Physics Mega Revision #6

- Rotation Motion
- Gravitation
- SHM
- Wave on String
- Sound Wave

Superfast Revision

🔥 Welcome Students 🔥

Complete Physics Mega Revision Timetable

15 Feb
Electrostatics
Current electricity
Capacitor
🎁 Surprise Gift 🎁

16 Feb
Calorimetry
Elasticity
Thermal Expansion
Heat Transfer
KTG
Thermodynamics
Fluid Mechanics

17 Feb
Magnetic effect of current
Magnetism and matter
Emi
AC

18 Feb
UD
Vector
Kinematics 1D
Kinematics 2D
NLM
Friction
Circular motion
Work power energy
COM

19 Feb
Ray optics
Optical Instruments
Wave optics
EM Waves
Errors in measurement

20 Feb
Rotation motion
Gravitation
SHM
Wave on string
Sound wave

21 Feb
Atomic structure
Dual nature of radiation
X-rays
Nuclear physics
Radioactivity
Semi conductor
Communication system

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What you get inside the course?

- Study from Kota's **Top IITian Faculties**
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- **30000+** Solved Qs
- Personalised date wise Time-table
- Live **4-Layered Doubt Solving** System
- Personalised 3-Layered **One to One Mentorship**
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- Quick Revision Video Lectures and **90+ Mind Maps**
- **97 JEE Main** and **94 JEE advanced** 1hr Topic wise **Tests**
- 3 Hour Regular Review tests and Test Series
- Instant Test Analysis Report
- Regular Motivation and Strategy Sessions

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Course Details

Lectures

Practice
- Sheets
- Prev. Yr.

Tests
- Topic-Wise
- Review

Study Plan

Doubt Solving

Mentorship


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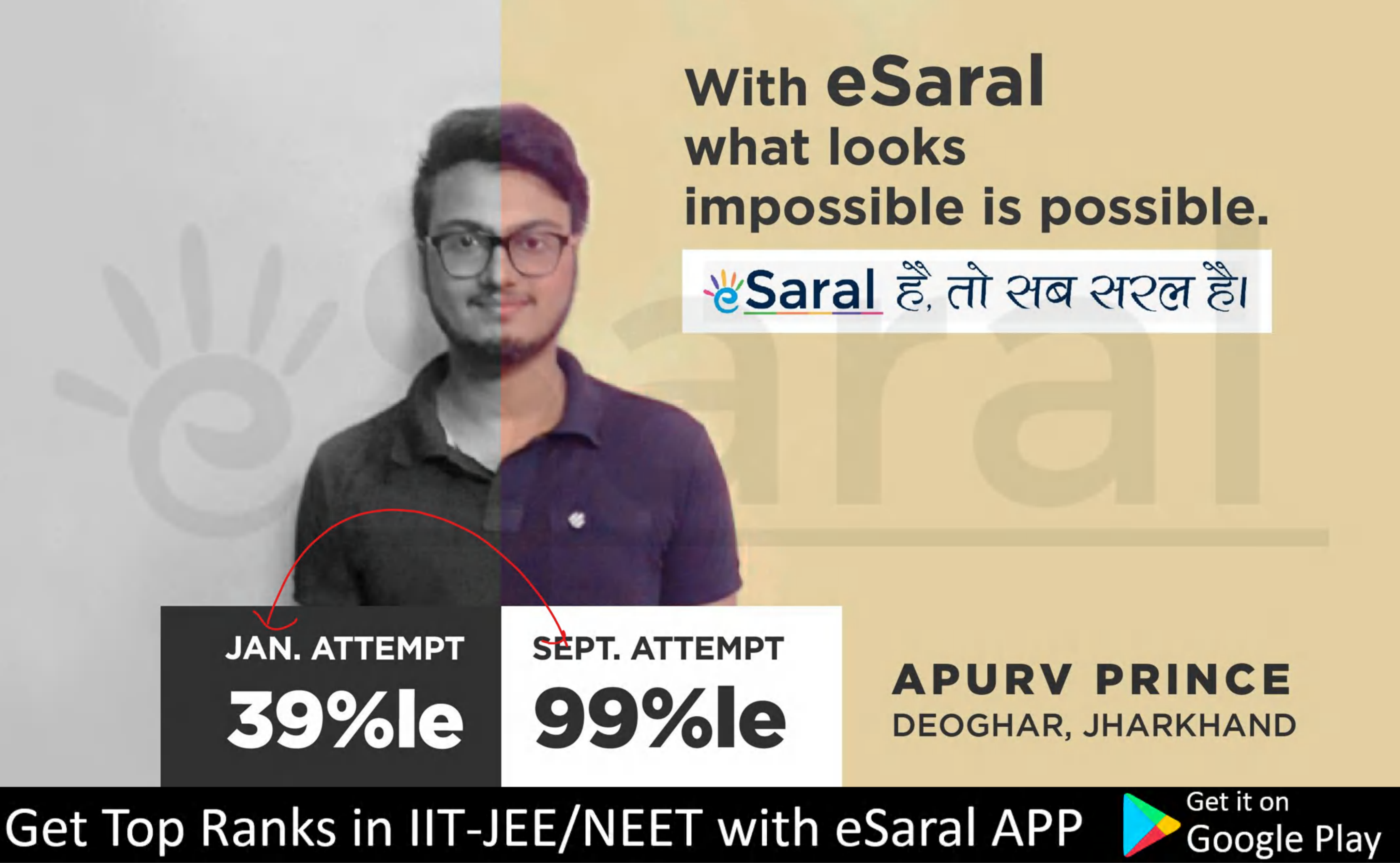
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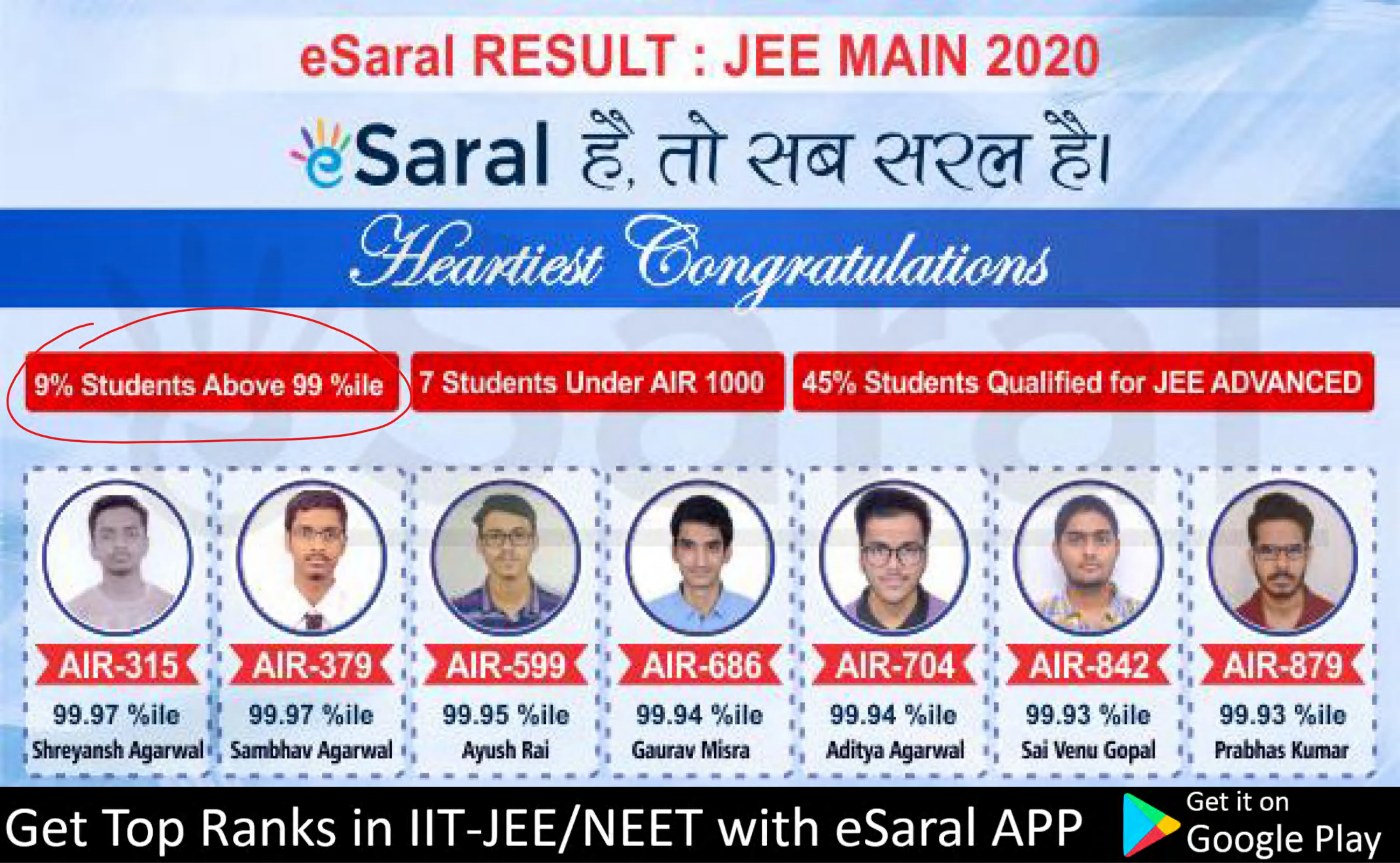
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Rotation Motion

Superfast Revision

Rotation Motion

Kinematics of Pure rotation motion

$S = R\theta$

$|v| = R\omega$

If $\alpha = \text{constant}$

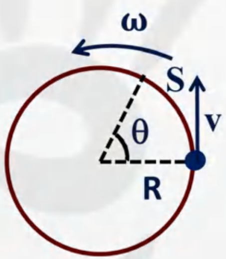
$\omega_f = \omega_i + \alpha t$

$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

$\omega_f^2 = \omega_i^2 + 2\alpha\theta$

$\theta = \left(\frac{\omega_i + \omega_f}{2}\right)t$

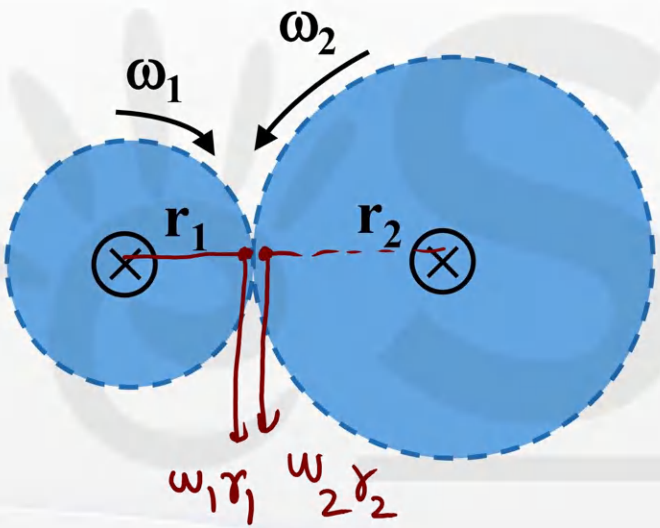
$\theta = \omega_f t - \frac{1}{2}\alpha t^2$



Rigid Body

Body in which distance between its constituent particles do not change with time is called rigid body.

No slipping



$\omega_1 r_1 = \omega_2 r_2$ for no slipping between disks

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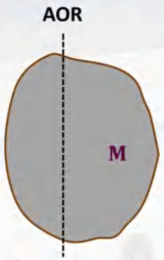
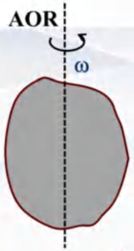
Rotation Motion

Radius of Gyration



$K = \sqrt{\frac{I}{M}}$ → RoG about an axis

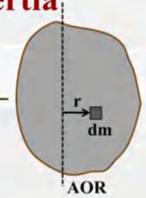
$I = MK^2$

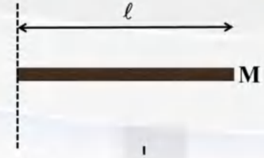


$KE_{sys} = \frac{1}{2} I \omega^2$

Moment of Inertia

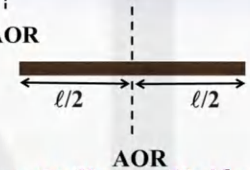
$I = \int r^2\, dm$ ←





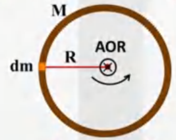
$I = \frac{M\ell^2}{3}$

$I = 0$



$I = \frac{M\ell^2}{12}$

Uniform Ring

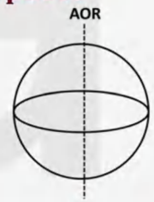


$I = MR^2$

Disk

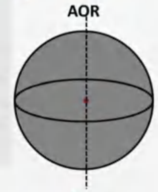
$I = \frac{MR^2}{2}$

Uniform Hollow Sphere



$I = \frac{2}{3}MR^2$ >

Uniform Solid Sphere



$I = \frac{2}{5}MR^2$

Parallel – axis theorem:

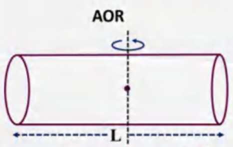
Among the given parallel axis MOI will be minimum about the axis passing through COM.

MOI about the parallel axis having same distance from COM is equal.

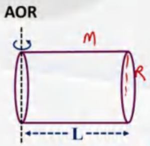
$I_{AA'} = I_{CC'} + Md^2$

TRICK

Hollow Cylinder

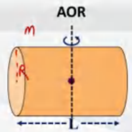


$I = \frac{MR^2}{2} + \frac{ML^2}{12}$

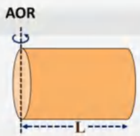


$I = \frac{MR^2}{2} + \frac{ML^2}{3}$

Solid Cylinder

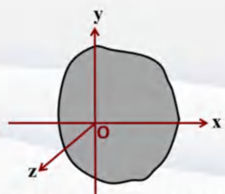


$I = \frac{MR^2}{4} + \frac{ML^2}{12}$



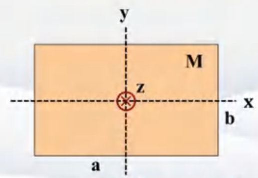
$I = \frac{MR^2}{4} + \frac{ML^2}{3}$

Perpendicular axis theorem:



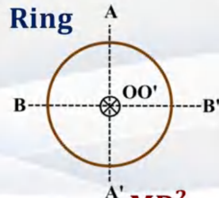
Planar body in (x-y)plane

$I_z = I_x + I_y$



$I_z = \frac{Mb^2}{12} + \frac{Ma^2}{12}$

Ring



$I_{AA'} = \frac{MR^2}{2}$

Disk

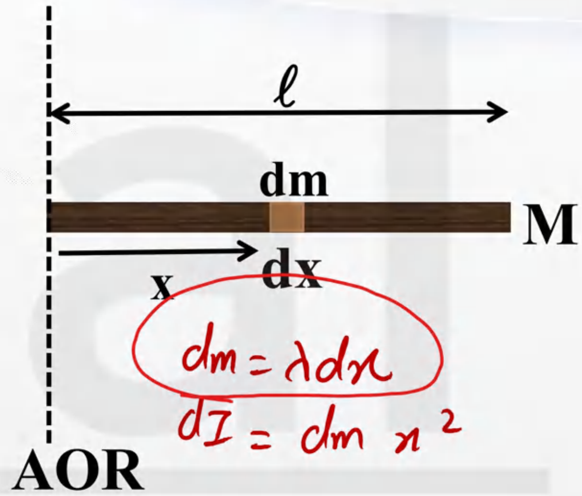
$I_{AA'} = \frac{MR^2}{4}$

Q) $\lambda = \lambda_0\left(1+\frac{x}{L}\right)$. Find MOI about an AOR at end perpendicular to rod.

Sol. $\int dI = \int x^2\, dm$

$$I = \int_0^L x^2 \lambda dx \Rightarrow \int_0^L x^2\lambda_0\left(1+\frac{x}{L}\right)dx$$

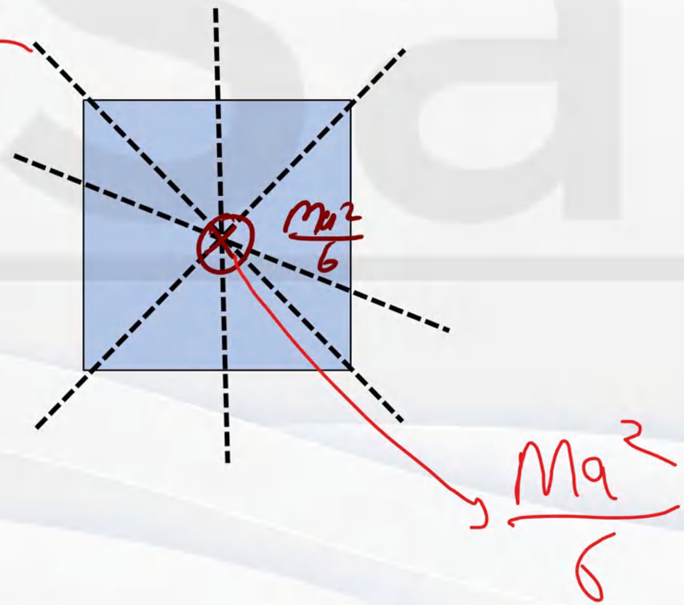
$$= \lambda_0\left[\int_0^L x^2 dx + \int_0^L \frac{x^3}{L}dx\right] = \left[\frac{L^3}{3}+\frac{L^3}{4}\right] = \lambda_0\frac{7L^3}{12}$$



Key Point

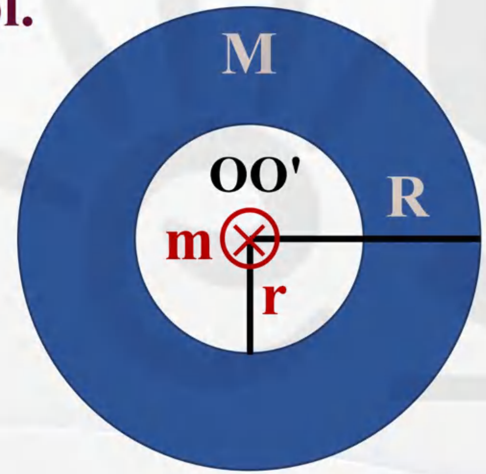
In uniform square plate, I about each axis through centre in plane of plate is given by

$$I = \frac{Ma^2}{12}$$



Q) A disk of mass m and radius r is cut out from a disk of mass M and radius R. Find $I_{OO'}$.

Sol.



$$I = I_{BD} - I_{CD} = \frac{MR^2}{2} - \frac{mr^2}{2}$$

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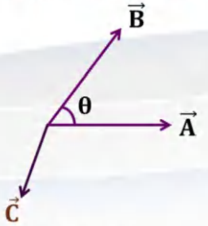
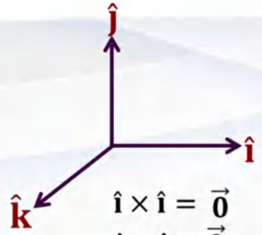
Rotation Motion

Cross Product





$\vec{C} = \vec{A} \times \vec{B}$

$|\vec{C}| = |\vec{A}||\vec{B}| \sin\theta$

θ is angle b/w $\vec{A}$ & $\vec{B}$

$\hat{i} \times \hat{i} = \vec{0}$

$\hat{j} \times \hat{j} = \vec{0}$

$\hat{k} \times \hat{k} = \vec{0}$

$\hat{i} \times \hat{j} = \hat{k}$

$\hat{j} \times \hat{k} = \hat{i}$

$\hat{k} \times \hat{i} = \hat{j}$

$\hat{j} \times \hat{i} = -\hat{k}$

$\hat{k} \times \hat{j} = -\hat{i}$

$\hat{i} \times \hat{k} = -\hat{j}$

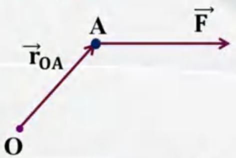
Properties

$\vec{A} \times \vec{B} \neq \vec{B} \times \vec{A}$

$\vec{A} \times \vec{B} = -(\vec{B} \times \vec{A})$

$\vec{A} \times \vec{A} = \vec{0}$

Torque



$\vec{\tau}_O = \vec{r}_{OA} \times \vec{F}$

$|\tau| = rF\sin\theta$

$(r\sin\theta)F$ → $|\tau| = r_\perp F$

$r(F\sin\theta)$ → $|\tau| = rF_\perp$

Step To Follow In Pure Rotation

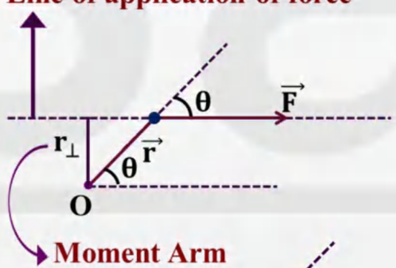
Step-1 : Identify AOR

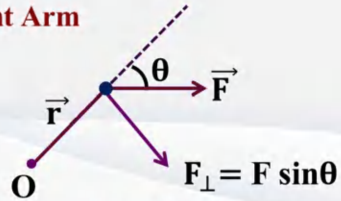
Step-2 : Take torque of all forces acting on the system.

Step-3 : Apply $\tau_{net} = I\alpha$ about the AOR.

To calculate work & torque of gravitational force, whole mass of body can be assumed to be concentrated at its Center of Gravity.

Line of application of force





$F_\perp$ is perpendicular component of $\vec{F}$

Condition of Equilibrium

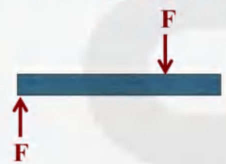
Translation Equilibrium | Rotational Equilibrium

1) $\sum \vec{F} = 0$ → $\sum \vec{F}_x = 0$, $\sum \vec{F}_y = 0$, $\sum \vec{F}_z = 0$

2) $\sum \vec{\tau} = 0$

If $\vec{F}_{net} = 0$ on a rigid body then $\vec{\tau}_{net}$ is same about every point of space.

Force Couple



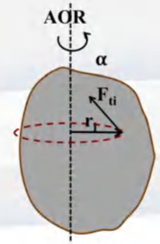
A pair of equal & opposite forces is called force couple.

Torque of force couple is same about any point of the space.

$\sum \tau_{int} = 0$

$\left(\sum \tau_{ext}\right)_{AOR} = (I)_{AOR}\alpha$

Valid only in inertial frame.



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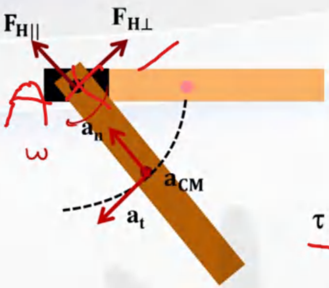
(1) COM AXIS OR (2) Inertial Point

Calculation of Hinge Force



$$F_H = \sqrt{F_{H||}^2 + F_{H\perp}^2}$$

($F_{H\perp}$) Perpendicular to rod

$$\sum F_{\perp} = m(a_{CM})_t = m\alpha\frac{L}{2}$$

$\tau = I\alpha \rightarrow \alpha \rightarrow (a_{CM})_t \rightarrow F_{H\perp}$

($F_{H||}$) Parallel i.e. along the rod

$$\sum F_{||} = m(a_{CM})_n = m\omega^2\frac{L}{2}$$

W-E Theorem $\rightarrow \omega \rightarrow (a_{CM})_n \rightarrow F_{H||}$

Inertial Pulley

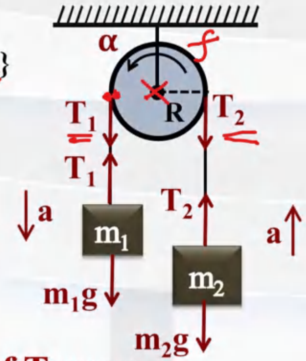
{No slipping of rope on disk}

$T_1R - T_2R = I\alpha$ ....(1)

$m_1g - T_1 = m_1a$ ....(2)

$T_2 - m_2g = m_2a$ ....(3)

$\alpha R = a$ ....(4)



Work done in terms of Torque

$$W = \int \tau d\theta \qquad P = \tau\,\omega$$

Q) Find F_H by support if the rod is released from rest. Δ in f position

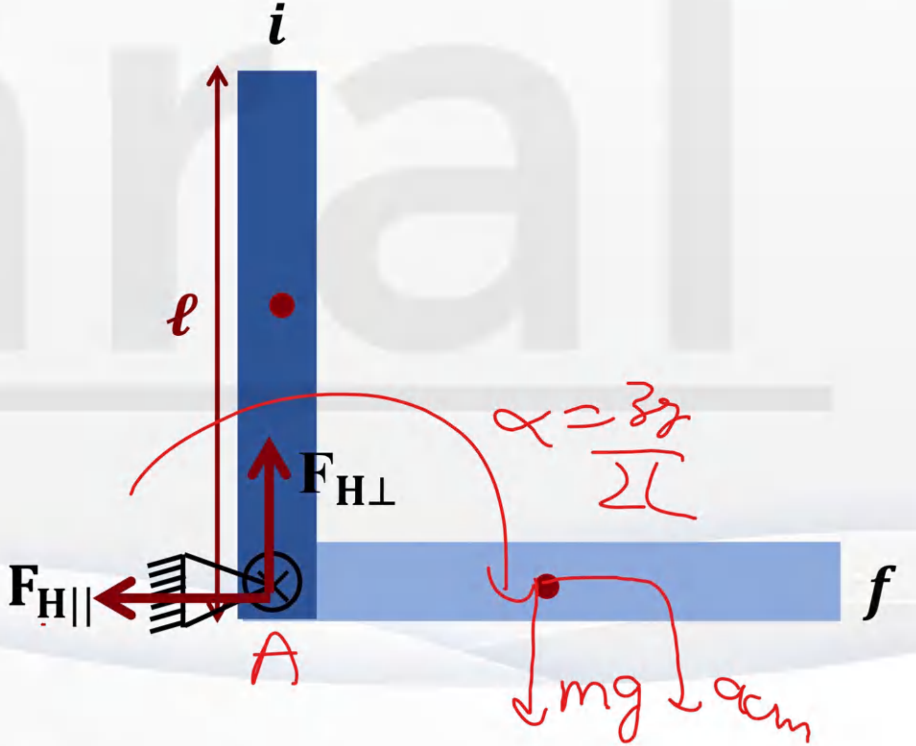
Sol. $\tau = I\alpha \longrightarrow \alpha \longrightarrow (a_{CM})_t \longrightarrow F_{H\perp}$

$\tau = I \times \alpha$ about A

$$\frac{mgL}{2} = \frac{mL^2}{3} \times \alpha \quad \therefore \alpha = \frac{3g}{2L}$$

$$mg - F_{H\perp} = ma_t = m \times \frac{L}{2} \times \frac{3g}{2L}$$

$$F_{H\perp} = \frac{mg}{4}$$



W-E Theorem → ω → $(a_{CM})_n$ → $F_{H||}$

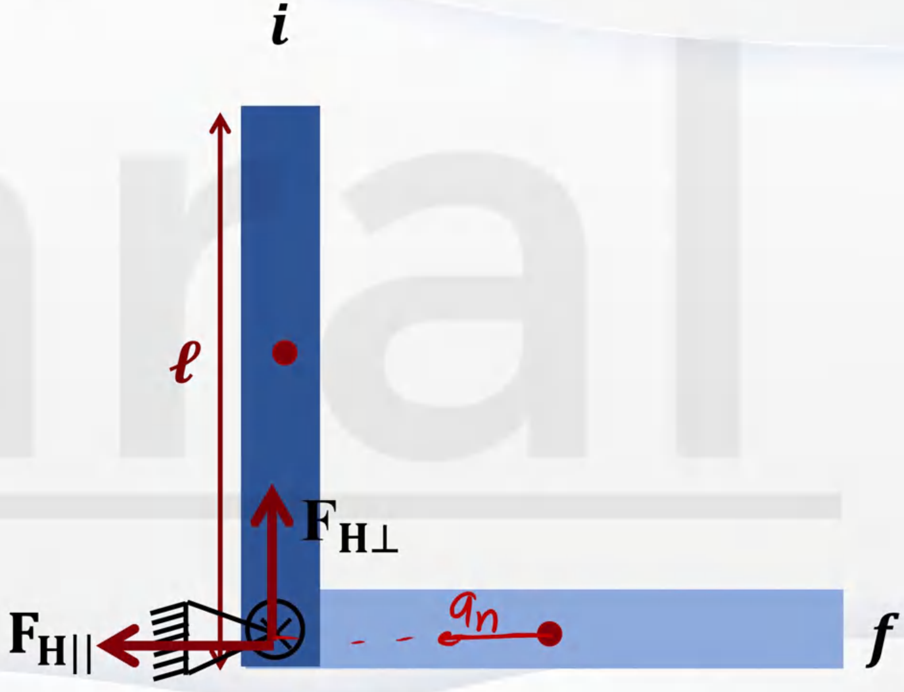
$$W_g + W_H = KE_f - KE_i$$

$$\frac{mgL}{2} + 0 = \frac{1}{2}\frac{mL^2}{3}\omega^2 - 0$$

$$\omega = \sqrt{\frac{3g}{L}}$$

$$F_{H||} = m(a_{CM})_n = m\omega^2\frac{L}{2}$$

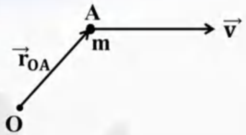
$$F_{H||} = \frac{3mg}{2}$$



Angular Momentum of Particle

Angular Momentum of Particle about point O is defined as

$$\vec{L}_O = \vec{r}_{OA} \times \vec{P}$$
$$= m\vec{r}_{OA} \times \vec{v}$$



where $\vec{P}$ is linear momentum of the particle present at A.

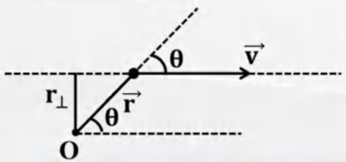
$$\vec{L} = \vec{r} \times \vec{P}$$

AM is also known as moment of LM.

$$|L| = mrv\sin\theta$$

$m(r\sin\theta)v \Rightarrow \vec{L} = \text{Constant}$

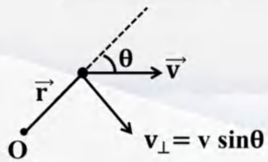
$$|L| = mr_{\perp}v$$



$r_{\perp}$ is the shortest distance from O to line of velocity.

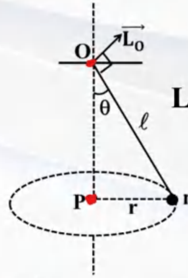
$mr(v\sin\theta)$

$$|L| = mrv_{\perp}$$

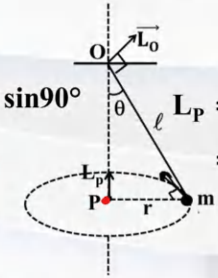


$v_{\perp}$ is perpendicular to $\vec{r}$

Conical Pendulum



$$L_O = m\,l\,v\sin 90^\circ$$
$$= mvl$$



$$L_P = m\,\ell\sin\theta\, v\sin 90^\circ$$
$$= mv\ell\sin\theta$$

$\vec{L}_O$ is not constant but its magnitude is constant.

$\vec{L}_P$ is constant

Angular Momentum of System of Particles

$$\vec{L}_{sys} = \sum \vec{L}_i$$

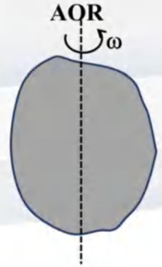
Angular Momentum Conservation Principle

$$\vec{\tau}_{net} = \frac{d\vec{L}}{dt} \quad \text{If } \vec{\tau}_{net} = 0 \Rightarrow \vec{L} = \text{Constant}$$

If $\vec{\tau}_{net}$ is zero then its A.M. is conserved.

A.M. of Rigid Body Performing Pure Rotation About Fixed Axis

$$(L_{sys})_{AOR} = I_{AOR}\,\omega$$



Relation Between Torque and Angular Momentum

$\vec{\tau}_{Net} = \frac{d\vec{L}}{dt}$ valid only in inertial frame.

$\vec{\tau}_{Net} = \frac{d\vec{L}}{dt}$

Particle

$\vec{\tau}_{Net} = \frac{d\vec{L}}{dt}$

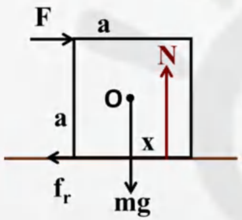
System

$\vec{\tau}_{Net} = \frac{d\vec{L}_{sys}}{dt}$

$\sum \tau_{ext} + \sum \tau_{int} = 0$

$(\vec{\tau}_{ext})_{Net} = \frac{d\vec{L}_{sys}}{dt}$

Condition of Toppling



$x > \frac{a}{2}$ Toppling will occur

$x = \frac{a}{2}$ On verge of toppling

$x < \frac{a}{2}$ No toppling

Angular Impulse

Linear Impulse $(\vec{I})$

$\vec{I} = \int \vec{F}\,dt$

Unit - Ns

$\vec{I}_{net} = \vec{P}_f - \vec{P}_i$

$\vec{J} = \vec{r} \times \vec{I}$

Angular Impulse $(\vec{J})$

$\vec{J} = \int \vec{\tau}\,dt$

Unit - Nms

$\vec{J}_{net} = \vec{L}_f - \vec{L}_i$

Q) Particle sticks to rod. Find ω of rod just after collision.

Sol. $(\tau_{Net})_{rod + particle} = 0$

$$\vec{L_i} = \vec{L_f}$$

$$Mv_0L + 0 = M(\omega L)L + \frac{ML^2}{3}\omega$$

$$\omega = \frac{3v_0}{4L}$$

Q) **Particle stops after collision. Find ω of Rod.**

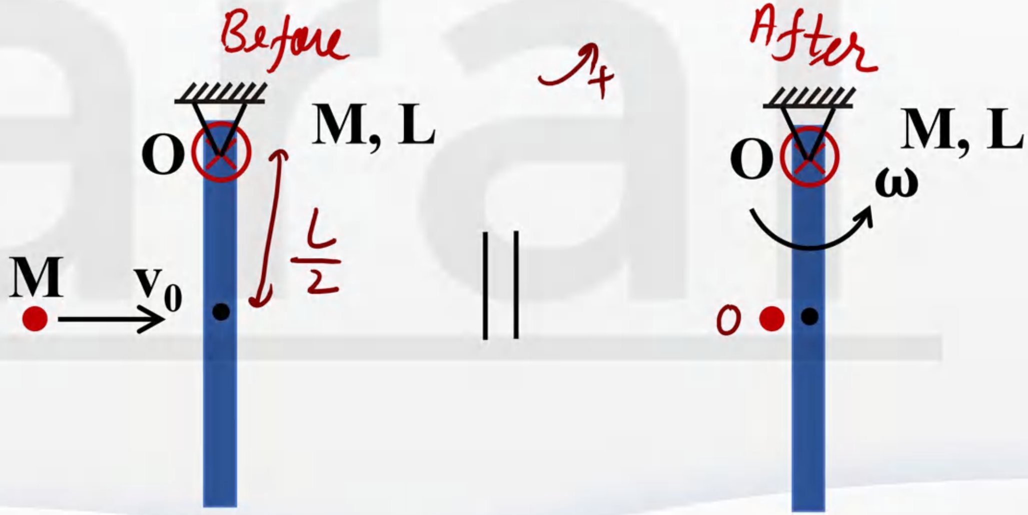
Sol. $(\tau_{Net})_o = 0$

$\vec{L_i} = \vec{L_f}$

Par Rod Par Rod

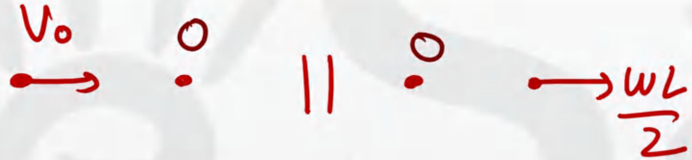
$$Mv_0\frac{L}{2} + 0 = 0 + \frac{ML^2}{3}\omega$$

$$\omega = \frac{3v_0}{2L}$$

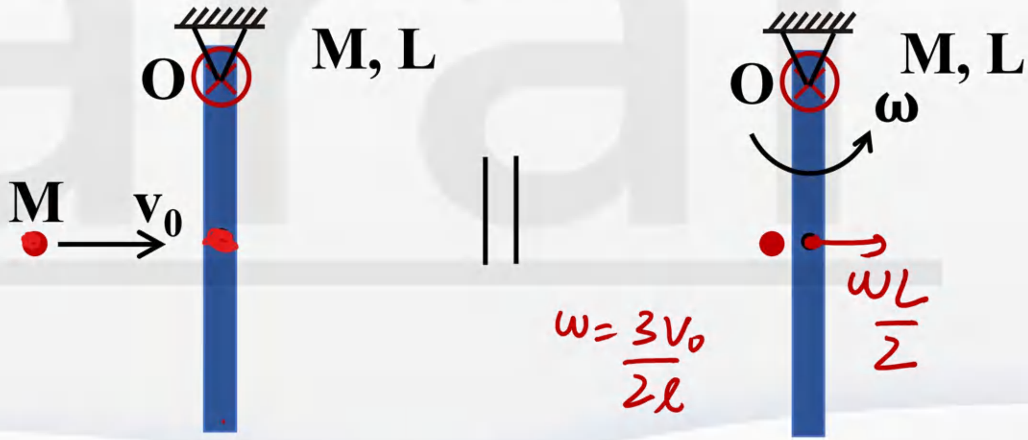


b) Find value of coefficient of restitution 'e'.

Sol. $e = \dfrac{\text{velocity of separation}}{\text{velocity of approach}}$



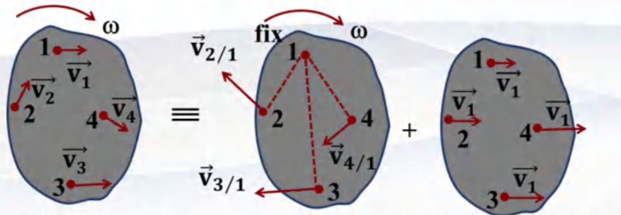
$e = \dfrac{\frac{\omega L}{2}}{v_0} = \boxed{\frac{3}{4}}$



Rotation Motion

Combined Rotation + Translational Motion [CRTM]

Velocity Analysis



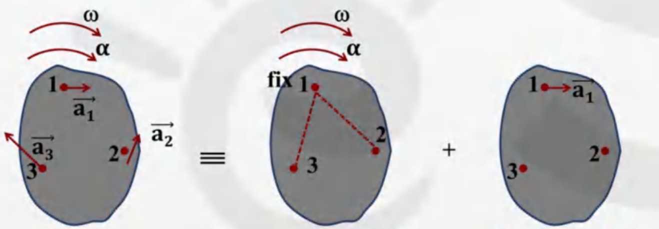
CRTM ≡ Pure rotation + Pure translation

$\vec{v}_2 = \vec{v}_{2/1} + \vec{v}_1$

$\vec{v}_3 = \vec{v}_{3/1} + \vec{v}_1$

$\vec{v}_4 = \vec{v}_{4/1} + \vec{v}_1$

Acceleration Analysis



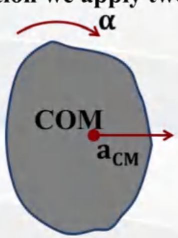
CRTM ≡ Pure rotation + Pure translation

Dynamics of CRTM

For analysing its motion we apply two equation

$\sum \vec{F}_{ext} = M\vec{a}_{CM}$

$\sum \vec{\tau}_{ext} = I\vec{\alpha}$



Dynamics of CRTM

Second equation is valid in inertial frame.

1) $\sum \vec{F} = M\vec{a}_{CM}$ 2) $\sum \vec{\tau} = I\vec{\alpha}$

$\sum \vec{F}_{ext} = M\vec{a}_{CM}$ $\sum \vec{\tau}_{ext} = I\vec{\alpha}$

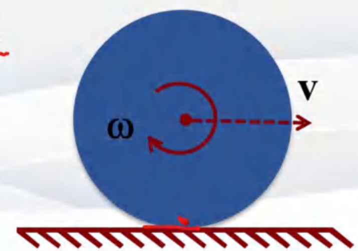
Most suitable point to apply Torque equation is about COM of the body because τ of pseudo force about COM is "zero".

To apply second equation about non-inertial point, Pseudo force is applied at COM of body & τ of Pseudo force is also taken into account.

Rolling Motion

If during the motion, there is no relative slipping between the points of contact, then motion is called Rolling.

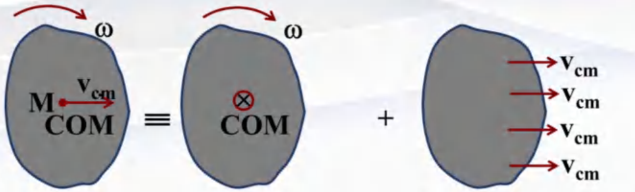
$v = \omega R$



Rotation Motion

Combined Rotation + Translational Motion [CRTM]

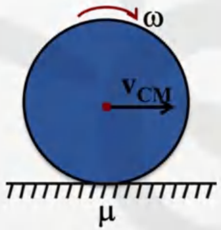
Kinetic Energy of Rigid Body Performing CRTM



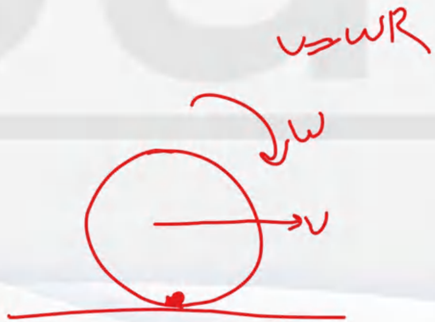
CRTM ≡ Rotational KE + Translational KE

$$KE = \frac{1}{2} I_{CM}\omega^2 + \frac{1}{2} M v_{CM}^2$$

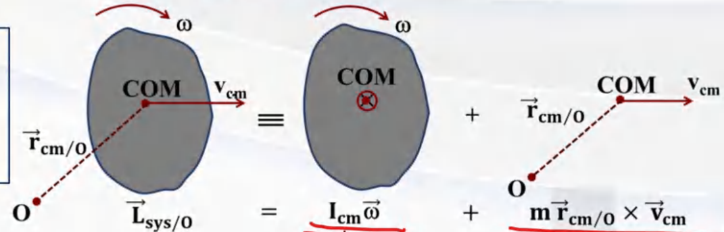
Keypoint



For a body performing rolling motion over a fixed surface, work done by friction force on the body will be zero as velocity of point of application of friction always zero.



Angular Momentum of R.B. Performing CRTM

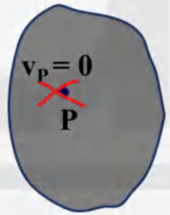


$\vec{L}_{sys/O} = I_{cm}\vec{\omega} + m\vec{r}_{cm/O} \times \vec{v}_{cm}$

Rotational as rigid body; Pure rotation about COM — Translation as a particle

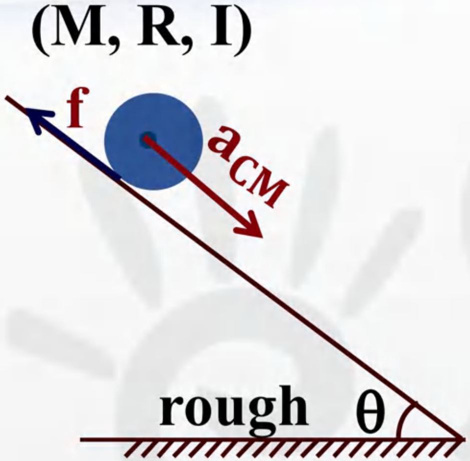
$$\vec{L}_{sys/O} = I_{cm}\vec{\omega} + m\vec{r}_{cm/O} \times \vec{v}_{cm}$$

Instantaneous Center of Rotation (I_{COR}) & Axis of Rotation (I_{AOR})



- ❖ Let at an instant of time velocity of point P is zero.
- ❖ To calculate velocity of other points of rigid body, rigid body can be assumed to perform pure rotation about an axis passing through point P at that instant. This point is called I_{COR} and axis passing through it is called I_{AOR}.

Rolling



$$a_{CM} = \frac{g\sin\theta}{1 + \frac{I}{MR^2}}$$

→ **For Rolling**

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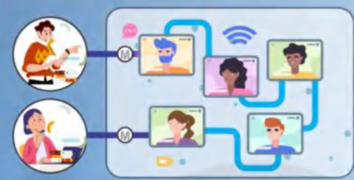
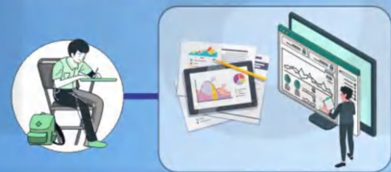


PROGRESS MENTOR FOR TRACKING PROGRESS



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Gravitation

Superfast Revision

Universal Law of Gravitation

$$F = \frac{Gm_1 m_2}{r^2}$$

$G = 6.67 \times 10^{-11}\ Nm^2/kg^2$

↓

Universal Gravitational Constant

Electrostatics Analogy

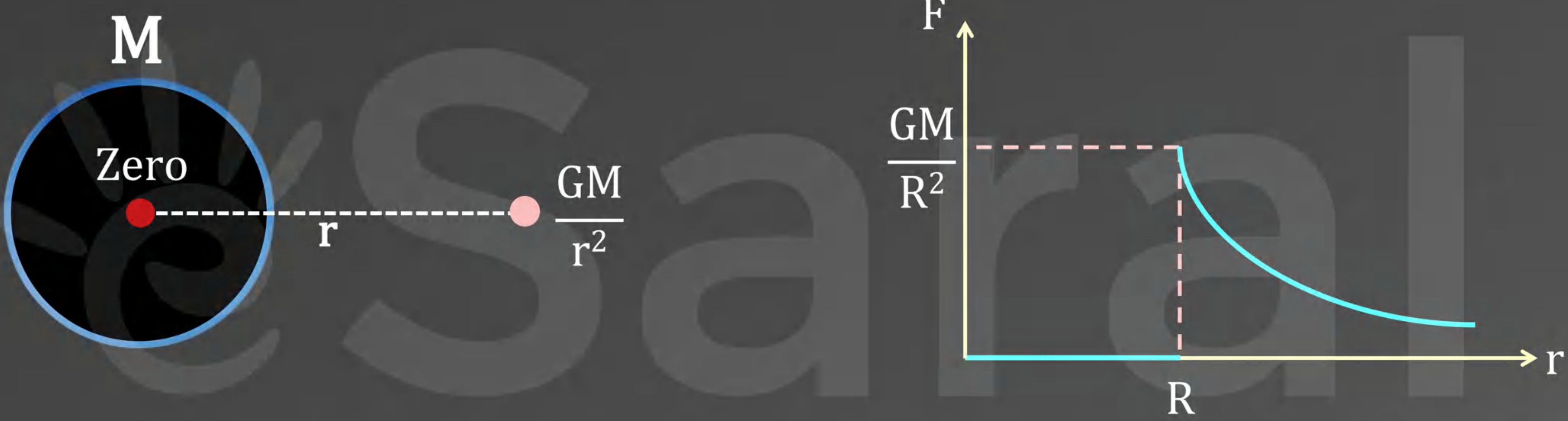
Electrostatics	Gravitation
$\frac{kq_1q_2}{r^2}$	$\frac{Gm_1m_2}{r^2}$
q	m
$k = \frac{1}{4\pi\varepsilon_0}$	G
$\lambda\,\sigma\,\rho$	$\lambda\,\sigma\,\rho$
$\vec{E}$	$\vec{G}$

Gravitational Field

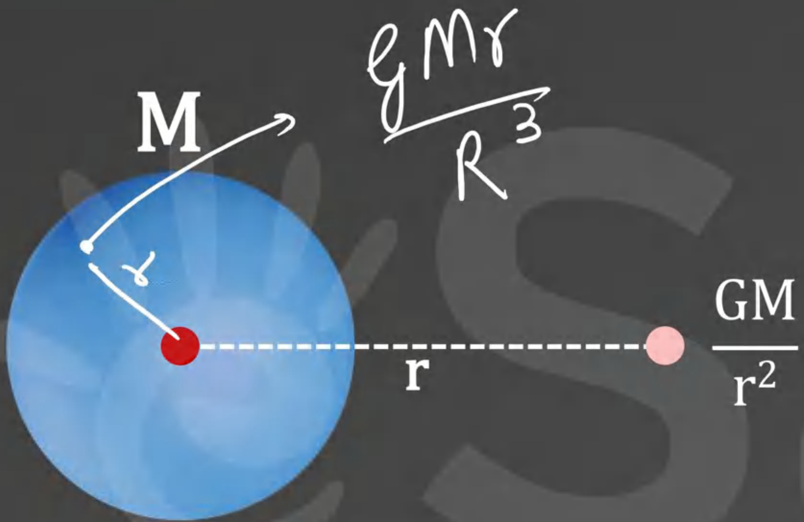
Gravitational Field Intensity $= \frac{GM}{r^2}$

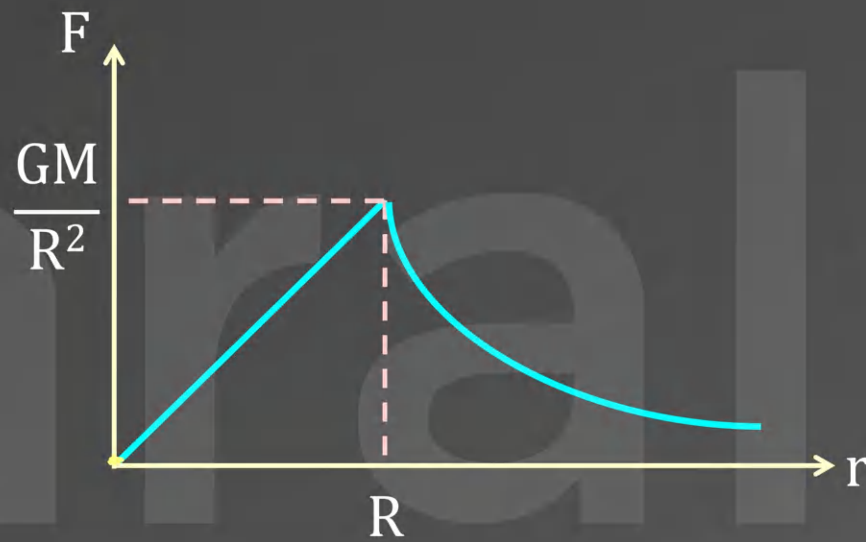
$= \frac{RQ}{r^2}$

Hollow Sphere

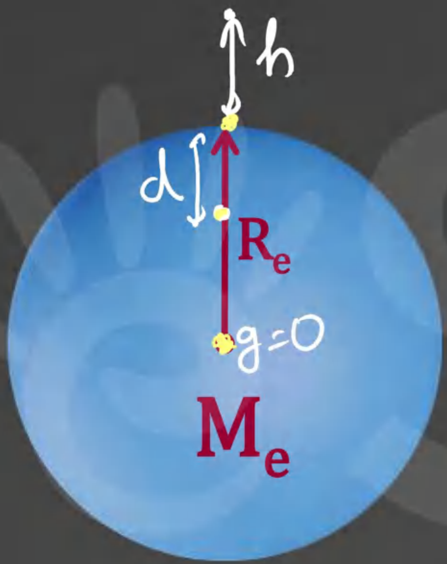


Solid Sphere





Acceleration due to Gravity



At surface

$$g_0 = \frac{GM_e}{R_e^2} = 9.8 \text{ m/s}^2$$

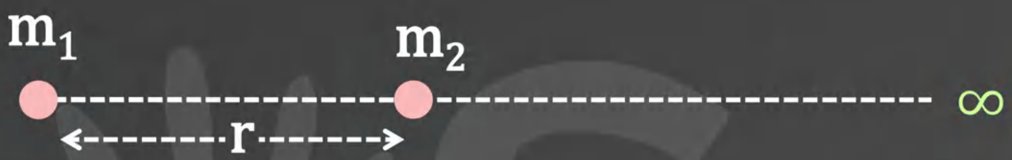
At height

$$g = \frac{g_0}{\left(1+\frac{h}{R_e}\right)^2} \approx g_0\left(1-\frac{2h}{R_e}\right) \quad (h \ll R_e)$$

At depth

$$g = g_0\left(1-\frac{d}{R_e}\right)$$

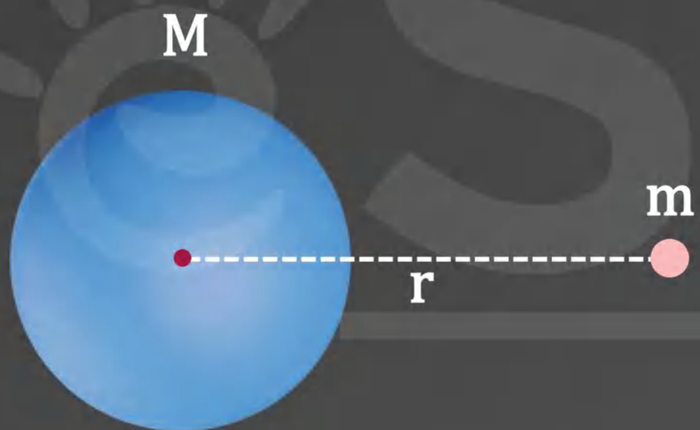
Gravitational Potential Energy



$U_\infty = 0$

$$U = \frac{-G\,m_1 m_2}{r}$$

$$\frac{kq_1q_2}{r}$$

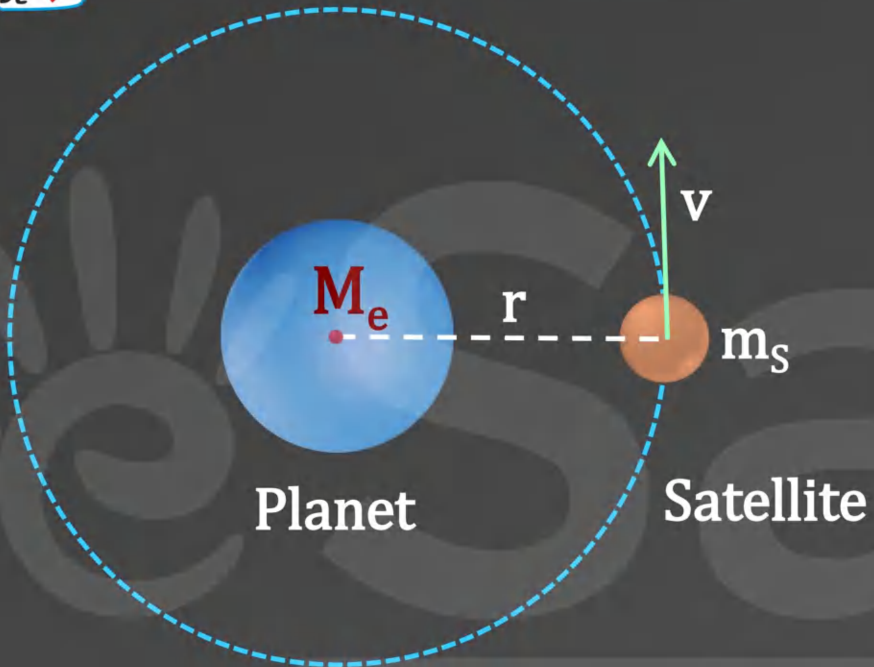


Gravitational Potential

$$V = \frac{U}{m}$$

$$U = \frac{-GMm}{r} \Rightarrow V = \frac{-GM}{r}$$ Scalar

Motion of Satellite (Circular Orbit)



$$\frac{GM_e m_s}{r^2} = \frac{m_s v^2}{r}$$

$$v = \sqrt{\frac{GM_e}{r}}$$ Orbital Speed

r → Distance between center of earth and Satellite

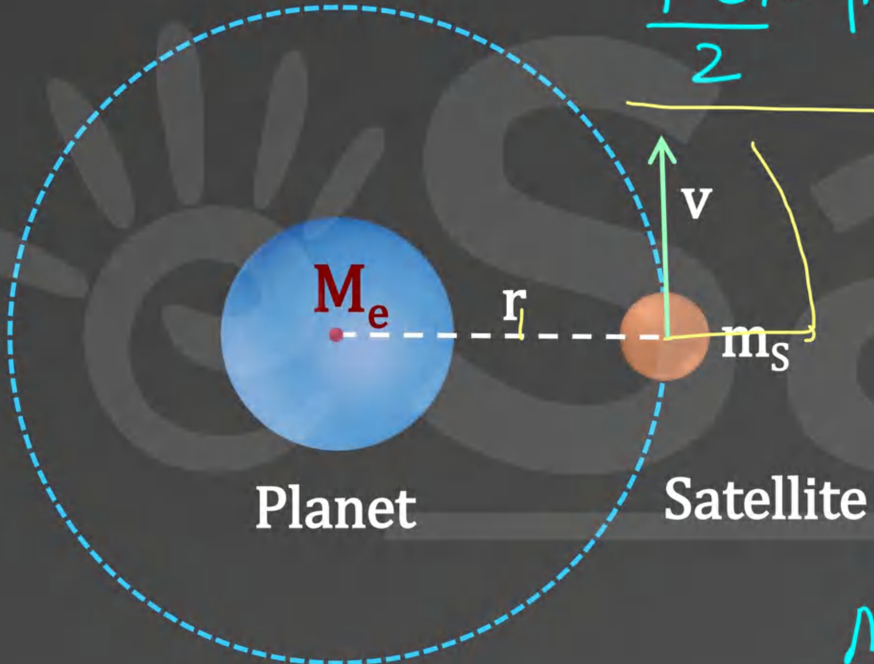
$$T = \frac{2\pi r}{v}$$

$$T = 2\pi\sqrt{\frac{r^3}{GM_e}}$$

$$T \propto r^{\frac{3}{2}}$$

Motion of Satellite (Circular Orbit)

$$\frac{|PE|}{2} = |KE| = |ME|$$



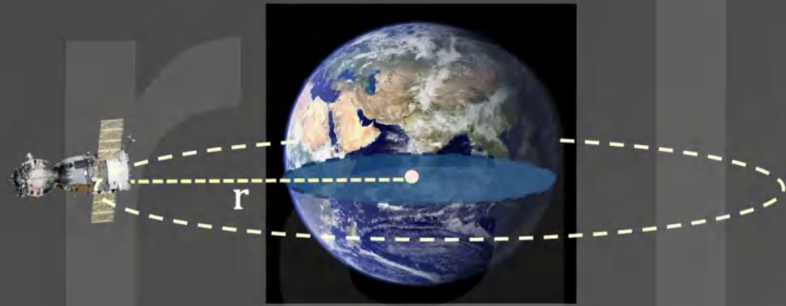
$$U = PE = -\frac{GM_e m_s}{r}$$

$$KE = \frac{1}{2} m_s v^2 = \frac{GM_e m_s}{2r}$$

$$ME = PE + KE = -\frac{GM_e m_s}{2r}$$

Geostationary Satellite

Satellites in a circular orbit around earth in equatorial plane with T=24 hours are called Geostationary Satellite.



It revolves in equatorial plane from west to east in same sense as earth.

Its angular velocity with respect to earth is Zero.

Its orbit is called Parking Orbit.

It is used for telecommunication, weather forecasting, etc.

Geostationary Satellite

24 hrs

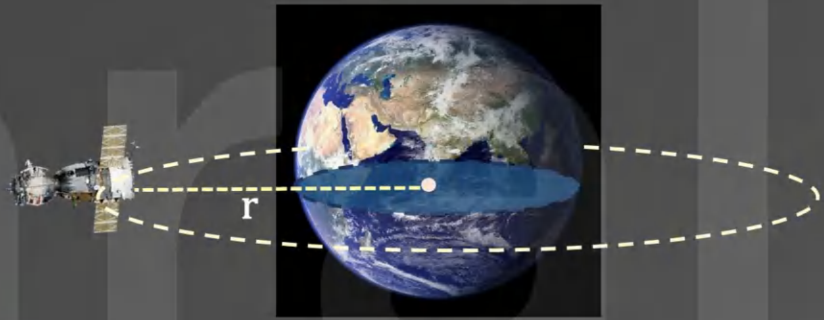
$$T = 2\pi\sqrt{\frac{r^3}{GM_e}}$$

$r = 42170$ km

From surface = 42170 – 6370

= 35800 km ≈ 36000 km

Orbital Velocity = 3.08 km/sec.



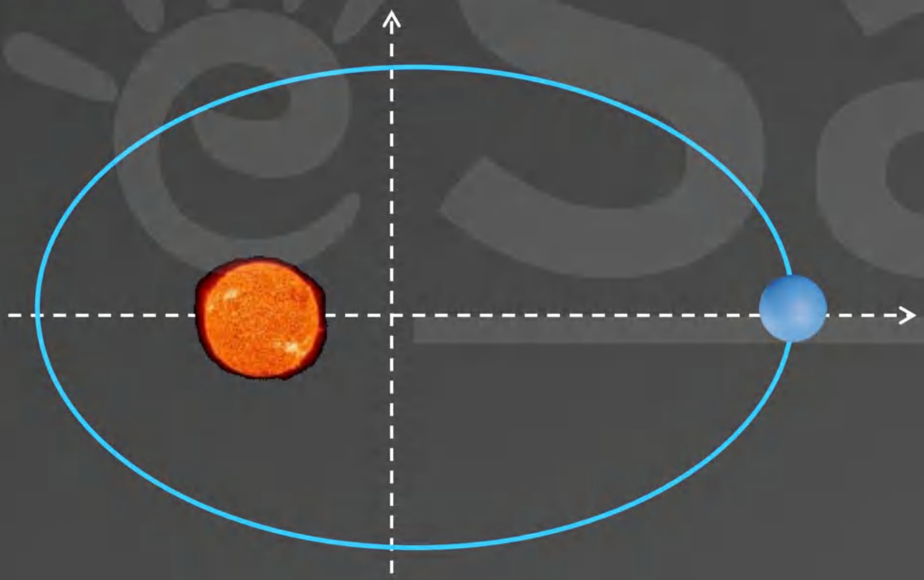
Polar Satellite

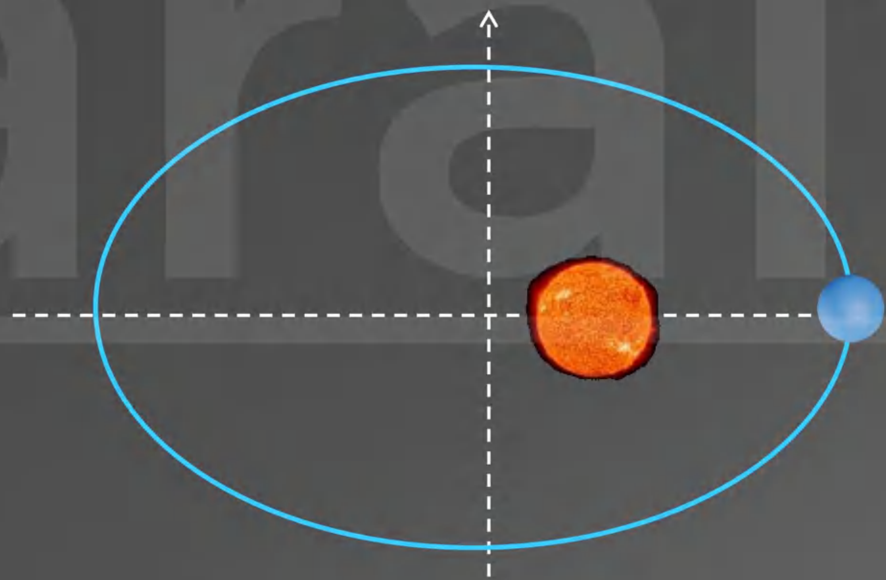
It is used for remote sensing, environmental studies.

Kepler's Laws

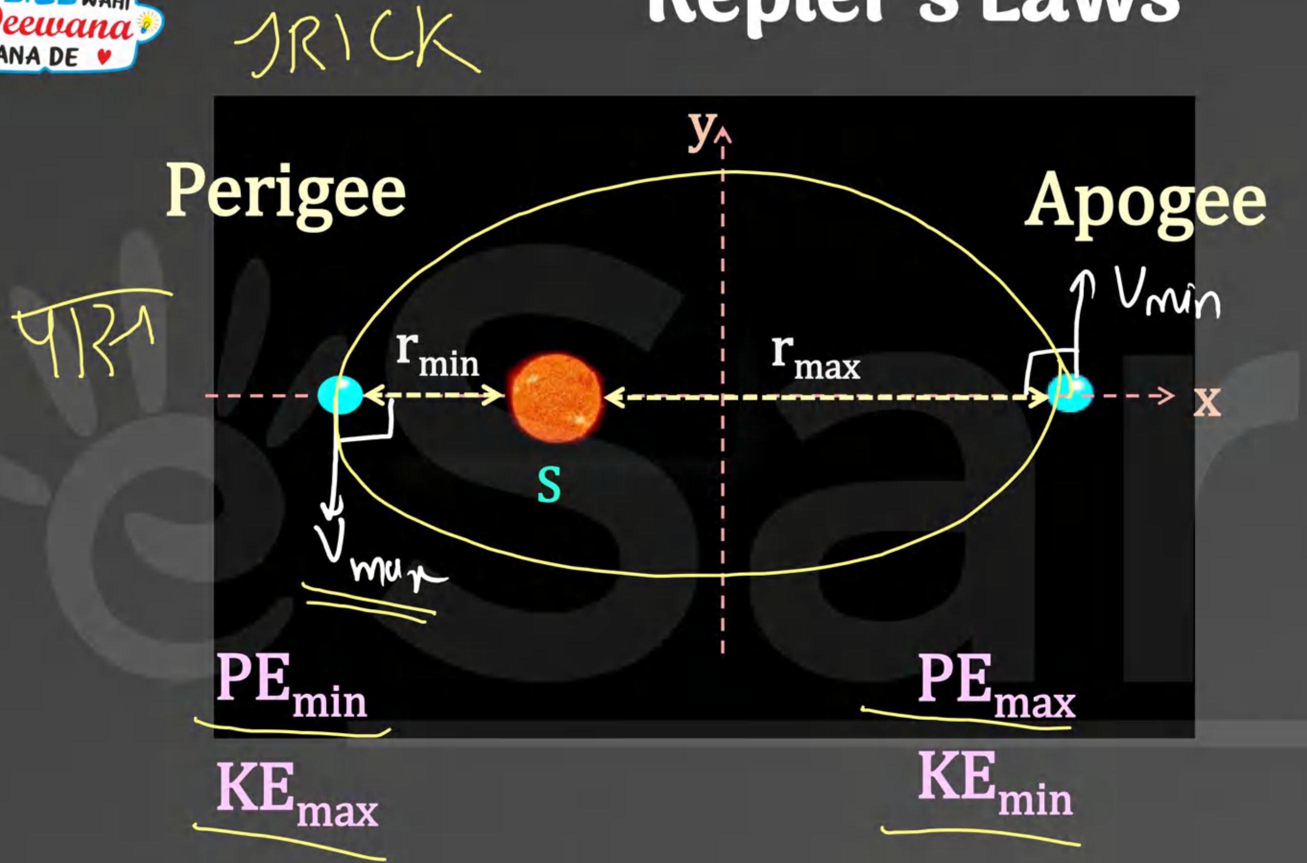
1-Law of Orbits

All planets move in elliptical orbits with the Sun situated at one of the foci.





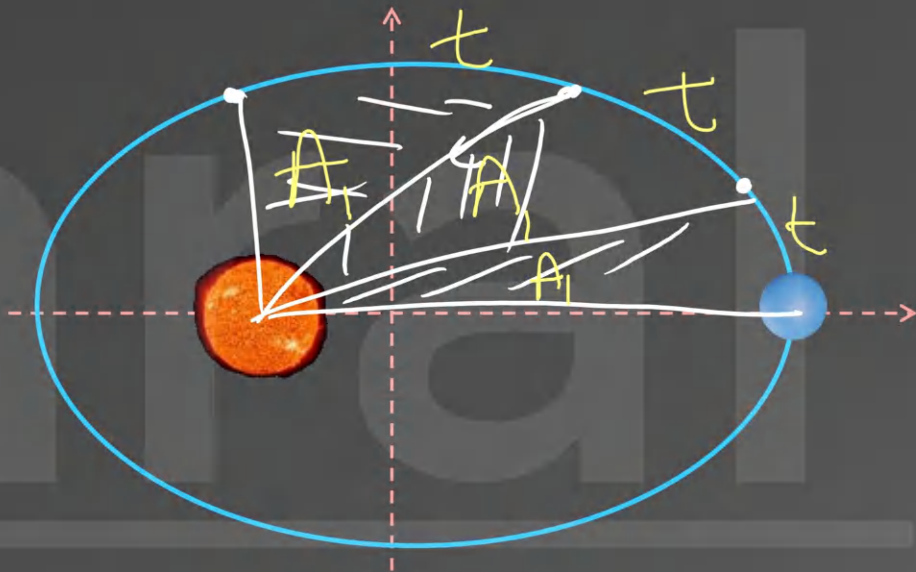
Kepler's Laws



Kepler's Laws

2-Law of Areas

Position vector from Sun to the planet sweeps out equal area in equal time intervals.



Areal velocity of planet around Sun always remains constant.

This law is based on angular momentum conservation.

Kepler's Laws

2-Law of Areas

$$A = \frac{LT}{2M_p}$$

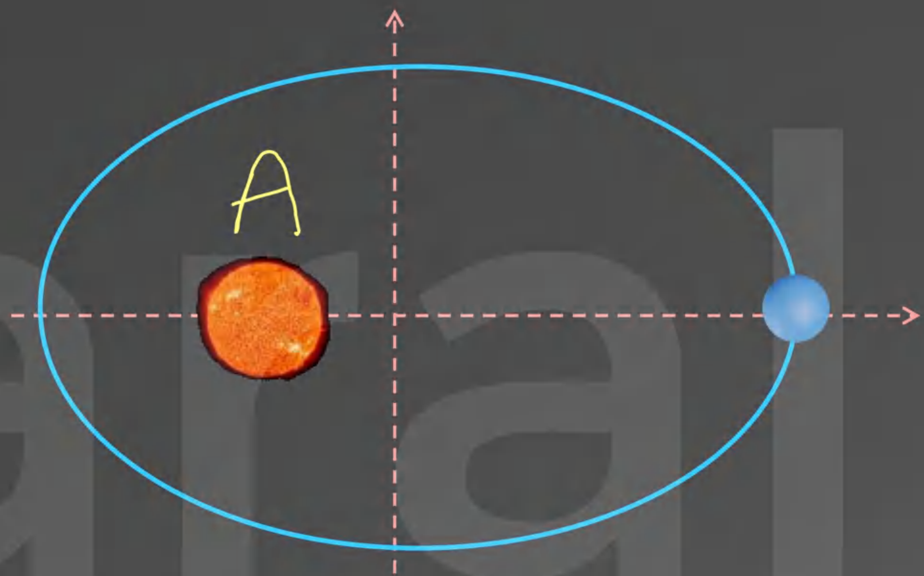
Constant

$$\frac{dA}{dt} = \frac{L}{2M_P}$$

L → Angular Momentum about Sun

$\frac{dA}{dt}$: Areal Velocity

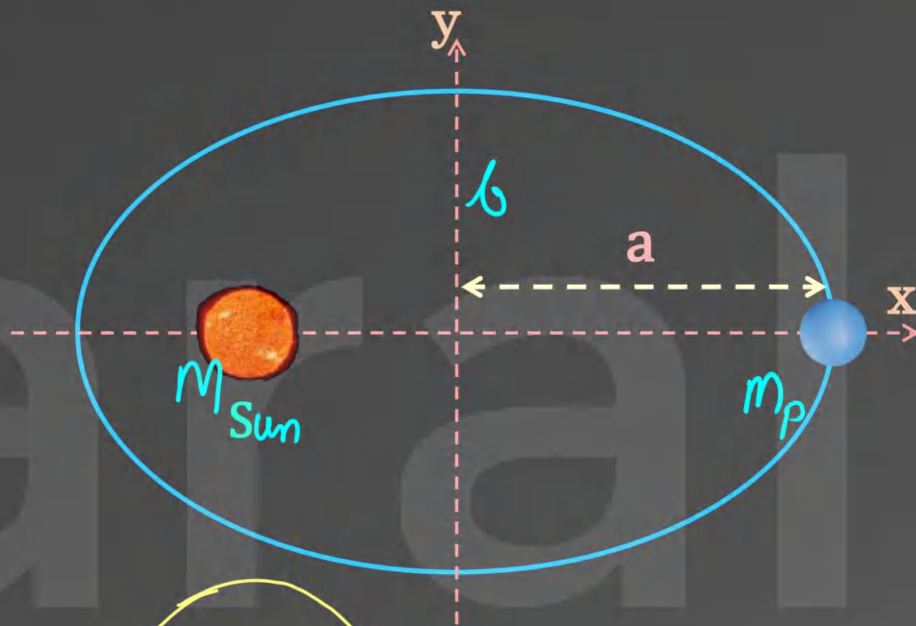
$$\frac{A}{T} = \frac{L}{2M_p}$$



Kepler's Laws

3-Law of Periods

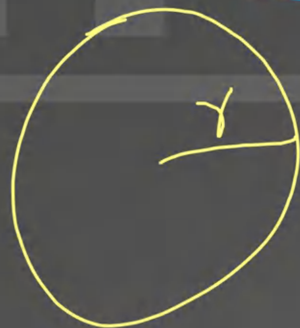
The square of the time period of revolution of a planet is proportional to the cube of the semi-major axis of the ellipse traced out by the planet.



$T^2 \propto a^3$

$\Rightarrow T \propto a^{3/2}$

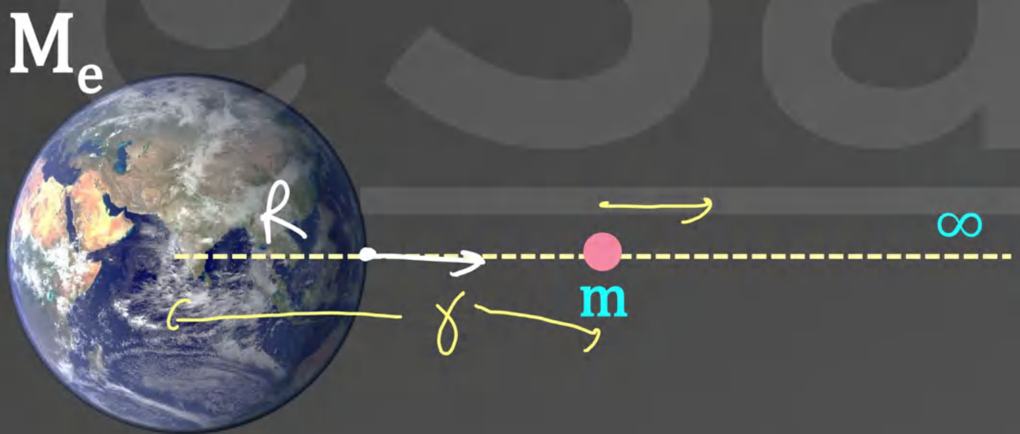
$$T = 2\pi\sqrt{\frac{a^3}{GM_{sun}}}$$

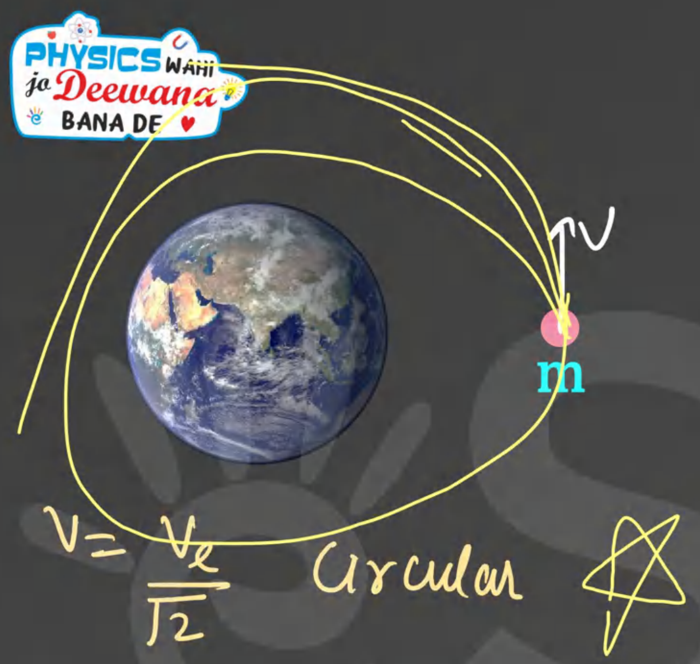


Escape Velocity

$$v_e = \sqrt{\frac{2GM_e}{r}}$$

At Earth's Surface, $v_e = \sqrt{2g_0R} = 11.2\ km/s$



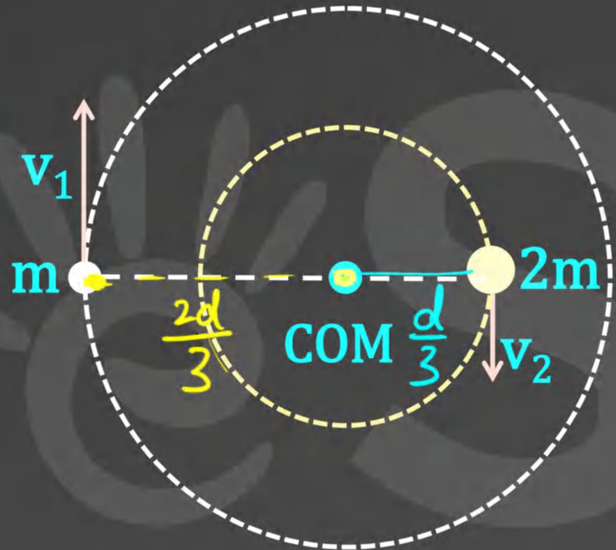


If $v < v_e$ $TE < 0$ Path: Bounded and Elliptical

If $v = v_e$ $TE = 0$ Path : Unbounded and Parabolic

If $v > v_e$ $TE > 0$ Path : Unbounded and Hyperbolic

Binary Star System

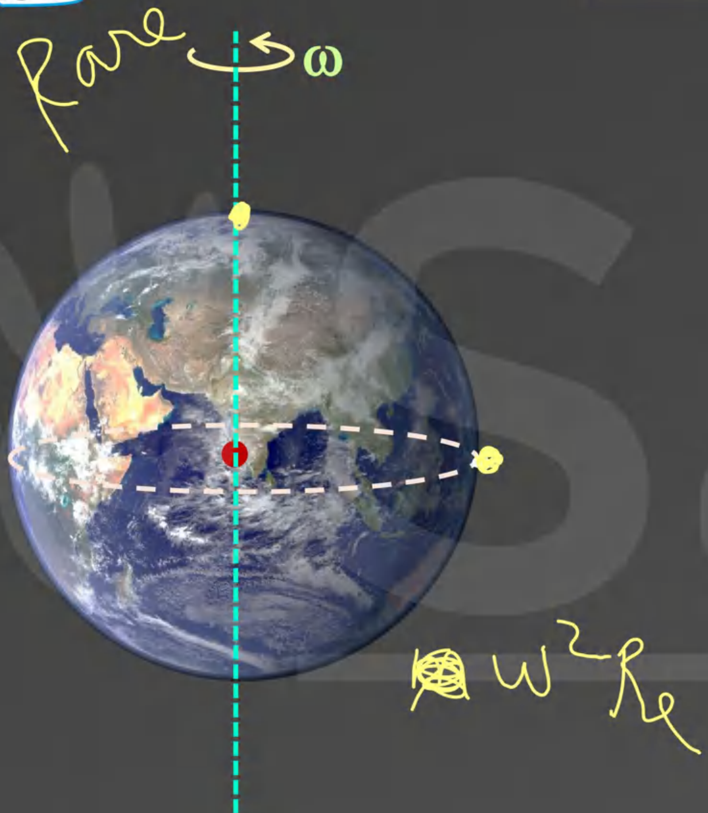


A pair of stars rotating about their COM (centre of mass).

$$\frac{v_1}{v_2} = \frac{2}{1} \qquad \frac{KE_1}{KE_2} = \frac{2}{1}$$

$$\frac{T_1}{T_2} = \frac{1}{1} \qquad \frac{L_1}{L_2} = \frac{2}{1}$$

Variation of g_{app} due to Rotation of Earth



max

$$g_{app} = g_0$$

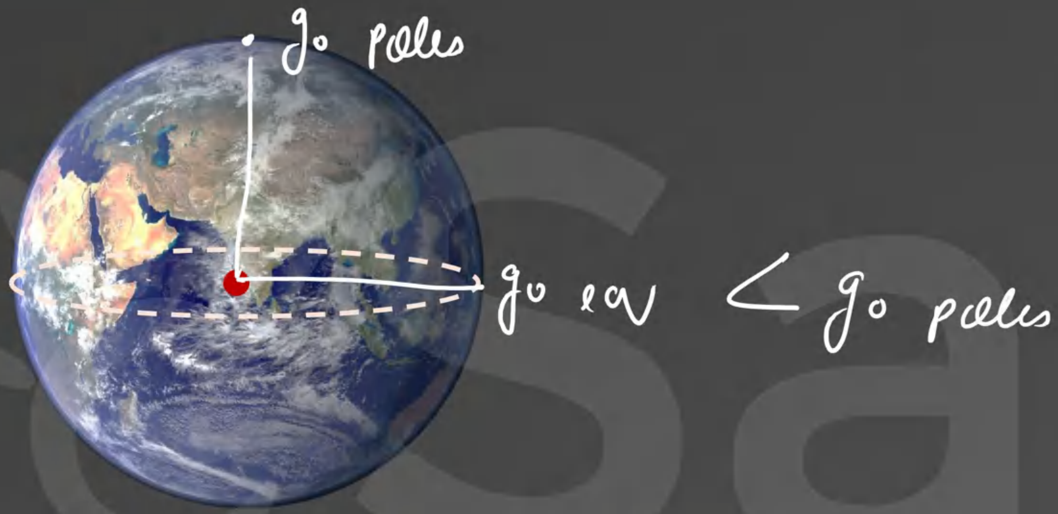
at poles

min

$$g_{app} = g_0 - \omega^2 R_e$$

at equator

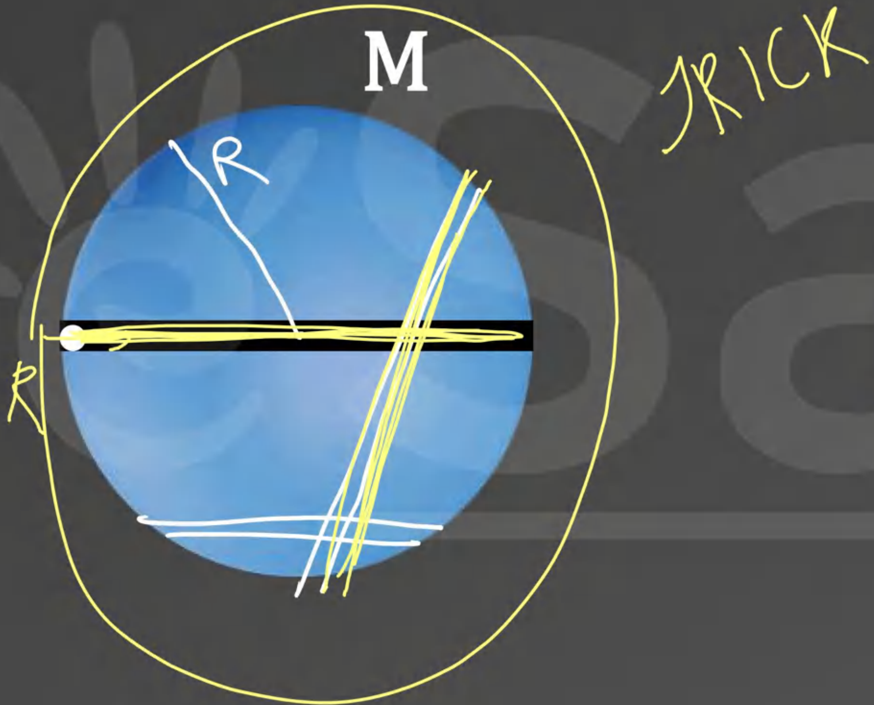
Variation of g due to non-spherical Shape of Earth



Earth is bulged at equator

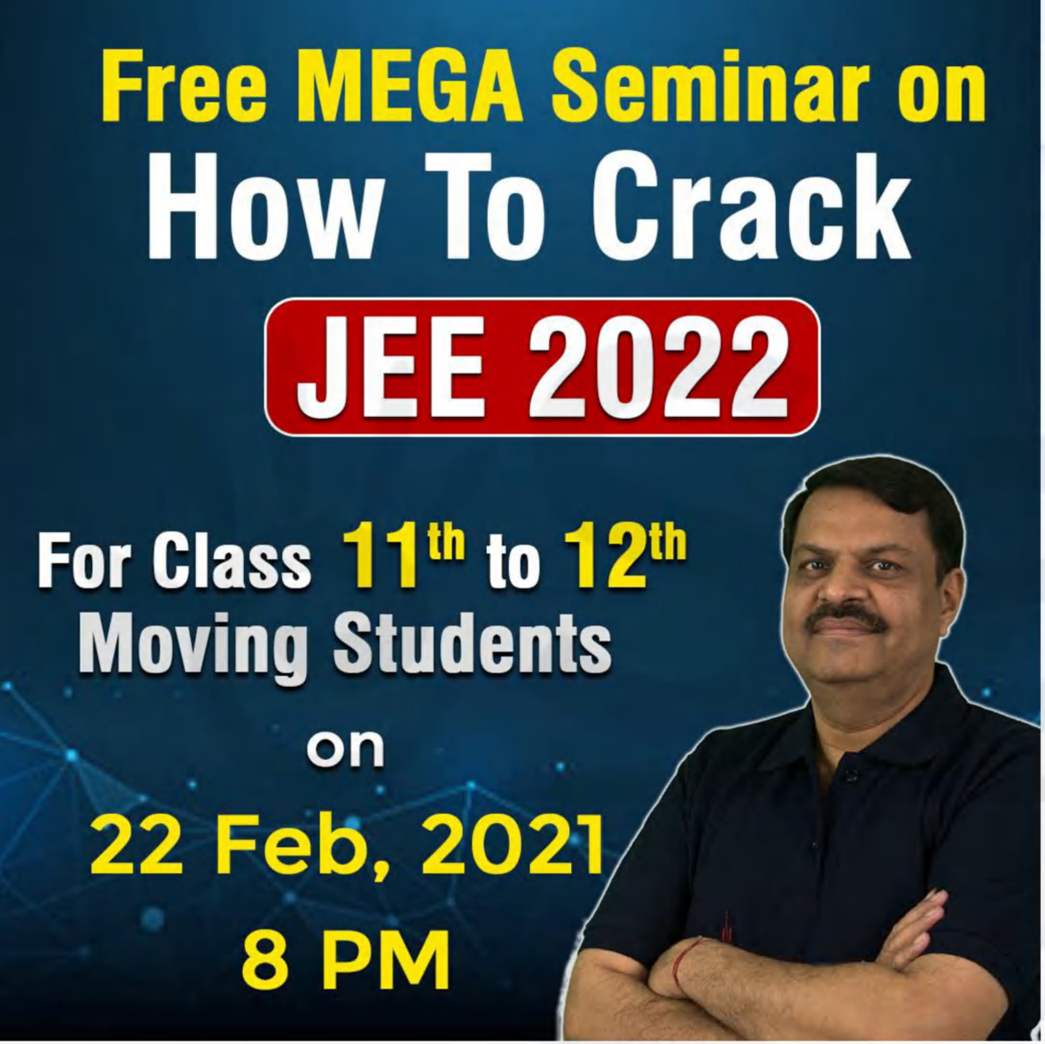
g_0 is more at poles than at equator.

Time period of particle in tunnel in Solid Sphere



$$T = 2\pi\sqrt{\frac{R^3}{GM}}$$

Lets Meditate !!



Link in Description

https://esaral.page.link/riBDzARasRyANRN87

Simple Harmonic Motion

Superfast Revision

Equation of SHM

$$x = A\sin(\omega t + \phi)$$

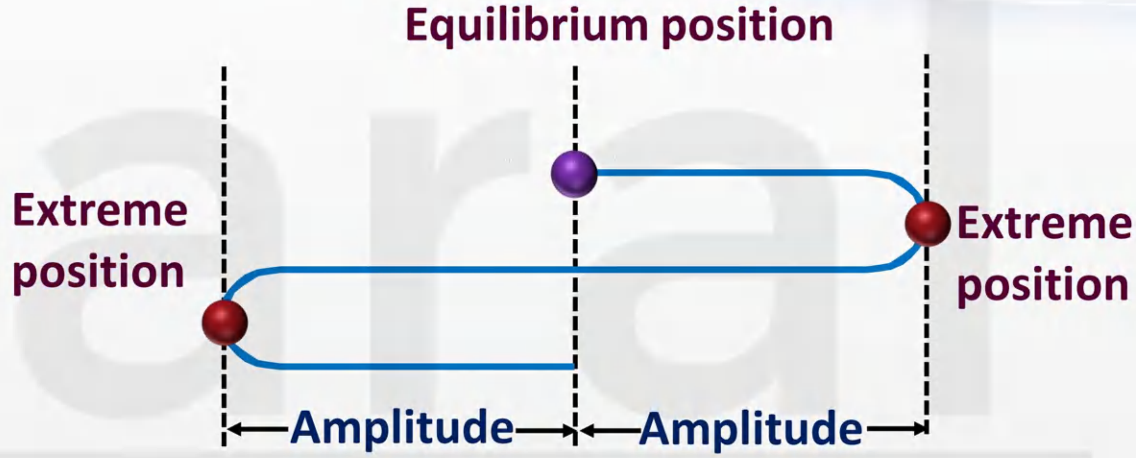
$$F_{net} = -kx$$

$$ma = -kx$$

$$a = -\omega^2 x$$

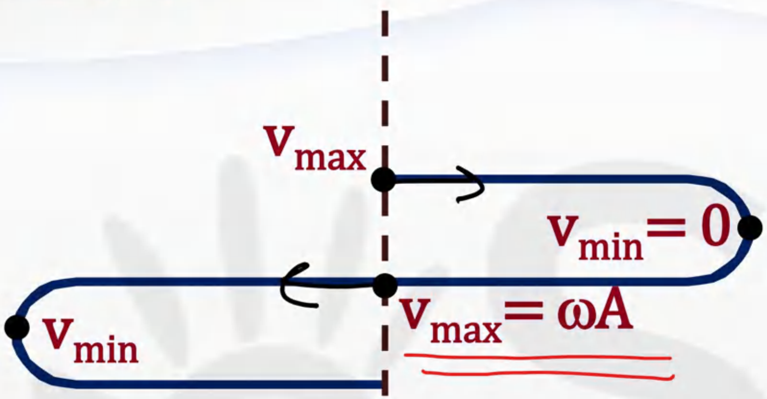
$$\omega = \sqrt{\frac{k}{m}}$$

→ Angular Frequency



$$T = \frac{2\pi}{\omega} \qquad f = \frac{1}{T} = \frac{\omega}{2\pi}$$

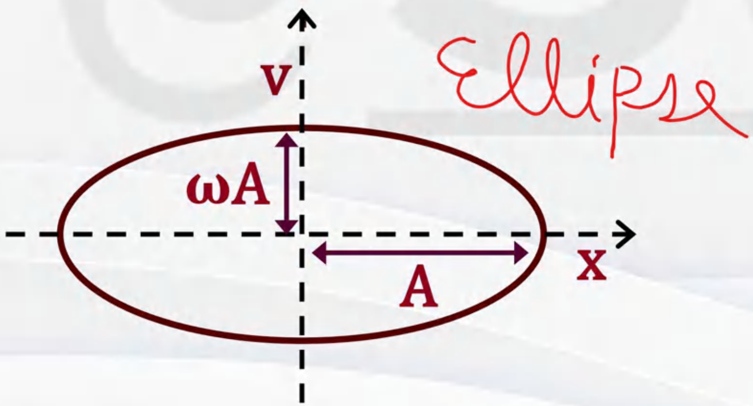
Velocity Analysis



$$x = A\sin(\omega t + \phi) \quad ...(1)$$

$$v = \frac{dx}{dt} = A\omega\cos(\omega t + \phi) \quad ...(2)$$

$$v = \omega\sqrt{(A^2 - x^2)}$$



$$\frac{x^2}{A^2} + \frac{v^2}{(\omega A)^2} = 1$$

Acceleration Analysis

$x = A\sin(\omega t + \phi)$

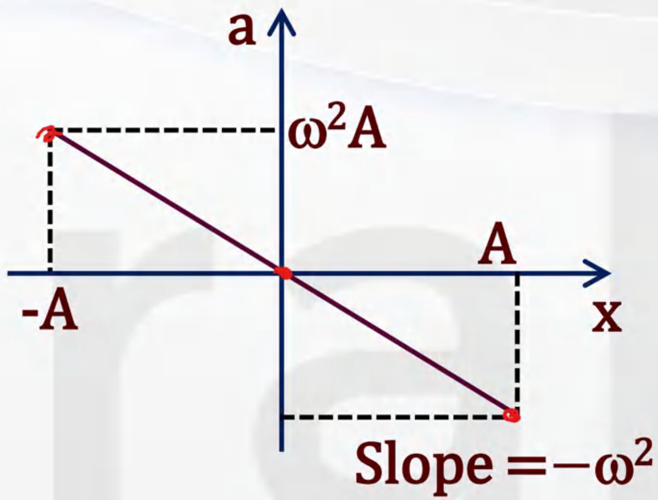
$v = A\omega\cos(\omega t + \phi)$

$a = -A\omega^2\sin(\omega t + \phi)$

$a = -\omega^2 x$

$a_{max} = \omega^2 A$

→ at extreme position

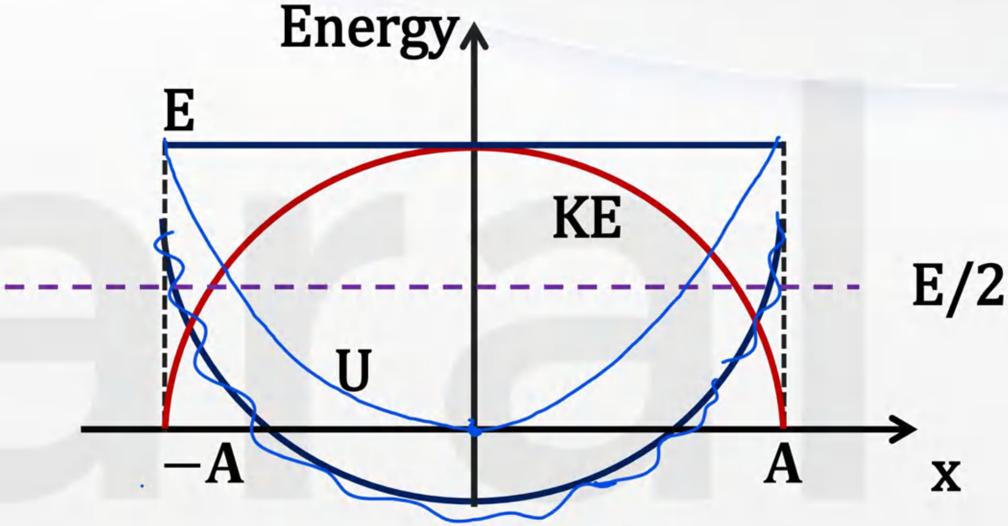


Energies v/s 'x'

$$U = \frac{1}{2}kx^2$$

$$KE = \frac{1}{2}k(A^2 - x^2)$$

$$KE + U = E \quad = \frac{1}{2}kA^2$$



Energies v/s 't'

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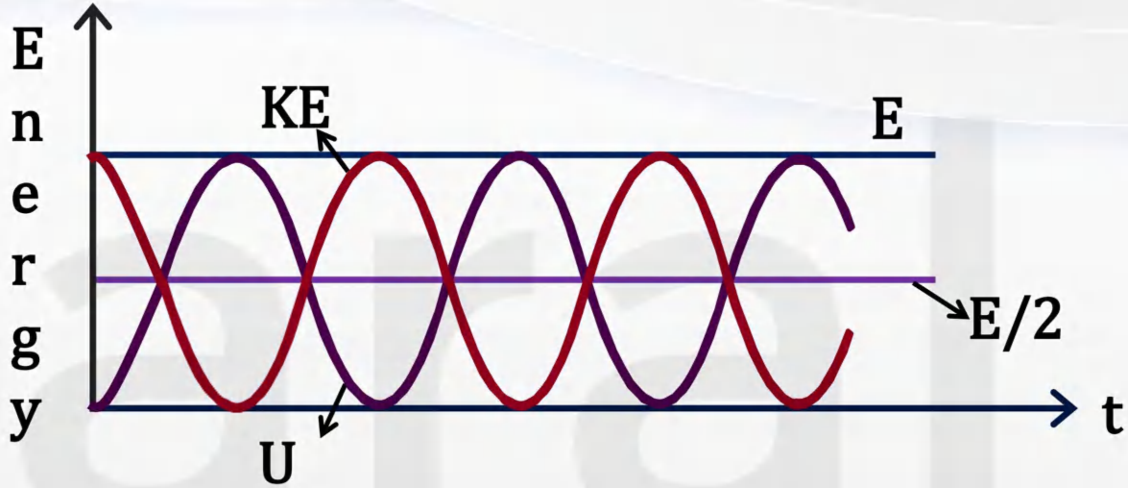
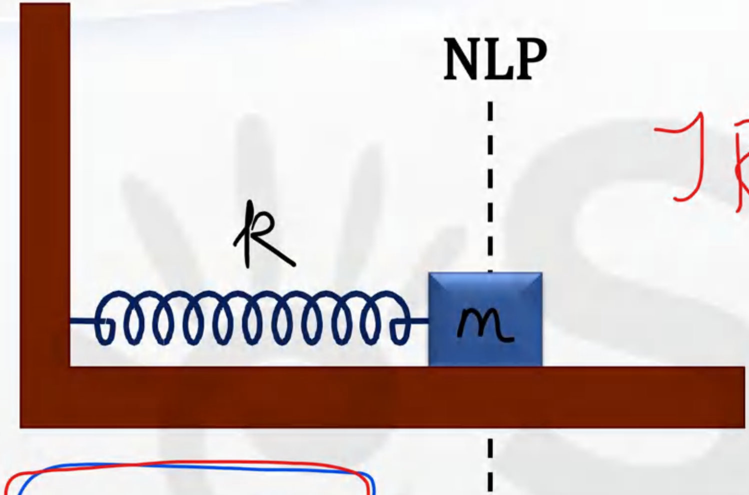


Spring Block System

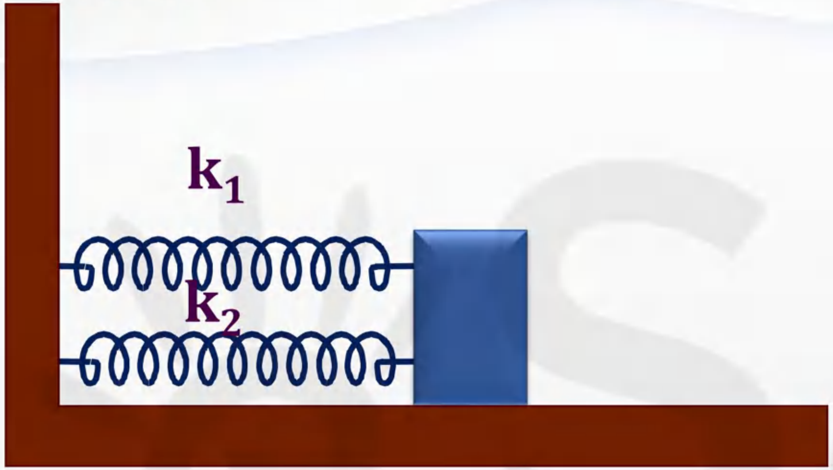


$$T = 2\pi\sqrt{\frac{m}{k}}$$

TRICK

In a spring block system, if an additional constant force (along line of SHM) is applied on the block then time period remains same.

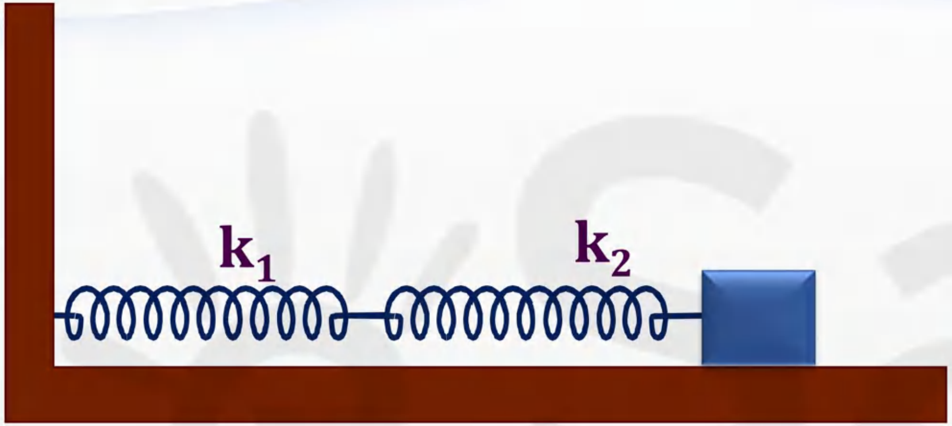
Spring Block System



$$k_{eq} = k_1 + k_2$$

$$T = 2\pi\sqrt{\frac{m}{k_{eq}}} = 2\pi\sqrt{\frac{m}{k_1 + k_2}}$$

Spring Block System



$$T = 2\pi\sqrt{\frac{m}{k_{eq}}}$$

$$k_{eq} = \frac{k_1 k_2}{k_1 + k_2}$$

$$\frac{1}{k_{eq}} = \frac{1}{k_1} + \frac{1}{k_2}$$

Cutting of Spring

k

natural length = ℓ

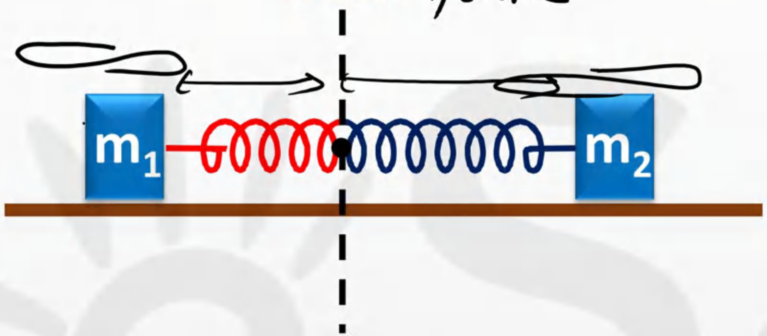
$k\ell$ = Constant

2k

natural length = $\ell/2$

$$k\ell = 2k\frac{\ell}{2}$$

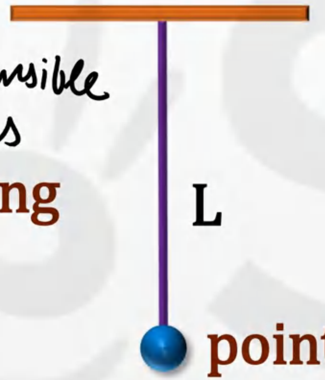
COM frame



$$\mu = \frac{m_1 m_2}{m_1 + m_2} \rightarrow \text{reduced mass}$$

$$T_1 = 2\pi\sqrt{\frac{m_1 m_2}{k(m_1 + m_2)}} = 2\pi\sqrt{\frac{\mu}{k}}$$

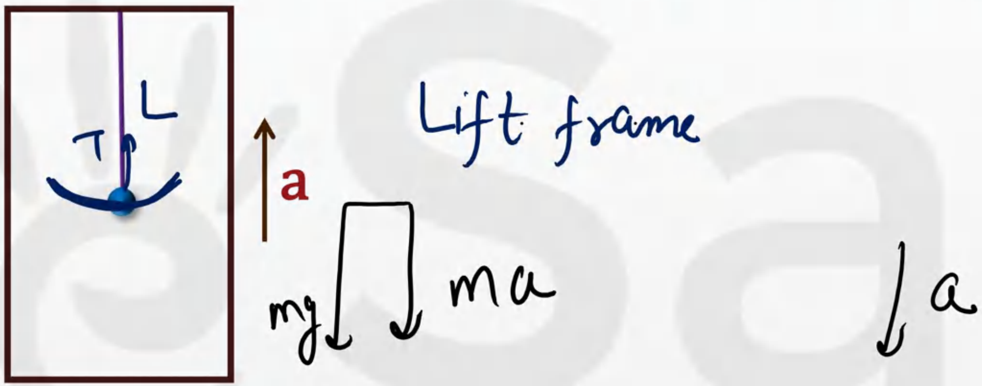
Simple Pendulum



small θ

$$T = 2\pi\sqrt{\frac{L}{g}}$$

Q) A pendulum is attached to the top wall of a lift which is going up with acceleration ‘a’. Find its time period in this situation.



Sol. $g_{eff} = (g+a)$

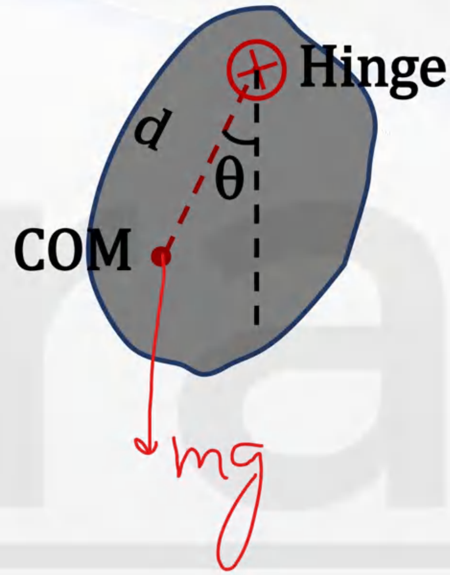
$$T = 2\pi\sqrt{\frac{L}{g_{eff}}} = 2\pi\sqrt{\frac{L}{g+a}}$$

$$T = 2\pi\sqrt{\frac{L}{g-a}}$$

Physical Pendulum

$$T = 2\pi\sqrt{\frac{I}{mgd}}$$

TRICK



I : MOI of system about hinge.

m : Mass of system

d : distance between COM and hinge.

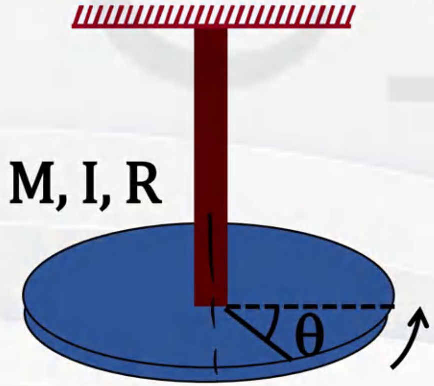
Torsional Pendulum

$\tau \propto -\theta$

$\tau = -C\theta$ (C= Torsional constant)

$$T = 2\pi\sqrt{\frac{I}{C}}$$

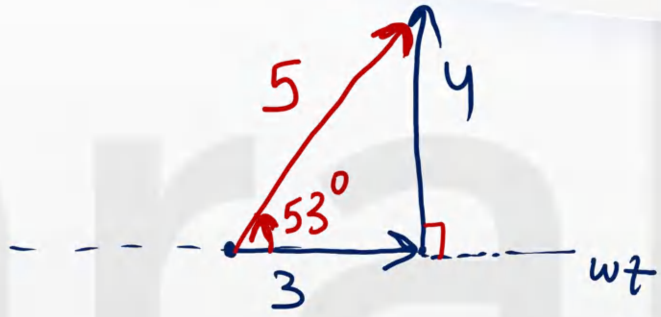
$2\pi\sqrt{\frac{m}{k}}$



Composition of SHMs

$$x = 3\sin(\omega t) + 4\sin\left(\omega t + \frac{\pi}{2}\right)$$

$$x = 5\sin(\omega t + 53^\circ)$$



$$A_{res}^2 = A_1^2 + A_2^2 + 2A_1A_2\cos\phi$$

Damped SHM

$$F_{drag} = -bv$$

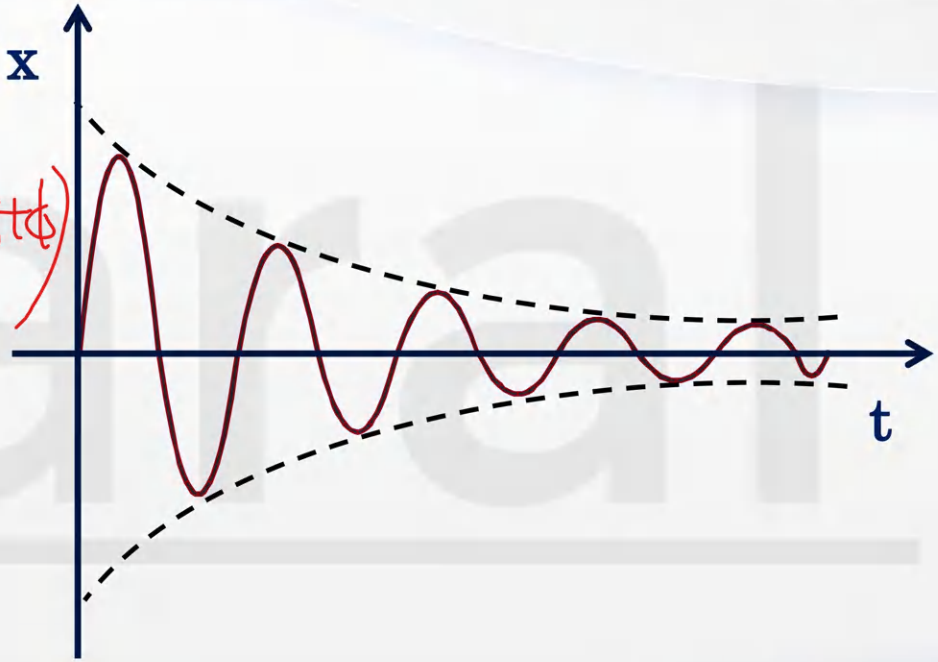
$$F = -kx - bv$$

$$x = Ae^{-bt/2m}\sin(\omega' t + \phi)$$

$$x = A\sin(\omega t + \phi)$$

$$\omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$$

$$E = \frac{1}{2}kA^2 e^{-bt/m}$$



Forced Oscillations and Resonance

$$F_{driving} = F_0 \sin(\omega_d t)$$

$$ma = -kx - bv + F_0 \sin(\omega_d t)$$

$$x = A \sin(\omega_d t + \phi)$$

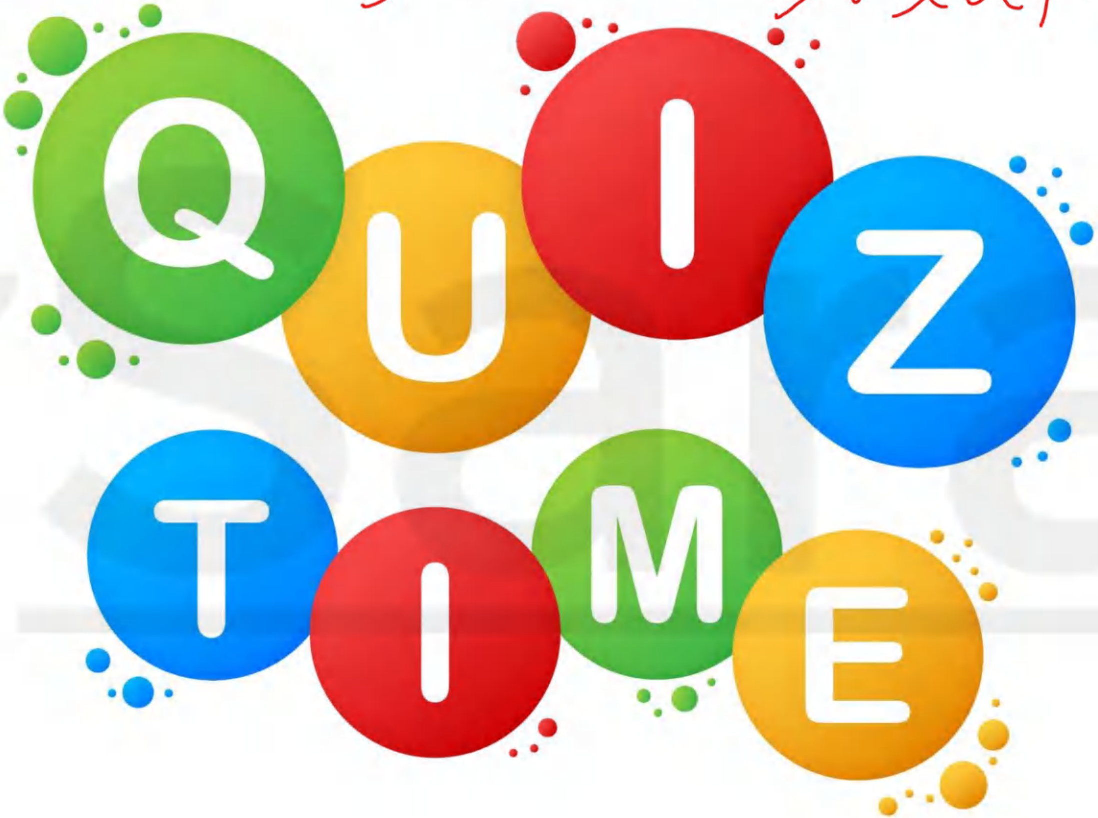
$$A = \frac{F_0/m}{\sqrt{(\omega^2 - \omega_d^2)^2 + (b\omega_d / m)^2}}$$

If small damping, (b very small)

$$A = \frac{F_0/m}{(\omega^2 - \omega_d^2)}$$

$\omega_d \approx \omega$ Resonance

3 min Break



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SIMPLE HARMONIC MOTION

Energies v/s 'x'

$U = \frac{1}{2}kx^2$

$KE = \frac{1}{2}k(A^2 - x^2)$

$KE + U = E = \frac{1}{2}kA^2$

$U = \frac{1}{2}kA^2\sin^2(\omega t + \phi)$

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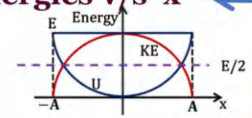
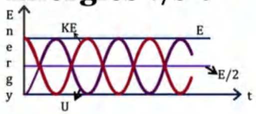
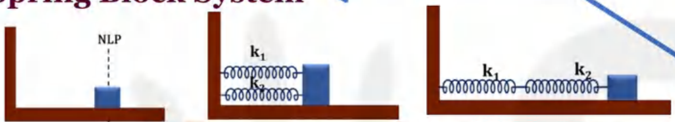


Energies v/s 't'



Spring Block System



$T = 2\pi\sqrt{\frac{m}{k}}$

1

$T = 2\pi\sqrt{\frac{m}{k_{eq}}}$

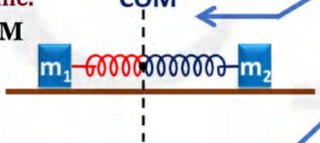
$= 2\pi\sqrt{\frac{m}{k_1 + k_2}}$

$T = 2\pi\sqrt{\frac{m}{k_{eq}}}$

$k_{eq} = \frac{k_1 k_2}{k_1 + k_2}$

In a spring block system, if an additional constant force (along line of SHM) is applied on the block then time period remains same.

Two Blocks SHM

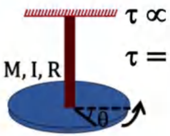


$\mu = \frac{m_1 m_2}{m_1 + m_2}$

Reduced Mass

$T_1 = 2\pi\sqrt{\frac{m_1 m_2}{k(m_1 + m_2)}} = 2\pi\sqrt{\frac{\mu}{k}}$

Torsional Pendulum

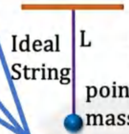


$\tau \propto -\theta$

$\tau = -C\theta$ (C= Torsional constant)

$T = 2\pi\sqrt{\frac{I}{C}}$

Simple Pendulum

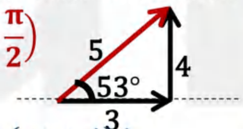


$T = 2\pi\sqrt{\frac{\mu}{k}}$

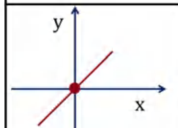
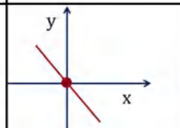
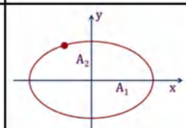
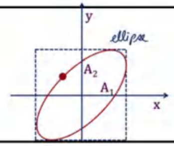
Composition of Two SHM's of same ω along mutually perpendicular directions

$x = 3\sin(\omega t) + 4\sin\left(\omega t + \frac{\pi}{2}\right)$

$x = 5\sin(\omega t + 53°)$



$\vec{x} = A_1\sin(\omega t)\hat{i}$ $\vec{y} = A_2\sin(\omega t + \phi)\hat{j}$

When $\phi = 0$	When $\phi = \pi$	When $\phi = \frac{\pi}{2}$	When $\phi \neq 0, \frac{\pi}{2}, \pi$
$y = \frac{A_2}{A_1}x$	$y = -\frac{A_2}{A_1}x$	$\frac{x^2}{A_1^2} + \frac{y^2}{A_2^2} = 1$	
			

Definition

(1) Periodic

(2) Oscillatory

(3) $|F| \propto |x|$

$F_{net} = -kx$

$a = -\omega^2 x$

$\omega = \sqrt{\frac{k}{m}}$

$x = A\sin(\omega t + \phi)$

Time Period & Frequency

$T = \frac{2\pi}{\omega}$ $f = \frac{1}{T} = \frac{\omega}{2\pi}$

Velocity Analysis

$x = A\sin(\omega t + \phi)$

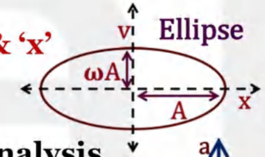
$v = \frac{dx}{dt} = A\omega\cos(\omega t + \phi)$

$v = \omega\sqrt{(A^2 - x^2)}$

Max velocity $v_{max} = \omega A$ at $x = 0$ (Mean Position)

Min velocity $v_{min} = 0$ at $x = \pm A$ (Extreme Position)

Graph b/w 'v' & 'x'



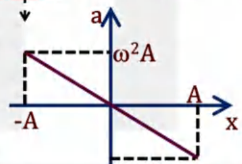
$\frac{x^2}{A^2} + \frac{v^2}{(\omega A)^2} = 1$

Acceleration Analysis

$a = -\omega^2 x$

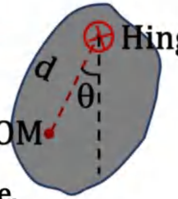
$x = 2 + 1\sin(\omega t)$

Position — 2: eq$^{m.}$ position — 1: Amplitude



Physical Pendulum

2



I : MOI of system about hinge.

m : Mass of system

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SIMPLE HARMONIC MOTION

eSaral

(1) Periodic
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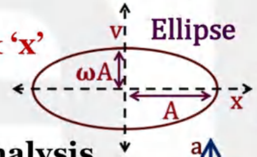

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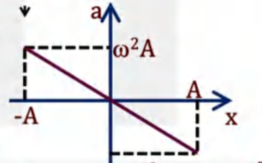

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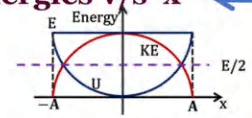

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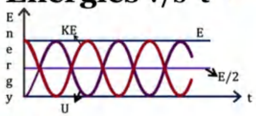
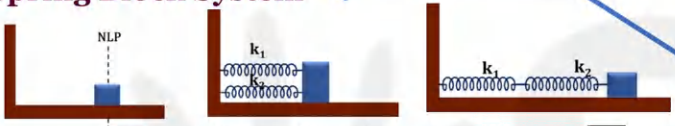


Spring Block System



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$k_{eq} = k_1 + k_2$

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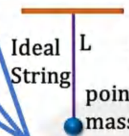
$T = 2\pi\sqrt{\dfrac{m}{k_{eq}}}$

$k_{eq} = \dfrac{k_1 k_2}{k_1 + k_2}$

Simple Pendulum



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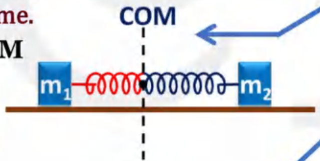
Two Blocks SHM



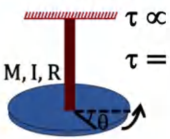
$\mu = \dfrac{m_1 m_2}{m_1 + m_2}$

↓

Reduced Mass

$T_1 = 2\pi\sqrt{\dfrac{m_1 m_2}{k(m_1 + m_2)}} = 2\pi\sqrt{\dfrac{\mu}{k}}$

Torsional Pendulum



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Composition of Two SHM's of same ω along mutually perpendicular directions

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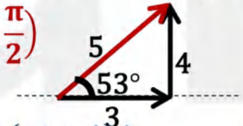

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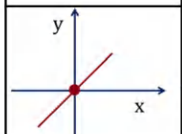
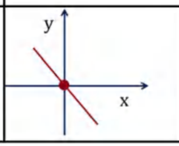
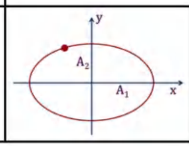
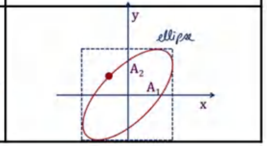
			

Wave on String
Superfast Revision

Sinusoidal Wave Equation

$$y = A\sin(\omega t - kx + \phi)$$

Angular Wave Number

Each Particle doing SHM

$$T = \frac{2\pi}{\omega} \qquad f = \frac{\omega}{2\pi}$$

$$\lambda = \frac{2\pi}{k} \quad ; \quad k = \frac{2\pi}{\lambda}$$

$$v_w = f\lambda$$

Velocity of wave

$$v_w = -\frac{\text{Coefficient of } t}{\text{Coefficient of } x}$$

$y = A\sin(kx - \omega t)$ $\quad v_w = -\frac{-\omega}{k} = \frac{\omega}{k}$ $\quad$ Wave travelling in + dir.

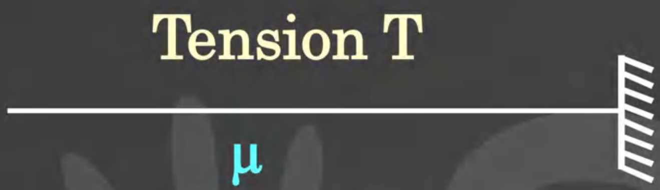
$y = A\sin(kx + \omega t)$ $\quad v_w = -\frac{\omega}{k} = -\frac{\omega}{k}$ $\quad$ Wave travelling in − dir.

Relation Between Particle Velocity And Wave Velocity

$$v_P = -v_w\left(\frac{\partial y}{\partial x}\right)$$

Slope of the string at point x.

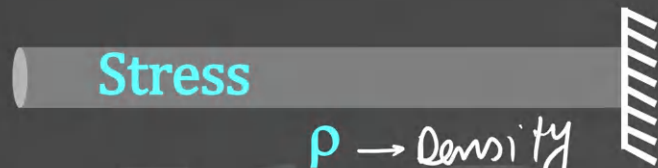
Velocity of Wave on String



$$v_w = \sqrt{\frac{T}{\mu}}$$

μ = mass per unit length

Linear Mass Density

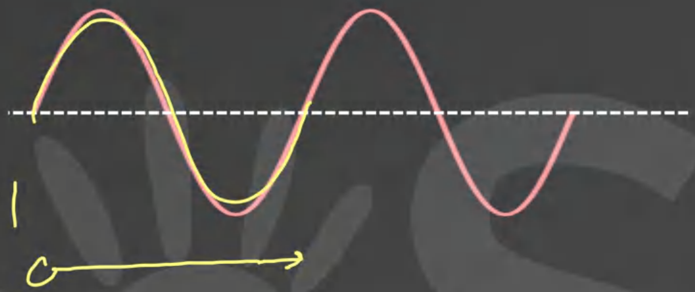


$\rho \rightarrow$ Density

$$v_w = \sqrt{\frac{T}{\mu}}$$

$$v_w = \sqrt{\frac{\text{Stress}}{\rho}}$$

Power Transmission in Travelling Wave on String



$$< P > = \frac{1}{2}\underbrace{\sqrt{T\mu}}_{\text{Property of medium}}\ \underbrace{A^2\omega^2}_{\text{Property of Source}}$$

Energy of string of one wave length

$$E = \frac{1}{2}\lambda\mu A^2\omega^2$$

$< P >$ Time Per = Energy

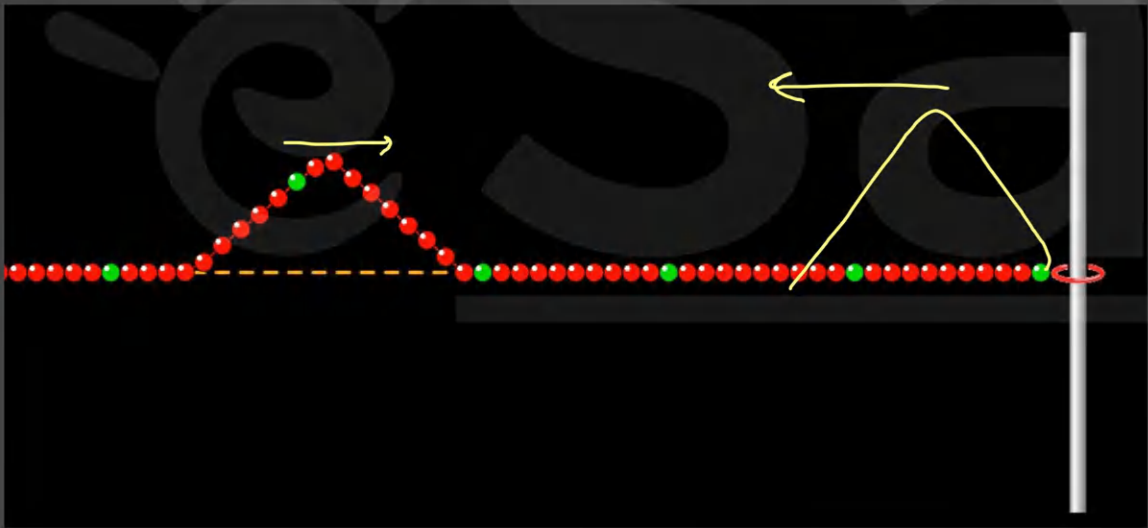
Reflection of Wave on String

Reflection from Fixed End

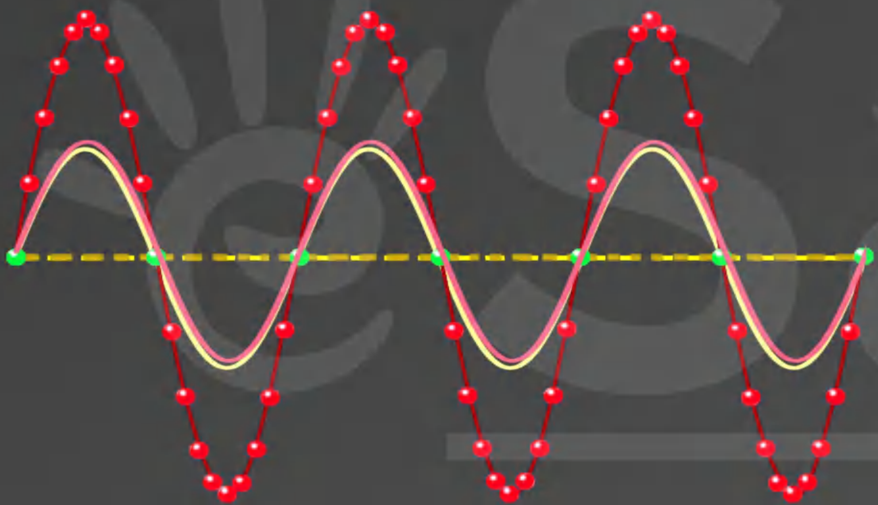
Due to reflection from fixed end shape of the pulse gets inverted.

Reflection of Wave on String

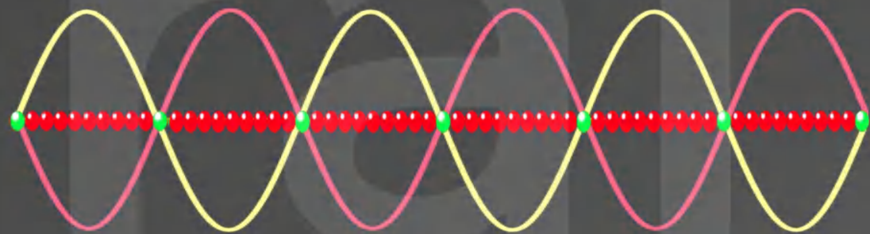
Reflection from Free End



Constructive Interference



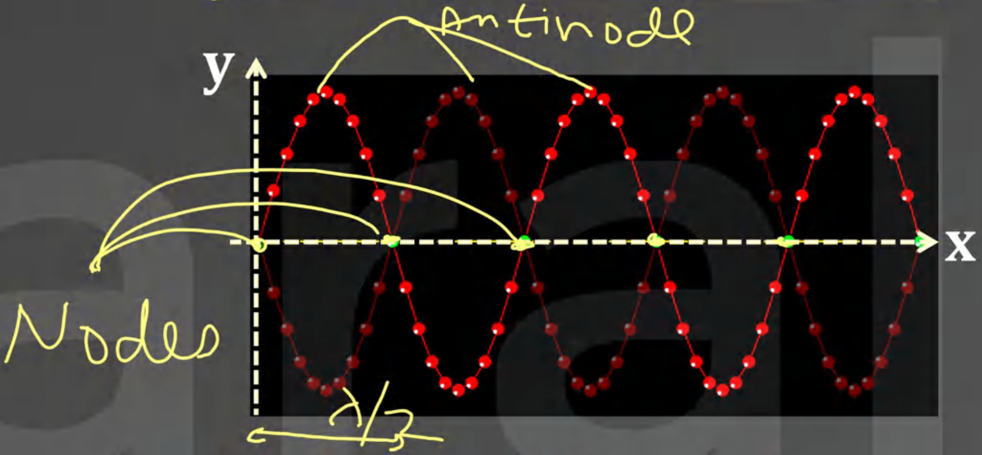
Destructive Interference



Standing Waves

When two waves of same amplitude, same frequency but moving in opposite direction interfere with each other then formation of Standing Waves takes place.

$$y_{res} = 2A\sin(kx)\cos(\omega t)$$



Distance between adjacent nodes is $\frac{\lambda}{2}$ & this portion of string is called a loop.

All the particles perform SHM of same frequency as of original component waves.

Nodes & Antinodes

General Equation of Standing Wave

$$y = 2A \sin(kx + \phi_1) \sin(\omega t + \phi_2)$$

Coefficient of $x = k$

Wavelength of component waves $= \dfrac{2\pi}{k}$

Coefficient of $t = \omega$

Time period of SHM of particle $= \dfrac{2\pi}{\omega}$

General Equation of Standing Wave

$$y = 2A\sin(kx + \phi_1)\sin(\omega t + \phi_2)$$

For Nodes:

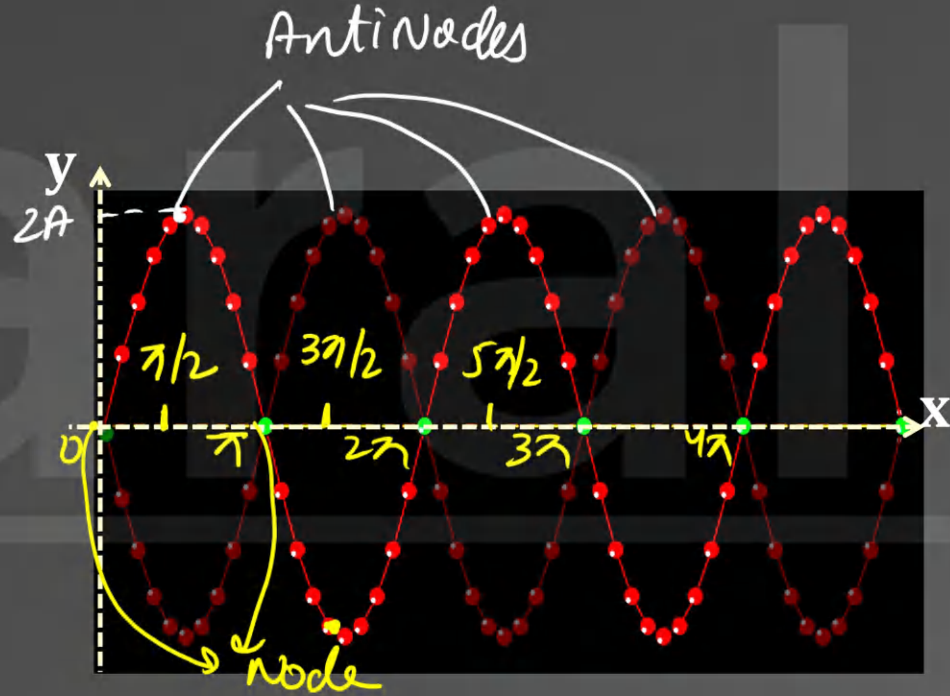
$$\sin(kx + \phi_1) = \pm 1$$

$$(kx + \phi_1) = \left(n + \frac{1}{2}\right)\pi$$

For Antinodes:

$$\sin(kx + \phi_1) = 0$$

$$kx + \phi_1 = n\pi$$



Normal Modes

String Fixed at Both Ends

$f = \frac{v}{\lambda}$

$\frac{\lambda}{2} = \ell$ $f_0 = \frac{v}{2\ell}$ Fundamental Frequency

$\frac{2\lambda}{2} = \ell$ $f = \frac{2v}{2\ell}$ 2^{nd} Harmonic 1^{st} Overtone

$\frac{3\lambda}{2} = \ell$ $f = \frac{3v}{2\ell}$ 3^{rd} Harmonic 2^{nd} Overtone

$\frac{n\lambda}{2} = \ell$ $f = \frac{nv}{2\ell}$ n^{th} Harmonic $(n-1)^{th}$ Overtone

PHYSICS WAHI jo Deewana BANA DE

Normal Modes

String Fixed at Both Ends

(1) $\frac{n\lambda}{2} = \ell$

(2) $f = \frac{nv}{2\ell}$

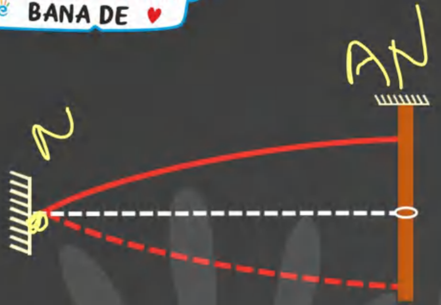
(3) $f = \frac{n}{2\ell}\sqrt{\frac{T}{\mu}}$

(4) $f = n f_0$

For fundamental frequency, $n = 1$

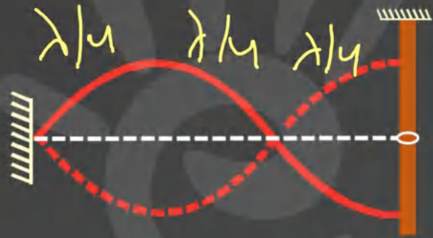
Normal Modes

String Fixed at One End & Free at Other



$\frac{\lambda}{4} = \ell \quad f = \frac{v}{4\ell}$

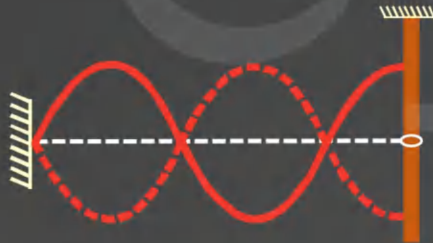
Fundamental Frequency



$\frac{3\lambda}{4} = \ell \quad f = \frac{3v}{4\ell}$

3rd Harmonic

1st Overtone



$\frac{5\lambda}{4} = \ell \quad f = \frac{5v}{4\ell}$

5th Harmonic

2nd Overtone

$\frac{(2n+1)\lambda}{4} = \ell \quad f = \frac{(2n+1)v}{4\ell}$

(2n +1)Harmonic n^{th} Overtone

Energy in Standing Wave

For Node

$KE = 0$

For Anitnode

$PE = 0$

Power transmission through node & antinode is zero. So, energy of one loop (even half loop) remains conserved.

QUIZ TIME

eSaral

Wave on String

Interference of Waves

Constructive Interference

Destructive Interference

Standing Waves

$$y_{res} = 2A \sin(kx) \cos(\omega t)$$

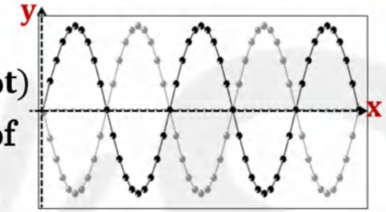
For $x = x_0$ Equation of Motion

$$y = \underbrace{2A \sin(kx_0)}_{A'} \cos(\omega t)$$

$$y = A' \cos(\omega t)$$

↓

SHM



$$y_{res} = 2A \sin(kx) \cos(\omega t)$$

$$v_P = \frac{\partial y}{\partial t} = \omega\sqrt{A^2 - y^2}$$

$$a_p = \frac{\partial^2 y}{\partial t^2} = -\omega^2 y$$

For Nodes - Amplitude = 0

$$\sin(kx + \phi_1) = 0$$

$$kx + \phi_1 = n\pi$$

For Antinodes - Amplitude = max

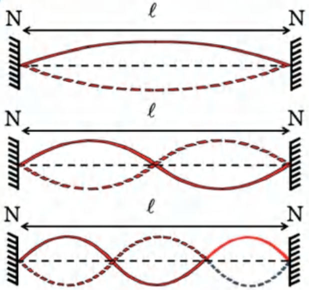
$$\sin(kx + \phi_1) = \pm 1$$

$$(kx + \phi_1) = \left(n + \frac{1}{2}\right)\pi$$

$$\frac{\lambda}{2} = l$$

$$f = \frac{v}{2l}$$

Normal Modes String Fixed at Both Ends



1 Fundamental Frequency

$\frac{2\lambda}{2} = \ell \quad f = \frac{2v}{2\ell}$ — 2nd Harmonic, 1st Overtone

$\frac{3\lambda}{2} = \ell \quad f = \frac{3v}{2\ell}$ — 3rd Harmonic, 2nd Overtone

$$\frac{n\lambda}{2} = \ell \quad f = \frac{nv}{2\ell}$$

n th Harmonic

(n–1)th Overtone

(1) $\frac{n\lambda}{2} = \ell$

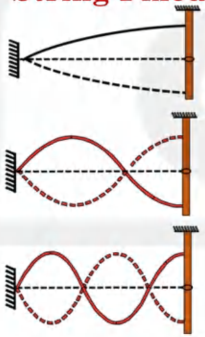
(2) $f = \frac{nv}{2\ell}$

(3) $f = \frac{n}{2\ell}\sqrt{\frac{T}{\mu}}$

(4) $f = n f_0$

For fundamental frequency, n = 1

String Fixed at One End & Free at Other



2 Fundamental Frequency

$\frac{3\lambda}{4} = \ell \quad f = \frac{3v}{4\ell}$ — 3rd Harmonic, 1st Overtone

$\frac{5\lambda}{4} = \ell \quad f = \frac{5v}{4\ell}$ — 5th Harmonic, 2nd Overtone

$$\frac{(2n+1)\lambda}{4} = \ell \quad f = \frac{(2n+1)v}{4\ell}$$

(2n +1)Harmonic

nth Overtone

Energy in Standing Wave

For Node	For Anitnode
$KE = 0$	$PE = 0$
$\frac{\partial y}{\partial t} = 0$	$\frac{\partial y}{\partial x} = 0$
$P_{Node} = 0$	$P_{Antinode} = 0$

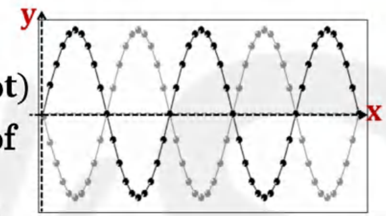
Power transmission through node & antinode is zero.
So, energy of one loop (even half loop) remains conserved.

Wave on String

Interference of Waves

Constructive Interference   Destructive Interference

Standing Waves



$y_{res} = 2A\sin(kx)\cos(\omega t)$

For $x = x_0$ Equation of Motion

$y = \underbrace{2A\sin(kx_0)}_{A'}\cos(\omega t)$

$y = A'\cos(\omega t)$

↓

SHM

$y_{res} = 2A\sin(kx)\cos(\omega t)$

$v_P = \frac{\partial y}{\partial t} = \omega\sqrt{A^2 - y^2}$

$a_p = \frac{\partial^2 y}{\partial t^2} = -\omega^2 y$

For Nodes - Amplitude = 0

$\sin(kx + \phi_1) = 0$

$kx + \phi_1 = n\pi$

For Antinodes - Amplitude = max

$\sin(kx + \phi_1) = \pm 1$

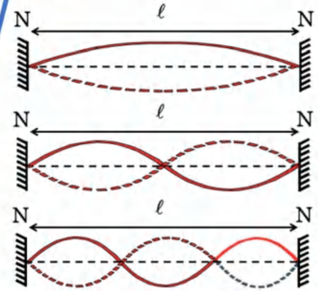
$(kx + \phi_1) = \left(n + \frac{1}{2}\right)\pi$

Energy in Standing Wave

For Node	For Anitnode
$KE = 0$	$PE = 0$
$\frac{\partial y}{\partial t} = 0$	$\frac{\partial y}{\partial x} = 0$
$P_{Node} = 0$	$P_{Antinode} = 0$

Power transmission through node & antinode is zero. So, energy of one loop (even half loop) remains conserved.

Normal Modes   String Fixed at Both Ends



$\frac{\lambda}{2} = \ell$ $f_0 = \frac{v}{2\ell}$ Fundamental Frequency

$\frac{2\lambda}{2} = \ell$ $f = \frac{2v}{2\ell}$ 2nd Harmonic, 1st Overtone

$\frac{3\lambda}{2} = \ell$ $f = \frac{3v}{2\ell}$ 3rd Harmonic, 2nd Overtone

$\frac{n\lambda}{2} = \ell$ $f = \frac{nv}{2\ell}$ n th Harmonic, (n–1)th Overtone

(1) $\frac{n\lambda}{2} = \ell$

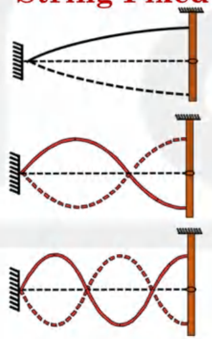
(2) $f = \frac{nv}{2\ell}$

(3) $f = \frac{n}{2\ell}\sqrt{\frac{T}{\mu}}$

(4) $f = n f_0$

For fundamental frequency, n = 1

String Fixed at One End & Free at Other



$\frac{\lambda}{4} = \ell$ $f = \frac{v}{4\ell}$ Fundamental Frequency

$\frac{3\lambda}{4} = \ell$ $f = \frac{3v}{4\ell}$ 3rd Harmonic, 1st Overtone

$\frac{5\lambda}{4} = \ell$ $f = \frac{5v}{4\ell}$ 5th Harmonic, 2nd Overtone

$\frac{(2n+1)\lambda}{4} = \ell$ $f = \frac{(2n+1)v}{4\ell}$ (2n +1)Harmonic, nth Overtone

→ Doppler Effect

Sound Wave

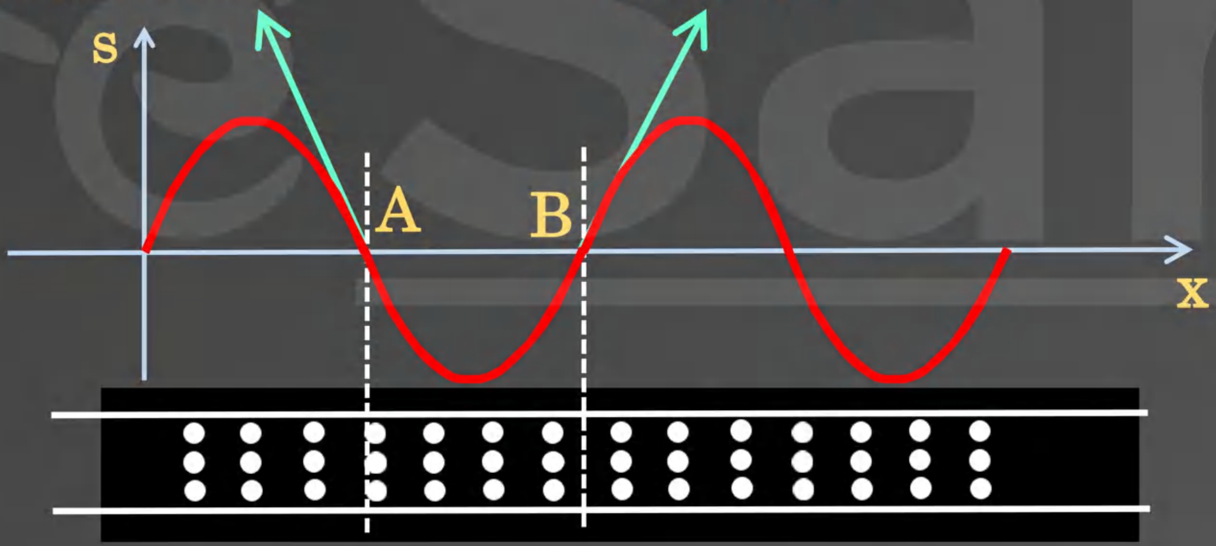
Superfast Revision

Equation of Sound Wave

$$s = s_0 \sin(\pm \omega t \pm kx + \phi)$$

Max Compressive Stress
Max. Density, Pressure
Compression

Max Tensile Stress
Min. Density, Pressure
Rarefaction



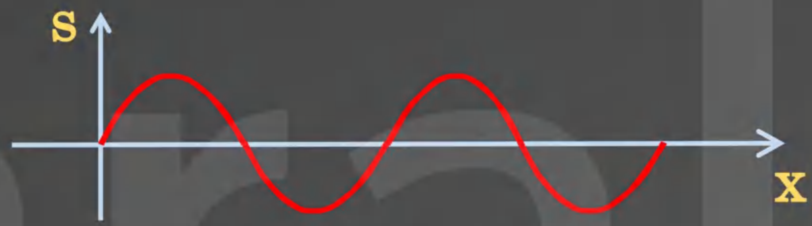
$$s = s_0 \sin(\omega t - kx + \phi)$$

$$v_w = -\frac{\text{Coefficient of t}}{\text{Coefficient of x}} = \frac{\omega}{k}$$

$$v_P = -v_w \left(\frac{\partial s}{\partial x}\right)$$

↓

Velocity of particle



Variation of Excess Pressure in Gas Due to Propagation of Longitudinal Wave

$$p = -B\left(\frac{\partial s}{\partial x}\right)$$

p → Excess pressure

$$|p_0| = |Bks_0|$$

Amplitude of excess pressure

$$s = s_0 \sin(\omega t - kx)$$

$$p = p_0 \cos(\omega t - kx)$$

Velocity of Sound Wave in Gas

$v_w = \sqrt{\dfrac{B}{\rho}}$ B → Bulk modulus, ρ → Density

$v_w = \sqrt{\dfrac{\gamma P}{\rho}}$

$v_w = \sqrt{\dfrac{\gamma RT}{M_0}}$

(T is in Kelvin)

On increasing P if T is constant v_w will not change

At same T if humidity increases, v_w increases $(\because M_0 \downarrow)$

Velocity of Sound Wave in Gas

$$v_w = \sqrt{\frac{\gamma RT}{M_0}}$$

For a small change, ΔT

$$\frac{\Delta v_w}{v_w} = \frac{1}{2}\frac{\Delta T}{T}$$

% change in $V_w = \frac{1}{2}$ % in T

$$\sqrt{\frac{T}{\mu}} \qquad \sqrt{\frac{B}{\rho}} \qquad \sqrt{\frac{Y}{\rho}} \qquad \sqrt{\frac{\text{Elastic Property of medium}}{\text{Inertial Property of medium}}}$$

Velocity of wave on string

Velocity of wave in gas

Velocity of wave in thin solid rod

Intensity in Sound Waves

$$\langle I \rangle = \frac{1}{2}\underbrace{\sqrt{B\rho}}_{\text{Property of medium}}\ \underbrace{s_0^2\omega^2}_{\text{Property of source}}$$

Characteristics of Sound

Pitch

(Dominant Frequency)

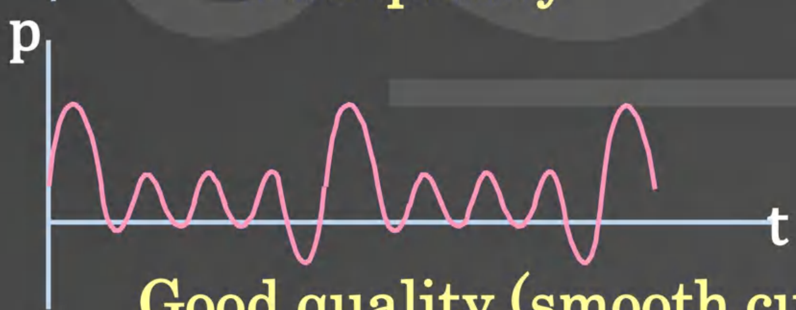
Low Frequency → Low Pitch

High Frequency → High Pitch

Quality

(Waveform of Sound wave)

Bad quality



Good quality (smooth curve)

Characteristics of Sound

Loudness

(Intensity)

Sound level (SL) $= 10 \log_{10}\left(\frac{I}{I_0}\right)$ → Intensity = Power / Area

↓

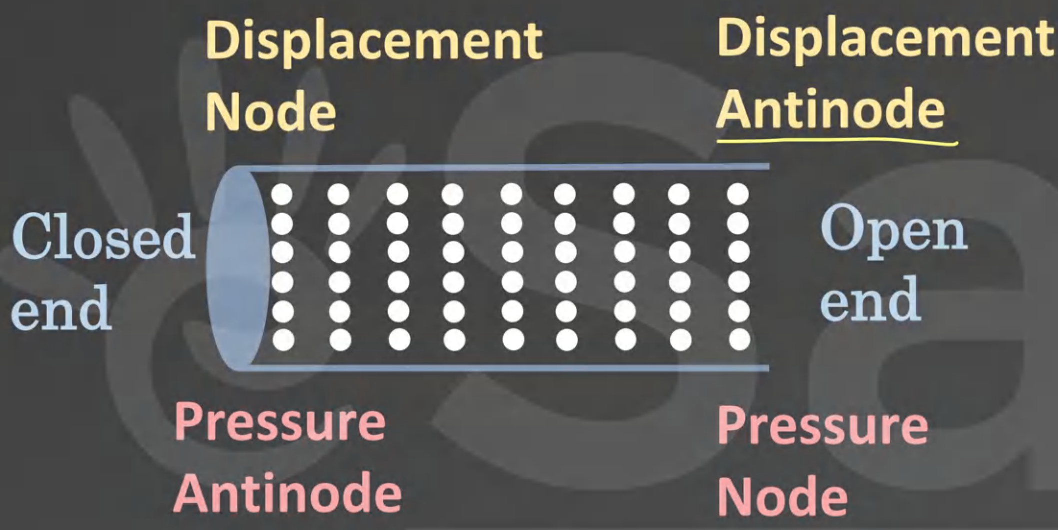
measured in decibel (dB)

$I_0 = 10^{-12}\ \frac{\text{Watt}}{\text{m}^2}$

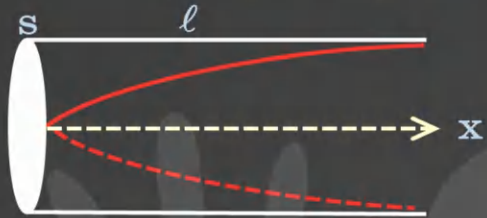
↓

Minimum audible intensity

Standing Wave Inside an Organ Pipe Closed at One End

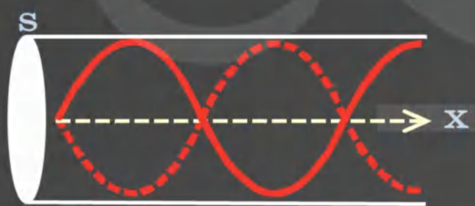


Standing Wave Inside an Organ Pipe Closed at One End



$\frac{\lambda}{4} = \ell$ $f = \frac{1v}{4\ell}$ Fundamental frequency

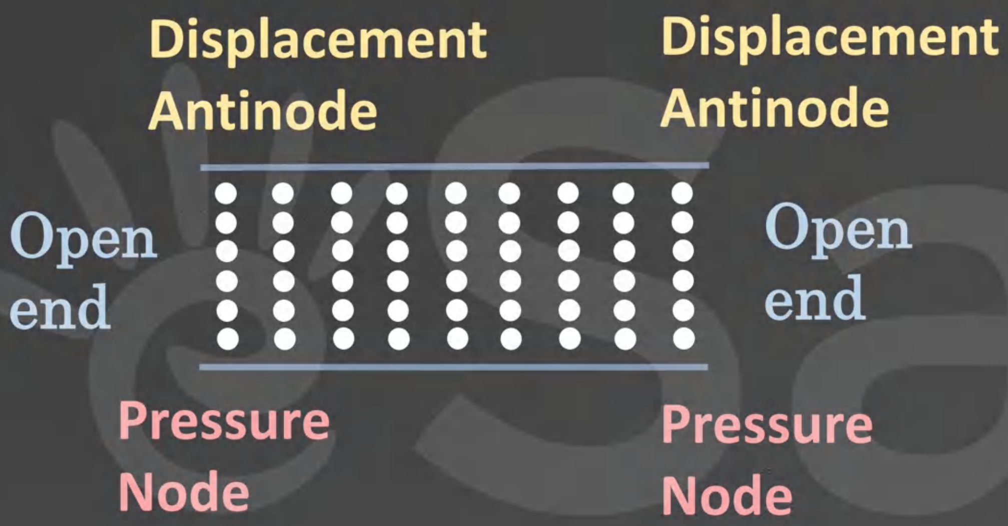
$\frac{3\lambda}{4} = \ell$ $f = \frac{3v}{4\ell}$ 3rd Harmonic, 1st overtone



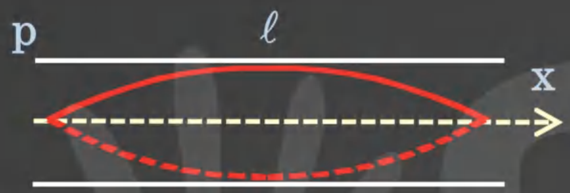
$\frac{5\lambda}{4} = \ell$ $f = \frac{5v}{4\ell}$ 5th Harmonic, 2nd overtone

$\frac{(2n+1)\lambda}{4} = \ell$ $f = \frac{(2n+1)v}{4\ell}$ $(2n+1)^{th}$ Harmonic, n^{th} overtone

Standing Wave Inside an Organ Pipe Closed at Both End



Standing Wave Inside an Organ Pipe Open at Both End



$\frac{\lambda}{2} = \ell \qquad f_0 = \frac{1v}{2\ell}$

Fundamental frequency

$\frac{2\lambda}{2} = \ell \qquad f = \frac{2v}{2\ell}$

2^{nd} Harmonic

1^{st} overtone

$\frac{3\lambda}{2} = \ell \qquad f = \frac{3v}{2\ell}$

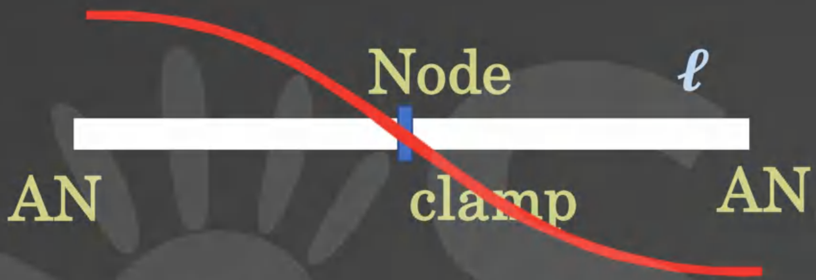
3^{rd} Harmonic

2^{nd} overtone

$\frac{n\lambda}{2} = \ell \qquad f = \frac{nv}{2\ell}$ $\quad n^{th}$ Harmonic $\quad (n-1)^{th}$ overtone

Standing Wave in Solids

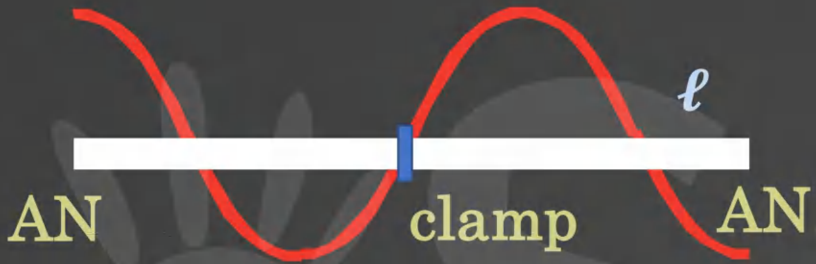
$$\sqrt{\frac{B}{\rho}} \qquad \sqrt{\frac{Y}{\rho}}$$



$$\frac{\lambda}{2} = \ell \qquad f = \frac{1}{2\ell}\sqrt{\frac{Y}{\rho}}$$

fundamental mode

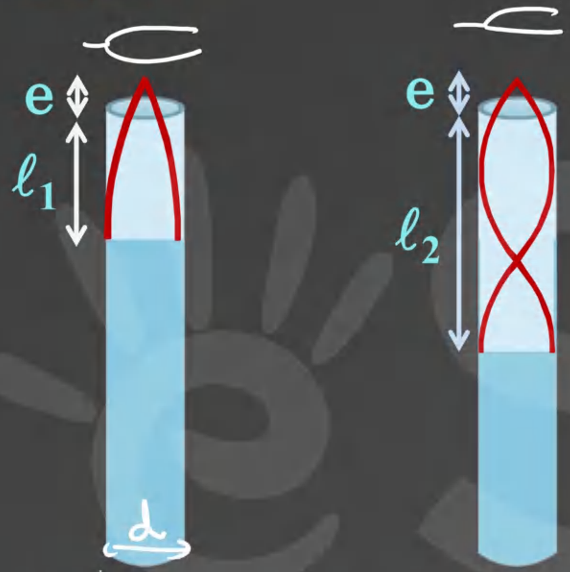
Standing Wave in Solids



$\frac{3\lambda}{2} = \ell$ $\quad f = \frac{3}{2\ell}\sqrt{\frac{Y}{\rho}}$ $\quad f_0 = \frac{1}{2\ell}\sqrt{\frac{Y}{\rho}}$

1st overtone, 3rd harmonic

Resonance Tube Method to Calculate Speed of Sound in Air



1st resonance

$$\frac{\lambda}{4} = \ell_1 + e$$

2nd resonance

$$\frac{3\lambda}{4} = \ell_2 + e$$

Pressure node forms a bit outside open end.

$$v = f\lambda$$

$$v = 2f(\ell_2 - \ell_1)$$

$$e = 0.3\,d$$

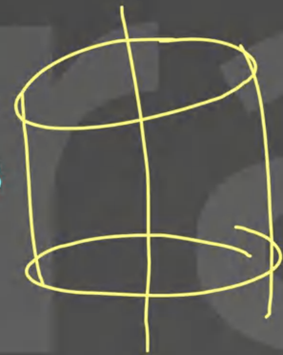
d → diameter of tube

Wavefront

It is the locus of points which are vibrating in same phase.

Point source — Spherical wavefronts

Line source — Cylindrical wavefronts

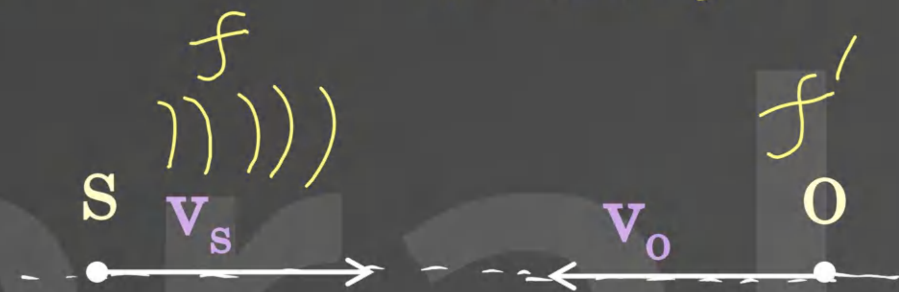


Planar wavefronts

Change in frequency observed due to motion of both source & observer

Doppler's Effect

$$f' = \left(\frac{v_w + v_O}{v_w - v_S}\right) f$$



where

f = frequency produced by source

f ′= frequency observed by observer

v_w = velocity of wave in medium

v_O = component of velocity of observer in medium towards source

v_s = component of velocity of source in medium towards observer

TRICK

$$f' = \left(\frac{v_w + v_o}{v_w - v_s}\right) f$$

v_o & v_s will be +ve if they reduce दूरी else −ve

$v_w = 300\ m/s$

1.

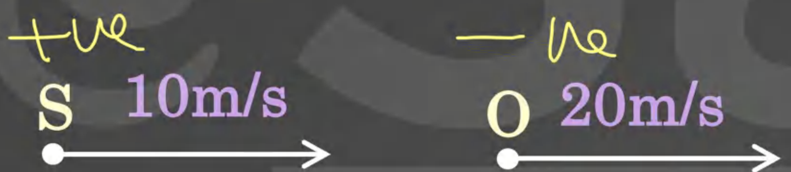
$$f' = \left[\frac{300 + (+20)}{300 - (+10)}\right] f$$

$$f' = \left(\frac{v_w + v_O}{v_w - v_S}\right) f$$

$$\left(\frac{300 + (-20)}{300 - (+10)}\right) f$$

$v_w = 300\ m/s$

2.

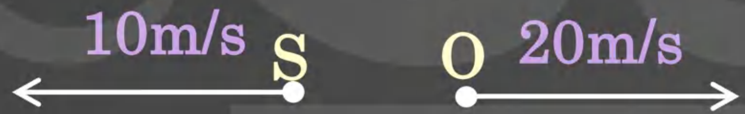


$$f' = \left[\frac{300 + (-20)}{300 - (+10)}\right] f$$

$$f' = \left(\frac{v_w + v_O}{v_w - v_S}\right) f$$

$$v_w = 300\ \text{m/s}$$

3.

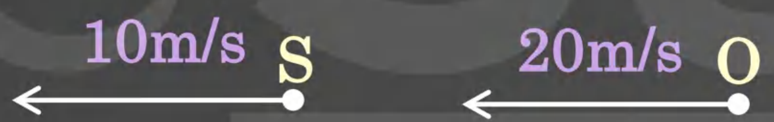


$$f' = \left[\frac{300 + (-20)}{300 - (-10)}\right] f$$

$$f' = \left(\frac{v_w + v_O}{v_w - v_S}\right) f$$

$$v_w = 300\ m/s$$

4.

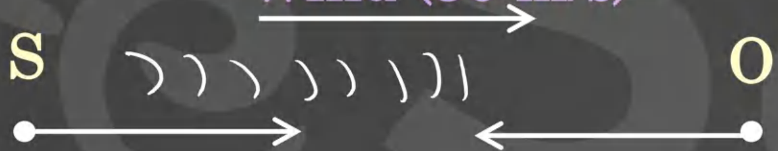


$$f' = \left[\frac{300 - (+20)}{300 - (-10)}\right] f$$

If wind is blowing

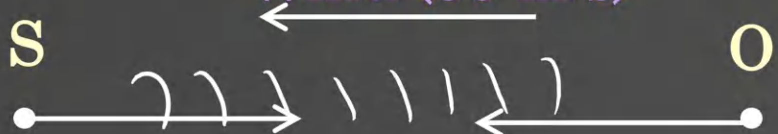
$$f' = \left(\frac{v_{wave} + v_O}{v_{wave} - v_S}\right) f \qquad v_w = 300\ m/s$$

Wind (30 m/s)



$$f' = \left(\frac{(v_{wave} + v_{wind}) + v_O}{(v_{wave} + v_{wind}) - v_S}\right) f$$

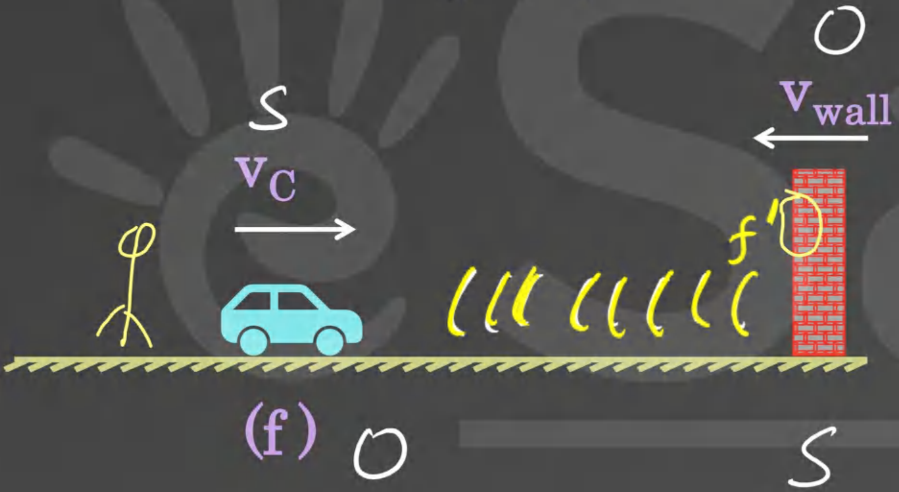
Wind (30 m/s)



$$f' = \left(\frac{(v_{wave} - v_{wind}) + v_O}{(v_{wave} - v_{wind}) - v_S}\right) f$$

$$f_{obs} = \left(\frac{v_w + v_O}{v_w - v_s}\right) f_{prod}$$

TRICK दीवारों के भी कान होते

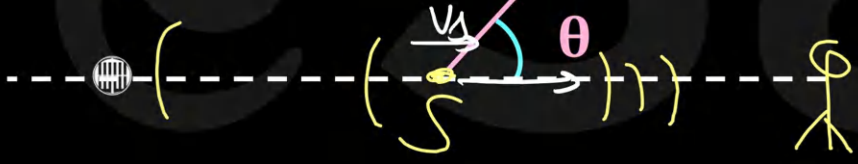


$$f' = \left[\frac{v_w + v_{wall}}{v_w - (v_c)}\right] f$$

दीवारों के भी मुँह होते हैं

$$f'' = \left[\frac{v_w + v_c}{v_w - (v_{wall})}\right] f'$$

Change in wavelength due to motion of a sound source



$$\lambda' = \frac{v_w + v_s}{f}$$

$$\lambda' = \frac{v_w - v_s\cos\theta}{f}$$

$$\lambda' = \frac{v_w - v_s}{f}$$

$$\lambda = \frac{v_w}{f}$$

Interference of Sound Waves

$$p_1 = p_{1_0}\sin(kx - \omega t)$$

$$p_2 = p_{2_0}\sin(kx - \omega t + \phi)$$

Constructive Interference

$$(p_{res_0})_{max} = p_{10} + p_{20}$$

$$(I_{res})_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$$

$$\Delta x = 0\ ,\ \lambda\ ,\ 2\lambda\ ,\ 3\lambda \ldots\ = n\lambda$$

Destructive Interference

$$(p_{res_0})_{min} = |p_{10} - p_{20}|$$

$$(I_{res})_{min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2$$

$$\Delta x = 0.5\lambda, 1.5\lambda, 2.5\lambda \ldots = \left(n + \frac{1}{2}\right)\lambda$$

Interference of waves having frequency slightly different from each other produces **beats.**

= 4 Hz

Beat frequency = $\Delta f = f_1 - f_2$

Q) A TF_1 has frequency f = 256 Hz. It produces beats of 4 Hz with TF_2. What could be the frequency f of TF_2?

Sol.

TF_1

TF_2

256 → −4 → 252 Hz

256 → +4 → 260 Hz

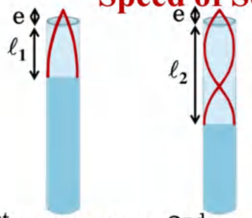
Key Points

- On applying wax on prongs of TF, its frequency decreases.
- On filling prongs of TF, its frequency increases.

QUIZ TIME

Sound Waves

Resonance Tube Method to Calculate Speed of Sound in Air



$v = f\lambda$

$v = 2f(\ell_2 - \ell_1)$

$e = 0.3\,d$ ↓ diameter of tube

1st resonance   2nd resonance

$\frac{\lambda}{2} = \ell$

Doppler f Formula

Beat frequency =

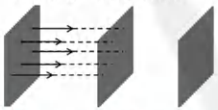
1

Wavefront

Point source – Cylindrical wavefronts

Line source – Spherical wavefronts

Planar wavefronts



Change in wavelength due to motion of a sound source

$$\lambda' = \frac{v_w \pm v_s}{f}$$

Change in frequency observed due to motion of both source & observer

$$f' = \left(\frac{v_w + v_o}{v_w - v_S}\right) f$$

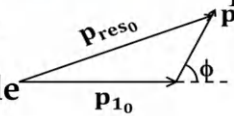
If wind is blowing, take its effect also

Interference of Sound Waves

$p_1 = p_{1_0}\sin(kx - \omega t)$

$p_2 = p_{2_0}\sin(kx - \omega t + \phi)$

By Superposition Principle



$(p_{res_0})^2 = p_{1_0}^2 + p_{2_0}^2 + 2\,p_{1_0}p_{2_0}\cos\phi$

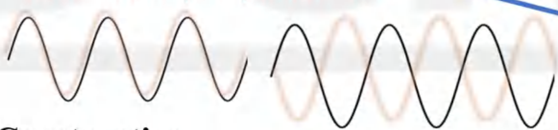
$I_{res} = I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}\cos\phi$ $(I \propto p_o^2)$

Constructive Interference

$(p_{res_0})_{max} = p_{1o} + p_{2o}$

$(I_{res})_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$

$\Delta x = 0, \lambda, 2\lambda, 3\lambda ... = n\lambda$



Constructive Interference   Destructive Interference

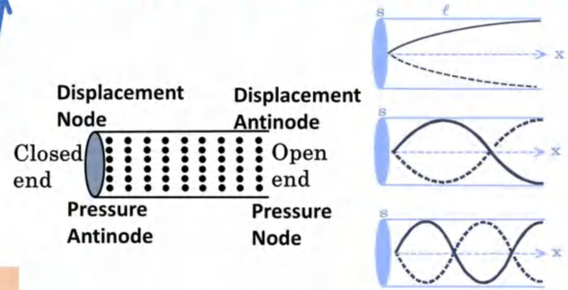
Destructive Interference

$(p_{res_0})_{min} = |p_{1o} + p_{2o}|$

$(I_{res})_{min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2$

$\Delta x = 0.5\lambda, 1.5\lambda, 2.5\lambda ... = \left(n + \frac{1}{2}\right)\lambda$

Standing Wave Inside an Organ Pipe Closed at One End



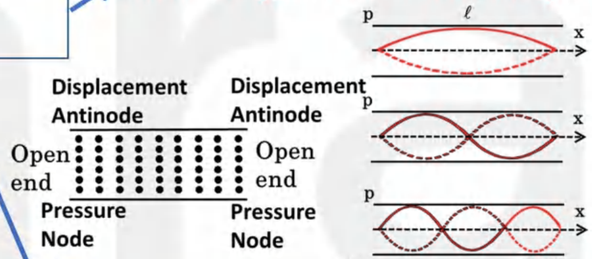
$\frac{\lambda}{4} = \ell$ $f = \frac{1v}{4\ell}$ Fundamental frequency

$\frac{3\lambda}{4} = \ell$ $f = \frac{3v}{4\ell}$ 3rd Harmonic, 1st overtone

$\frac{5\lambda}{4} = \ell$ $f = \frac{5v}{4\ell}$ 5th Harmonic, 2nd overtone

$\frac{(2n+1)\lambda}{4} = \ell$ $f = \frac{(2n+1)v}{4\ell}$ (2n + 1)th Harmonic, nth overtone

Standing Wave Inside an Organ Pipe Open at Both End



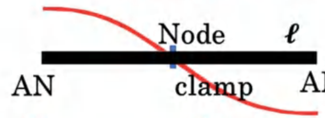
$\frac{\lambda}{2} = \ell$ $f_o = \frac{1v}{2\ell}$ Fundamental frequency

$\frac{2\lambda}{2} = \ell$ $f = \frac{2v}{2\ell}$ 2nd Harmonic, 1st overtone

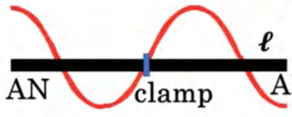
$\frac{3\lambda}{2} = \ell$ $f = \frac{3v}{2\ell}$ 3rd Harmonic, 2nd overtone

$\frac{n\lambda}{2} = \ell$ $f = \frac{nv}{2\ell}$ nth Harmonic, (n − 1)th overtone

Standing Wave in Solids



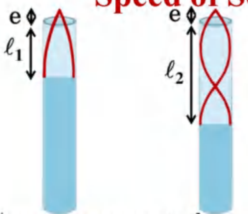
$\frac{\lambda}{2} = \ell$ $f = \frac{1}{2\ell}\sqrt{\frac{Y}{\rho}}$ fundamental mode



$\frac{3\lambda}{2} = \ell$ $f = \frac{3}{2\ell}\sqrt{\frac{Y}{\rho}}$ 1st overtone, 3rd harmonic

Sound Waves

Resonance Tube Method to Calculate Speed of Sound in Air



1st resonance   2nd resonance

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$v = 2f(\ell_2 - \ell_1)$

$e = 0.3\,d$ → diameter of tube

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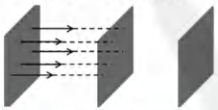
$$f' = \left(\frac{V_w + V_0}{V_w - V_s}\right) f$$

Beat frequency $= \Delta f$
$= f_1 - f_2$

Wavefront

Point source — Cylindrical wavefronts
Line source — Spherical wavefronts
Planar wavefronts



Change in wavelength due to motion of a sound source

$$\lambda' = \frac{v_w \pm v_s}{f}$$

Change in frequency observed due to motion of both source & observer

S v_s → ← v_0 O

$$f' = \left(\frac{v_w + v_0}{v_w - v_S}\right) f$$

If wind is blowing, take its effect also

Interference of Sound Waves

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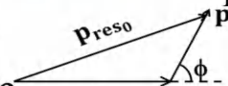

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$\Delta x = 0, \lambda, 2\lambda, 3\lambda ... = n\lambda$

Constructive Interference   Destructive Interference

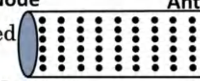
Destructive Interference

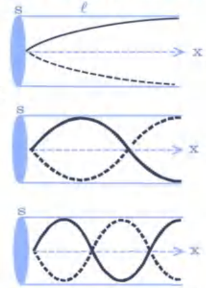
$(p_{res_0})_{min} = |p_{1o} + p_{2o}|_2$

$(I_{res})_{min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2$

$\Delta x = 0.5\lambda, 1.5\lambda, 2.5\lambda ... = \left(n + \frac{1}{2}\right)\lambda$

Standing Wave Inside an Organ Pipe Closed at One End





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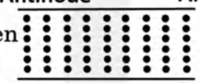
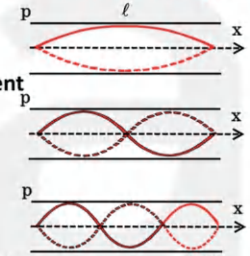
$\frac{(2n+1)\lambda}{4} = \ell$ $f = \frac{(2n+1)v}{4\ell}$ $(2n+1)^{th}$ Harmonic, n^{th} overtone

Standing Wave Inside an Organ Pipe Open at Both End





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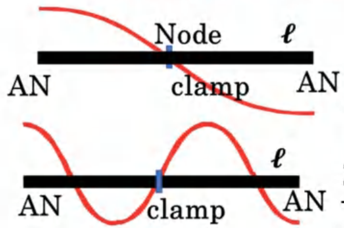
$\frac{3\lambda}{2} = \ell$ $f = \frac{3v}{2\ell}$ 3rd Harmonic, 2nd overtone

$\frac{n\lambda}{2} = \ell$ $f = \frac{nv}{2\ell}$ n^{th} Harmonic, $(n-1)^{th}$ overtone

Standing Wave in Solids



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$\frac{3\lambda}{2} = \ell$ $f = \frac{3}{2\ell}\sqrt{\frac{Y}{\rho}}$ 1st overtone, 3rd harmonic

Course Details

Lectures

Practice
- Sheets
- Prev. Yr.

Tests
- Topic-Wise
- Review

Study Plan

Doubt Solving

Mentorship


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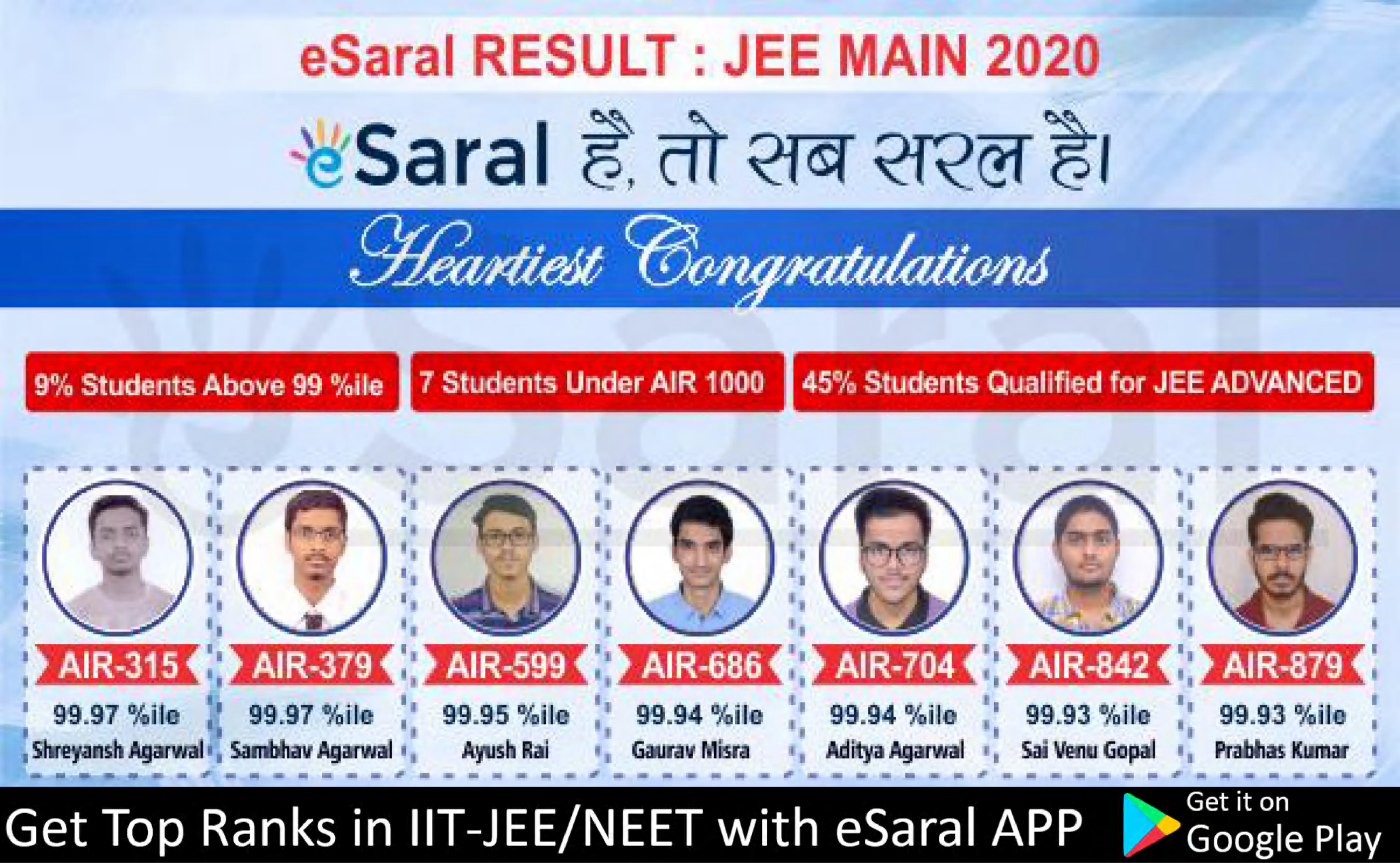
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AIR-599
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EWS
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Prabhas Kumar
AIR-190
Apoorv Bansal
AIR-211
Vivek Kumar Singhal
AIR-240
Shiva Ganesh Reddy
AIR-295
Shikhar Gupta
AIR-635
Chitraansh Pandey
AIR-669
Harsh Vijayvargiya
AIR-782
Param Shah
AIR-802
Loveneesh Lawaniya
OBC
AIR-263
Abhay Saini
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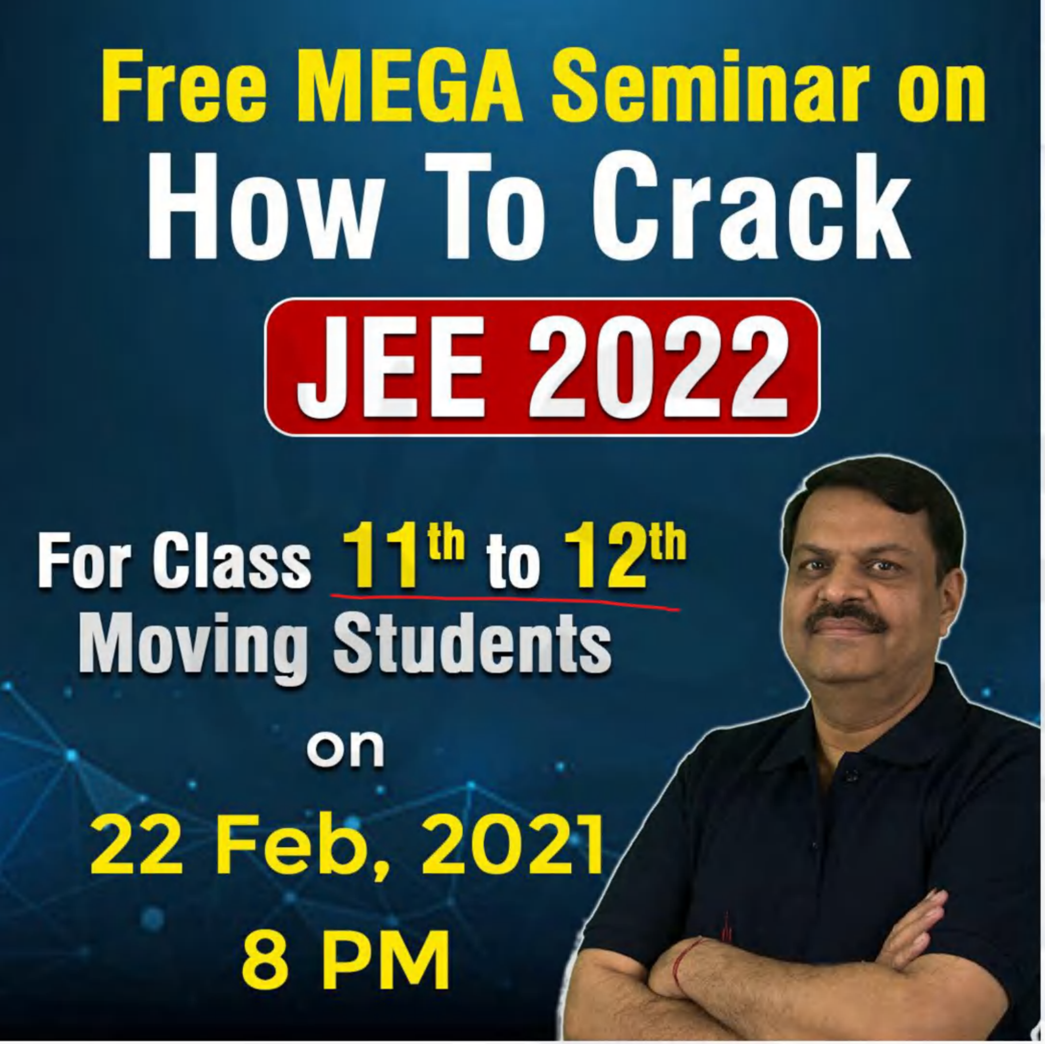
AIR-3537
Brijesh kumar
AIR-3622
Kshitij Shrivastava
AIR-3733
Priyam Goenka
AIR-4000
Vishnu Bhagawat
AIR-4906
Sonish Singhal
AIR-5000
Rohan Nain

11th to 12th moving



Link in Description

https://esaral.page.link/riBDzARasRyANRN87

Complete Physics Mega Revision Timetable

15 Feb
Electrostatics
Current electricity
Capacitor
🎁 Surprise Gift 🎁

16 Feb
Calorimetry
Elasticity
Thermal Expansion
Heat Transfer
KTG
Thermodynamics
Fluid Mechanics

17 Feb
Magnetic effect of current
Magnetism and matter
Emi
AC

18 Feb
UD
Vector
Kinematics 1D
Kinematics 2D
NLM
Friction
Circular motion
Work power energy
COM

19 Feb
Ray optics
Optical Instruments
Wave optics
EM Waves
Errors in measurement

20 Feb
Rotation motion
Gravitation
SHM
Wave on string
Sound wave

21 Feb
Atomic structure
Dual nature of radiation
X-rays
Nuclear physics
Radioactivity
Semi conductor
Communication system