MAGNETIC FIELDS

TOPICS TO BE COVERED

- **Magnetic Fields**
- Magnetic Fields and Forces . 895
- Right-Hand rule

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Magnetic Fields

An electric field surrounds any electric charge. Similarly, ***The region of space surrounding any MOVING electric charge also contains a magnetic field.***

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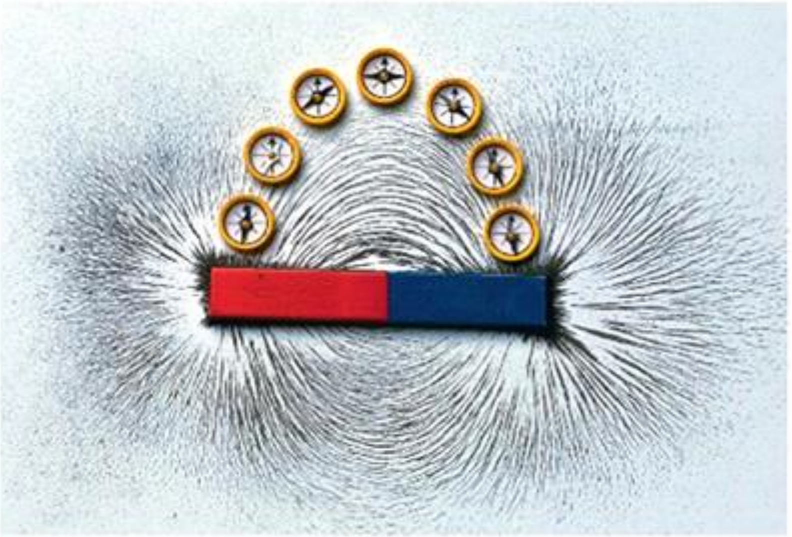
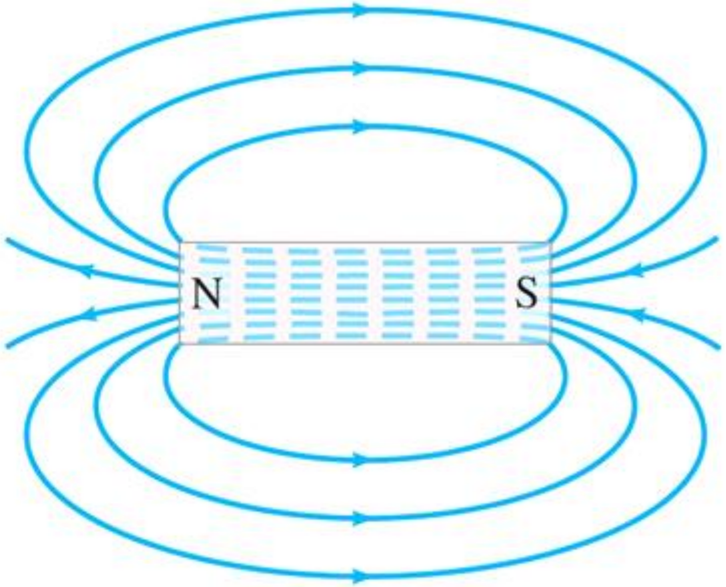
Magnetic fields can be visualized using

Magnetic Field Lines,

which are ***always closed loops*.**





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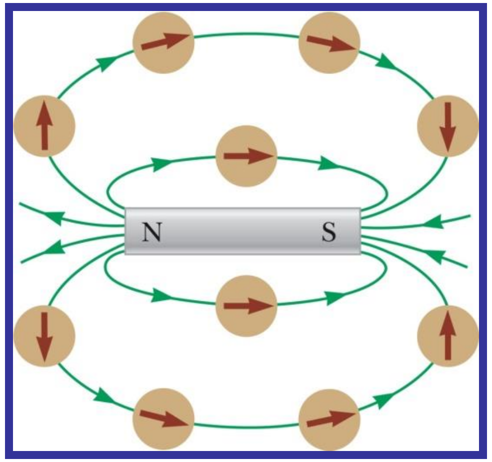
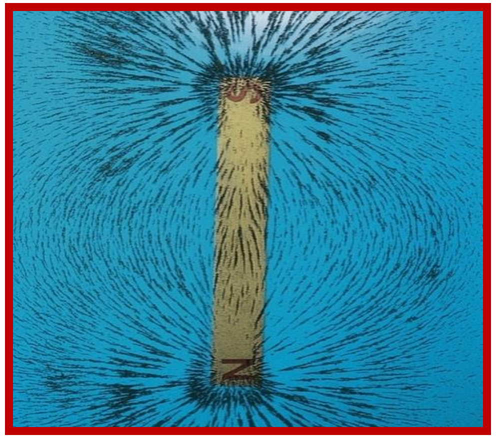
Magnetic Field Lines, Bar Magnet

- A compass can be used to trace the field lines.
- The lines outside the magnet point from the North pole to the South pole.
- Iron filings can also be used to show the pattern of the magnetic field lines.
- The direction of the magnetic field is the direction a north pole would point.





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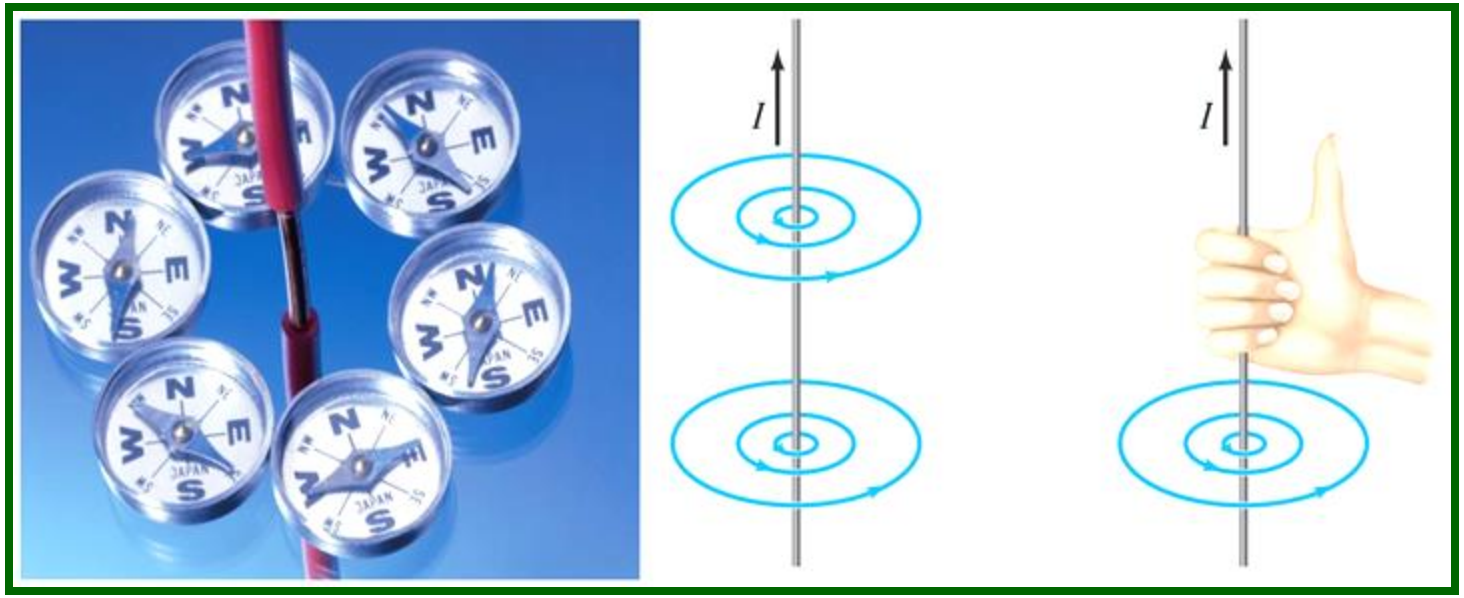
Electric Currents Produce Magnetic Fields

Experiments show that *Electric Currents Produce Magnetic Fields.*

- The direction of the field is given by a *Right-Hand Rule*.



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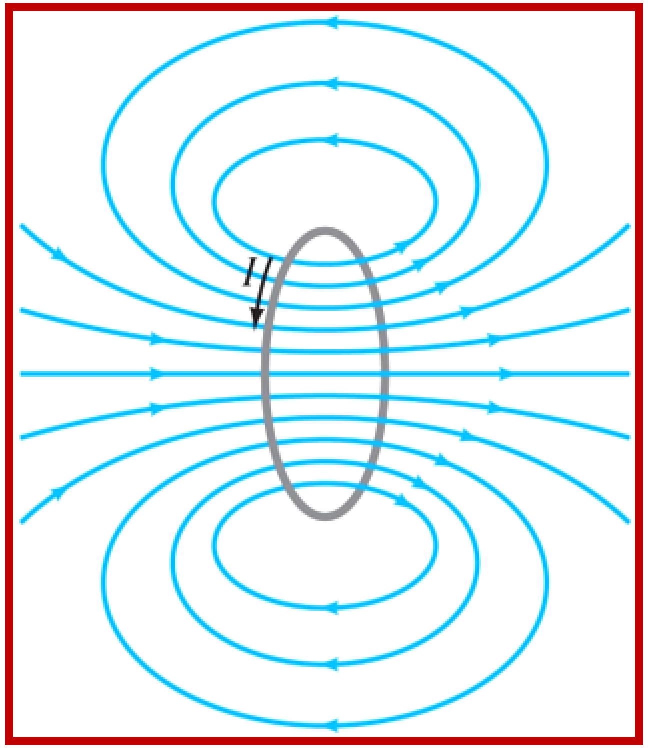
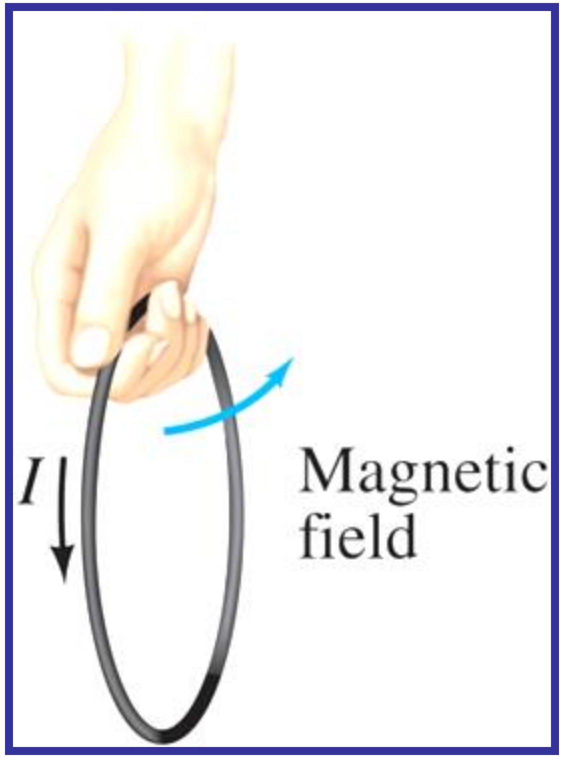
Magnetic Field Due to a Current Loop

The direction is given by a

***Right-Hand Rule*.**





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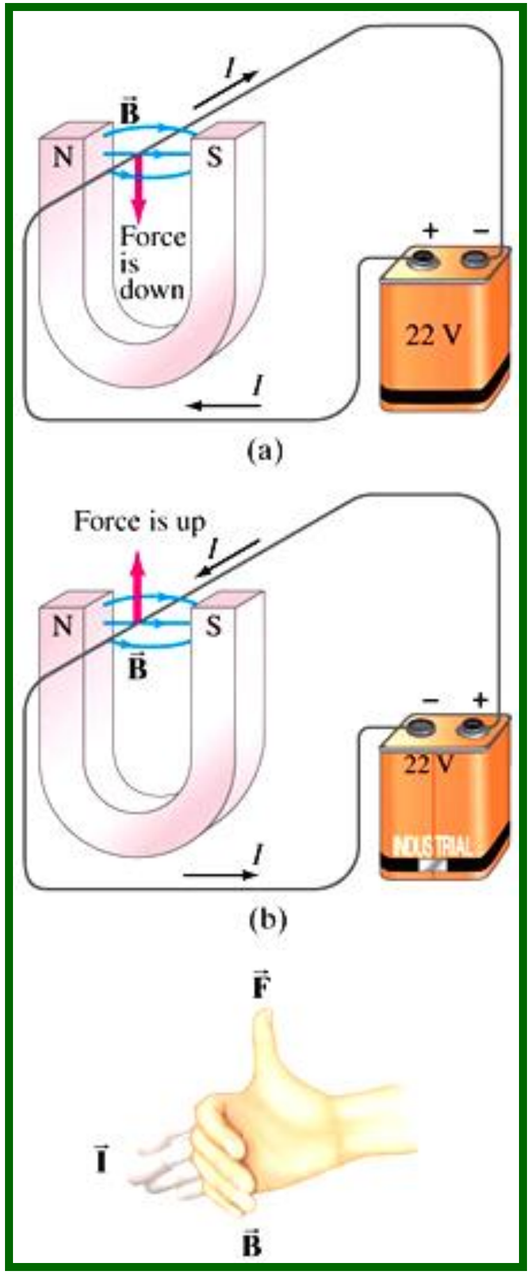
Force on a Current in a Magnetic Field
&

the ***DEFINITION*** of B

- A magnet exerts a force F on a current-carrying wire. The *DIRECTION* of F is given by a *Right-Hand Rule*



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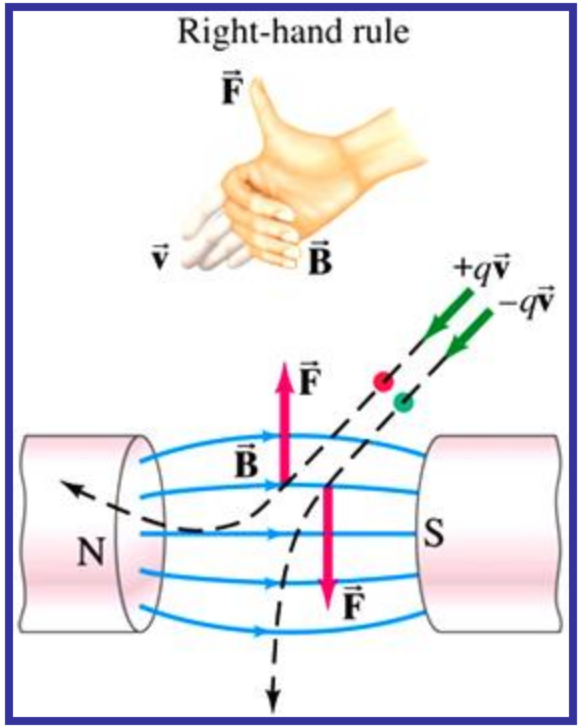
Force on a *Moving* Charge in a Uniform Magnetic Field

- For this case, the **force F** is obviously related to the force on a current & is given by:

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



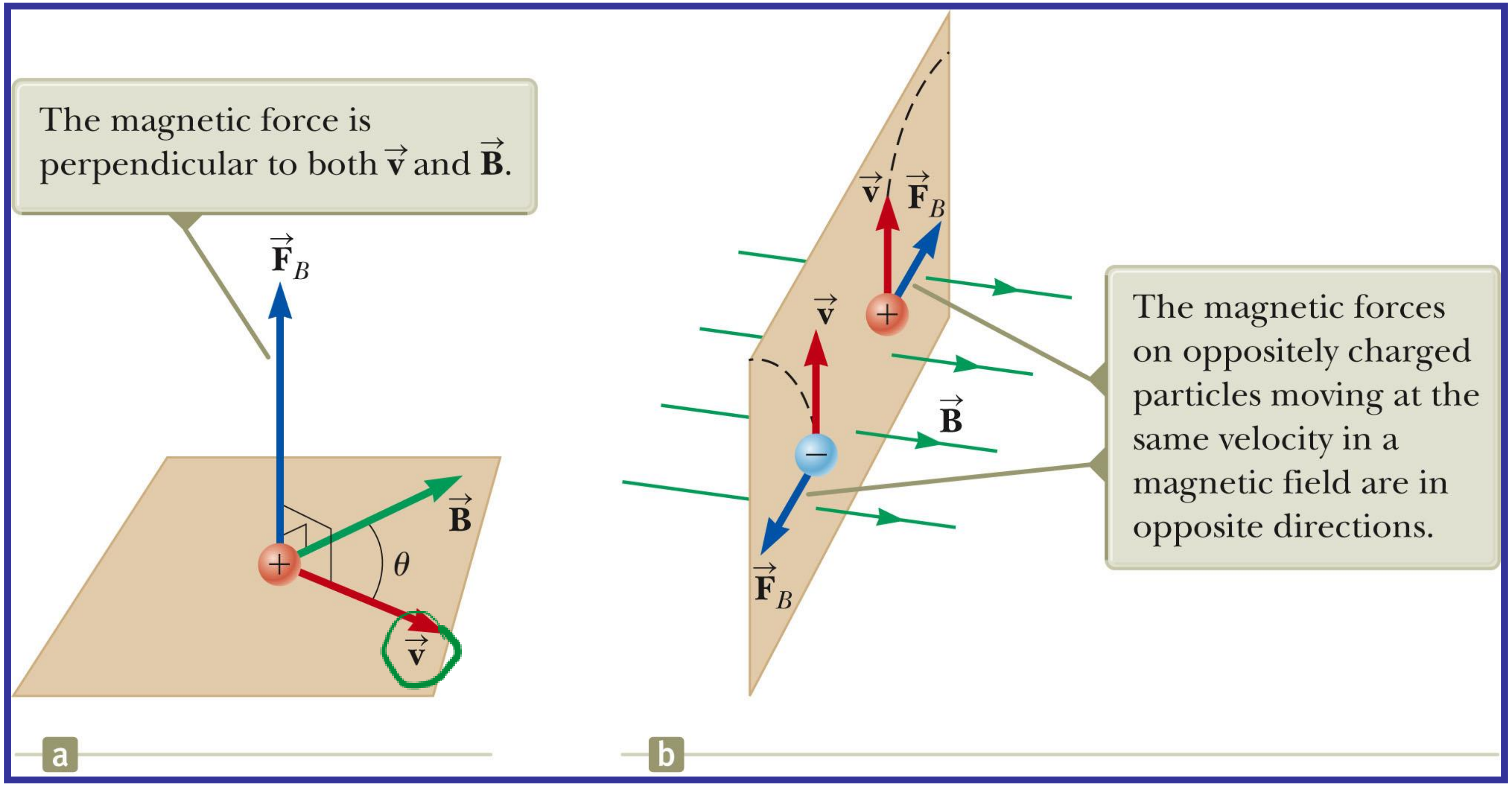
The SI Unit of the **Magnetic Field B is**

The **Tesla (T): 1 T ≡ 1 N/A·m**

Another unit that is sometimes used (from the cgs system) is

The **Gauss (G): 1 G = 10^{-4} T**

More About Direction

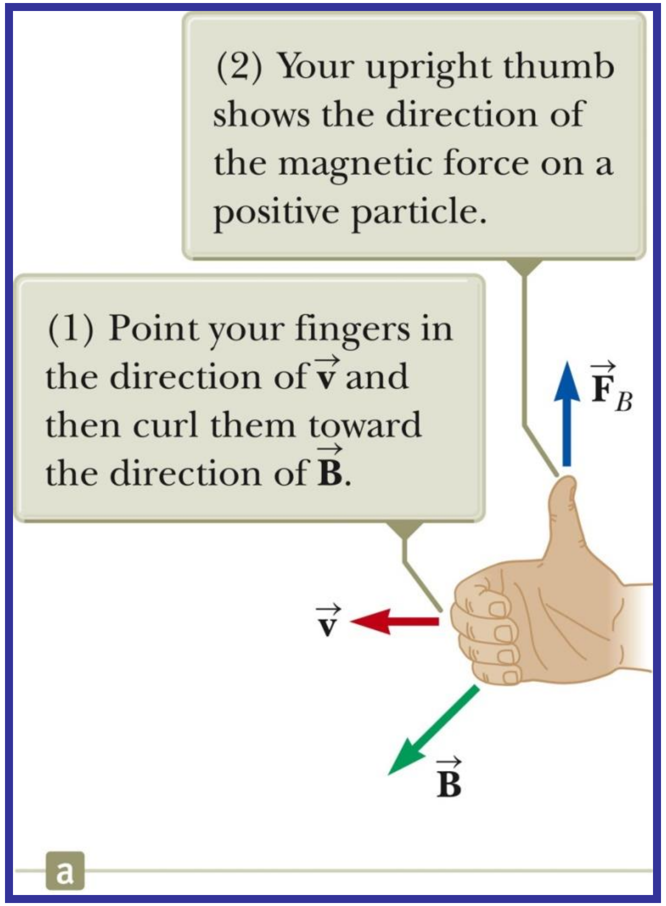


Direction: Right-Hand rule

This rule is based on the right-hand rule for the cross product.

Your thumb is in the direction of the force if **q** is positive.

The force is in the opposite direction of your thumb if **q** is negative.



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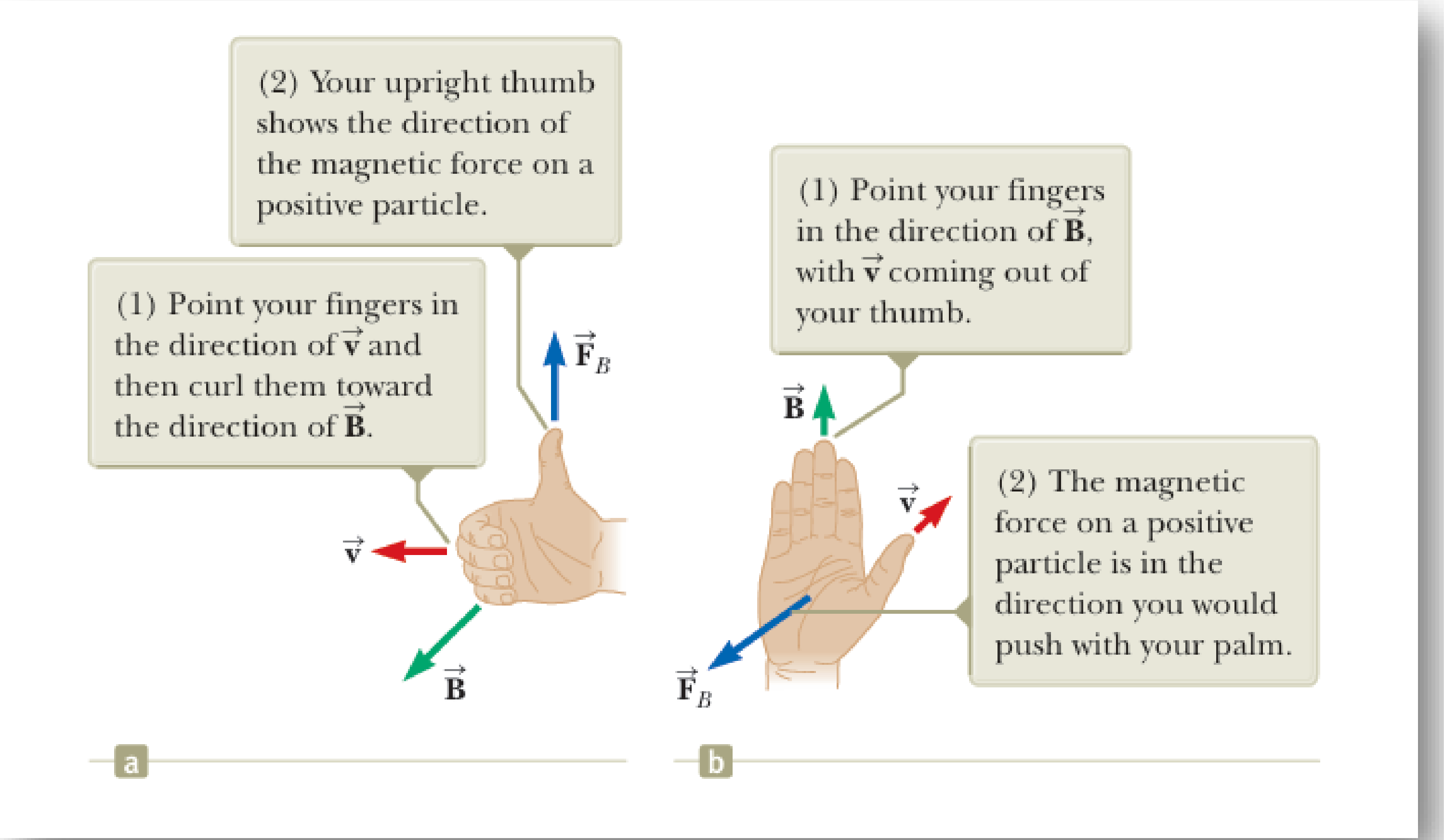
Direction: Right-Hand rule



(a) In this rule, the magnetic force is in the direction in which your thumb points.
(b) In this rule, the magnetic force is in the direction of your palm, as if you are pushing the particle with your hand.

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More About the Magnitude of F

- The magnitude of the magnetic force on a charged particle is

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

- θ is the smaller angle between **v** & **B**
- F_B is zero when the field & velocity are parallel or antiparallel (θ = 0 or 180°)
- F_B is a maximum when the field & velocity are perpendicular θ = 90°

Differences Between Electric & Magnetic Fields

- **Direction of the Force on a Point Charge**

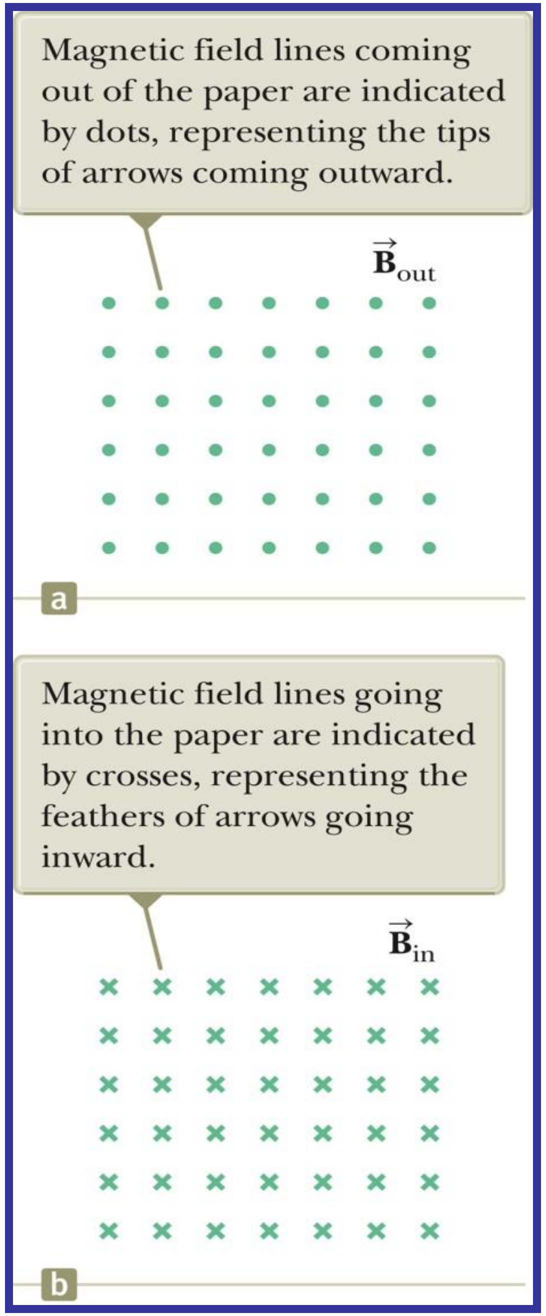
- The electric force acts along the direction of the electric field.
- The magnetic force acts perpendicular to the magnetic field.

Motion

- The electric force acts on a charged particle regardless of whether the particle is moving.
- The magnetic force acts on a charged particle only when the particle is in motion.

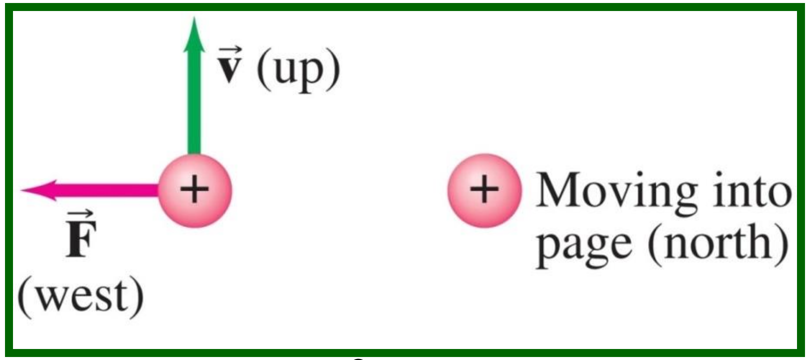
Notation Notes

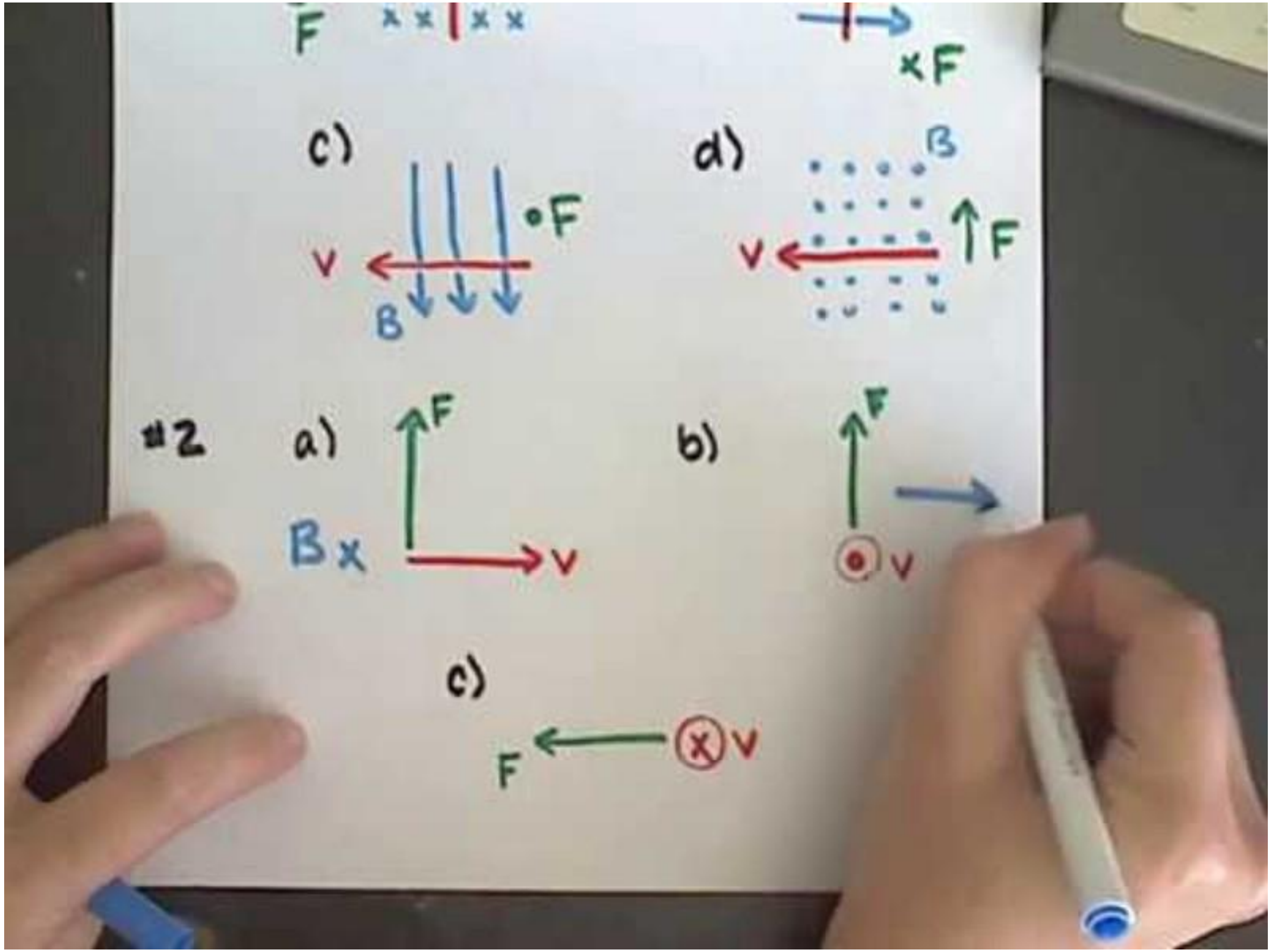
- When vectors are perpendicular to the page, dots & crosses are used.
- The dots represent the arrows coming out of the page.
- The crosses represent the arrows going into the page.
- The same notation applies to other vectors.



Example: Magnetic Force on a Proton.

A magnetic field exerts a force **$F = 8.0 \times 10^{-14}$ N** **toward** the **west** on a proton moving **vertically up** at a **speed** **$v = 5.0 \times 10^{6}$ m/s**. When moving horizontally in a northerly direction, the force on the proton is zero. Calculate the magnitude & direction of the magnetic field **B** in this region. (Proton charge: ***q* = +*e* = 1.6 x 10^{-19} C**.)

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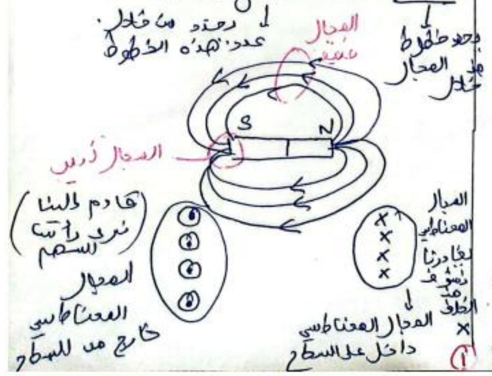

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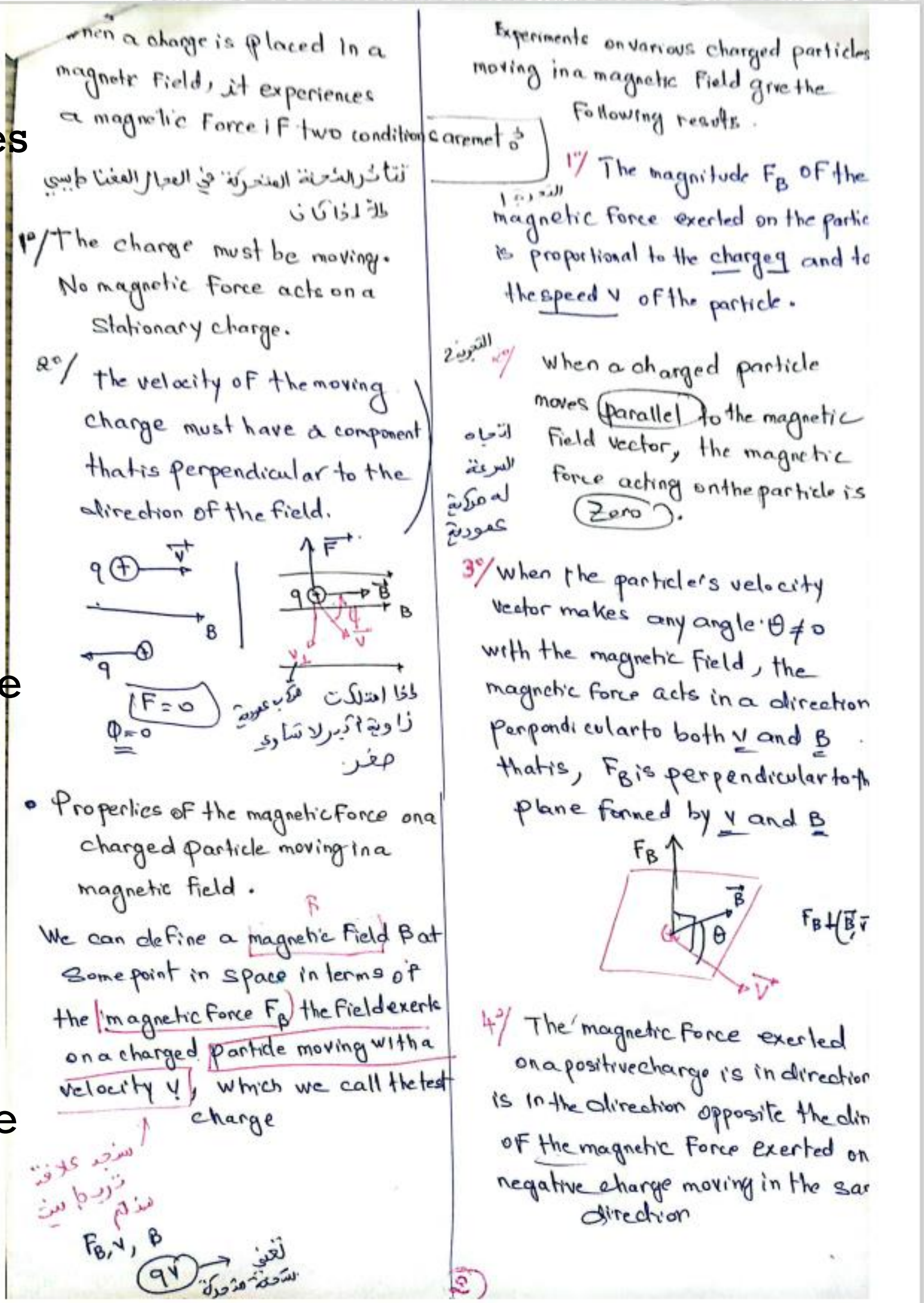

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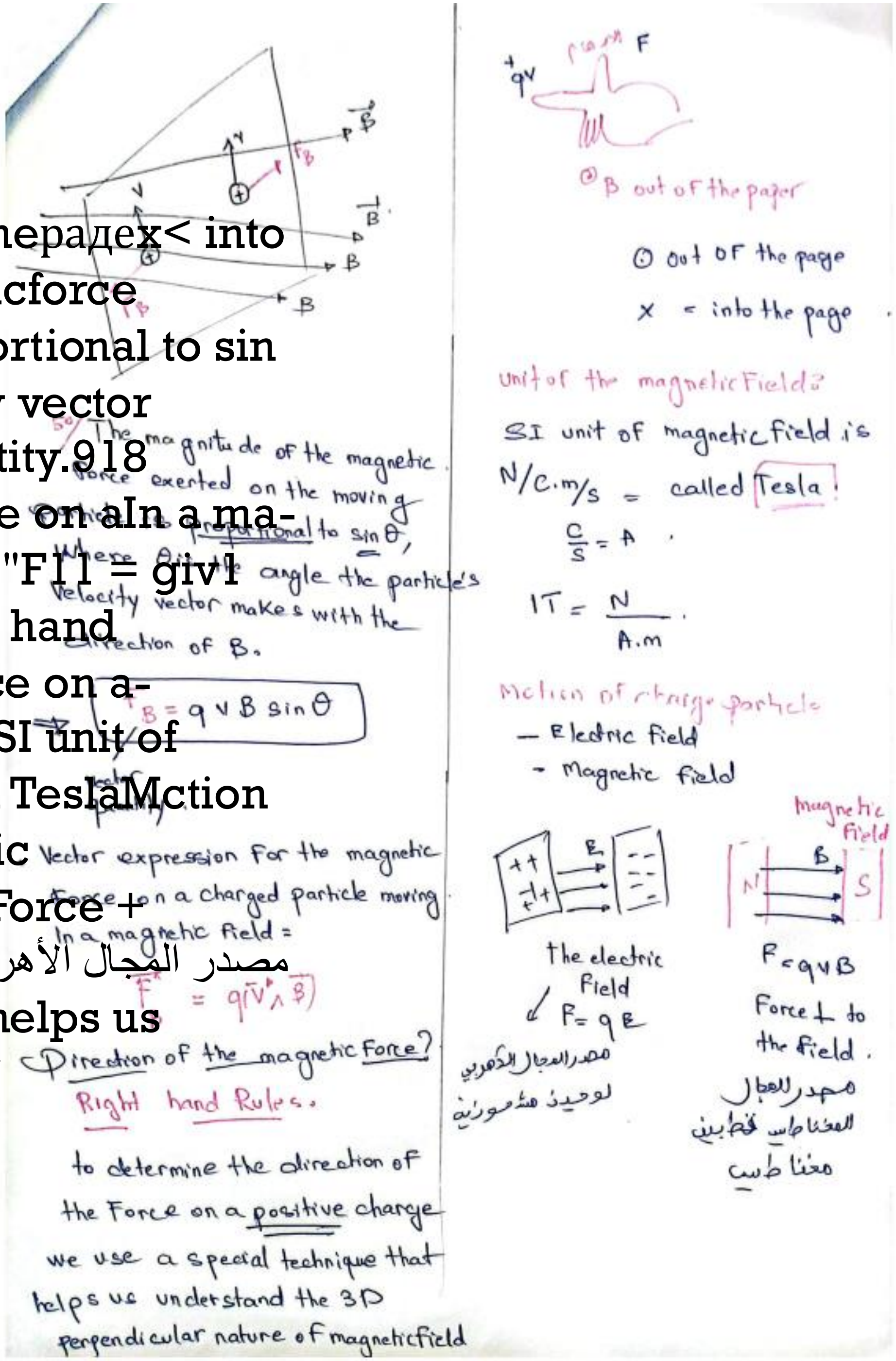

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