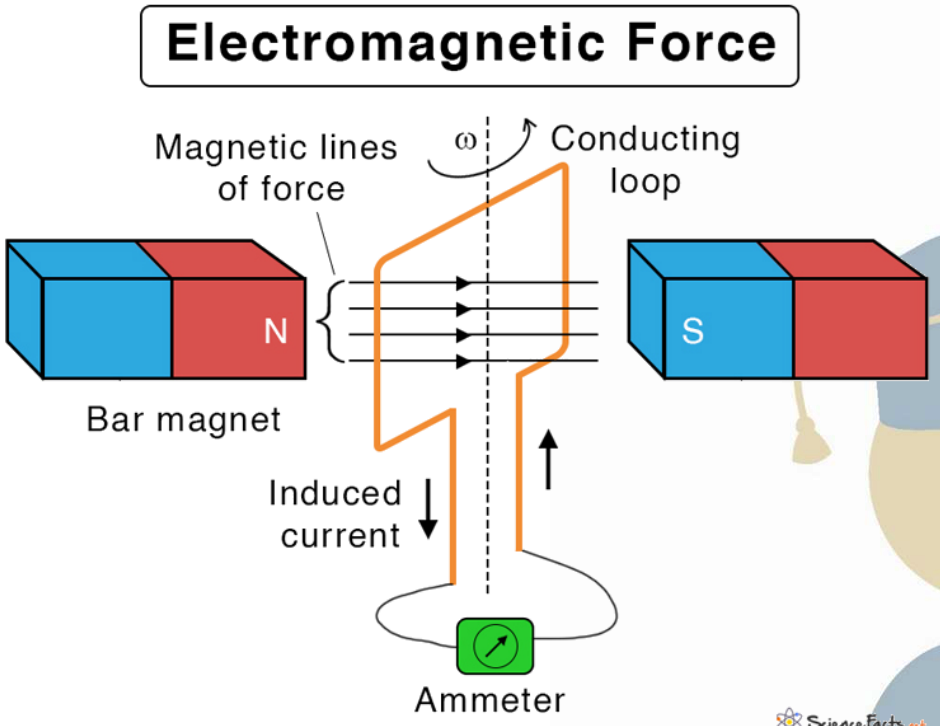
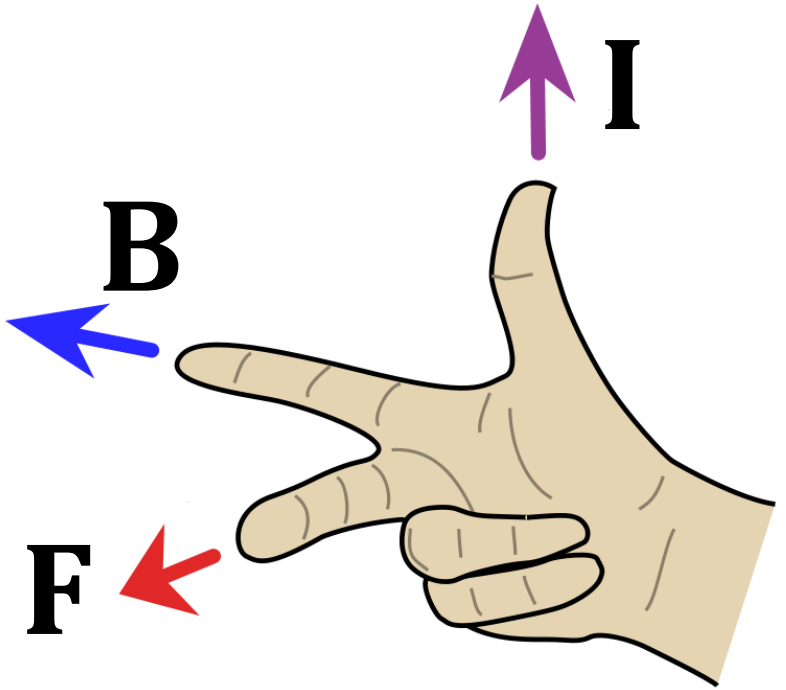


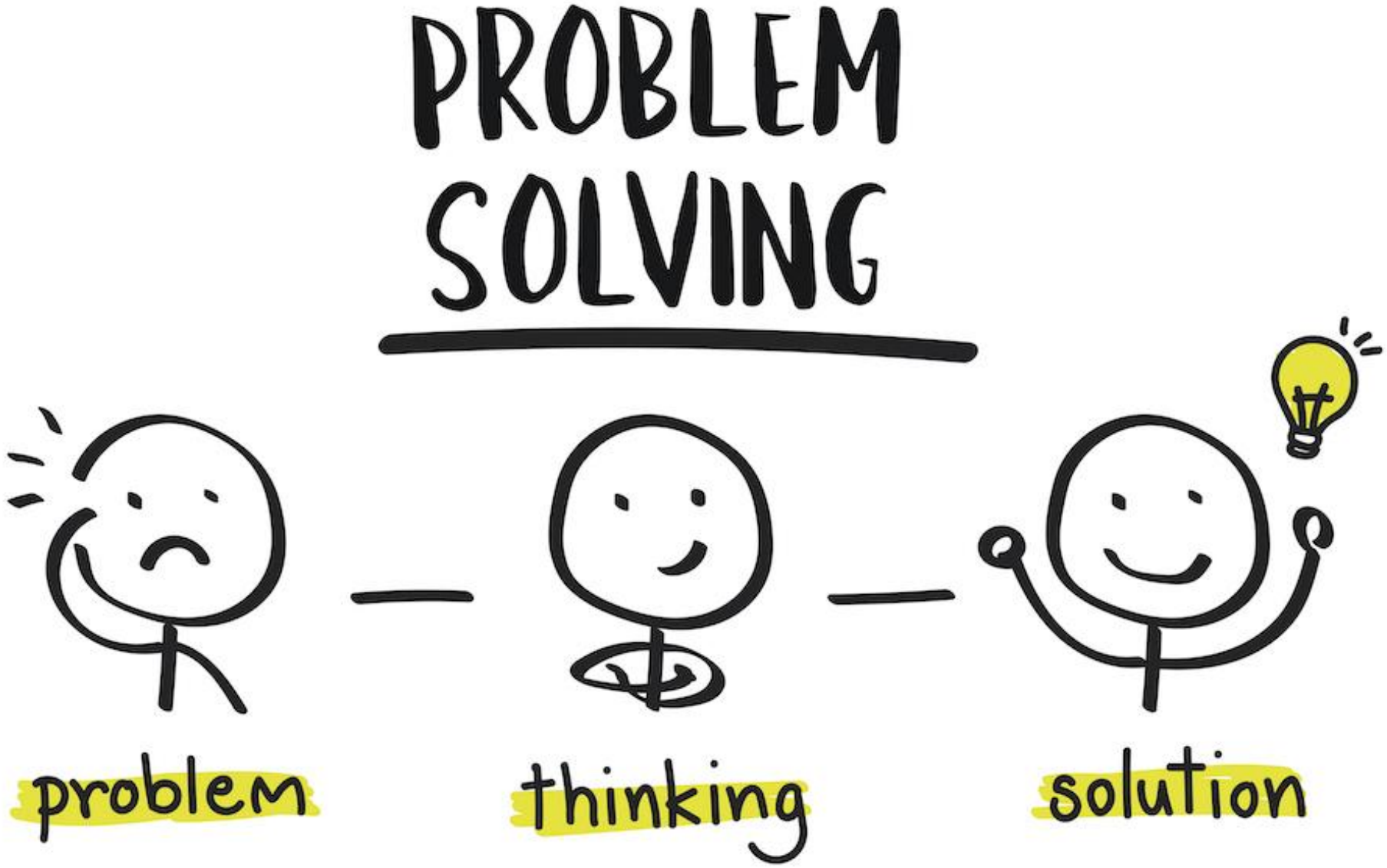


Chapter 19

Electromagnetic force

Prepared & Presented by: Mr. Mohamad Seif

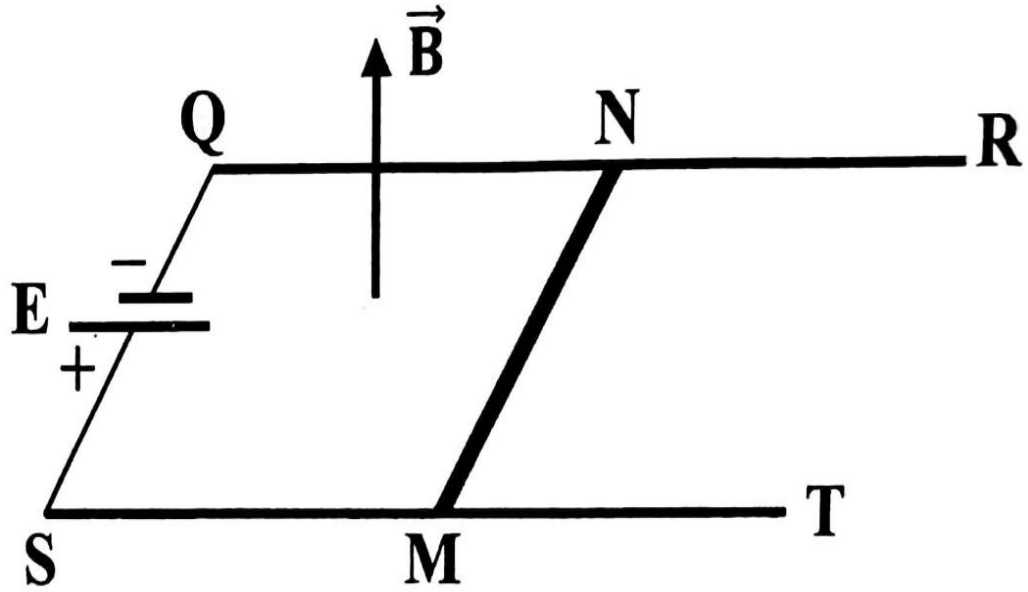
Exercises electromagnetic force



Exercise 1

Two conducting rails QR and ST of negligible resistances are placed in a horizontal plane.

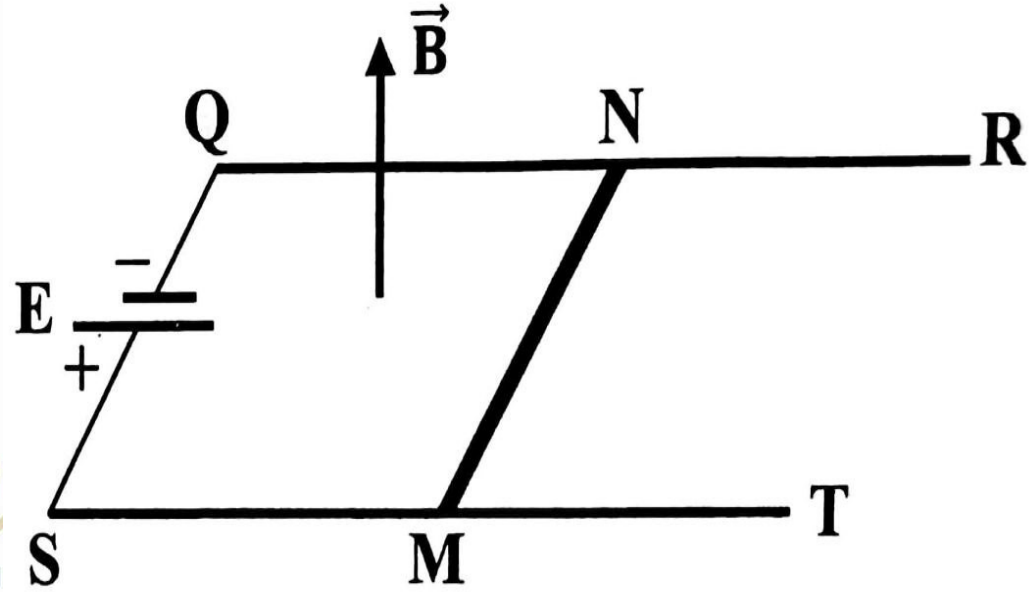
The two extremities Q and S are connected to an ideal generator of e.m.f E=10V.



A rod MN of resistance $r = 2\Omega$, mass $m = 50g$, and length L=20cm is free to move without friction on the rails so that it stays perpendicular to then.

Exercise 1

This assembly is placed in a uniform magnetic field of intensity B=0.25T as shown in the adjacent figure.

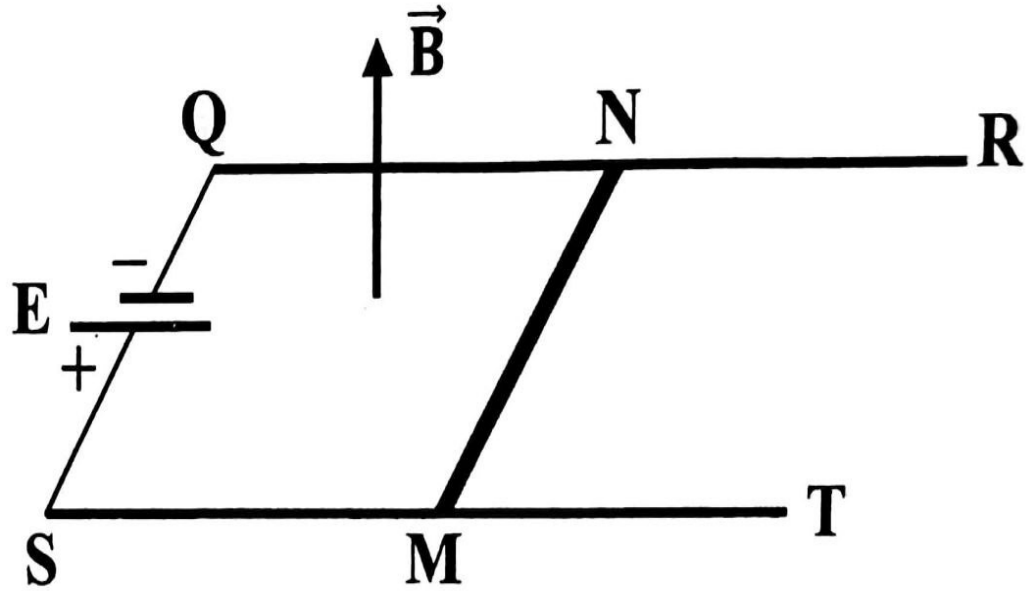


1) **Calculate the intensity of the electric current traversing the rod MN.**
2) **Determine the characteristics of the electromagnetic force acting on the rod MN.**
3) **Name and represent the external forces acting on MN.**

Exercise 1

4) What is the nature of motion of the rod MN.

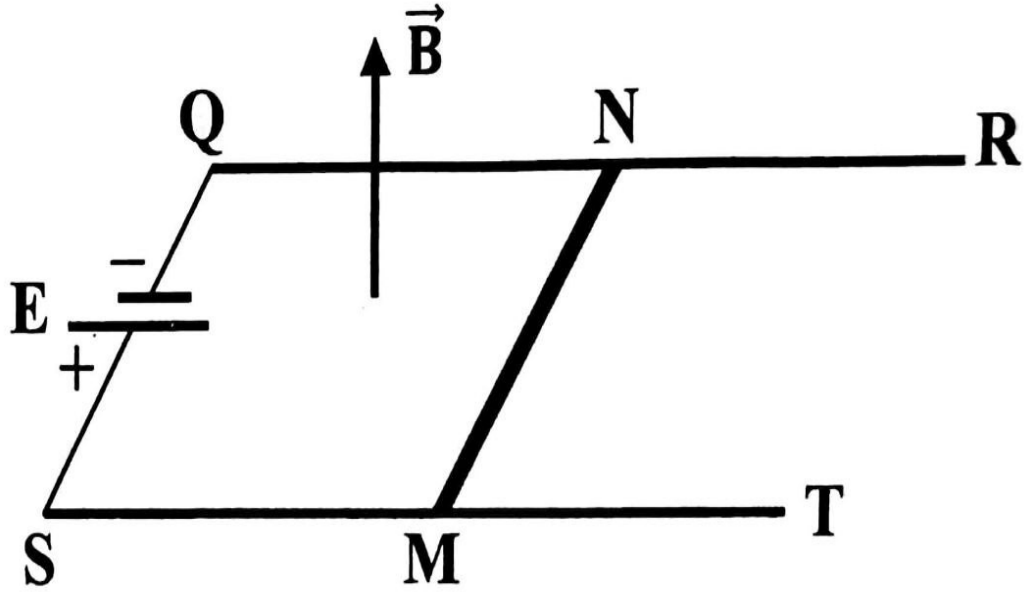
5) Determine the speed and the distance covered by MN after 0.1s



Exercise 1

E=10V; $r = 2\Omega$; $m = 50g$; L=20cm; B=0.25T

1) Calculate the intensity of the electric current traversing the rod MN.



Using ohm's law:

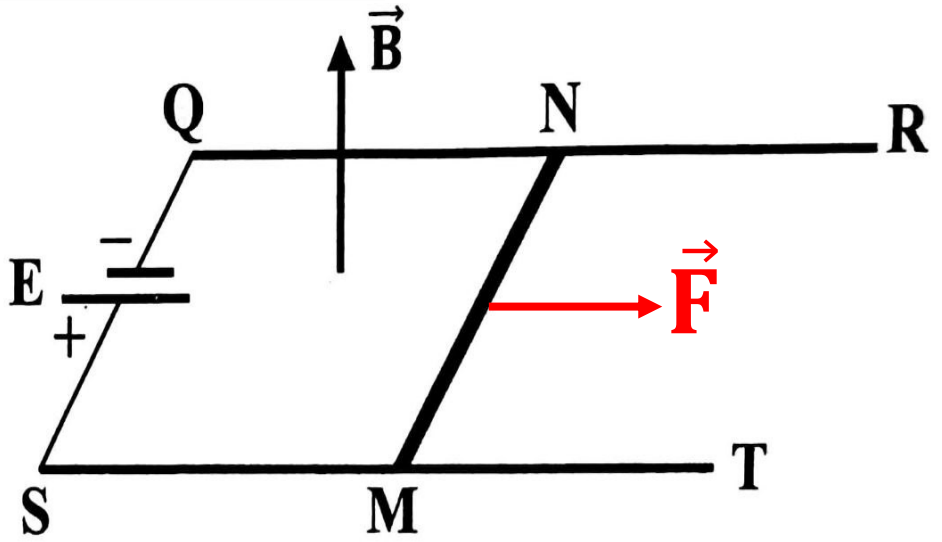
$$U = RI \Rightarrow E = RI$$

$$\Rightarrow I = \frac{E}{R} = \frac{10}{2} \Rightarrow I = 5A$$

Exercise 1

E=10V; $r = 2\Omega$; $m = 50g$; L=20cm; B=0.25T

2)Determine the characteristics of the electromagnetic force acting on the rod MN.



Point of application: center of gravity of MN.

Line of action: horizontal.

Direction: by R.H.R, to right.

Magnitude: $F = ILBsin(I,B)$

$$F = 5 \times 0.2 \times 0.25 \times sin(90) \Rightarrow F = 0.25N$$

Exercise 1

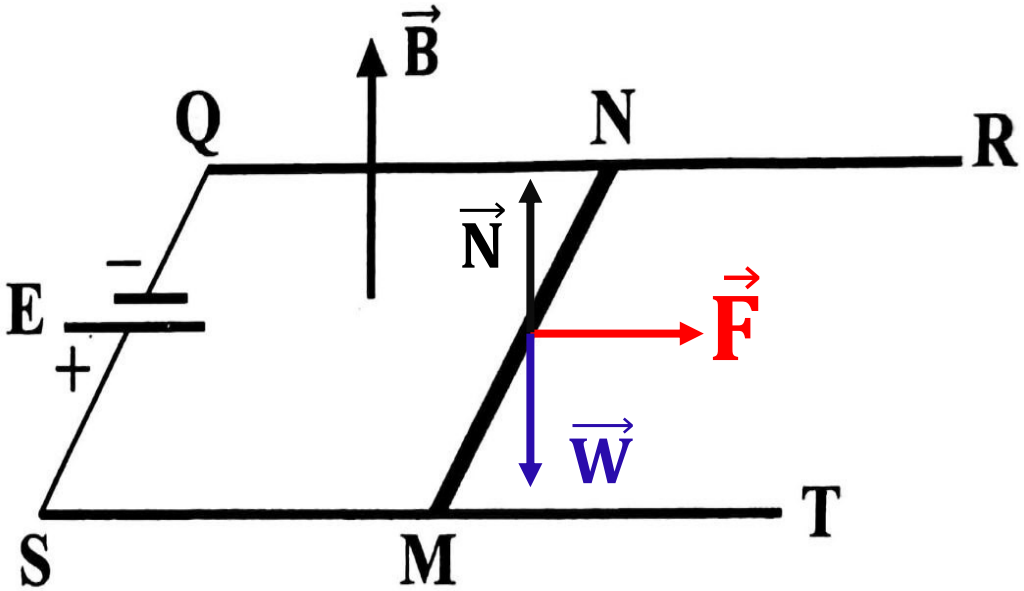
E=10V; $r = 2\Omega$; $m = 50g$; L=20cm; B=0.25T

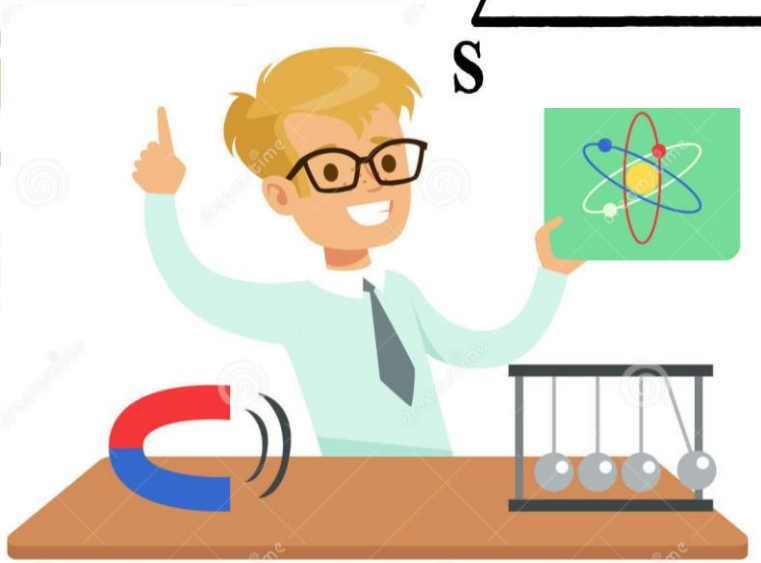
3)Name and represent the external forces acting on MN.

Weight: $\overrightarrow{W}$

Normal: $\overrightarrow{N}$

Electromagnetic force: $\overrightarrow{F}$

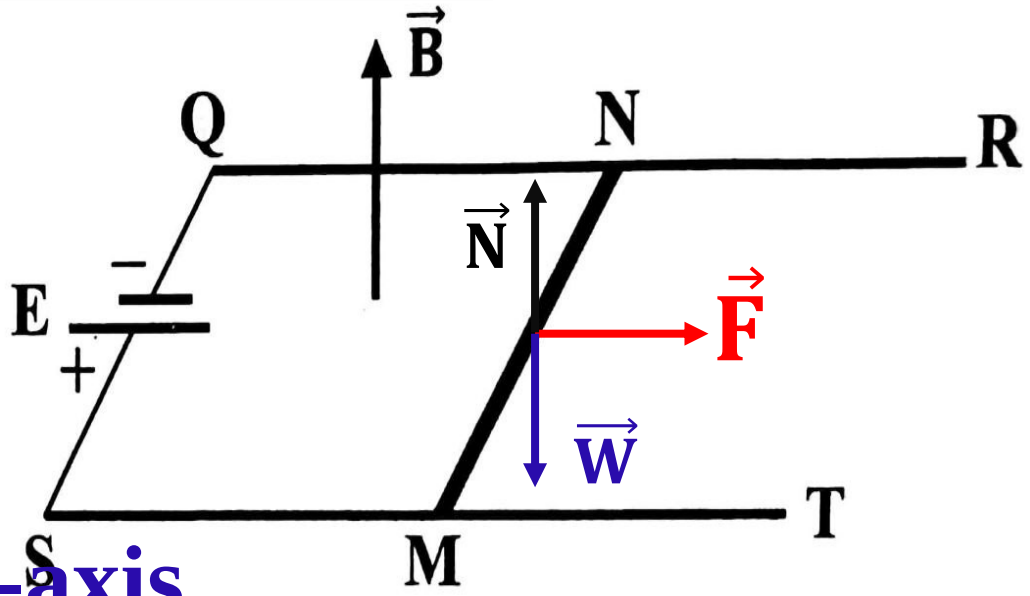




Exercise 1

E=10V; $r = 2\Omega$; $m = 50g$; L=20cm; B=0.25T

4)What is the nature of motion of the rod MN



Apply newton's second law:

$$\sum \vec{F}_{ex} = m\vec{a}$$

$\vec{W} + \vec{N} + \vec{F} = m\vec{a}$ **Project along x-axis**

$F = ma$ ➡ $a = \frac{F}{m} = \frac{0.25}{0.05} = 5m/s^2 > 0$ **then UARM**

Exercise 1

E=10V; $r = 2\Omega$; $m = 50g$; L=20cm; B=0.25T

5)Determine the speed and the distance covered by MN after 0.1s

$$v = at + v_0$$

$$v = 5 \times 0.1 + 0$$

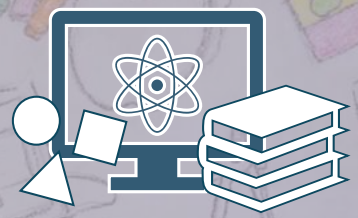
$$v = 0.5m/s$$

$$x = \frac{1}{2}at^2 + v_0t + x_0$$

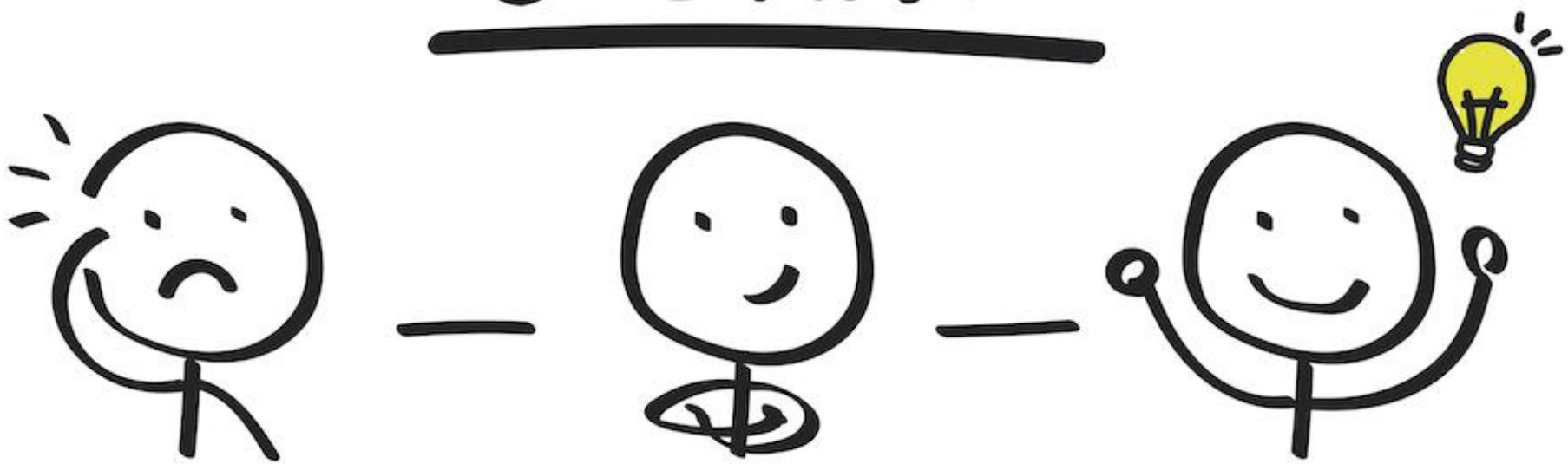
$$x = 0.5 \times 5(0.1)^2 + 0 + 0$$

$$x = 0.025m$$

The End

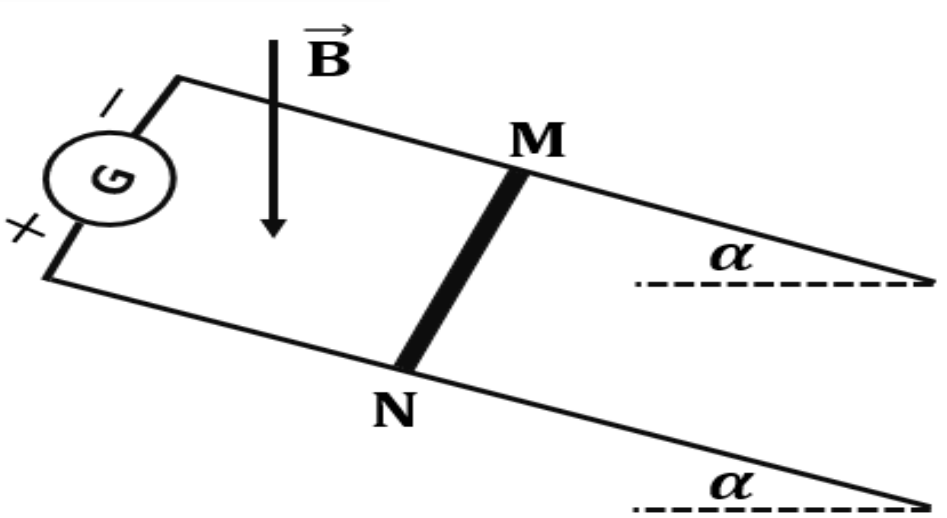


PROBLEM SOLVING



Exercise 2

A rigid rod MN of mass m=50g, can slide without friction on two parallel rails separated by a distance d=40cm and inclined at an angle $\alpha = 30$ with respect to the horizontal plane.

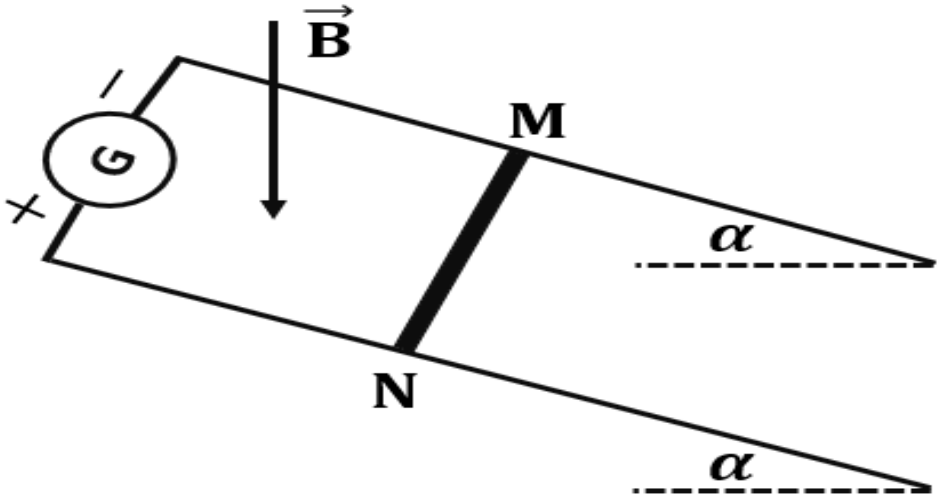


A generator delivering a current I=2A is connected to the two extremities of the rails.

The system is placed in a uniform magnetic field $\vec{B}$ directed vertically downwards and of intensity B. given $g = 10N/kg$.

Exercise 2

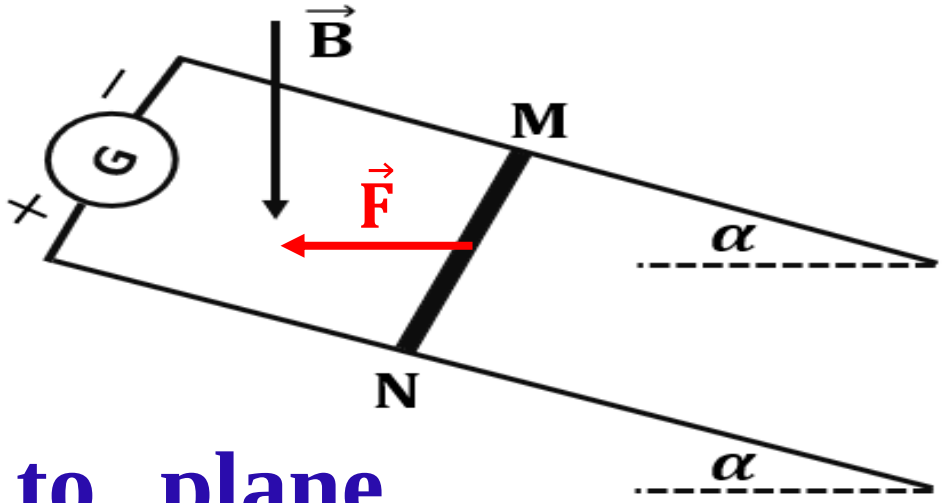
1) Determine the line of action and direction of the electromagnetic force acting on the rod MN.
2) Name and represent the external forces acting on MN.
3) Determine B, knowing that the rod is in equilibrium.



Exercise 2

m=50g; $f = 0N$; $MN = 40cm$; $\alpha = 30$; $I = 2A$; $g = 10N/kg$

1) Determine the line of action and direction of the electromagnetic force acting on the rod MN.



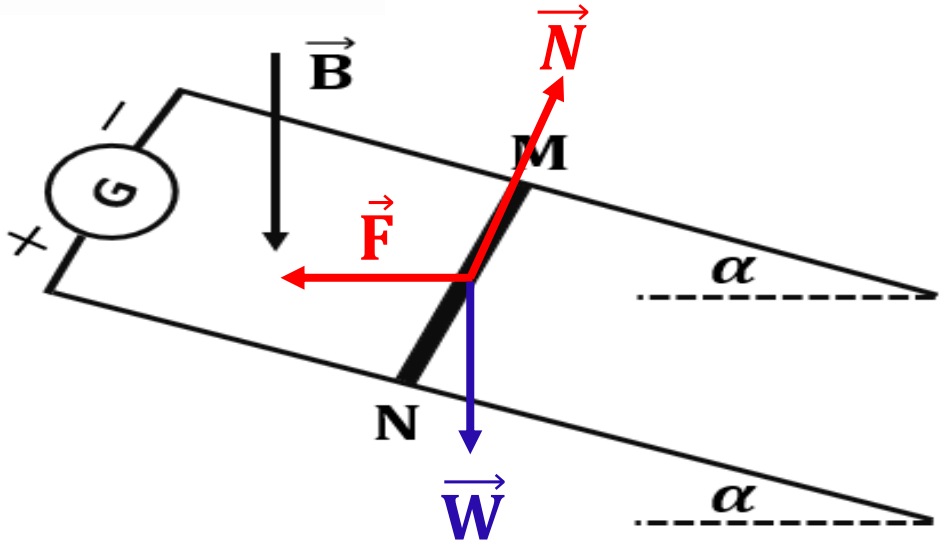
- **Line of action: horizontal & ⊥ to plane containing MN and $\vec{B}$.**
- **Direction: by RHR, to left**

Exercise 2

m=50g; $f = 0N$; $MN = 40cm$; $\alpha = 30$; $I = 2A$; $g = 10N/kg$

2)Name and represent the external forces acting on MN.

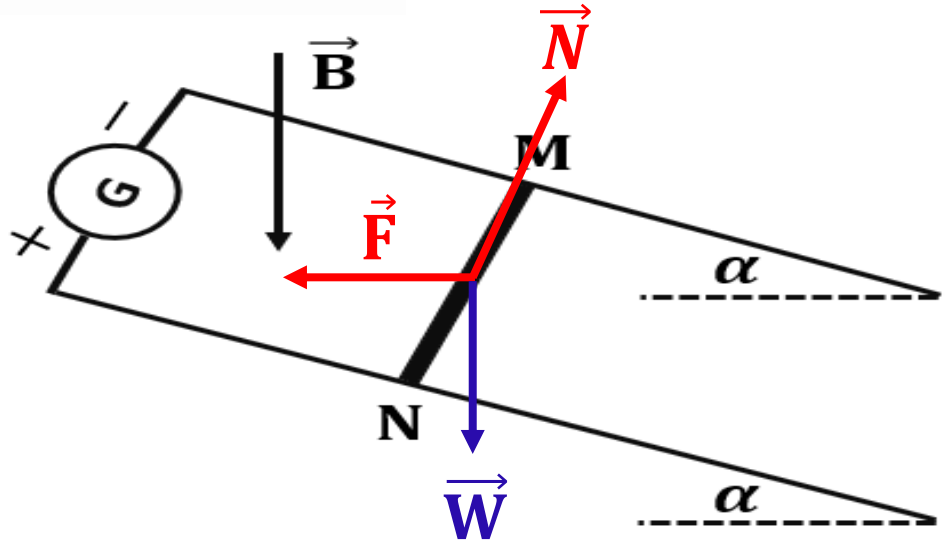
- **Weight: $\vec{W}$**
- **Normal: $\vec{N}$**
- **Electromagnetic force: $\vec{F}$**



Exercise 2

m=50g; $f = 0N$; $MN = 40cm$; $\alpha = 30$; $I = 2A$; $g = 10N/kg$

3) Determine B, knowing that the rod is in equilibrium.



Apply newton's 1st law:

$$\sum \vec{F}_{ex} = m\vec{a}$$

$\vec{W} + \vec{N} + \vec{F} = \vec{0}$ **Project along x-axis**

$-F\cos\alpha + mg\sin\alpha = 0 \Rightarrow F\cos\alpha = mg\sin\alpha$

Exercise 2

m=50g; $f = 0N$; $MN = 40cm$; $\alpha = 30$; $I = 2A$; $g = 10N/kg$

$$F\cos\alpha = mg\sin\alpha$$

$$F = \frac{mg\sin\alpha}{\cos\alpha}$$

$$F = mg.\tan\alpha$$

$$F = 0.05 \times 10 \times tan(30)$$

$$F = 0.28N$$

$$F = ILB\sin(I, \vec{B})$$

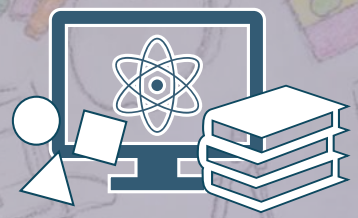
$$0.28 = 2 \times 0.4B\sin(90)$$

$$0.28 = 2 \times 0.4B\sin(90)$$

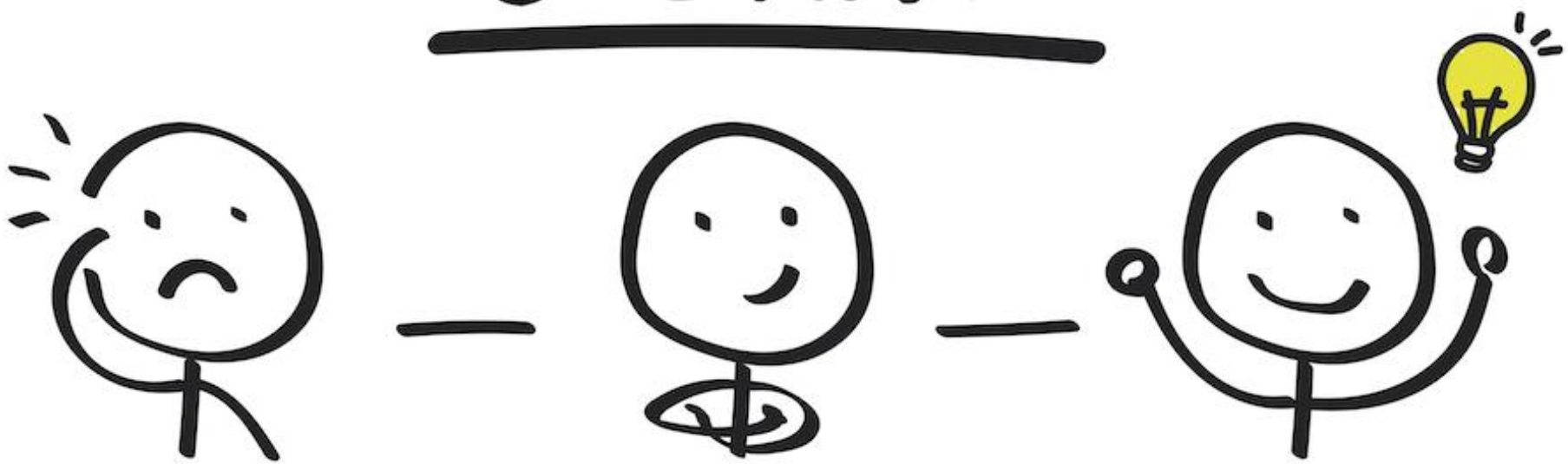
$$B = \frac{0.28}{2 \times 0.4\sin(90)}$$

$$B = 0.35N$$

The End

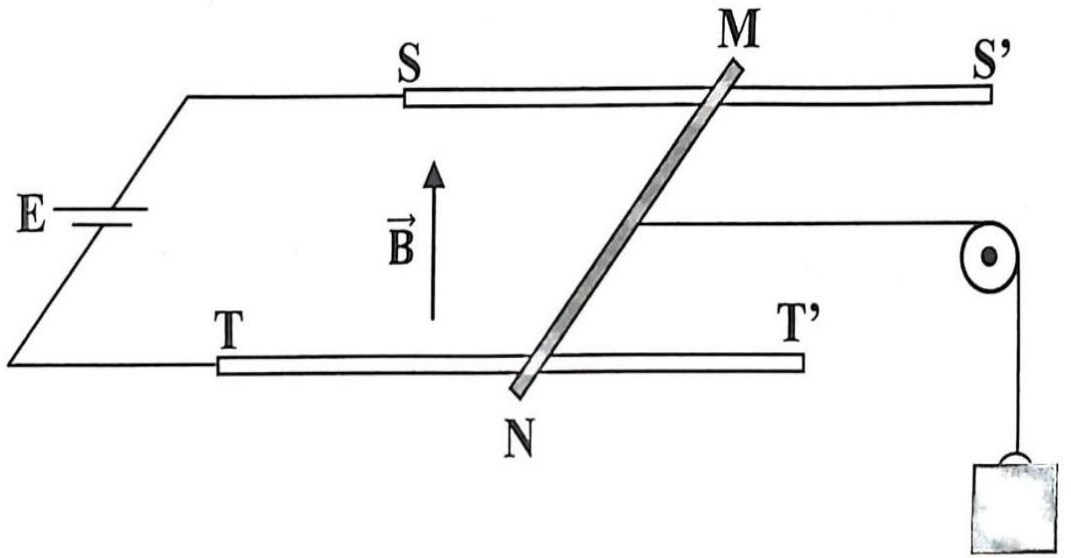


PROBLEM SOLVING



Exercise 3

Two parallel conducting rails SS' and TT', separated by a distance d=10cm, are connected to an ideal generator of electromotive force E=12V.



On these two rails, a metal rod MN can slide without while remaining ⊥ to the rails.

MN is connected to a block of mass m by means of a light and inextensible chord that wraps over a light pulley as shown in the figure.

Exercise 3

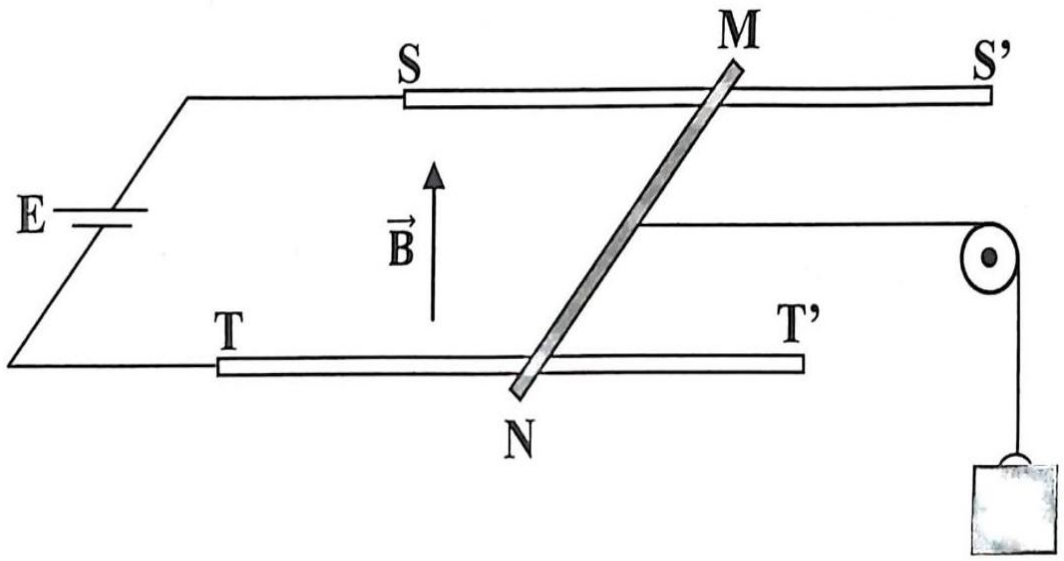
The whole setup is placed in a uniform magnetic field that is directed vertically upwards and of intensity B=1T. Neglect all resistive forces and take $g = 10N/kg$.

1) **Calculate the current traversing the circuit knowing that the resistance of MN is 4Ω.**
2) **Determine the characteristics of the electromagnetic force acting on the rod MN.**
3) **The system [Rod; pulley; block] is in equilibrium. Determine the value of the mass m.**

Exercise 3

d=10cm; E=12V; m=??; B=1T; $g = 10N/kg$.

1)Calculate the current traversing the circuit knowing that the resistance of MN is 4Ω.



Applying ohm's law:

$$U = RI$$

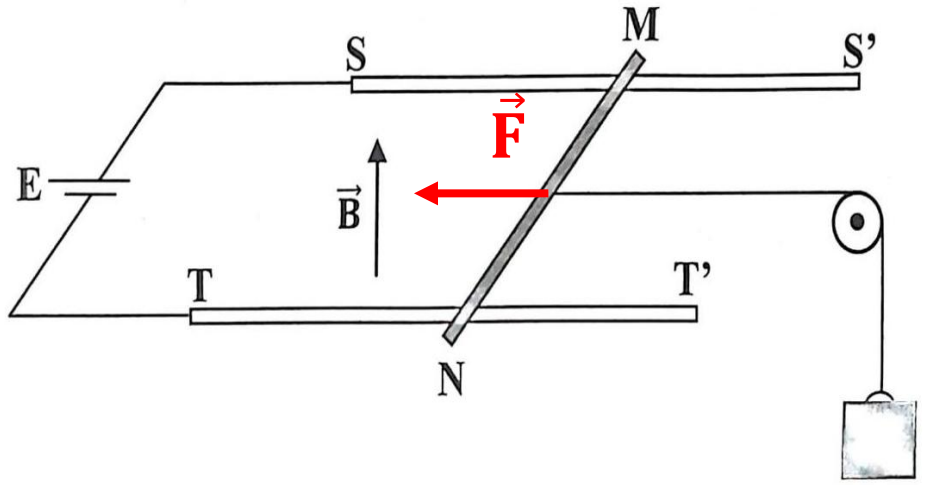
$$E = RI \Rightarrow I = \frac{E}{R}$$

$$I = \frac{12}{4} \Rightarrow I = 3\Omega$$

Exercise 3

d=10cm; E=12V; m=??; B=1T; $g = 10N/kg$; I=3A.

2) **Determine the characteristics of the electromagnetic force acting on the rod MN.**



- **Point of application: center of gravity of MN**
- **Line of action: horizontal**
- **Direction: by RHR, to left.**
- **Magnitude: $F = ILBsin\alpha$**

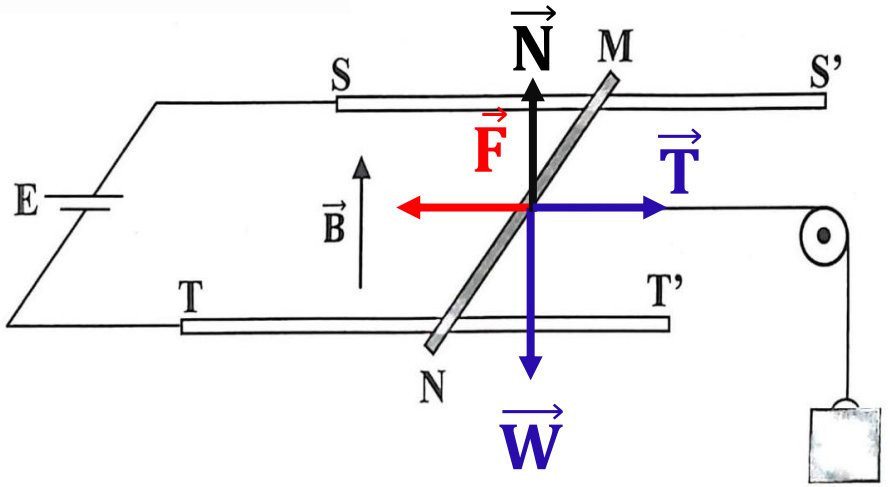
$$F = 3 \times 0.1 \times 1 \times sin90$$

$$F = 0.3N$$

Exercise 3

d=10cm; E=12V; m=??; B=1T; $g = 10N/kg$; I=3A.

3)The system [Rod; pulley; block] is in equilibrium. Determine the value of the mass m.



The forces acting on MN are:

Weight: $\vec{W}$; Normal: $\vec{N}$;

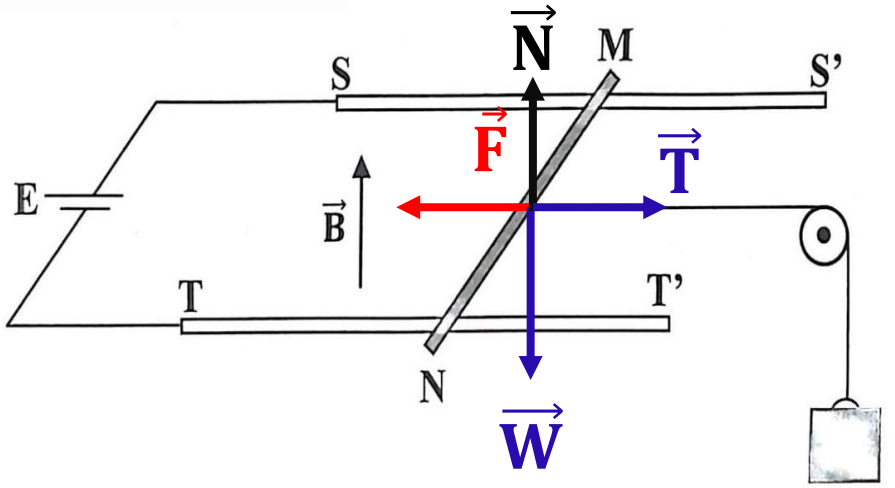
Tension $\vec{T}$ Electromagnetic force: $\vec{F}$

$$\sum \vec{F}_{ex} = \vec{0}. \Rightarrow \vec{W} + \vec{N} + \vec{T} + \vec{F} = \vec{0}$$

Exercise 3

d=10cm; E=12V; m=??; B=1T; $g = 10N/kg$; I=3A.

$$\vec{W} + \vec{N} + \vec{T} + \vec{F} = \vec{0}$$



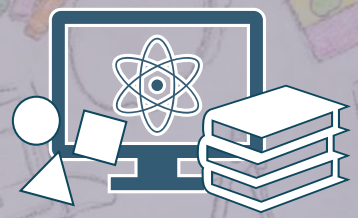
Isolate the rod: $\vec{W} + \vec{N} = \vec{0}$

$$T = F = 0.3N$$

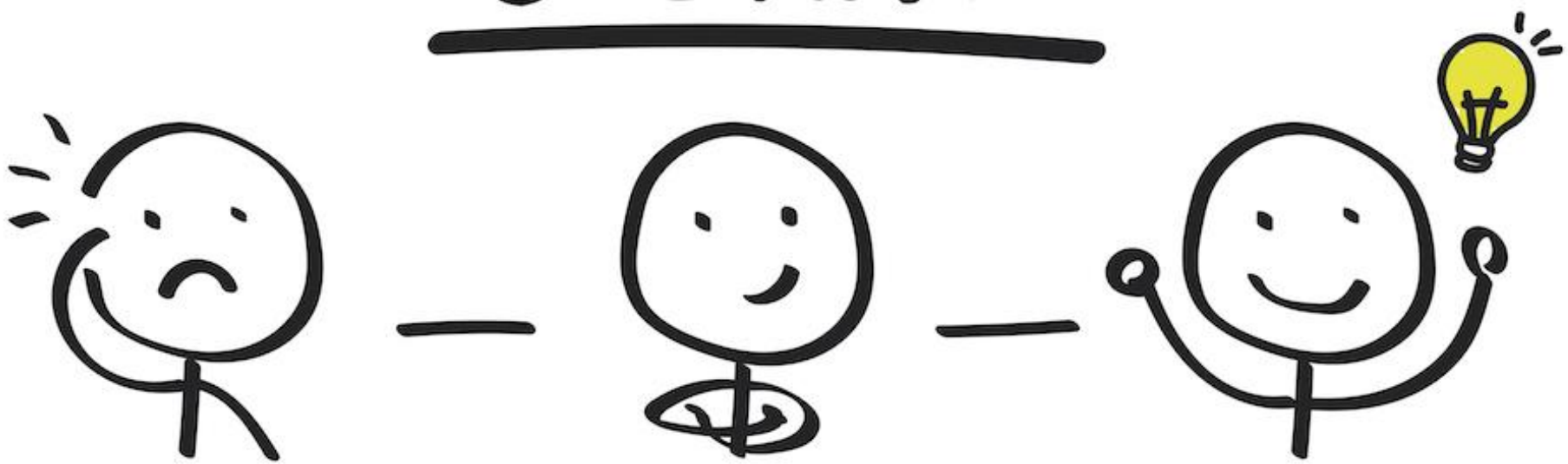
Isolate the block: $\vec{W}_{block} + \vec{T} = \vec{0}$

$$W_{block} = T \Rightarrow mg = 0.3 \Rightarrow m = \frac{0.3}{10} = 0.03kg$$

The End

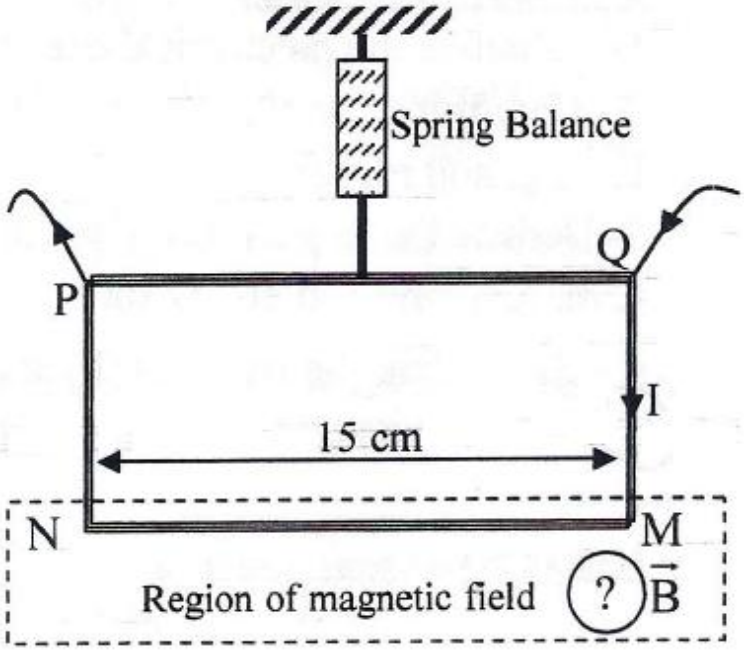


PROBLEM SOLVING



Exercise 4: Laplace force

MNPQ is a rectangular conducting coil of mass 0.1kg and made up of 100 loops.
MNPQ is held in the vertical plane by a spring balance attached to a support.
The lower MN of the coil is put within a uniform horizontal magnetic field B.
The magnetic field is ⊥ to the plane of the figure. See the figure and use $g = 10m/s^2$.

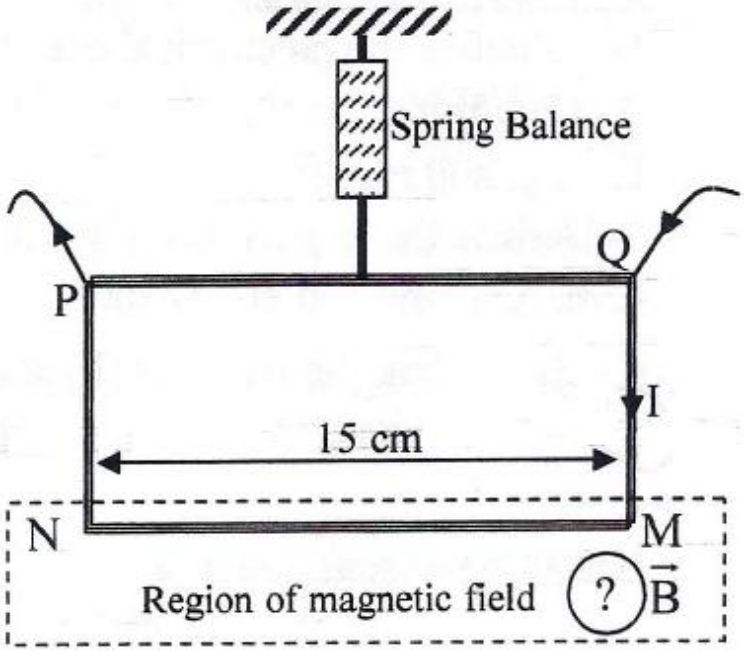


Exercise 4: Laplace force

1) The coil is not traversed by a current; determine the indication of the spring balance
2) An electric current of intensity I=2A traverses the coil as shown in the figure. The spring balance indicates 1.2N.
   a) Determine the direction and magnitude of the electromagnetic force acting on the loops.
   b) Determine the direction and the magnitude of the magnetic field vector.

Exercise 4: Laplace force

$m = 0.1kg$; N $= 100$; $g = 10m/s^2$.



1)The coil is not traversed by a current; determine the indication of the spring balance.

Two forces acting within this setup weight ($\vec{W}$) and tension ($\vec{T}$).

At equilibrium $\vec{T} + \vec{W} = \vec{0}$

T = W ➡ T = mg ➡ $T = 0.1 \times 10 = 1N$

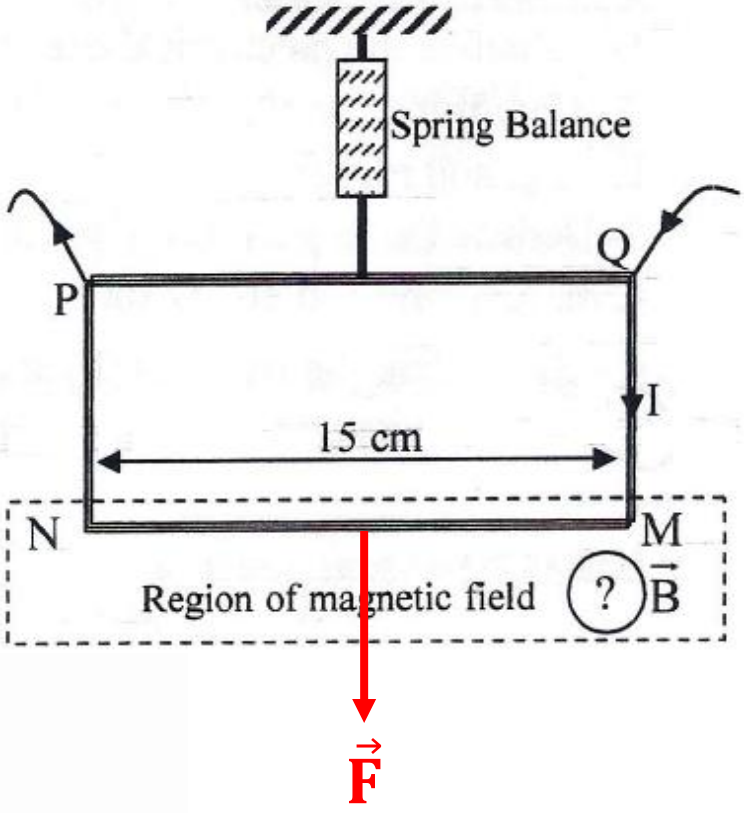
The spring balance indicated 1N

Exercise 4: Laplace force

$m = 0.1kg$; N $= 100$; $g = 10m/s^2$.

2)An electric current of intensity I=2A traverses the coil as shown in the figure. The spring balance indicates 1.2N.

a)Determine the direction and magnitude of the electromagnetic force acting on the loops



At equilibrium $\vec{T} + \vec{W} + \vec{F} = \vec{0}$ ➡ $T = (W + F)$

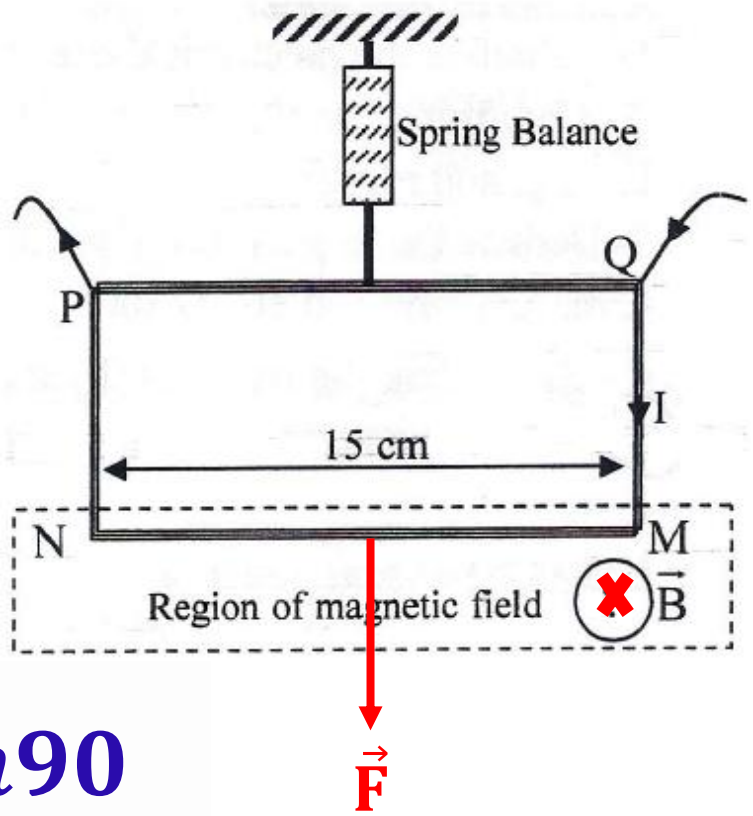
➡ $1.2 = (1 + F)$ ➡ $F = 0.2N$

$\vec{F}$ is directed downward

Exercise 4: Laplace force

$m = 0.1kg$; N $= 100$; $g = 10m/s^2$.

b)Determine the direction and the magnitude of the magnetic field vector



Using the RHR, we deduce $\vec{B}$ is directed in the page

$F = ILBsin\alpha$ ➡ $0.2 = 2 \times 0.15 \times Bsin90$

➡ $0.2 = 0.3 \times B$ ➡ $B = \frac{0.2}{0.3} = 0.67T$

The End