B.E Civil Engineering **2019-2020**

Semester-II

19BECE241 **Mechanics and Mechanics of Solids (Theory &lab.)** **7H-5C**

Instruction Hours/week: L:3 T:1 P:3 **Marks:** Internal:**40** External:**60** Total:**100**

End Semester Exam:3 Hours

(i) Theory

Course Objective:

This course is designed for science or engineering majors in related areas, The main goal of the course is to learn the fundamentals of this important topic.

Course Outcome:

The students will have the knowledge on how to use Newton's laws of motion to solve advanced problems involving the dynamic motion of classical mechanical systems.

Theory

Unit 1- Vector mechanics of a particle

Transformation of scalars and vectors under Rotation transformation; Forces in Nature; Newton's laws and its completeness in describing particle motion; Solving Newton's equations of motion in polar coordinates.Potential energy function; F = - Grad V, equipotential surfaces and meaning of gradient.

Unit 2- Planar rigid body mechanics

Definition and motion of a rigid body in the plane; Rotation in the plane; Kinematics in a coordinate system rotating and translating in the plane;Euler's laws of motion, their independence from Newton's laws, and their necessity in describing rigid body motion. Introduction to three-dimensional rigid body motion.

Unit 3 - Statics

Free body diagrams with examples on modelling of typical supports and joints; Condition for equilibrium in three- and two- dimensions; Friction: limiting and non-limiting cases; Force displacement relationship; Geometric compatibility for small deformations.

Unit 4 - Mechanics of solids

Concept of stress at a point; Planet stress: transformation of stresses at a point, principal stresses and Mohr's circle; Displacement field; Concept of strain at a point; Plane strain:transformation of strain at a point, principal strains and Mohr's circle; Concepts of elasticity, plasticity, strain hardening, failure (fracture / yielding); Idealization of one dimensional stress-strain curve.

Unit 5 - Stress and strain

Bending stress; Shear stress; Cases of combined stresses; Concept of strain energy; Yield criteria; Deflection due to bending; Integration of the moment-curvature relationship for simple boundary conditions; Method of superposition (without using singularity functions); Strain energy and complementary strain energy for simple structural elements.

SUGGESTED READINGS:

MK Harbola,(2015),Engineering Mechanics (2nd ed.), Oxford University Press.
MK Verma, (2015),Introduction to Mechanics, GEMS Publisher, Coimbatore.
D Kleppner& R Kolenkow,(2012), An Introduction to Mechanics, Dhanpat Rai Publications
JL Synge & BA Griffiths,(2007), Principles of Mechanics, Milward Press
JL Meriam, (2012),Engineering Mechanics - Dynamics(7th ed), Wiley (7th Edition)
JP Den Hartog, (1985),Mechanical Vibrations, Courier Corporation.
SH Crandall, NC Dahl & TJ Lardner,(1978), An Introduction to the Mechanics of Solids(2nd ed.), McGraw-Hill Publishing Company.
EP Popov, (1998),Engineering Mechanics of Solids, Pearson.

KARPAGAM ACADEMY OF HIGHER EDUCATION

(Deemed to be University Established under Section 3 of UGC Act 1956)

COIMBATORE – 641021

FACULTY OF ENGINEERING

DEPARTMENT OF SCIENCE AND HUMANITIES

LECTURE PLAN

Subject : MECHANICS AND MECHANICS OF SOLIDS
Code : 19BECE241

Unit No.	List of Topics	No. of Hours
UNIT I	**Vector mechanics of a particle**	
	Transformation of scalars and vectors under Rotation transformation	1
	Forces in Nature	1
	Newton's laws and its completeness in describing particle motion	1
	Tutorial	1
	Solving Newton's equations of motion in polar coordinates	2
	Potential energy function	1
	F = - Grad V	1
	Equipotential surfaces and meaning ofgradient	1
	Tutorial	1
	TOTAL	**10**
UNIT – II	**Planar rigidbody mechanics**	
	Definition and motion of a rigid body in the plane	1
	Rotation in the plane	1
	Kinematics in a coordinate system rotating and translating in the plane	2
	Tutorial	1
	Euler's laws of motion , their independence from Newton's laws and their necessity in describing rigid body motion	2
	Introduction to three- dimensional rigid body motion	2
	Tutorial	1
	TOTAL	**10**
UNIT – III	**Statics**	
	Free body diagrams with examples on modelling of typical supports and joints	2
	Condition for equilibrium in three- and two- dimensions	2
	Friction : limiting and non-limiting cases	2
	Tutorial	1
	Force displacement relationship	1
	Geometric compatibility for small deformations	1
	Tutorial	1
	TOTAL	**10**

UNIT – IV	**Mechanicsofsolids**	
	Concept of stress at a point	1
	Planet stress: transformation of stresses at a point, principal stresses and Mohr’s circle	2
	Displacement field	1
	Concept of strain at a point	1
	Tutorial	1
	Plane strain:transformation of strain at a point, principal strains and Mohr’s circle	1
	Concepts of elasticity, plasticity, strain hardening, failure (fracture / yielding)	1
	Idealization of one dimensional stress-strain curve	1
	Tutorial	1
	TOTAL	**10**
UNIT – V	**Stressand strain**	
	Bending stress	1
	Shear stress	1
	Cases of combined stresses	1
	Concept of strain energy	1
	Tutorial	1
	Yield criteria	1
	Deflection due to bending; Integration of the moment-curvature relationship for simple boundary conditions	1
	Method of superposition (without using singularity functions)	1
	Strain energy and complementary strain energy for simple structuralelements	1
	Tutorial	1
	TOTAL	**10**
	TOTAL NO OF HOURS	**50**

TEXT BOOK& REFERENCES:

S.NO	AUTHOR(S) NAME	TITLE OF THE BOOK	PUBLISHER	YEAR OF PUBLICATION
1.	MK Harbola	Engineering Mechanics U (2nd ed.)	Oxford niversity Press	2015
2.	MK Verma	Introduction to Mechanics	GEMS Publisher, Coimbatore.	2015
3.	D Kleppner& R Kolenkow	An Introduction to Mechanics	DhanpatRai Publications	2012
4.	JL Synge & BA Griffiths	Principles of Mechanics	Milward Press	2007
5.	JL Meriam	Engineering Mechanics - Dynamics(7thed)	Wiley (7th Edition)	2012
6.	JP Den Hartog	MechanicalVibrations	Courier Corporation	1985
7.	SH Crandall, NC Dahl & TJ Lardner	An Introduction to the Mechanics of Solids (2nd ed.)	McGraw-Hill Publishing Company	1978
8.	EP Popov	Engineering Mechanics of Solids	Pearson	1998

WEBSITES:

1. www.nptel.ac.in
2. www.ocw.mit.edu

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Planar rigid body mechanics.

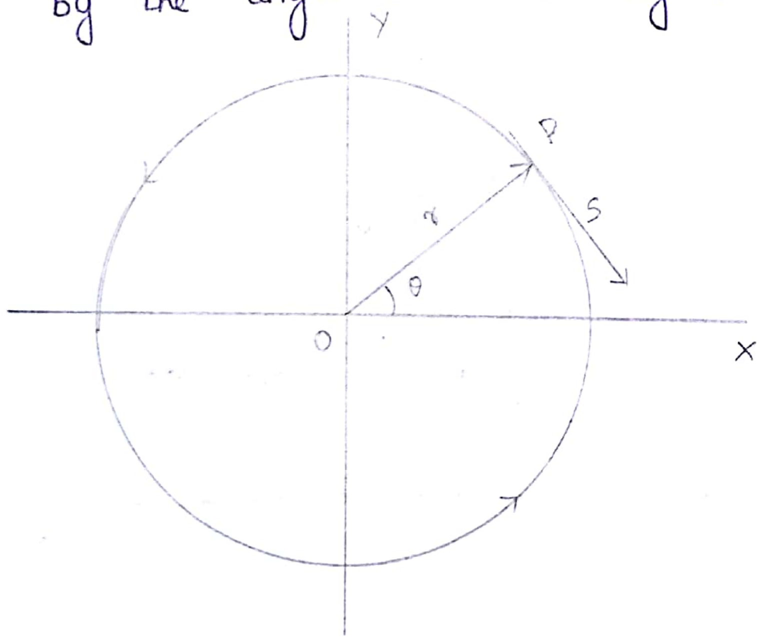
Rigid body

A body is said to be rigid if it doesn't change size or shape under the action of forces.

Rotational kinematics.

kinematics in a coordinate system rotating and translating in the pl

Consider a point P on a body rotating in the xy - plane about the z-axis passing through O. Let the angular position of the particle P with reference to the x-axis be indicated by the angle θ in the xy plane.



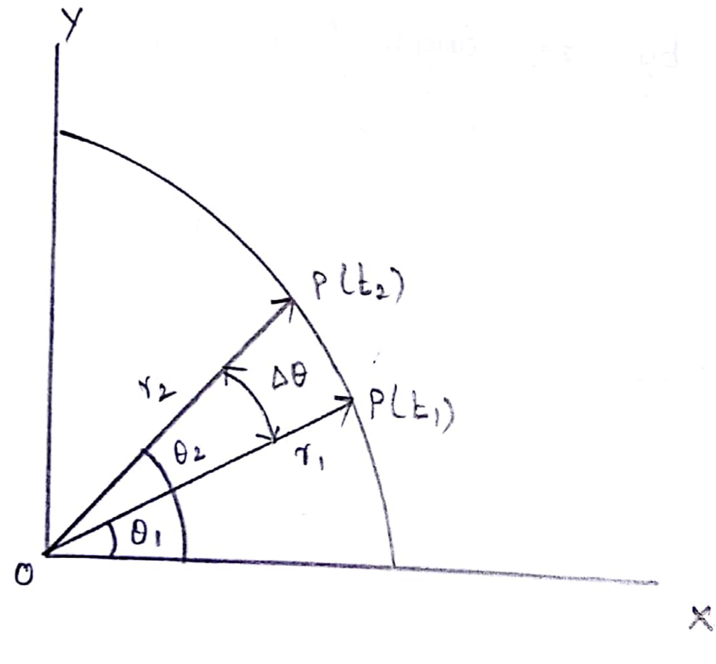
By convention a counter-clockwise rotation is called Positive, that is θ increases, and a clockwise rotation is one in which θ decreases.

If s be the length of the arc and r the radius of the circle, then the angle θ is given by

$$\theta = \frac{s}{r} \quad \text{——— (1)}$$

The angular position of P as θ_1 at time t_1 and θ_2 at a later time t_2. The angular displacement of P will be $\Delta\theta = \theta_2 - \theta_1$ in the time interval $\Delta t = t_2 - t_1$. The average angular velocity in this time interval is given by

$$\bar{\omega} = \frac{\theta_2 - \theta_1}{t_2 - t_1} = \frac{\Delta\theta}{\Delta t} \quad \text{——— (2)}$$



For a rigid body, all the particles of the body would undergo identical angular displacement in the same interval of time irrespective of the location of the particles so that each particle rotates with the same angular speed about the given axis.

If ω_1 and ω_2 are the angular speed at time t_1 and t_2 respectively, then the average acceleration $\bar{\alpha}$ of the particle P is defined as.

$$\bar{\alpha} = \frac{\omega_2 - \omega_1}{t_2 - t_1} = \frac{\Delta\omega}{\Delta t} \quad \text{——} \quad (3)$$

In the translational motion, if we consider motion along a curve in three dimensions, then we have to deal with vector quantities r, v and a. Similarly, in the case of rotational motion in general we have to deal with vector quantities.

Rotation with constant Angular Acceleration

We shall now derive the fundamental kinematical formulae for rotational motion of a particle or rigid body around a fixed axis under the assumption that the angular acceleration is constant.

Let ω_0 be the angular speed at time $t = 0$. For constant acceleration $\alpha = \bar{\alpha}$

$$\alpha = \frac{\omega - \omega_0}{t}$$

$$\alpha t = \omega - \omega_0$$

$$\omega = \omega_0 + \alpha t \quad \text{——— (4)}$$

Since $\omega = \frac{d\theta}{dt}$

$$\frac{d\theta}{dt} = \omega_0 + \alpha t$$

$$d\theta = \omega_0 \, dt + \alpha t \, dt$$

Integrating the above equation

$$\theta = \omega_0 t + \frac{\alpha t^2}{2} \quad \text{——— (5)}$$

Also, the mean angular speed

$$\bar{\omega} = \frac{\omega_0 + \omega}{2} = \frac{\theta}{t}$$

$$\theta = \frac{(\omega_0 + \omega) t}{2} \quad \text{——— (6)}$$

Rewriting equ (6)

$$\omega + \omega_0 = \frac{2\theta}{t}$$

and rearranging equation (4)

we get,

$$\omega - \omega_0 = \alpha t$$

multiplying out the last two equations and rearranging

$$\omega^2 - \omega_0^2 = 2\alpha\theta \quad \text{——— (7)}$$

Euler's laws of motion

The equation of motion is given by

$$\frac{dJ}{dt} = T$$ is valid in an inertial reference frame.

——— (1)

In order to transform the vector J from an inertial frame to a rotating frame we can write

$$\left(\frac{dJ}{dt}\right)_f = \left(\frac{dJ}{dt}\right)_R + \omega \times J \quad \text{——— (2)}$$

where f – fixed axes

R – rotating axes

ω – angular velocity of rotating frame

$$T = \left(\frac{dJ}{dt}\right) + \omega \times J \quad \text{——— (3)}$$

for J as observed from the rotating frame.

Let the cartesian axes in the rotating frame lie along the principal axes 1, 2, 3. Then the equations can be written as

$$I_1 \frac{d\omega_1}{dt} + (I_3 - I_2)\,\omega_2\,\omega_3 = \tau_1 \quad \text{——— (4)}$$

$$I_2 \frac{d\omega_2}{dt} + (I_1 - I_3)\,\omega_1\,\omega_3 = \tau_2 \quad \text{——— (5)}$$

$$I_3 \frac{d\omega_3}{dt} + (I_2 - I_1)\,\omega_1\,\omega_2 = \tau_3 \quad \text{——— (6)}$$

The set of above equations are called Euler's equations

Applications of Euler's Equations

Conservation of Energy

Let torque $\tau = 0$. Then the Euler's Equations become

$$I_1 \dot{\omega}_1 + (I_3 - I_2)\,\omega_2\,\omega_3 = 0 \quad \text{——— (7)}$$

$$I_2 \dot{\omega}_2 + (I_1 - I_3)\,\omega_3\,\omega_1 = 0 \quad \text{——— (8)}$$

$$I_3 \dot{\omega}_3 + (I_2 - I_1)\,\omega_1\,\omega_2 = 0 \quad \text{——— (9)}$$

multiplying ⑦ by ω_1, ⑧ by ω_2 and ⑨ by ω_3 and adding

$$I\dot{\omega}_1\omega_1 + I_2\dot{\omega}_2\omega_2 + I_3\dot{\omega}_3\omega_3 = \frac{1}{2}\frac{d}{dt}\left(I_1\omega_1^2 + I_2\omega_2^2 + I_3\omega_3^2\right) = 0 \quad \text{——— (10)}$$

But the quantity within parenthesis on the right hand side of ⑩ is just twice the kinetic energy of rotation, referred to principal axes.

Hence ⑩ may be written as

$$\frac{dK}{dt} = 0 \quad \text{——— (11)}$$

$$K = \text{constant}$$

Conservation of Angular momentum

multiplying ⑦ by $I_1\omega_1$, ⑧ by $I_2\omega_2$ and ⑨ by $I_3\omega_3$ and adding

$$I_1^2\dot{\omega}_1\omega_1 + I_2^2\dot{\omega}_2\omega_2 + I_3^2\dot{\omega}_3\omega_3$$

$$= \frac{1}{2}\frac{d}{dt}\left(I_1^2\omega_1^2 + I_2^2\omega_2^2 + I_3^2\omega_3^2\right)$$

$$= \frac{1}{2} \frac{d}{dt} (J^2) = J\dot{J} = 0 \qquad (12)$$

Where we have used the fact that for principal axes

$$J = I_1 \omega_1 \bar{i} + I_2 \omega_2 \bar{j} + I_3 \omega_3 \bar{k}$$

According to (12) either $\dot{J} = 0$

$\dot{J} = 0$ since $T = 0$ and so J remains constant in magnitude; i.e. angular momentum is conserved.

Introduction to three - dimensional rigid body motion

We shall be concerned with the motion of a rigid body in space which consists of translation of a fixed point of the body, for example the centre of mass, plus rotation about an axis through a fixed point which may not be restricted to one direction. Thus, this type of motion is more general than that either to considered

If ω is the instantaneous angular velocity of the body about an axis through the origin, the velocity of the n^{th} particle referred to the origin is given by

$$V_n = \omega \times r_n \quad \text{——} \; (1)$$

Also, we know that the angular momentum of a rigid body with one point fixed about the instantaneous axis through the fixed point is given by

$$J = \Sigma m_n r_n \times V_n = \Sigma m_n r_n \times (\omega \times r_n) \quad \text{——} \; (2)$$

We now use the vector identity

$$A \times (B \times C) = B\,(A \cdot C) - C\,(A \cdot B)$$

With the substitution $A = r_n$; $B = \omega$; $C = r_n$

$$r_n \times (\omega \times r_n) = \omega r_n^2 - r_n (r_n \cdot \omega)$$

$$= (\omega_x i + \omega_y j + \omega_z k)(x_n^2 + y_n^2 + z_n^2) - (x_n i + y_n j + z_n k)(\omega_x x_n + \omega_y y_n + \omega_z z_n)$$

$$= \{\omega_x (y_n^2 + z_n^2) - \omega_y x_n y_n - \omega_z x_n z_n\} i + \{\omega_y (x_n^2 + z_n^2) - \omega_x x_n y_n - \omega_z y_n z_n\} j + \{\omega_z (x_n^2 + y_n^2) - \omega_x x_n z_n - \omega_y y_n z_n\} k.$$

Multiplying by m_n, summing over n and equating the coefficients of i, j and k to J_x, J_y, J_z respectively (since $J = J_x i + J_y j + J_z k$) we obtain the following relations.

$$J_x = \left\{ \Sigma m_n (y_n^2 + z_n^2) \right\} \omega_x + \left\{ -\Sigma m_n x_n y_n \right\} \omega_y + \left\{ -\Sigma m_n x_n z_n \right\} \omega_z$$

$$= I_{xx} \omega_x + I_{xy} \omega_y + I_{xy} \omega_z \quad \text{—— (3)}$$

$$J_y = \left\{ -\Sigma m_n x_n y_n \right\} \omega_x + \left\{ \Sigma m_n (x_n^2 + z_n^2) \right\} \omega_y + \left\{ -\Sigma m_n y_n z_n \right\} \omega_z$$

$$= I_{xy} \omega_x + I_{yy} \omega_y + I_{yz} \omega_z \quad \text{—— (4)}$$

$$J_z = \left\{ -\Sigma m_n x_n z_n \right\} \omega_x + \left\{ -\Sigma m_n y_n z_n \right\} \omega_y + \left\{ \Sigma m_n (x_n^2 + y_n^2) \right\} \omega_z$$

$$= I_{xy} \omega_x + I_{yz} \omega_y + I_{zz} \omega_z \quad \text{—— (5)}$$

Moments of Inertia:

In equ 3, 4, and 5, the quantities

$$I_{xx} = \Sigma m_n (y_n^2 + z_n^2), \quad I_{yy} = \Sigma m_n (z_n^2 + x_n^2), \quad I_{zz} = \Sigma m_n (x_n^2 + y_n^2) \quad \text{—— (6)}$$

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are called the moments of inertia about the x, y and z axis respectively.

The quantities

$$\left.\begin{aligned} I_{xy} &= -\Sigma m_n x_n y_n = I_{yx} \\ I_{yz} &= -\Sigma m_n y_n z_n = I_{zy} \\ I_{zx} &= -\Sigma m_n z_n x_n = I_{xz} \end{aligned}\right\} \qquad \text{———} \quad (7)$$

are called products of inertia.

Moment of inertia Matrix

It can be written as

$$\begin{bmatrix} I_{xx} & I_{xy} & I_{xz} \\ I_{yx} & I_{yy} & I_{yz} \\ I_{zx} & I_{zy} & I_{zz} \end{bmatrix}$$

Each quantity is called an element of the matrix or tensor.

Application

Three dimensional analyses are needed to determine the forces and mements on the gimbals of gyroscopes, the joints of robotic welders and the supports of radio telescopes.

Unit - I

Vector mechanics of a particle

Transformation of Scalars and vectors under Rotation transformation.

Vectors and Scalar

A Scalar is a quantity that has only magnitude

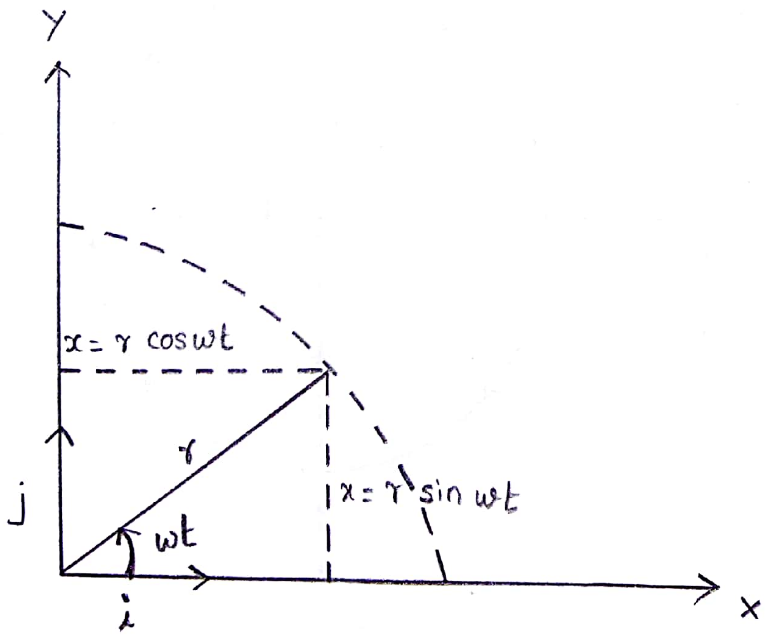
Ex: Distance, mass, temperature, time etc,

A vector is a quantity that has both magnitude and direction

Ex: Displacement, force, ~~velo~~ Velocity etc.,

Rotational Motion

Rotational motion plays an important role in physics. Here the simplest and most important case is uniform circular motion at constant speed.



Consider a particle moving in the xy plane according to $r = r(\cos\omega t\, i + \sin\omega t\, j)$, where r and ω are constants

$$\therefore |r| = [r^2 \cos^2\omega t + r^2 \sin^2\omega t]^{1/2}$$

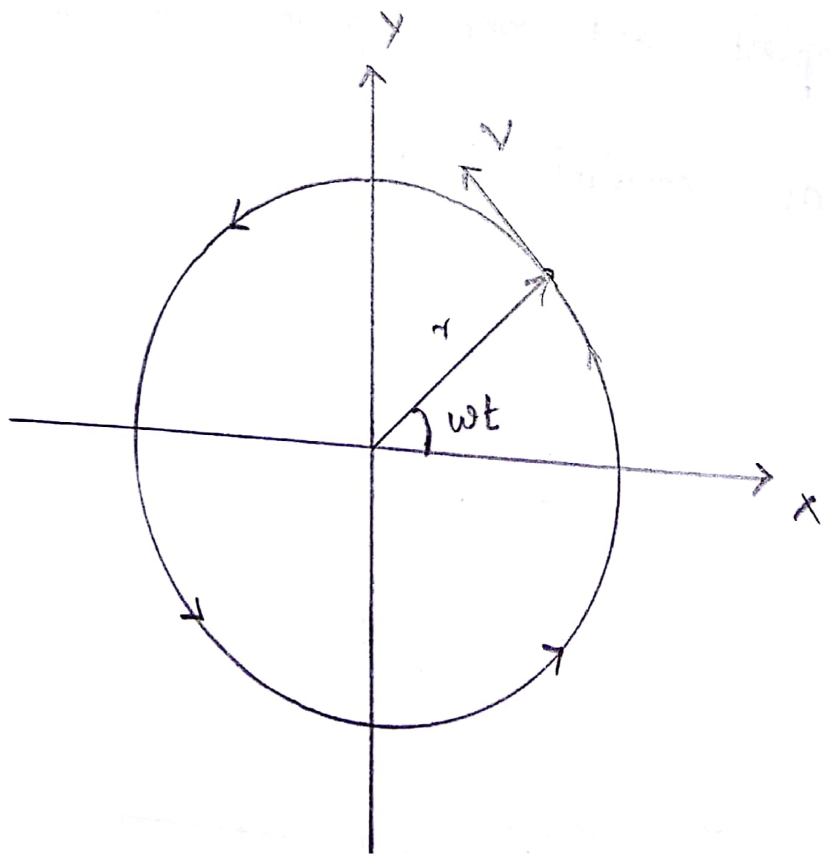
using the familiar identity

$$\sin^2\theta + \cos^2\theta = 1$$

$$|r| = [r^2(\cos^2\omega t + \sin^2\omega t)]^{1/2}$$

$$= [r^2]^{1/2}$$

$$\therefore |r| = r = \text{constant}$$



Now the particle moves clockwise around the circle starting from $(r, 0)$ at $t=0$. It tranverses the circle in a time T such that $\omega = \frac{2\pi}{T}$ is called angular velocity of the motion.

The time required to execute one complete cycle is called the time period.

Then the velocity v is

$$V = r\omega\,(-\sin\omega t\,\bar{i} + \cos\omega t\,\bar{j})$$

Since

$$\cancel{r.v = r^2\omega\,(-\cos}$$

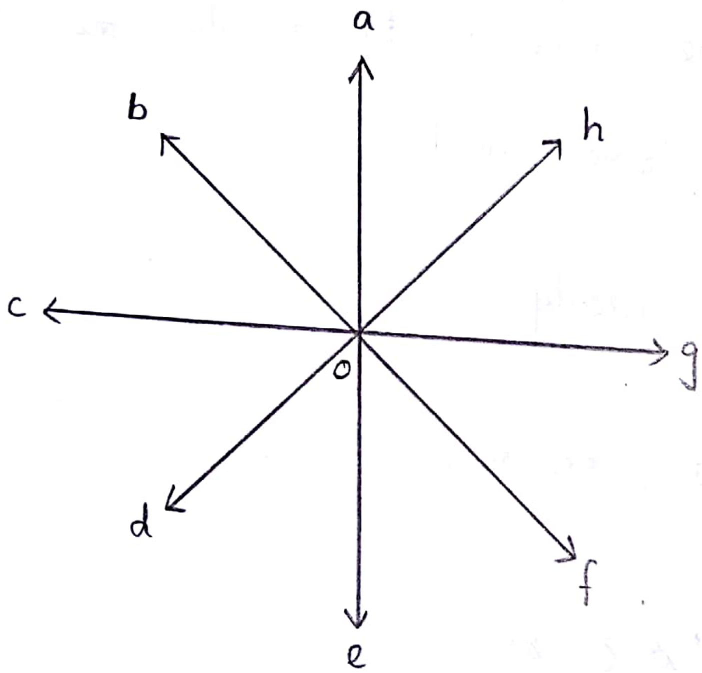
$$\cancel{r.v = (r\cos\omega t + r\sin\omega t)\,(}$$

$$r.v = r^2\omega\,(-\cos\omega t\,\sin\omega t + \sin\omega t\,\cos\omega t)$$

$$= r^2\omega\,(0)$$

$$r.V = 0$$

$\therefore$ $\frac{dr}{dt}$ is perpendicular to r. We conclude that the magnitude of r is constant. so that the only possible change in r is due to rotation. The same velocity vectors are drawn from a common origin.



Suppose a vector A(t) has constant magnitude A. The only way A(t) can change in time is by rotating $\frac{dA}{dt}$. The direction of $\frac{dA}{dt}$ is always perpendicular to A.

The magnitude of $\frac{dA}{dt}$ can be found by the following equation

$$\Delta A = A(t+\Delta t) - A(t)$$

using the angle $\Delta\theta$

$$|\Delta A| = 2A \sin \frac{\Delta\theta}{2}$$

$$\left[\Delta\theta << 1 \ , \quad \sin\frac{\Delta\theta}{2} \approx \frac{\Delta\theta}{2} \right]$$

$$|\Delta A| = \cancel{2}A \cdot \frac{\Delta\theta}{\cancel{2}}$$

$$= A\,\Delta\theta$$

and

$$\left|\frac{\Delta A}{\Delta t}\right| = A \cdot \frac{\Delta\theta}{\Delta t}$$

$$\frac{dA}{dt} = A \cdot \frac{d\theta}{dt}$$

$\frac{d\theta}{dt}$ is called the angular velocity of A

For finding the rotating vector

$$\left|\frac{dr}{dt}\right| = r\frac{d}{dt}(\omega t) = r\omega$$

Let the scalar c and the vectors A and B be the functions of time.

$$\frac{d}{dt}(cA) = \frac{dc}{dt} . A + c . \frac{dA}{dt}$$

$$\frac{d}{dt}(A.B) = \frac{dA}{dt} . B + A \frac{dB}{dt}$$

$$\frac{d}{dt}(A \times B) = \frac{dA}{dt} \times B + A \frac{dB}{dt}$$

We see again that if $\frac{dA}{dt}$ is perpendicular to A, then the magnitude of A is constant.

Forces in nature

There are four types forces in nature. They are

1. Gravitational force
2. Electromagnetic force
3. strong Nuclear force
4. Weak Nuclear force.

Newton's laws and its completeness in describing particle motion

i) Newton's first law

In the absence of a resultant force a body keeps moving with a uniform velocity

ii) Newton's Second law

A body acted upon by a force equals to the rate of change of momentum

$$F = ma$$

iii) Newton's Third law

To every action there is an equal and opposite reaction

Mechanics of a particle

Conservation of Linear momentum

For the case of a single particle of mass m, Newton's Second Law of motion is, "Rate of change of momentum is equal to the applied force."

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

If no force is applied then,

$$\frac{d}{dt}(m\dot{r}) = 0$$

where $m\dot{r} = P$; constant vector

Conservation Theorem for the Linear momentum

If the total force F is zero, then $\dot{P}=0$ and the linear momentum is conserved.

Conservation of Angular momentum

We shall consider the angular momentum J of a particle. It is also called the moment of momentum and is given by the vector product

$$J = r \times m\dot{r} \qquad \tau = \frac{dJ}{dt}$$

J = constant vector ; τ = Total Torque

Conservation Theorem for the Angular momentum

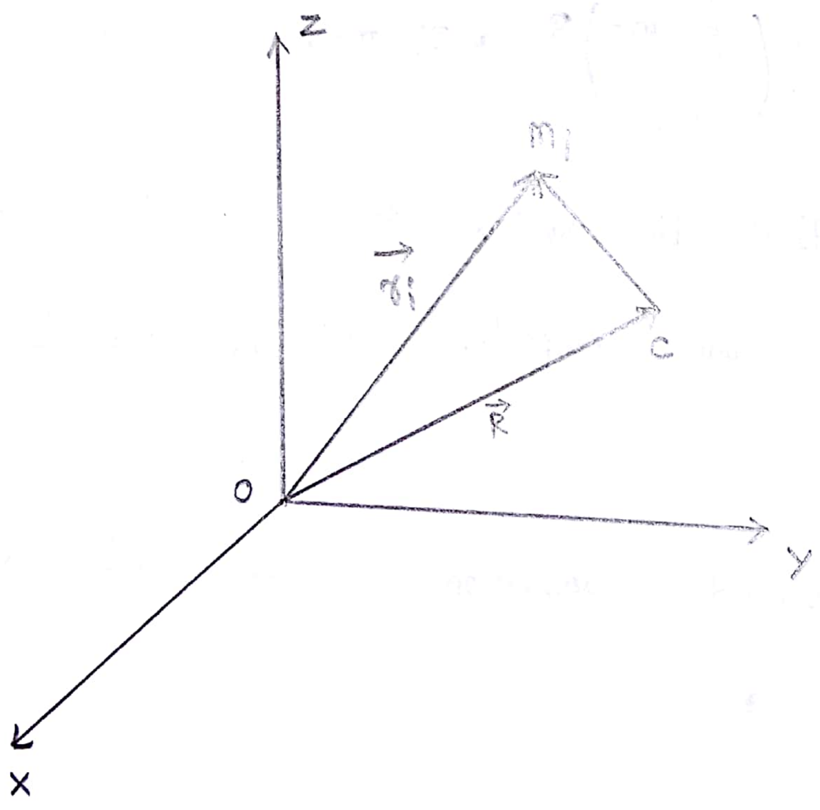
If the total torque τ is zero, then $\dot{J} = 0$ and the angular momentum J is conserved.

Energy conservation Theorem for a particle

If the forces acting on a particle are conservative, then the total energy of the particle is conserved

Centre of mass of a system of particles

The concept of centre of mass of a body plays an important role in dynamics. Consider a cartesian co-ordinate system oxyz. The co-ordinates of n particles of masses $m_1, m_2 \ldots m_n$ are indicated by the position vectors $r_1, r_2 \ldots r_n$ respectively



The vector r_i is the position vector to the particle of mass m_i. Choose a point C such that the position vector from O to C is R. Since the three vectors from a closed triangle.

$$r_i = R + r_{ci} \quad \text{—— (1)}$$

multiplying both sides by m_i

$$m_i r_i = m_i R + m_i r_{ci} \quad \text{—— (2)}$$

For the remaining particles similar equations can be written by adding them all

$$\sum_{i=1}^{n} m_i r_i = \left(\sum_{i=1}^{n} m_i\right) R + \sum_{i=1}^{n} m_i r_{ci} \quad \text{—— (3)}$$

observe that the vector R is not being summed since it is the same irrespective of the particle under considerations.

If the second summation in the right side is zero. Then equ 3

$$\sum_{i=1}^{n} m_i r_{ci} = 0$$

then the point C is defined as the centre of mass.

$$\sum_{i=1}^{n} m_i = M$$

the total mass of all particles.

$$R = \frac{1}{M} \sum_{i=1}^{n} m_1 r_1$$

where R is the position vector of the centre of mass from the origin O

$$\therefore \quad F = M\ddot{R}$$

if $F = M\ddot{R} = 0$, then $\dot{R}$ = constant, that is centre of mass moves with constant velocity.

Solving Newton's equations of motion in polar coordinates.

Let us first consider the problem of motion in one dimension under the action of a force. According to Newton's Law

$$F = ma \quad \text{——} \quad (1)$$

Equ (1) is a differential equation for the position function $x(t)$. It is a second order differential equation

We may define the potential energy associated with the force f as follows

$$V(x) = -\int_{x_0}^{x} f(s)\, ds$$

where x_0 is a reference point.

The total mechanical energy of the mass during its motion is given by the sum of its kinetic and potential energies

$$E(t) = \frac{1}{2} m v(t)^2 + V(x(t))$$

$$= \frac{1}{2} m v(t)^2 + m g x(t)$$

Potential energy function

a force field $F : R^n \to R^n$ is conservative if there exists a
vector
scalar-valued potential function V

$$F = -\nabla V$$

questions	opt1	opt2	opt3	opt4	opt5
If a body is subjected to plastic impact, _______	only kinetic energy is conserved	only momentum is conserved	only kinetic energy is conserved	one of the above	only momentum is conserved
The total momentum of a system __________, if no external impressed force acts on it.	increases	decreases	remains constant	none of the above	remains constant
According to the principle of conservation of energy, under the action of _________ force, the sum of P.E and K.E of a particle remains constant.	conservative force	dissipative force	frictional force	air resistance force	conservative force
A stone undergoes projectile motion when thrown from top of the building. If it strikes the ground surface at a distance away from the building then its horizontal direction is __________	less than range	more than range	same as range	unpredictable	more than range
The radial component of velocity for a particle moving in circular path is ______	constant	radius itself	variable	zero	zero
If an elevator travels at constant velocity, the normal reaction R is given as ______	m (g +a)	m (g - a)	mg	ma	mg
A block sliding down an inclined plane has acceleration _________ acceleration due to gravity.	less than	greater than	same as	none of the above	less than
When acceleration is _______, velocity of a particle is constant.	constant but non zero	maximum	zero	none of the above	zero
Which of the following statements is false about forces/couple?	Moment of couple is free vector	Resultant and equilibrant are equal in magnitude and direction	Resultant of a couple is always zero	Parallelogram law is to be proved experimentally	Resultant and equilibrant are equal in magnitude and direction
Which of the following statements is true for flat belts?	They are used for short distances between the pulleys	They have high efficiency	They are used in lathe machines	All of the above	They are used in lathe machines
Which of the following force(s) is a type of conservative force?	Frictional force	Gravity force	Both a. and b.	None of the above	Gravity force
Which of the following factors are related by work energy principle?	force, displacement and time	force, velocity, time and mass	force, velocity, displacement	displacement, time and mass	force, velocity, displacement
What are the limitations of string law?	Direction of motion cannot be specified	Valid only when more than three particles are connected by a single string	Both a. and b.	None of the above	Direction of motion cannot be specified
Which of the following conditions do not change the effect of couple?	Shifting of couple to a new position in its plane	Shifting of couple to a parallel plane	Rotation of couple in its plane	All of the above	All of the above
Frictional force depends on ________	surface area in contact	roughness of surface	both a. and b.	none of the above	roughness of surface
Which motion has magnitude of static frictional force directly proportional to normal reaction?	Actual motion	Impending motion	Both a. and b.	None of the above	Impending motion
If a body in equilibrium condition is acted by three forces at three points, then the line of action of these forces should be _____	always concurrent	always parallel	concurrent or parallel	none of the above	concurrent or parallel
Which of the following laws derive impulse moment principle?	Newton's 3rd law	Newton's 2nd law	Newton's 1st law	All of the above	Newton's 2nd law
The force for which work done is independent of _______ is called as conservative force.	distance	path	time	all of the above	path
According to work energy principle, a particle of mass m when subjected to unbalanced force system, the work done during displacement by all forces is equal to change in ____________ during displacement.	gravitational energy	kinetic energy	mechanical energy	potential energy	kinetic energy
Which of the following is represented by the area under force-displacement diagram?	Impulse	Momentum	Power	Work done	Work done
In projectile motion, which of the following factors affecting the actual path of motion are neglected?	Curvature of earth	Rotation of earth	Wind resistance	All of the above	All of the above
When motion is _______, the normal component of acceleration is zero.	curvilinear	rotational	rectilinear	translation	rectilinear
According to which law, every action has an equal and opposite reaction?	Newton's first law	Newton's second law	Newton's third law	None of the above	Newton's third law
A particle moving with respect to fixed frame of reference is called as __________	absolute motion	relative motion	rectilinear motion	none of the above	absolute motion
During unidirectional motion, the displacement and distance traveled by a particle with uniform acceleration is ______	different	same	variable	none of the above	same
The rate of change of __________ with respect to time is called as jerk.	acceleration	density	displacement	volume	acceleration
If a material has no uniform density throughout the body, then the position of centroid and center of mass are ________	identical	not identical	independent upon the density	unpredictable	not identical
Which of the following laminas do not have centroid at its geometrical centre?	Circle	Equilateral triangle	Right angled triangle	None of the above	Right angled triangle
Couple is formed due to two ______	like, parallel and non-collinear forces of same magnitude	like, perpendicular and collinear forces of different magnitude	unlike, parallel and non-collinear forces of same magnitude	unlike, perpendicular and non-collinear forces of different magnitude	unlike, parallel and non-collinear forces of same magnitude
Varignon's theorem is used to find ________	direction of resultant force	location of resultant force	magnitude of resultant force	nature of resultant force	location of resultant force
Forces passing through a common point are known as _____	collinear forces	co-planer forces	concurrent forces	none of the above	concurrent forces
The resultant of two forces is the diagonal formed on two vectors of those forces.	parallelogram law	resolution	cosine law	triangle law	parallelogram law
The forces are in equilibrium only when equal in magnitude ,opposite in direction and collinear in action.	principle of transmissibility of a force	axioms of mechanics	characteristics of force	scalar and vector quantities	axioms of mechanics
Is a convenient corollary of the parallelogram law.	parallelogram law	resolution	cosine law	triangle law	triangle law
The determination of the resultant of 3 or more concurrent forces that are not collinear.	resultant of concurrent,coplanar	collinear forces system	parallel,coplanar	non concurrent,coplanar	resultant of concurrent,coplanar
It is defined as the time rate of change of velocity	displacement	speed	acceleration	none of the above	acceleration
The _______ is a force that results from the attraction between the mass of the body and the mass of the earth.	weight	density	volume	none of the above.	weight
It is defined as, regardless of the forces acting on a fluid, the fluid continues to flow	Newtonian fluid	non-Newtonian fluid	Lagrangian fluid	non-Lagrangian fluid	Newtonian fluid

questions	opt1	opt2	opt3	opt4	opt5
When a particle moves along a straight path, then the particle has	tangential acceleration only	centripetal acceleration only	both tangential and centripetal acceleration	none of the mentioned	tangential acceleration only
When a particle moves with a uniform velocity along a circular path, then the particle has	tangential acceleration only	centripetal acceleration only	both tangential and centripetal acceleration	none of the mentioned	centripetal acceleration only
When the motion of a body is confined to only one plane, the motion is said to be	plane motion	rectilinear motion	curvilinear Motion	none of the mentioned	plane motion
_______________ is the simplest type of motion and is along a straight line path.	plane motion	rectilinear motion	curvilinear Motion	none of the mentioned	rectilinear motion
_________________ is the motion along a curved path.	plane motion	rectilinear motion	curvilinear Motion	none of the mentioned	curvilinear Motion
Displacement of a body is a ___________ quantity.	scalar	vector	scalar and vector	none of the mentioned	vector
It is defined as the science which considers the effects of forces on rigid bodies	Kinetics	Engineering Mechanics	Statics	Dynamics.	Engineering Mechanics
It considers the effects is distribution of forces on rigid bodies which are and remain at rest.	Dynamics	kinetics	statics	kinematics	statics
It is defined as a definite amount of matter the parts which are fixed in position relative to each other.	kinematics	force system	rigid body	dynamics	rigid body
It is the branch of mechanics which deals with the study of bodies in motion	statics	dynamics	kinetics	none of the above.	dynamics
It is defined as a condition in which the resultant of a system of force is equal to zero.	resultant	axes	Equilibrium	displacement	Equilibrium
The forces by which determine how the loads applied to a structure are distributed throughout the structure.	force system	analysis of structure	rigid body	none of the above	analysis of structure
In _____ the members are subjected to bending action.	forces	trusses	frames	structure	frames
In _____ the internal force in a bar is directed along the axis of bars.	frame	structure	forces	trusses	trusses
It may be defined as the contact resistance exerted by one body upon a second body when the second body moves or tends to move past the first body.	resistance	pressure	friction	motion	friction
The term ______ is used when rotating to the center of gravity of a weightless figure such as a line, an area or a volumes.	centroid	axis	area	base	centroid
The moment of inertia is sometimes called the _______________.	parallel axis	second moment of area	polar moment of inertia	none of the above	second moment of area
The term ________ is used to describe another mathematical expression appears and appears must frequently in column formulas.	radius of gyration	centroidal axis	moments of inertia	mohr's circle	radius of gyration
The pendulum clock was developed by ________	Robert Hooke	Hygens	Galileo	Aristotle	Hygens
It is the geometry of motion.	static	kinematics	kinetic	dynamics	kinematics
It is the branch of mechanics that relates the force acting on a body to its mass and acceleration.	Dynamics	statics	kinematic	kinetic.	Dynamics
The ____ expresses the relation between the external forces applied to a system of particles and the effective force on each particle of the system.	Newtons Law of Motion	D'alemberts principle	Inertia force of particle	none of the above.	Newtons Law of Motion
It is defined as the motion of a rigid body in which a straight live passing through any two point of the body always remain parallel to its initial position.	Translation	velocity	acceleration	none of the above	Translation
The motion of translating body moving in a straight line is called _______.	rectilinear translation	curve linear translation	parallel axis	kinematic equation of motion	rectilinear translation
The path of the translating body is curved, the motion becomes _____.	rectilinear translation	parallel axes	curve linear translation	none of the above.	curve linear translation
The area under a v-t curve represents the change in ______	displacement	velocity	mass	acceleration	displacement
The area under an a-t curve represents the change in _______	acceleration	displacement	velocity	none of the above.	acceleration
It is define as that motion of rigid body in which the particles move in a circular paths with their centers on a fixed straight line.	translation	rotation	acceleration	none of the above.	rotation
It is a motion which repeats itself after a define internal of time	frequency	vibration	precession	none of the above	none of the above
The maximum displacement of the body from its equilibrium position is known as the ____ of the vibration.	frequency	acceleration	amplitude	force	amplitude
Each repetition of the motion is called a _______.	period	vibrations	cycle	none of the above	period
The ____ of the vibration is the reciprocal of the period and is measured in cycles per second.	amplitude	frequency	vibrations	none of the above	frequency
The time required to complete one oscillation backward and forward is called the _____ of the motion.	cycle	vibrations	period	none of the above.	period
The condition existing when the impressed frequency is equal to the natural frequency is known as_______.	resonance	displacement	cycle	amplitude	resonance
The speed of rotation at which resonance occurs is called ________.	cycle	vibrations	critical speed	rotation	critical speed
. __________ is the time rate at which work is done on a body.	motion	cycle	power	resultant	power
It is the ratio of power output to power input.	amplitude	frequency	efficiency	none of the above.	efficiency
It is defined as that which changes, or tends to change, the state of motion of a body.	acceleration	force	speed	velocity	velocity
An axis passing through the centroid of an area is known as a _________	parallel axis	centroidal axis	radius	none of the above	centroidal axis
It is defined as the time rate of change of displacement.	speed	velocity	distance	none of the above	velocity
It is defined as the time rate of change of velocity	displacement	speed	acceleration	none of the above	acceleration
The _______ is a force that results from the attraction between the mass of the body and the mass of the earth.	weight	density	volume	none of the above.	weight

Unit - III

Statics

Statics which concerns the equilibrium of bodies under the action of forces.

Free-body-diagram

The free body diagram method is the key to the understanding of mechanics.

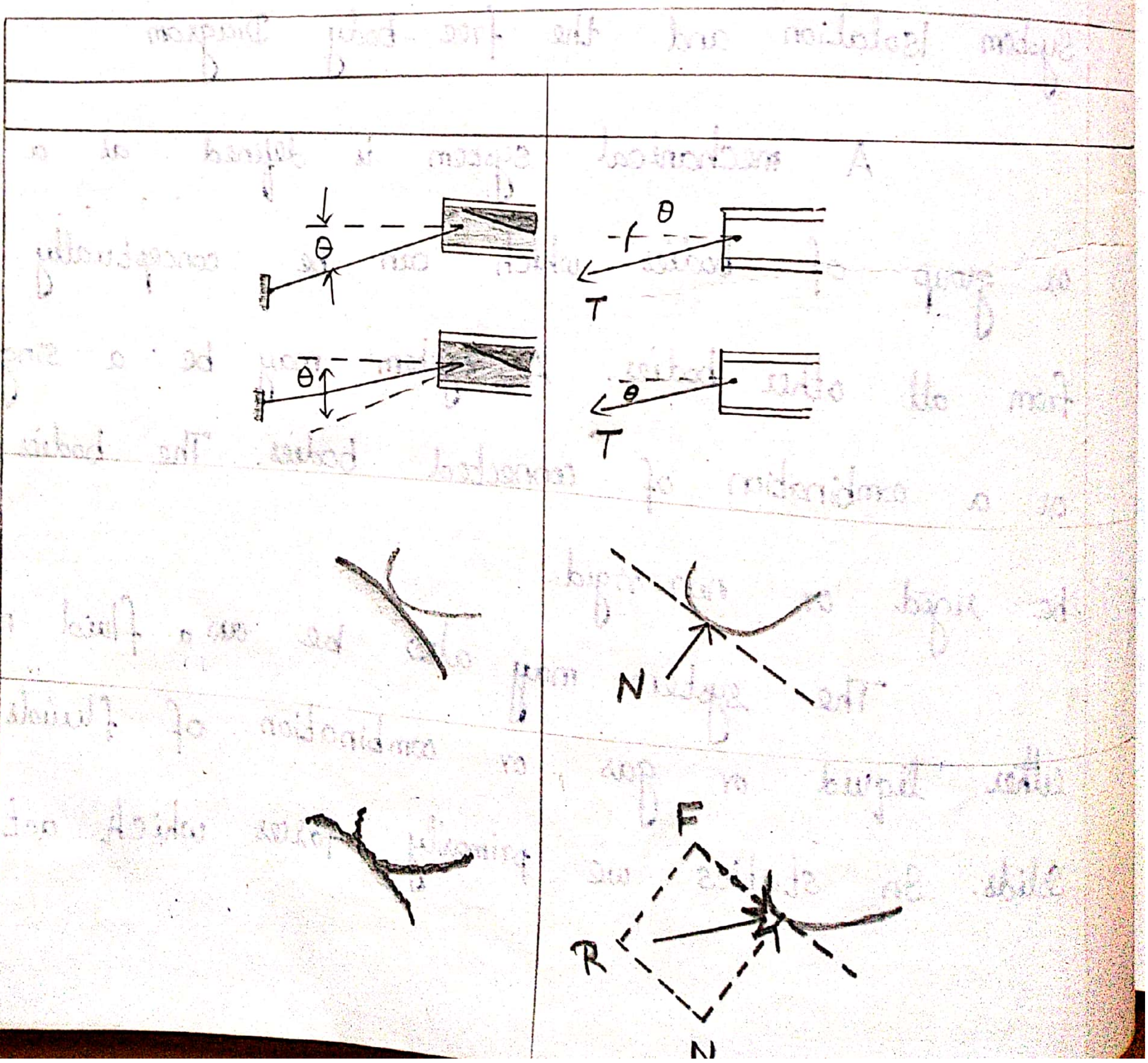
The diagram of such an isolated body with the representation of all external forces acting on it is called a free-body diagram.

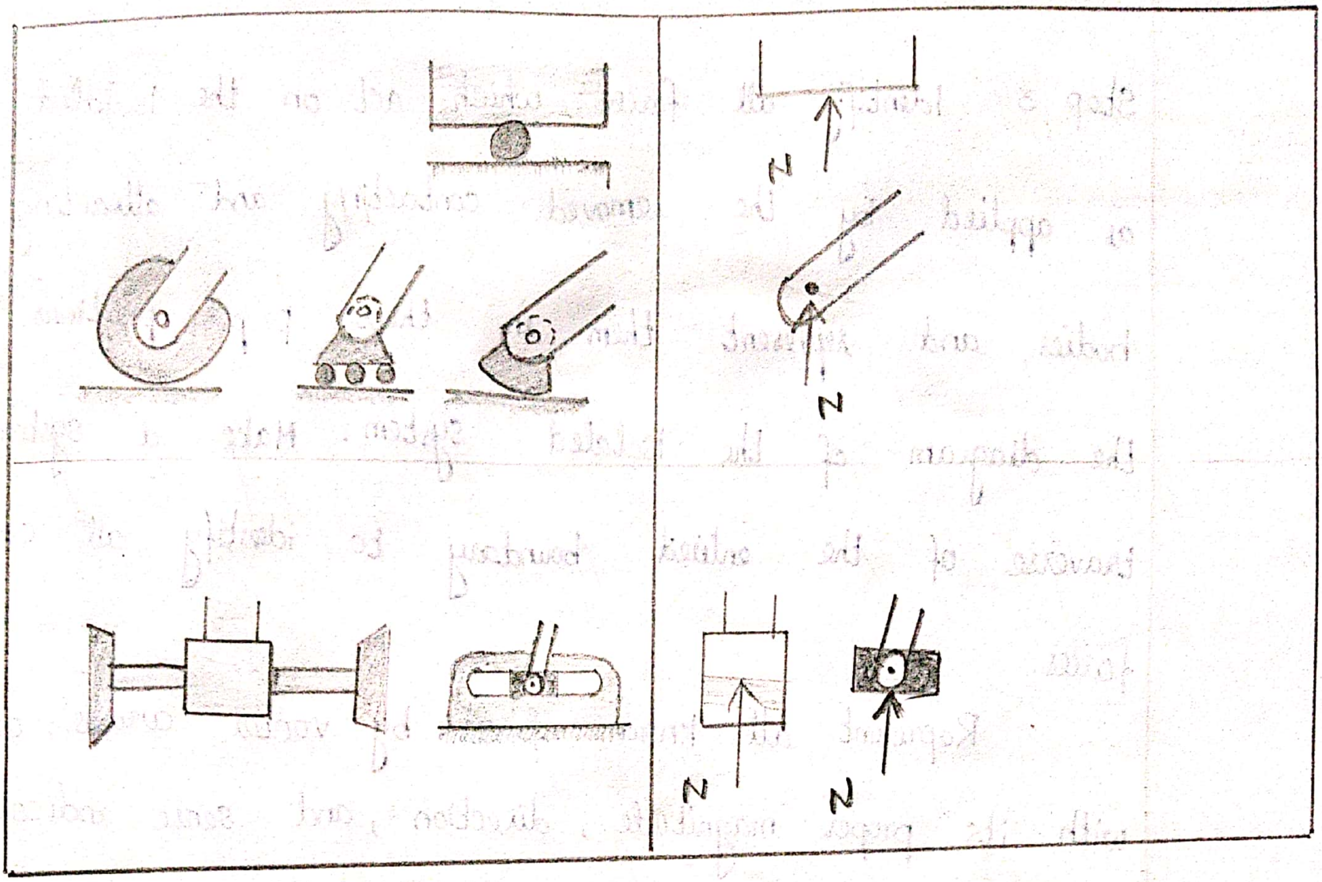
System Isolation and the free-body Diagram

A mechanical system is defined as a body or group of bodies which can be conceptually isolated from all other bodies. A system may be a single body or a combination of connected bodies. The bodies may be rigid or non-rigid.

The system may also be ~~an~~ a fluid mass, either liquid or gas, or combination of fluids and solids. In statics we primarily forces which act on rigid bodies at rest, although we also study forces acting on fluids in equilibrium.

Before attempting to draw a free-body diagram we must recall the basic charateristics were described in Art. Forces can be either internal or External to the system under consideration. Application of force is accompanied by reactive force, and both applied and reactive force may be either concentrated or distributed.





Construction of free-Body diagrams

The full procedure for drawing a free-body diagram which isolates a body or system consists of the following steps

step 1 : Decide which system to isolate. The system chosen should usually involve one or more of the desired unknown quantities.

step 2 : Next isolate the chosen system by drawing a diagram which represents its complete external boundary. This boundary defines the isolation of the system from all other attracting or contacting bodies, which are considered ~~removed~~.

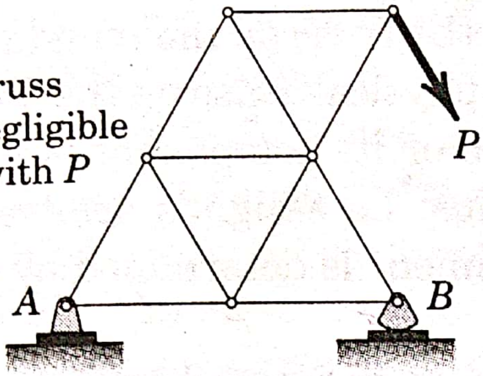
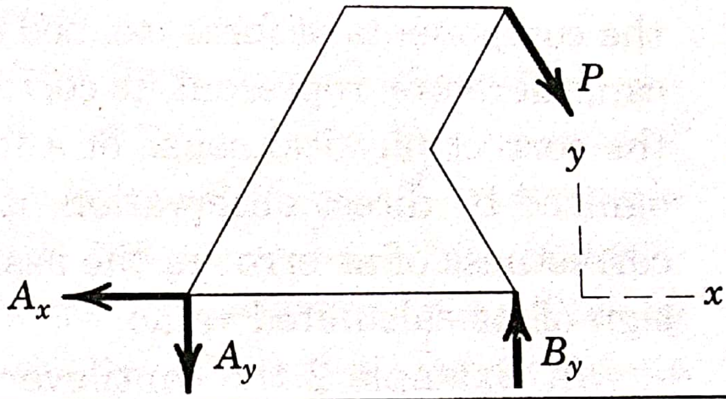
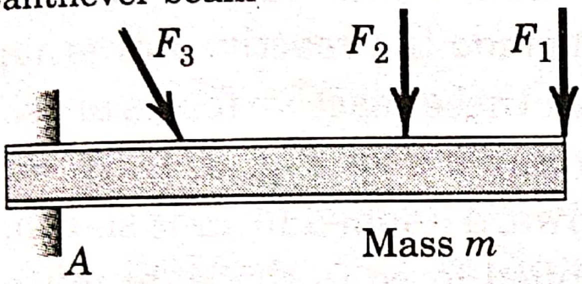
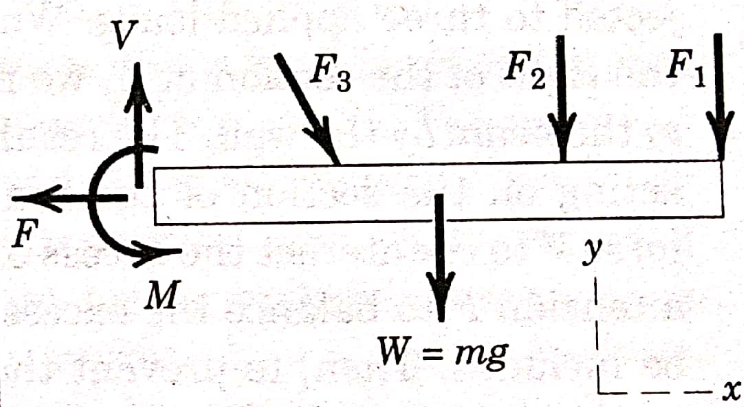
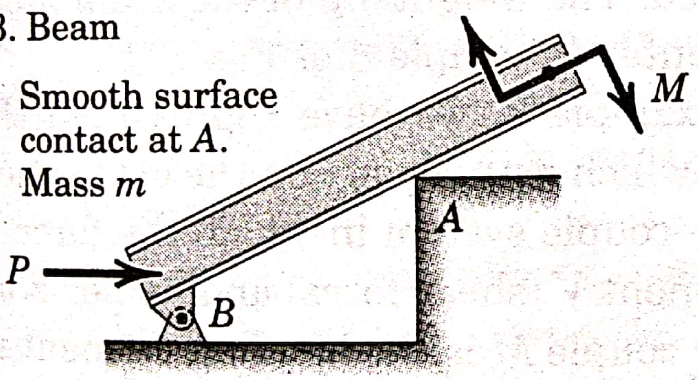
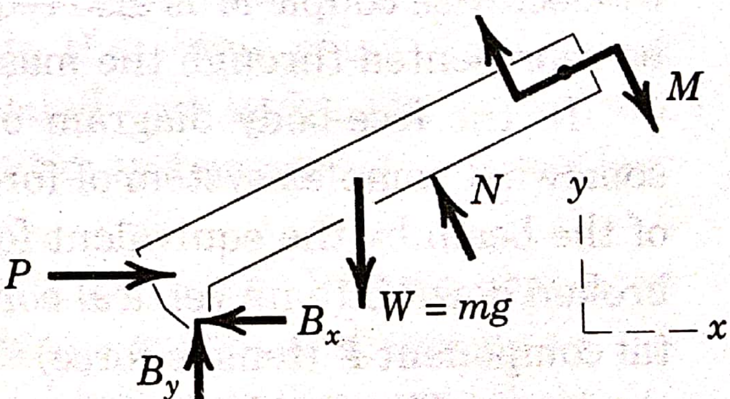
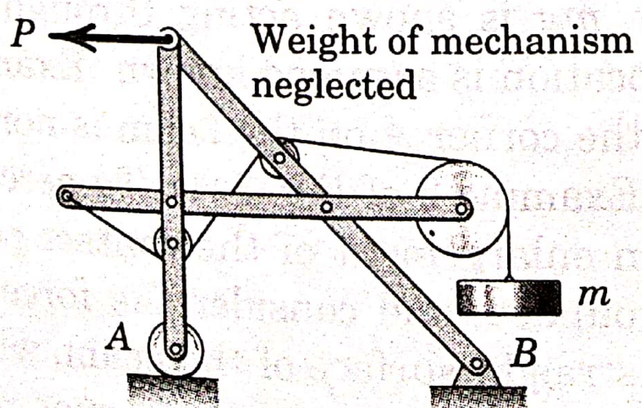
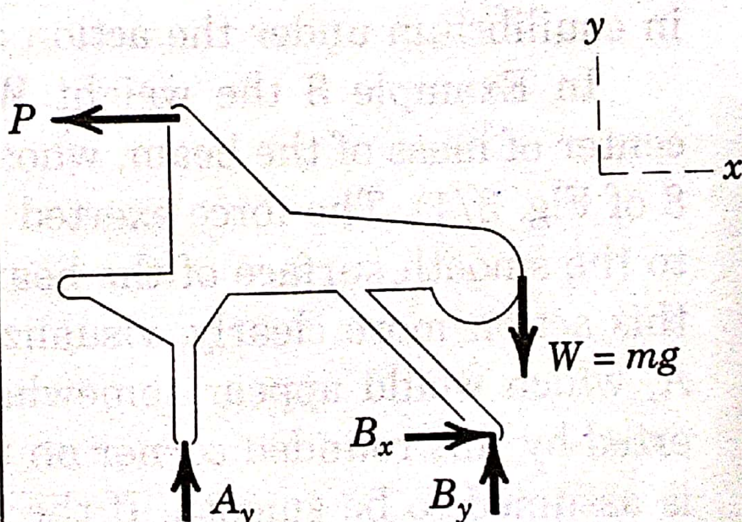
Step 3: Identify all forces which act on the Isolated system as applied by the removed contacting and attracting bodies, and represent them in their proper positions on the diagram of the Isolated system. Make a systematic traverse of the entire boundary to identify all contact forces.

Represent all known forces by vector arrows, each with its proper magnitude, direction, and sense indicated.

Step 4:

Show the choice of coordinate axes directly on the diagram. pertinent dimensions may also be represented for convenience. However, that the free-body diagram serves the purpose of focusing attention on the action of the external forces, and therefore the diagram should not be cluttered with excessive extraneous information. clearly distinguish force arrows from arrows representing quantities other than forces. For this purpose a colored pencil may be used.

SAMPLE FREE-BODY DIAGRAMS

Mechanical System	Free-Body Diagram of Isolated Body
1. Plane truss Weight of truss assumed negligible compared with P 	
2. Cantilever beam 	
3. Beam Smooth surface contact at A. Mass m 	
4. Rigid system of interconnected bodies analyzed as a single unit Weight of mechanism neglected 	

Equilibrium Conditions in Two Dimensions.

We defined equilibrium as the condition in which the resultant of all forces and moments acting on a body is zero. stated in another way, a body is in equilibrium if all forces and moments applied to it are in balance.

The vector equations of equilibrium which in two dimensions may be written in scalar form as

$$\Sigma F_x = 0 \quad \Sigma F_y = 0 \quad \Sigma M_o = 0$$

The above conditions are necessary because, if they are not satisfied, there can be no force or moment balance.

categories of Equilibrium

category 1

Equilibrium of collinear forces, clearly requires only the one force condition equation in the direction of the forces (x-direction), since all other equations are automatically satisfied.

Category 2:

Equilibrium of forces which lie in a plane (x-y plane) and are concurrent at a point O, requires the two force equations only, since the moment sum about O, that is about a z-axis through O, is necessarily zero.

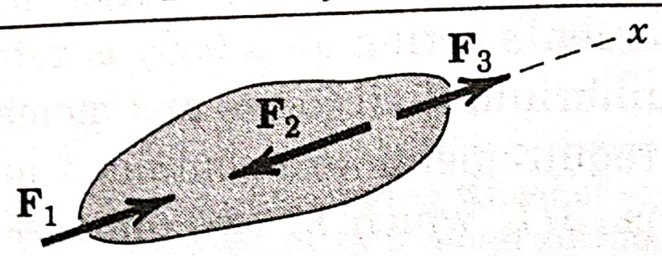
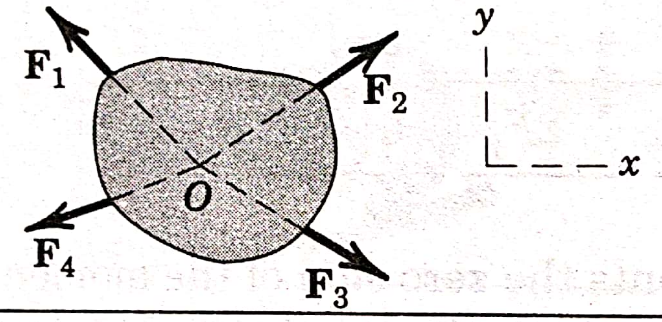
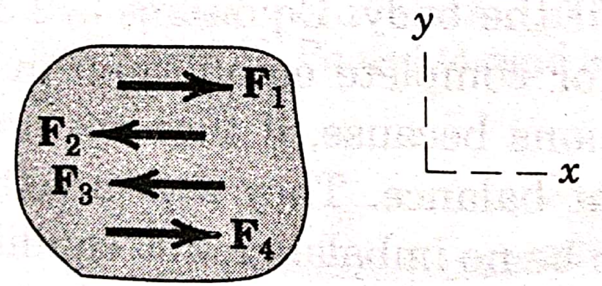
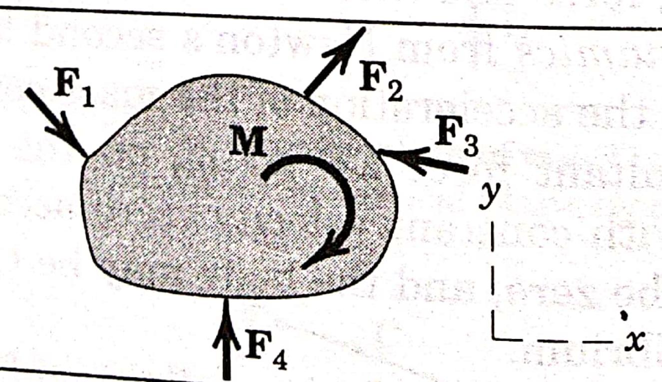
Category 3:

Equilibrium of parallel forces in a plane, requires the one force equation in the direction of the forces (x-direction) and one moment equation about an axis (z-axis) normal to the plane of the forces.

Category 4:

Equilibrium of a general system of forces in a plane (x-y) requires the two force equations in the plane and one moment equation about an axis (z-axis) normal to the plane.

CATEGORIES OF EQUILIBRIUM IN TWO DIMENSIONS

Force System	Free-Body Diagram	Independent Equations
1. Collinear		$\Sigma F_x = 0$
2. Concurrent at a point		$\Sigma F_x = 0$ $\Sigma F_y = 0$
3. Parallel		$\Sigma F_x = 0$ $\Sigma M_z = 0$
4. General		$\Sigma F_x = 0$ $\Sigma M_z = 0$ $\Sigma F_y = 0$

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Equilibrium Conditions in Three Dimensions.

We now extend our principles and methods developed for two-dimensional equilibrium to the case of three-dimensional equilibrium. The general conditions for the equilibrium of a body require that the resultant force and resultant couple on a body in equilibrium be zero.

These two vector equations of equilibrium and their scalar components may be written as

$$\Sigma F = 0 \quad (\text{or}) \quad \begin{cases} \Sigma F_x = 0 \\ \Sigma F_y = 0 \\ \Sigma F_z = 0 \end{cases}$$

$$\Sigma M = 0 \quad (\text{or}) \quad \begin{cases} \Sigma M_x = 0 \\ \Sigma M_y = 0 \\ \Sigma M_z = 0 \end{cases}$$

The first three scalar equations state that there is no resultant force acting on a body in equilibrium in any of the three coordinate directions.

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The second three Scalar equations express the further equilibrium requirement that there be no resultant moment acting on the body about any of the coordinate axes or about axes parallel to the coordinate axes. These six equations are both necessary and sufficient conditions for complete equilibrium.

The six Scalar relationships are independent conditions because any of them can be valid without the others.

In applying the vector form of the above equation we first express each of the forces in terms of the coordinate unit vectors i, j, and k. For the first equation, $\Sigma F = 0$, the vector sum will be zero only if the coefficients of i, j, and k in the expression are, respectively, zero.

categories of Equilibrium

Category 1:

Equilibrium of forces all concurrent at point O, requires all three force equations, but no moment equations because the moment of the forces about any axis through O is zero.

category 2,

Equilibrium of forces which are concurrent with a line, requires all equations except the moment equation about that line, which is automatically satisfied.

category 3.

Equilibrium of parallel forces, requires only one force equation, the one in the direction of the forces (x- direction) and two moment equations about the axes (y and z) which are normal to the direction of the forces.

category 4.

Equilibrium of a general system of forces, requires all three force equations and all three moment equations.

Friction.

The ~~common~~

Friction

Friction is the force that opposes the relative motion or tendency of such motion of two bodies surfaces in contact. It is not, however, a fundamental force, as it originates from the electromagnetic forces and exchange force between atoms.

Types of Friction

i) Dry Friction

ii) Fluid Friction

iii) Internal Friction

Limiting Friction

When a body just starts to slide over the surface of another one, the frictional force is developed between the surfaces. The maximum value of that frictional force is known as the limiting friction (or) static friction.

Laws of Limiting Friction

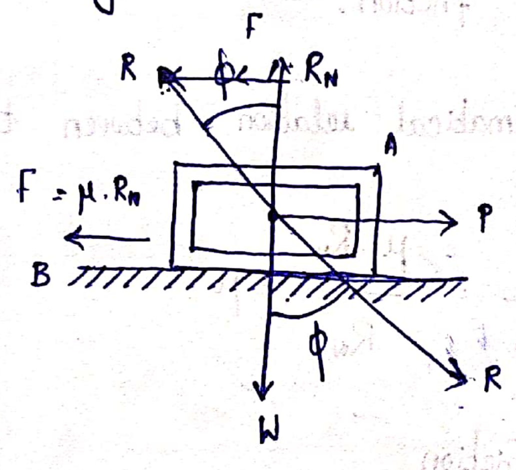
* The direction of limiting friction force is always the opposite of the motion of the body.
* The magnitude of the friction force is equal to the force that tends to move the body

* The magnitude of the limiting friction always have a constant ratio with the normal reaction force which acts between the two surfaces.

* Limiting friction force depends on the roughness of the surface.

* Area between the surfaces is not responsible for the magnitude of the frictional force.

Conditions for limiting cases of friction



a body 'A' is resting on a surface B. Now force P is applied to the body. It will not move untill the force P is equal to the limiting friction force F.

Here

$F = \mu W = \mu . R_n$ (Here R_n is the normal reaction force).

No relative motion will take place if P is ~~...~~ equals to F. And the force F will work opposite to the force P.

In the case of limiting force will be in equilibrium under the actions of three forces, ie weight of the body W, and Reaction fa, applied force, and Reaction force between A & B.

So for the equilibrium condition the reaction R will be equal to the weight W. P will be inclined at an angle ϕ to the reaction force R_n. Here ϕ is called the limiting angle of friction.

The mathematical relation between the angle and force is

$$\tan\phi = \frac{F}{R_N} = \frac{\mu . R_N}{R_N} = \mu$$

Non-limiting friction

When a body is in the static condition before it reaches an impending state, the frictional force developed is called non-limiting friction.

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Compatibility of small deformations.

The displacements can be determined from the strains through integration, to within a rigid body motion. In the two-dimensional case, there are three strain-displacement relations but only two displacement components. This implies that the strains are not independent but are related in some way. The relations between the strains are called compatibility conditions.

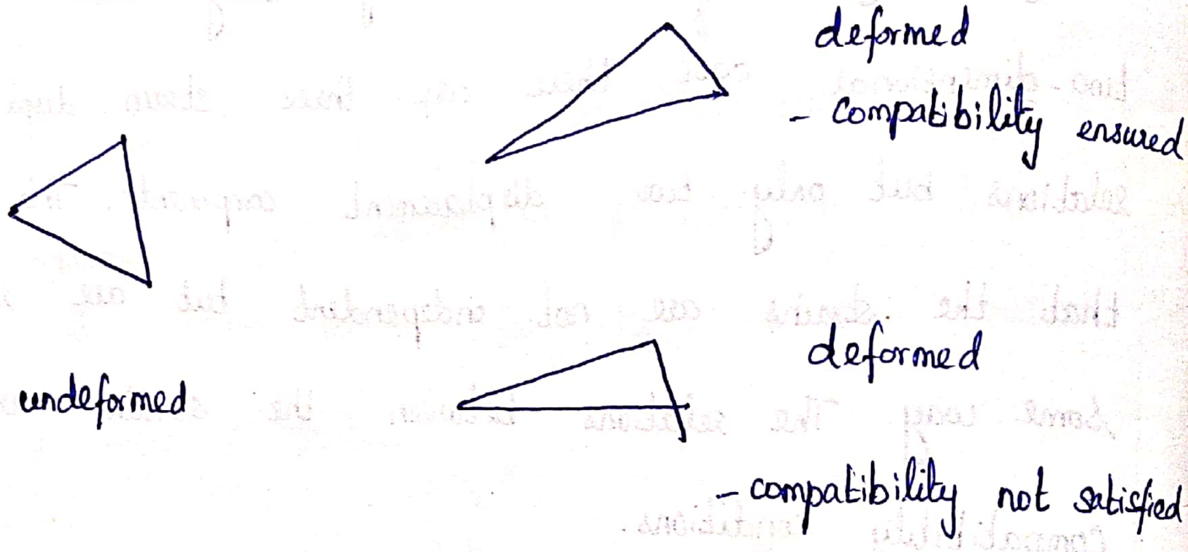
The compatibility Relations.

$$\frac{\partial^2 \epsilon_{xx}}{\partial y^2} + \frac{\partial^2 \epsilon_{yy}}{\partial x^2} = 2\frac{\partial^2 \epsilon_{xy}}{\partial x \partial y} \rightarrow \text{2-D compatibility equation}$$

This compatibility condition is an equation which must be satisfied by the strains at all material particles.

Physical Meaning of the compatibility condition

The following fig illustrates possible deformations and rigid body motions for three line elements in a material.



questions	opt1	opt2	opt3	opt4	opt5
A physical quantity that is completely described by a real number is called ___________.	scalar	vector	tensor	none of the above	scalar
A convenient means of representing physical quantities that have magnitude and direction.	scalars	vectors	tensors	none of the above	vectors
The product of a scalar and a vector is a	scalar	vector	tensor	none of the above	vectors
It is simply a vector whose magnitude is 1	moment vector	tensor	unit vector	vector unity	unit vector
It is sometimes called the scalar product.	dot product	vector product	cross product	unit scalar	dot product
To calculate for the force exerted on a charged particle by a magnetic field, _________ is used.	vector product	scalar product	dot product	vector sum	vector product
It is sometimes called the vector product.	dot product	cross product	tensor product	unit vector	cross product
Which of the following statements is false?	The cross product is commutative.	The cross product is associative with respect to scalar	The cross product is distributive with respect to	The angle between two identical vectors placed tail to	The cross product is commutative.
When a force is represented by a vector, the straight line collinear with the vector is called the ________.	line of apsides	line of reaction	line of vector	line of action	line of action
A system of forces is __________ if the lines of action of the forces intersect at a point.	parallel	coplanar	concurrent	two-dimensional	concurrent
Force acting on an object is called a ___________ if its acts on the volume of the object.	internal force	external force	body force	surface force	body force
If each point on the object has the same constant velocity, this is referred to as __________.	continuum translation	discrete translation	finite translation	steady translation	steady translation
The moment of a force about a point P is equal to the sum of the moments of its components about P.	Cavalieri’s Theorem	Pascal’s Theorem	Varignon’s Theorem	Torricelli’s Theorem	Varignon’s Theorem
It is the measure of the tendency of a force to cause rotation about a line or axis.	moment	momentum	impulse	torsion	moment
A couple is composed of two forces that are	equal	equal and opposite	equal and different lines of action	equal, opposite and different lines of action	equal, opposite and different lines of action
Which of the following statements is true about a couple?	A couple does not tend to cause a rotation of an object.	The vector sum of the force couple always has a value.	A couple tends to cause a rotation of an object.	The moment it exerts is not the same about any point.	A couple tends to cause a rotation of an object.
A type of force acting on a body due to the acceleration of gravity.	load	shear	bear	mass	load
A type of force acting on a body caused by the friction between the body and the ground.	load	shear	bear	mass	shear
When a body is in contact with the ground, the force that is reflected back to the body is called	ground reflected force	gravity reflected force	ground reaction force	gravity reaction force	ground reaction force
The ground reaction force on a body can be represented by a single force acting on a point called	center of force	center of reaction	center of reflection	center of pressure	center of pressure
The tuning effect on a body is dependent on which of the following?	mass of the load	acceleration of gravity	moment arm	all of the above	all of the above
If the force is moved in the direction parallel to the direction of the force, the moment exerted by the force ___________.	increases	decreases	is unchanged	becomes zero	is unchanged
The moment of force is zero when	the applied force is zero.	the force is applied at the moment axis.	the line of action of the force is parallel to the axis.	all of the above	all of the above
__________ is finding a single force which shall be equal to two or more given forces when acting in given directions.	resolution of forces	integration of forces	composition of forces	quantization of forces	composition of forces
He is the father of the modern engineering mechanics	Gilbert Lewis	Stephen Timoshenko	J. Gordon	A. Cotrell	Stephen Timoshenko
It is a method of applying mechanics that assumes all objects are continuous.	Discrete Mechanics	Finite Element Method	Continuum Mechanics	Contact Mechanics	Continuum Mechanics
Which of the following is an example of contact force?	gravitational force	magnetic force	air resistance force	electric force	air resistance force
It occurs when an object is moving across a surface.	dynamic friction	static friction	kinetic friction	sliding friction	sliding friction
“Observed from an internal reference frame, the net force on a particle is proportional to the time rate of change of its linear momentum”. This is known as Newton’s ___________ of motion.	Zeroth Law	First Law	Second Law	Third Law	Second Law
It is also known as quantity of motion.	momentum	force	mass	acceleration	momentum
This concept assumes that the substance of the body is distributed throughout and completely fills the space it occupies.	Finite Element	Contact	Discrete	Continuum	Continuum
In fluids, _________ is used to assess to what extent the approximation of continuity can be made.	Brayton Number	Knudsen Number	Reynolds Number	Prandtl Number	Knudsen Number
Material derivative is also known as __________.	substantial derivative	commoving derivative	convective derivative	all of the above	all of the above
The vector connecting the positions of a particle in the undeformed and deformed configuration is called the ________.	displacement vector	position vector	displacement field	position field	displacement vector
A __________ is a vector field of all displacement vectors for all particles in the body.	position field	action field	displacement field	path field	displacement field
_________ is the study of the physics of continuous solids with a defined rest shape.	Continuum Mechanics	Solid Mechanics	Fluid Mechanics	Discrete Mechanics	Solid Mechanics
It is an experimental method for visualizing and analyzing fluid flow.	Particle Image Velocimetry	Particle Image Accelerometry	Particle Image Flowmeter	Particle Image Viscosimetry	Particle Image Velocimetry
A fluid at rest has no	longitudinal stress	shear stress	tensile stress	compressive stress	shear stress
A property of fluids which is the force generated by a fluid in response to a velocity gradient.	compressibility	plasticity	elasticity	viscosity	viscosity
These equations state that changes in momentum of fluid particles depend only on the external pressure and internal viscous forces acting on the fluid.	Navier – Stokes Equations	Torricelli Equations	Reynolds Equations	Lagrangian Equations	Navier – Stokes Equations
It is defined as, regardless of the forces acting on a fluid, the fluid continues to flow	Newtonian fluid	non-Newtonian fluid	Lagrangian fluid	non-Lagrangian fluid	Newtonian fluid

UNIT - IV

Mechanics of Solids.

Stress

stress is defined as the restoring force per unit area which brings back the body to its original state from the deformed state. As long as no permanent change is produced in the body, the restoring force is equal to the force applied. unit of stress is N/m^2.

Types of stress

(i) Normal stress :

when the force is applied perpendicular to the surface of the body, then the stress applied is called as normal stress.

(ii) Tangential Stress

when the ~~sur~~force is applied along the surface of the body, then the stress applied is called tangential stress. It is also called shearing stress.

Hooke's law

Stress is directly proportional to the strain produced, within the elastic limit.

$$\text{stress} \propto \text{strain}$$

$$\text{stress} = E \times \text{strain}$$

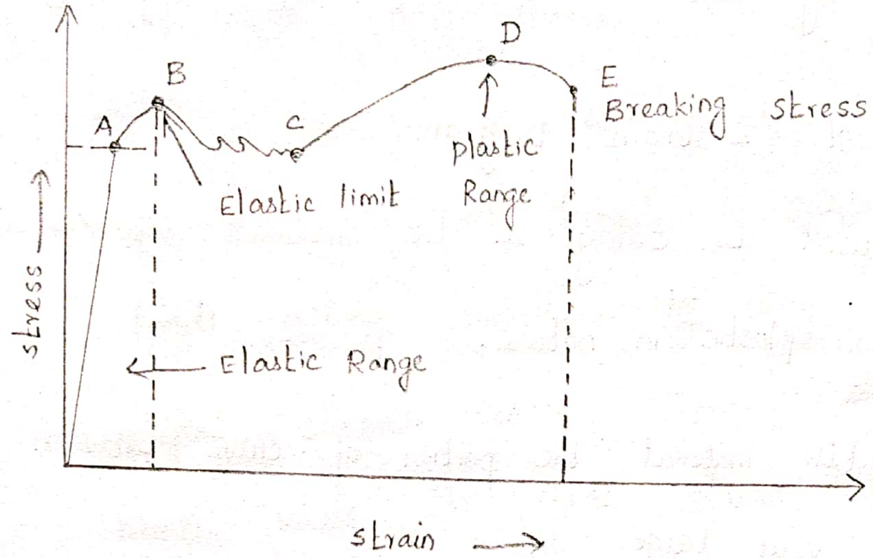
$$E = \frac{\text{stress}}{\text{strain}}$$

E is called as modulus of Elasticity.

Stress - strain Diagram And Its uses

Let us consider a body which is subjected to an uniformly increasing stress. Due to the application of the stress, the change in dimension of the body takes place. If we plot a graph between stress and strain, we get a curve, and is called as stress - strain diagram.

V. From the diagram it is for



1. From the diagram, it is found that the body obeys Hooke's law upto the region OA called as elastic range.

2. As soon as the maximum elastic limit (i.e) yield point 'B' is crossed, the strain increases rapidly than the stress.

3. At this stage, the body remains partly elastic and partly plastic which is represented by the curve BC.

4. Now, even if a small external force is applied, the body will take a new path CD and remains as plastic called as plastic range, where D is called as ultimate strength.

5. After this, the body will not come to its original state and the body acquires a permanent residual strain and it

breaks down at a point called as breaking stress, indicated by dotten line EF.

uses of stress - strain Diagram

1. It is used to catagorize the materials into ductile (or) Brittle (or) plastic in nature.

2. For ductile material the portion of curve between C to E will be very large.

Ex: brass, aluminium etc.,

3. For a brittle material, the yield point coincides with the breaking point.

Ex: Glass, cast Iron, brick, stone etc.

4. For a plastic material the stress strain diagram runs parallel to the strain axis beyond the yield point.

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Principal stresses and Mohr's circle

Analysis of stress and strain

As we learned in the previous

When a structural element is subjected to several types of loads acting simultaneously, say bending and torsion, Principal stresses occur. These stresses act on principal planes where the shear stresses are zero. In addition, many engineering problems, such as axial bars, beam in bending and circular members in torsion, are examples of a state of stress called plane stress ($\sigma_z = \tau_{zx} = \tau_{zy} = 0$)

Procedure for determining principal stresses. for a state of plane stress.

1. Determine the point on the body in which the principal stresses are to be determined.

2. Treating the load cases independently and calculated the stresses for the point chosen. When applicable combine the stresses to determine the state of stress

at the point.

3. Choose a set of x-y reference axes and draw a square element centered on the axes.

4. Identify the stresses σ_x, σ_y and $\tau_{xy} = \tau_{yx}$ and list them with the proper direction.

5. calculate the principal stresses, the maximum shear stress and the principal plane if required.

Principal stresses (shear stress = 0)

$$\sigma_1 = \frac{\sigma_x + \sigma_y}{2} + \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$\sigma_2 = \frac{\sigma_x + \sigma_y}{2} - \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

Maximum shear stress

$$\tau_{max} = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$\tau_{max} = \frac{\sigma_1 - \sigma_2}{2}$$

Principal planes

$$2\theta_p = \tan^{-1} \frac{2\tau_{xy}}{\sigma_x - \sigma_y}$$

Plane of maximum shear stress

$$2\theta_p = \tan^{-1} \cancel{2\tau_{xy}}$$

$$2\theta_p = \tan^{-1}\left(-\frac{\sigma_x - \sigma_y}{2\tau_{xy}}\right)$$

Average stress

$$\sigma_{avg} = \frac{\sigma_x + \sigma_y}{2}$$

Important observations

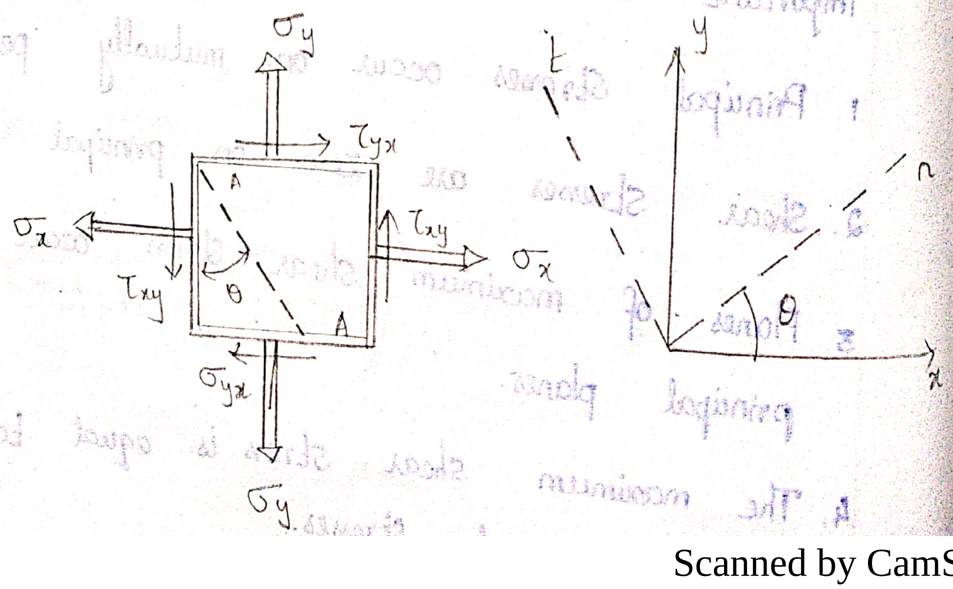
1. Principal stresses occur on mutually perpendicular planes
2. Shear stresses are zero on principal axes planes.
3. Planes of maximum shear stress occur at 45° to the principal planes.
4. The maximum shear stress is equal to one half the difference of the principal stresses.

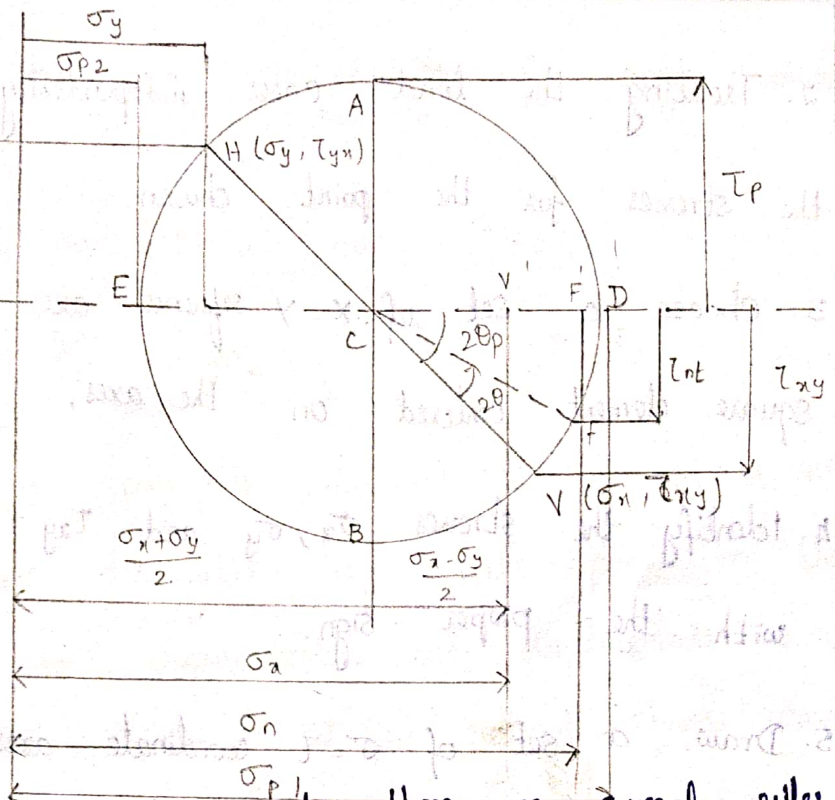
It should be noted that the equation for principal planes, $2\theta_p$, yields two angles between 0° and 360°. This can be determined by substituting one of the values into the stress transformation equation for normal stress.

Mohr's circle for plane stress

The transformation equations for plane stress can be represented in a graphical format known as Mohr's circle.

This representation is useful in visualizing the relationships between normal and shear stresses acting on various inclined planes at a point in a stressed body.





For constructing Mohr's circle there are several rules that apply.

stress component	Plot
Normal stresses (Horizontal Axis)	+ For Tension - For Compression
Shear stresses (Vertical Axis)	+ For clockwise shear - For counterclockwise shear.

Construct Mohr's circle as follows

1. Determine the point on the body in which the principal stresses are to be determined

2. Treating the load cases independently and calculated the stresses for the point chosen.

3. Choose a set of x-y reference axes and draw a square element centered on the axes.

4. Identify the stresses σ_x, σ_y and $\tau_{xy} = \tau_{yx}$ and list them with the proper sign.

5. Draw a set of σ-τ coordinate axes with σ being positive to the right and τ being positive in the upward direction. choose an appropriate Scale for the each axis.

6. using the rules on the previous page, plot the stresses on the x face of the element in this coordinate system (Point V). Repeat the process for the Y face (Point H).

7. Draw a line between the two point V and H. The point where this line crosses the σ axis establishes the center of the circle.

8. Draw the complete circle

9. The line from the center of the circle to point V

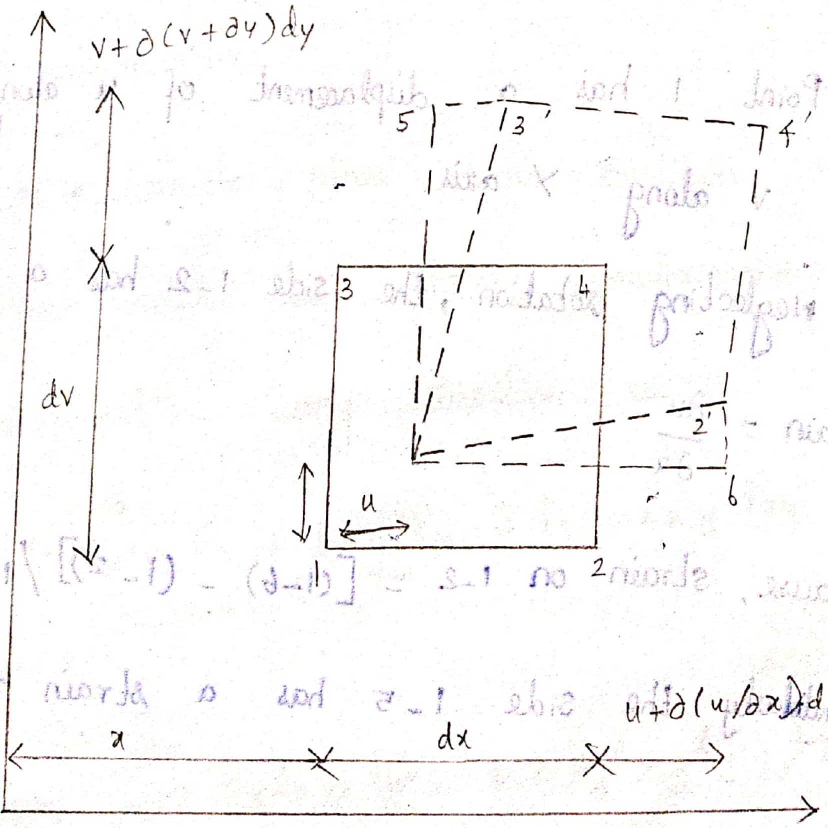
identifies the axis or reference axis for angle measurements.

2 Principal strains and Mohr's circle

General state of strain

When a body is subjected to stress, it undergoes deformation. When deformation happens, the points in the body are subjected to displacement. Such displacements include deformation, translation and rotation. Normal stress causes deformation, while shear stress can cause both rotation and translation. Considering normal strain, we ignore rotation and translation.

state of strains on a body - normal and shear



Consider a small elemental plane of a solid subjected to elastic deformation. The sides of the element undergo distortion as shown by dotted lines. The side 1-2 gets translated and sheared to 1'-2'. Let's ignore the rotation of the elements.

The displacements of various points in the element is assumed to be linearly propotional to their distance. Farther points in the element will undergo more displacement. This assumption is valid for small displacements and elastic bodies.

Point 1 has a displacement of u along x axis and v along y axis.

Neglecting rotation, the side 1-2 has a linear

strain $= \frac{\partial u}{\partial x}$

Because, strain on 1-2 $= [(1-6) - (1-2)] / 1-2$

Similarly the side 1-5 has a strain $= \frac{\partial v}{\partial y}$

Now consider the angular strain (shear strain) on 1-6 & 1-5

shear strain on 1-6 = $\frac{\partial v}{\partial x}$

shear strain on 1-6 = $\frac{\partial v}{\partial x}$

||ly shear strain on 1.5 = $\frac{\partial v}{\partial y}$

Total shear strain = $\gamma_{xy} = \left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}\right)$

Now consider the rotation of 1-6 and 1-5 :

We can write the total rotation $\omega_{xy} = \frac{1}{2}\left(\frac{\partial u}{\partial y} - \frac{\partial v}{\partial x}\right)$

Here we consider anticlockwise rotation as positive.

Strain transformations :

Let's assume plane strain condition

We can write the strain transformations similar to stress transformations using direction cosines.

$$\varepsilon_x' = l_{x'x}^2 \varepsilon_x + l_{x'y}^2 \varepsilon_y + l_{x'x} l_{x'y} \gamma_{xy}$$

Similarly

$$\gamma_{x'y'} = 2 \varepsilon_x l_{x'x} l_{y'x} + 2 \varepsilon_y l_{x'y} l_{y'y} + \gamma_{xy} (l_{x'x} l_{y'y} + l_{y'x} l_{x'y})$$

Here

$l_{x'x} = \cos\theta$ and $l_{x'y} = \sin\theta$

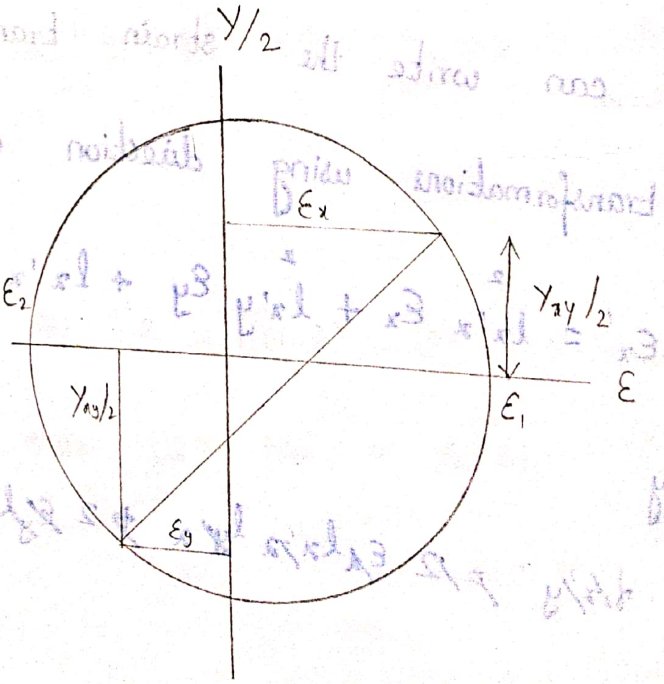
strain transformation equations for plane strain condition can be written as

$$\varepsilon_{x_1} = \frac{\varepsilon_x + \varepsilon_y}{2} + \frac{\varepsilon_x - \varepsilon_y}{2}\cos 2\theta + \frac{\gamma_{xy}}{2}\sin 2\theta$$

$$\frac{\gamma_{x_1y_1}}{2} = \frac{\varepsilon_x - \varepsilon_y}{2}\sin 2\theta + \frac{\gamma_{xy}}{2}\cos 2\theta$$

Mohr's circle for strain:

Mohr's circle for strain is similar to that for stress.

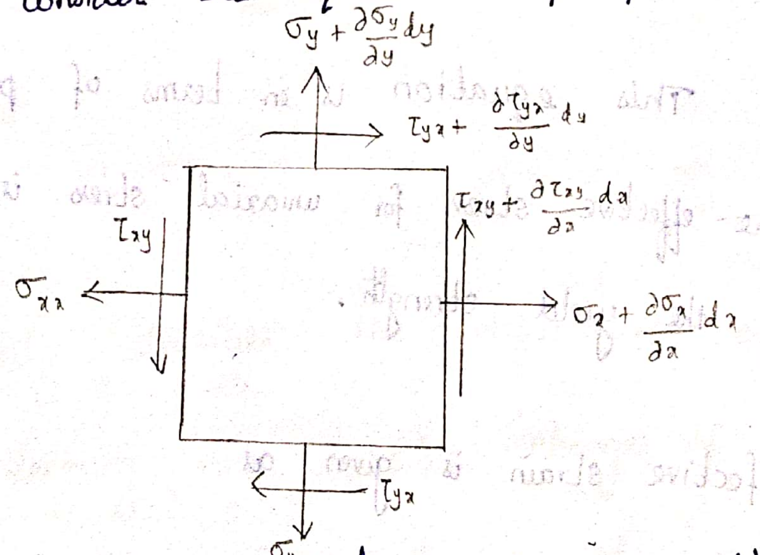


Here

The principal normal and principal shear stresses as well as strains are oriented at an angle of 45° with respect to each other.

Equation of equilibrium forces :

We can consider a plane of side dx and dy. Let's consider the equilibrium of forces on this plane.



The equilibrium equations are now written for biaxial stress as :

Along x direction , the force balance gives :

$$\frac{\partial \sigma_x}{\partial x} + \frac{\partial \tau_{yx}}{\partial y} = 0$$

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Along y direction

$$\frac{\partial \sigma_y}{\partial y} + \frac{\partial \tau_{yx}}{\partial x} = 0$$

Effective stress is given as

$$\bar{\sigma} = \frac{1}{3}\left[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2\right]$$

This equation is in terms of principal stresses.

The effective stress for uniaxial stress is simply equal to the yield strength.

Effective strain is given as

$$\bar{\varepsilon} = \frac{\sqrt{2}}{3}\left[(\varepsilon_1 - \varepsilon_2)^2 + (\varepsilon_2 - \varepsilon_3)^2 + (\varepsilon_3 - \varepsilon_1)^2\right]$$

In uniaxial stress, we can prove that the effective strain

$\bar{\varepsilon}$ = longitudinal strain.

Elasticity

Elasticity is the ability of a body to resist a distorting influence and to return to its original size and shape when that influence or force is removed.

This elastic behaviour can be quite different for different materials.

Plasticity

Plasticity describes the deformation of a material undergoing non-reversible changes of shape in response to applied forces. For example, a solid piece of metal being bent (or) pounded into a new shape displays plasticity as permanent changes occur within the material itself.

In engineering, the transition from elastic behaviour to plastic behaviour is called yield.

Plastic deformation is observed in most materials particularly metals, soils, rocks, concrete, foams, bone and skin.

Elasticity

questions	opt1	opt2	opt3	opt4	opt5
It is the science which deals with bodies in motion or at rest with specific attention being directed primarily to the external effects of a force or a system.	statics	thermodynamics	kinetics	mechanics	mechanics
Deals with the conditions of equilibrium of rigid bodies acted upon by a balanced systems of forces.	statics	thermodynamics	kinetics	mechanics	statics
Deals with bodies being acted upon by an unbalanced system of forces the resultant of which causes the body to be accelerated.	statics	kinematics	dynamics	kinetics	dynamics
Deals with the geometry of motion.	statics	kinematics	dynamics	kinetics	kinematics
Deals with the forces required to produced motion.	statics	kinematics	dynamics	kinetics	kinetics
A specific amount of matter all particles of which remain at fixed distance to each other.	mass	force	rigid body	static body	rigid body
Results when a body is acted upon by the force.	bending	deformation	scattering	compression	deformation
A fixed body property of a body which determines its resistance to change in motion.	mass	force	rigid body	static body	mass
The action of one body on another body which changes or tends to change the motion of the body acted on.	mass	force	rigid body	static body	force
It is the intensity of the force.	magnitude	direction	mass	force	magnitude
Sense and slope of angles with respect to reference axes.	magnitude	direction	mass	force	direction
The resultant of two forces which is the diagonal formed on the vectors of this force.	parallelogram law	equilibrium law	superposition law	action and reaction	parallelogram law
Any pressure on the support causes an equal and opposite pressure from the support.	parallelogram law	equilibrium law	superposition law	action and reaction	action and reaction
Two forces on a rigid body will in no way to be changed if we added or subtract from them another system of forces in equilibrium.	parallelogram law	equilibrium law	superposition law	action and reaction	superposition law
Quantities which possess magnitude.	tensors	vector quantities	system of forces	scalar quantities	scalar quantities
Quantities having both magnitude and direction.	tensors	vector quantities	system of forces	scalar quantities	vector quantities
Quantities which posses magnitude but require two or more directional aspects.	tensors	vector quantities	system of forces	scalar quantities	tensors
When several forces act in a given situation.	tensors	vector quantities	system of forces	scalar quantities	system of forces
All forces of the system are in a common line action.	concurrent,coplanar	collinear forces system	parallel,coplanar	non concurrent,coplanar	collinear forces system
The action lines of all the forces are in the same plane and intersect a common point.	concurrent,coplanar	collinear forces system	parallel,coplanar	non concurrent,coplanar	concurrent,coplanar
The action lines of all the forces of the system are parallel and lie in the same plane.	concurrent,coplanar	collinear forces system	parallel,coplanar	non concurrent,coplanar	parallel,coplanar
The action lines of all the forces of the system are in the same plane,but they are not parallel and don’t intersect in a common point.	concurrent,coplanar	collinear forces system	parallel,coplanar	non concurrent,coplanar	collinear forces system
The action lines of all the forces are not in the same plane and intersect a common point.	concurrent,non coplanar	collinear forces system	parallel,non coplanar	non concurrent,non coplanar,non parallel	concurrent,non coplanar
The action lines of all the forces of the system are parallel and not all lie in the same plane.	concurrent,non coplanar	collinear forces system	parallel,non coplanar	non concurrent,non coplanar,non parallel	parallel,non coplanar
The action lines of all the forces of the system are all not in the same plane, but they are all not parallel and do not all intersect in a common point.	concurrent,non coplanar	collinear forces system	parallel,non coplanar	non concurrent,non coplanar,non parallel	collinear forces system
The simplest force system that can replace the original system without changing its external effect.	couple	resultant	composition	graphical	resultant
A pair of parallel forces having same magnitude but opposite senses.	couple	resultant	composition	graphical	couple
The process of replacing a force system by its resultant	couple	resultant	composition	graphical	composition
A pictorial representation in solving a system	couple	resultant	composition	graphical	graphical
Is used to obtain the magnitude and direction of the resultant of any two concurrent forces.	parallelogram law	resolution	cosine law	triangle law	triangle law
An analytical method of finding the resultant of concurrent forces.	parallelogram law	resolution	cosine law	triangle law	resolution
Means that either one of two coplanar forces having the given force as resultant.	components	polygon method	moment of force	couple	components
Is used to check the results obtained from the resolution and composition method.	components	polygon method	moment of force	couple	polygon method
Is a vector quantity that is represented as a vector along the moment axis.	components	polygon method	moment of force	couple	moment of force
The algebraic sum of the moment of its forces about any axis perpendicular to the plane of the couple.	the magnitude of the couple	the slope of the plane of the couple.	the sense of rotation of the couple.	the moment of the couple.	the moment of the couple.
The force of attraction of the earth on a body.	mass	density	weight	direction	weight
Theorem used in locating the centroid of the semicircle arc.	pythagorean theorem	newton’s theorem	pappus theorem	none of the above	pappus theorem
A system of forces acting on a body which has no resultant.	free body diagram	equilibrium	coplanar	force	equilibrium
Is a sketch of a body completely isolated or free from all other bodies.	free body diagram	equilibrium	coplanar	force	free body diagram
Is a definite amount of matter the parts of which are fixed in position relative to one another.	mass	force	rigid body	static body	rigid body
Is the action exerted by one body upon another.	mass	force	rigid body	static body	force
A unit of force	meter squared	pascal	pounds	newton	newton
The external effect of a force in a rigid body is the same for all points along its line of action.	principle of transmissibility of a force	axioms of mechanics	characteristics of force	scalar and vector quantities	principle of transmissibility of a force
The resultant of two forces is the diagonal formed on two vectors of those forces.	parallelogram law	resolution	cosine law	triangle law	parallelogram law
The forces are in equilibrium only when equal in magnitude ,opposite in direction and collinear in action.	principle of transmissibility of a force	axioms of mechanics	characteristics of force	scalar and vector quantities	axioms of mechanics
Is a convenient corollary of the parallelogram law.	parallelogram law	resolution	cosine law	triangle law	triangle law
The determination of the resultant of 3 or more concurrent forces that are not collinear.	resultant of concurrent,coplanar	collinear forces system	parallel,coplanar	non concurrent,coplanar	resultant of concurrent,coplanar

UNIT - V

Relationship between Three modulii of Elasticity.

classification of Elastic Modulus.

Depending on the three types of strain, there are three types of Elastic modulus.

(i) Young's modulus (Y)

(ii) Bulk modulus (K)

(iii) Rigidity modulus (n)

(i) Young's modulus (Y)

Defenition

It is defined as the ratio between the longitudinal stress to the longitudinal strain, within the elastic limits.

$$\text{Young's Modulus } (Y) = \frac{\text{Longitudinal stress}}{\text{Longitudinal strain}} \quad Nm^{-2} \text{ (or) Pascals}$$

Explanation:

Let us consider a wire of length 'L' with an area of cross section 'A'. Let one end of the wire be fixed and the other end is loaded

Let 'l' be change in length due to the action of force, then

The longitudinal stress = F/A

The longitudinal strain = l/L

$\therefore$ Young's modulus $Y = \dfrac{\text{longitudinal stress}}{\text{longitudinal strain}}$

$$Y = \frac{F/A}{l/L}$$

$$\boxed{Y = \frac{FL}{Al}}$$ Nm^{-2} (or) pascals.

(ii) Bulk modulus (K)

Definition : It is defined as the ratio between the volume stress (or) bulk stress to the volume strain (or) bulk strain within the elastic limits.

Bulk Modulus (K) = $\dfrac{\text{Bulk stress}}{\text{Bulk strain}}$ Nm^{-2} (or) pascals

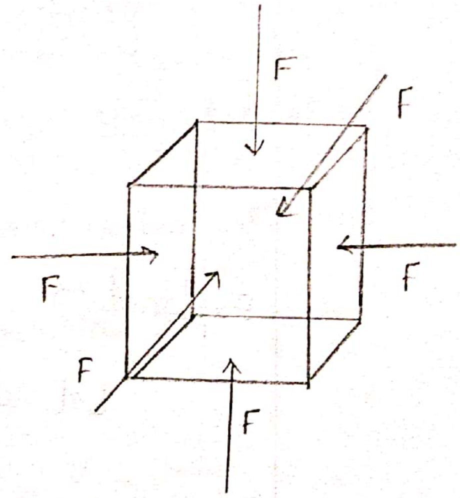
Explanation

Let us consider a body of volume 'V' with an area of cross section 'A'. Let three equal forces act on the body in mutually perpendicular directions. Let 'v' be the change in volume, due to the action of forces.

The Volume Stress (or) bulk stress = F/A

The volume strain (or) bulk strain = $\dfrac{v}{V}$

$\therefore$ Bulk modulus (K) = $\dfrac{\text{Bulk stress}}{\text{Bulk strain}}$



$$= \frac{F/A}{v/V}$$

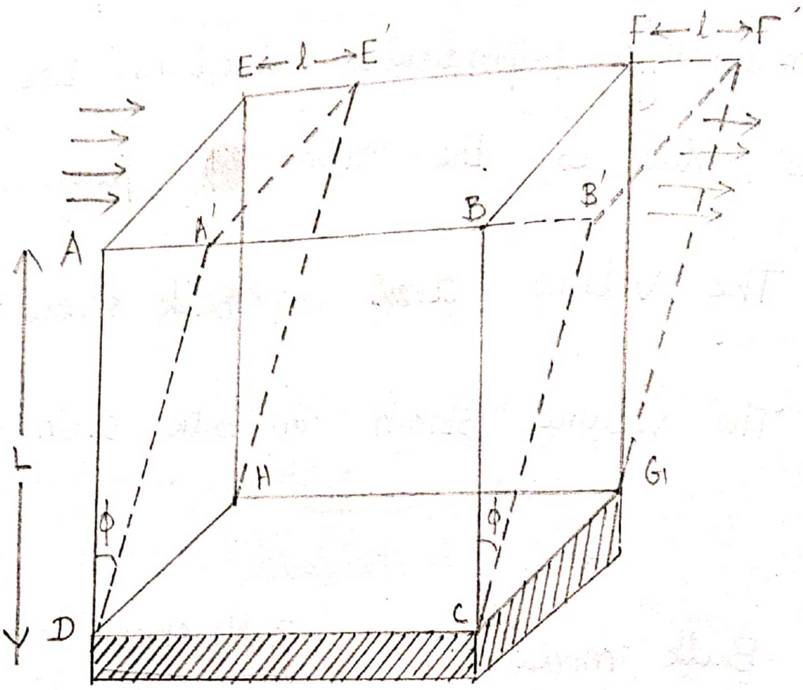
$$\boxed{K = \frac{FV}{vA}}$$ Nm^{-2} (or) Pascals.

(iii) Rigidity modulus (n)

Defenition

It is defined as the ratio between the tangential stress to the shearing strain, within the elastic limits.

Rigidity modulus (n) = $\frac{\text{Tangential stress}}{\text{Shearing strain}}$ Nm^{-2} (or) Pascals.



Explanation

Let us consider a Solid cube ABCDEFGH, whose lower face CDHG is fixed. A tangential force 'F' is applied over the upper face ABEF. The result is that the cube gets deformed into a rhombus shape A'B'CDE'F' (ie) The lines joining the two faces are shifted to an angle ϕ. If 'L' is the original length and 'l' is the relative displacement of the upper face of the cube with respect to the lower fixed face, then

Tangential stress = F/A

$\therefore$ Rigidity modulus (n) = $\dfrac{\text{Tangential stress}}{\text{shearing strain}}$

$$\boxed{n = \frac{F}{A\phi}}$$ Nm^{-2} (or) Pascals.

Relationship between three modulii of Elasticity

There are many relations connecting the lateral strain (β), longitudinal strain (α), Poisson's ratio (σ) and the three elastic modulii. Some of the relations are given

i) Relation between α and Young's modulus $\alpha = \dfrac{1}{Y}$

ii) Relation between α and β with k is $\alpha - 2\beta = \dfrac{1}{3K}$

iii) Relation between α and β with n is $\alpha + \beta = \dfrac{1}{2n}$

iv) Relation between Y, n and k is $Y = \dfrac{9Kn}{3K+n}$

v) Relation between n, K and σ is $= \dfrac{3K-2n}{6K+2n}$

vi) Relation between Y, n and σ is $\sigma = \frac{Y}{2n} - 1$

Relations Between the Elastic Constants

Through any point of the body there will be three directions which are mutually perpendicular before and after straining. These are called the axes of the strain and the corresponding magnitudes are called the principal strains. For isotropic substances these axes will be the directions of the normal stresses, and thus, the complete stress-strain relations will be given by the ratios of the principal stresses and their corresponding strains.

The elastic constants Y, n, k and σ are interdependent since a body when deformed, its new size and shape may be obtained by first changing the shape but not the size as in the case of shear and then changing the size but not the shape as in the case of volume strain. Actually only two out of the four constants are independent.

Consider a cube of the given material with x, y, and z axes parallel to the edges of the cube. Let the cube be subjected to stresses P, Q, R along these three directions.

If the body is isotropic its elastic properties are uniform in all direction, it will be unaltered in shape. stress in a given direction produces extension in that direction but contraction in directions perpendicular to it. Since elastic region is being considered, the extension and contraction are expected to be proportional to the relevant stresses. If α represents the constant of proportionality for the extension and β that for contraction we have the following relations for the extension in the three directions.

$$e = \alpha P - \beta(Q+R) \quad \text{--- (1)}$$

$$f = \alpha Q - \beta(R+P) \quad \text{--- (2)}$$

$$g = \alpha R - \beta(P+Q) \quad \text{--- (3)}$$

For Young's modulus we need to consider only one stress say P directed parallel to one of the edge of the cube. The other two stresses

$$Q = R = 0$$

Hence

$$e = \alpha P$$

$$P/e = \frac{1}{\alpha} = Y \quad \text{--- (4)}$$

For Bulk modulus, since stresses are identical in all directions, $P = Q = R$.

Hence

$$e = (\alpha - 2\beta) P \quad \text{--- (5)}$$

If the side of the original cube is 1 unit then the original volume $V = 1$, and the new volume is

$$V' = (1+e)^3 \simeq (1+3e)$$

Where we have neglected the terms $3e^2$ and e^3 as e is small change in volume $\Delta V = V' - V$

$$= (1+3e) - 1$$

$$= 3e$$

volume strain $= \Delta V / V$

$$= 3e/1 = 3e$$

Bulk modulus $K = \frac{\text{Volume stress}}{\text{Volume strain}} = \frac{P}{3e} = \frac{P}{3P(\alpha - 2\beta)}$

$$K = \frac{1}{3(\alpha - 2\beta)} \quad \text{——— (6)}$$

Finally we consider rigidity modulus

By defenition, the rigidity modulus

$$n = \frac{P}{\theta} = \frac{e}{2(\alpha+\beta)e} = \frac{1}{2(\alpha+\beta)} \quad \text{——— (7)}$$

Poisson's ratio is obtained by setting

$Q = R = 0$ in (1) and (2)

$$\sigma = -\frac{f}{e} = \frac{\beta}{\alpha} \quad \text{——— (8)}$$

$$\therefore \quad \alpha - 2\beta = \frac{1}{3K} \quad \text{——— (9)}$$

$$2\alpha + 2\beta = \frac{1}{n} \quad \text{———} \quad (10)$$

Adding (9) and (10)

$$3\alpha = \frac{1}{3K} + \frac{1}{n} \quad \text{———} \quad (11)$$

$$Y = \frac{9nK}{(3K+n)} \quad \text{———} \quad (12)$$

Deviding (13) by α

$$2\left(\frac{1+\beta}{\alpha}\right) = \frac{1}{n\alpha} \quad \text{———} \quad (13)$$

$$\therefore \quad Y = 2n\,(1+\sigma) \quad \text{———} \quad (14)$$

Dividing (9) by α

$$1 - \frac{2\beta}{\alpha} = \frac{1}{3K\alpha} \quad \text{———} \quad (15)$$

$$\therefore \quad Y = 3K\,(1-2\sigma) \quad \text{———} \quad (16)$$

Combining (12), (14), and (16)

$$Y = \frac{9nK}{3K+n} = 2n\,(1+\sigma) = 3K\,(1-2\sigma)$$

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An expression for σ can be obtained by eliminating y between (14) and (16)

$$\sigma = \frac{3K - 2n}{6K + 2n}$$

Elastic Fatigue

Each time a piece of material is subjected to stress, its internal structure undergoes change in the course of time. The continuous process over long time intervals causes certain regions of the material to be weakened, resulting in loss of strength called fatigue.

Poisson's Ratio

It is defined as the ratio of Lateral strain per unit stress to the Longitudinal strain per unit stress.

$$\sigma = \frac{\text{Lateral strain}}{\text{Longitudinal strain}}$$

=

Hooke's Law

It states that stress is directly propotional to the strain within the elastic limit.

stress α strain

stress = E x strain

$$E = \frac{\text{Stress}}{\text{strain}}$$

E → Modulus of elasticity.

Elastic limit

It is defined as the maximum stress a material can withstand without a permanent elongation or set remaining after the stress is removed.

Fracture

under the extreme stress conditions materials tend to fracture.

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questions	opt1	opt2	opt3	opt4	opt5
Stress is	External force	Internal resistive force	Axial force	Radial force	Internal resistive force
Following are the basic types of stress except	Tensile stress	Compressive stress	Shear stress	Volumetric stress	Volumetric stress
Which of the following is not a basic type of strain?	Compressive strain	Shear strain	Area strain	Volume strain	Area strain
Hooke's law is applicable within	Elastic limit	Plastic limit	Fracture point	Ultimate strength	Elastic limit
The deformation per unit length is called	Strain	Stress	Elasticity	None of these	Strain
The ability of the material to deform without breaking is called	Elasticity	Plasticity	Creep	None of these	Plasticity
Which of the following material is more elastic?	Rubber	Glass	Steel	Wood	Steel
The percentage elongation and the percentage reduction in area depends upon	Tensile strength of the material	Ductility of the material	Toughness of the material	None of these	Ductility of the material
The property of a material by which it can be beaten or rolled into thin sheets, is called	Elasticity	Plasticity	Ductility	Malleability	Malleability
The property of a material by which it can be drawn to a smaller section by applying a tensile load is called	Elasticity	Plasticity	Ductility	Malleability	Ductility
If a material has identical properties in all directions, it is called	Elastic	Plastic	Isotropic	Homogeneous	Isotropic
The stress at which extension of a material takes place more quickly as compared to increase in load, is called	No elastic zone	Plastic point	Yield point	Breaking point	Yield point
A brittle material has	No elastic zone	No plastic zone	Large plastic zone	None of these	No plastic zone
Every material obeys the Hooke's law within	Elastic limit	Plastic limit	Limit of proportionality	None of these	Elastic limit
The ratio of lateral strain to linear strain is called	Modulus of Elasticity	Modulus of Rigidity	Bulk Modulus	Poisson's Ratio	Poisson's Ratio
A perfectly elastic body	Can move freely	Has perfectly smooth surface	Is not deformed by any external surface	Recovers its original size and shape	Recovers its original size and shape
The value of Poison's ratio depends upon	Nature of load, tensile or compressive	Magnitude of load	Material of the test specimen	Dimensions of the test specimen	Material of the test specimen
Which of the following is a dimensionless quantity?	Shear stress	Poison's ratio	Strain	Poison's ratio and Strain	Poison's ratio and Strain
Percentage elongation during tensile test is indication of	Ductility	Malleability	Creep	Rigidity	Ductility
Brittleness is opposite to	Toughness	Plasticity	Malleability	None of these	Plasticity
The statement : stress is proportional to strain, i.e. the Hooke's law holds good upto	Elastic Limit	Proportional Limit	Plastic Limit	Yield point	Proportional Limit
The limit beyond which the material does not behave elastically is known as	Proportional limit	Elastic limit	Plastic limit	Yield Point	Elastic limit
When mild steel is subjected to a tensile load, its fracture will conform to	Star shape	Granular shape	Cup and cone shape	Fibrous shape	Cup and cone shape
When a wire is stretched to double in length, the longitudinal strain produced in it is	0.5	1	1.5	2	1
When a bar is subjected to a change of temperature and its longitudinal deformation is prevented, the stress induced in the bar is	Tensile	Compressive	Shear	Temperature	Temperature
When a bar is subjected to increase in temperature and its deformation is prevented, the stress induced in the bar is	Tensile	Compressive	Shear	None of the above	Compressive
In a composite body, consisting of two different materials……….will be same in both materials.	Stress	Strain	Both stress and strain	None of these	Strain
The external effect of a force in a rigid body is the same for all points along its line of action.	principle of transmissibility of a force	axioms of mechanics	characteristics of force	scalar and vector quantities	principle of transmissibility of a force
The resultant of two forces is the diagonal formed on two vectors of those forces.	parallelogram law	resolution	cosine law	triangle law	parallelogram law
The forces are in equilibrium only when equal in magnitude ,opposite in direction and collinear in action.	principle of transmissibility of a force	axioms of mechanics	characteristics of force	scalar and vector quantities	axioms of mechanics
Is a convenient corollary of the parallelogram law.	parallelogram law	resolution	cosine law	triangle law	triangle law
The determination of the resultant of 3 or more concurrent forces that are not collinear.	resultant of concurrent,coplanar	collinear forces system	parallel,coplanar	non concurrent,coplanar	resultant of concurrent,coplanar
Stress is	External force	Internal resistive force	Axial force	Radial force	Internal resistive force
Following are the basic types of stress except	Tensile stress	Compressive stress	Shear stress	Volumetric stress	Volumetric stress
Which of the following is not a basic type of strain?	Compressive strain	Shear strain	Area strain	Volume strain	Area strain
Tensile Strain is	Increase in length per original length	Decrease in length per original length	Change in volume per original volume	All of the above	Increase in length per original length
Compressive Strain is	Increase in length per original length	Decrease in length per original length	Change in volume per original volume	All of the above	Decrease in length per original length
Hooke's law is applicable within	Elastic limit	Plastic limit	Fracture point	Ultimate strength	Elastic limit
Young's Modulus of elasticity is	Tensile stress per Tensile strain	Shear stress per Shear strain	Tensile stress per Shear strain	Shear stress per Tensile strain	Tensile stress per Tensile strain