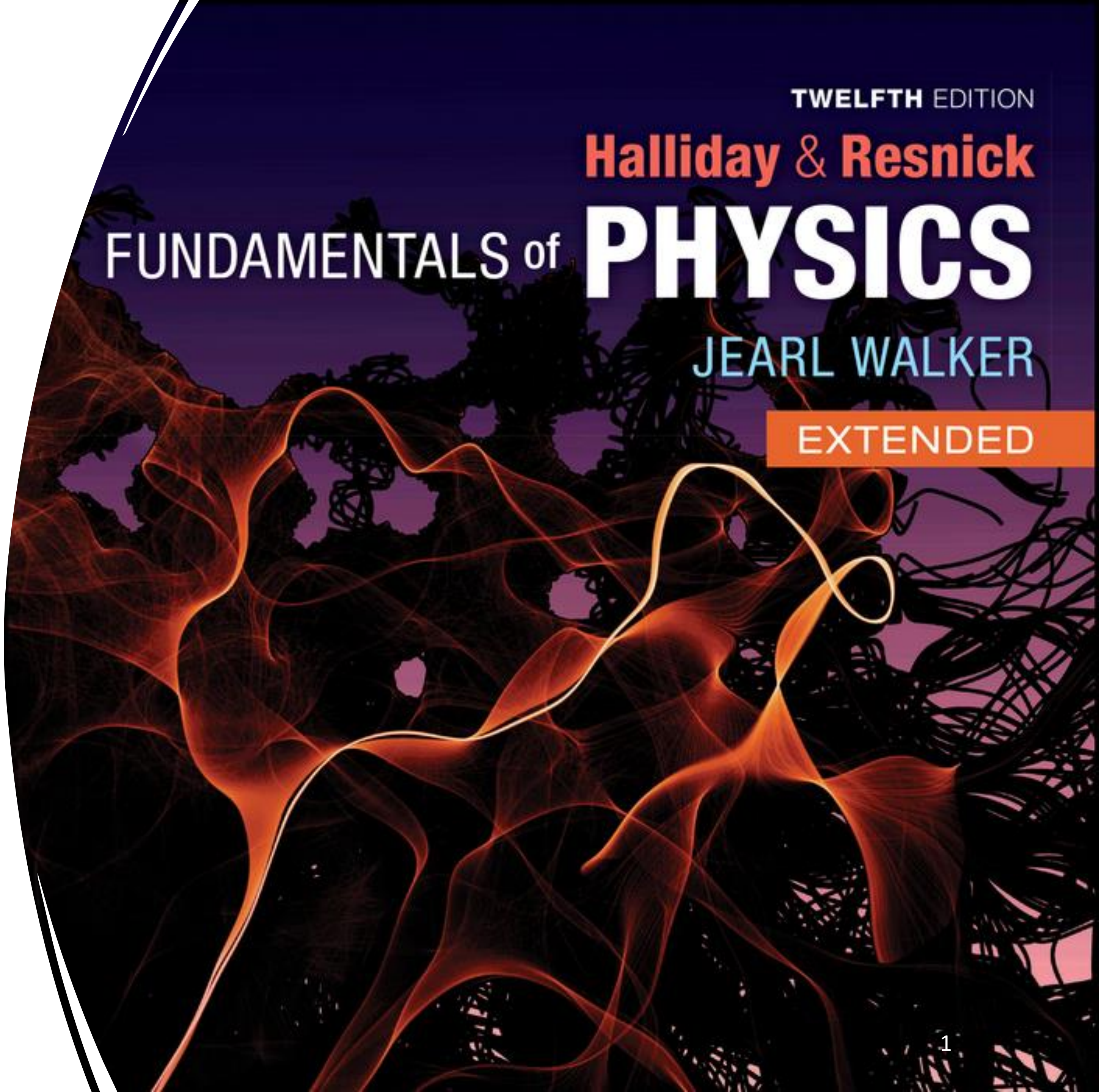
Tue 28 Apr

Chapter 28

Magnetic Fields

***Fundamentals of Physics*, Twelfth Edition. Halliday & Resnick, Walker**



Chapter 28 Magnetic Fields

28.1 Magnetic Fields and the Definition of Vector B

28.6 Magnetic Force on a Current-Carrying Wire

Section 28.1 Magnetic Fields and the Definition of Vector B

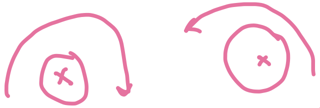
$\vec{c} = \vec{a} \times \vec{b}$ cross product

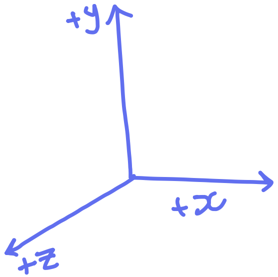
$\vec{a} \times \vec{b} = -\vec{b} \times \vec{a}$

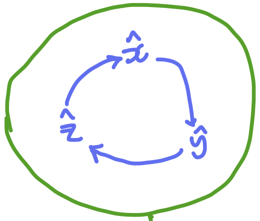
$c = |\vec{a}| \times |\vec{b}| \times \sin\theta$

$\theta = 0 \quad c = 0 \quad \sin 0 = 0$

$\theta = 90^\circ \quad c_{max} \quad \sin 90 = 1$







important + not in sliders

$\hat{x} \times \hat{y} = \hat{z}$

$\hat{y} \times \hat{z} = \hat{x}$

$\hat{z} \times \hat{x} = \hat{y}$

If orders flipped } all same but opposite sign

sin → cross
cos → dot

a charge (q) moving ($\vec{v}$) in the presence of magnetic field $\vec{B}$ (Tesla)

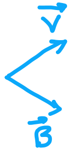
⇓

Magnetic force

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

$F = |q| v \times B \times \sin\theta$

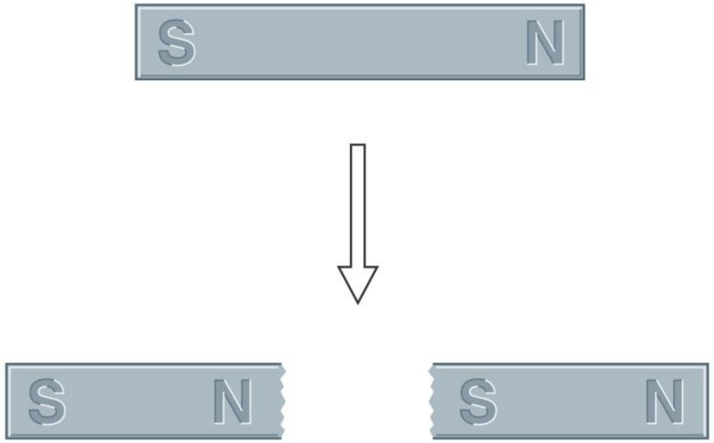
N C $\frac{m}{s}$ T



Magnetic Field

General observations regarding magnets and the field they produce:

A) Permanent bar magnets



1. They have *opposite poles* on each end, called North and South.

2. Like poles repel; opposites attract.

3. Magnets always have two poles (there are no magnetic monopoles*)*. If a magnet is broken in half, each half will still have two poles

B) Magnetic field lines

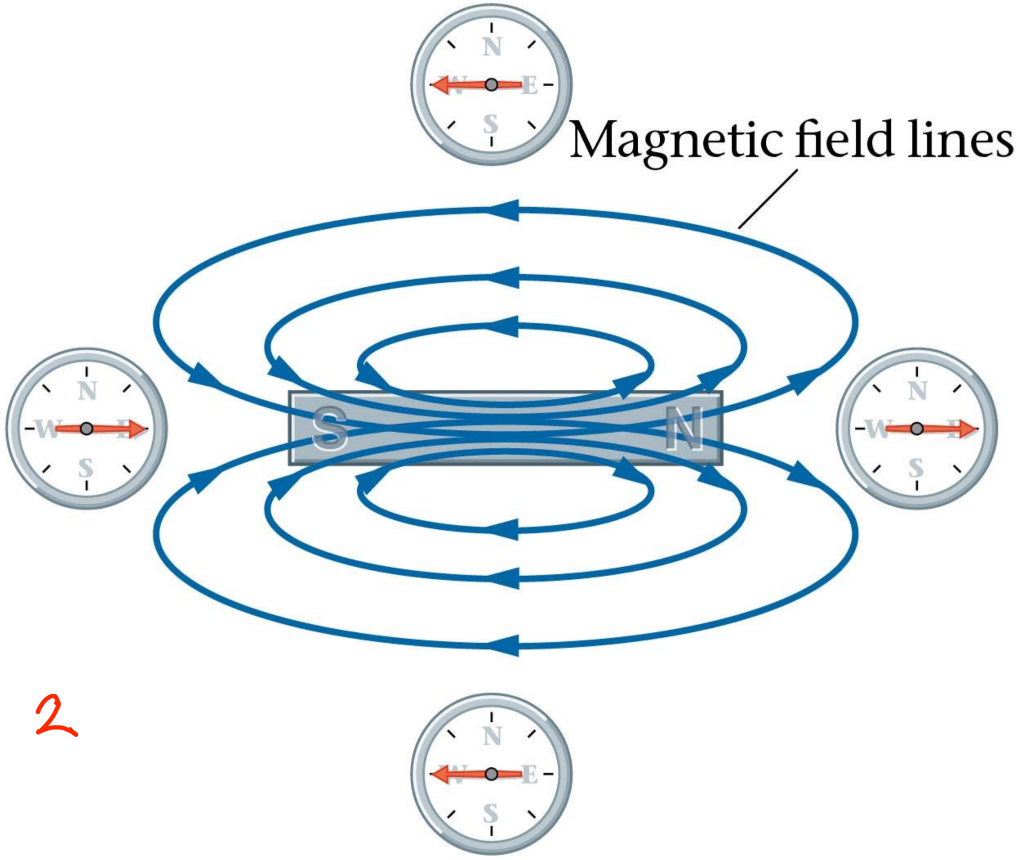
A magnet creates **magnetic field ($\vec{\mathbf{B}}$)** in its vicinity (just like an electric charge will create an electric field around it).

- The direction of the magnetic field ($\vec{B}$) at any position, is the direction in which the *North* Pole of a compass points when placed at that location.

- By definition, magnetic field **lines exit from the *North Pole*** of a magnet and ***enter at the South Pole*** (they always form closed loops)

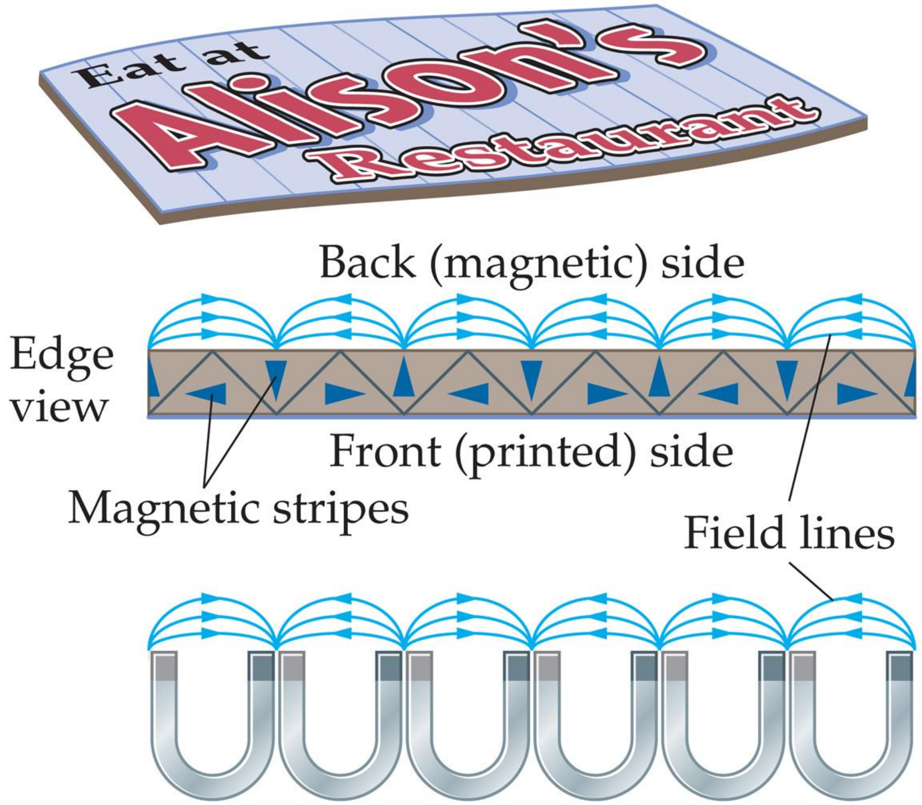
- Magnetic field lines *CANNOT CROSS*, just as electric field lines cannot.

compass can't in 2 direction

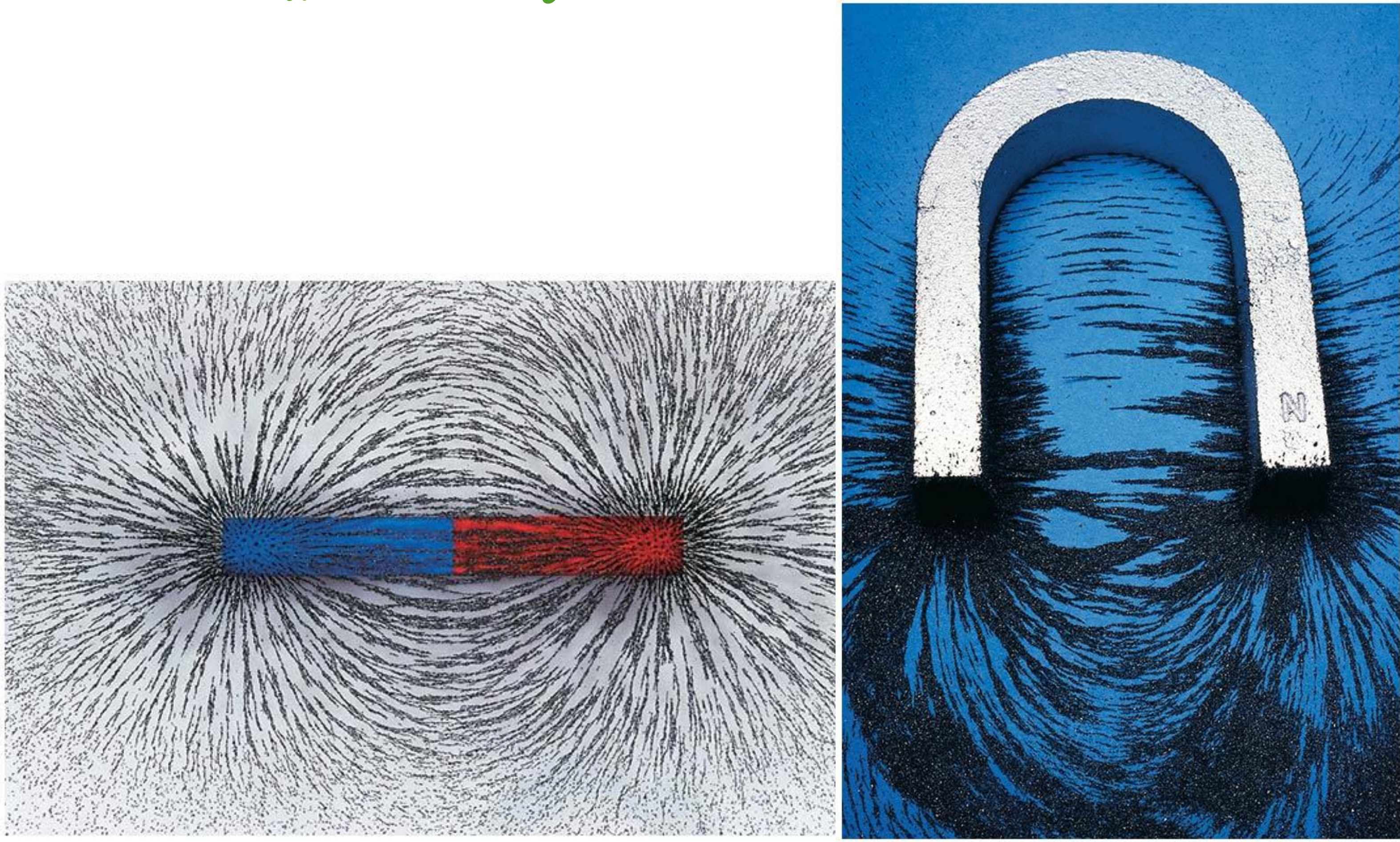


Magnetic field lines

Magnetic field lines
Strong: a lot of lines
weak: less
uniform: straight, parallel

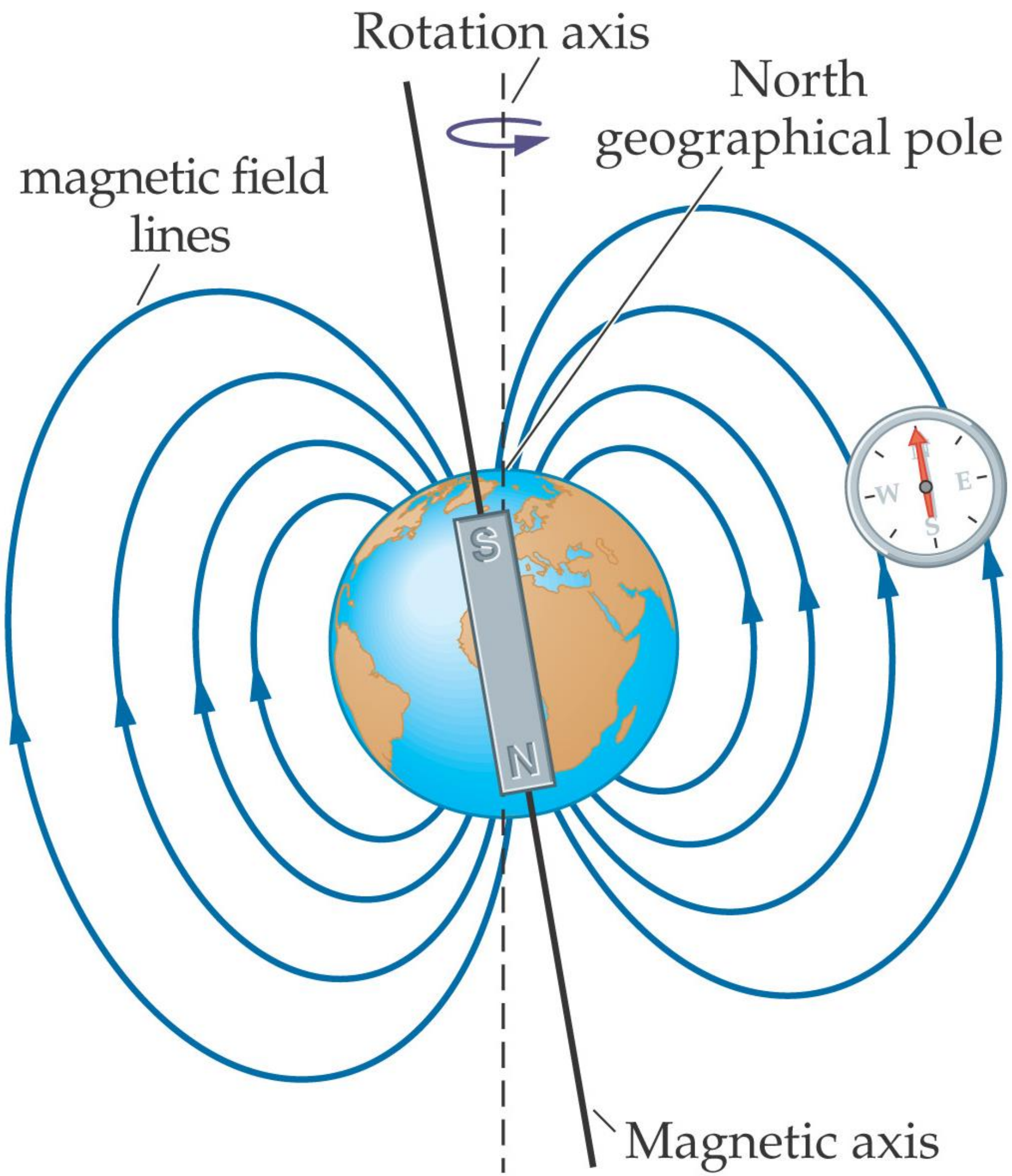


Magnetic field lines more intense on one side than the other



(a) (b)

- The Earth's magnetic field resembles that of a bar magnet. Since the north pole of a compass points toward the North magnetic pole of the earth, and since opposites attract, it follows that:
    - The ***north geographic pole*** of the earth is actually *near* the ***south magnetic pole.***



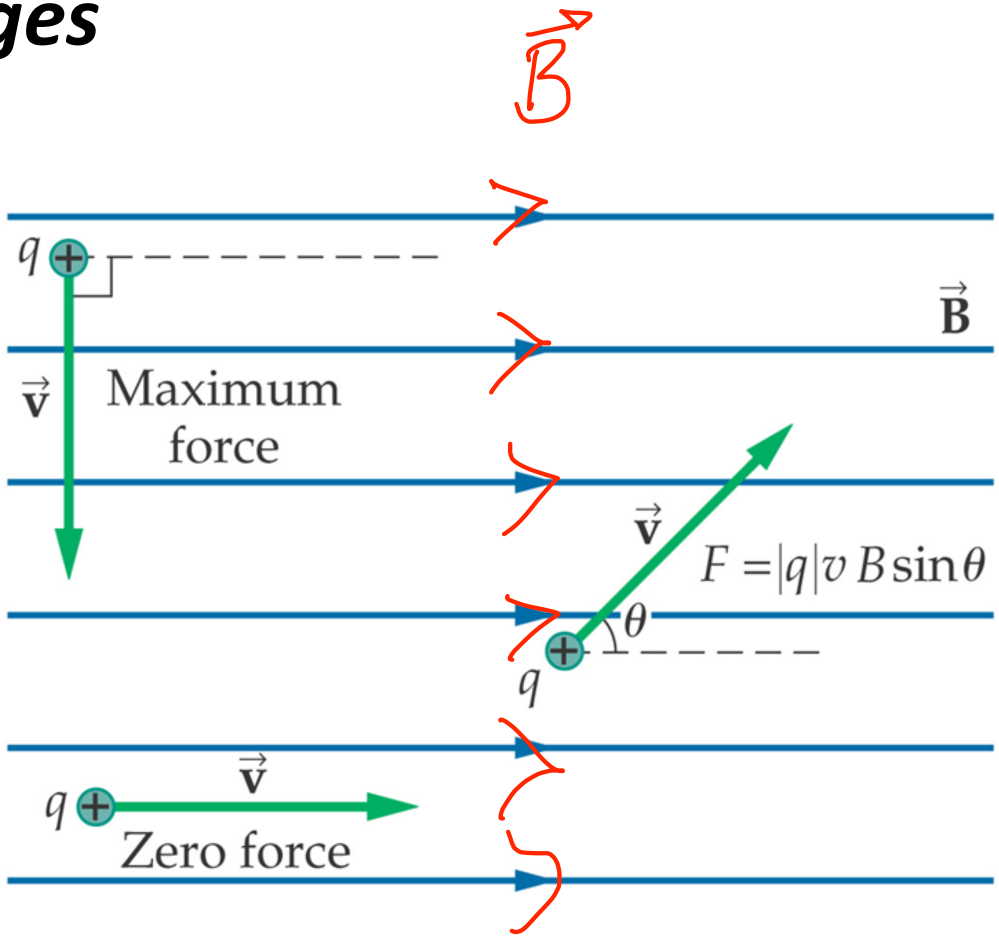
The SI-unit of the magnetic field **B** is the TESLA (T). A more practical unit is the Gauss (G) **(1 T = 10,000 G).**

TABLE 22-1 Typical Magnetic Fields

Physical system	Magnetic field (G)
Magnetar (a magnetic neutron star formed in a supernova explosion)	10^{15}
Strongest man-made magnetic field	6×10^5
High-field MRI	15,000
Low-field MRI	2000
Sunspots	1000
Bar magnet	100
Earth	0.50

The Magnetic Force on Moving Charges

- For a particle of charge $\boldsymbol{q}$, moving through a magnetic field $\vec{B}$ that points to the right, with a velocity $\vec{v}$, and if the angle between the velocity and the magnetic field is $\boldsymbol{\theta}$ then the magnitude of the magnetic force on this charge is:



> **Magnitude of the Magnetic Force, *F***
>
> $F = |q|vB \sin\theta$
>
> SI unit: newton, N

positive z, outward

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

$+(-\hat{y}) \times (+\hat{x}) = +\hat{z}$ ⊙

Note: The magnetic force on a moving charge will be zero when the charge moves in the direction of the field or opposite to it (θ = 0, 180^o).

In fact, the magnetic force on a moving charge is used

to **define the magnetic field**:

Definition of the Magnitude of the Magnetic Field, *B*

$$B = \frac{F}{|q|v \sin\theta}$$

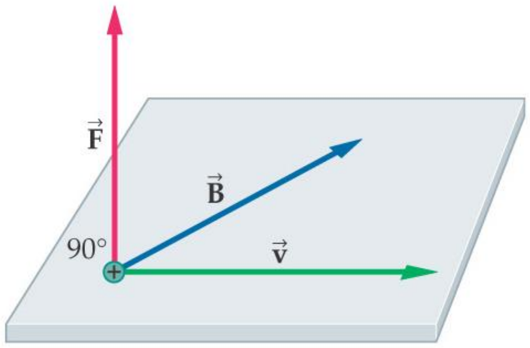
SI unit: 1 tesla $= 1\,\mathrm{T} = 1\,\mathrm{N/(A \cdot m)}$

Magnetic force right hand rule:

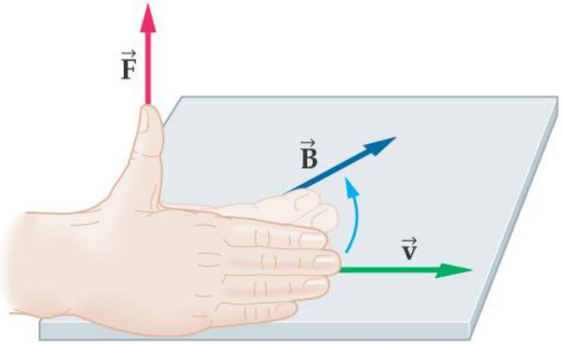
In order to figure out which **direction the force** is on a moving charge, you can use a right-hand rule. This ***gives the direction of the force on a positive charge***; the force on a negative charge would be in the opposite direction.

This relationship between the three vectors – magnetic field, velocity, and force – can also be written as a vector cross product:

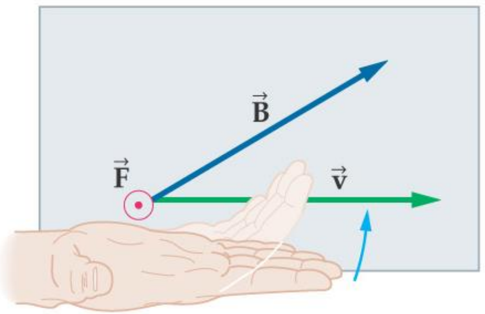
$$\vec{\mathbf{F}} = q\vec{\mathbf{v}} \times \vec{\mathbf{B}}$$



(a)

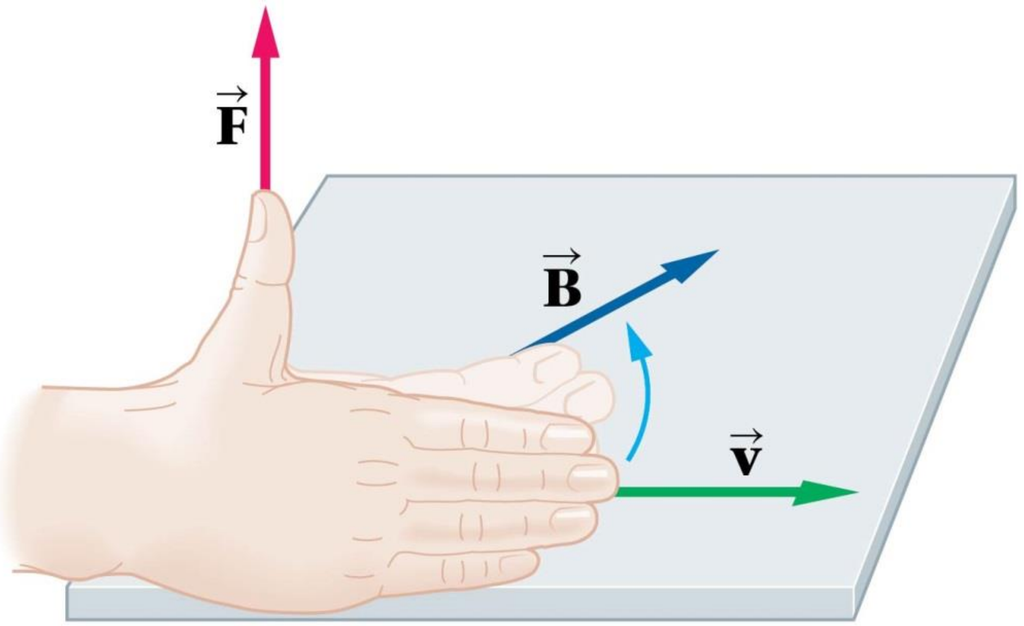


(b)

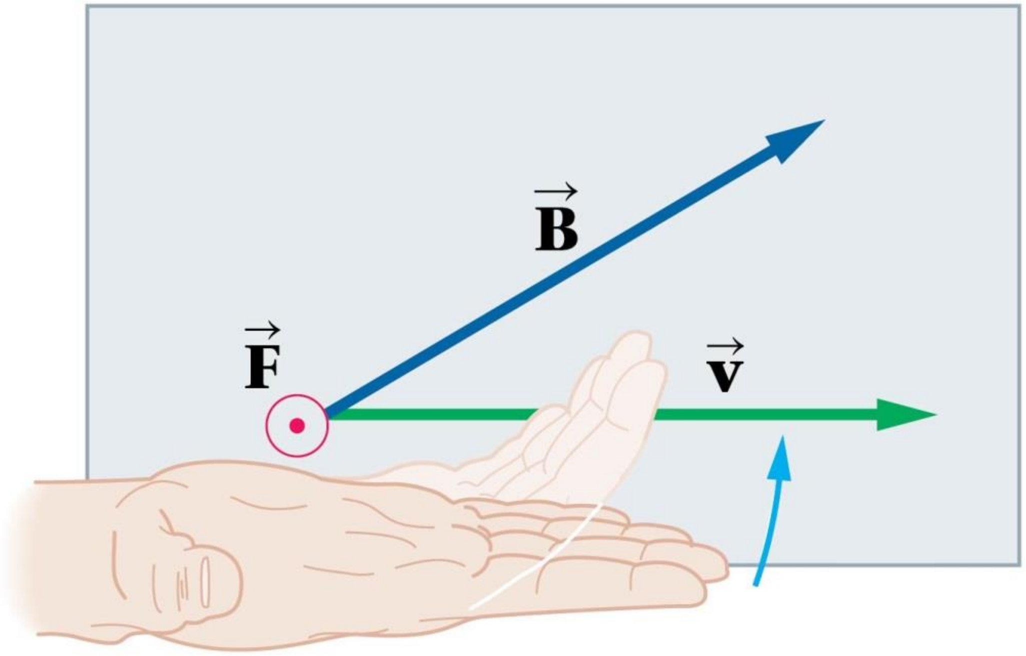


(c) Top view

- For the direction of the force on a positive charge use the RHR
- For negative charges use left hand OR reverse the direction obtained by the RHR



(b) Curl fingers from $\vec{v}$ to $\vec{B}$; thumb points in direction of $\vec{F}$



(c) Top view, looking down on $\vec{F}$

Checkpoint #1

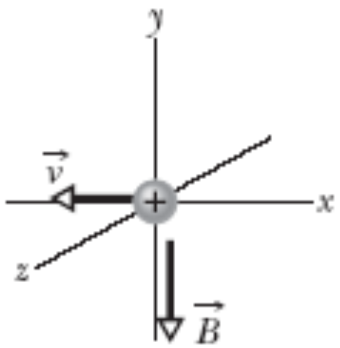
$\vec{F} = q\vec{v} \times \vec{B}$

$F = |q| v B \sin\theta$

$\hat{x} \rightarrow \hat{y} \rightarrow \hat{z} \rightarrow \hat{x}$

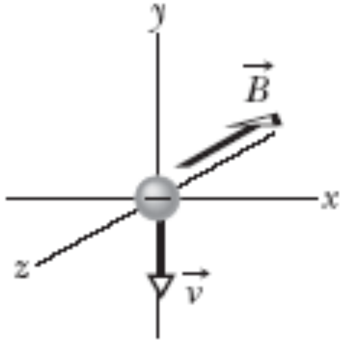
The figure shows three situations in which a charged particle with a velocity $\vec{v}$ travels through a uniform magnetic field $\vec{B}$. In each situation, what is the direction of the magnetic force $\vec{F}_B$ on the particle?

(a)



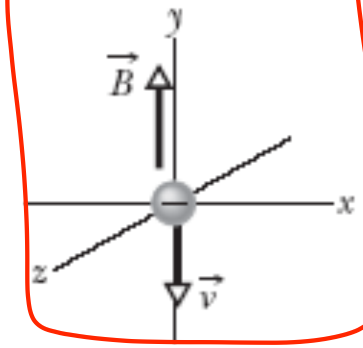
$-(-\hat{y}) \times (-\hat{z})$

(b)



$\boxed{-\hat{x}}$

(c)



$F = 0$

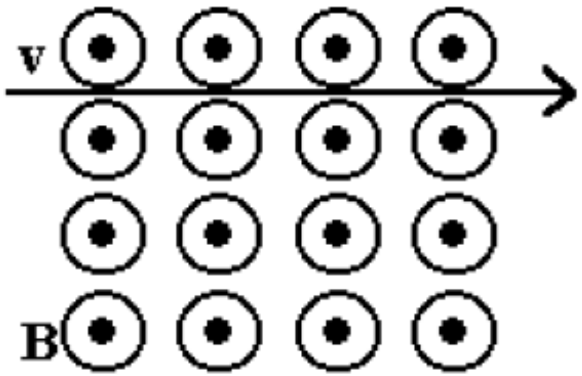
$\theta = 180$

$\sin(180) = 0$

Answer:

(a) towards the positive *z*-axis; (b) towards the negative *x*-axis;
(c) none (cross product is zero)

Checkpoint #2

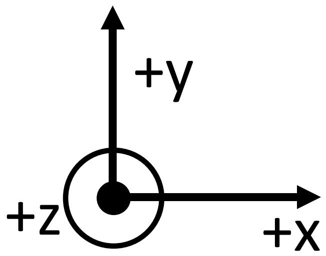


B =+z

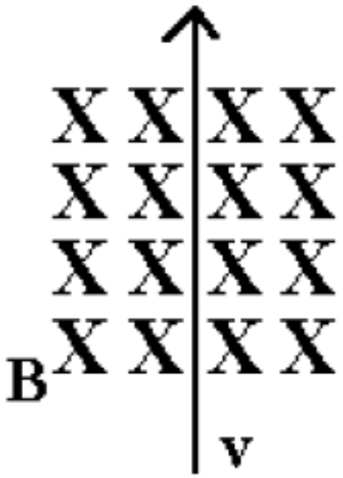
v = +x

F = -y

(for a positive charge)



$\vec{B}$

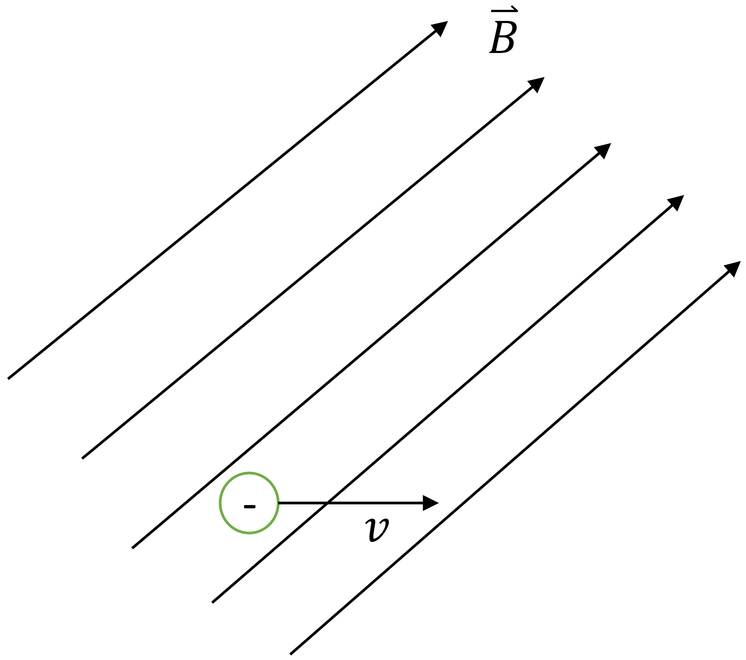


B = -z

v = +y

F = -x

(for a positive charge)



Example 1,

Particle 1, with a charge q_1 = 3.6 μc and a speed v_1= 862 m/s, travels at right angles to a uniform magnetic field. The magnetic force it experience is F_1 = 4.25 X 10^{-3} N.

Particle 2, with a charge q_2= 53 μc and a speed v_2 = 1.3 x 10^3 m/s, moves at an angle of (55.0 °) relative to the same magnetic field.

a) Find the magnetic field **B**.

b) Find $\mathbf{F_2}$ (the magnetic force exerted on the second object)

$\theta = 90°$

a

$\frac{F}{qv} = \frac{qv \times B}{qv} \times \cancel{\sin\theta}$ 1

$\frac{F}{qv} = B$

$B = 1.37$

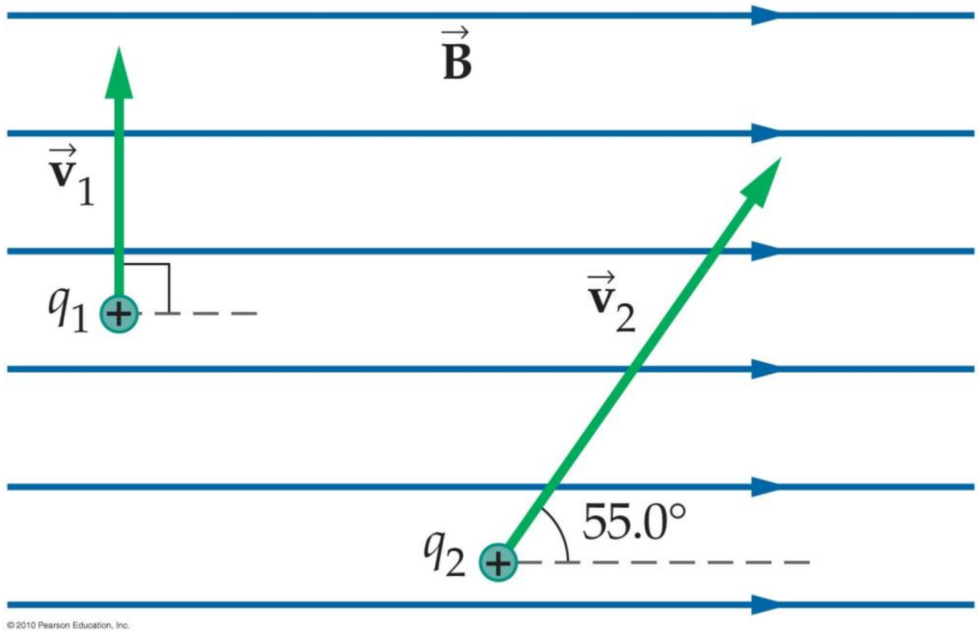
b $F_2 = |q_2| \times v_2 \times B \times \sin 55$

$\boxed{F_2 = 0.0773 N}$

Answers

a) 1.37 T

b) 0.0773 N



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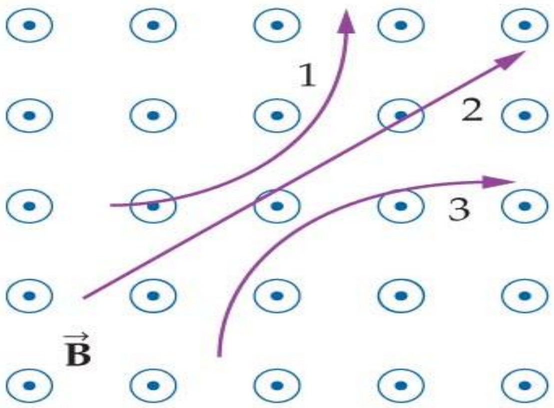
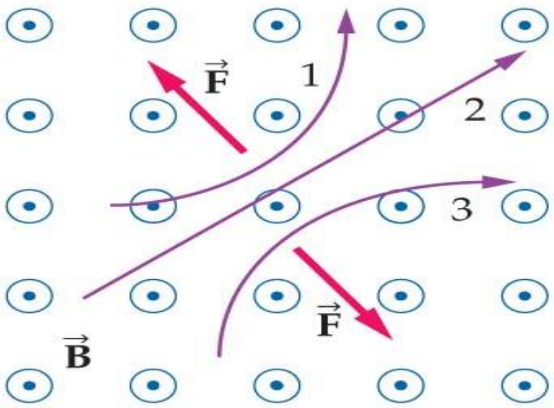
Checkpoint #3

Three particles travel through a region of space where the magnetic field is out of the page, as shown below in the sketch to the left. For each of the three particles, state whether the particle's charge is positive, negative, or zero.



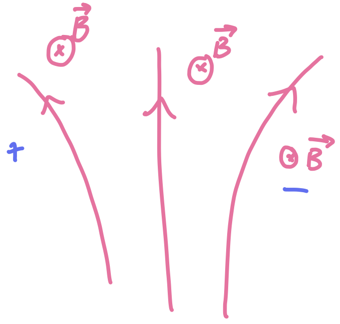


REASONING AND DISCUSSION

In the second sketch, we indicate the general direction of the force required to cause the observed motion. The force indicated for particle 3 is in the direction given by the magnetic force RHR; hence, particle 3 must have a positive charge. The force acting on particle 1 is in the opposite direction; hence, that particle must be negatively charged. Finally, particle 2 is undeflected; hence, its charge, and the force acting on it, must be zero.

ANSWER

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



neither deflect to right nor left

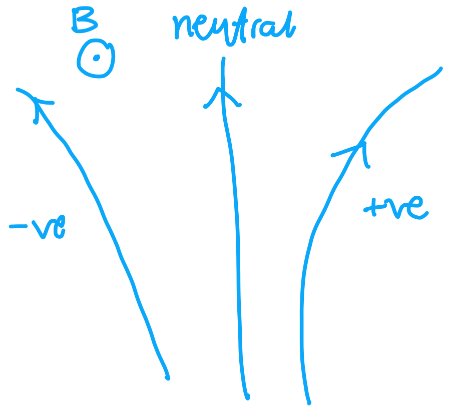
path unchanged = neutral

MCQ question

if right hand → positive

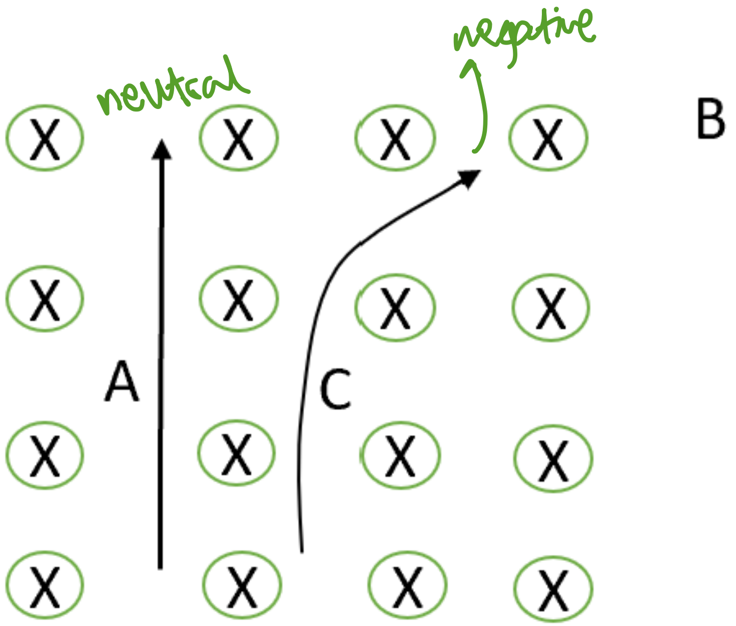
left → negative

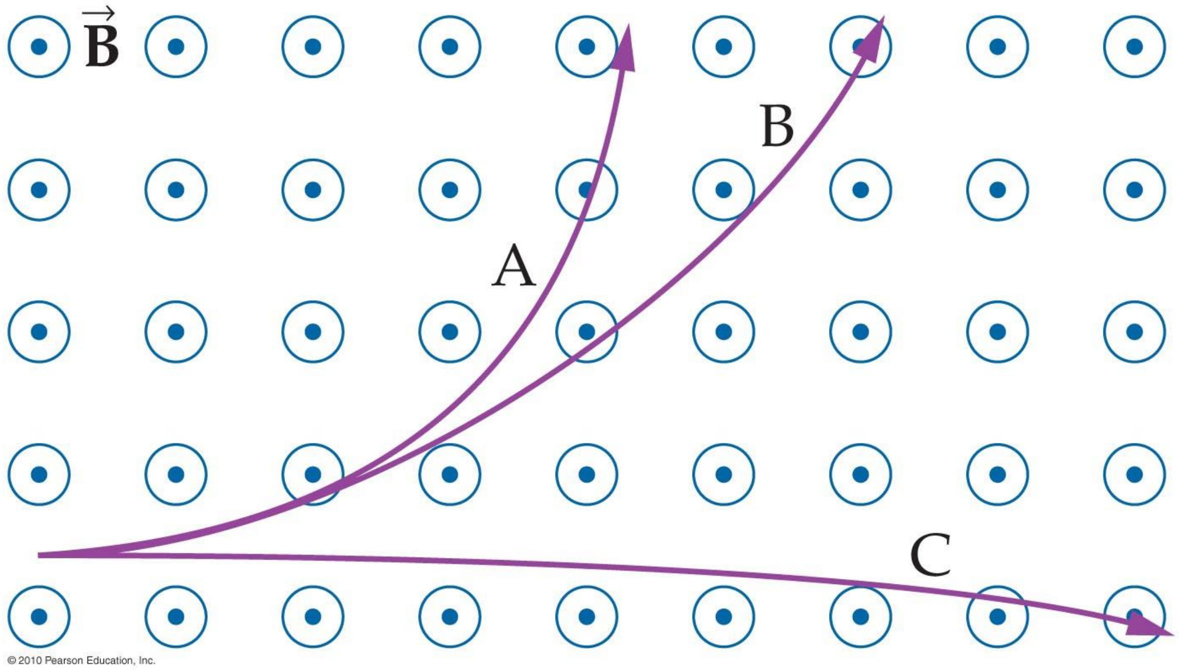
Figure out one, you'll be able to know the other



Exercise 1

For the figures shown, what is the sign of the charge for each of the three particles? explain





Straight : neutral

positive

C → since curve safe to say it's charged

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Exercise 2,

- An electron moves at right angles (90°) angle to a magnetic field of (0.18 T).

What is it's speed if the force exerted on it is 8.9 x 10^{-15} N

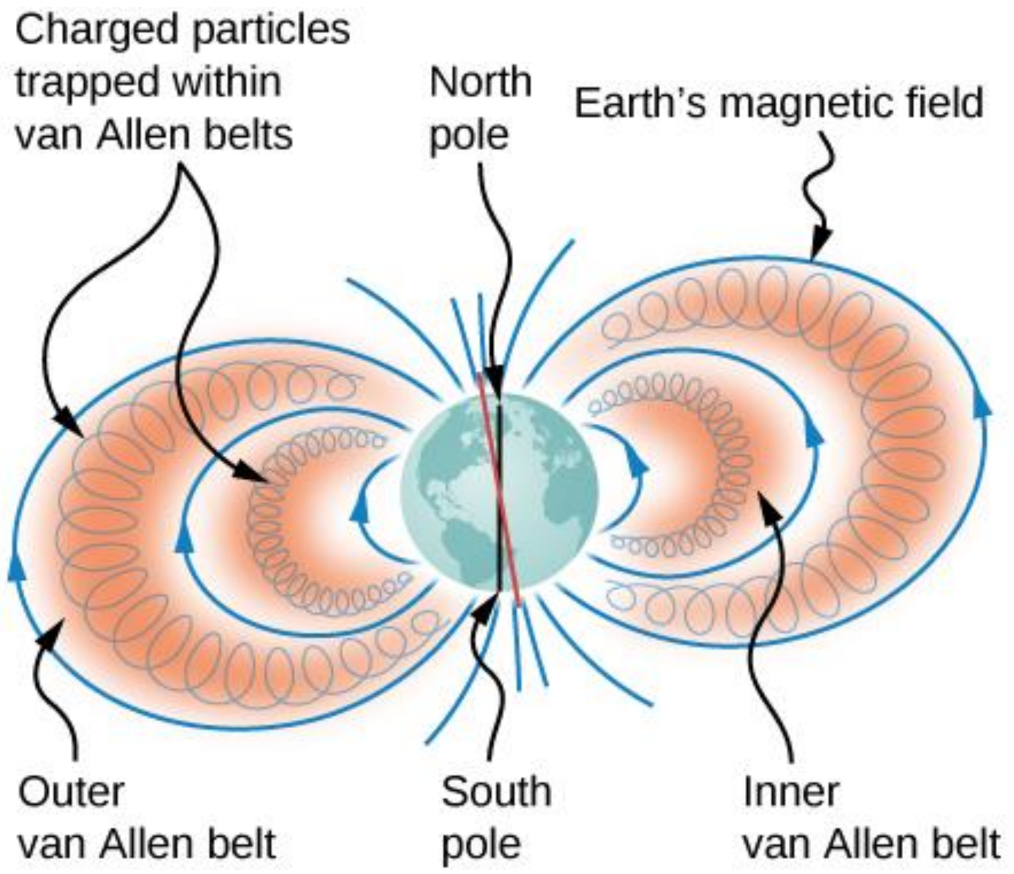
$\theta = 90^{\circ}$
$B = 0.18T$
$F = 8.9 \times 10^{-15} N$
$q = ?$

$F = qBv \sin(90)$

1.6×10^{-10}

3.1 X 10^{5} m/s

$3.09 \times 10^{5} \frac{m}{s}$



(a)

(b)

(a) The Van Allen radiation belts around Earth **trap ions produced by cosmic rays striking Earth's atmosphere**.
(b) The magnificent spectacle of the aurora borealis, or northern lights, glows in the northern sky above Bear Lake near Eielson Air Force Base, Alaska. Shaped by Earth's magnetic field, this light is produced by glowing molecules and ions of oxygen and nitrogen.

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Section 28.6 Magnetic Force on a Current-Carrying Wire

The Magnetic Force Exerted on a Current-Carrying Wire

The ***magnetic force*** *on a* ***segment of a current-carrying wire*** of length (***L***) with a current (***I***) flowing in this wire *in a magnetic field is given by:*

$$\vec{F}_B = i\vec{L} \times \vec{B} \quad \text{(force on a current).}$$

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

$I = \frac{q}{t}$ $\quad v = \frac{L}{t}$

$\vec{F} = I\cancel{t}\,\frac{L}{\cancel{t}} \times \vec{B}$

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

Magnetic Force on a Current-Carrying Wire

$$F = ILB\sin\theta$$

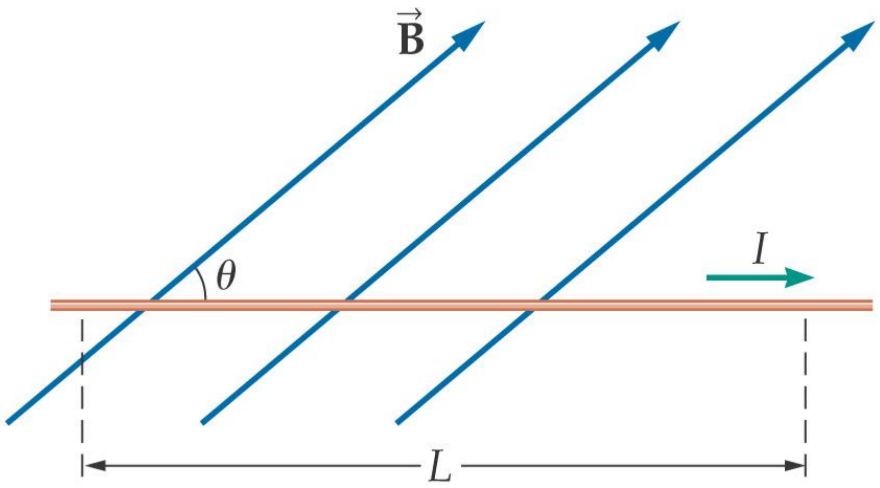
SI unit: newton, N

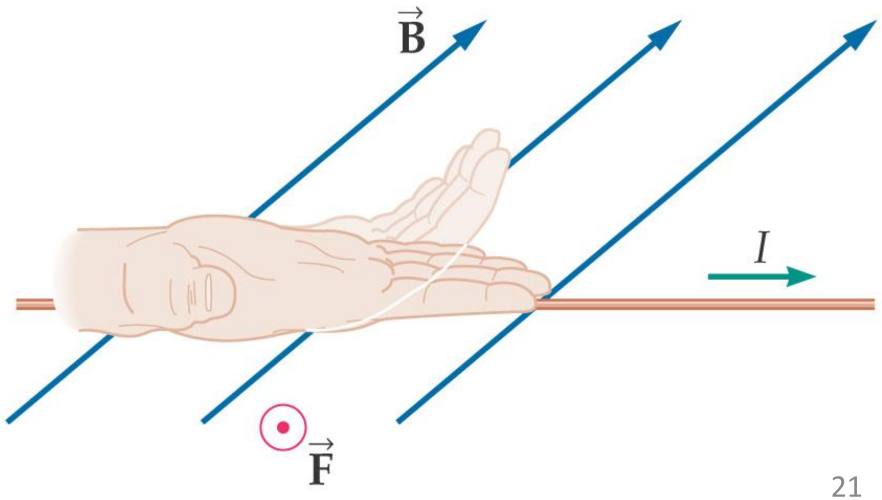
$F = ILB\sin\theta$

N A m T

B I F

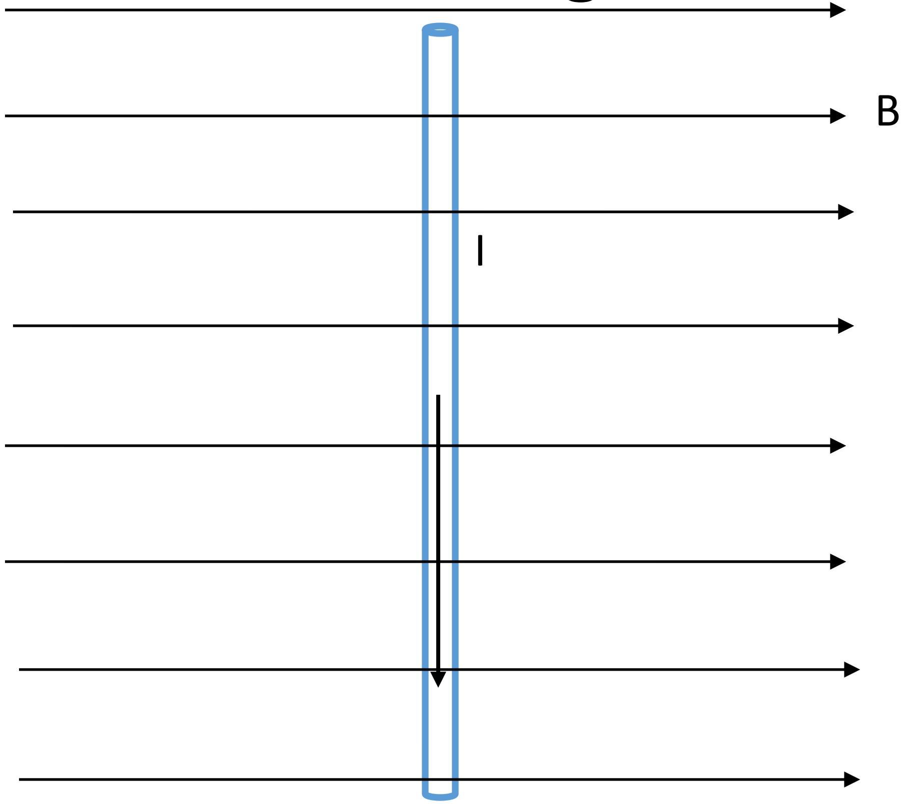
these are fingers...





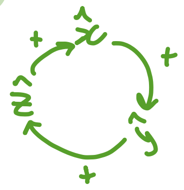
Exercise 1

Find the direction of the magnetic Force ?



outward

Other method:

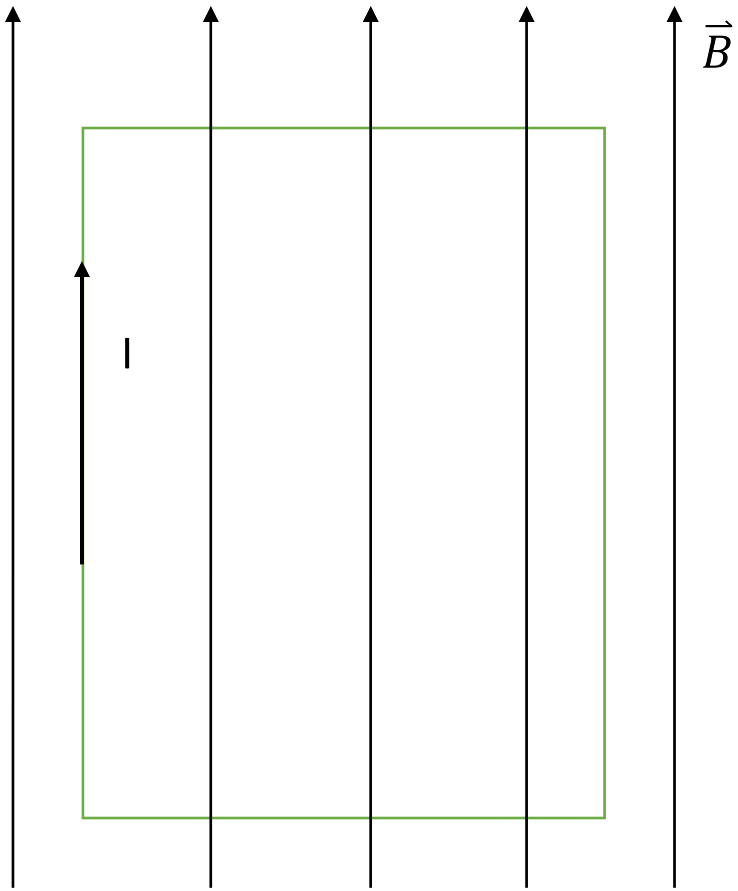


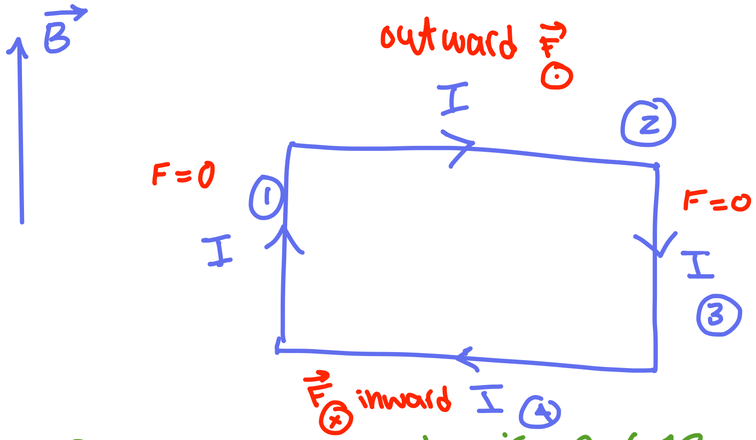
$(-\hat{y}) \times (+\hat{x})$ → since not in order take $\hat{z}$ but with negative

$-(-\hat{z}) = (+\hat{z})$

Exercise 2

Find the direction of the magnetic Force on each wire of the loop?





no force, since angle is 0 / 180

Exercise 3

What is the magnetic force exerted on a (2.15 m) length of wire carrying a current of (0.899 A) perpendicular to a magnetic field of (0.72 T)

means 90

so sin90 = 1

Answer: 1.4 N

$\vec{F} = ILB \overset{1}{\cancel{\sin\theta}} = 1.39N$

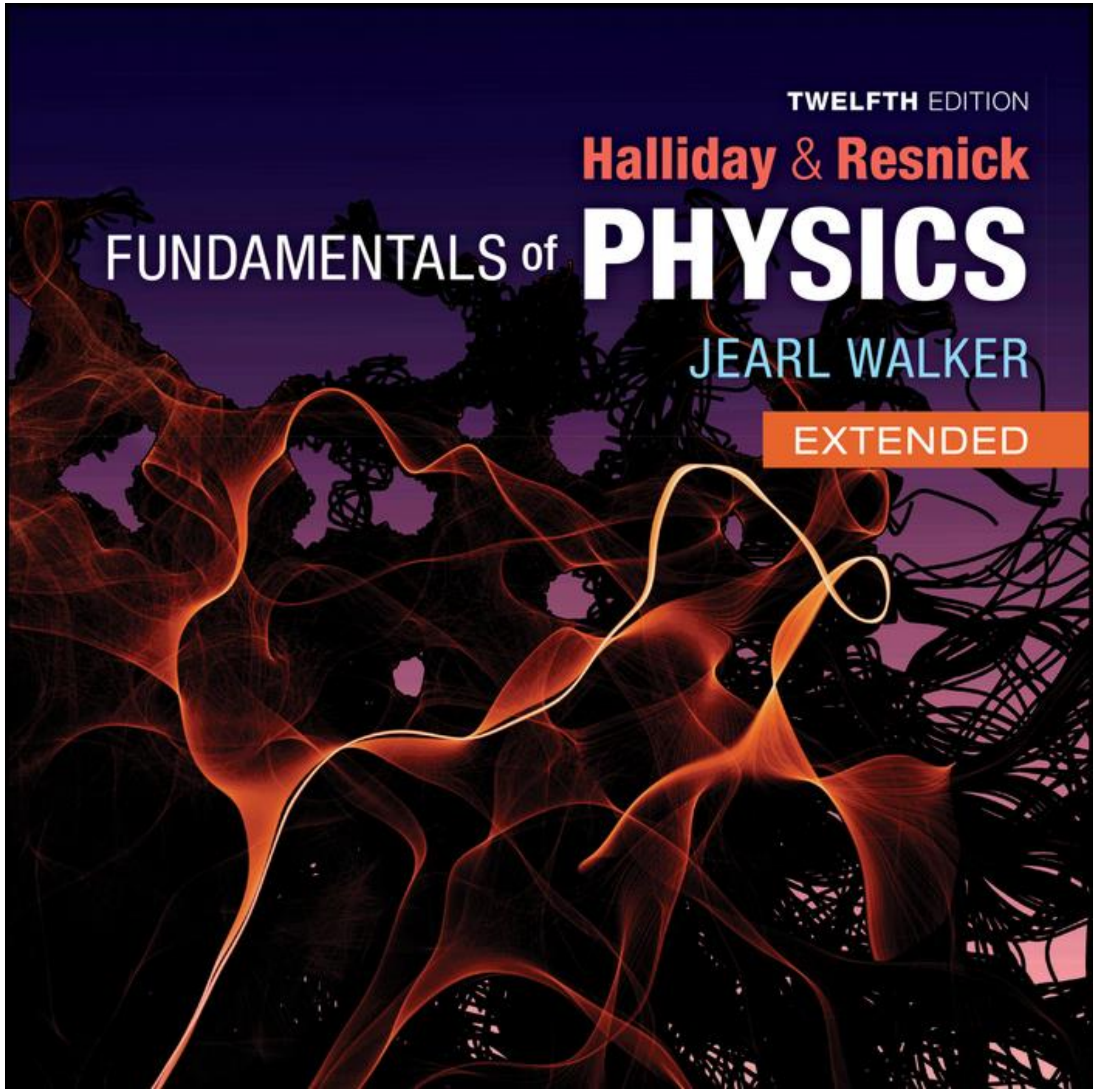
x → sin

· → cos

Fundamentals of Physics, Twelfth Edition. Halliday & Resnick, Walker

Chapter 29

Magnetic Fields due to Currents

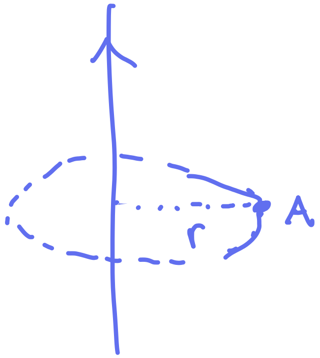


Chapter 29
Magnetic Fields due to Currents

29.1 Magnetic Field Due to A Current

29.2 Force Between Two Parallel Current

Section 29.1 Magnetic Field Due to A Current

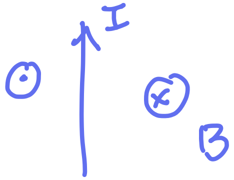


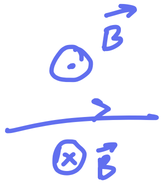
$$B_{at_A} = \frac{\mu_0 I}{2\pi r}$$

A

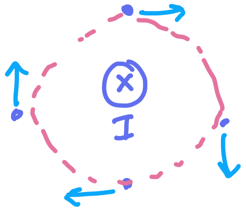
MCQ

$$B_{at_A} = \frac{\cancel{4\pi}\times 10^{-7} I}{\cancel{2\pi} r} = \frac{2\times 10^{-7} I}{r}$$





Tangent

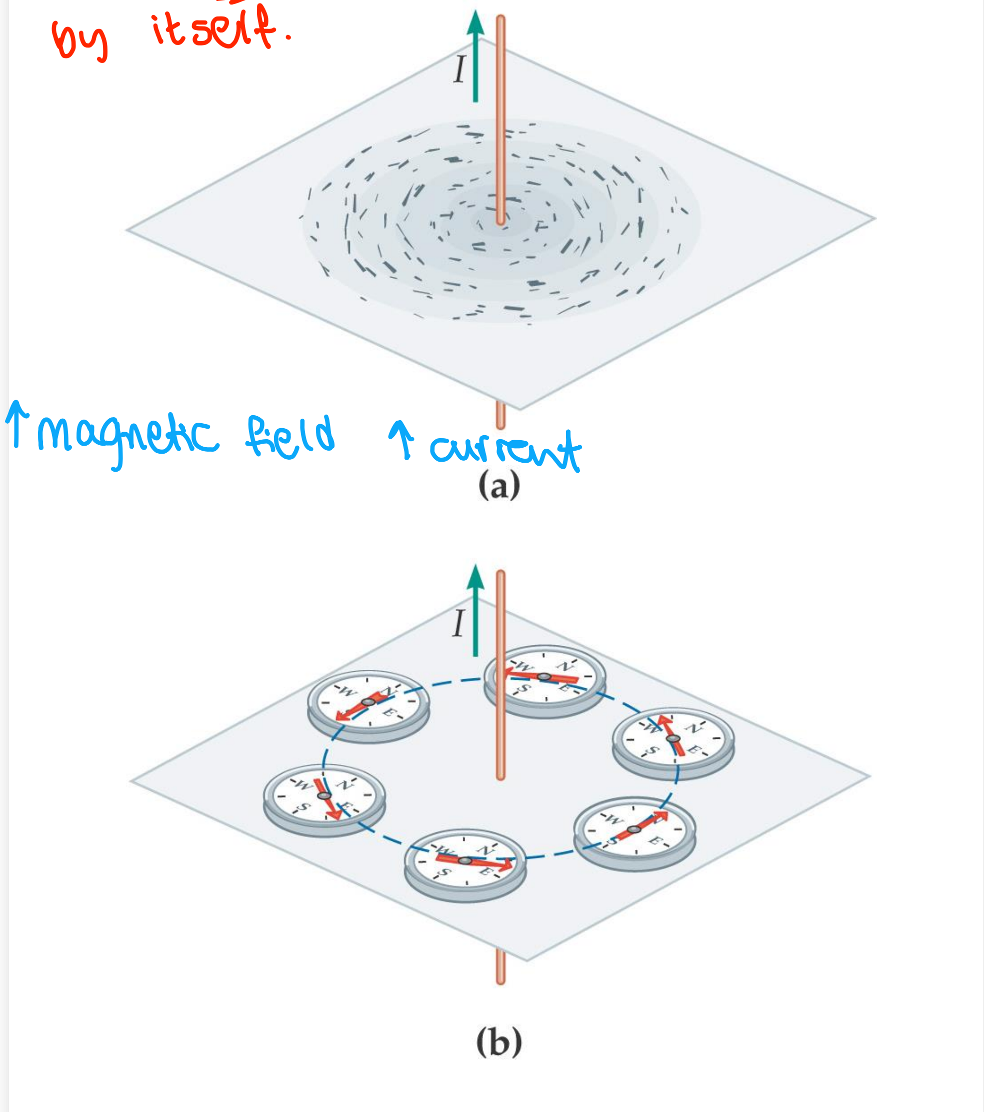


Current can create magnetic field

wire can ~~not~~ create magnetic field by itself.

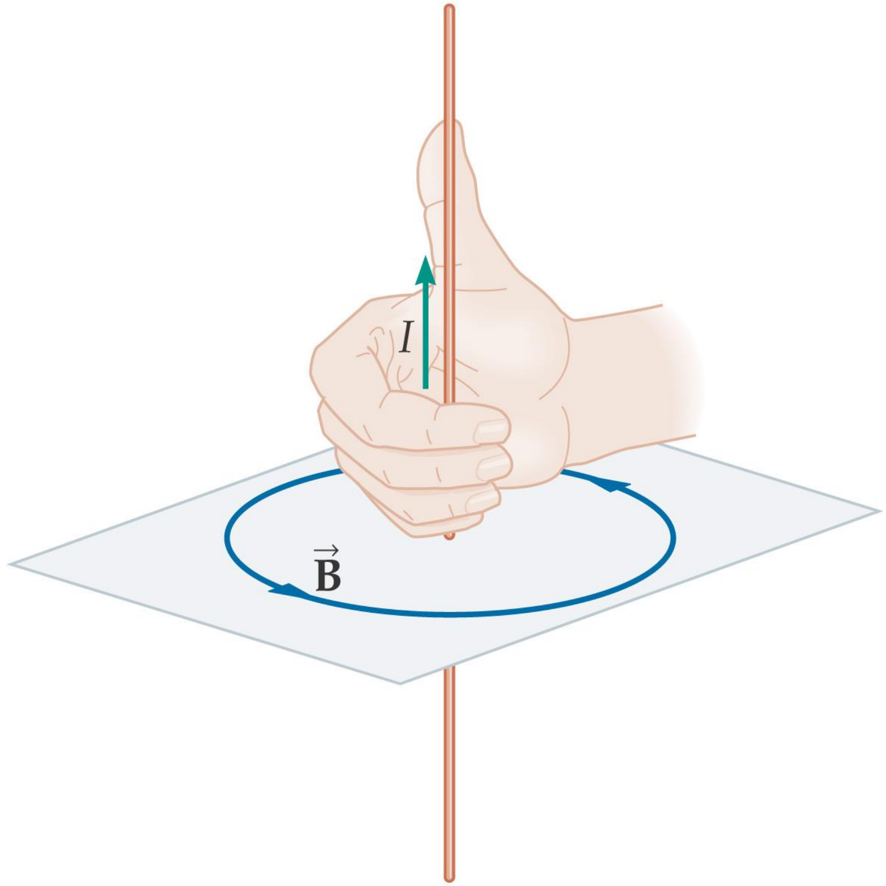
Electric Currents, Magnetic Fields, and Ampère's Law

- In this section, our attention is shifted from knowing the effect of the magnetic field, to the **production of magnetic field**.
- **Experimental observation**: **Electric currents create magnetic fields**.
- For a straight infinitely long wire that carries a current, these **field lines form circles around the current.** (spread iron filings around the current carrying wire, and they will form loops)



A) Direction

- To find the **direction of the magnetic field** due to this current-carrying wire:
    - **point the thumb** of your right hand along the wire **in the direction of the current I**.
    - Your **fingers** are now **curling** around the wire **in the direction of the magnetic field**.



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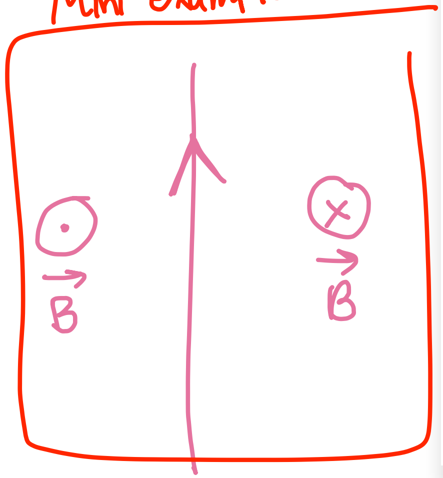
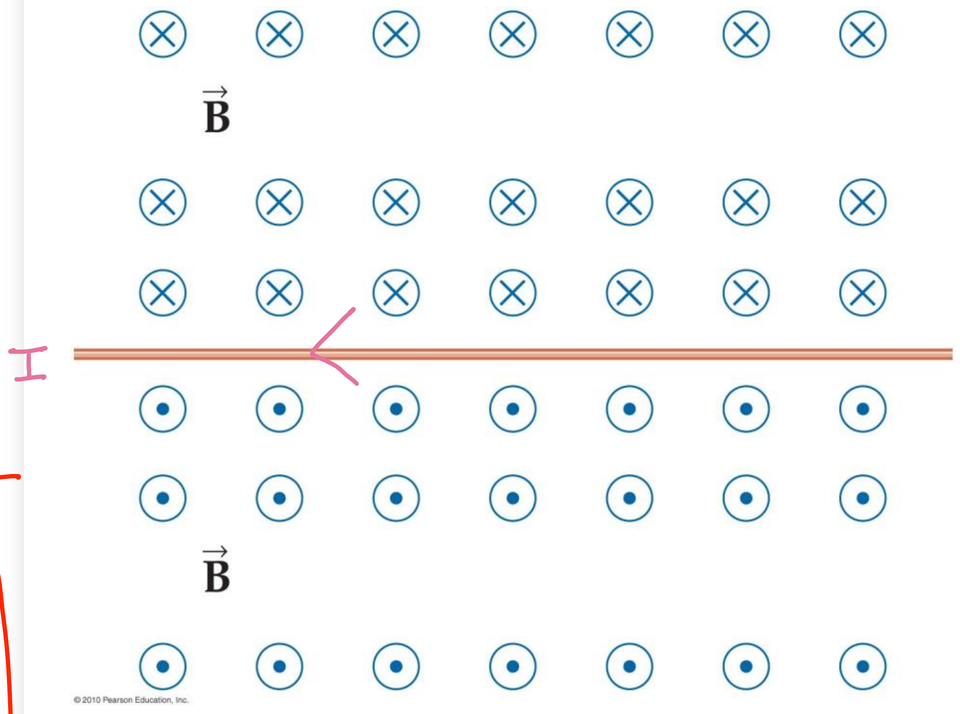
Conceptual checkpoint

The magnetic field shown in the sketch is due to the horizontal current carrying wire. Does the current in the wire flows to the right or to the left?

left

Mini example





Answer: Left

B) Ampère's Law

We can use **Ampère's Law** to find the **magnetic field** around a long, straight wire:

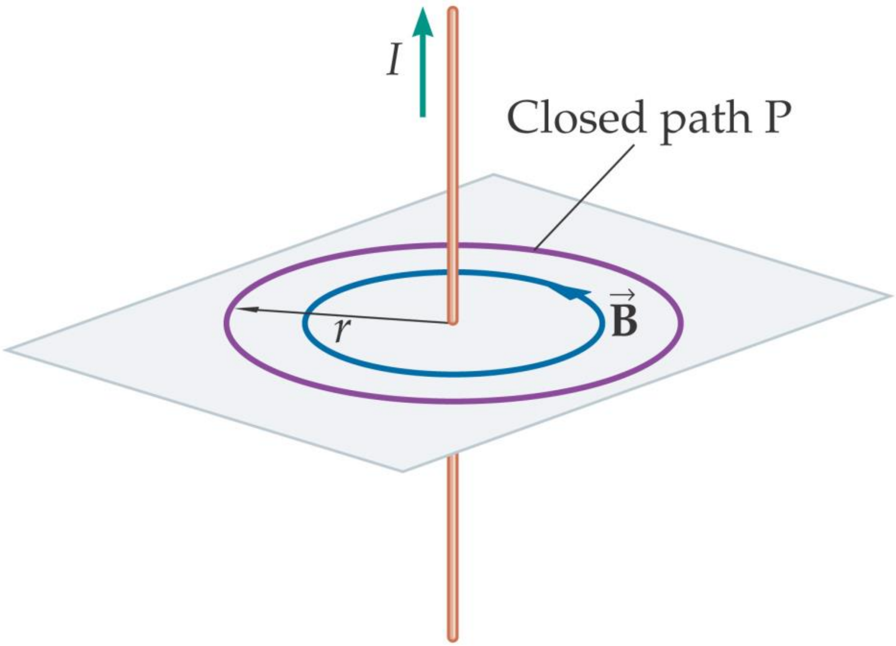
Magnetic Field for a Long, Straight Wire

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

m

SI unit: tesla, T

$$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{T \cdot m/A}$$

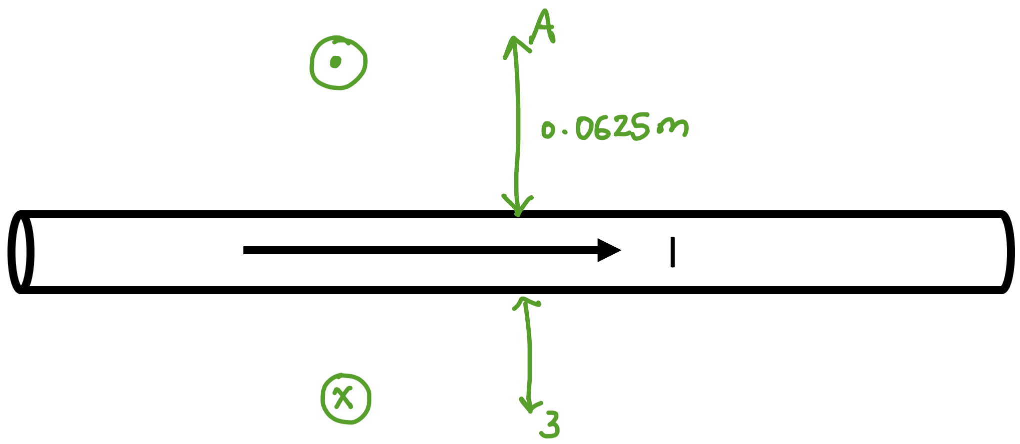


Exercise 1

Find the magnetic field (6.25 cm) from a long, straight wire that carries a current of (7.81 A)

$$B = \frac{2\times10^{-7}\, I}{r} = \frac{(2\times10^{-7})(7.81)}{(0.0625)} = \boxed{}$$

Answer: 2.5 x 10^{-5} T



Example 1

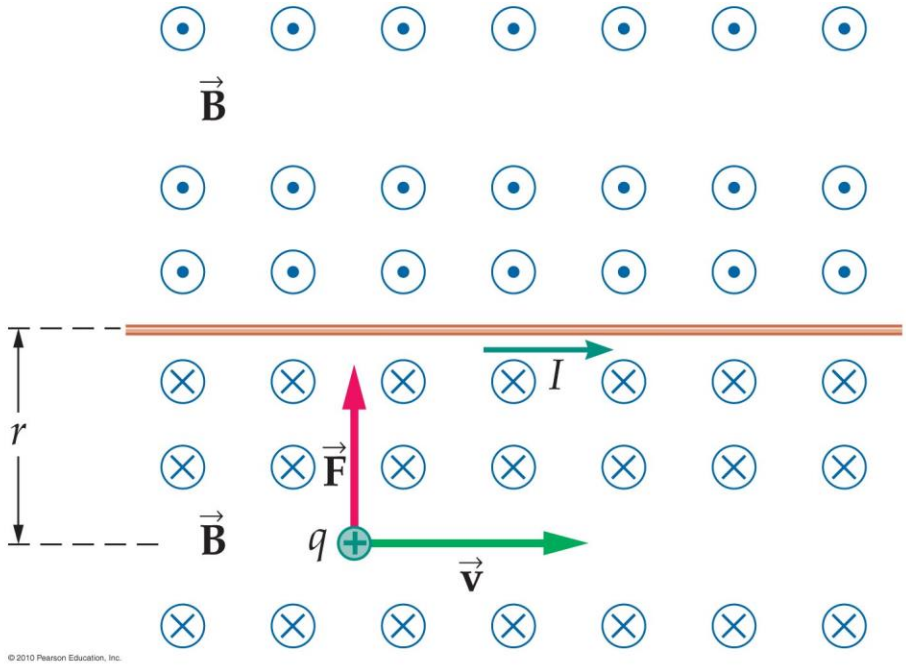
A (52 μc) charged particle moves parallel to a long wire with a speed of (720 m/s). The separation between the particle and the wire is (13 cm), and the magnitude of the force exerted on the particle is (1.4 x 10 $^{-7}$ N). Find:

a) The magnitude of the magnetic field at the location of the particle.

b) The current in the wire.

Answers: (a) $F = q\, v\, B \sin 90 \Rightarrow B = 3.7 \times 10^{-6}$ T

(b) $B = \frac{\mu_o I}{2\pi r} \Rightarrow I = \frac{2\pi r B}{\mu_o}$ = 2.4 A



$q = 52 \times 10^{-6}\, C$

$v = 720\, \frac{m}{s}$

$r = \frac{13}{100}$

a

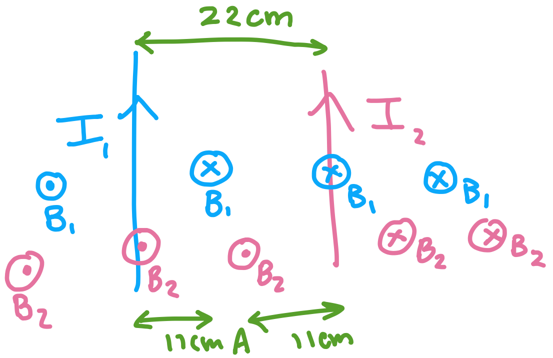
$F = 1.4 \times 10^{-7}\, N$

$\theta = 90$ so $\sin(90) = 1$

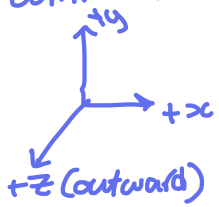
$$\frac{F}{qv} = \frac{\cancel{qv} B \overbrace{\cancel{\sin\theta}}^{1}}{\cancel{qv}} \quad 1$$

$$\boxed{B = 3.74 \times 10^{-6}\, T}$$

Example 2,



common mistake:



anything inward is negative

2 wires immediately know it's new formula

Two wires separated by a distance of **22 cm**, carry currents in the **same direction**. The current in one wire is **1.5 A**, and the current in the other wire is **4.5 A**.

I_1 I_2

Find the **magnitude of the magnetic field halfway** between the wires.

Answer: $B_1 = 2.7 \times 10^{-6}$ T IN

$B_2 = 8.2 \times 10^{-6}$ T OUT

$B = B_2 - B_1 = 5.5 \times 10^{-6}$ T

$B_1 = \frac{2\times10^{-7}\, I}{0.11} = 2.7\times10^{-6}\,T$

$B_2 = \frac{2\times10^{-7}\, I}{0.11} = 8.2\times10^{-6}\,T$

$-2.7\times10^{-6} + 8.2\times10^{-6} = +5.5\times10^{-6}\,T$ ⊙

$\boxed{\text{outward}}$

Section 29.2 Force Between Two Parallel Currents

Sun 3 May

derivation:

$F_{1 on 2} = F_{2 on 1}$ (Newton's 3rd law) Action and Reaction

Force between current carrying wires

Why blue on pink & vice versa? current can never create magnetic field on itself

Since a current-carrying wire experiences a force when placed in a magnetic field, and a magnetic field is created by a current-carrying wire, there is a force between current-carrying wires:

$$F = I_2 L B = I_2 L\left(\frac{\mu_0 I_1}{2\pi d}\right) = \boxed{\frac{\mu_0 I_1 I_2}{2\pi d} L}$$

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

both in meter so be careful

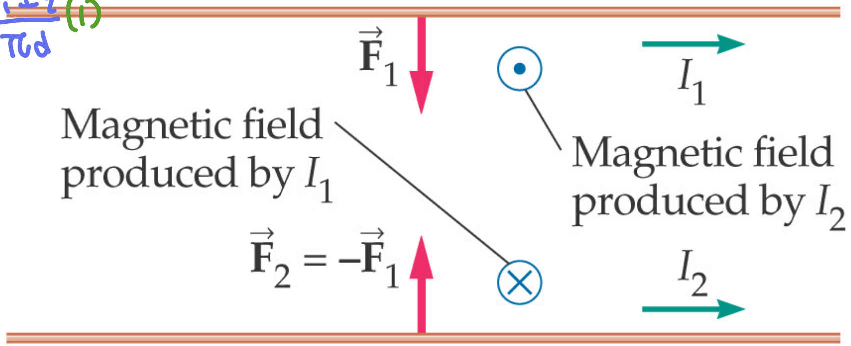
Force per unit length → length = 1

(N) $\frac{F}{L}$ (m) $= \frac{\mu_0 I_1 I_2 (1)}{2\pi d}$

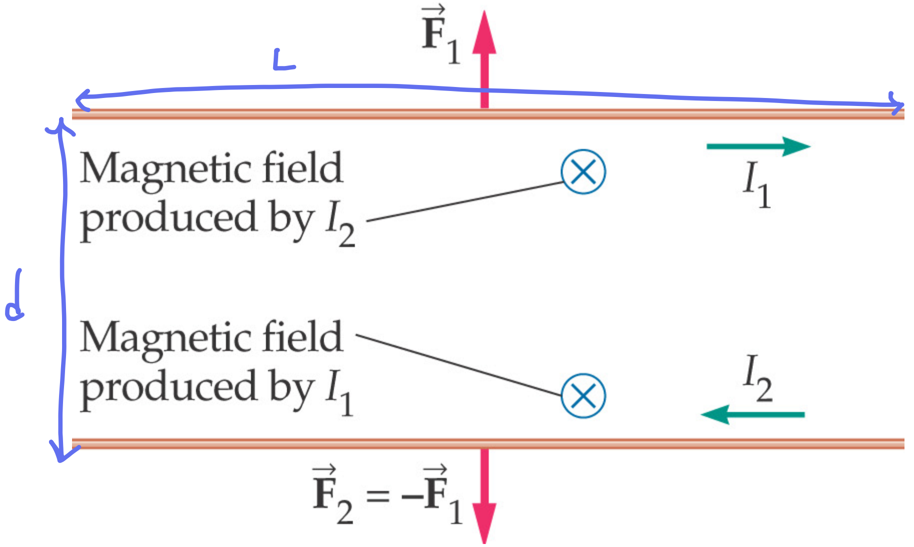
NOTE: must write formula with L even if it's $\boxed{1}$

2 wires carrying current in same direction attract

$\boxed{\text{opp} \rightarrow \text{repel}}$



The two wires will **attract each other**



The two wires will **repel each other**

Exercise 1,

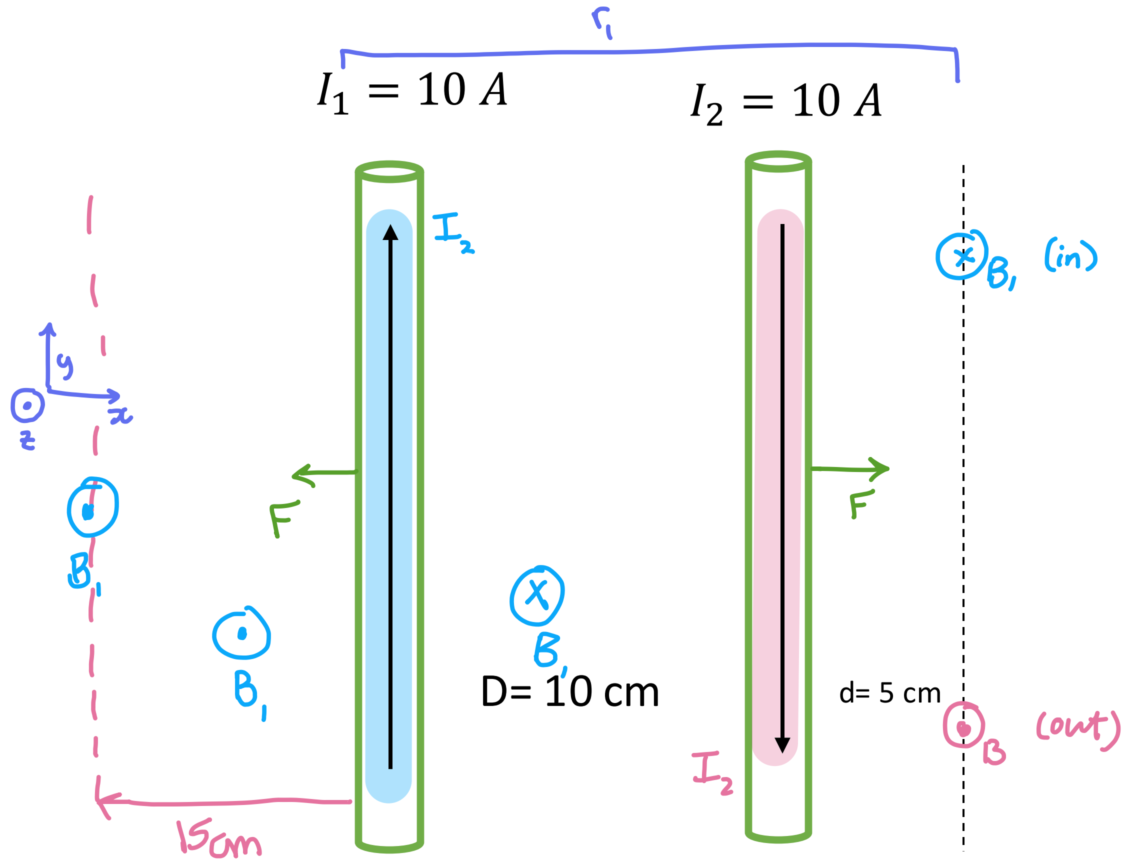
Past exams

$B = \frac{\mu_0 I}{2\pi r} = \frac{2\times10^{-7} I}{r}$

Calculate:

a) The net magnetic field at the position of the dashed line

b) The force between the two wires per unit length.



ⓐ

$B_1 = \frac{2\times10^{-7} I_1}{r_1} \rightarrow \frac{2\times10^{-7}\times10}{\frac{15}{100}} = 1.33\times10^{-5}\,T \otimes$

trick question

$\boxed{B_1 = -1.33\times10^{-5}\,T \text{ (inward)}}$

$B_2 = \frac{2\times10^{-7}\times10}{0.05} = 4\times10^{-5}\,T \odot$

$\vec{B}_{net} = \vec{B}_1 + \vec{B}_2$

$1.33\times10^{-5} + 4\times10^{-5}$

$2.67\times10^{-5}\,T \odot$

ⓑ

$\frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi r} = \frac{2\times10^{-7}\times10\times10}{\frac{10}{100}} = 2\times10^{-4}\,\frac{N}{m}$ (repel)

Exercise 2,

Two long straight wires are separated by a distance of 9.25 cm. One wire carries a current of 2.75 A, the other carries a current of 4.33 A.

A) Find the force per meter exerted on the 2.75 A wire.

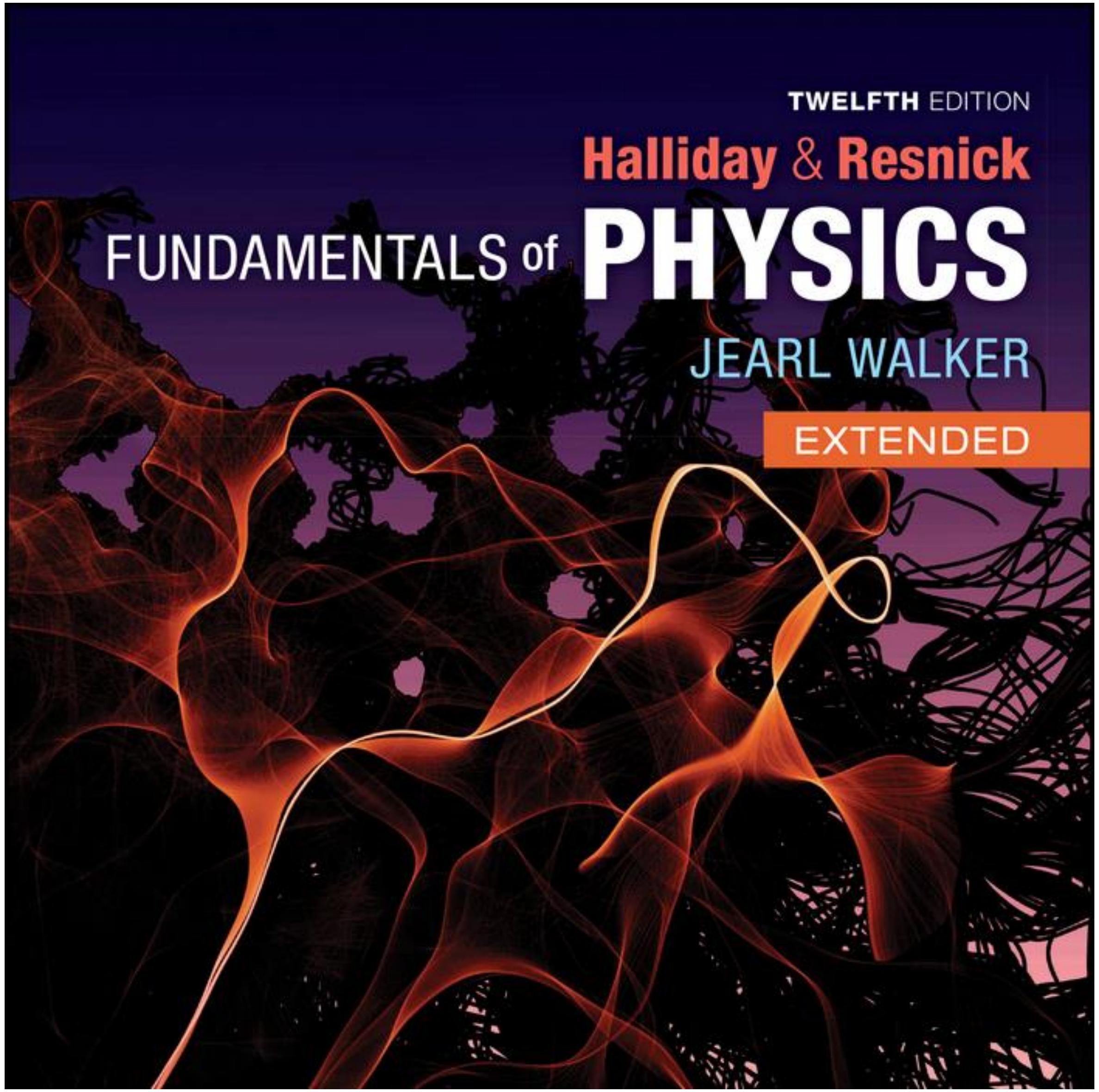
B) Is the force per meter exerted on the 4.33 A wire greater than, less than, or the same as the force per meter exerted on the 2.75 A wire?

Tue 5 May

Chapter 30

Induction and Inductance

***Fundamentals of Physics*, Twelfth Edition. Halliday & Resnick, Walker**



Chapter 30

Induction and Inductance

30.1 Faraday’s Law and Lenz’s Law

Section 30.1 Faraday’s Law and Lenz’s Law

Sun 3 May

NOTE: Flux = flow

Electric flux

$\Phi_{Electric} = E \times A \times \cos\theta$ → $\boxed{\text{angle between normal to Area } \& \ \vec{E}}$

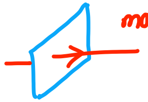
Magnetic flux

important to be uniform

$\Phi_{magnetic} = \underbrace{B \times A}_{} \times \cos\theta$

(weber) (T)(m^2)

$\boxed{\text{angle between B and normal to Area}}$

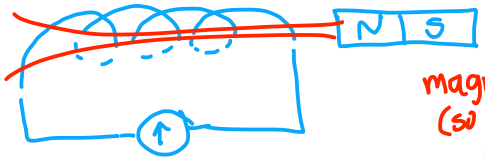


angle

angle 90 → cos (90) = 0

Tue 5 May

Electromagnetic induction (Lenz law)



magnetic field flow (so yes we have magnetic flux)

(wire)rod connected to sensitive voltmeter + magnetic

Galvanometer will deflect indicating voltage has been created. (globally how electicity is done)

induced emf $\mathcal{E}$ → battery ⊣⊢ $\mathcal{E}$

↓ created

voltage created because we have change in magnetic flux

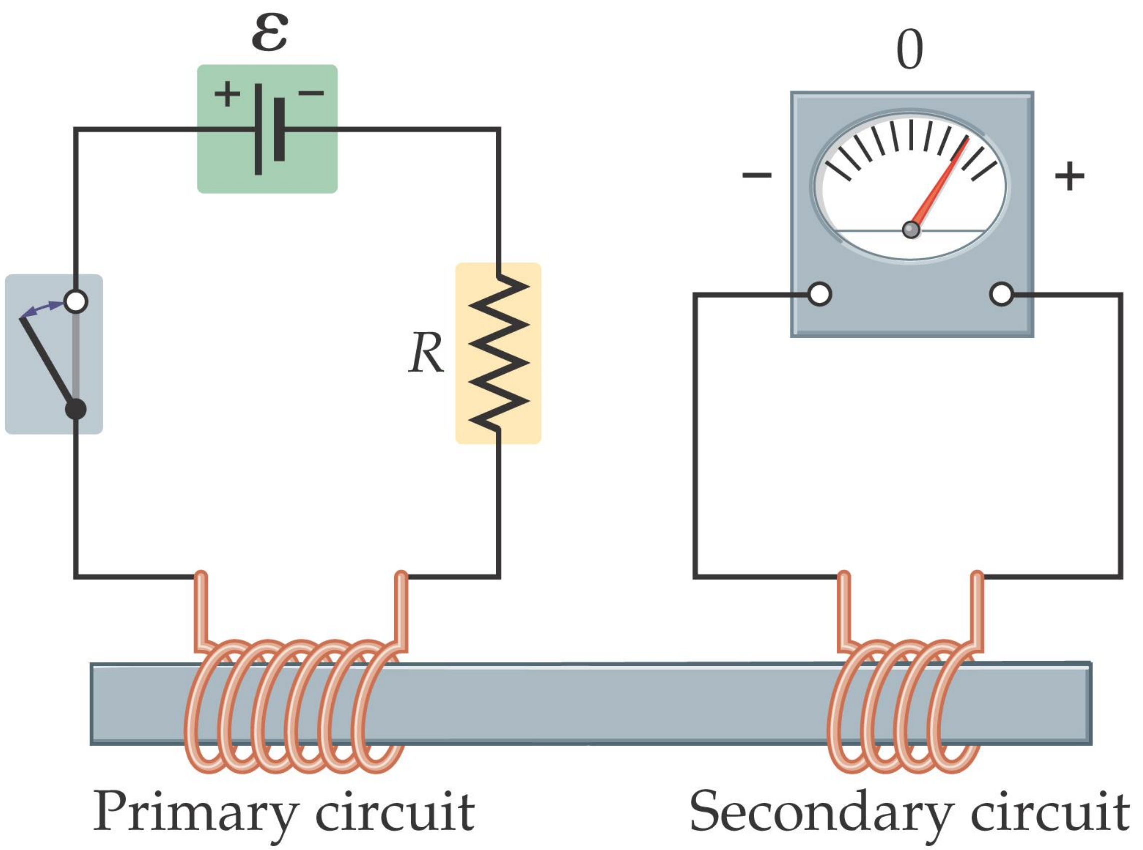
Induced Electromotive Force

- ❑ In the previous chapter, we found out that a magnetic field will be created when a current is passing through a wire, loop or a solenoid.

- ❑ The question is, can a ***magnetic field produce*** an ***electric current?***

❑ *Faraday's Experiment*

Closing the switch in the primary circuit induces a current in the secondary circuit, only while the current in the primary circuit is changing.



- The **current in the secondary** circuit **is zero** as long as the **current in the primary circuit is constant**
  - Therefore, the magnetic field in the iron bar is not changing (constant).

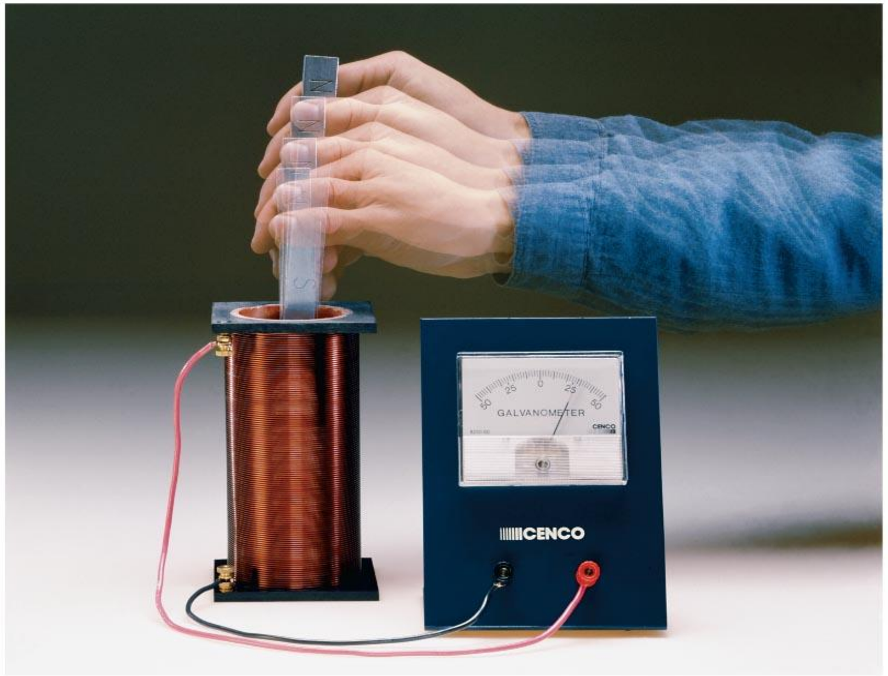
- When the **magnetic field** passing through the **secondary coil increases**, a **current is observed** to flow in one direction in the secondary circuit; **when the magnetic field decreases**, **a current** is observed in the **opposite direction**.

- This current produced in the secondary circuit is called an **induced current** (without direct contact between the primary and the secondary circuits). This current behaves like a real current created from a real **emf.** We say that the changing magnetic field creates an **induced emf**.

- The magnitude of the **induced current** and the **induced emf** are proportional to the **rate at which the magnetic field is changing**: the **more rapid the magnetic field is changing**, the **greater the induced current and emf**.

__Question__: Can the primary circuit be replaced by a bar magnet in order to produce an induced emf and induced current in the secondary circuit?

Stationary magnet = 0 emf = 0 Current



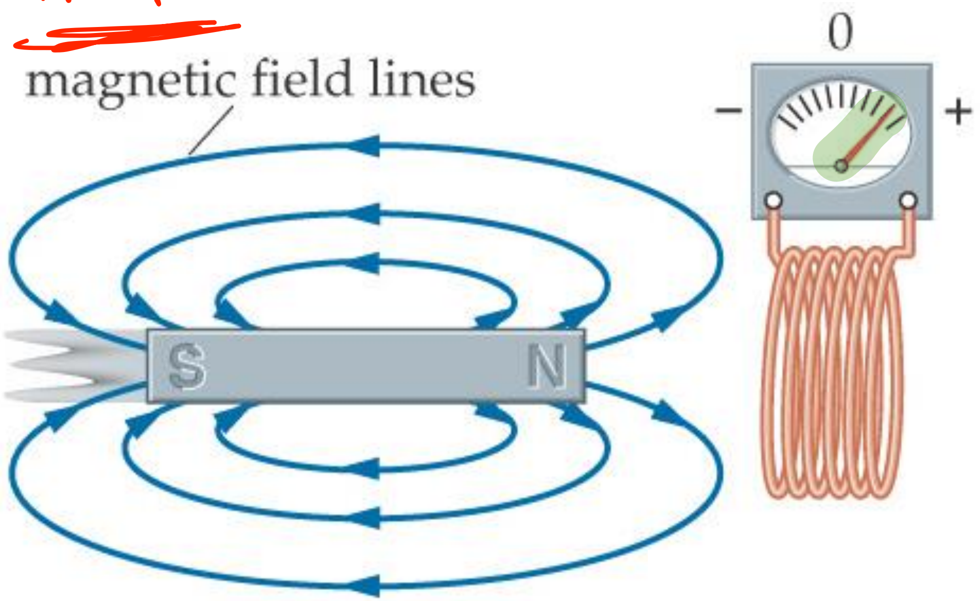
If we look at the figure on the right: An induced current is produced in the secondary circuit by moving the bar magnet ***Toward or away from a coil connected to an Ammeter***.

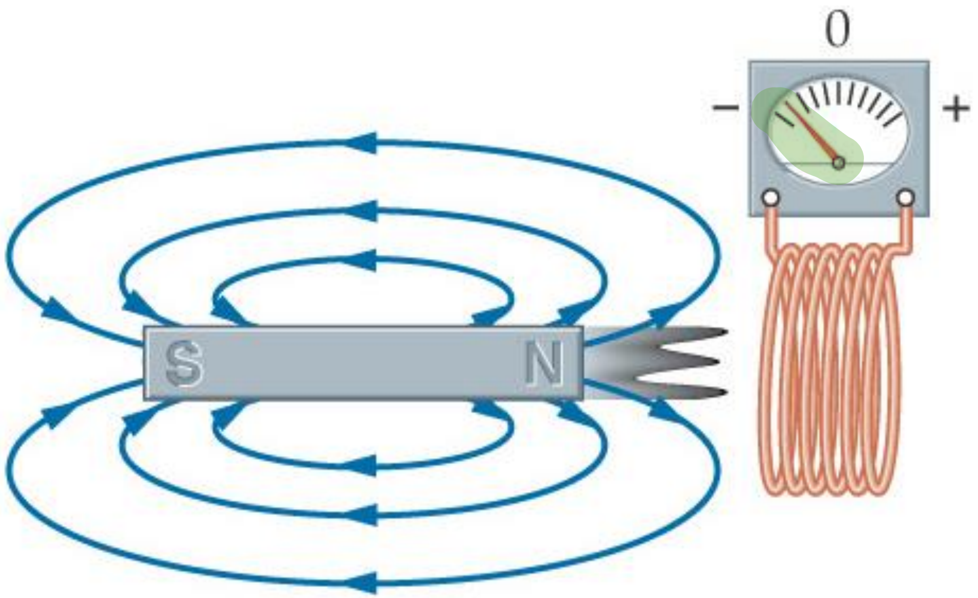
__Notice__ that the direction of deflection will be ***Reversed*** when moving the bar magnet ***__away__***

__And the induced current will be zero__ when the magnet is not moving.

Note the motion of the magnet in each image:

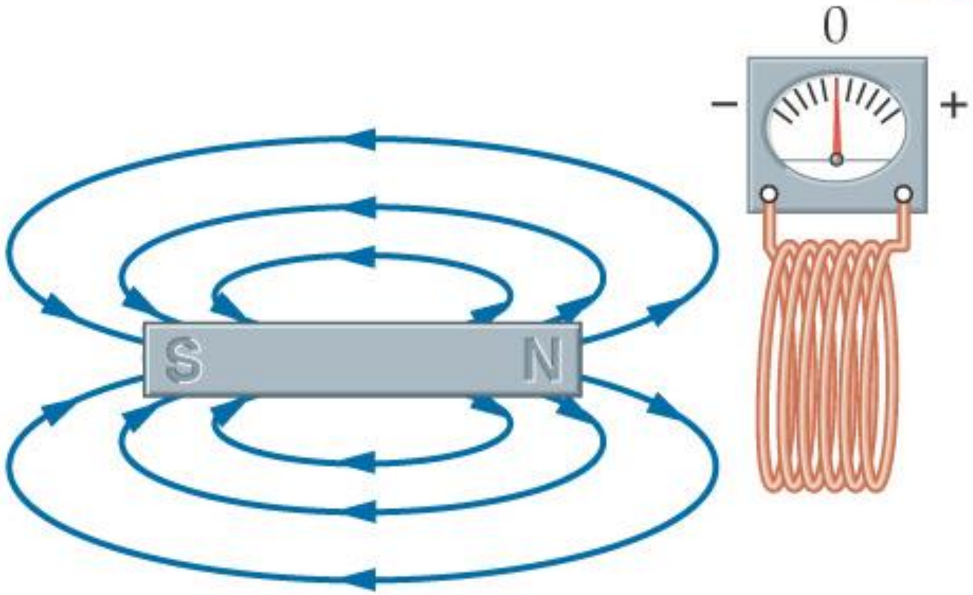
IMP





- more turns
- stronger magnet
- faster

higher created voltage



Magnetic Flux

Definition: Magnetic flux (Φ) is a measure of the number of magnetic field lines that cross a given area.

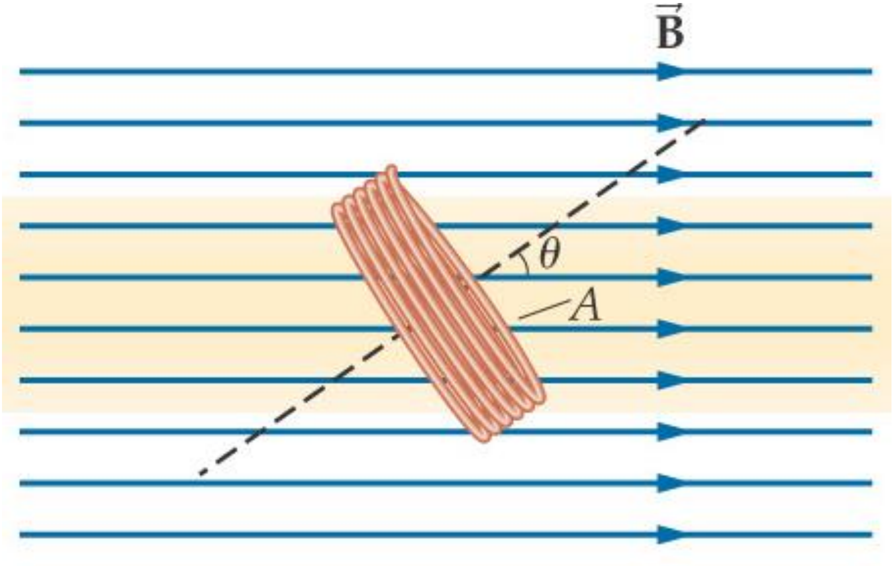
dot product → cos θ
cross product → sin θ

$$\Phi = \int \vec{B} . d\vec{A} = \int B dA \cos\theta$$

If the surface is **flat** the magnetic field $\vec{B}$ **is uniform**, we get:

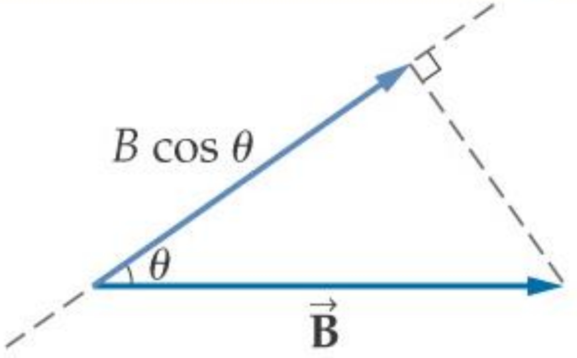
$$\boldsymbol{\Phi = B\cos\theta \int dA = BA\cos\theta}$$

$$\text{SI unit: } 1\,\text{T}\cdot\text{m}^2 = 1\,\text{weber} = 1\,\text{Wb}$$

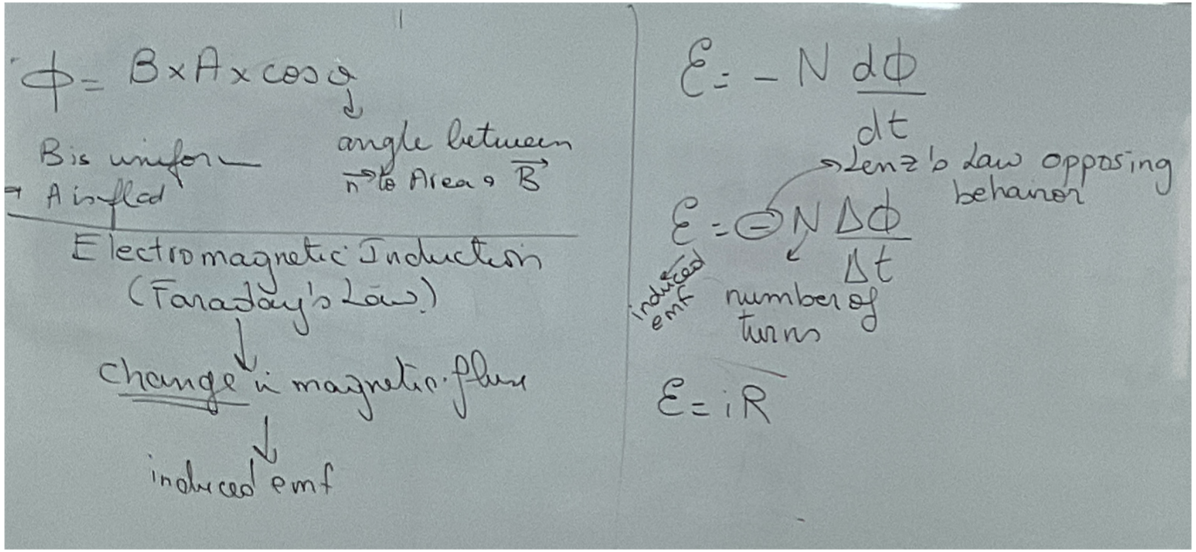


Note: θ is the angle between the **magnetic field** and **the normal to the surface.**

Or we need to use the component of the magnetic field perpendicular to the surface $\Phi = (B\cos\theta)\,A = \mathrm{B}_{\perp}\ \mathrm{A}$



Wed 6 May



Change in magnetic Flux

↓

generate electricity

Fuel → heat

water → evaporate → moves coil → generate electricity

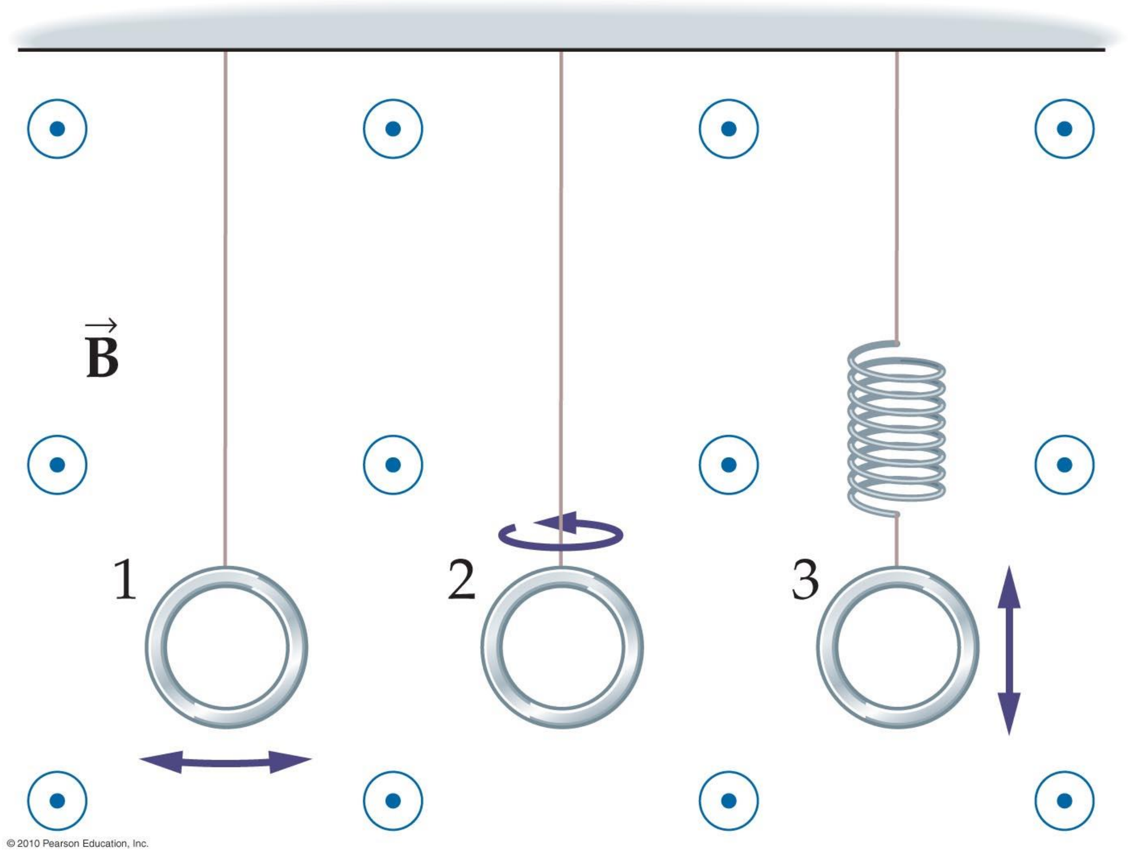
Conceptual checkpoint,

The three loops of wire shown in the figure are all in a region of space with a uniform constant magnetic field.

- Loop 1 swings back and forth, like the bob of a pendulum.
- Loop 2 rotates about a vertical axis.
- Loop 3 oscillates vertically on the end of a spring.

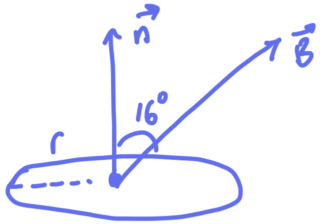
Which loop or loops have a magnetic flux that changes with time ?

Loop 2 has change in magnetic flux



Exercise 1, : A 0.055 T magnetic field passes through a circular ring of radius 3.1 cm at an angle of 16 ° with the normal. Find the magnitude of the magnetic flux through the ring.

draw flux → draw normal



$A = \pi r^2 = \pi (0.031)^2$

$\Phi = BA\cos\theta$

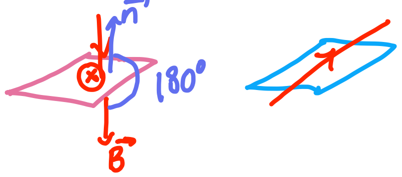
$= 0.055 \times \pi (0.031)^2 \times \cos(16)$

$\Phi = 0.00016$ weber

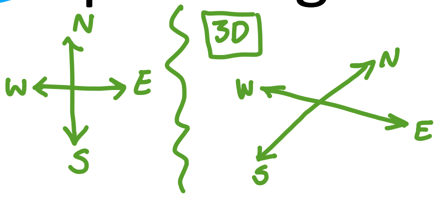
IMP

Exercise 2, : Find the magnitude of the magnetic flux through the floor of a house that measures 22 m by 18 m. Assume that the earth's magnetic field at the location of the house has a horizontal component of no flux $\boxed{2.6 \times 10^{-5}}$ T pointing north and a downward vertical component of there is flux $\boxed{4.2 \times 10^{-5}\ \text{T.}}$

$A = 3.96\ m^2$



2D 3D



$\Phi = BA\cos(180)$

$= |-1.66 \times 10^{-2}|$ weber

(we only care ab magnitude)

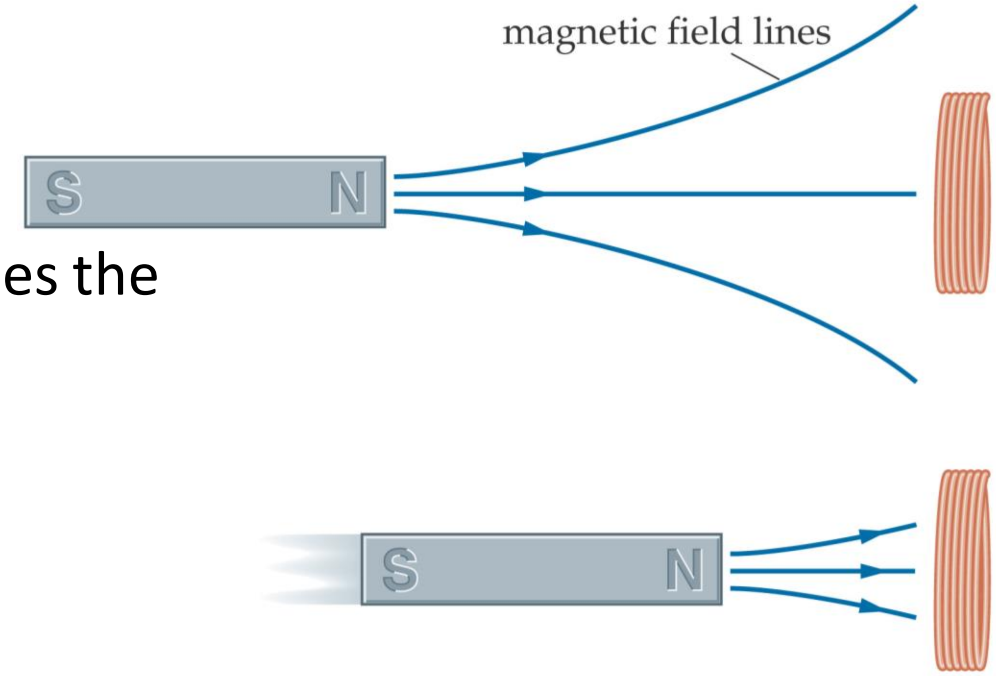
Faraday's Law of Induction

An **emf** is induced only when the magnetic flux through a loop changes with time.

Faraday's law: The magnitude of the emf $\mathcal{E}$ induced in a conducting loop is equal to the rate at which the magnetic flux through that loop changes with time.

For a loop with N turns, we get:

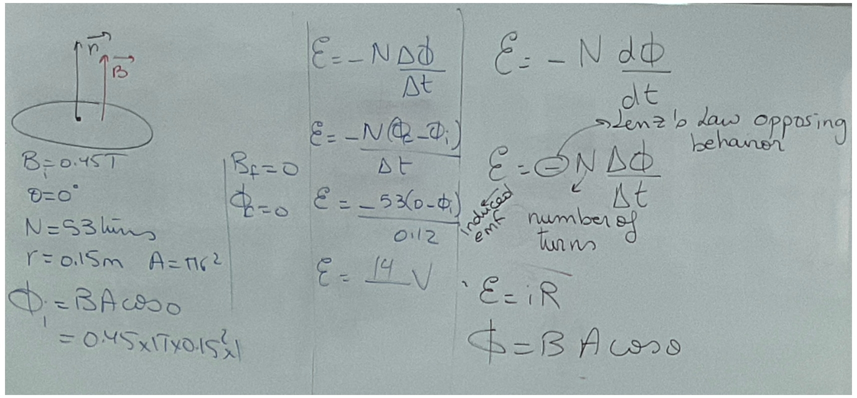
$$\boldsymbol{\mathcal{E} = -N\frac{d\Phi}{dt}}$$



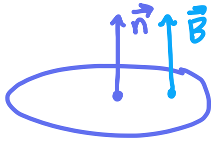
- The minus sign indicates that the induced emf opposes the change in magnetic flux.
- If the change is uniform over that time we get:

$$\mathcal{E} = -N\frac{\Delta\Phi}{\Delta t}$$

Exercise 3, : A (0.45 T) magnetic field is perpendicular to a circular loop of wire with (53 turns) and a radius of (15 cm). If the magnetic field is reduced to zero in (0.12 s), what is the magnitude of the induced emf ?



Answer: 14 V



$\theta = 0°$

$B_i = 0.45T$

$N = 53$ turns

$r = 0.15m$

$\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$

$\varepsilon = -\frac{53(\Phi_f - \Phi_i)}{\Delta t} \rightarrow \varepsilon = 14V$

$B_f = 0$

$\Phi_f = 0$

Exercise 4, A single conducting loop of wire has an area of $(7.2 \times 10^{-2}\ m^2)$ and a resistance of (110 Ω). Perpendicular to the plane of the loop is a magnetic field of strength (0.48 T). At what rate in (T/s) must this field change if the induced current in the loop is to be (0.32 A).

Answer: 489

$N = 1$ turn

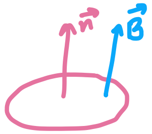
$A = 7.2 \times 10^{-2} m^2$

$R = 110\Omega$

$i = 0.32A$

$\theta = 0°$

$\frac{\Delta B}{\Delta t}$



$\varepsilon = iR = 35.2V$

$\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$

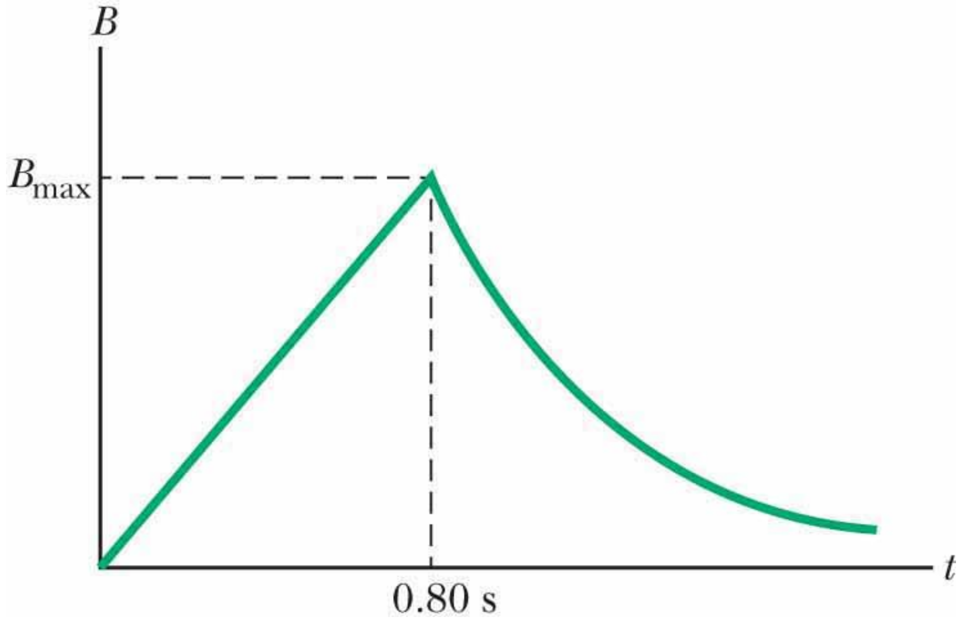
$\varepsilon = -\frac{N\Delta BA\cos\theta}{\Delta t} \rightarrow \varepsilon = -NA\frac{\Delta B}{\Delta t} \rightarrow \frac{-\varepsilon}{NA} = \frac{\Delta B}{\Delta t} = -4.89 \times 10^2 T$

Example: A coil consists of 200 turns of wire. Each turn is a square of side d = 18 cm, and a uniform magnetic field directed perpendicular to the plane of the coil is turned on. From t = 0 to t = 0.80 s, the field changes linearly from 0 to 0.50 T. After t = 0.80 s, the magnitude of the field decays in time according to the expression $\boldsymbol{B = B_{max}e^{-at}}$, where a is some constant and B_{max} = 0.50 T.

(A) What is the magnitude of the induced emf in the coil between t = 0 and t = 0.80 s?

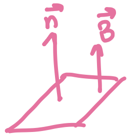
$$|\varepsilon| = N\frac{\Delta\Phi_B}{\Delta t} = N\frac{\Delta(BA)}{\Delta t} = NA\frac{\Delta B}{\Delta t} = Nd^2\frac{B_f - B_i}{\Delta t}$$

$$|\varepsilon| = (200)(0.18\text{ m})^2\frac{(0.50\text{ T} - 0)}{0.80\text{ s}} = \boxed{4.0\text{ V}}$$



$N = 200$ turns

$A = d^2 = 0.18^2 \rightarrow 0.0324\ m^2$



$\theta = 0$

(a) $|\mathcal{E}| = \frac{N\Delta\Phi}{\Delta t} = \frac{N\Delta B A \cancel{\cos\theta}^{\,1}}{\Delta t} = \frac{NA\,\Delta B}{\Delta t} = \frac{200 \times 0.18^2 \times (\overset{0\text{T}}{B_f} - \overset{0.5\text{T}}{B_i})}{0.8} = 4.05\text{V}$

(b) $|\mathcal{E}| = \frac{Nd\Phi}{dt} = \frac{NdBA\cancel{\cos\theta}^{\,1}}{t} = \frac{NAdB}{dt}$

$\mathcal{E} = 200 \times 0.18^2 \times \frac{d}{dt}\left(0.5e^{-at}\right) = 200 \times 0.18^2 \times 0.5\left(-ae^{-at}\right)$

(B) What is the magnitude of the induced emf in the coil after t = 0.80 s?

$$\varepsilon = -N\frac{d\Phi_B}{dt} = N\frac{d\left(AB_{\max}e^{-at}\right)}{dt}$$

$$= -NAB_{\max}\frac{d}{dt}e^{-at} = \boxed{aNd^2B_{\max}e^{-at}}$$

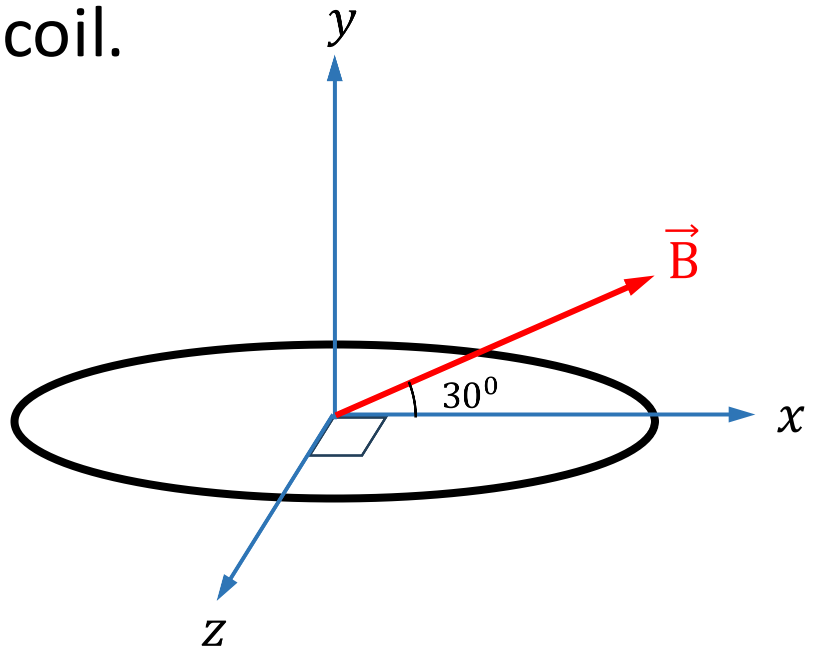
$$\varepsilon = a\left(200\right)\left(0.18\text{ m}\right)^2\left(0.50\text{ T}\right)e^{-at} = 3.2ae^{-at}$$

magnetic field given in exam

Example: A circular coil of wire with a radius of 15 cm and 50 turns is inserted into a region of space containing a uniform magnetic field directed in the xy-plane, making an angle of 30° with the x-axis, as shown in the figure. The plane of the coil is the xz-plane.

(a) Determine the magnetic flux through the coil in its initial position.

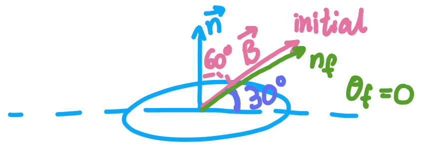
(b) If the coil is rotated about the z-axis by 60° clockwise in 0.01 s at a constant rate, calculate the induced emf in the coil.



$A = \pi r^2 = \pi(0.15)^2$

$N = 50$ turns

$B = 0.5T$ (should be given)



(a)

$\Phi_i = BA\cos(60)°$

$0.5 \times \pi(0.15)^2 \times \cos(60) = 1.77 \times 10^{-2}$ V

(b) θ between magnetic & normal is now 0 since only rotating

$\Phi_f = BA\cos\theta$

$\mathcal{E} = \frac{-N\Delta\Phi}{\Delta t} = \frac{-50(\Phi_f - \Phi_i)}{0.01} =$