PHYSICS

Unit - 1

NEWTON'S LAWS

Law of Inertia

Ist law :- It states that A body at rest or in motion remains at rest or in motion until and unless an external force is applied.

Standard International Unit : → MKS (metre, kg, sec)

\# mass remains same. It does not change with gravity.
\# weight changes with gravity

Speed = $\frac{\text{Distance}}{\text{Time}}$ → Scaler quantity
↳ Unit : m/s
Eg: 10 m/s

Velocity = $\frac{\text{Displacement}}{\text{Time}}$ → vector quantity
↳ Unit: m/s
Eg: 10 m/s towards east

→ Mass m
→ velocity v
→ Momentum 'P' = mv

$$v = \frac{s}{t} = \frac{dS}{dt}$$

$$a = \frac{dv}{dt} \text{ (acceleration)}$$

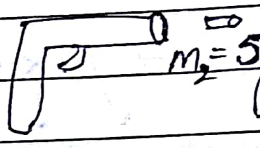
$$a = -\frac{dv}{dt} \text{ (retardation)}$$

II^{nd} Law :- It states that the rate of change of momentum is directly proportional to the external force applied.

$$\frac{dp}{dt} \propto F \quad , \quad \frac{dp}{dt} = (1)F$$

Recoiling of Gun

Find v_1?



$m_2 = 5g$ $\quad v_2 = 200\ m/s$

$m_1 = 250\ g$

$$m_1 v_1 = m_2 v_2$$

$$250 \times v_1 = 5 \times 200$$

$$v_1 = \frac{\cancel{5} \times \cancel{200}^{4}}{\cancel{250}_{\cancel{5}}} = 4\ m/s$$

Conservation of Momentum

Let 'p' be the momentum, 'm' be the mass, 'v' be the velocity & 't' be the time.

$$F = \frac{dp}{dt}$$

$$F = \frac{d(mv)}{dt}$$

$$F = m\frac{dv}{dt}$$

$$\boxed{F = ma}$$

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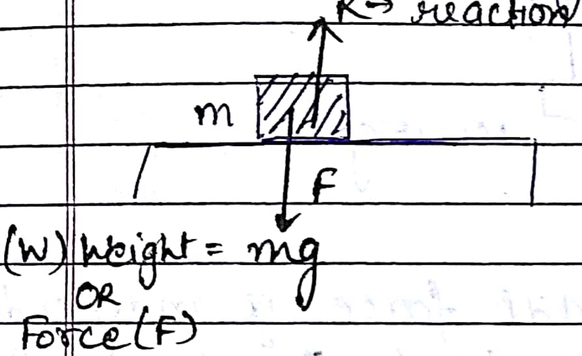
IIIrd Law :- It states that every action has an equal and opposite reaction.

$$F_1 = -F_2$$

FRICTION

Inertia → the inability of an object to change its position.



$F \propto R$

$F = \mu R$

μ → coefficient of friction

Types of Friction

1. Static Friction :- Friction when the body is at rest.
2. Dynamic Friction :- Friction when the body is in motion.
3. Limiting Friction - Friction when the object / body just starts sliding / moving from the state of rest.

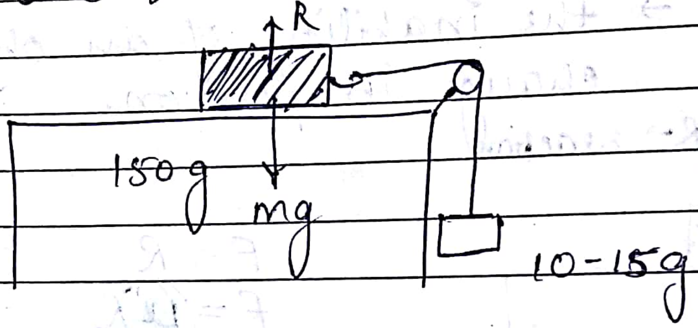
Laws of Friction

1. $F \propto R$
2. Frictional force is independent of area of contact.
3. Frictional force depends on nature of ~~contact~~ surface in contact and their state of polish.

★ Coefficient of friction (μ) depends on the material.

Laws of Friction

1. First Law :- It states that friction ~~at force~~ is directly proportional to the normal reaction (R). If the mass increases, then weight of the body increases, hence force increases and then reaction will also increase.



Second Law :- Frictional force is independent of the area of contact. Since, $F \propto R$ So reaction is directly proportional to the mass of the body and not depends on the area because mass is uniformly distributed.

Third Law :- $F \propto R$

$$F = \mu R$$

μ differs with different contact surfaces. For eg :- In case of honey & water, μ of honey is more than that of water. Hence, frictional force of object on honey is greater than that ~~of~~ on water.

Coefficient of friction (μ) → It is defined as the ratio of friction to the normal reaction (R).

$$\boxed{\mu = \frac{F}{R}}$$

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Paper Code : BCA 109 | **L** 3 | **T** 1 | **C** 4
Paper ID: 20109
Paper : Physics
Aim: To know the fundamentals of Physics
Objectives

- To get the knowledge about the basic laws of nature such as motion, work, power and energy
- To study the electrostatics, semiconductors and devices.

INSTRUCTIONS TO PAPER SETTERS: **MAXIMUM MARKS: 75**

1. Question No. 1 should be compulsory and over the entire syllabus. It should be of 25 marks and it may contain objective or short type question.
2. Rest of the paper shall contain two questions from each unit. However students will attempt only one question from each unit. Each question should be 12.5 marks.

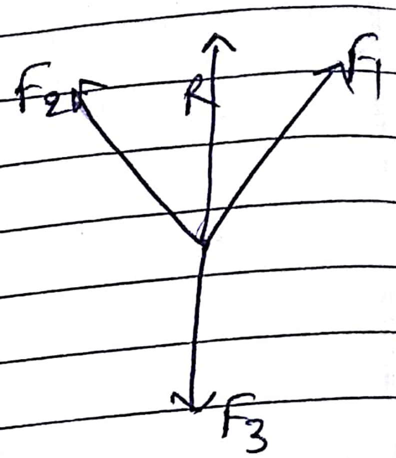
UNIT – I
Law of Motion: Force and Inertia, Law of inertia or Newton's first law of motion, Newton's Second law of motion, Newton's third law of motion and it's applications, Basic forces in nature, Weight of body in lift, Equilibrium of concurrent forces, Lemi's Theorem
Friction: Cause of friction, Types of friction, Laws of friction, Angle of friction and repose, Centripetal and centrifugal force, velocity of vehicle on curved leveled and banked road.
[T1] [T2] **[No. of Hrs: 11]**

UNIT – II
Work, Energy & Power: Work, Conservative force, Power, Kinetic Energy, Work energy theorem, Potential Energy, Conservation of gravitational P.E. into K.E., P.E. of spring. Collisions: Types of collision, elastic collision in 1D & 2D, Inelastic collision in 1D, Perfectly inelastic collision in 1D. **[T1] [T2]** **[No. of Hrs: 11]**

UNIT – III
Electricity & electromagnetism: Electric charge, Electron theory of electrification, Frictional electricity, Properties of electric charge, Coulomb's Law, Superposition Principle, Electric field intensity, Electric Lines of forces.
Electrostatics: Line integral of electric field, Electrostatic potential, State & Proof of Gauss's theorem.
Capacitance: Principal of Capacitor, Parallel and spherical capacitors, Grouping of capacitors and their capacitance, Effect of dielectric in capacitors.
Current Electricity: Current, Ohm's Law, Resistance, Grouping of resistance, Krichoff's rule, Wheatstone bridge, Slide Wire Bridge. **[T3] [T4] [No. of Hrs: 11]**

UNIT – IV:
Structure of Atom: Thomson's atomic model, Rutherford's alpha scattering experiment and atomic model, Postulates of Bohr's Model.
Semiconductors: Energy bands in solids, Difference between metals, insulators and semi conductors, Current carriers in semiconductors, Intrinsic semiconductor, Doping, Extrinsic semiconductors, Formation of p-n junction, Biasing of p-n junction, Light emitting diode. Transistors: Action of n-p-n & p-n-p transistors, Advantages of transistors, Integrated Circuit. **[T3] [T4]** **[No. of Hrs: 11]**

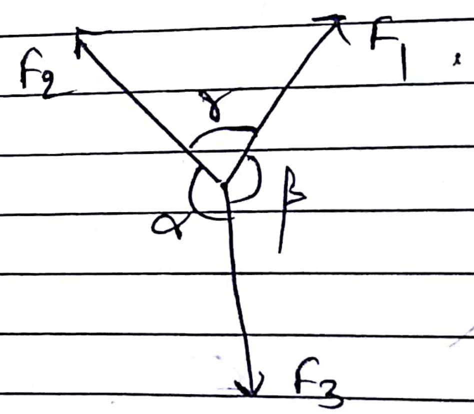
Concurrent Forces (3M)



Let F_1 be the force applied in one direction and F_2 be the force applied in another direction. Their net force is represented by the resultant R in which the body will move. A force F_3 is applied in opposite direction to the resultant force. Now the body won't move. These forces together acting on the body are called concurrent forces.

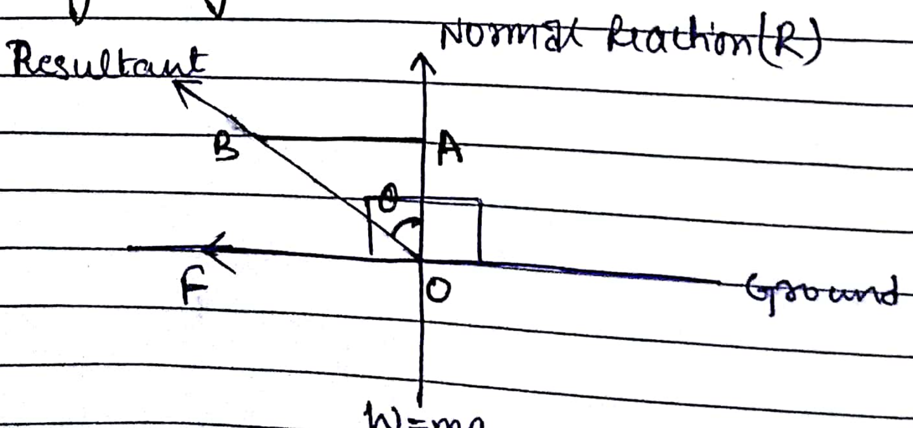
$$\boxed{F_1 + F_2 + F_3 = 0}$$

Lami's Theorem



$$\boxed{\frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\beta} = \frac{F_3}{\sin\gamma}}$$

Angle of Friction (θ)



Weight always acts towards the centre of earth.

$$\tan\theta = \frac{F}{R} \quad \text{—} \ (1)$$

Earlier → $F \propto R$

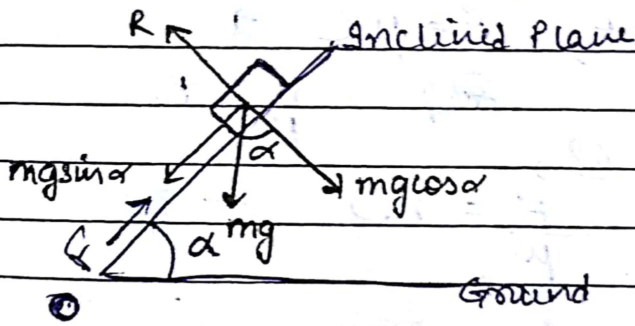
$$F = \mu R$$

$$\mu = \frac{F}{R} \quad \text{—} \ (2)$$

From (1) & (2)

$$\boxed{\mu = \tan\theta = \frac{F}{R}}$$

<u>Angle of Repose or Slide</u>



$$F = mg\sin\alpha \quad \text{—} \ (1)$$

$$R = mg\cos\alpha \quad \text{—} \ (2)$$

(1)/(2)

$$\frac{F}{R} = \frac{\cancel{mg}\sin\alpha}{\cancel{mg}\cos\alpha} = \tan\alpha = \tan\theta = \mu$$

↳ Show that angle of repose = angle of friction.

INERTIA

1. Inertia of rest
2. Inertia of motion
3. Inertia of direction

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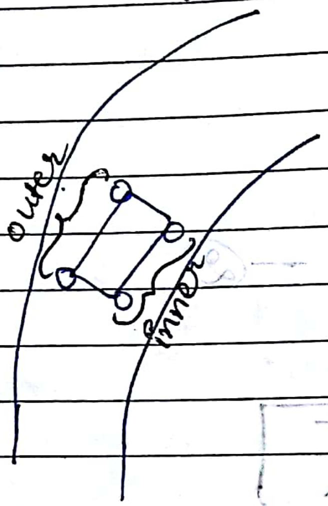
Bending Of Road



Let us consider a curved road and a car is moving on it.

Let 'm' the mass of the car, R_1 be the reaction from inner wheels and R_2 be the reaction from outer wheels, r be the radius of curvature of the road, v be the velocity of the vehicle and 'g' be the acceleration due to gravity.

So we can apply,

$$\underbrace{R_1 + R_2}_{} = mg$$

Let 'R' be the net reaction. Hence,

$$R = mg \quad \text{---(1)}$$

We know that,

$$F = \mu R \quad \text{---(2)}$$

$$\frac{F}{\mu} = R$$

From (1) and (2),

$$\frac{F}{\mu} = mg \quad \text{---(3)}$$

While moving on the curved road, the car will experience some centripetal force which is given by :-

$$F = \frac{mv^2}{r} \quad \text{---(4)}$$

Substituting the value of eq (4) in eq (3),

$$\frac{\cancel{m}v^2}{\mu r} = \cancel{m}g$$

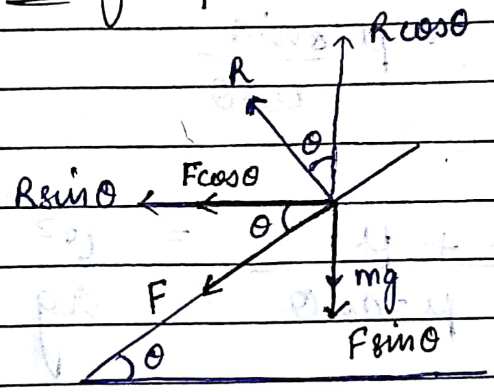
$$v^2 = \mu r g$$

Max. velocity of car on curved road $\rightarrow$ $\boxed{v = \sqrt{\mu r g}}$

GOOD WRITE

From this eq, we conclude that the max. velocity of the car depends upon the - 1. radius and 2. coefficient of friction.

Banking Of Roads → The phenomenon of raising outer edge of the curved road to provide necessary centripetal force to the vehicles for safe turn.



Here F = frictional force

$$R\cos\theta = mg + F\sin\theta \quad \text{— ①}$$

$$R\sin\theta + F\cos\theta = \frac{mv^2}{r} \quad \text{— ②}$$

Rearranging eq ① → $R\cos\theta - F\sin\theta = mg$ — ③

We know that, $F = \mu R$ — ④

Substituting value of F from eq ④ in ② & ③

Eq 2 → $R\sin\theta + \mu R\cos\theta = \frac{mv^2}{r}$

Eq 3 → $R\cos\theta - \mu R\sin\theta = mg$

②/③ → $$\frac{R\sin\theta + \mu R\cos\theta}{R\cos\theta - \mu R\sin\theta} = \frac{\cancel{m}v^2}{r\cancel{m}g}$$

$$= \frac{\cancel{R}(\sin\theta + \mu\cos\theta)}{\cancel{R}(\cos\theta - \mu\sin\theta)} = \frac{v^2}{rg}$$

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→ Dividing ~~cosθ by~~ numerator and denominator by $\cos\theta$

$$\Rightarrow \frac{\frac{\sin\theta}{\cos\theta} + \frac{\mu\cos\theta}{\cos\theta}}{\frac{\cos\theta}{\cos\theta} - \mu\frac{\sin\theta}{\cos\theta}} = \frac{v^2}{rg} \quad \frac{\cancel{\cos\theta}}{\cancel{\cos\theta}}$$

$$\Rightarrow \frac{\tan\theta + \mu}{1 - \mu\tan\theta} = \frac{v^2}{rg}$$

$$\Rightarrow \boxed{v^2 = \left[\frac{\tan\theta + \mu}{1 - \mu\tan\theta}\right] rg}$$

→ By raising the road, ~~we~~ coefficient of friction increases and hence, velocity of the car on a banked road also increases.

UNIT - 2

Potential Energy & Kinetic Energy

Potential Energy $= W = mgh$

Prove: We know that, $F = ma$ — (1) and
$W = F.s$ — (2)

Substituting value of F from eq (1) in (2)

$$W = (ma)s$$

$$\boxed{W = mgh}$$

→ h is the height

→ where g is acceleration due to gravity

Prove: Now,

$$W = mas$$

$$W = m\left(\frac{dv}{dt}\right)ds$$

$$W = m\,dv\left(\frac{ds}{dt}\right)$$

$$W = m\,v\,dv$$

$$W = m\int v\,dv$$

$$W = m\left(\frac{v^2}{2}\right)$$

$$\left[\begin{aligned} a &= \frac{dv}{dt} \\ v &= \frac{ds}{dt} \end{aligned}\right]$$

$$\boxed{W = \frac{1}{2}mv^2}$$ → Kinetic Energy

Collision

Elastic Collision

1. Energy is conserved
2. Momentum is conserved

Inelastic Collision

1. No conservation of energy
2. Momentum is conserved.

Elastic Collision in One Dimension

Consider two objects A and B. Let m_1 and m_2 be the masses of the spheres A and B respectively. Both are moving in a straight line in same direction. Let their initial velocities be u_1 and u_2 respectively before collision.

Before Collision		Collision	After Collision	
A →	B →	A B	A	B
m_1	m_2		$v_1 = ?$	$v_2 = ?$
$u_1 = 50$	$u_2 = 40$			

Let the two objects collide.
Let v_1 and v_2 be the final velocities of the two objects after collision.
~~Let the two objects~~

According to conservation of momentum,

$$\underbrace{m_1 u_1 + m_2 u_2}_{\text{Total momentum before collision}} = \underbrace{m_1 v_1 + m_2 v_2}_{\text{Total momentum after collision}} \quad (1)$$

According to conservation of energy,

$$\frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2 = \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 \quad - (2)$$

$$\underbrace{\frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2}_{\text{Total kinetic energy before collision}} \qquad \underbrace{\frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2}_{\text{Total kinetic energy after collision}}$$

From (1)

$$\Rightarrow m_1 u_1 - m_1 v_1 = m_2 v_2 - m_2 u_2$$

$$\Rightarrow m_1 (u_1 - v_1) = m_2 (v_2 - u_2) \quad - (3)$$

From (2)

$$\Rightarrow \frac{1}{2} m_1 u_1^2 - \frac{1}{2} m_1 v_1^2 = \frac{1}{2} m_2 v_2^2 - \frac{1}{2} m_2 u_2^2$$

$$\Rightarrow \cancel{\frac{1}{2}} m_1 (u_1^2 - v_1^2) = \cancel{\frac{1}{2}} m_2 (v_2^2 - u_2^2)$$

$$\Rightarrow m_1 (u_1 - v_1)(u_1 + v_1) = m_2 (v_2 - u_2)(v_2 + u_2) \quad - (4)$$

Eq (4) / Eq (3)

$$\Rightarrow \frac{\cancel{m_1} \cancel{(u_1 - v_1)} (u_1 + v_1)}{\cancel{m_1} \cancel{(u_1 - v_1)}} = \frac{\cancel{m_2} \cancel{(v_2 - u_2)} (v_2 + u_2)}{\cancel{m_2} \cancel{(v_2 - u_2)}}$$

$$\Rightarrow u_1 + v_1 = v_2 + u_2$$

$$\Rightarrow \boxed{\underbrace{u_1 - u_2}_{\text{velocity of approach}} = \underbrace{v_2 - v_1}_{\text{velocity of seperation}}}$$

Now, $v_2 = u_1 - u_2 + v_1$

Substituting the value of v_2 in eq (1)

$$(1) \Rightarrow m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$\Rightarrow m_1u_1 + m_2u_2 = m_1v_1 + m_2(u_1 - u_2 + v_1)$$

$$\Rightarrow m_1u_1 + m_2u_2 = m_1v_1 + m_2u_1 - m_2u_2 + m_2v_1$$

$$v_1(m_1 + m_2) = m_1u_1 + m_2u_2 - m_2u_1 + m_2u_2$$

$$v_1 = \frac{m_1u_1 + m_2u_2 - m_2u_1 + m_2u_2}{m_1 + m_2}$$

$$v_1 = \frac{u_1(m_1 - m_2) + 2m_2u_2}{m_1 + m_2} \quad \text{— (5)}$$

Similarly, $v_2 = \dfrac{u_2(m_2 - m_1) + 2m_1u_1}{m_1 + m_2}$ — (6)

<u>Case 1</u> $\rightarrow$ When $m_1 = m_2 = m$

From (5) $\rightarrow$ $v_1 = \dfrac{u_1(0) + 2mu_2}{2m} = \dfrac{\cancel{2}u_2\cancel{m}}{\cancel{2}\cancel{m}}$

$$\boxed{v_1 = u_2}$$

From (6) $\rightarrow$ $v_2 = \dfrac{u_2(0) + 2mu_1}{2m} = \dfrac{\cancel{2}\cancel{m}u_1}{\cancel{2}\cancel{m}}$

$$\boxed{v_2 = u_1}$$

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From this, we conclude that when two identical spheres are colliding, they exchange their velocities.

Case 2 → when $m_1 = m_2 = m$ and $u_2 = 0$

From (5) → $v_1 = \frac{u_1(0) + 2m(0)}{2m} = 0$

$$\boxed{v_1 = 0}$$

from (6) → $v_2 = \frac{\cancel{u_2}\ 0 + 2mu_1}{2m} = \frac{\cancel{2m}u_1}{\cancel{2m}}$

$$\boxed{v_2 = u_1}$$

We conclude that;
After collision, first body will come to rest and second one will be moving.

Case 3 → when $m_1 >>> m_2$ and $u_2 = 0$

from (5) → $v_1 = \frac{u_1(m_1 - 0) + 2(0)(0)}{m_1 + 0} = \frac{u_1 m_1}{m_1}$

$$\boxed{v_1 = u_1}$$

from (6) $v_2 = \frac{(0)(0 - m_1) + 2m_1 u_1}{m_1 + 0} = \frac{2\cancel{m_1}u_1}{\cancel{m_1}}$

$$\boxed{v_2 = 2u_1}$$

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We conclude that, after collision the second body will move with ~~a velocity~~ twice the velocity of first body.

Case 4 → When $m_2 >> m_1$ and $u_2 = 0$

From (5) → $$v_1 = \frac{u_1(0 - m_2) + 2m_2(0)}{m_2 + 0}$$

$$v_1 = -\frac{u_1 \cancel{m_2}}{\cancel{m_2}}$$

$$\boxed{v_1 = -u_1}$$

From (6) →

$$v_2 = \frac{0(m_2 - 0) + 2(0)u_1}{m_2}$$

$$\boxed{v_2 = 0}$$

We conclude that, the first body will move with the same velocity as it has before collision but in opposite direction.

Inelastic Collision in One Dimension

(only momentum is conserved)

Coefficient of Restitution (e) → The ratio of velocity of seperation to the velocity of approach.

It is given by :-
$$e = \frac{v_2 - v_1}{u_1 - u_2}$$

→ Coefficient of restitution is defined as the ability to regain its original position.

when $e = 1$

The collision is said to be perfectly elastic.

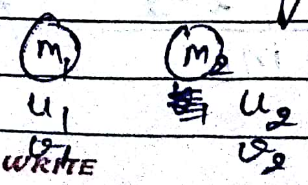
When $e = 0$

The collision is said to be perfectly inelastic.

⇒ e ranges from 0 to 1.

Derivation :-

Consider two spheres of masses m_1 and m_2 respectively. Let their initial velocities be u_1 and u_2 and final velocities be v_1 and v_2 respectively.



$$e = \frac{v_2 - v_1}{u_1 - u_2} \quad (1)$$ → coefficient of restitution

$$e(u_1 - u_2) = v_2 - v_1$$

$$v_2 = e(u_1 - u_2) + v_1 \quad \text{— (2)}$$

According to conservation of momentum,

$$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$$

→ Substituting the value of v_2 from (2)

$$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 \left[e(u_1 - u_2) + v_1\right]$$

$$\cancel{m_1 u_1 - m_1 v_1 = m_2 v_1 + m_2 e(u_1 - u_2) - m_2 u_1}$$

$$m_1 v_1 + m_2 v_1 = m_1 u_1 + m_2 u_2 - m_2 e(u_1 - u_2)$$

$$v_1 (m_1 + m_2) = m_1 u_1 + m_2 u_2 - m_2 e(u_1 - u_2)$$

$$\boxed{v_1 = \frac{m_1 u_1 + m_2 u_2 - m_2 e(u_1 - u_2)}{m_1 + m_2}}$$

$$v_1 = \frac{m_1 u_1 + m_2 u_2 - m_2 \cancel{(u_1 - u_2)} \frac{(v_2 - v_1)}{\cancel{(u_1 - u_2)}}}{m_1 + m_2}$$

$$v_1 = \frac{m_1 u_1 + m_2 u_2 - m_2 v_2 + m_2 v_1}{m_1 + m_2}$$

Similarly,

$$\boxed{v_2 = \frac{m_2u_2 + m_1u_1 - m_1e(u_2 - u_1)}{m_1 + m_2}}$$

Case 1 $m_1 = m_2 = m$

$$v_1 = \frac{mu_1 + mu_2 - me(u_1 - u_2)}{m + m}$$

$$= \frac{\cancel{m}[u_1 + u_2 - e(u_1 - u_2)]}{2\cancel{m}}$$

$$v_1 = \frac{1}{2}[u_1 + u_2 - e(u_1 - u_2)]$$

Similarly, $v_2 = \frac{1}{2}[u_2 + u_1 - e(u_2 - u_1)]$

Case 2 $m_1 = m_2 = m$ and $u_2 = 0$

$$v_1 = \frac{1}{2}[u_1 + u_2 - e(u_1 - u_2)]$$

$$v_1 = \frac{1}{2}[u_1 + 0 - e(u_1 - 0)]$$

$$v_1 = \frac{1}{2}(u_1 - eu_1) = \boxed{\frac{1}{2}u_1(1 - e)}$$

$$v_2 = \frac{1}{2}[u_1 + 0 - e(0 - u_1)]$$

$$\boxed{v_2 = \frac{1}{2}u_1(1 + e)}$$

Case 3 $m_2 >>> m_1$ and $u_2 = 0$

$$v_1 = \frac{0(u_1) + m_2(0) - m_2 e(u_1 - 0)}{m_2 + 0}$$

$$v_1 = -\frac{\cancel{m_2} e(u_1)}{\cancel{m_2}} = -eu_1$$ Imp.

$$v_2 = \frac{m_2(0) + 0(u_1) - (m_1) e(0 - u_1)}{m_2 + 0}$$

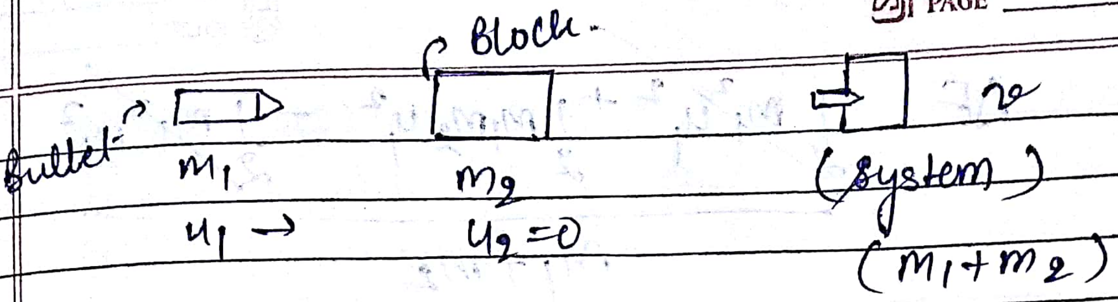
$$v_2 = 0$$

↳ Show that velocity of bouncing ball depends upon its coefficient of restitution.

Loss of Energy in inelastic collision (perfect)

Consider two objects - a bullet and a wooden block. Let their masses be 'm_1' and 'm_2' respectively.

Let the first object move with an initial velocity 'u_1' and the second object is at rest i.e $u_2 = 0$.



let collision takes place.
Now, the whole system moves with a common final velocity 'v'.

According to conservation of momentum,

$$m_1 u_1 + \underset{\substack{\downarrow \\ 0}}{m_2 u_2} = (m_1 + m_2) v$$

$$m_1 u_1 = (m_1 + m_2) v$$

$$\boxed{v = \frac{m_1 u_1}{m_1 + m_2}} \quad \text{--- (1)}$$

Loss of energy (ΔE) = Total K.E before collision − Total K.E after collision

$$\Delta E = \frac{1}{2} m_1 u_1^2 - \frac{1}{2}(m_1 + m_2) v^2$$

Substing the value of v from (1)

$$\Delta E = \frac{1}{2} m_1 u_1^2 - \frac{1}{2}(m_1 + m_2)\left(\frac{m_1 u_1}{m_1 + m_2}\right)^2$$

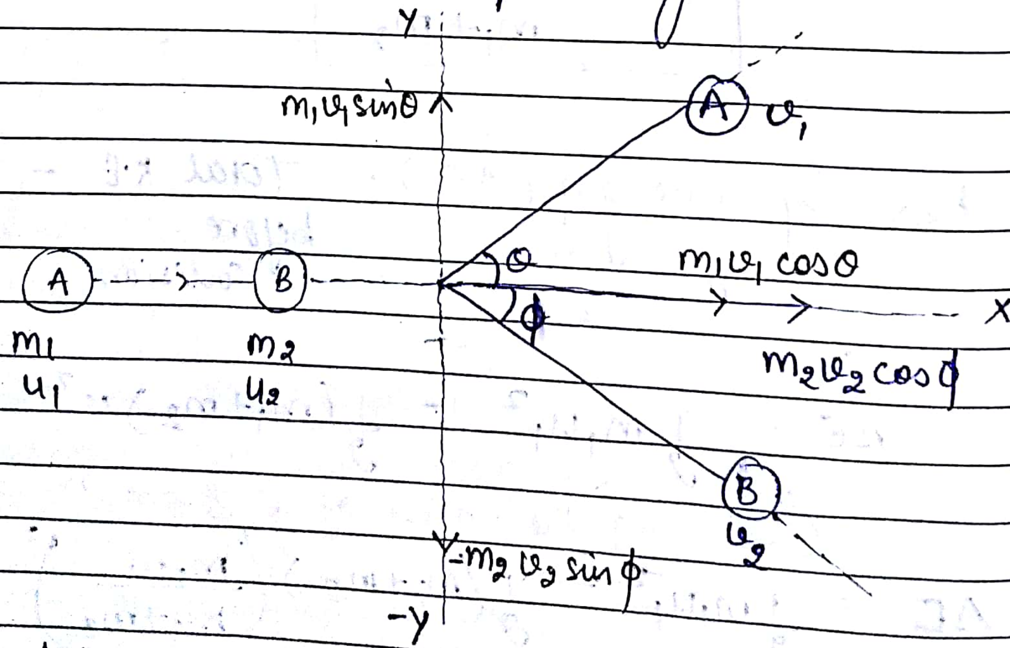
$$\Delta E = \frac{1}{2} m_1 u_1^2 - \frac{1}{2}\left(\frac{m_1^2 u_1^2}{m_1 + m_2}\right)$$

$$\Delta E = \frac{\cancel{\frac{1}{2} m_1^2 u_1^2} + \frac{1}{2} m_1 m_2 u_1^2 - \cancel{\frac{1}{2} m_1^2 u_1^2}}{m_1 + m_2}$$

$$\boxed{\Delta E = \frac{1}{2}\frac{m_1 m_2 u_1^2}{(m_1 + m_2)}}$$

Two Dimension Elastic Collision

Consider two spheres A and B having masses m1 and m2 respectively. Let their initial velocities be u_1 and u_2 and final velocities be v_1 and v_2 respectively.



Let the two bodies / spheres collide at point O. Let θ be the angle made by sphere A after collision with respect to X-axis. Let ϕ be the angle made by sphere B after collision with respect to X-axis.

→ Before collision both A and B are moving in same direction. But after collision, A moves in upward direction and B moves in downward direction.

→ According to law of conservation of momentum,

Along X-axis → $m_1u_1 + m_2u_2 = m_1v_1\cos\theta + m_2v_2\cos\phi$ — (1)

Along Y-axis → $0 + 0 = m_1v_1\sin\theta - m_2v_2\sin\phi$

$m_1v_1\sin\theta = m_2v_2\sin\phi$ — (2)

→ According to conservation of energy,

$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$ — (3)

→ Now let $m_1 = m_2 = m$ and $u_2 = 0$

Eq (1) → $mu_1 + \cancel{mu_2}\,m(0) = mv_1\cos\theta + mv_2\cos\phi$

$\cancel{m}u_1 = \cancel{m}(v_1\cos\theta + v_2\cos\phi)$

$\boxed{u_1 = v_1\cos\theta + v_2\cos\phi}$ — (4)

Eq (2) → $\cancel{m}v_1\sin\theta = \cancel{m}v_2\sin\phi$

$\boxed{v_1\sin\theta = v_2\sin\phi}$ — (5)

Eq (3) → $\frac{1}{2}mu_1^2 + \frac{1}{2}m(0)^2 = \frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2$

$$\frac{1}{\cancel{2}}\cancel{m}u_1^2 = \frac{1}{\cancel{2}}\cancel{m}v_1^2 + \frac{1}{\cancel{2}}\cancel{m}v_2^2$$

$$\boxed{u_1^2 = v_1^2 + v_2^2} \quad \text{— (6)}$$

→ Rearranging equations (4), (5) and (6),

- $u_1 - v_1\cos\theta = v_2\cos\phi$ — (7)
- $u_1^2 - v_1^2 = v_2^2$ — (8)
- $v_1\sin\theta = v_2\sin\phi$ — (9)

→ Squaring equations (7) and (9) and then adding them,

$$\Rightarrow (u_1 - v_1\cos\theta)^2 + (v_1\sin\theta)^2 = (v_2\cos\phi)^2 + (v_2\sin\phi)^2$$

$$\Rightarrow u_1^2 + v_1^2\cos^2\theta - 2u_1v_1\cos\theta + v_1^2\sin^2\theta = v_2^2\cos^2\phi + v_2^2\sin^2\phi$$

$$\Rightarrow u_1^2 + v_1^2(\cos^2\theta + \sin^2\theta) - 2u_1v_1\cos\theta = v_2^2(\cos^2\phi + \sin^2\phi)$$

$$\Rightarrow \boxed{u_1^2 + v_1^2 - 2u_1v_1\cos\theta = v_2^2} \quad \text{— (10)}$$

→ Now, ~~comparing~~ equating (8) and (10)

$$\cancel{u_1^2} + v_1^2 - 2u_1v_1\cos\theta = \cancel{u_1^2} - v_1^2$$

$$\cancel{2}v_1^{\cancel{2}} = \cancel{2}u_1\cancel{v_1}\cos\theta$$

$$\boxed{v_1 = u_1\cos\theta}$$

Substituting the value of v_1 in eq (8)

$$u_1^2 - (u_1\cos\theta)^2 = v_2^2$$

$$u_1^2 - u_1^2\cos^2\theta = v_2^2$$
$$u_1^2(1-\cos^2\theta) = v_2^2$$
$$u_1^2\sin^2\theta = v_2^2$$
$$\boxed{v_2^2 = u_1^2\sin^2\theta}$$

Hence, $\boxed{v_2 = u_1\sin\theta}$

→ Now putting the values of v_1 and v_2 in eq(9)

$$\cancel{u_1}\cos\theta\cancel{\sin\phi} = \cancel{u_1}\sin\cancel{\theta}\sin\phi$$

$$\cos\theta = \sin\phi$$
$$\sin(90-\theta) = \sin\phi$$

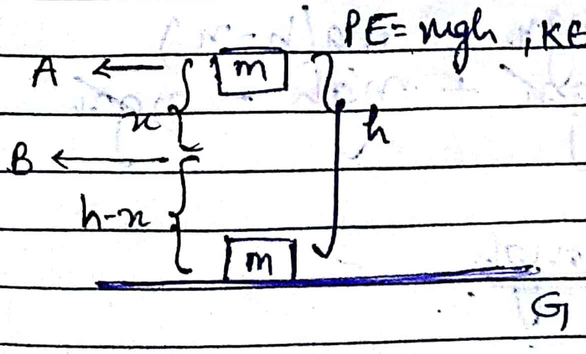
→ On comparison, we get, $90-\theta = \phi$

$$\boxed{\theta + \phi = 90^\circ}$$

If a body collides with another body of same mass which is at rest, then two bodies move at right angles.

CONSERVATION OF ENERGY

PE = mgh , KE = 0



$W = F.s$
$W = mah$
$PE = W = mgh$

At A

$K \cdot E = 0$ and $PE = mgh$

Mechanical energy (ME) $= P.E + K.E.$
$= mgh + 0$
$= mgh$

$T.E / M.E = mgh$

At B

$K.E = \frac{1}{2}mv^2$

we know,
$v^2 - u^2 = 2as$
$v^2 - 0 = 2gx$
$v^2 = 2gx$

$K.E = \frac{1}{\cancel{2}} m(\cancel{2}gx)$

$K.E = mgx$

$P.E = mg(h-x)$

$T.E. = K.E + P.E$
$= mgx + mg(h-x)$
$= \cancel{mgx} + mgh - \cancel{mgx}$

$T.E = mgh$

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At G

$PE = mg(0)$

$\boxed{P.E = 0}$

$K.E = \frac{1}{2} mv^2$

$KE = \frac{1}{\cancel{2}} m (\cancel{2}gh)$

$\boxed{K.E = mgh}$

NOTE: $v^2 = u^2 + 2as$

$v^2 = 0 + 2gh$

$v^2 = 2gh$

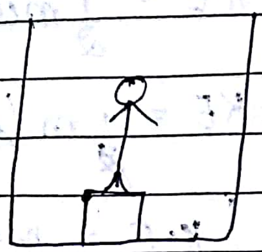
Now $TE = K.E + P.E$

$T.E = mgh + 0$

$T.E = mgh$

Since, the total energy remains same at points A, B and G.
Hence, the total energy is conserved.

LIFT MOTION (UNIT-1 CONTINUE)



$m = 40\ kg$
$g = 10\ m/s^2$

$\boxed{W = mg}$

1. **Lift at rest**

$W = 40 \times 10\ kgm/s^2$
$W = 400\ N$ → actual weight

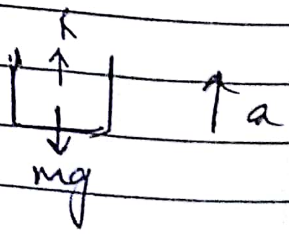
2. **Lift moving with uniform velocity**

Uniform velocity means acceleration zero.
i.e. $a = 0$

$W = mg$
$W = 40 \times 10$
$W = 400 N$ actual weight

3. **Lift moving upwards with acceleration**

$a = 2 m/s^2$

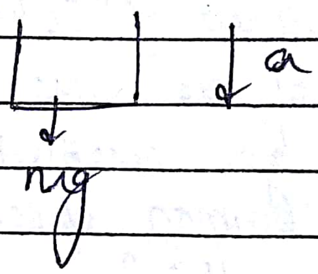


$W = m(g+a)$
$W = 40 (10+2)$
$W = 40 \times 12$
$W = 480 N$
→ apparent weight > actual weight

4. <u>Lift moving downwards with acceleration</u>

$a = 2m/s^2$

$W = m(g-a)$
$W = 40(10-2)$
$W = 40 \times 8$
$W = 320N$

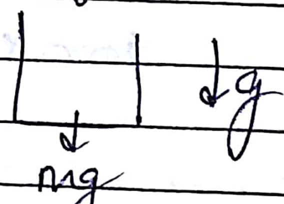


↳ apparent weight < actual weight

5. <u>Lift falling freely.</u>

→ lift is falling with acceleration equals to g (acceleration due to gravity).

$W = m(g-g)$
$W = 0$



↳ apparent weight = 0 i.e. weightlessness of body

★ Use always $9.8 = g$ until specified.

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Numerical

Q A railway carriage of mass 9000 kg moving with a speed of 36 km/h collides with a stationary carriage of the same mass. After collision, the carriages get coupled and move together. What is their common speed after collision? What type of collision is this?

Ans $m_1 = 9000\,kg$ $\quad u_1 = 36\,km/h = 10\,m/s$

$m_2 = 9000\,kg$ $\quad u_2 = 0$

$v_1 = v_2 = v = ?$

By conservation of momentum,

$$m_1u_1 + m_2u_2 = (m_1+m_2)v$$

$$9000 \times 10 + 0 = 2 \times 9000 \times v$$

$$\boxed{v = 5\,m/s}$$

Total K.E before collision → $\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2$

$= \frac{1}{2}\,9000\;10 \times 10 + 0$

$= 450000\,J$

Total K.E after collision → $\frac{1}{2}(m_1+m_2)v^2$

$= \frac{1}{2} \times 2 \times 9000 \times 5^2$

$= 225000\,J$

Since, total K.E after collision < total K.E before collision
Hence, the collision is inelastic.

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Q1 A cricket ball is rolled with velocity of 5.6 m/s and comes to rest after travelling 8 m. Find the coefficient of friction. ~~Given: u = 5.6 m/s~~

Ans
$u = 5.6\ m/s$
$s = 8\ m$
$v = 0$
$g = 10\ m/s^2$

$v^2 - u^2 = 2as$
$0 - (5.6)^2 = 2 \times a \times 8$
$a = \frac{-(5.6)^2}{16}$

$a = 1.96\ m/s^2$

$F = \mu R$
$\mu = \frac{F}{R} = \frac{\cancel{m}a}{\cancel{m}g} = \frac{a}{g} = \frac{1.96}{10} = 0.196$

Q2 A helicopter of mass 1000 kg rises with a vertical acceleration of $15\ m/s^2$. The crew and the passengers weigh 300 kg. Give the magnitude and direction :-
a) Force on the floor by the crew and passenger.
b) Action of the of the helicopter on the surroundings
c) Force on the helicopter due to the surrounding air.

Ans a)
$a = 15\ m/s^2$, $g = 10\ m/s^2$
$m_c = 300\ kg$
$F = m(g+a)$
$F = 300(10+15)$

$F = 7500\ N$ (downwards)

b) $m_h = 1000\ kg$

Total mass $(m_{e+h}) = 1000 + 300 = 1300\ kg$

$F = m(g+a)$

$F = 1300(10+15)$

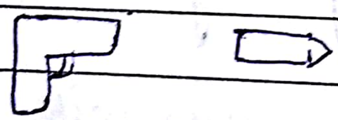
$F = 32500\ N$ downwards

c) $F = 1300(10+15)$

$= 32500\ N$ (upwards)

Q3 Find the recoil velocity of a gun having mass equal to 5kg if a bullet of 25gm acquires the velocity of 500 m/s after firing from the gun

Ans.



$m_2 = 5\ kg$

$u_2 = 0$

$v_2 = ?$

$m_1 = 25\ gm = 0.025\ kg$

$u_1 = 0$

$v_1 = 500\ m/s$

Acc to law of conservation of momentum,

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$0 + 0 = 0.025 \times 500 + 5 \times v_2$

$5v_2 = -125$

$\boxed{v_2 = -25\ m/s}$

Unit 3 . Electrostatics.

Electric field → the field in which the electric influence of a charge can be experienced.

$$\boxed{E = \frac{Kq}{r^2}}$$

q → charge is always quantised.

$$Q = ne$$

↳ integral multiple of no. of electrons.

q^+ ne q^- np

→ **Coulumb's Law** :- It states that force of attraction or repulsion between two electric charges placed at a distance 'r' is directly proportional to the product of magnitude of the charges and inversely proportional to the square of distance b/w them.

q_1 q_2
←— r —→

$$F \propto q_1 q_2$$
$$F \propto \frac{1}{r^2}$$
$$\boxed{F = \frac{K q_1 q_2}{r^2}}$$

where $K = 1/4\pi\epsilon_0$ → Permitivity of free space
$K = 9 \times 10^9$

Electric Potential :- It is defined as the work done in bringing a charge from infinity to a particular point.

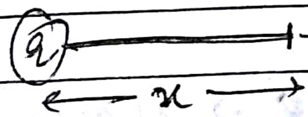
$$V = -E \cdot dx$$

$$\int_0^V dV = -\int_\infty^x E\cdot dx$$

$$\left\{ E = \frac{F}{q} = \frac{kq}{r^2} \right\}$$

$$V = -\frac{kq}{x^2}\int_\infty^x dx$$

$$V = -kq\int_\infty^x \frac{dx}{x^2}$$



$$V = -kq\left[\frac{-1}{x}\right]_\infty^x$$

$$V = kq\left[\frac{1}{x} - \frac{1}{\infty}\right]$$

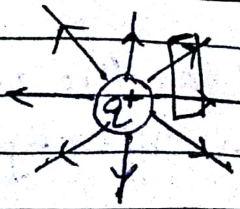
$$V = kq\left(\frac{1}{x} - 0\right)$$

Electric Potential → $\boxed{V = \frac{kq}{x}}$

⇒ SI unit of electric potential is Volts (V).

Imp: <u>Gauss's Law</u> or <u>Gauss's Theorem</u>

<u>Electric Flux (φ)</u> → No. of electric field lines passing through a particular area.

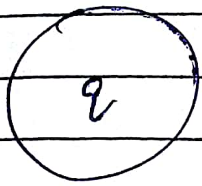


$$\boxed{\phi = \frac{q}{\epsilon_0}}$$

Proof:

Mathematically, $\phi = E \oint ds$

Consider a charge q is enclosed inside a spherical surface



$$\phi = E \oint ds$$

$$\phi = \frac{kq}{r^2} \oint ds$$

$$\phi = \frac{1}{\cancel{4\pi}\epsilon_0}\left(\frac{q}{\cancel{r^2}}\right) \cancel{4\pi r^2}$$

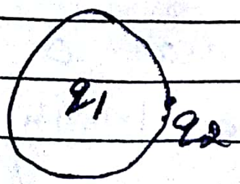
$$\phi = \frac{q}{\epsilon_0}$$

Hence, proved.

Q. Derive Coulomb's law from Gauss's law.

According to Gauss's law, $\phi = \frac{q_1}{\epsilon_0}$ — (1)

Mathematically, $\phi = E . \oint ds$ — (2)



Equating (1) and (2)

$$\Rightarrow \frac{q_1}{\epsilon_0} = E . \oint ds$$

$$\left\{ \begin{array}{l} F = Eq_2 \\ E = \frac{F}{q_2} \end{array} \right\}$$

$$\Rightarrow \frac{q_1}{\epsilon_0} = E \; 4\pi r^2$$

$$\Rightarrow \frac{q_1}{4\pi r^2 \epsilon_0} = E$$

Substituting the value of E

$$\frac{q_1}{4\pi r^2 \epsilon_0} = \frac{F}{q_2}$$

$$F = \frac{q_1 q_2}{4\pi r^2 \epsilon_0}$$

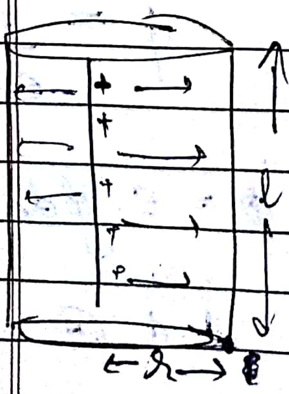
$$F = \frac{q_1 q_2}{(4\pi \epsilon_0) r^2} = \frac{K q_1 q_2}{r^2}$$

coulumb's law

Applications of Gauss's theorem

1. Electric field due to lengthy conductor of length 'l'

Consider a lengthy charged conductor is enclosed inside a ~~spherical~~ cylindrical guassian surface.



The conductor has a linear charge density 'λ'.

$$q = \lambda l$$

According to gauss's law, $\phi = \frac{q}{\epsilon_0} = \frac{\lambda l}{\epsilon_0}$ — ①

Also , $\phi = E\oint ds$ — (2)

Equating (1) and (2)

$$E\oint ds = \frac{\lambda l}{\epsilon_0}$$

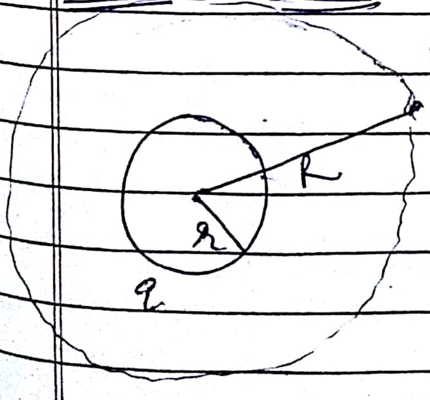
$$E \cdot 2\pi r \cancel{l} = \frac{\lambda \cancel{l}}{\epsilon_0}$$

$$\boxed{E = \frac{\lambda}{\epsilon_0 2\pi r}}$$

Conclusion : Therefore we conclude that electrical field intensity is inversely proportional to the distance 'r'.

2. <u>Electric field due to hollow spherical shell.</u>

<u>Case I</u> <u>$r < R$</u>



Consider a charged hollow sphere of radius 'r', having charge q enclosed inside a spherical gaussian surface of radius 'R'.

$$\phi = \frac{q}{\epsilon_0} \quad — (1)$$

$$\phi = E\oint ds \quad — (2)$$

Equating (1) and (2)

$$\frac{q}{\epsilon_0} = E(4\pi R^2)$$

Case 1. $\boxed{E = \frac{q}{4\pi\epsilon_0 R^2}}$

Case 2 if $r = R$ i.e on the surface of hollow sphere.

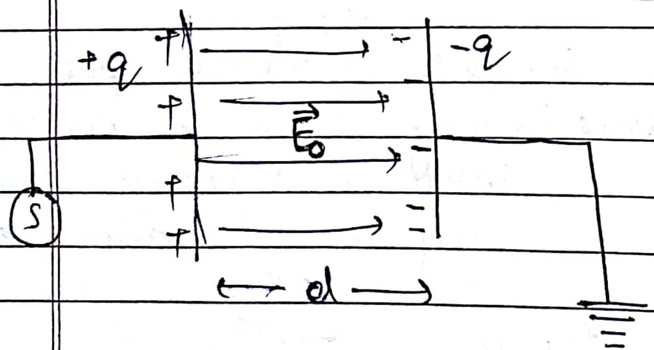
$$E = \frac{q}{4\pi\epsilon_0 r^2}$$

Case 3 $r > R$.

$E = 0$ (no charge present inside a hollow sphere).

CAPACITORS

Capacitance of || plate capacitor with air as medium



Consider two identical parallel plate capacitors with charge q, that are kept at a distance 'd'.
Let the area of the plate ~~capacitor~~ be 'A'.

An electric field E is set up between the plates. Let V be the potential difference b/w the plates.

$V = E_0 d$ — (1)

$q = \sigma A$ — (2)

$\sigma = \frac{q}{A}$ →

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Electric field $(E) = \frac{\sigma}{\epsilon_0}$ ⟵ (3)

Substituting (3) in (1)

$$V = \frac{\sigma}{\epsilon_0} d$$

Now put value of σ from (2)

$$V = \frac{q\,d}{A\epsilon_0} \longleftarrow (4)$$

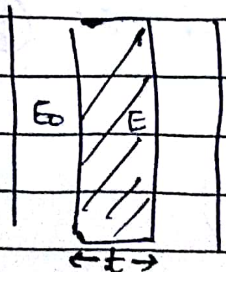
The capacitance C of parallel plate capacitor is given by : $C = \frac{q}{V}$

Substituting the value of V from (4)

$$C = \frac{\cancel{q}}{\frac{\cancel{q}\,d}{A\epsilon_0}}$$

$$\boxed{C = \frac{A\epsilon_0}{d}}$$

Capacitance of || plate capacitor with dielectric slab as medium



$$V = E_0(d-t) + Et \longleftarrow (1)$$

$$E = E_m = \frac{E_0}{\varepsilon_r}$$

Put value of E in (1)

$$V = E_0(d-t) + \frac{E_0 t}{\varepsilon_r}$$

$$V = E_0\left[d - t + \frac{t}{\varepsilon_r}\right] \quad — (2)$$

Now, capacitance (C) = $\frac{q}{V}$

Putting value of V from (2) in

$$C = \frac{q}{E_0\left(d-t+\frac{t}{\varepsilon_r}\right)} \quad — (3)$$

We know, $E_0 = \frac{\sigma}{\varepsilon_0}$ and $\sigma = \frac{q}{A}$

$$\therefore E_0 = \frac{q}{\varepsilon_0 A}$$

Put value of E in eq (3)

$$C = \frac{\cancel{q} \times \varepsilon_0 A}{\cancel{q}\left(d-t+\frac{t}{\varepsilon_r}\right)}$$

$$\boxed{C = \frac{A\,\epsilon_0}{\left[d - t + \frac{t}{\epsilon_r}\right]}}$$

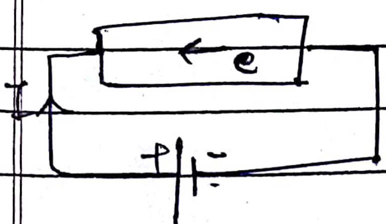
NOTE: If a capacitor is completely filled with dielectric slab i.e. $d = t$, then

$$\boxed{C = \frac{\epsilon_0 \epsilon_r A}{d}}$$

Current → rate of flow of charge

$$I = \frac{q}{t} = \frac{\text{Coloumb}}{\cancel{\text{time}}\ \text{second}} = \frac{C}{s} = C/s$$

SI Unit of current = Ampere (A)



Drift velocity (v_d)

$$v = \frac{d}{t}, \quad a = \frac{v_d}{t}$$

$F = ma$ — (1)
$F = eE$ — (2)

From eq (1) and (2)

$$ma = eE$$

$$\boxed{a = \frac{eE}{m}}$$

Hence,

$$\frac{eE}{m} = \frac{v_d}{t}$$

$$v_d = \frac{eEt}{m}$$

$$v_d = \underbrace{\left(\frac{et}{m}\right)}_{\text{mobility}} E$$

Here, $t = \tau$ (relaxation time)

$$\boxed{v_d = \frac{eE\tau}{m}}$$

Relation b/w I and v_d

$q = nAle$

$$I = \frac{q}{t} = \frac{nAle}{t}$$

$$v_d = \frac{l}{t} = \frac{\cancel{l} \times I}{nA\cancel{l}e}$$

$$v_d = \frac{I}{nAe}$$

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$$\boxed{I = neA\,v_d}$$

Ohm's Law

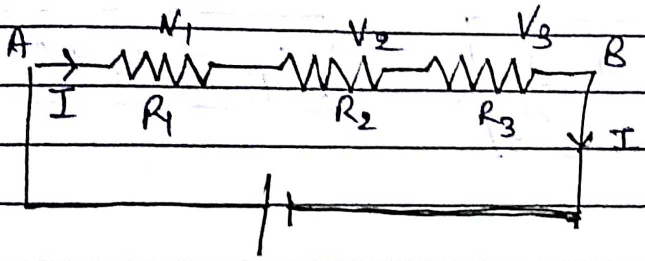
The current flowing through the conductor is directly proportional to the potential difference across its ends.

$V \propto I$

$\boxed{V = IR}$ ↳ Resistance

Resistance

In series



Current remains same and voltage is dividing.

$\cancel{I = I_1 + I_2 + I_3}$

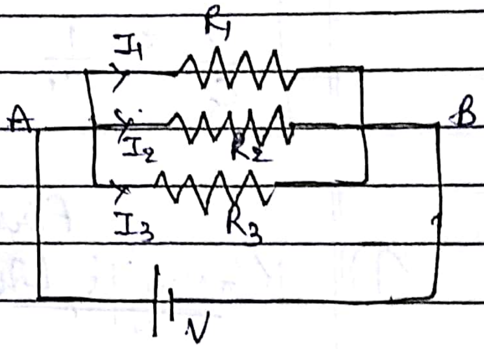
$\cancel{\frac{V}{R} = \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}}$

$V = V_1 + V_2 + V_3$

$\cancel{I}R_s = \cancel{I}R_1 + \cancel{I}R_2 + \cancel{I}R_3$

$\boxed{R_s = R_1 + R_2 + R_3}$

In parallel



Voltage remains same and current is dividing.

$I = I_1 + I_2 + I_3$

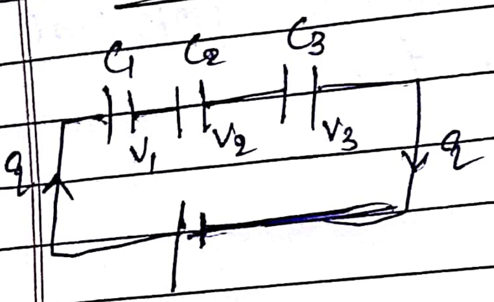
$\frac{\cancel{V}}{R_p} = \frac{\cancel{V}}{R_1} + \frac{\cancel{V}}{R_2} + \frac{\cancel{V}}{R_3}$

$\boxed{\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$

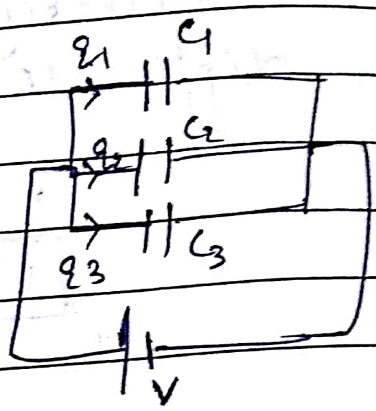
Capacitors.

In series.

$$\boxed{Q = CV}$$



In parallel



charge remains same

$V = V_1 + V_2 + V_3$

$\frac{\cancel{Q}}{C_s} = \frac{\cancel{Q}}{C_1} + \frac{\cancel{Q}}{C_2} + \frac{\cancel{Q}}{C_3}$

$$\boxed{\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}}$$

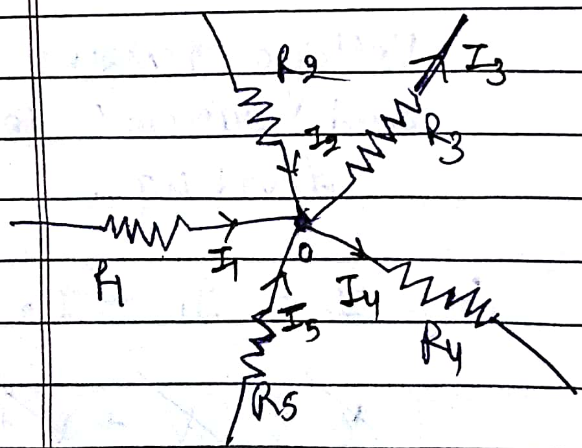
voltage remains same

$Q = Q_1 + Q_2 + Q_3$

$C_pV = C_1V + C_2V + C_3V$

$$\boxed{C_p = C_1 + C_2 + C_3}$$

① Kirchoff's First Law (Junction law or current law)



→ Towards junction +ve

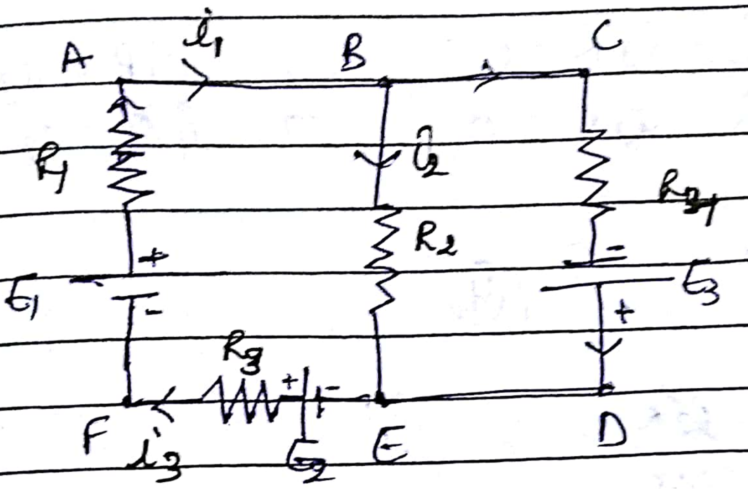
→ Away from junction −ve

$$\boxed{I_1 + I_2 - I_3 - I_4 + I_5 = 0}$$

$I_1 + I_2 + I_5 = I_3 + I_4$

Statement : Net ~~of~~ current at a junction is always zero.

② Kirchoff's Second law (Voltage law or Loop law)



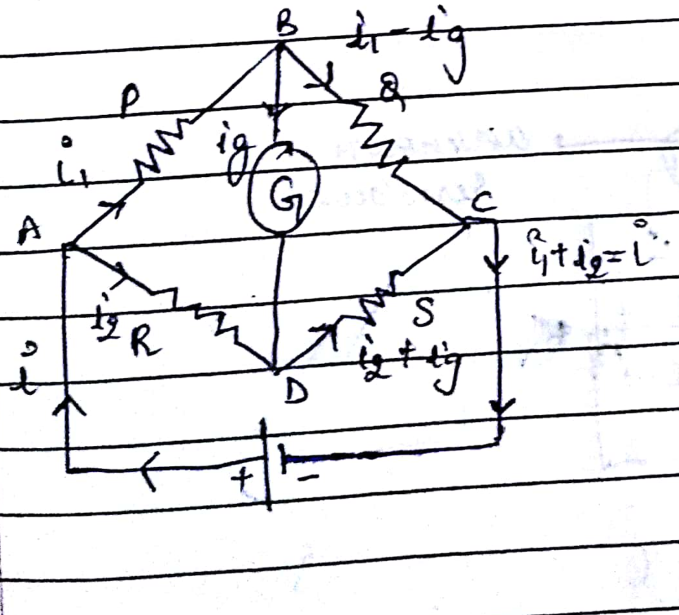
→ Current clockwise is +ve

→ current anti clockwise is −ve

Loop ABEFA.

$$i_2 R_2 + i_3 R_3 \cancel{+E_2} + i_1 R_1 = E_1 + E_2 .$$

Wheatstone Bridge / Wheatstone Network.



Loop ABDA.

$$i_1 P + i_g G - i_2 R = 0 \quad \text{— ①}$$

loop BCDB.

$$(i_1 - i_g) Q = (i_2 + i_g) S - i_g G \quad \text{— ②}$$

\# Galvanometer is a device used to find the direction of a current.

Scanned by CamScanner

~~If~~ If $i_g = 0$

From ① → $i_1 P - i_2 R = 0 \Rightarrow i_1 P = i_2 R$ — ③

From ② → $i_1 Q - i_2 S = 0 \Rightarrow i_1 Q = i_2 S$ — ④

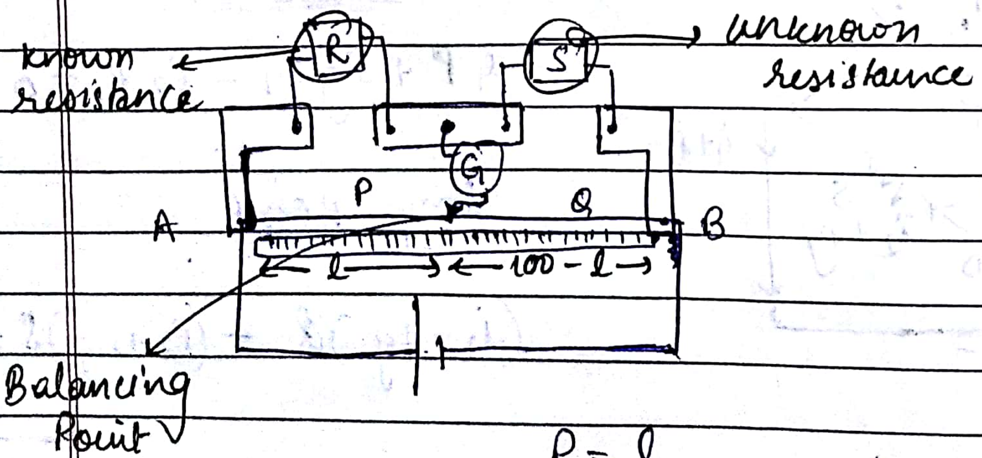
~~From ③ and ④~~ ③ / ④

$$\frac{\cancel{i_1} P}{\cancel{i_1} Q} = \frac{\cancel{i_2} R}{\cancel{i_2} S}$$

$$\boxed{\frac{P}{Q} = \frac{R}{S}}$$

This condition is called balanced condition of ~~met~~ wheatstone bridge.

Metre Bridge



$P = l$

$Q = 100 - l$

We know,

$$\frac{P}{Q} = \frac{R}{S}$$

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$$\frac{l}{100-l} = \frac{R}{S}$$

$$\boxed{\frac{S}{100-l} = \frac{R}{l}}$$

Applications of Metre Bridge

1. To find unknown resistance
2. To find unknown temperature
3. To compare two resistances (R_1 & R_2)

$$R_t = R_0(1+\alpha t)$$

$$R_t = R_0 + R_0 \alpha t$$

$$R_t - R_0 = R_0 \alpha t$$

temp. coefficient

Unit - 4

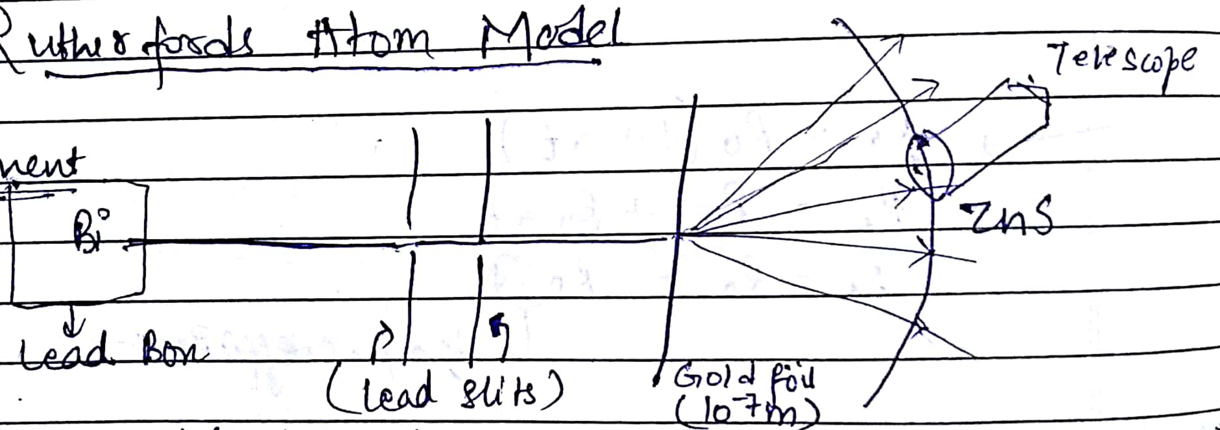
~~Model of Atoms~~ Structure of Atoms

Thomson's Model

Atom → Positively charged sphere in which electrons are embedded.
Eg: Watermelon model

Rutherford's Atom Model

Experiment



⇒ α-particle is the doubly charged helium atom i.e He^{++}

Q. Why ZnS? → It will produce [illegible] when radiation falls on it.

Conclusion

1. Very few particles reflected back by 180°. So, there must be some +ve charge concentrated in the centre. Which is the nucleus.

2. Atom has very free space. as many of the α-particles went undeflected.

3. Electrons are revolving around the nucleus in circular orbits.

Distance of Closest Approach (r)

$$\frac{1}{2} m v^2 = \frac{q_1 q_2}{4\pi\epsilon_0 r}$$

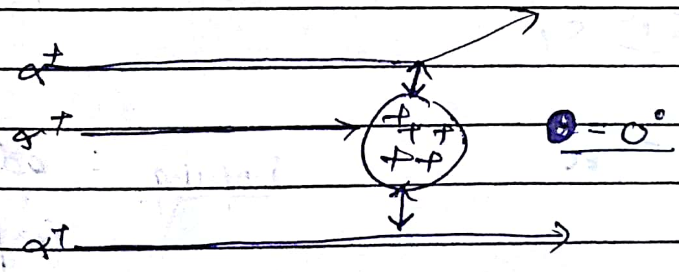
$$\frac{1}{2} m v^2 = \frac{2e \times Ze}{4\pi\epsilon_0 \times r}$$

$q_1 \rightarrow$ charge of α-particle

$q_2 \rightarrow$ charge of nucleus of gold foil

$$\boxed{r = \quad ?}$$

Impact Parameter



Drawbacks of Rutherford's Model

→ Could not explain the spectral ~~lines~~ series of hydrogen atom.

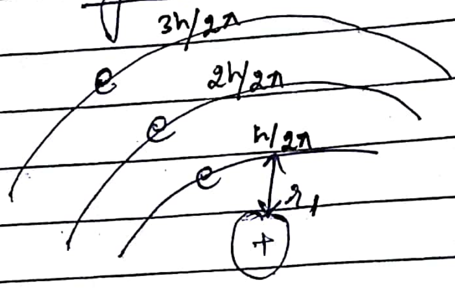
→ Stark Effect

→ Zeeman Effect

Bohr's Model of Atom

linear momentum (P) = mv

angular momentum, $mvr = \frac{nh}{2\pi}$



where $n = 1, 2, 3, 4 \ldots$

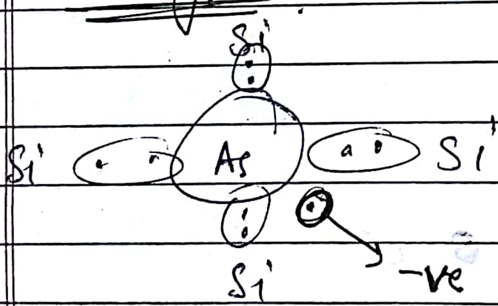
VIBGYOR

$\nu \leftarrow$

$\lambda \rightarrow$

Semiconductors

N-Type (−ve)

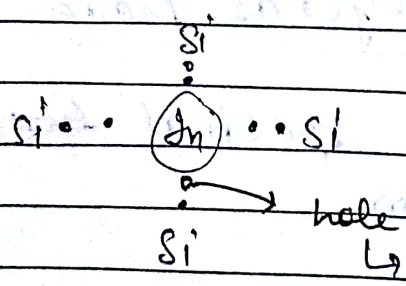


Si → 4 Tetravalent

As → 5 Pentavalent

Doping : addition of impurities

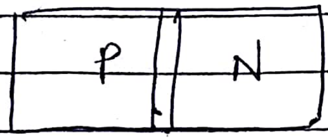
P-Type (+ve)

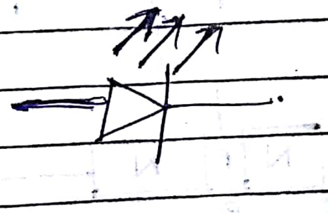


In → 3 Trivalent

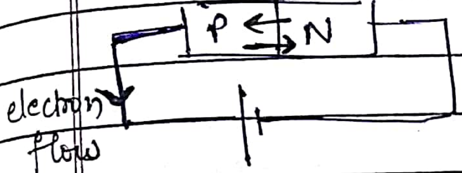
↳ It is considered as positive as it has the ability to attract the electron.

P-N Junction Diode



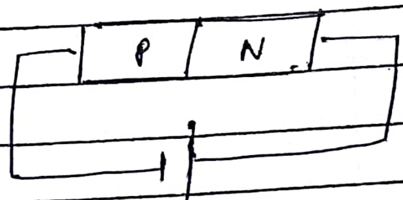


Forward Biased



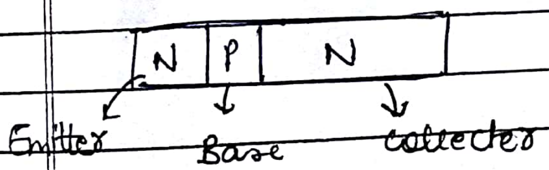
Positive connected to positive.

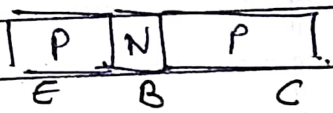
Reverse Biased

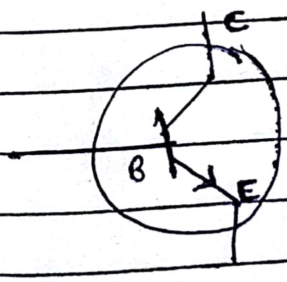


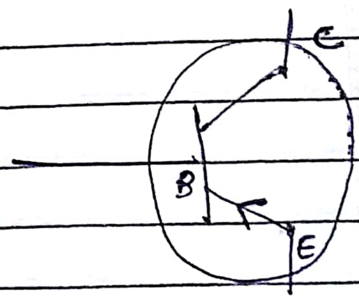
Positive connected to negative.

Transistor





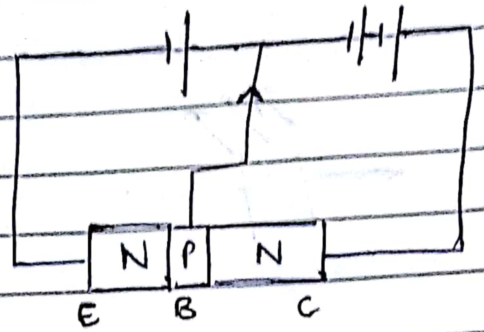




Emitter → highly (doped)
↳ always forward biased.

Base → moderately doped

Collector → lightly doped
↳ always reverse biased.


N
P
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