Applied Physics

BS Software Engineering/Information Technology

1st Semester

Lecture # 19

Magnetic fields

Presented By

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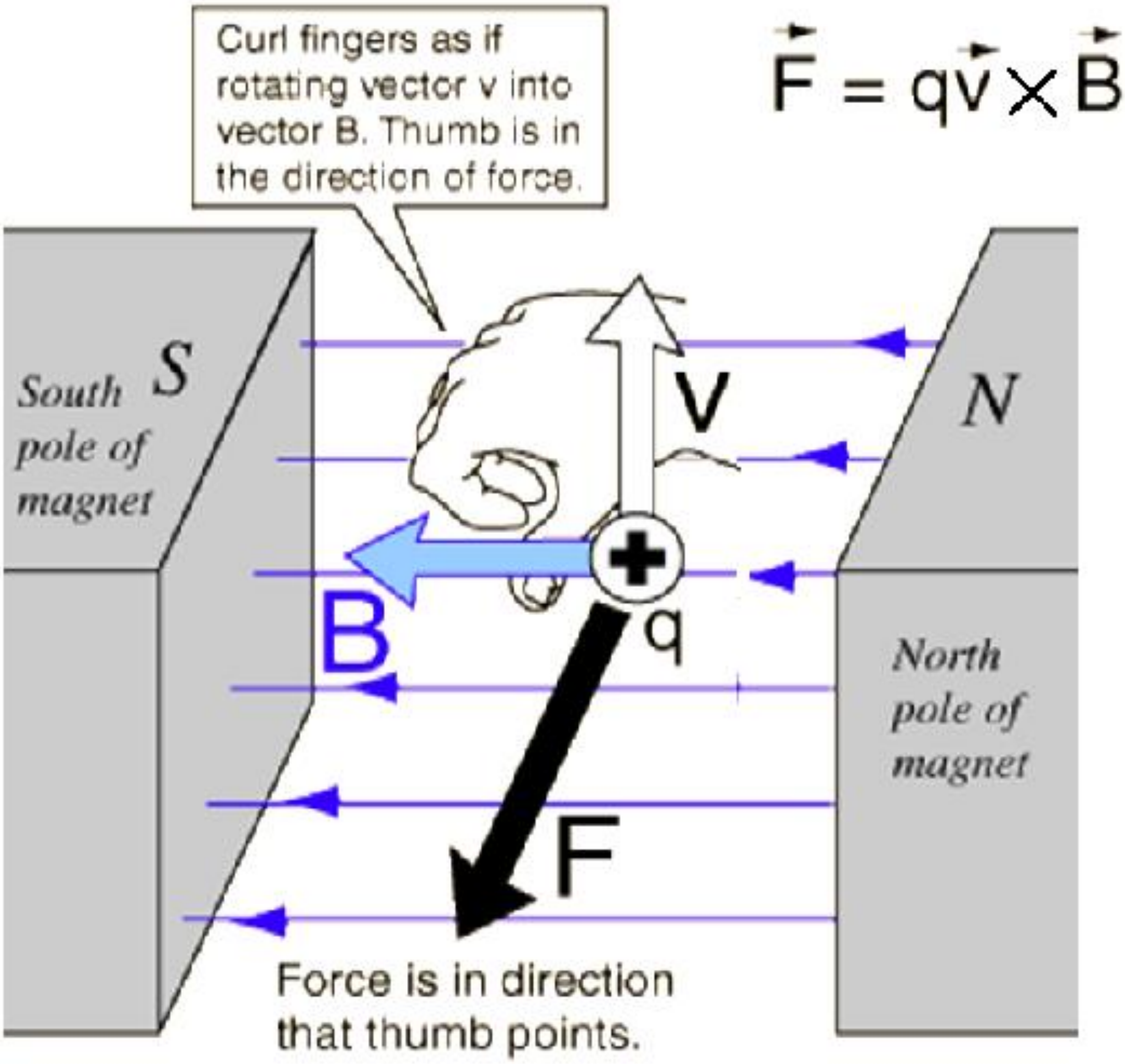

Curl fingers as if rotating vector v into vector B. Thumb is in the direction of force.
$\vec{F} = q\vec{v} \times \vec{B}$
South pole of magnet
S
N
V
B
q
North pole of magnet
F
Force is in direction that thumb points.

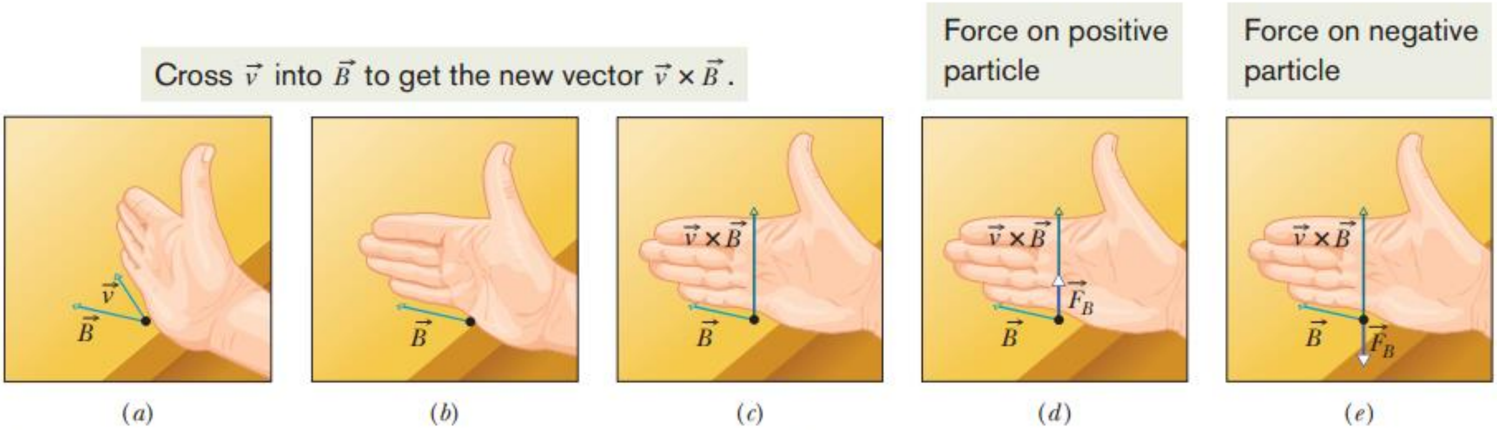


Figure (a)–(c) The right-hand rule (in which $\vec{v}$ is swept into $\vec{B}$ through the smaller angle ϕ between them) gives the direction of $\vec{v} \times \vec{B}$ as the direction of the thumb. (d) If q is positive, then the direction of $\vec{F}_B = q\vec{v} \times \vec{B}$ is in the direction of $\vec{v} \times \vec{B}$. (e) If q is negative, then the direction of $\vec{F}_B$ is opposite that of $\vec{v} \times \vec{B}$.

Combined electric and magnetic forces (Lorentz Force)

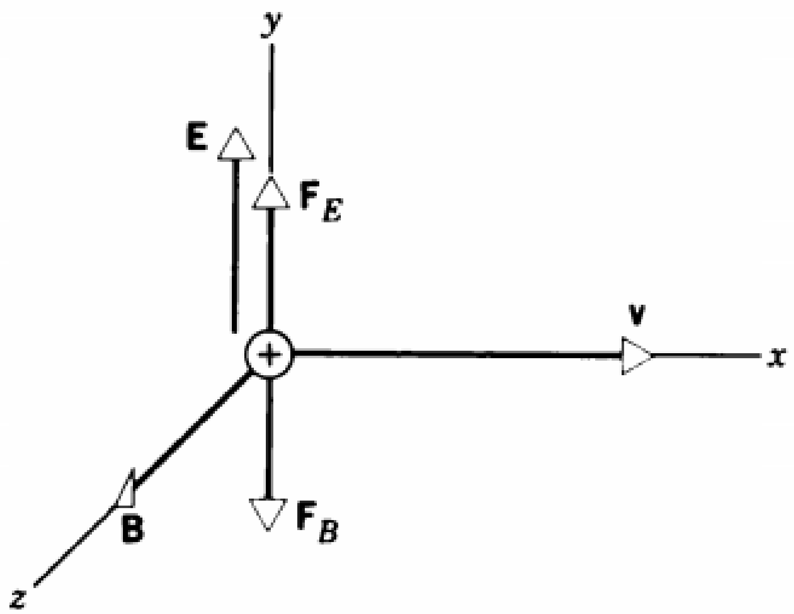
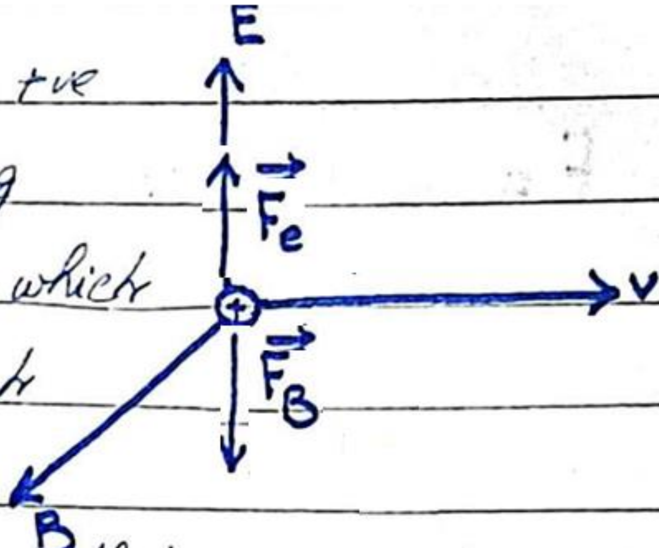


Figure 7 A positively charged particle, moving through a region in which there are electric and magnetic fields perpendicular to one another, experiences opposite electric and magnetic forces $\mathbf{F}_E$ and $\mathbf{F}_B$.

Consider, a +ve charge and the following $\vec{E}$, $\vec{B}$ & $\vec{v}$ acts on it which are perpendicular to each other.



From this, we get that F_e works in upward direction

The total force acting on the charge particle will be;

$$\Rightarrow \vec{F} = \vec{F_e} + \vec{F_B} \quad \text{—— (i)}$$

result as;

$$F = qE + (-qvB\sin\theta) \quad \text{—— (ii)}$$

This resultant force is known as **Lorentz Force**

If the Lorentz force become zero, then we have;

$$qE - qvB = 0$$

So, both the forces i.e electric force & magnetic force becomes equal, so;

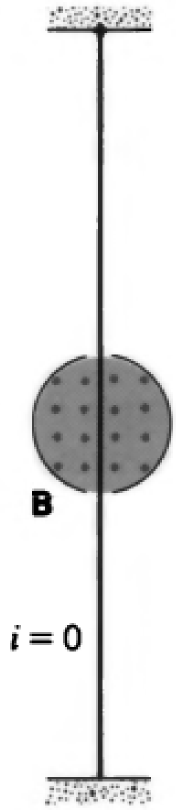
$$\cancel{q}vB = \cancel{q}E$$

The velocity of charge particle will be;

$$v = E/B \quad \text{——} \quad (iv)$$

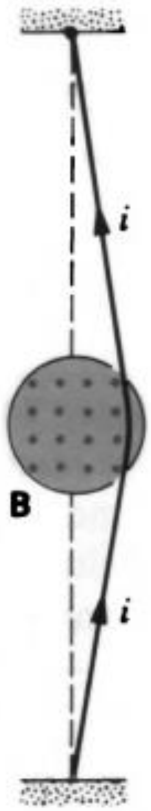
The magnetic force on a current

When there is No Current



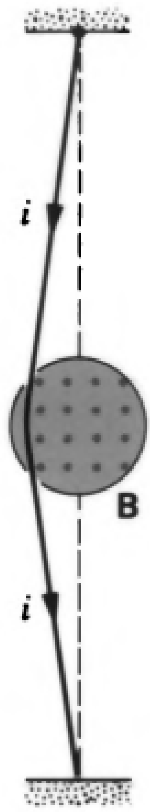
(*a*)

When there is Current in up word direction



(b)

When there is Current in downword direction



(c)

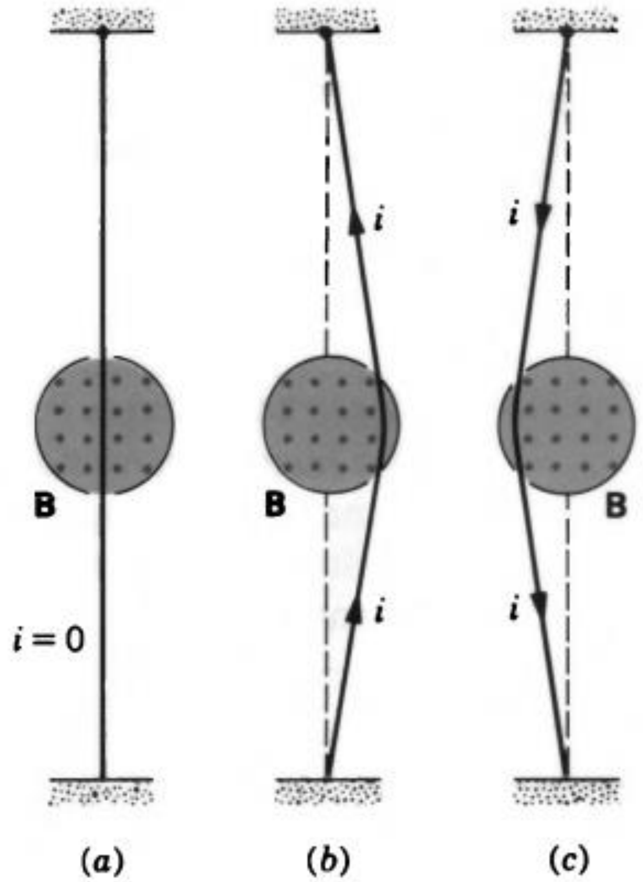
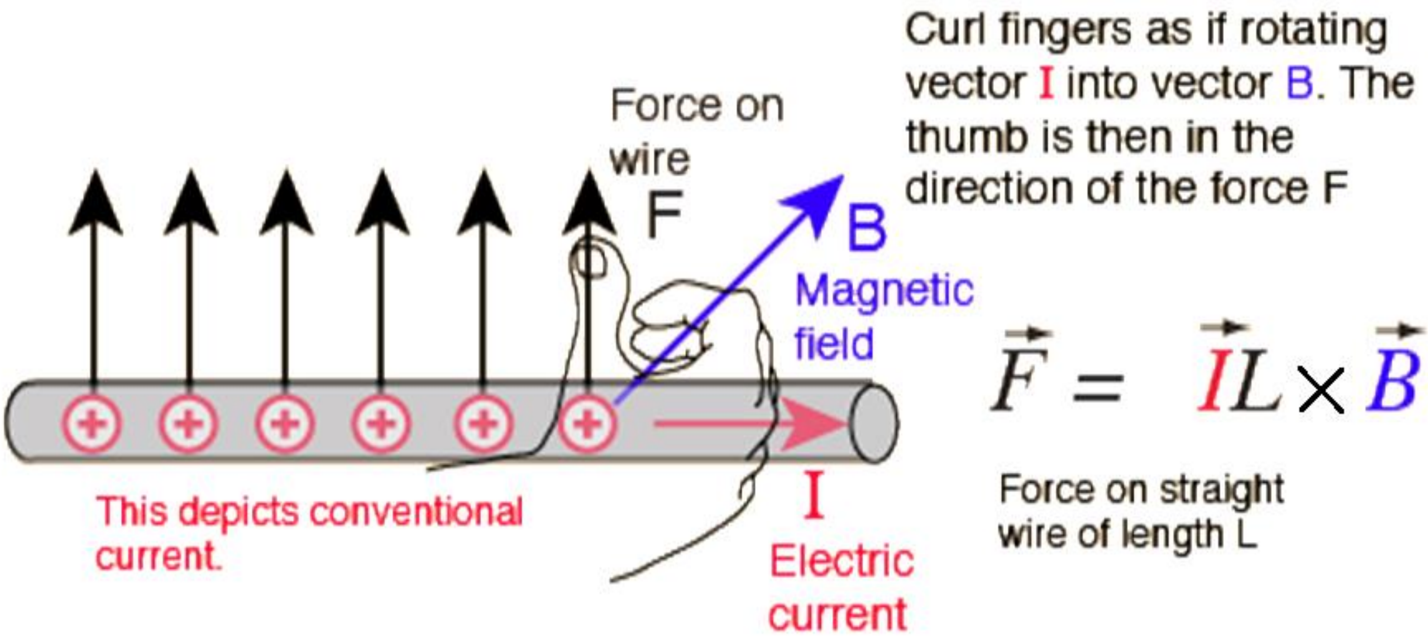
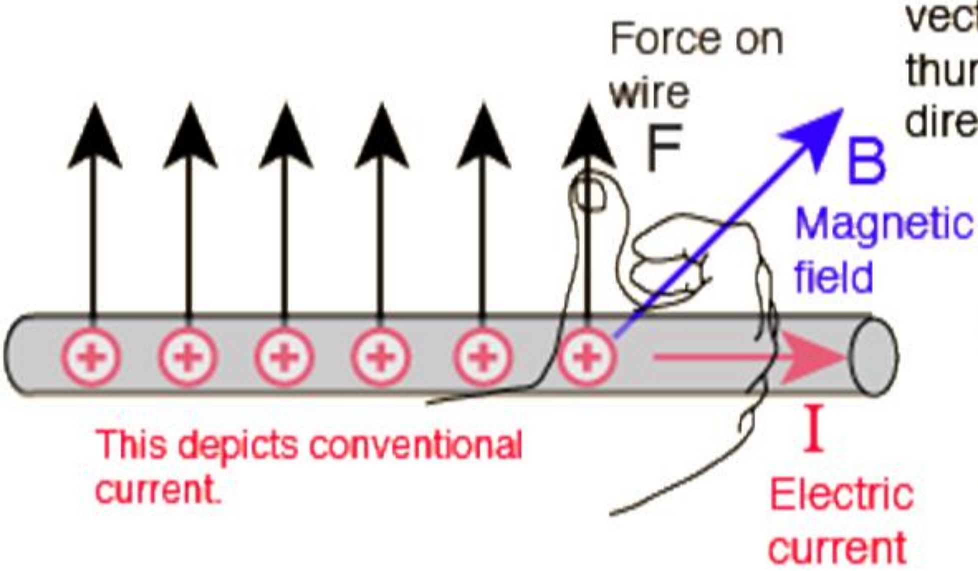


Figure 20 A flexible wire passes between the poles of a magnet. (*a*) There is no current in the wire. (*b*) A current is established in the wire. (*c*) The current is reversed.


Curl fingers as if rotating vector I into vector B. The thumb is then in the direction of the force F
Force on wire
F
B
Magnetic field
$\vec{F} = \vec{I}L \times \vec{B}$
This depicts conventional current.
I
Electric current
Force on straight wire of length L



Curl fingers as if rotating vector I into vector B. The thumb is then in the direction of the force F

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

Force on straight wire of length L

PROBLEMS

Section 34-2 The Magnetic Force on a Moving Charge

1. Four particles follow the paths shown in Fig. 29 as they pass through the magnetic field there. What can one conclude about the charge of each particle?
2. An electron in a TV camera tube is moving at 7.2×10^6 m/s in a magnetic field of strength 83 mT. (*a*) Without knowing the direction of the field, what could be the greatest and least magnitudes of the force the electron could feel due to the field? (*b*) At one point the acceleration of the electron is 4.9×10^{16} m/s^2. What is the angle between the electron's velocity and the magnetic field?
3. An electric field of 1.5 kV/m and a magnetic field of 0.44 T act on a moving electron to produce no force. (*a*) Calculate

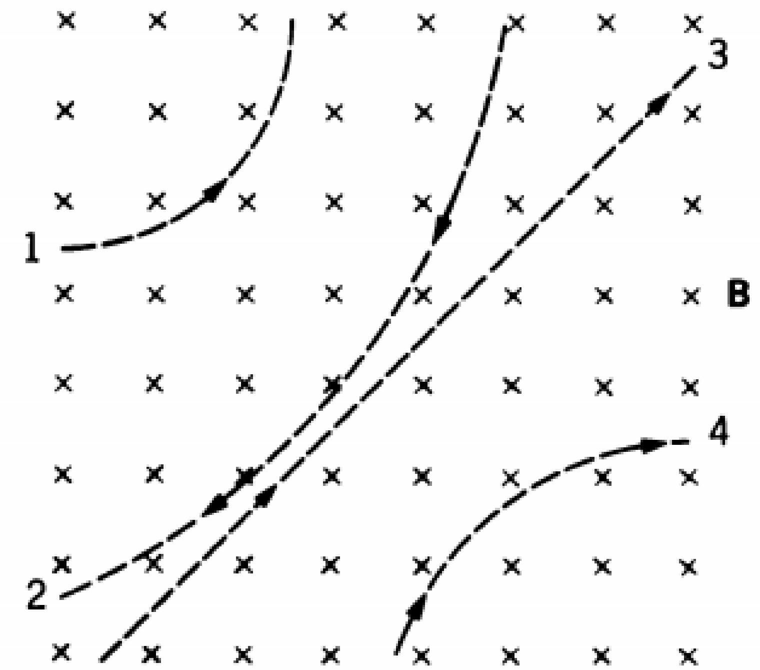


Figure 29 Problem 1.

the minimum electron speed v. (*b*) Draw the vectors **E**, **B**, and **v**.

4. A proton traveling at 23.0° with respect to a magnetic field of strength 2.63 mT experiences a magnetic force of 6.48×10^{-17} N. Calculate (*a*) the speed and (*b*) the kinetic energy in eV of the proton.
5. A cosmic ray proton impinges on the Earth near the equator with a vertical velocity of 2.8×10^7 m/s. Assume that the horizontal component of the Earth's magnetic field at the equator is 30 μT. Calculate the ratio of the magnetic force on the proton to the gravitational force on it.
6. An electron is accelerated through a potential difference of 1.0 kV and directed into a region between two parallel plates separated by 20 mm with a potential difference of 100 V between them. If the electron enters moving perpendicular to the electric field between the plates, what magnetic field is necessary perpendicular to both the electron path and the electric field so that the electron travels in a straight line?