}\ m/s$$

⇒ Only those charged particles which will entre the cross field presisely with a velocity of $1.0 \times 10^{6}\ m/s$ are expected to go undeflected through the cross field.

Ques) There are 3 charged particles A, B & C all entering a cross field.

$V_A = 5.0 \times 10^{7}\ m/s$ ⇒ Greater velocity.

$V_B = 1.0 \times 10^{6}\ m/s$ ⇒ Equal velocity

$V_C = 6.0 \times 10^{5}\ m/s$ ⇒ lesser velocity.

Ans = $F_m = Bqv$ so $F_m \propto v$

$F_E = Eq$ so F_E does not depend upon velocity

Topic: _____ Date: _____

V_A is greater than 1.0×10^6 m/s greater velocity means that its F_m will be greater i.e F_m will outweight the F_E since F_m causes upward deflection

∴ moves upwards.

For V_B it matches 1.0×10^6 m/s ∴ goes straight.

V_C is less than 1.0×10^6

lesser velocity means that its F_m will be less i.e F_E outweighth F_m. Since F_E causes downward deflection ∴ moves down

Conclusion: the idea of cross field can be used as a velocity selector.

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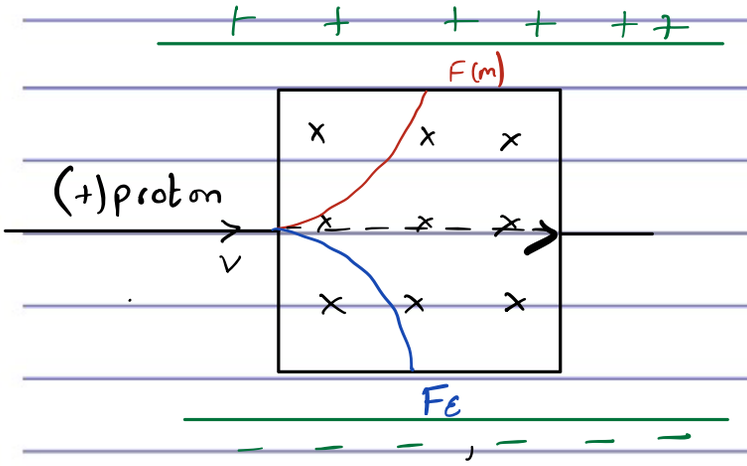


$Bqv \neq Eq$

⇒ Suggest and Explain what happens if following changes are made independently.

① Proton is replaced with Alpha particle.

mass has no Effect = Bqv and Eq (no mass)

amount of charge = q on both sides (no effect)

type of charge = same

α = remains undeflected.

② proton replaced with Electron.

Since e^- has opposite types of charge ∴ the individual Forces ie (F_m & F_E) will both get reversed

i.e F_m (downward) & F_E (upwards)

Electron remains undeflected.

Topic: _____ Date: _____

(3) Proton's velocity changed from v to 2v

$F_M = Bqv$ $\quad F_E = Eq$

(double) (double)

⇒ Doubling the velocity Fm will be doubled so particle will be deflected upwards.

(4) proton with velocity v is replaced by Electron with 2v

proton ⟶ Electron

Individual forces will get Reversed for an Electron F_m = downwards

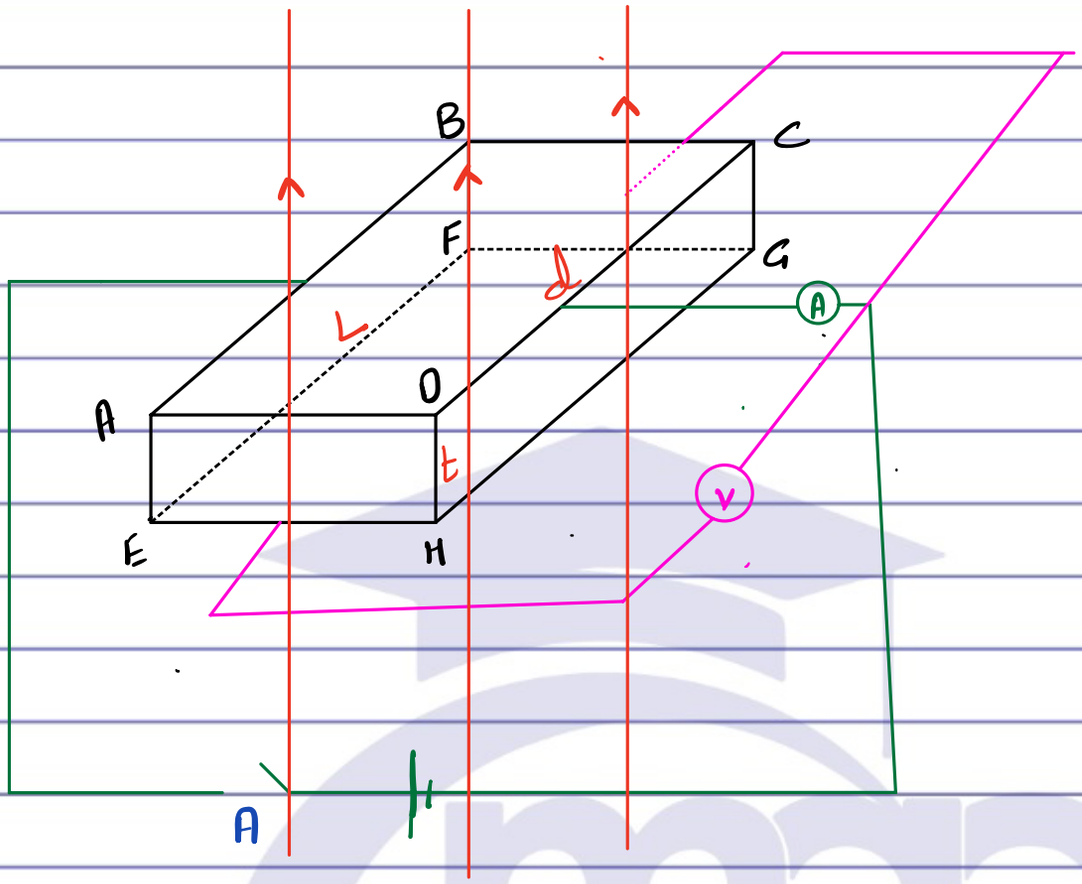
F_E = upwards

Now lets consider velocity

Since velocity is doubled F_m will be doubled and Electron travelling with 2v will deflect downwards.

Topic: Hall Probe Date:

Purpose: Measure the strength of magnetic field in a given region B.



→ ABFE & COHG are connected to switch, —(A)— and a battery.

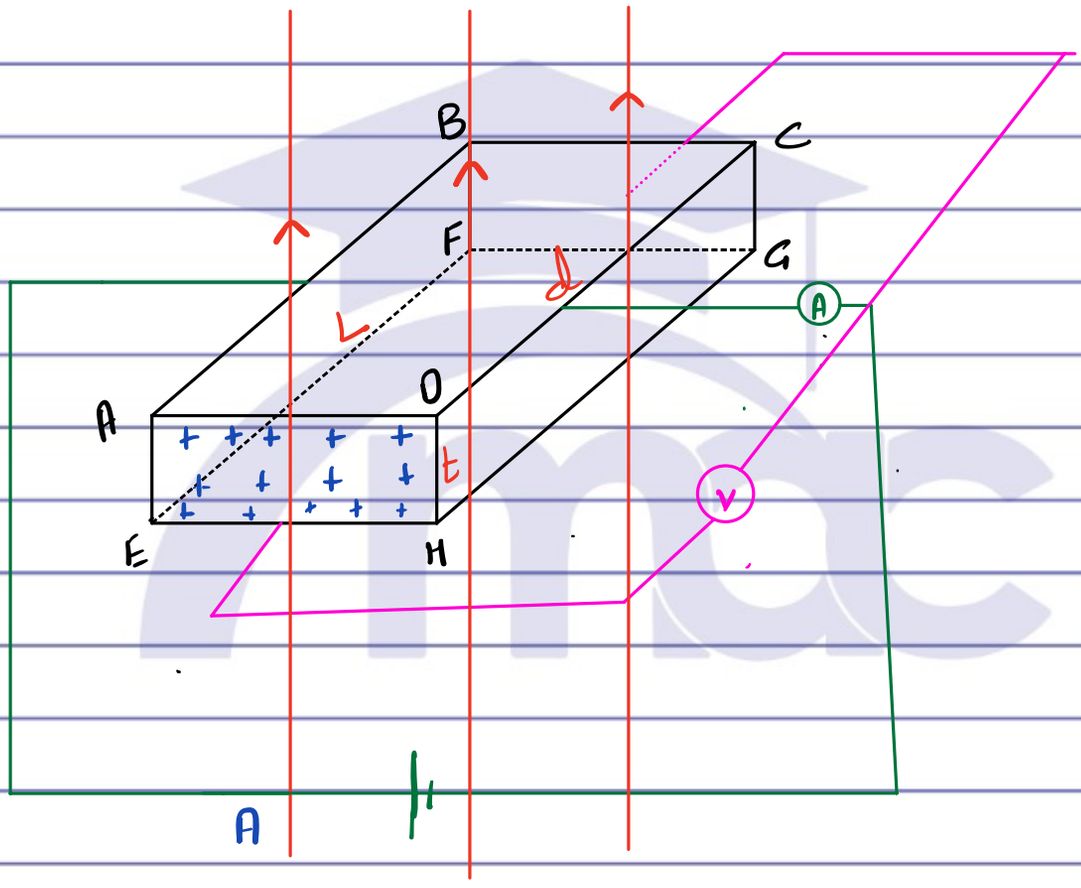
→ ADHE & BCGF are connected to a —(V)— meter

→ ABCD & EFGH are placed in a magnetic field (B) whose strength is determined such that the field lines enter from the one side and Exits from the opposite side.

Topic: _____ Date: _____

As switch A is closed the magnetic field applies a force on this current (+q) causing the charge particle entering the hall probe to undergo deflection

direction of Deflection = out of the page according to flemings left hand rule.



Direction of deflection towards ADHE

An Electric field will be set up b/w sides ADHE and BCGF

Now a cross field will be created.

Topic: _____ Date: _____

After some time F_m and F_E will become numerically Equal then the charges will be undeflected.
& Ammeter gives a reading at this point we note down Ammeter reading and note down Voltmeter reading.

$$F_M = F_E$$
$$Bqv = Eq$$

Since $E = \frac{V}{d}$

$$B = \frac{E}{v}$$

$$B = \frac{V/d}{\frac{I}{n(dt)q}}$$

$$B = \frac{V(nqt)}{I}$$

$$v = \frac{I}{nAq}$$

$$v = \frac{I}{n(d \times t) \times q}$$

(nqt) = Constant

V = Voltage
I = Current
q = Charge
t = thickness of Hall prope
n = no of charges per unit Volume.

2) Why do we prefer to make a Hall probe using a semiconductor rather than conductor

$$B = \frac{V}{I} nqt \qquad V = \frac{BI}{nqt} \qquad V \propto \frac{1}{n}$$

For conductors n is very high so Voltage is very low for Semiconductors n is low so Voltage is very high hence easy to measure.

Topic: _____ Date: _____

This Voltage is known as "Hall voltage" (V_H)

Formula $B = \frac{V}{I}(nqt)$

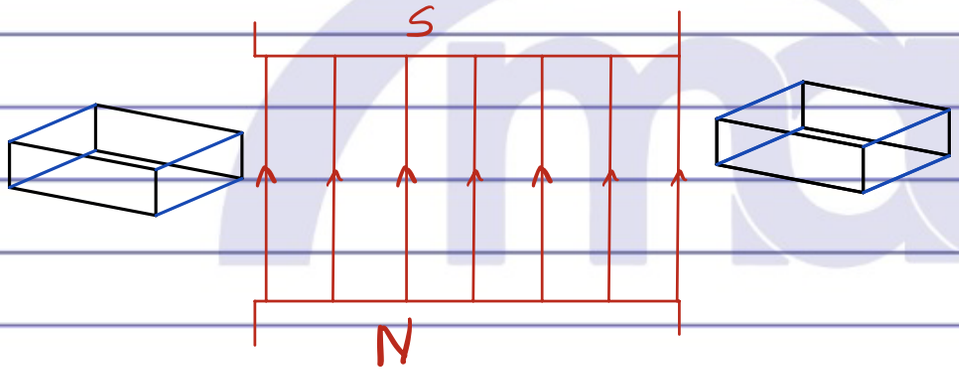
$$V = \frac{BI}{nqt}$$

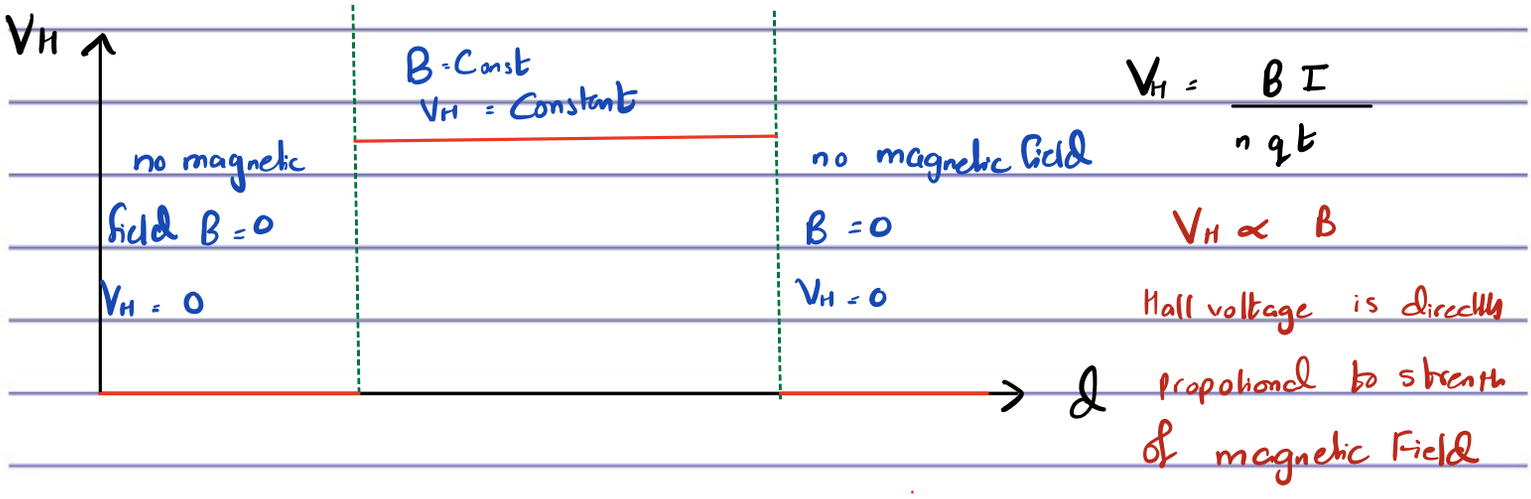
V_H = Hall voltage

nqt = Constant.

Note: Position of Hall probe in the magnetic field must be such that, the magnetic field must be enter through one face (ABCD) and Exit through the opposite face (EFGH)

* How to construct graph of Hall voltage against Distance





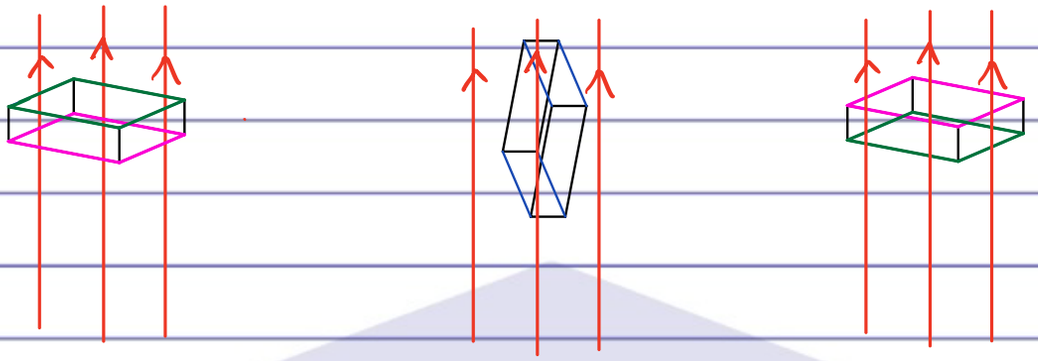
$$V_H = \frac{BI}{nqt}$$

$V_H \propto B$

Hall voltage is directly propotional to strength of magnetic Field

Topic: _____ Date: _____

* The Diagram shows a uniform magnetic Field. A hall probe is positioned appropriately in this field as shown this hall probe is now rotated through 180° about its axis as shown



Explain why the reading on the —(V)— might Fluctuate b/w max, zero and negative max?

For Hall Voltage to be recorded the concerned sides must be perpendicular to the magnetic field lines hence we can say that V_H depends on the angle b/w its sides & the field lines

(1) Initially alligned appropiately V_H = max

(2) When rotated to 90° the concerned sides now became parallel to the field (mis alligned) ∴ $V_H = 0$

(3) When rotated through 180°, the slides reverse, hence V_H reverse ∴ V_H = -ve maximum.

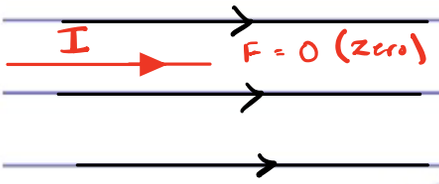
Topic: _____ Date: _____

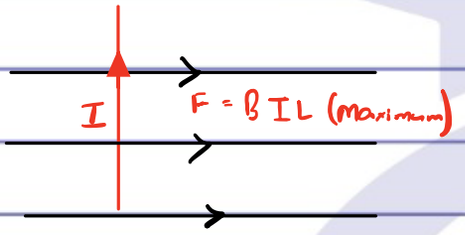
⇒ Force on a current carrying wire:

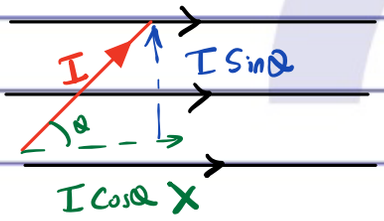
* Calculating force on a current carrying conductor placed in a magnetic Field.

$$F = BIL$$

B = magnetic field strength
I = current
L = Length.







$$F = B(I\sin\theta)L$$

$$F = BIL\sin\theta$$

① No Force when current is parallel to field

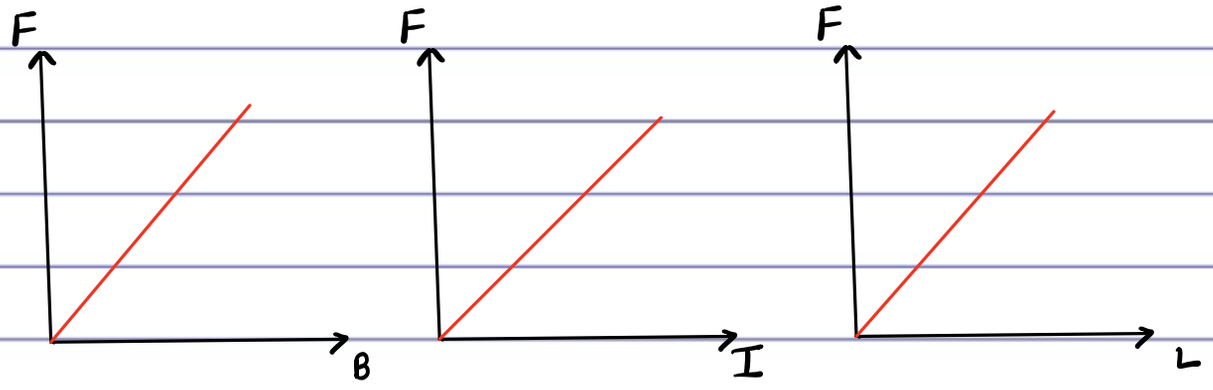
② Maximum Force if current is perpendicular to the field.

③ Resolve to obtain vertical component i.e $I\sin\theta$

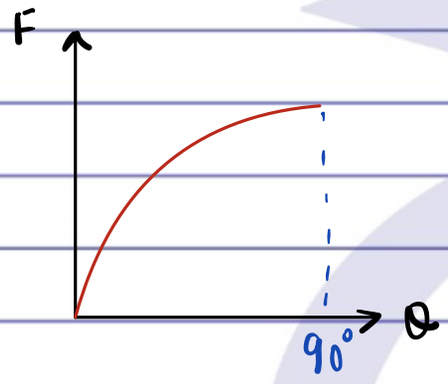
Topic: _____ Date: _____

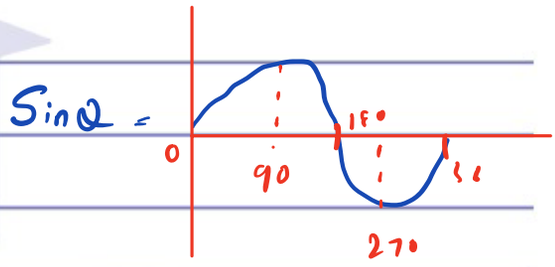
Graphs

$F = BIL$



$F = BIL\sin\theta$ $\quad F \propto \sin\theta$

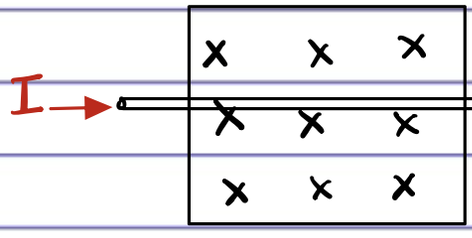




⇒ How to find the direction of the magnetic Force.

Use Flemings left hand rule.

First finger = Magnetic field
Second Finger = Current
thumb = Force (unknown)

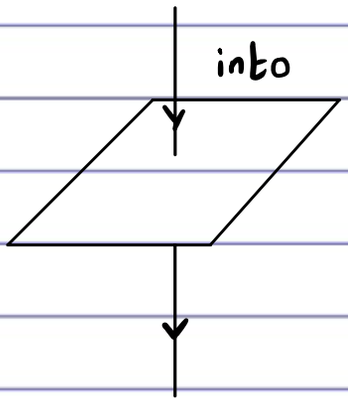


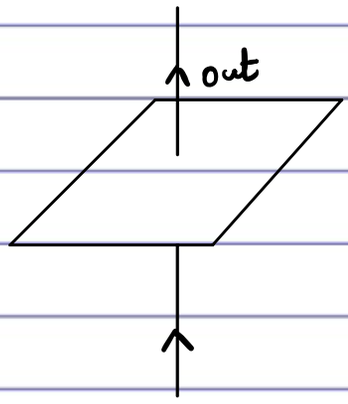
⊗ Magnetic field into the page.

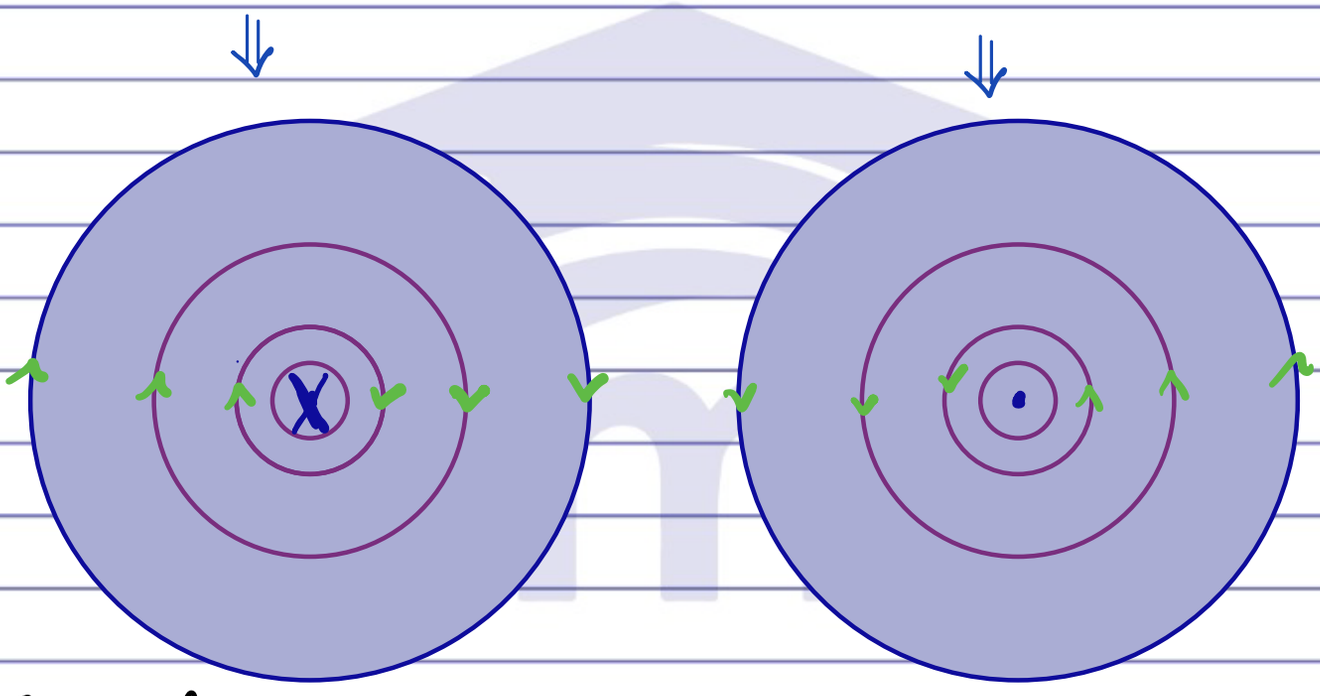
Force is upwards

Topic: _____ Date: _____

→ How to construct magnetic Field pattern around a current carrying wire :







Right hand grip rule

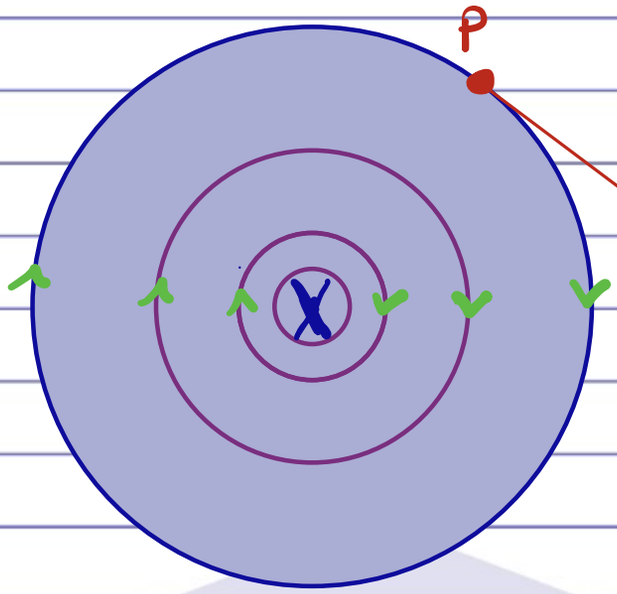
Point finger in direction of current curl of fingers will give direction of magnetic Field.

* When current is into the page ∴ Direction of magnetic field is clockwise

* When current of the page : Direction of Magnetic field = Anti Clockwise

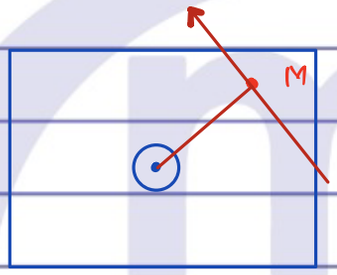
Topic: _____ Date: _____

On Point P mark direction of magnetic Field.



Just Draw a Tangent.

Generally in your Exams.

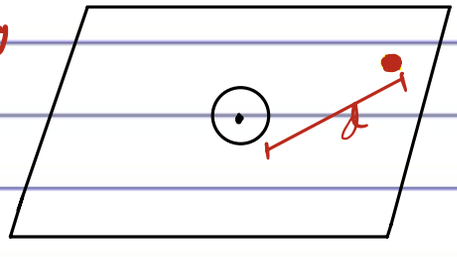


⇒ Mark Direction of magnetic field at Point M.

In Exam they ask you to calculate the strength of this magnetic field (magnetic flux density) at a certain distance (d) away from the wire.

$$B = \frac{\mu_0 I}{2\pi d}$$

μ_0 = permiability of free Space.



B = Magnetic field density (T)

I = Current in a wire (A)

d = distance (m)

μ_0 = Constant.

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$\mu_0 = 4\pi \times 10^{-7} \quad TmA^{-1}$

$\mu_0 = \dfrac{B \times 2\pi d}{I}$

d is also denoted by x and r

$B = \dfrac{\mu_0 I}{2\pi d}$

$B = \dfrac{2 \times 10^{-7} \times I}{d}$

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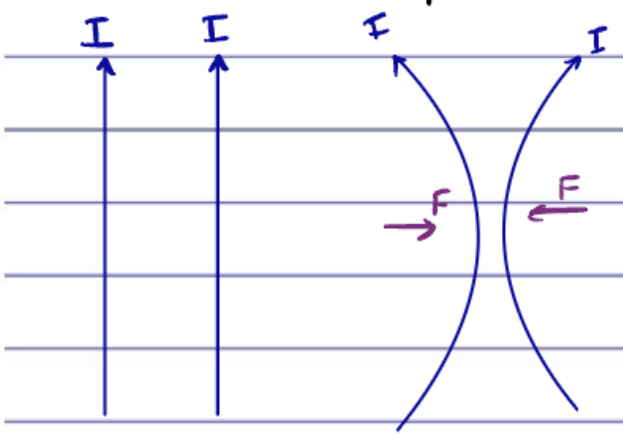
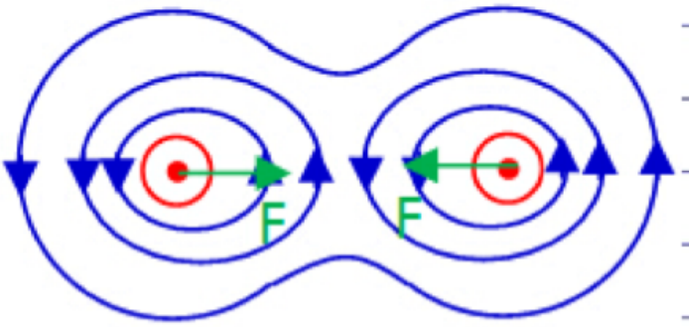
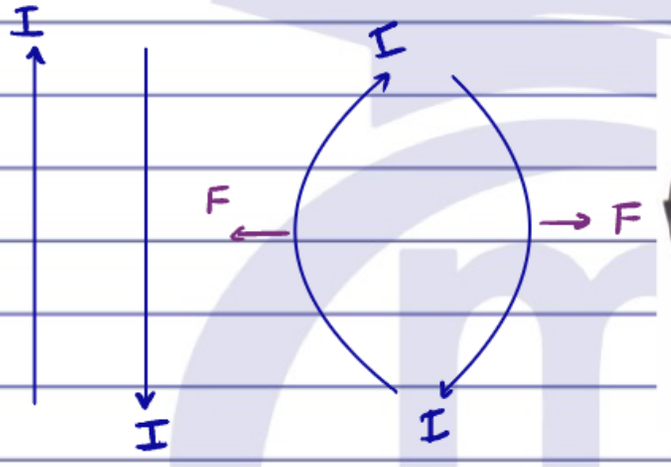
* Like currents Attract ✓
* Unlike Currents Repel.

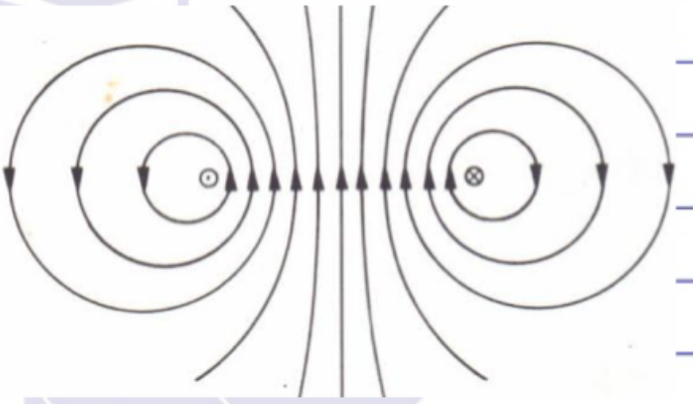


Like currents Attract

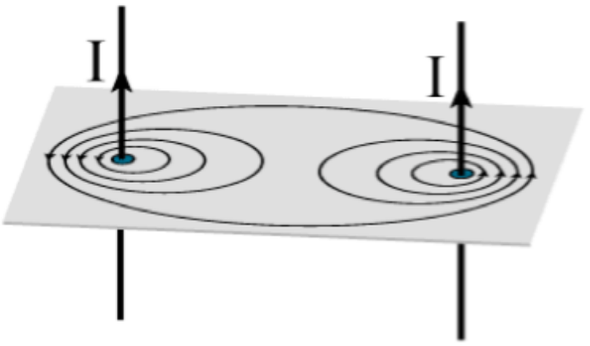


↳ Paper wali Diagram.

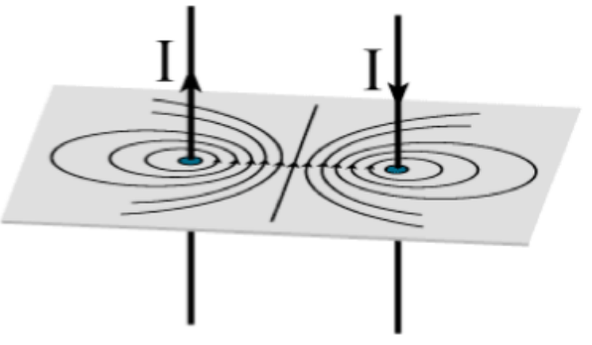




Current in the same direction



Current in opposite direction



Catapult field produced by 2 straight curretn carrying conductors

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How to calculate force of Attraction / Force of repulsion b/w two wires.

$$F = \frac{\mu_0 I_1 I_2 L}{2\pi d}$$

$$F = \frac{2 \times 10^{-7} I_1 I_2 L}{d}$$

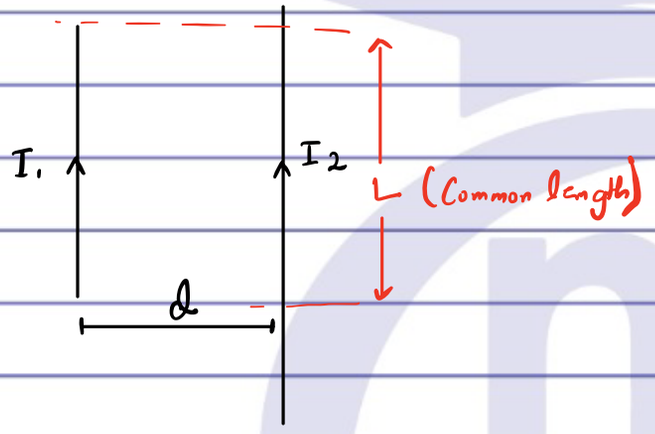
I_1 and I_2 = Current in the wire

L = Common length of the wire

d = distance b/w 2 wires

$\mu_0 = 4\pi \times 10^{-7} T_m A^{-1}$

$$F = \frac{2 \times 10^{-7} I_1 I_2 L}{d}$$



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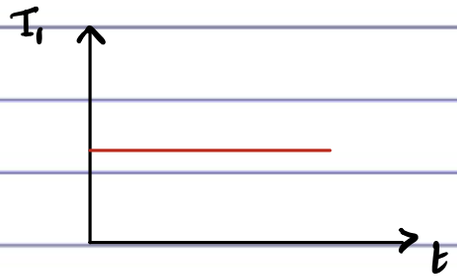
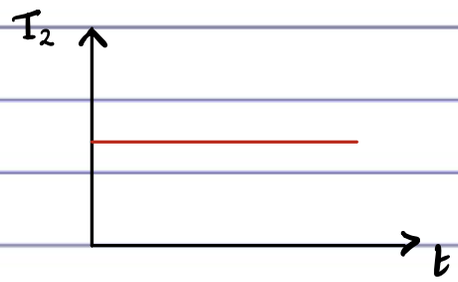
Sketch a graph to show how magnitude of force changes with time (t) if

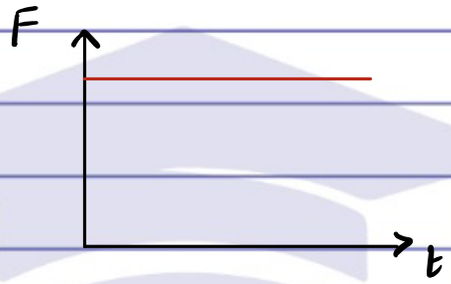
I_1 = d.c I_2 = d.c



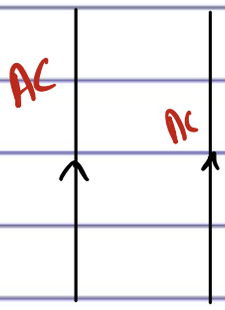


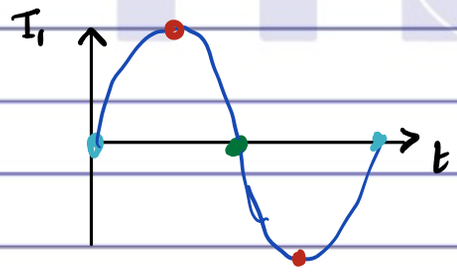
$F \propto I_1 I_2$

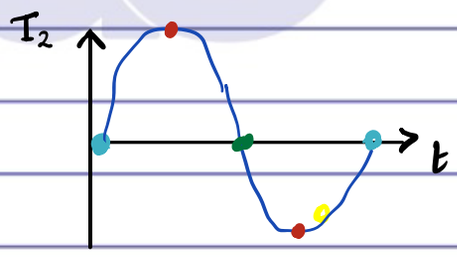
$$F = \frac{\mu_0 I_1 I_1}{2\pi d}$$



b) I_1 = AC I_2 = A.C

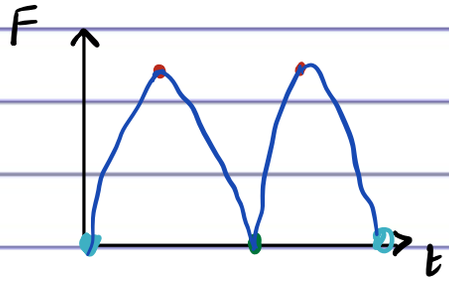






$F \propto I_1 I_2$

$$F = \frac{\mu_0 I_1 I_1}{2\pi d}$$



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- For DC current wires Experience a constant force

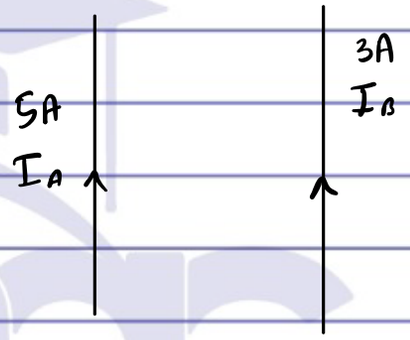
- For AC current, The force varies twice b/w maximum and zero for one complete cycle of current

(∴ we can observe wires to vibrate when they carry A.C current)

Q) Example

Wire A I_A (d.c) = 5A

Wire B I_B (d.c) = 3A



They are both close together
So that they Experience a force.

Which wire A or B experience more Force?

Since $F \propto I_1 \cdot I_2$ (Force is propotional to the product of the two both wires experience the same force irrespective of the current in each wire.

OR

Based on Newton's third law $F_A = -F_B$
hence both wire experience same force.

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