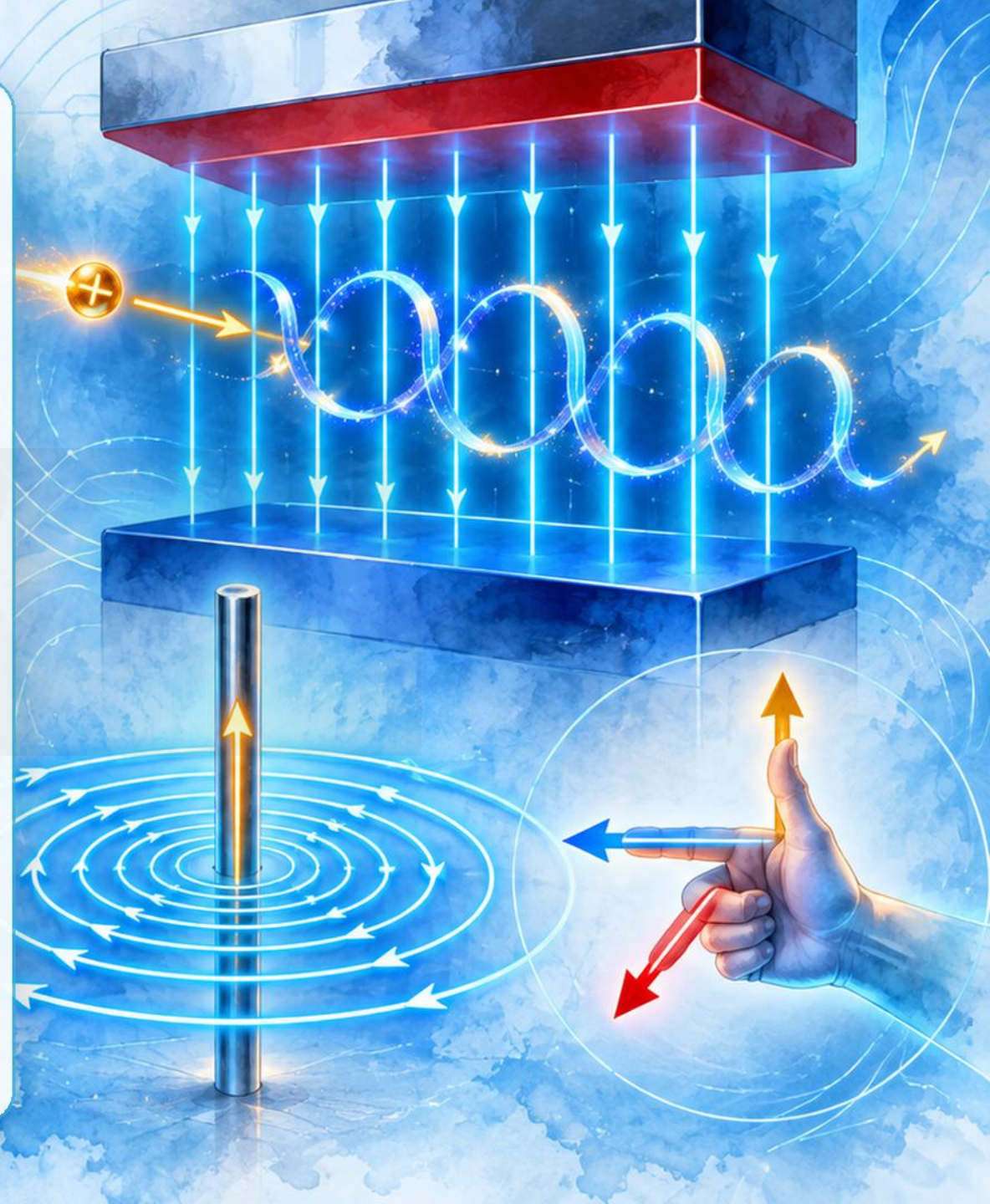


PHYSICS • CLASS 12

CHAPTER 4

Moving Charges and Magnetism

CHAPTER NOTES

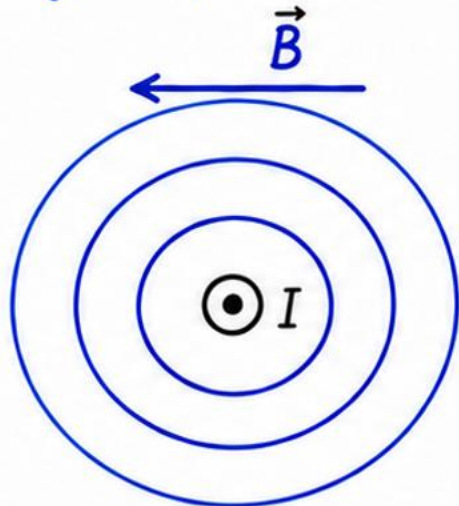


MOVING CHARGES & MAGNETISM

Field sources, Lorentz force & particle motion

① OERSTED & FIELD SOURCES

A current-carrying wire produces a magnetic field and deflects a nearby compass.



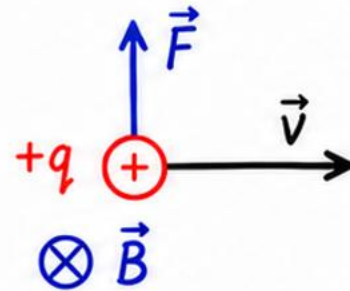
anticlockwise

B is tangent to concentric circles around a long straight wire. Use the right-hand thumb rule.

② LORENTZ FORCE

Electric and magnetic fields exert force on a charge:

$$\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$$



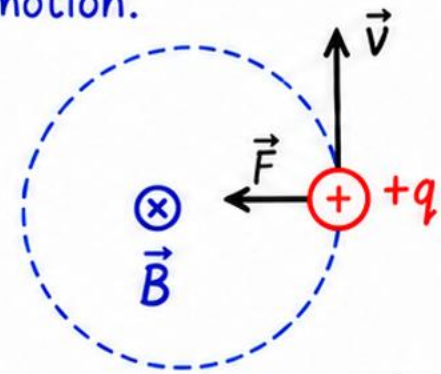
For $\vec{v}$ perpendicular to $\vec{B}$:

$$F_B = |q|vB.$$

Magnetic force is perpendicular to $\vec{v}$ and $\vec{B}$. Its direction reverses for negative q .

③ CHARGED-PARTICLE MOTION

For $\vec{v}$ perpendicular to a uniform $\vec{B}$: circular motion.



$$r = \frac{mv_{\perp}}{|q|B} \quad T = \frac{2\pi m}{|q|B}$$

If both perpendicular and parallel velocity components are nonzero: helical motion.

If $\vec{v}$ is parallel to $\vec{B}$: straight-line motion.

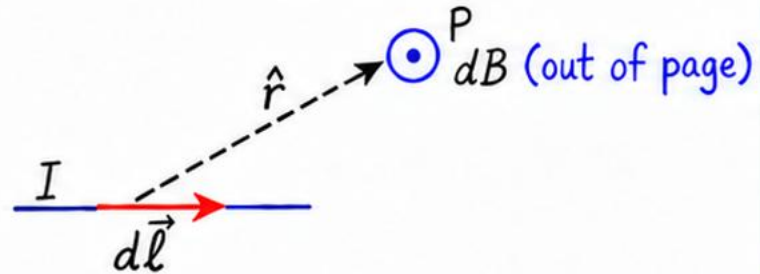
MOVING CHARGES & MAGNETISM

Fields due to currents, loops & galvanometer

4 BIOT-SAVART & STRAIGHT-WIRE FIELD

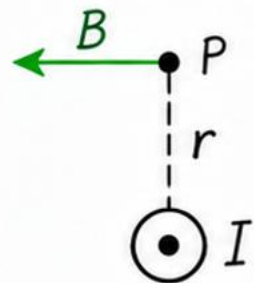
- Field due to a current element:

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I(d\vec{\ell} \times \hat{r})}{r^2}$$



- For a very long straight wire in vacuum:

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

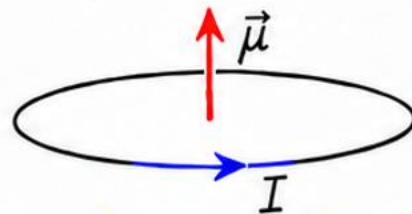


- Field direction: right-hand thumb rule.

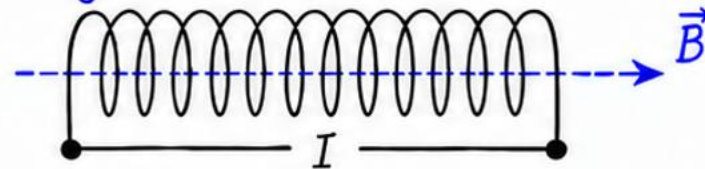
5 LOOPS, SOLENOIDS & FORCES

- A current loop behaves as a magnetic dipole:

$$\vec{\mu} = NI\vec{A}$$

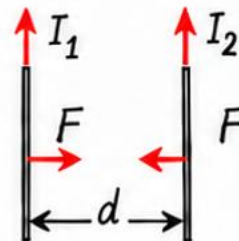


- The moment is normal to the loop.
- A solenoid produces a magnetic field along its axis.



- For two long parallel wires:

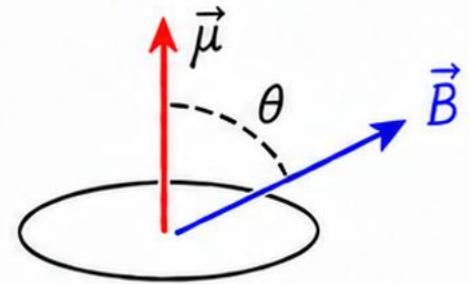
$$\frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi d}$$



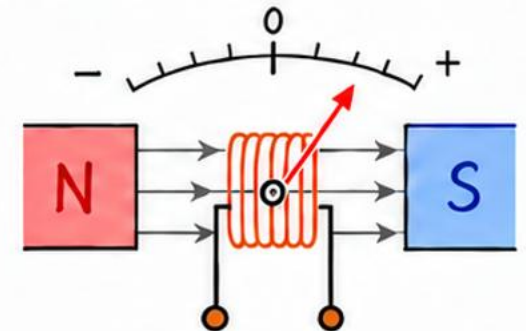
- Same-direction currents attract; opposite-direction currents repel.

6 TORQUE & GALVANOMETER

- $\vec{\tau} = \vec{\mu} \times \vec{B}$; $\tau = \mu B \sin \theta$.
- θ is the angle between $\vec{\mu}$ and $\vec{B}$.



- A moving-coil galvanometer uses torque on a current-carrying coil to indicate current.



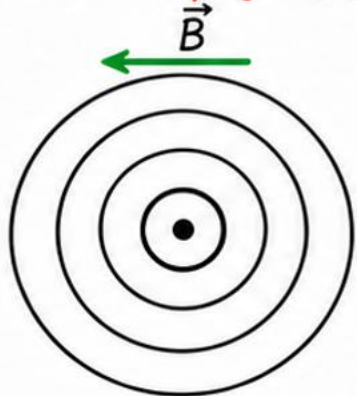
OERSTED, FIELD SOURCES & VECTOR SIGNS

Oersted observation, page symbols & right-hand rule

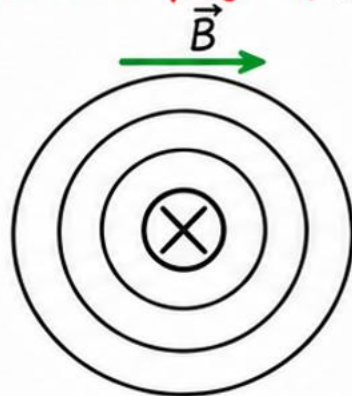
1) OERSTED OBSERVATION

- A current-carrying straight wire deflects a nearby magnetic compass.
- The compass aligns with the local resultant field; when the wire's field dominates, the needles are tangent to circles around the wire.
- For a very long straight wire, the field increases with current I and decreases with distance r : $|\vec{B}| \propto I$; $|\vec{B}| \propto \frac{1}{r}$.
- Reversing I reverses $\vec{B}$ and the compass deflection.

I out of page ($\odot$)



I into page ($\otimes$)



2) PAGE VECTOR SIGNS



means out of the page:
the arrow comes towards you.



means into the page:
the arrow goes away from you.

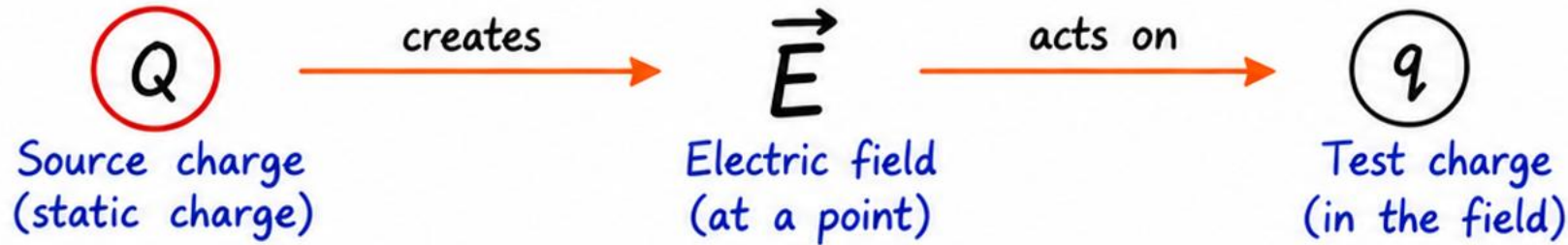
3) RIGHT-HAND GRIP RULE

- Point the right thumb along conventional current I .
- Curled fingers give the direction of $\vec{B}$ around the wire.
- I out of page ($\odot$) $\rightarrow \vec{B}$ anticlockwise.
- I into page ($\otimes$) $\rightarrow \vec{B}$ clockwise.

OERSTED, FIELD SOURCES & VECTOR SIGNS

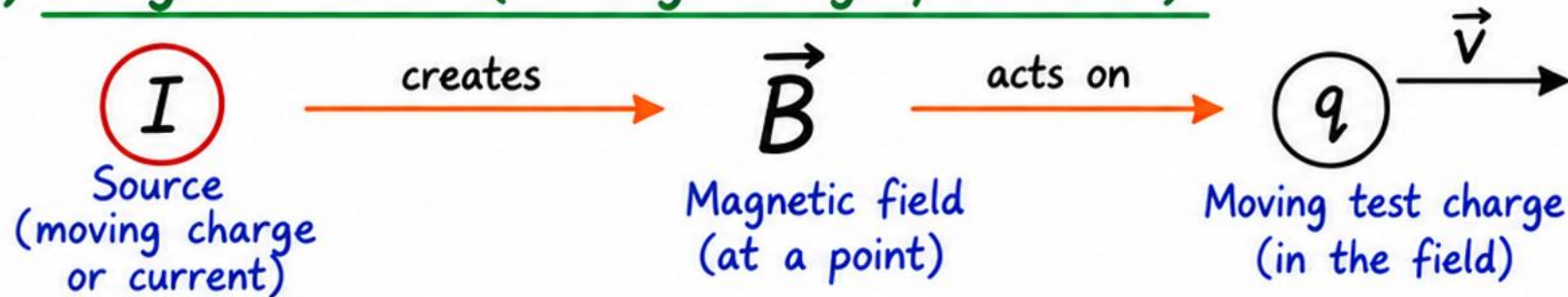
Source $\rightarrow$ field $\rightarrow$ test object

(a) Electric case (static charge)



$$\vec{F}_E = q \vec{E}$$

(b) Magnetic case (moving charge / current)



$$\vec{F}_B = q(\vec{v} \times \vec{B})$$

GENERAL NOTES

- $\vec{E}$ and $\vec{B}$ are physical vector fields. They can carry energy and momentum.
- Fields obey vector superposition:
- This chapter treats steady currents and time-independent fields unless stated otherwise.

$$\vec{B}_{\text{total}} = \sum_i \vec{B}_i$$

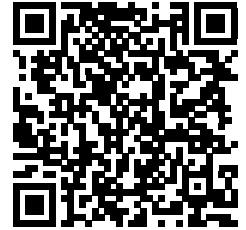


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