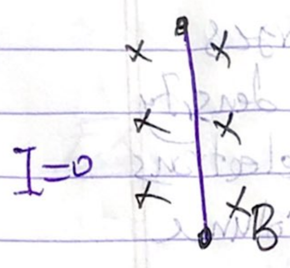
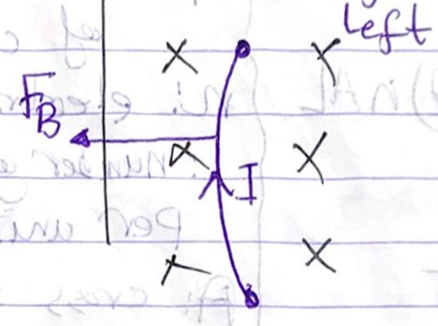
Magnetic Force Acting on a Current Carrying Conductor

A charge moving in a magnetic field experience a magnetic force Thus a current-carrying wire will also experience a magnetic force when placed in a magnetic field (current is a collection of many charges)

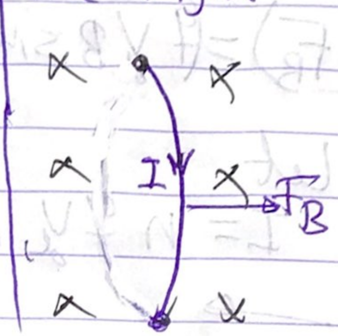
when there is no current in the wire the wire remains vertical



when the current is upward the wire deflects to the ~~right~~ left



when the current is dowonward the wire deflects to the right



How to find the direction of the magnetic force acting on a conductor carrying current

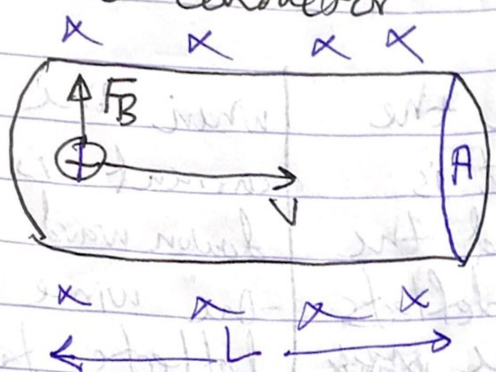
كيف تحدد اتجاه القوة المغ على موصل للتيار

Fingers to B
thumb to I
⊥ on the hand to F_B

what is the magnitude of F_B on conductor

$(F_B = qvB \sin\theta)$ on charge q

on conductor



the number of charges in the segment

$N = nV$
$= nAL$

N: total number of charges
n: electron density
: number of electrons per unit volume
A: cross section area
L: Length of wire

$(F_B) = (q v_d B \sin\theta) nAL$

Let
$I = n q v_d A$

$$F_B = ILB\sin\theta$$

magnetic force acting on current carrying conductor

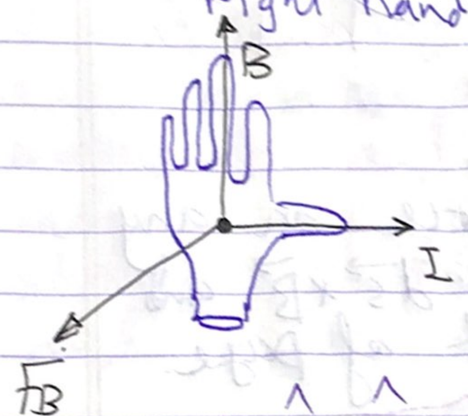
$$F_B = I\vec{L} \times \vec{B}$$

where $\vec{L}$ is ~~a vect~~ a vector that points in the direction of the current I.

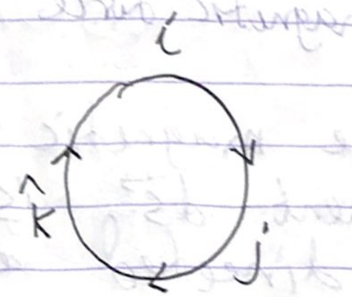
$$\vec{F_B} = I\vec{L}\times\vec{B}$$

$$F_B = ILB\sin\theta$$

right hand

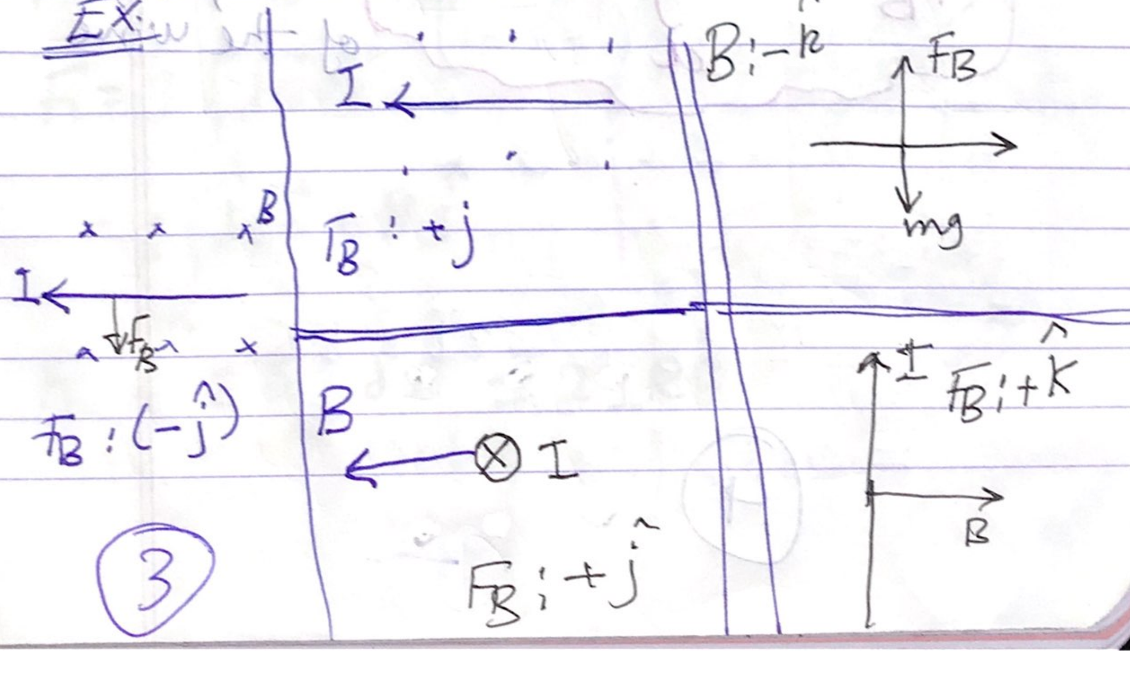


cycle Rule

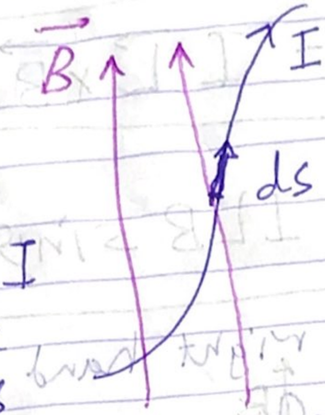


$\hat{i}\times\hat{j}=\hat{k}$, $\hat{j}\times\hat{k}=\hat{i}$ $\hat{k}\times\hat{i}=\hat{j}$

Ex.



For an arbitrary shaped wire segment of uniform cross section placed in a magnetic field



A wire segment of arbitrary shape carrying a current I in uniform magnetic field B experiences a magnetic force

The magnetic force on any segment $\vec{ds}$ is $\vec{ds} \times \vec{B}$ and is directed out of page

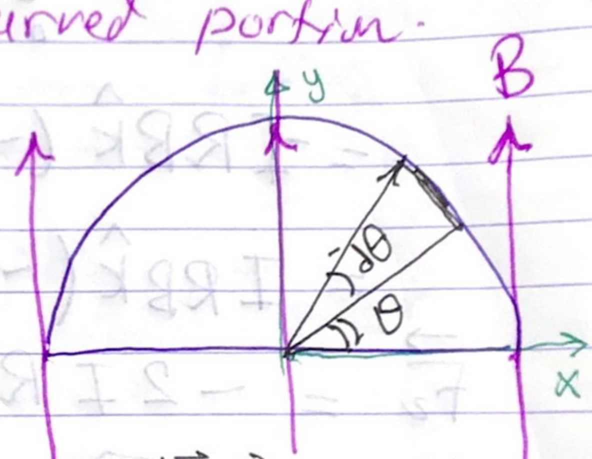
$$\vec{F_B} = I \int_a^b \vec{ds} \times \vec{B}$$

a, b are end points of the wire

Example 29.4

Force on a Semicircular conductor

A wire bent into a semicircle of radius R forms a closed circuit and carries a current I. The wire lies in the xy plane, and a Uniform magnetic field is directed along the positive y axis as in Figure. Find the magnitude and direction of the magnetic force acting on the straight portion of the wire and on the curved portion.



On the straight portion of the wire

$$F_1 = I\int d\vec{s} \times \vec{B}$$

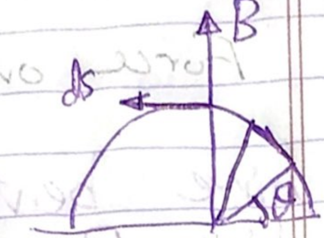
$$= I\int_{-R}^{R} dx\,\hat{i} \times B\,\hat{j}$$

$d\vec{s}\times\vec{B} = dx\,\hat{i}\times B\,\hat{j}$
$= B\,dx\,\hat{k}$

$$F_1 = IB\int_{-R}^{R} dx = 2IRB\,\hat{k}$$

On the curved part

$d\vec{F_2} = I\,d\vec{s} \times \vec{B}$



$= I\,dx(-\hat{i}) \times B\hat{j}$

$= -IB\sin\theta\,ds\,\hat{k}$

$ds = R\,d\theta$

$\vec{F_2} = -\int_0^{\pi} IRB\sin\theta\,d\theta\,\hat{k}$

$= -IRB\hat{k}\int_0^{\pi}\sin\theta\,d\theta$

$= -IRB\hat{k}(-\cos\theta)\Big|_0^{\pi}$

$= IRB\hat{k}(-1-1)$

$\vec{F_2} = -2IRB\,\hat{k}$

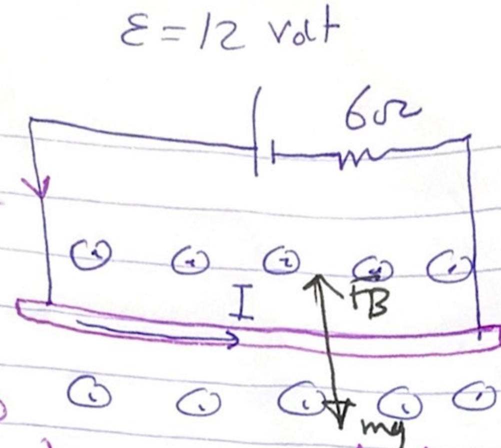
$\vec{F} = \vec{F_1} + \vec{F_2}$

$= 2IRB\,\hat{k} - 2IRB\hat{k}$

$= 0$ The magnetic Force on closed Loop is zero

6

Ex



A wire of 1.5 m Length and 60 gm mass is connected to a battery as shown and freely to slide vertically. The wire lies along the x-axis with a uniform magnetic Field into the page
Find the magnetic field B that make the wire stops sliding downward

$$\vec{F_B} = mg \qquad I = \frac{\varepsilon}{R}$$

$$ILB = mg \qquad = \frac{12}{6}$$

$$2 \times 1.5 \times B = 0.06 \times 10$$

$$B = 0.2\ T \qquad = 2A$$