ENGINEERING MECHANICS

UNIT – I BASICS AND STATICS OF PARTICLES

TWO MARKS

1. **Define principle of transmissibility of forces**
   If a force acts at any point on a rigid body it may also be considered to act at any other point on its line of action

2. **State the lami's theorem.**
   It states that if three coplanar forces acting at a point be in equilibrium then each force is proportional to the sine of the angle between the other two.

   Mathematically $P/Sin\alpha = Q/Sin\beta = R/Sin\gamma$

3. **Explain parallelogram law of force**
   It states that if two forces acting simultaneously at a point be represented in magnitude and direction by the two adjacent sides of a parallelogram then the resultant of these forces is represented in magnitude and direction by the diagonal of that parallelogram originating from that point

   Mathematically $R = \sqrt{(P^2 + Q^2 + (2PQCos\theta))}$

4. **Explain triangular law of forces**
   It states that if two forces acting at a point are represented by the two sides of a triangle taken in order then their resultant force is represented by the third side taken in opposite order.

5. **Explain polygon law of forces**
   It states that if a number of coplanar forces are represented in magnitude and direction by the sides of a polygon taken in a order then their resultant force is represented by the closing side of the polygon taken in the opposite order.

6. **What are the classifications of vector?**
   i). Free vector ii).sliding vector iii).bound or fixed vector iv).unit vector v).negative vector vi).zero vector or null vector

7. **Define free vector**
   A free vector may be moved anywhere in space provided it maintains the same direction and magnitude

8. **Define sliding vector**

A sliding vector is the vector which may be applied at any point along its line of action

9. **Define bound or fixed vector**

A bound or fixed vector is the vector which remain at the same point of application

10. **Define unit vector**

A unit vector is the vector of one unit in length

11. **Define negative vector**

A negative vector of any vector is the vector which has the same magnitude and inclination but is of the opposite sense.

12. **Define zero vector or null vector**

A zero vector or null vector is obtained when a vector is subtracted from itself.

13. **What is a force?**

Force is an agent which changes or tends to change the state of rest or of uniform motion of a body upon which it acts. A force represents the action of one body on another. Force is a vector quantity.

14. **What are the characteristics of a force**

A force is characterized by i). Magnitude ii).line of action iii).direction

15. **What are the classification of force system**

A system of force is classified into i).coplanar forces ii).Non coplanar forces or spatial forces

16. **What is a coplanar force?**

Coplanar force systems have all the forces acting in one plane. They may be collinear, concurrent, parallel, non-concurrent or non-parallel.

17. **What is a concurrent force?**

A concurrent coplanar force system is a system of two or more forces whose lines of action all intersect at a common point
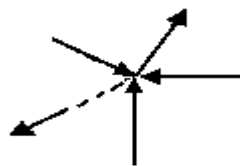
Concurrent

18. What is a non coplanar force?
In non coplanar force system the forces do not act in one plane

19. What is a collinear force?
The force which acts on a common line of action are called collinear forces. If they act in same direction they are called like collinear and if they act in opposite direction they are called unlike collinear

20. What is a parallel force?
In parallel system line of action of forces are parallel to each other. Parallel forces acting in same direction are called like parallel forces and the parallel forces acting in opposite direction are called unlike parallel forces

21. A force of 500N forms angles 60°, 45° and 120° respectively with x, y and z axes. Write the force in vector form.
F = 500N, $\theta x = 60^o$, $\theta y = 45^o$, $\theta z = 120^o$

$\overrightarrow{}$

F= FCos θxi + FCos θyj + FCos θzk

= (500Cos60)i+(500cos45)j+(500cos120)k

= 250i+353.55j-250k

$\overrightarrow{}$ $\overrightarrow{}$ $\overrightarrow{}$

22. A force F=700i +1500j is applied to a bolt A. Determine the magnitude of the force and the angle it forms with the horizontal
Magnitude F = $\sqrt{(Fx^2 + Fy^2)}$

= $\sqrt{(700^2 + 1500^2)}$ = 1655.29N

Angle of he force with horizontal

$\theta x = \cos^{-1}(Fx/F)$

$\theta x = \cos^{-1}(700/1655.29)$ = 64.98^o

$\overrightarrow{}$

23.A force F= 6i-3j-2k acts at a point P (2, 3, 4). Determine the moment of this force about the point of origin
Coordinates of P (2, 3, 4).

$\overrightarrow{}$

Position vector r = 2i+3j+4k

Moment $\overrightarrow{Mo} = \overrightarrow{r} \times \overrightarrow{F}$

$$= \begin{vmatrix} i & j & k \\ 2 & 3 & 4 \\ 6 & -3 & -2 \end{vmatrix}$$

$= i(-6+12)-j(-4-24)+k(-6-18) = \underline{6i+28j-24k}$

23. A force of magnitude 750N is directed along AB where A is (0.8, 0, 1.2) m and B is (1.4, 1.2, 0) m. writes the vector form of the force.

A = (0.8, 0, 1.2) m, X1= 0.8m, Y1= 0, Z1=1.2m

B = (1.4, 1.2, 0) m X2=1.4m, Y2= 1.2m Z2= 0

F_{AB} =750N

γ_{AB} = (X2-X1)i +(Y2-Y1)j+(Z2-Z1)k

    =(1.4-0.8)i+(1.2-0)j+(0-1.2)k

    = 0.6i+1.2j-1.2k

$\lambda_{AB} = \gamma_{AB} / I\gamma I \quad = \quad$ 0.6i+1.2j-1.2k / $\sqrt{(0.6^2+1.2^2+(-1.2^2))}$ = 0.6i+1.2j-1.2k / (1.8)

$\rightarrow$

$F_{AB} = F_{AB}$ x λ_{AB} = 750 x (0.6i+1.2j-1.2k / (1.8))

    = 250i+500j-500k

24. **The line of action of a 100N force F Passes through the points A(2,5,8)m and B(7,2,6)m. the direction of the force is from A to B. Express F in terms of the unit vectors i,j and k**

A = (2,5,8) m, X1= 2m, Y1= 5m, Z1=8m

B = (7,2,6) m X2=7m, Y2= 2m Z2= 6m

F_{AB} =100N

γ_{AB} = (X2-X1)i +(Y2-Y1)j+(Z2-Z1)k

   =(7-2)i+(2-5)j+(6-8)k

   = 5i-3j-2k

λ_{AB} = γ_{AB} / IγI   =   5i-3j-2k / √ $(5^2+(-3^2)+(-2^2))$ = 5i-3j-2k / (6.16)

$\rightarrow$

F_{AB} = F_{AB} x λ_{AB} = 100 x (5i-3j-2k / (6.16))

   = 81.1i-48.7j-32.46k

25. **Two forces of magnitude 10N and 8N acting at a point. If the angle between the two force is 60°. Determine the magnitude and direction of the resultant force.**

P=10N, Q= 8N and θ=60°

Magnitude R = √ $(P^2+Q^2+2PQCos\theta)$ = √ $((10^2+8^2+((2x10x8)Cos60°))$

        = 15.62N

Direction of resultant

tanα=(QSinθ) / (P+QCosθ)

α = tan^{-1} (8Sin60°)/(10+8Cos60°)

  = 26.30°

26. **What is the difference between coplanar concurrent force and coplanar non concurrent force?**
Coplanar concurrent force

Forces intersects at a common point and lies in a single plane

Coplanar non concurrent force

Forces which do not intersects at a common point but acts in one plane

27. What is the difference between like collinear coplanar force and unlike collinear coplanar force?
Like collinear coplanar force

Forces acting in same direction, lies on a common line of action and acts in a single plane

Unlike collinear coplanar force

Forces acting in opposite direction, lies on a common line of action and acts in a single plane

28. What is the difference between like non coplanar concurrent force and non coplanar non concurrent force?
Non coplanar concurrent force

Forces intersects at one point but their lines of action do not lie on the same plane

Non coplanar non concurrent force

Forces do not intersects at one point and also their lines of action do not lie on the same plane

29. What is resultant force?
If a number of forces acting on a particle simultaneously are replaced by a single force, which could produce the same effect as produced by the given forces, that single force is called Resultant force. It is equivalent force of all the given forces.

30. Define statics
It is defined as the branch of rigid body mechanics, which deals with the behaviour of a body when it is at rest

31. Define Dynamics
It is defined as the branch of rigid body mechanics, which deals with the behaviour of a body when it is in motion.

32. What are the characteristics of force?
  i).Magnitude ii). Line of action iii). Direction and angle of inclination

33. A force of 500N acts at 30° with x axis. Write the force in Cartesian coordinates.

  $F = 500N$, $\theta x = 30^o$, $\theta y = (90^o - 30^o) = 60^o$

$\rightarrow$

F= FCos θxi + FCos θyj

= (500Cos30)i+(500cos60)j

= 433i+250j

34. Define force

Force is defined as an agent which changes or tends to change the state of rest or of uniform motion of a body. It represents the push or pull exerted by one body on another. It is a vector quantity.

36. State Newton's law of motion

Newton's first law: Every body preserves in its state of rest, or of uniform motion in a straight line unless it is compelled to change that state by forces impressed there on.

Newton's second law: The acceleration of a particle will be proportional to the force and will be in the direction of the force

Newton's third law: To every action there is an equal and opposite reaction.

37. UNITS

QUANTITY	mass	time	current	temp	intensity	length
UNIT	kilogram	second	ampere	Kelvin	candela	Meter

38. PARELLOGRAM LAW

$R=\sqrt{(P^2 +Q^2 +2PQCOS\theta)}$

Where R-Resultant P-1st force Q-2nd force θ-Angle between two forces

39. SCALAR QUANTITY

"It's one having only magnitude"

40. VECTOR QUANTITY

"It's one having both magnitude and direction"

41. POSITION VECTOR

$R=\sqrt{(x^2+y^2+z^2)}$

42. DOT PRODUCT

.	I	J	k
I	1	0	0
j	0	1	0
k	0	0	1

43. CROSS PRODUCT

X	I	J	k
I	0	K	-j
j	-k	0	I
k	J	-I	0

44, LAMIS THEOREM
If three coplanar forces are acting at a point in equilibrium then each force is directly proportional to sine of opposite two forces.
$P/Sin\alpha = Q/Sin\beta = R/Sin\varphi$

45. LAW OF MECHANICS
1. A particle remains in its position if resultant force is zero
2. If the resultant force is not zero then acceleration is proportional to resultant force F= ma.
3. Action and reaction forces are in same line of action, equal in equal in magnitude but opposite in direction.

46. NEWTONS LAW OF GRAVITATION
The law states that two particles of mass `m` and mutually attracted By two opposite forces F,-F then magnitude of F is given by

$$F = G\, Mm/R^2 \text{ Newton}$$

47. PRINCIPLEOF TRASMISSIBILITY
Principle of transmissibility states that " the motion of a rigid body remains unchanged if a force acting on a point is replaced by another force having same magnitude and direction in the same line of action.

48. RESULTANT FOR MORE THAN 2 FORCES
For a system when resolving $\qquad F_X = F\cos\theta$,
$F_Y = F\sin\theta$

The resultant force is $R = Sqrt((F_X)^2 + (F_Y)^2)$

49. EQULIBRANT
A force E with same magnitude and same line of action but opposite Direction is called equilibrant.

50. EQULIBRIUM
The equilibrant used to arrest the movement of the particle, then the The body is said to be in equilibrium. Here Resultant = 0.

51. CONDITIONS FOR EQUILIBRIUM
For collinear forces, £H = 0, £V = 0
For concurrent forces, £H = 0 , £V = 0

52. FREE BODY
A body which has been isolated from surroundings is called Free body.

53. FREE BODY DIAGRAM
The sketch showing all the forces and moments acting on the Free body is called free body diagram

54. FORCES I N THREE DIMENSION
Consider a system of force in three dimensions So

that $\_F = F\cos\emptyset x + F\sin\emptyset y + F\sin\emptyset y$

$\emptyset x = \cos^{-1}\ (Fx / F)$

$\emptyset y = \cos^{-1}\ (Fy / F)$

$\emptyset y = \cos^{-1}\ (Fy / F)$

55. CONDITIONS

$$\cos^2\emptyset X + \cos^2\emptyset Y + \cos^2\emptyset Z = 1$$
$$\mathbf{L^2 + m^2 + n^2 = 1}$$

56. RESULTANT

$R = Rx\ I + Ry\ j + Rz\ k$

$R = \text{Sqrt}\ (\ Rx^2 + Ry^2 + Rz^2$

Where $\emptyset x = \cos^{-1}\ (Rx / F)$, , $\emptyset y = \cos^{-1}\ (Ry / F)$, $Z = \cos^{-1}\ (RZ / F)$

UNIT – II EQUILIBRIUM OF RIGID BODIES

TWO MARKS

1. Define equilibrium

A body is said to be in a state of equilibrium, if the body is either at rest or is moving at a constant velocity.

2. What is two force equilibrium principle?

If a body is in equilibrium acted upon by two forces they must be of collinear forces of equal magnitude and opposite sense.

3. What is three force equilibrium principle?

If a body is in equilibrium acted upon by three forces, they the resultant of any two forces must be equal, opposite and collinear with the third force.

4. What is three four equilibrium principle?

If a body is in equilibrium acted upon by four forces, they the resultant of any two forces must be equal, opposite and collinear with the resultant of the other two.

5. How many equations of equilibrium are defined for a concurrent force system and coplanar force system?

For concurrent force system: two equations

$\Sigma H = 0$, and $\Sigma V = 0$

For coplanar force system: three equations

$\Sigma H = 0$, $\Sigma V = 0$ and $\Sigma M = 0$

6. State varignon's theorem

If a number of coplanar forces are acting simultaneously on a body, the algebraic sum of the moments of all the forces about any point is equal to the moment of the resultant force about the same point.

7. What is stable equilibrium?

A body is said to be in stable equilibrium, if it returns back to its original position after it is slightly displaced from its position of rest.

8. What is unstable equilibrium?

A body is said to be in unstable equilibrium, if it does not returns back to its original position, and heels farther away after slightly displaced from its position of rest.

9. What is neutral equilibrium?

A body is said to be in neutral equilibrium, if it occupies a new position (also remains at rest) after slightly displaced from its position of rest.

10. What is free body diagram?

It is a sketch of the particle which represents it as being isolated from its surroundings. It represents all the forces acting on it.

11. What are the characteristics of a couple?

i). the algebraic sum of the forces is zero

ii). the algebraic sum of the moments of the forces about any point is the same and equal to the moment of the couple itself.

12. Define moment of a force?

The moment of a force about a point is defined as the turning effect of the force about that point

Moment = force X perpendicular distance

13. For what condition the moment of a force will be zero?

A force produces zero moment about an axis or reference point which intersects the line of action of the force.

14. What is the difference between a moment and a couple?

The couple is a pure turning effect which may be moved anywhere in its own plane, or into a parallel plane without change of its effect on the body, but the moment of a force must include a description of the reference axis about which the moment is taken.

15. What is the difference between a fixed vector and a free vector?

A force which is applied at a particular location on a body is a fixed vector Ex. A moment

A Force which can be moved anywhere in its own plane or in a parallel plane without change in its effect on the body is called free vector Ex. A couple

16. What are the common types of supports used in two dimensions?

i). Roller support ii). Hinged support iii). Fixed support.

17. What are the common types of supports used in three dimensions?

i). Ball support ii). Ball and socket support iii). Fixed or welded support.

18. Define equilibrant

The force which brings the system of forces into equilibrium is called equilibrant. It is equal to the resultant force in magnitude collinear but opposite in nature.

19. What are the common types of loads?

i).point load or concentrated load ii).uniformly distributed load iii).uniformly varying load

20. What is statically determinate structure?

A structure which can be completely analyzed by static conditions of equilibrium $\Sigma H = 0$, $\Sigma V = 0$ and $\Sigma M = 0$ alone is called statically determinate structure.

21. A force of magnitude 200N is acting along the line joining P(2,4,6)m and Q(4,7,10)m. find the moment of the force about (7,10,15)

P= (2,4,6) m, X1= 2m, Y1= 4m, Z1=6m

Q = (4,7,10) m X2=4m, Y2= 7m Z2= 10m

F_{AB} =200N

γ_{AB} = (X2-X1)i +(Y2-Y1)j+(Z2-Z1)k

=(4-2)i+(7-4)j+(10-6)k

= 2i+3j+4k

$\lambda_{AB} = \gamma_{AB} / I\gamma I$ = 2i+3j+4k / $\sqrt{(2^2+(3^2)+(4^2))}$ = 2i+3j+4k / $\sqrt{(29)}$

→

F_{AB} = F_{AB} x λ_{AB} = 100 x (2i+3j+4k / $\sqrt{(29)}$)

= 74.28i+111.42j+148.56k

Moment Mo = r XF

$\gamma_{Ac} = (X2-X1)i +(Y2-Y1)j+(Z2-Z1)k$

$=(7-2)i+(10-4)j+(15-6)k$

$= 5i+6j+9k$

$$= \begin{vmatrix} i & j & k \\ 5 & 6 & 9 \\ 74.28 & 111.42 & 148.56 \end{vmatrix} \qquad = -111.42i-74.28j+111.42k$$

22. A force (10i+20j-5k)N applied at A (3,0,2)m is moved to point B(6,3,1)m. Find the work done by the force.

Work done= force X displacement

Displacement $r = (X2-X1)i +(Y2-Y1)j+(Z2-Z1)k$

$=(6-3)i+(3-0)j+(1-2)k$

$= 3i+3j-k$

$$= \begin{vmatrix} i & j & k \\ 3 & 3 & -1 \\ 10 & 20 & -5 \end{vmatrix}$$

$= 5i+5j+30k$

$\rightarrow$

23. A force F= (3i-5j+7k)N acts at A of coordinates (1, 3, 4). Determine the moment of this force about the coordinate axes

Coordinates of A (1, 3, 4).

$\rightarrow$

Position vector r = 1i+3j+4k

$\rightarrow \rightarrow$

Moment Mo = r XF

$$= \begin{vmatrix} i & j & k \\ 1 & 3 & 4 \\ 3 & -5 & 7 \end{vmatrix}$$

$= i(21+20)-j(7-12)+k(-5-9) = 41\underline{i+5j-14k}$

Moment about OX axis = i x Mo = 41 units

Moment about OY axis = jx Mo = 5 units

Moment about OZ axis = k x Mo = -14 units

24. What are the types of couple?

i).clockwise couple ii).anticlockwise couple

25. What is beam?

A beam is a horizontal structure member which carries a load, transverse (perpendicular) to its axis and transfers the load through support reactions to supporting columns or walls

26. What is frame?

A structure made up of several members, riveted or welded together is known as frame.

27. What is a point load?

A load acting at a point on a beam is known as a point load

28. What is a uniformly distributed load?

A load which is spread over a beam in such a manner that each unit length of the beam carries same intensity of the load, is called uniformly distributed load

29. What are the difference between roller support and hinged support?

Roller support has the known line of action of reaction, always normal to the plane of rollers. But, hinged support has an unknown line of action of reaction, at any angle θ with horizontal.

30. What is support reaction of beam?

The force of resistance exerted by the support on the beam is called as support reaction. Support reaction of beam depends upon the type of loading and the type of support.

31. What is statically indeterminate structure?

A structure which cannot be completely analyzed by these equations ($\Sigma H = 0$, $\Sigma V = 0$ and $\Sigma M = 0$) and needs some additional equations to solve is called statically indeterminate structure.

32. What is resultant force?

To replace the given system of forces into an equivalent single force called resultant force.

33. What is the difference between action and reaction?

Consider a ball placed on a horizontal surface. The self weight of the ball (W) is acting vertically downwards through its centre of gravity. This force is called action. Now, the ball can move horizontally but its vertical downward motion is resisted due to resisting force developed at support, acting vertically upwards. This force is called reaction.

34. What is free body?

A Body which has been so separated or isolated from the surrounding bodies is called free body.

$\rightarrow$

35. Find the unit vector along the force F=2i+3j+5k

Unit vector $\lambda = \quad \gamma_f / I\gamma I \quad = \quad 2i+3j+5k / \sqrt{(2^2+(3^2)+(5^2))} \quad = 0.324i+0.486j+0.811k$

35. A position vector and force are 2i-3j+4k and 120i-260j+320k respectively. find the moment of the force about the origin

$\rightarrow \qquad\qquad\qquad\qquad \rightarrow$

Position vector r = 2i-3j+4k   force vector F =120i-260j+320k

Moment $\overrightarrow{Mo} = \overrightarrow{r} \times \overrightarrow{F}$

$$= \begin{vmatrix} i & j & k \\ 2 & -3 & 4 \\ 120 & -260 & 320 \end{vmatrix}$$

$= \underline{80i\text{-}160j\text{-}160k}$

36. Define the term couple?
A couple is that two forces are of equal magnitude, opposite sensed parallel forces, which lie in the same plane.

37. Rigid bodies When a body is not subjected to collinear or concurrent force system, then the body is to be idealized as a rigid body.

38. **Moment of force** Moment of force is defined as the product of the force and the perpendicular distance of the line of action of force from the point. It's unit is N-m. M=F*r   N-m

 39.   Clockwise moment → positive sign   **Anticlockwise** → negative sign
40. Varignon's theorem of moment :
The algebraic sum of moments of any number of forces about any point in their plane is equal to moment of their resultant about the same point.
(ie.) F1d1 + F2d2+ F3d3+ - - -- - -- - = R × d
41.   **In the parallel force system, resultant should be in between the two forces and parallel to the forces**.

42.   **Force – couple system Couple:** Two forces F and –F having the same magnitude, parallel line of action but in opposite direction are said to form a couple.

43. In general, **moment of couple** = F × arm length

44. Types of couple
.a.   Clockwise couple
.b.   Anticlockwise couple

45. Equilibrium of rigid body in two dimension
For the equilibrium state of rigid body, the resultant force and the resultant force and the resultant moment with respect to any point is zero. $\sum H = 0$; $\sum V = 0$; $\sum M = 0$

46. For parallel forces acting on a rigid body
$\sum V = 0$; $\sum M = 0$

47. For inclined forces acting on a rigid body
$\sum V = 0$; $\sum H = 0$; $\sum M = 0$

48. Difference between moment and couple
The couple is a pure turning effect, which may be moved anywhere in it's own plane whereas, moment of force must include a description of the reference axis about which the moment is taken.

49. Action
The self weight of a body acting vertically downwards is known as action.

50. Reaction
The resulting force against the action acting vertically upwards is known as reaction. It is developed at the support.

51. Support reaction
The resistance force on the beam against the applied load at support is called support reaction.

52. Types of support
  i. Roller support
  ii. Hinged support
  iii. Fixed support

53. Types of load on a beam
1. Point load
2. Uniformly distributed load (UDL)
3. Uniformly varying load (UVL

UNIT – III PROPERTIES OF SURFACES AND SOLIDS

TWO MARKS

1. **State parallel axis theorem**
   It states that the moment of inertia of a lamina about any axis in the plane of lamina is equal to the sum of the moment of inertia about a parallel centroidal axis in the plane of lamina and the product of the area of the lamina and square of the distance between the two axes.

   $I_{AB} = I_G + Ah^2$

2. **State perpendicular axis theorem**
   It states that if Iox and Ioy be the moment of inertia about two mutually perpendicular axes OX and OY in the plane of the lamina and Ioz be the moment of inertia of the lamina about an axis normal to the lamina and passing through the point of intersection of the axes OX and OY then,

   $$Ioz = Iox + Ioy$$

3. **State Polar Moment Of Inertia**
   The area moment of inertia for an area relative to an axis perpendicular to the plane of the area is called polar moment of inertia. It id denoted by Ip

   $$Ip = Ixx + Iyy$$

4. **What is radius of gyration?**
   Radius of gyration about an axis is defined as the distance from that axis at which all the elemental parts of the lamina would have to be placed, such that the moment of inertia about the axis is same

5. **Define centre of gravity**
   Centre of gravity is an imaginary point at which the entire weight of the body is assumed to act

6. **Define centroid**
   Centre of gravity of a plane figure is referred as centroid. Centroid is the point at which the entire area of the figure is assumed to be concentrated

7. **Define principal axes and principal moment of inertia**
   The axes about which the product of inertia is zero are called principal axes. The moment of inertia with respect to the principal axes is known as principal moment of inertia

8. **Define product of inertia**

Second moment of area with respect to a set of perpendicular axes is known as product of inertia

9. **State the location of centroid of semicircle arc whose radius is r with a sketch**

-

X = r

-

Y = 4 r / 3π

10. **A semi circular area having radius 100 mm is located in the xy plane such that its diameteral edge coincides with x y axis. Determine the x coordinate of its centroid**

-

X = 4 r / 3π

= 4 X 100 / (3π)

=42.44 mm

11. **Define centroidal axis**

The central point is defined as a point where the entire physical quantity can be assumed to be concentrated to give the same first moment as that obtained by considering the elements of the body. The central points for a length an area and a volume are called centroids. The axes passing through the centroid is called centroidal axes.

12. **Name the axis on a plane laminar, about which sum of moment of elementary axis equals zero?**
Centroidal axis

13. **If an area has an axis of symmetry, the centroidal line lies on the axis of <u>symmetry</u>**
14. **I xy = O for a figure, which is <u>symmetrical</u> about either x or y axis.**
15. Moment of inertia of triangle about an axis passing through C.G and parallel to base is **$bh^3/36$**
16. **Determine the first moment of inertia of a triangle of base b and height h about its base is**
I base = $bh^3/ 12$

17. **Determine the second moment of area of a triangle of base b and height h about its base is**

I base = bh³/ 12

I C.G = bh³/36

18. **Define first moment of area**
Moment of area about a point is the product of area and its centroidal distance from the point

19. **Define second moment of area**
The role played by the moment of inertia in the rotary motion is similar to the role played by the mass in the translatory motion. The moment of inertia of an area is called as the area moment of inertia or the second moment of area

20. **Define mass moment of inertia**
The moment of inertia of the mass of a body is called as the mass moment of inertia

21. **A quadrant of a circle has 3 cm radius. Locate the centroid of the lamina with respect to the radii**

-

X = 4 r / 3π = 4 X 3 / 3π

= 4 /π

-

Y = 4 r / 3π = 4 X 3 / 3π

= 4 /π

22. **The coordinates of a centroid of an area may be obtained by dividing the first moment of area by the <u>area.</u>**
23. **The radius of gyration of an area about a given axis is defined as the effective distance where the entire area may be considered to be located <u>with respect to the axis of</u> rotation**
24. **Under what conditions do the following coincide?**
    A) Centre of mass and centre of gravity

    B) Centre of gravity and centroid of area

    - The gravitational force on a body of mass m must also pass through its centre of mass
    - For thin plate of constant thickness and homogeneous material

25. State the relationship between the second moment of area and mass moment of inertia for a thin uniform plate

Mass moment of inertia for a thin uniform plate about any axis = (thickness X density X second moment of area of the plate about the same axis)

26. A body has <u>one</u> number of centre of gravity

27. The coordinates of centroid is

$\bar{X}, \bar{Y}$

UNIT IV
DYNAMICS OF PARTICLES

TWO MARKS

1. DISPLACEMENT (S)
It is the distance travelled by the particle. It is a scalar quantity. Unit: meter

2. VELOCIYT (V)
It is the rate of change of displacement. It is a vector quantity. Unit: ms
$V=ds/dt$

3. ACCLERATION (a)
It is the rate of change of velocity. It is a vector
quantity.Unit: ms^{-2} $a = dv/dt = d^2s /dt$
Acceleration = Change of velocity/ Time
taken t
$=$ V-U /t

4. RETARDATION / DECELERATION
If initial   velocity > final velocity then the acceleration is negative

5. SPEED
Speed = distance travelled / Time taken

6. AVERAGE SPEED
Average speed = total distance travelled / Total time taken

7. AVERAGE VELOCITY
Average velocity = (initial + final) velocity/ 2

8. DISTANCE TRAVELLD (S)
s = velocity x time
s = vt

9. EQUATIONS OF MOTION IN A STRAIGHT LINE

$v=u+at$ $s=ut+½at^2$
$v^2=u^2+2as$ $u = 0$, body starts from rest,
$v = 0$, body comes to rest

10. DISTANCE TRAVELLED IN N SECONDS

Distance travelled in n^{th} second = sn - sn

sn > sn-1 nth

$s = u +a/2(2n - 1)$

11. EQUATION OF MOTION OF PARTICLE UNDER GRAVITY
when particle comes down: $h = ut + gt^2$,$v = u + gt$,$v^2 = u^2 + 2gh$
when particle moves upwards : $h = ut -gt^2$ $v = u -gt$ $v^2 = u^2 - 2gh$

12. MAXIMUM HEIGHT ATTAINED BY PROJECTED PARTICLE
(V=0) h max = $u^2/ 2g$

13. TIME TAKEN TO REACH MAX. HEIGHT
$(V = 0)$ $t = u/g$

14. TOTAL TIME TAKEN
Total time taken = 2 x time taken to reach max. Height
= $2u/g$

15. STRIKING VEIOCITY OF THE PARTICLE (U = 0)
$v = (2gh)^{1/2}$

Velocity with which a particle is thrown ($v = 0$)
$u = (2gh)^{1/2}$

16. DISPLACEMENT IN TERMS OF TIME
$s = f(t)$,
$v = ds/dt = d/dt(ft)$
$a = dv/dt = d^2 f(t)/dt^2$

17. EQUATION OF MAXIMUM VEIOCITY
Equation of maximum velocity $dv/dt = 0$

18. PROJECTILE: A Particle projected in the space at an angle to horizandal. Plane is called projected. And motion is called projectile motion.

19. TIME OF FLIGHT: $t = u \sin\alpha / g$
$u \sin\alpha$ = initial velocity in the upward (vertical component)
α = angel of projection
total time $T = 2 u \sin\alpha / g$

20. MAXIMUM HEIGHT ATTAINED:
$h \max = u^2 \sin^2\alpha / 2g$

21. RANGE, (R) $R = u^2 \sin^2\alpha / 2g$
Maximum horizontal range, $R = u^2/g$ when $\alpha = 45^0$

22. MOTION OF PARTICLE FROM KNOWN HEIGHT

Range=Horizandal Velocity ×time taken
= $u \times t$
$h = gt^2/2$

23 . WORK DONE
Work Done=Force X displacement
Unit=Nm=Joules

24. POWER
Rate of doing work
Power = Work done/ Time
=Force x displacement/Time
= force x velocity
=unit: Nms^{-1} = watt

25. MOMENTUM   Momentum= Mass x Velocity
$M=mv$
Unit: Kgm^{-1}

$$1 \text{ Newton} = \text{kgm}^{-1}$$

26. WEIGHT

Weight = mass x acceleration due to gravity   W

   = mg

Unit: Newton

27. STATIC EQUATION OF EQULIBRIUM

$\sum H=0; \sum V=0; \sum M=0$

28. D'ALEMBERTS EQUATIONS OF EQILIBRIUM

P-ma= 0

a = P /m

a= P1+P2+P3 …….. /m

D'alelemberts principle stats that system of force acting on a body in motion is in Equlibrium with the inertia a force or imaginary force (ma) of the body

29. MECHANICAL ENERGY: P.E = mg x h

= (Force) x (Displacement)

30. KINETIC ENERGY:

KE = ½mv²   [if u = 0]

   = ½m (v² - u²)   [u ≠ 0]

   = w/2g (v² - u²)

   = ½mv² - ½mu²

Work done by body in motion = final kinetic energy - initial kinetic energy

$\sum fx$ = sum of forces that induce the motion of a body.

31. IMPULSE-MOMENTUM EQUATION

Impulse = Final momentum-Initial momentum

32. LAW OF CONSERVATION OF LINEAR MOMENTUM

Initial momentum = Final momentum

Total momentum before impact = Total momentum after impact

m1u1 + m2u2 = m1v1+m2v2

33. IMPACT An sudden short term action between two bodies

34. ELASTIC BODY If body retains its original shape and size when the external forces are removed, then the body is said to be perfectly elastic body.

35. PERIOD OF DEFORMATION

The time elapsed from the instant of initial contact to the maximum deformation is period of deformation.

36. PERIOD OF RESTITUTION

The time elapsed from the instant of maximum deformation to the instant of just separation is called period of restitution.

period of impact = period of deformation + period of restitution

37. NEWTON'S LAW OF COLLISTION (CO-EFFICIENT OF RE

Coefficient of restitution (e) = Impulse during restitution /Impulse during deformation

$$= V2-V1/ u1-u2$$

38. LINE OF IMPACT

It is an imaginary line passing through the point of contact and normal to the plane of contact

39. DIRECT IMPACT   The velocities of two colliding bodies before impact and after impact are collinear with the line of impact

40. OBLIQUE IMPACT   The velocities of two collding bodies after collision are not collinear with the line of impact Vertical component before impact = vertical component after impact Horizontal component before impact = horizandal component after impact

UNIT – V FRICTION AND ELEMENTS OF RIGID BODY DYNAMICS

TWO MARKS

1. **Define friction.**
   When two surfaces are in contact with each other and one surface tends to move with respect to other, a tangential force will be developed at the contact surface, in the opposite direction of motion. This tangential force is called frictional force or friction.

2. **What are the types of friction?**
   Two types of friction I).Dry friction or coulomb friction II).Fluid friction

   Two types of dry friction i).static friction ii).dynamic friction

   Dynamic friction is further classified into I).sliding friction II).rolling friction

3. **Define coefficient of friction**
   The ratio of limiting friction to the normal reaction is known as coefficient of friction. It is denoted by the symbol μ

   Coefficient of friction = limiting friction / normal reaction

4. **Define angle of repose**
   The angle of the inclined plane at which the body tends to slide down is known as angle of repose

5. **What is simple contact friction**?
   The friction force is the resisting force developed at the contact surface of two bodies due to their roughness and when the surface of one body moves over the surface of an another body.

6. **Name some applications of simple contact friction**
   - Ladder friction
   - Wedge friction
   - Screw friction
   - Belt friction

7. **What is rolling resistance?**
   When one body is made to roll freely over an another body, a resistance is developed in the opposite direction known as rolling resistance

8. **What is impending motion?**
   The state of motion of a body which is just about to move or slide is called impending motion.

9. **Angle of repose is equal to <u>angle of friction</u>**

10. State the laws of dynamic friction

i). the frictional force always acts in the opposite direction to that the body moves

ii).coefficient of kinetic friction is less than the coefficient of static friction

iii).in moderate speeds, the force of friction remains constant and it decreases with the increase of speed

iv).the magnitude of dynamic friction bears a constant ratio to the normal reaction between the two surfaces.

11. State the laws of static friction

i). the frictional force always acts in the opposite direction to that the body movesii).the frictional force does not depend on the shape and area of contact of the bodiesiii).the frictional force depends on the degree of roughness of the contact area between two bodies.iv).the frictional force is equal to the force applied to the body, so long as the body is at restv). the limiting friction force bears a constant ratio to the normal reaction between the surfaces of contact

12. What is coefficient of rolling resistance?

Horizontal distance of point of resistance measured from centre of wheel known as coefficient of rolling resistance

13. Define angle of friction

It is the angle between the line of action of the total reaction of one body on another and the normal to the common tangent between the bodies when motion is impending

14. What is called the coefficient of static friction?

The ratio of limiting friction to the normal reaction is known as coefficient of static friction. It is denoted by the symbol μ

Coefficient of static friction = limiting friction (F) / normal reaction (N)

15. What is the condition interms of efficiency for a machine to be self locking?

If the friction angle φ is larger than the lead angle θ, the screw is said to be self locking i.e., load will remain in place even after the removal of effort.

16. What are the laws of sliding friction?

- the frictional force always acts in the opposite direction to that the body moves
- the magnitude of the sliding friction bears a constant ratio to the normal reaction between the surfaces of contact
- in moderate speeds, the force of friction remains constant and it decreases with the increase of speed

17. State the coloumb's laws of dry friction

- the frictional force always acts in the opposite direction to that the body moves

- the limiting friction force bears a constant ratio to the normal reaction between the surfaces of contact
- the frictional force is independent of the area of contact between the two surfaces, and it depends on the of roughness of the surface.
- The magnitude of friction force is equal to the force, which tends to move the body

18. Limiting friction

The maximum resistance offered by a body against the external
force which tends to move the body is called limiting force of friction.

19. Coefficient of friction (μ)

$\mu = Fm/NR$
Fm - Force of friction.
NR - Normal reaction.

20. For static friction

$(Fm)s = \mu s\ NR > (Fm)k$

For dynamic friction
$(Fm)k = \mu k\ NR$

21. Reaction of friction

$R = \sqrt{(NR^2 + Fm^2)}$

22. Angle of friction (ϕ)

Angle between normal reaction and reaction is called angle of friction.

$\tan \varphi = Fm/NR = \mu$

23. Simple contact friction

The type of friction between the surface of block and plane is called simple contact friction.

24. Applications of simple contact friction

Ladder friction
Screw friction
Belt friction

25. Screw jack

Screw jack is a device used to lift or lower loads gradually.

26. Screw friction

Friction in screw jack.

27. Belt friction

$T2/T1 = e^{\mu \theta}$

$T1 \rightarrow$ Tension in slack side
$T2 \rightarrow$ Tension in tight side
$\mu \rightarrow$ Coefficient of friction between belt and wheel
$\theta \rightarrow$ Angle of contact

28. Rolling resistance

When a body is made to roll over another body the resistance developed in the opposite direction of motion is called the rolling resistance. Rcosα is called rolling resistance.

29. Coefficient of resistance

Horizontal distance b is called as coefficient of resistance. b=Pr/ W

P→ applied force

r→ radius of the body

W→ weight of the body

30. Types of motion of rigid bodies

1.Translation

a) Rectilinear→ straight-line path motion

b) Curvilinear→ curved path motion

2.Rotation (with respect to a fixed point)

3.Rotation & Translation (General plane method)