ملزمة الوحدة السابعة Magnetism and Electricity منهج انسباير المسار النخبة

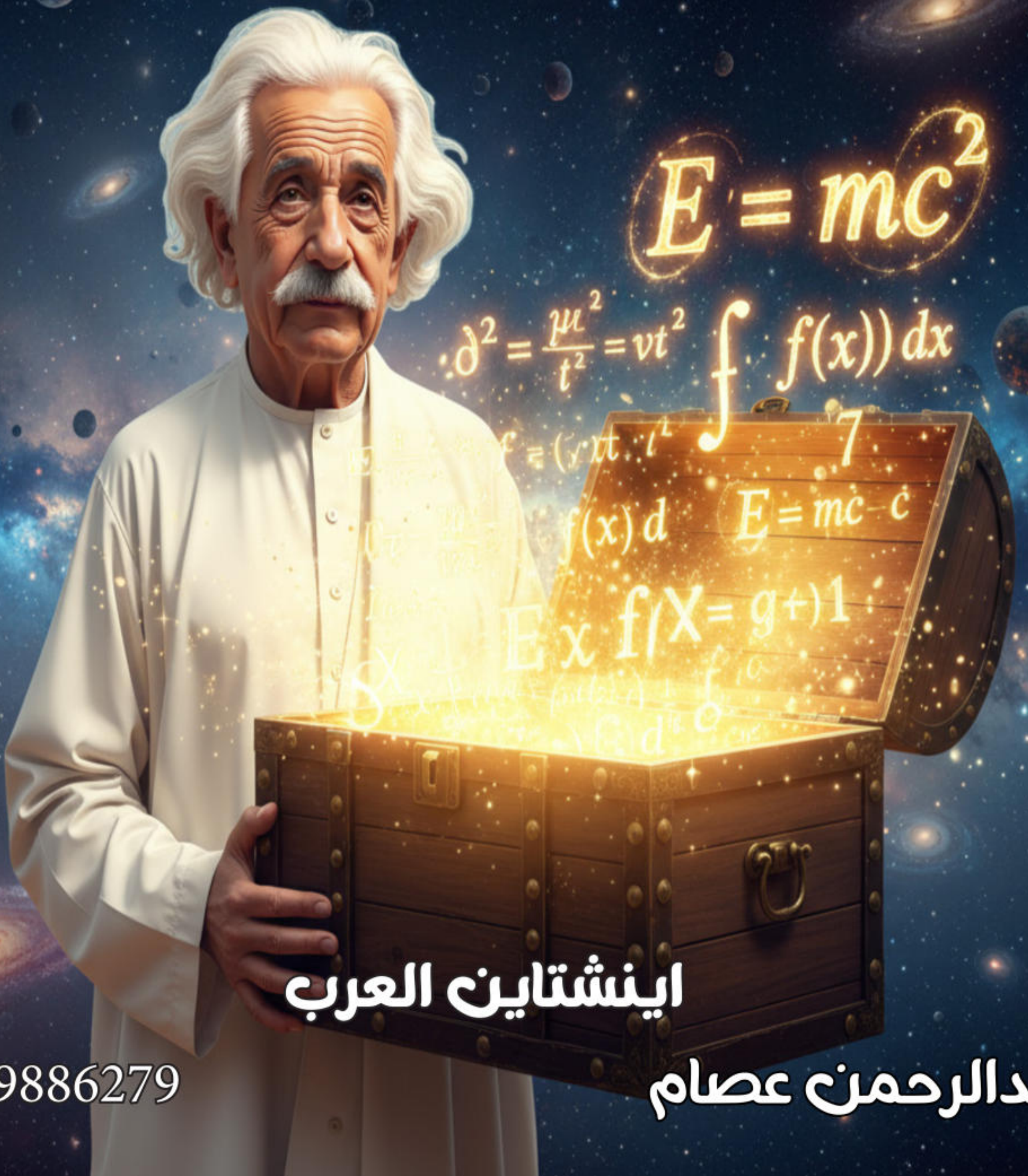
Term 2

2026-2025

اينشتاين العرب

AP PHYSICS C ELECTRICITY AND MAGNETISM

GRADE 12 ELITE = PHYSICS



اينشتاين العرب

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Chapter 7

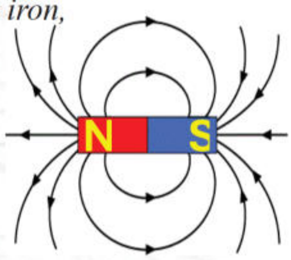
Magnetism

هذا المحتوي مدفوع خاص بالمشتركين

7.1 Permanent Magnets

A magnet is a material or object that produces a magnetic field.

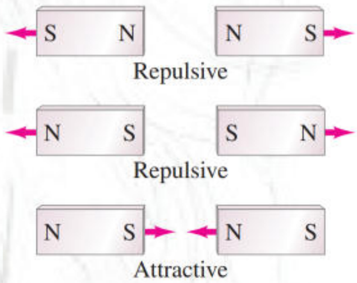
This magnetic field is invisible but is responsible for the most notable property of a magnet: a force that pulls on other ferromagnetic materials, such as iron, and attracts or repels other magnets.



Magnetic Poles :

All magnets have two poles (North) and (south).
A magnetic mono pole cannot exist.

Magnetic Properties :



1. Magnets exert magnetic force on each other:

➢ *Alike poles repel each other.*
(Same repel)

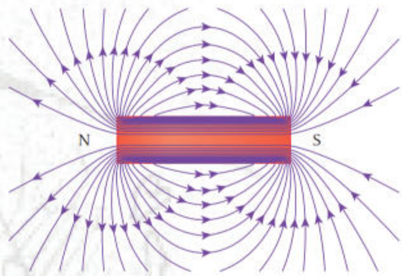
➢ *Unlike poles attract each other.*
(Different attractions)

2. If a magnet is broken, each piece.

each piece will have two poles North and South.
each of the broken pieces will act perfectly as individual magnets.

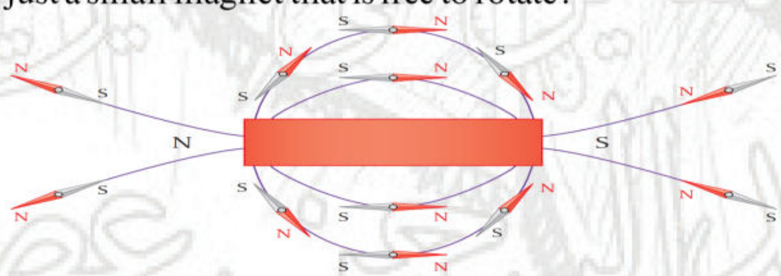
Magnetic Field (B): the region where magnetic forces exist around a magnet.

Properties Magnetic Field :



1. Imaginary lines show the strength and direction of magnetic field.
2. Magnetic field is a vector quantity.
3. Start from the north pole and end in south pole, outside the magnet.
4. Move from south pole to north pole, inside the magnet.
5. Magnetic Field lines are loops.
6. The strongest magnetic field around the poles where lines concentrated.
7. Magnetic Field is decreased with distance (inverse proportional).

A compass :is just a small magnet that is free to rotate .

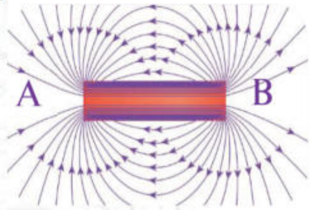


Check your understanding:

1. The figure shows the magnetic field lines of a permanent magnet. Which of the following is correct when determining the north pole and south pole of the magnet?

ⓐ *B is the north pole* ⓒ *B is the south pole*

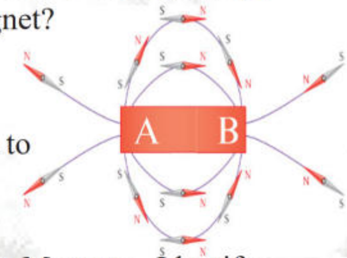
ⓑ *A is the north pole* ⓓ *There isn't enough data to determine the poles*



2. The figure shows the magnetic field lines of a permanent magnet. Which of the following is correct when determining the north pole and south pole of the magnet?

ⓐ B is the north pole ⓒ A is the south pole

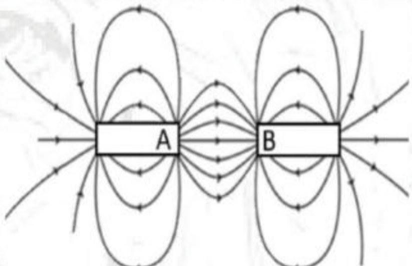
ⓑ A is the north pole ⓓ There isn't enough data to determine the poles



3. The diagram below represents the magnetic field lines around two bar Magnets . Identify the poles at positions A and B.

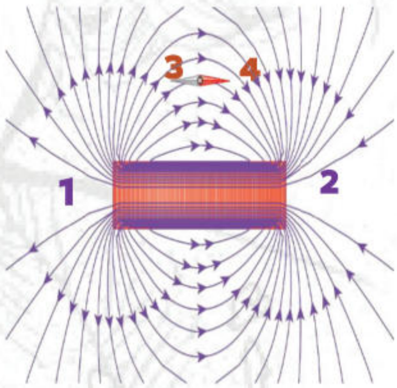
ⓐ *pole A=north pole B=south* ⓒ *pole A=south pole B=south*

ⓑ *pole A=south pole B=north* ⓓ *pole A=north pole B=north*



4. The figure shows a compass close to a magnet. Which of the following rows show the correct positions of the magnetic poles of the magnet and compass?

	North Pole of Magnet	South Pole o f Magnet	North Pole of Compass	South Pole of Compass
ⓐ	1	2	3	4
ⓑ	1	2	4	3
ⓒ	2	1	3	4
ⓓ	2	1	4	3

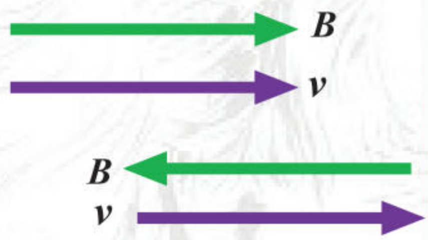
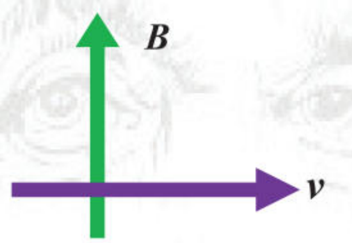
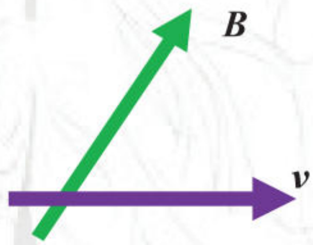


7.2 Magnetic Force

"When a charged particle moves velocity in a magnetic field, a force is generated."

F: magnetic force (N)
q: electric charge (C)
v: velocity of charge (m/s)
B: magnetic field (T ≡ Tesla)
θ: angle between field and velocity (charge)

$$F = qvB\sin\theta$$

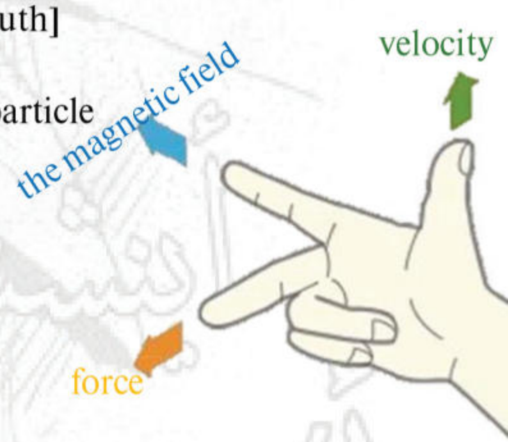
Magnetic field is parallel or antiparallel to velocity (charge)	***Magnetic field is perpendicular or normal to velocity (charge)***	***Magnetic field is diagonal to velocity (charge)***
$\theta = 0^o \Rightarrow F_{min} = 0$ $\theta = 180^o \Rightarrow F_{min} = 0$	$\theta = 90^o \Rightarrow F_{max} = qvB$	$0^o < \theta < 90^o$ or $90^o < \theta < 180^o \Rightarrow F$ **Between min and max**
		

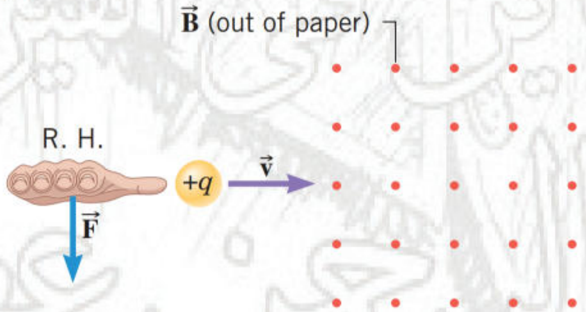
into page

Direction Magnetic field

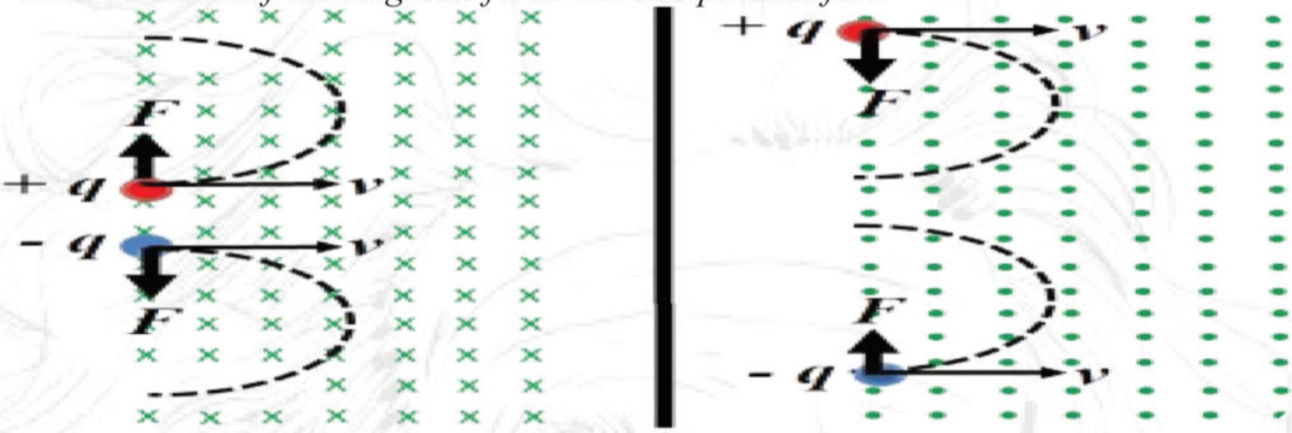
out of page

The right-hand rule: (positive charge)
Fingers : in the direction of the magnetic field (B) [North to South]
Thumb :in the direction of the charge velocity
Palm : in the direction of the force upon the positive charged particle
NOTES:
positive charge Direction Same
Negative charge Opposite Direction

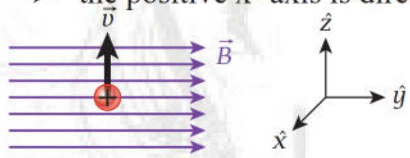




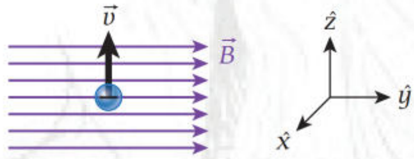
Check your understanding:
When a particle with charge, +q and -q, move with a velocity toward right direction in a uniform magnetic field with the direction pointing into the screen, What direction of the magnetic force will this particle feel?



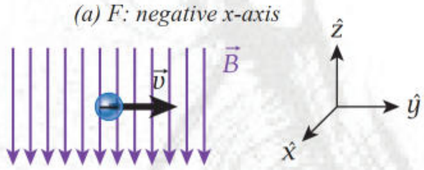
5. Draw on the x y z coordinate system and specify (in terms of the unit vectors(x, y, z) the direction of the magnetic force on each of the moving particles shown in the figures.
Note:
- The positive y-axis is toward the right,
- the positive z-axis is toward the top of the page.
- the positive x- axis is directed out of the page.



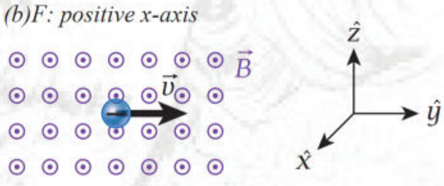
(a) F: negative x-axis



(b)F: positive x-axis

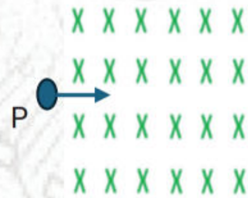


(c)F: positive x-axis



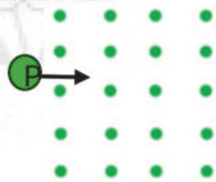
(d)F: positive z-axis

6. According to the figure, in what direction the proton (p) will be deflected as it enters the constant magnetic field (B) ?



ⓐ *Toward y positive* ⓒ *Into the page*
ⓑ *Toward y negative* ⓓ *Out of the page*

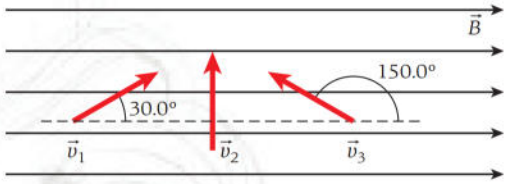
7. According to the figure, in what direction the proton (p) will be deflected as it enters the constant magnetic field (B) ?



ⓐ *Toward y positive* ⓒ *Into the page*
ⓑ *Toward y negative* ⓓ *Out of the page*

8. Three particles, each with charge q = 6.0 μC and speed v = 400 m/s, enter a uniform magnetic field with magnitude B = 0.2 T (see the figure). What is the magnitude of the magnetic force on each of the particles?
Slove :

$$F = qvB\sin\theta$$



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9. A proton moving with a speed of 4×10^{5} m/s in the positive y-direction enters a uniform magnetic field of 0.4 T pointing in the positive x-direction.
Calculate the magnitude of the force on the proton.
Slove :

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10. The magnitude of the magnetic force on a particle with charge –2e moving with speed $v = 1\times10^{5} m/s$ is 3.0×10^{-18} N. What is the magnitude of the magnetic field component perpendicular to the direction of motion of the particle? $e = 1.6\times10^{-19}$ c
Slove :

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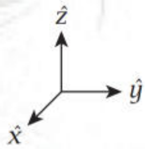
11. A particle with charge q is at rest when a magnetic field is suddenly turned on. The field points in the z-direction. *notes at rest Velocity zero*

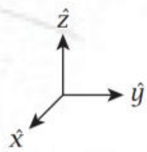
12. What is the direction of the net force acting on the charged particle?



ⓐ *in the x-direction* ⓒ *the net force is zero*

ⓑ *in the z-direction* ⓓ *in the y-direction*

13. In which direction does a magnetic force act on an electron that is moving in the positive x-direction in a magnetic field pointing in the positive z-direction?



ⓐ *To the direction of +y axis* ⓒ *To the direction of +x axis*

ⓑ *To the direction of -y axis* ⓓ *To the direction of -x axis*

14. A particle with charge (q=+3.2μC) and speed (v=520m/s), enters a uniform magnetic field of (B=0.2T) as seen in the figure.
What is the magnitude of the magnetic force on the particle?

ⓐ 332.8μN ⓒ 3.2μN ⓑ 166.4μN ⓓ 520μN

15. Which of the following is an equivalent unit of Tesla?

ⓐ $\frac{N.s}{C.m}$ ⓒ $\frac{N}{A.m}$ ⓑ $\frac{N.C}{s.m}$ ⓓ A& C are correct

16. *By analyzing the units:*
What does the tesla unit equal to in terms of newtons, amperes, and meters?
Slove :

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17. An electron enters a uniform magnetic field at a velocity of 2.0×10^6 m/s at right angle as shown in the figure. The field exerts a force of 5×10^{-15} N on the electron.

a-What is the magnetic field strength?

The charge of the electron is $(qe) = -1.6 \times 10{-}19$ C

b- What is the direction of the force acting on the electron?

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18. A negatively charged particle enters perpendicularly into a region of uniform magnetic field of strength 1.5 T at a constant speed of $7.4 \times 10^5 m/s$.
It experiences a magnetic force of $1.8 \times 10^{-13} N$.
a. What is the direction of the magnetic force on the charge as it enters the magnetic field?
b. What is the magnitude of the charge on the particle?
c. What is the work done on the charge by the magnetic force? Explain your answer.

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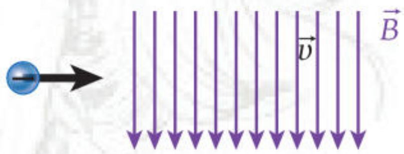

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7.3 Motion of Charged Particles in a Magnetic Field

Magnetic Force and Work

Magnetic force are the vector product of the velocity vector and magnetic field vector and thus is perpendicular to both vectors.

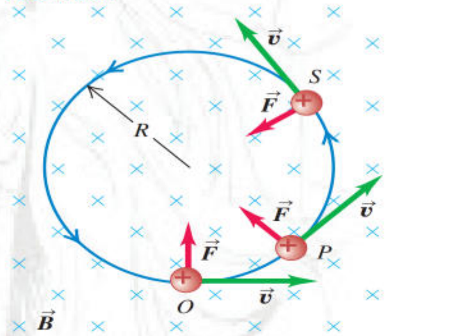
This implies that $\vec{F}\ \vec{v} = 0$ and, since the force is the product of mass and acceleration,

We saw that this condition means that the direction of the velocity vector can change but the

magnitude of the velocity vector, the speed, remains the same.

Therefore, the kinetic energy remains constant for a particle subjected to a magnetic force, and the magnetic force does not work on the moving particle

A charge moving at right angles to a uniform $\vec{B}$ field moves in a circle at constant speed because $\vec{F}$ and $\vec{v}$ are always perpendicular to each other.



The magnetic force of charge q and mass m moves with velocity.

For circular motion:

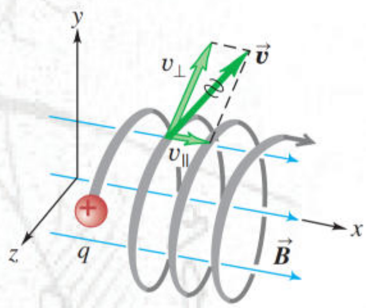
$$F = \frac{mv^2}{r}$$

$$F = qvB = \frac{mv^2}{r}$$

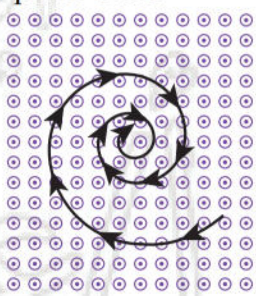
$$qB = \frac{mv}{r}$$

NOTES: FORMALA	
1. *the magnetic field magnitude B*	$B = \frac{mv}{qr}$
2. *the orbital radius r*	$r = \frac{mv}{qB}$
3. *the momentum of the particle*	$P(mv) = qBr$
4. *Newton's second law*	$F = ma = qvB$
5. *Acceleration*	$a = \frac{F}{m} = \frac{qvB}{m}$

This particle's motion has components both parallel ($v_{\parallel}$) and perpendicular ($v_{\perp}$) to the magnetic field, so it moves in a spiral.



A uniform magnetic field is directed out of the page (the standard notation of a dot within a circle represents the tip of the arrowhead of a field line). A charged particle is traveling in the plane of the page, as shown by the arrows in the figure



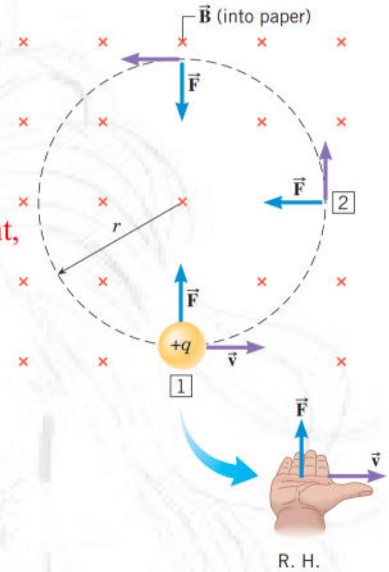
What is the charge of the particle?

What happens to the velocity of the particle inside the magnetic field

What is the work on the particle?

The work of the magnetic force on a charged particle travelling in a magnetic field is always zero.

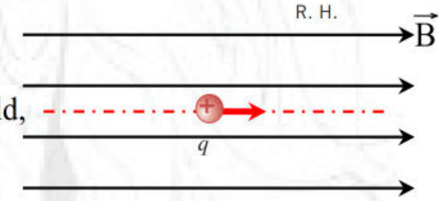
The magnetic force acting on a charged particle moving in a magnetic field is always perpendicular to the speed of the particle.



Cases

1-If the direction of motion of the particle is perpendicular to the magnetic field, the particle moves in two circular paths .The magnitude of the velocity is constant, and the direction is variable according to the direction of the turn and at any point is the direction of the tangent

2-If the direction of motion of the particle is parallel to the magnetic field, the particle moves in a straight path



When a charge is moving at a constant speed parallel to a uniform magnetic field, the charge is not affected by a magnetic force so it remains moving in a straight line parallel to the magnetic field.

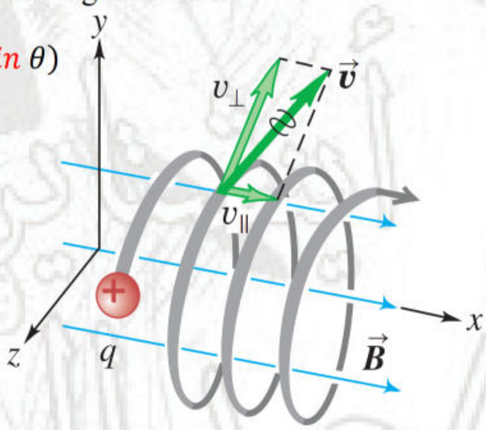
Since θ = 0,180 and therefore sin θ = 0 and therefore $F_B = 0$

3-If the direction of motion of the particle is inclined at an angle to the magnetic field, the particle moves in a spiral path

when the charge moves at a constant speed that is not perpendicular or parallel to the magnetic field, but the velocity vector is inclined at an angle from the direction of the magnetic field.

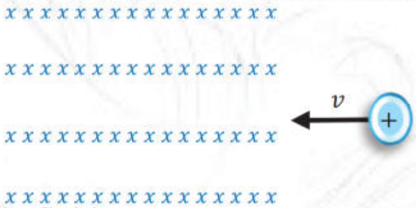
Then The component of the velocity vector perpendicular ($v_\perp = Sin\ \theta$) to the field and makes it move in a circular path

The component of the velocity vector parallel ($v|| = cos\ \theta$) to the field pulls the charge towards the field



Both perpendicular and parallel motions make the charged particle move in a spiraling path

According to the figure below a proton Is travelling at a constant velocity Of $V = 2.40 \times 10^5 m/s$, then enter a uniform that is magnetic field of $B = 2.7 \times 10^{-2} T$ directed into the page



A-After the proton enters the magnetic field $\vec{B}$
calculate the magnitude of the magnetic force acting on the proton.

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B- Find the radius of the proton's orbit inside the magnetic field.

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C-Find the centripetal acceleration of the proton's orbit inside the magnetic field.

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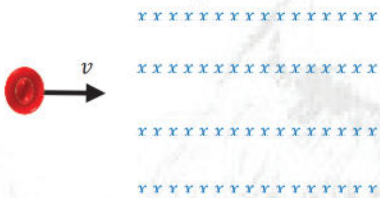
According to the Figure below an electron is travelling at a constant velocity of $v = 5.3 \times 10^6 m/s$, then enters a uniform magnetic field $\vec{B} = 8.6 \times 10^{-3} T$ that is directed into-the page.



A-After the electron enters the magnetic field, $\vec{B}$
calculate the magnitude of the magnetic force acting on the electron.

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B-Find the centripetal acceleration of the electron's orbit inside the magnetic field.

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C- Find the radius of the electron's orbit inside the magnetic field.

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D-Does the magnitude of the velocity per time of the electron change Inside the magnetic field? Explain your answer?

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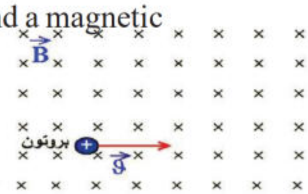
A proton enters a uniform magnetic field of magnitude 0.20T as in the diagram, and a magnetic force of $6.4X10^{-15}$N is applied to it.



Calculate the magnitude of the proton's velocity

Find the radius of the proton and plot its path on the diagram.

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According to the figure below a proton Is travelling at a constant velocity Of $V = 2.6 \times 10^5 m/s$, then enter a uniform that is magnetic field of $B = 4.2 \times 10^{-2} T$ directed into the page

A-After the proton enters the magnetic field $\vec{B}$

calculate the magnitude of the magnetic force acting on the proton.

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B- Find the radius of the proton's orbit inside the magnetic field.

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C- Suppose the direction of the velocity at which the proton is travelling changes, so that the direction of the velocity is not perpendicular to the direction of the magnetic field and is also not parallel to direction of the magnetic field.

What happens to the orbit of the proton's motion inside the magnetic field? Explain Why?

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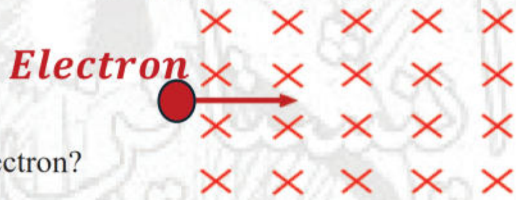
As shown in the figure, an electron moving at a velocity of ($v = 720\ m/s$) ,*enters a uniform magnetic field of* ($B = 2.4 \times 10^{-10}\ T$)

(Ignore the effect of earth gravitation)



A. *Calculate the acceleration of the electron.*

B. What is the direction of the force acting on the electron?

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Check your understanding:

1. A small aluminum ball with a mass of 5.063 g and a charge of 11.03 C is moving northward at 3079 m/s. You want the ball to travel in a horizontal circle with a radius of 2.137 m and in a clockwise direction when viewed from above. Ignoring gravity, what is the magnitude of the magnetic field ?

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2. A small aluminum ball with a charge of 11.17 C is moving northward at 3131 m/s. You want the ball to travel in a horizontal circle with a radius of 2.015 m and in a clockwise direction when viewed from above. Ignoring gravity, the magnitude of the magnetic field that must be applied to the aluminum ball to cause it to move in this way is B = 0.8000 T. What is the mass of the ball?

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3. A small, charged aluminum ball with a mass of 3.435 g is moving northward at 3183 m/s. You want the ball to travel in a horizontal circle with a radius of 1.893 m and in a clockwise direction when viewed from above. Ignoring gravity, the magnitude of the magnetic field that must be applied to the aluminum ball to cause it to move in this way is B = 0.5107 T. What is the charge on the ball?

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4. An electron is moving at $v = 6.00\times10^{7}$ m/s perpendicular to the Earth's magnetic field. If the field strength is 0.500×10^{-4} T, what is the radius of the electron ?

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5. The radius of the circular trajectory a particle is following is r = 2.300 m. The magnitude of the magnetic field in the TPC is B = 0.5000 T. We can assume that the particle has charge $|q| = 1.6 \times 10^{-19}$ C. What is the component of the particle's momentum that is perpendicular to the magnetic field?

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6. An electron moves in a circular trajectory with radius r_i in a constant magnetic field. What is the final radius of the trajectory when the magnetic field is doubled?

ⓐ $\frac{ri}{4}$ ⓑ $2ri$ ⓒ $\frac{ri}{2}$ ⓓ $4ri$

7.4 Magnetic Force on a Current-Carrying Wire

Cross product or RHR direction

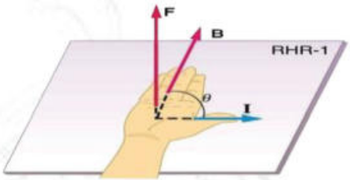
$$F = I\,l\,b\,\sin(\theta)$$

F: *magnetic force on wire* (N)

I: *conventional electric current* (A)

L: *length of affected wire* (m)

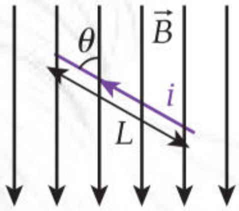
B: *magnetic field strength* (T)



Check your understanding:

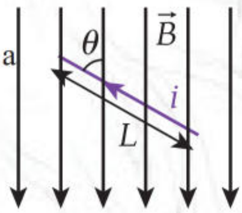
1. An isolated segment of wire of length L = 4.50 m carries a current of magnitude i = 35.0 A at an angle θ = 50.3° with respect to a constant magnetic field of magnitude $B = 6.70\times10^{-2}$ T (see the figure).

What is the magnitude of the magnetic force on the wire?



ⓐ *2.66 N* ⓑ *3.86 N* ⓒ 5.60 N ⓓ 8.12 N

7. According to the figure, an isolated segment of wire of length (L=8.3m) carries a current of magnitude (i=1.5A) at an angle (θ=60.0°) with respect to a constant magnetic field of magnitude ($B=5.4\times10^{-2}$T).
   What is the magnitude of the magnetic force on the wire?



ⓐ 058 *N* ⓑ 2.16 *N* ⓒ 0.29 N ⓓ 0.33 N

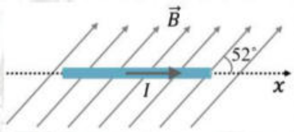
8. A wire of length 5 m, placed in a magnetic field of strength 0.80 T, experiences a force of 12 N. If the current through the wire is 6 A,
   What approximate angle does the wire make with the magnetic field?

ⓐ 30° ⓑ 60° ⓒ 15° ⓓ 30°

9. A 7.0 cm straight wire carrying a current of 4.2 A is placed in a uniform magnetic field of strength 4.25 T oriented at 52° to the x-axis as shown below.

What is the magnetic force on the wire?

ⓐ *2.12 N* ⓑ *0.98 N* ⓒ 2.16 N ⓓ 1.75 N



10. A straight wire carrying a 5.0A current is in a uniform magnetic field oriented at right angles to the wire. When 0.10 m of the wire is in the field, the force on the wire is 0.20 N.
    What is the strength of the magnetic field (B)?

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11. A wire that is 75 cm long and carrying a current of 6.0 A is at right angles to a uniform magnetic field. The magnitude of the force acting on the wire is 0.60 N.
    What is the strength of the magnetic field?

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12. How much current would be required to produce a force of 0.38 N on a 10.0-cm length of wire at right angles to a 0.49T field?

13. A straight wire of length 2.00 m carries a current of 24.0 A. It is placed on a horizontal tabletop in a uniform horizontal magnetic field. The wire makes an angle of 30.0° with the magnetic field lines. If the magnitude of the force on the wire is 0.500 N

What is the magnitude of the magnetic field?

A loudspeaker produces sound by exerting a magnetic force on a voice coil in a magnetic field, as shown in Figure. The movable voice coil is connected to a speaker cone that actually produces the sounds. The magnetic field is produced by the two permanent magnets as shown. The magnitude of the magnetic field is $B = 1.50$ T. The voice coil is composed of $n = 100$ turns of wire carrying a current, $i = 1.00$ mA. The diameter of the voice coil is $d = 2.50$ cm.

What is the magnetic force exerted by the magnetic field on the loudspeaker's voice coil?

$F = iLB\sin\theta, L = n\pi d.$

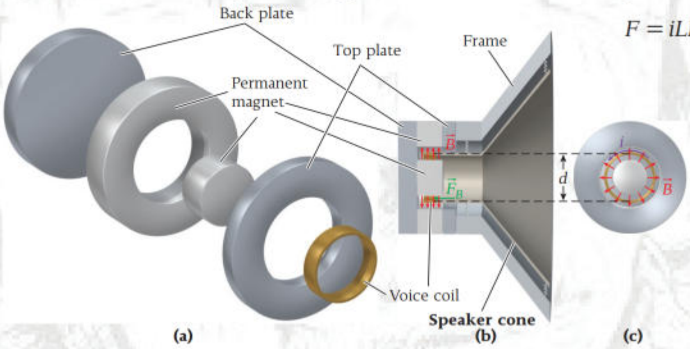
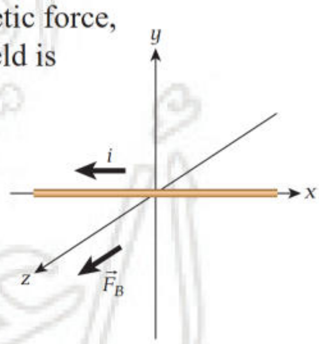


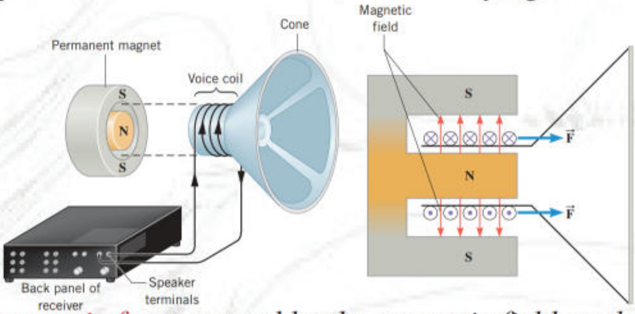
FIGURE Schematic diagram of a loudspeaker: (a) an exploded three-dimensional view of the driver end of the loudspeaker; (b) a cross-sectional side view of the loudspeaker; (c) a front view of the driver end of the loudspeaker.

The figure shows a 12cm wire lying along the x-axis with a current, , $i = 2.00$ mA, flowing in the negative x direction. The wire is in a uniform magnetic field. The magnetic force, FB, acts on the wire is 3.6×10^{-2}N in the positive z-direction. The magnetic field is oriented so that the force is maximum.

What is the magnitude and direction of the magnetic field ?

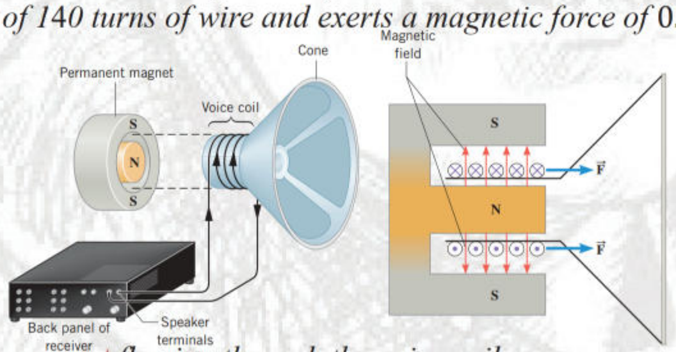


A loudspeaker produces sound by exerting a magnetic force on a voice coil in a magnetic field, as shown in the Figure below. The movable voice coil is connected to a speaker cone that actually produces the sounds. The magnetic field is produced by the two permanent magnets as shown, the magnitude of the magnetic field is 2.2 T. The voice coil has a radius of 1.4 cm, is composed of 150 turns of wire, and is carrying a current 3.3 mA .



Calculate the magnetic force exerted by the magnetic field on the loudspeaker's voice coil.

A loudspeaker produces sound by exerting a magnetic force on a voice coil in a magnetic field, as shown in the figure below. The movable voice coil is connected to a speaker cone that actually produces the sounds. The magnetic field is produced by the two permanent magnets as shown, with a magnitude of 37 T. The voice coil has a diameter 6cm, *is composed of 140 turns of wire and exerts a magnetic force of* $0.015\ N$.



Calculate the current flowing through the voice coil.

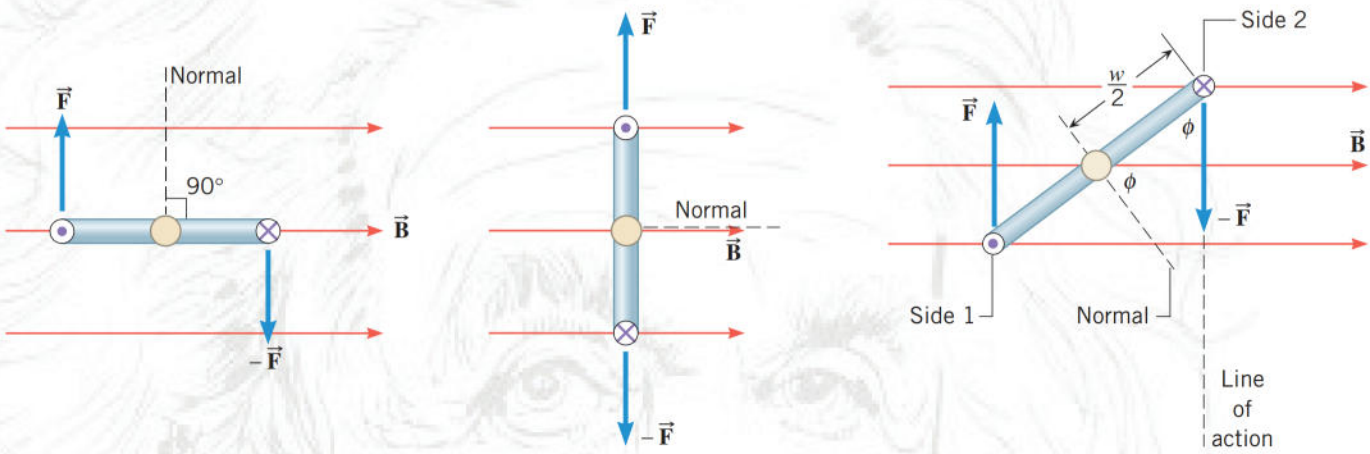
7.5 Torque on a Current-Carrying Loop

NOTES

$$\tau = NiAB\sin(\theta)$$

N: number of loops
I: current (A)
A: Area loop (m^2)
B: magnetic field strength(T)

circular loop $A = \pi r^2$
square loop $A = L^2$
rectangle loop $A = L \times W$



(a) Maximum torque (b) Zero torque

Check your understanding:

1. A coil is composed of circular loops of radius r = 5.13 cm and has N = 47 windings. A current, i = 1.27 A, flows through the coil, which is inside a homogeneous magnetic field of magnitude 0.911 T.
   What is the maximum torque on the coil due to the magnetic field?

ⓐ *0.148 N.m* ⓑ *0.662 N.m* ⓒ 0.450 N.,m ⓓ 0.350 N.m

14. A coil (X) consists of (400) loop and a coil (Y) consists (900) loop, If the torque on each loop of the coil (X) is equal to the torque on each loop of the coil (Y).
    What is the ratio between the two torques($\frac{\tau x}{\tau y}$)?

ⓐ 2/3 ⓑ 9/4 ⓒ 4/9 ⓓ 3/2

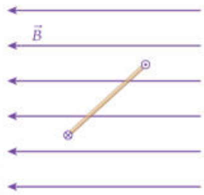
15. If the coil (X) consists of (1000) loops and the coil (Y) consists of (2500) loops. If the torque acting on each ring of the coil (X) is equal to the torque acting on each ring of the coil (Y) What is the ratio between the two torques($\frac{\tau x}{\tau y}$)?

ⓐ $\frac{4}{9}$ ⓑ $\frac{9}{4}$ ⓒ $\frac{2}{3}$ ⓓ $\frac{3}{2}$

16. If the coil (X) consists of (2800) loops and the coil (Y) consists of (3500) loops.
    If the torque acting on each ring of the coil (X) is equal to the torque acting on each ring of the coil (Y) What is the ratio between the two torques($\frac{\tau x}{\tau y}$)?

ⓐ $\frac{4}{5}$ ⓑ $\frac{5}{4}$ ⓒ $\frac{2}{3}$ ⓓ $\frac{3}{2}$

17. The top view of a current-carrying loop in a constant magnetic field is shown in the figure. The torque on the loop will cause it to rotate
a) clockwise.
b) counterclockwise.



18. A rectangular coil with 20 windings carries a current of 2.00 mA flowing in the counterclockwise direction. It has two sides that are parallel to the y-axis and have length 8.00 cm and two sides that are parallel to the x-axis and have length 6.00 cm. A uniform magnetic field of 50.0 μT acts in the positive x-direction.

What torque must be applied to the loop to hold it steady?

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A circular coil with a radius of 10.0 cm has 100 turns of wire and carries a current, $I = 1.00$ mA. It is free to rotate in a region with a constant horizontal magnetic field given by $B = (0.0100\ T)\hat{x}$. If the unit normal vector to the plane of the coil makes an angle of 30.0° with the horizontal, what is the magnitude of the net torque acting on the coil?

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