VELAMMAL INSTITUTE OF TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

GE8292-ENGINEERING MECHANICS
2 MARKS Q & A

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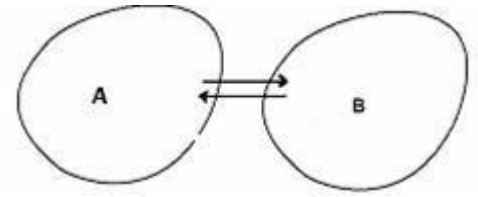
UNIT-I
BASICS & STATICS OF PARTICLES

1. **What are the different laws of mechanics?**

First law: *A body does not change its state of motion unless acted upon by a force or* Every object in a state of uniform motion tends to remain in that state motion unless an external force is applied to it. This law is also called "law of inertia".

Second law: It gives the force in terms of a quantity called the mass and the acceleration of a particle. It says that a force of magnitude *F* applied on a particle gives it an acceleration *a* proportional to the force.

Third Law: Newton's third law states that if a body *A* applies a force F on body *B*, then *B* also applies an equal and opposite force on *A* . (Forces do not cancel such other as they are acting on two different objects)



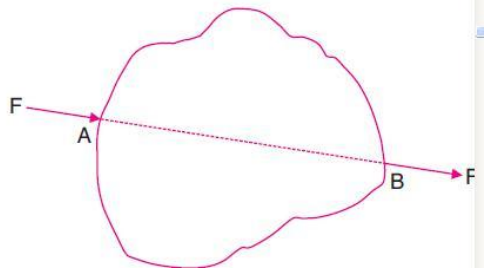
Law of gravitational attraction : Two particles will be attracted towards each other along their connecting line with a force whose magnitude is directly proportional to the product of the masses and inversely proportional to the distance squared between the particles.

$F = G\frac{m_1 m_2}{r^2}$ where *G* is called the universal gravitational constant.

2. **Explain concurrent forces.**

Two or more forces are said to be concurrent at a point if their lines of action intersect at that point.

3. **State the principle of Transmissibility?**



According to this law *the state of rest or motion of the rigid body is unaltered if a force acting on the body is replaced by another force of the same magnitude and direction but acting anywhere on the body along the line of action of the replaced force.*

Let *F* be the force acting on a rigid body at point *A* as shown in Fig. According to the law of transmissibility of force, this force has the same effect on the state of body as the force *F* applied at point *B*.

4. **Define Coplanar and Non-coplanar forces.** Coplanar forces: All the forces act on the same plane Non-coplanar forces : The forces act on different planes.

5. **Explain parallelogram law.**

This law states that "*if two forces acting simultaneously on a body at a point are presented in magnitude and direction by the two adjacent sides of a parallelogram, their resultant is represented in magnitude and direction by the diagonal of the parallelogram which passes through the point of intersection of the two sides representing the forces."*

6. **State triangle law of forces. What is the use of this law?**

"If the two forces acting simultaneously on a body are represented by the sides of a triangle taken in order, then their resultant is represented by the closing side of the triangle in the opposite order."

This law is used to find the resultant of two forces.

7. **Define Engineering mechanics.**

The branch of physical science that deals with the study of bodies under the state of rest or the state of motion subjected to external mechanical disturbances such as forces, moments etc.,

The mechanics of the rigid bodies dealing with the bodies at rest is termed as **Statics** and that dealing with bodies in motion is called **Dynamics**.

8. **What is rigid body?**

The bodies which will not deform or the body in which deformation can be neglected in the analysis are called as **Rigid bodies**.

9. **Define Kinematics and Kinetics.**

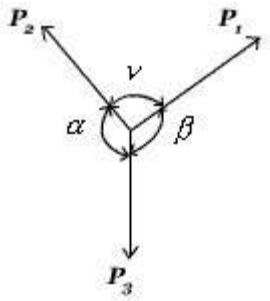
The dynamics dealing with the problems without referring to the forces causing the motion of the body is termed as **Kinematics** and if it deals with the forces causing motion also, is called **Kinetics.**

10. **Define "particle".**

A particle may be defined as an object which has only mass and no size. Such a body cannot exist theoretically. However in dealing with problems involving distances considerably larger compared to the size of the body, the body may be treated as particle, without sacrificing accuracy.

11. **State Lami's theorem.**

If three forces coplanar and concurrent forces acting on a particle keep it in equilibrium, then each force is proportional to the sine of the angle between the other two and the constant of proportionality is the same



For the system shown in figure ,

$$\frac{P_1}{\sin\alpha} = \frac{P_2}{\sin\beta} = \frac{P_1}{\sin\gamma}$$

12. **Define Unit Vector.**

    Unit vector is a vector having a unit magnitude or unit length.

13. **A force vector F= 700i + 1500j is applied to a bolt. Determine the magnitude of the force and angle it forms with the horizontal.**

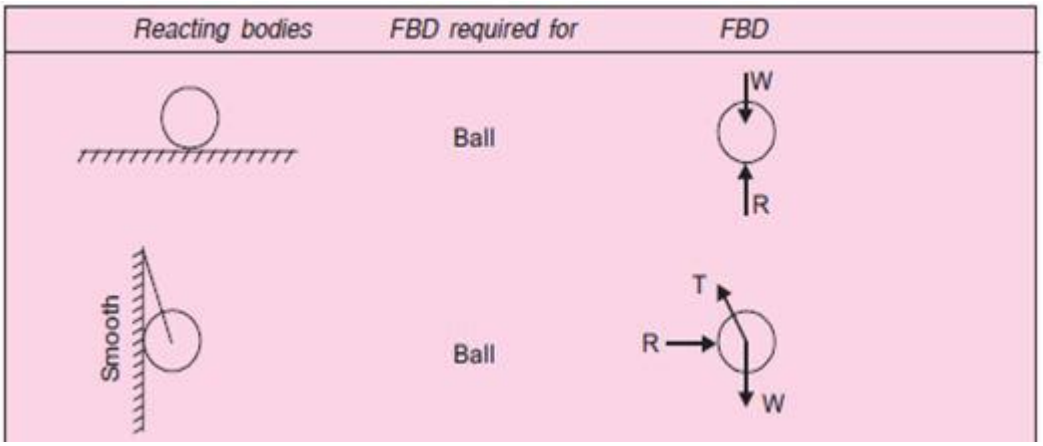
14. **A force of magnitude 50 KN is acting along the line joining A(2,0,6) and B(3,-2,0). Write the vector form of the force.**

15. **Two forces of magnitude 50 KN and 80 KN are acting on a particle, such that the angle between the two is 135°. If both the force are acting away from the particle, calculate the resultant and find its direction.**

16. **A 100N force acts at the origin in a direction defined by the angles θx = 75° and θy = 45°. Determine θz and the component of the force in the Z-direction.**

UNIT-II
EQUILIBRIUM OF RIGID BODIES

1. **State the Varignon's theorem.**
   It states that " the moment of the resultant of a number of forces about any point is equal to the algebraic sum of the moments of all the forces of the system about the same point"
2. **Differentiate Resultant and equilibrant.**
   Resultant is the single force which is equivalent to the given system of forces on a body.
   Equilibrant is the single force which brings the body to equilibrium. It has same magnitude as that of resultant and in opposite direction to it.
3. **With the help of a simple illustration define free body diagram.**
   It is a diagram of the body in which the body under consideration is freed from all the contact surfaces and all the forces acting on it (including reactions at contact surfaces) shows, is called a **Free Body Diagram (FBD).**



4. **A simply supported beam of 6 m span carries a concentrated load P at 2 m from the left end. If the support reaction at the left end support is 8 kN, find P.**

5. **What are the types of supports?**
   The beams usually have three different types of support:
   a. Hinged or pinned support
   b. Roller support
   c. Fixed support
6. **Define moment and couples.**
   Moment of a force about a point is the measure of its rotational effect. *Moment* is defined as the product of the magnitude of the force and the perpendicular distance of the point from the line of action of the force from that point.

Two parallel forces equal in magnitude and opposite in direction and separated by a definite distance are said to form a **couple**. The sum of the forces forming a couple is zero, since they are equal and opposite which means the translatory effect of the couple is zero.

7. Distinguish between a particle and a rigid body.

Particle	Rigid Body
A body of infinitely small volume and is considered to be concentrated at a point.	Rigid body is the one which retains its shape and size, if subjected to some external forces.
Here mass is negligible.	Here mass is considered

8. List the different types of beams?

a. Cantilever beam
b. Simply Supported beam
c. Fixed beam
d. Overhanging beam
e. Continuous beam

9. What are the conditions of equilibrium of a two dimensional rigid body?

a. $\sum F_x = 0$ b. $\sum F_y = 0$ $\sum M = 0$

10. State the analytical conditions for equilibrium of coplanar forces in a plane. The two conditions for equilibrium of coplanar forces are:

a. The algebraic sum of all the forces of a force system is equal to zero.

$$\sum F = 0$$

b. The algebraic sum of the moments of all the forces is equal to zero.

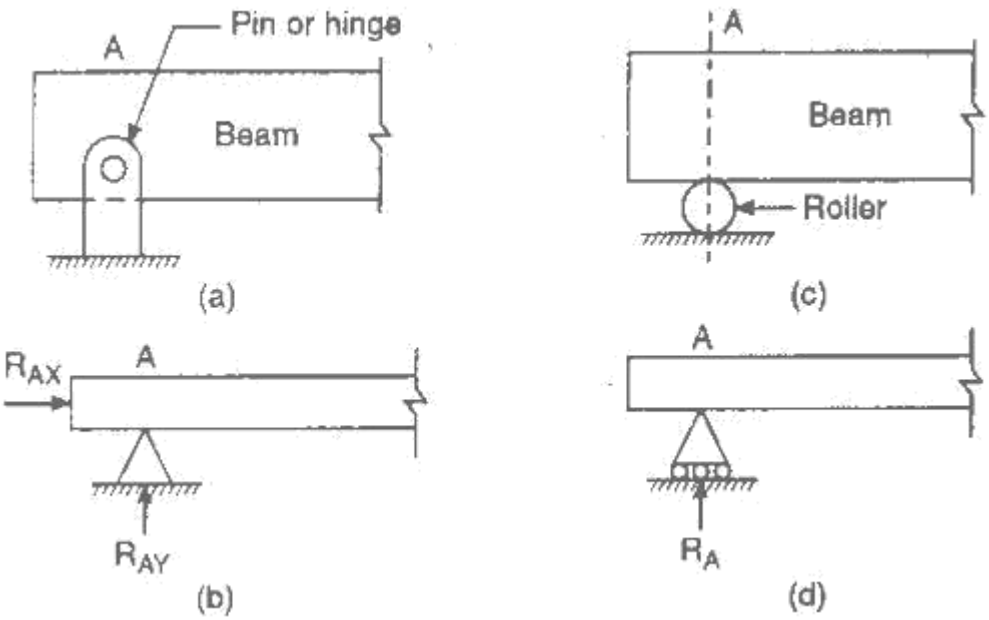
$$\sum M = 0$$

11. Explain Hinged or pinned support:

The hinged support is capable of resisting force acting in any direction of the plane. Hence, in general the reaction at such a support may have two components, one in horizontal and another in vertical direction. To determine these two components two equations of statics must be used. Usually, at hinged end the beam is free to rotate but translational displacement is not possible. (fig. A and B)

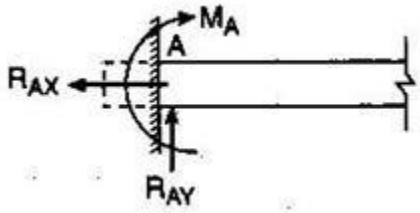
12. Explain Roller support:

The roller support is capable of resisting a force in only one specific line or action. The roller can resist only a vertical force or a force normal to the plane on which roller moves. A reaction on this type of supports corresponds to a single unknown figure. (fig. C and D). **The hinged and roller supports are also termed as simple supports.**



13. **Explain Fixed Support:**

The fixed support is capable of resisting of force in any direction and is also capable of resisting a couple or a moment. A system of three forces can exist at such a support (i.e., two components of force and a moment).



UNIT III
PROPERTIES OF SURFACES AND SOLIDS

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 moment of inertia about a parallel centroidal axis in the plane of lamina and the product of area of the lamina and square of the distance between the two axis"
   $$I_{AB} = I_{XX} + Ah^2$$
2. **State perpendicular axis theorem.**
   It states that "if I_{OX} and I_{OY} be the moment of inertia of a lamina about two mutually perpendicular axes OX and OY in the plane of the lamina and I_{OZ} 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
   $$I_{OZ} = I_{OX} + I_{OY}$$
3. **Find the polar moment of inertia of a hollow circular section of external diameter 'D' and internal diameter'd'.**
   Moment of inertia about XX axis $I_{XX} = (\prod/4)(D^2-d^2)$
   Moment of inertia about YY axis $I_{YY} = (\prod/4)(D^2-d^2)$
   Polar moment of inertia $I_P = I_{XX} + I_{XY}$
   $$I_P = (\prod/2)(D^2-d^2)$$
4. **Define principal axes and principal moment of inertia**
   The perpendicular axes about which product of inertia is zero is called " principal axes" and the moments of inertia wrt these axes are called as "principal moment of inertia".
5. **Locate the centroid and calculate the moment of inertia about centroidal axes of a semicircular lamina of radius 2m.**

6. **A semicircular area having a radius of 100 mm is located in the XY-plane such that its diameter coincides with Y-axis. Determine the X-coordinate of the center.**

7. **Distinguish between centroid and center of gravity.**

   Center of gravity is defined as the point through which the entire weight of the body acts.

   The term center of gravity is applied to the solids and centroid refers to the areas.

8. **Define polar moment of inertia.**

   It is defined as "the moment of inertia of the lamina or plane about the axis perpendicular to the plane of the section. It is denoted by I_P or J"

9. **Differentiate between 'Mass moment of inertia' and 'Area moment of inertia'.**

Mass moment of inertia	Area moment of inertia
Mass moment of inertia about an axis is the product of elemental mass and the square of the distance between the mass centre of the elemental mass and the axis. Mass moment of inertia = $\int X^2$ dm	Area moment of inertia about an axis is the product of elemental area and the square of the distance between the centroid of the elemental area and the axis. Area moment of inertia = $\int X^2$ da

10. **Write down the expression for finding mass moment of inertia of a cylinder of radius 'R' and height 'h' about its base.**

$$I_{XX} = (M/12)\ (3R^2 + 4h^2)$$

11. **State the theorems of Pappus and Guldinus.**

    Theorem I : The area of the surface of the revolution is equal to the product of length of the generating curve and the distance travelled by the centroid of the curved line while the surface is being generated.

    Theorem II : The volume of the body of the revolution is equal to the product of the generating area and the distance travelled by the centroid of the area while the body is being generated.

12. **Define 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 (i.e., the entire area of the figure is assumed to be concentrated) such that the moment of inertia about the axis is same.

$$r_{xx} = \sqrt{(I_{xx}/A)}$$
$$r_{yy} = \sqrt{(I_{yy}/A)}$$

13. **What is section modulus?**

    The modulus of section (or) section modulus) of a figure is the quantity obtained by dividing the moment of inertia of the figure, about its center of gravity by the distance of the extreme fibre from the centroidal axis.

UNIT IV

Dynamics of Particles

1. **Define D'Alembert's principle.**
   D'Alembert's principle states that " the system of external forces acting on a body in motion is in dynamic equilibrium with the inertia force of the body".
2. **Write down the equations of motion of a particle under gravitation.**
   a. $V = u + gt$
   b. $h = ut + (gt^2/2)$
   c. $V^2 = u^2 + 2gh$

   Where, V - Final velocity (m/s)
   U - Initial velocity (m/s)
   g - acceleration due to gravity (9.81 m/s^2)
   t - time (sec)
3. **A car accelerates uniformly from a sped of 30 Km/Hr to a speed of 75 Km/Hr in 5 secs. Determine the acceleration of the car and the distance traveled by the car during 5 secs.**

4. **Distinguish between kinetics and kinematics.**

Kinetics	Kinematics
The study of relation existing between the forces acting on the body, the mass of the body and motion of the body.	It is the study of the geometry of motion, which is used to relate displacement, velocity, acceleration and time, without reference to the force causing the motion.

5. **State the law of conservation of momentum.**
   It states that "the total momentum of two bodies remains constant before and after impact or any other mutual action"
   i.e. Initial momentum = Final momentum $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$
6. **A car starts from rest with a constant acceleration of 4m/sec2. Determine the distance traveled in the 7th second.**

7. **A point P moves along a straight line according to the equation x= 4t3+2t+5, where x is in meters and t is in secs. Determine the velocity and acceleration at t=3 secs.**

8. **stone is projected in space at an angle of 45° to horizontal at an initial velocity of 10 m/sec. Find the range of the projectile.**

9. **Define impulse and impulsive force.**
   If a constant force acts on a body for the given interval of time, the product of force and the time during which it acts, measures the impulsive of forces.
   When a large force acts over a short period of time then the force is called as impulsive force.

10. **Define rectilinear and curvilinear motion.**
    When the particle moves along a straight line, the motion of the body is called rectilinear motion.
    When the body moves in a curved path it is said to have curvilinear motion.
11. **What is a projectile?**
    When an object is thrown upwards at some angle, wrt the earth's surface, it moves in a curved path in the atmosphere and finally it returns to the ground at some other point. The path traced by the particle in air is known as the trajectory of the particle whereas the particle is called a projectile. The path traced by the projectile is parabolic.
12. **Define inertia force.**
    Inertia force of a body can be defined as the resistance to change in the condition of rest or of uniform motion of body.

14. State the difference between impulse and momentum.

Impulse is equal to the change in the momentum and is given by the product if the impulsive force and the time of application of that force.

Momentum is the quantity of motion and is the product of mass and velocity of the body.

15. Define impact and elastic impact. What are the two types of impact?

The phenomenon of collision of two bodies which occurs in a very small interval of time and during which the two bodies exert very large force on each other is called an impact.

If there is no loss of kinetic energy during collision it is known as elastic impact. The two types of impact are:

a. Direct Impact and
b. Indirect or oblique impact.

16. Define Co-efficient of restitution.

It is defined as the ratio of the relative velocity of their separation after collision to the relative velocity of their approach before collision.

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

17. State Newton's law of collision of elastic bodies.

It states that "when two moving bodies collide with each other, their velocity of separation bears a constant ratio to their velocity of approach"

i.e. Velocity of separation = (velocity of approach) constant

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

18. What should be the value of coefficient of restitution, if body is said to be perfectly elastic and perfectly inelastic?

For perfectly elastic bodies, $e = 1$

For perfectly inelastic or plastic bodies, $e = 0$

UNIT V
Friction and Elements of Rigid Body Dynamics

1. **Give mathematical definitions of velocity and acceleration.**
   Velocity is defined as the rate of change of displacement, v = (dx/dt)

2. **Define friction and classify its types.**
   When a body moves over another body, it experiences an opposing force at the contact surfaces. The opposing force is called friction. It is always opposite to the direction of motion. There are two types of friction. They are :
   a. Dry friction (or) Solid friction (or) Coulomb friction
   b. Fluid friction
3. **Explain dynamic friction.**
   If one surface starts moving on the other which is at rest, then the force experienced by the moving surface is called dynamic friction. It is also called as kinetic friction.
4. **Define Limiting friction.**
   When the external force, which tends to move the body exceeds the limit, then the body will start to move. This maximum resistance offered by the body is called the "Limiting friction".
5. **Define coefficient of friction and express its relationship with angle of friction.**
   It is defined as the ratio of the limiting friction to the normal reaction between the two bodies and is generally denoted by μ.
   $$\mu = (F/R)$$
   Relationship between coefficient of friction and angle of friction
   $$F = \mu \cos\Phi$$
6. **Stat coulomb's laws of dry friction.**
   I. Laws of static friction
      a. The force of friction always acts in the direction, opposite to that in which the body tends to move.
      b. The magnitude of force of friction, is always equal to the applied force.
      c. The magnitude of statistical frictional force bears a constant ratio to the normal reaction between the body and the surface.
         (Static frictional force / Normal reaction) = a constant
      d. The force of friction depends upon the roughness of the surface.
      e. The force of friction is independent of the area of contact between the bodies.
   II. Laws of dynamic friction
      a. The force of friction always acts in the direction, opposite to that in which the body is moving.
      b. The magnitude of dynamic frictional force bears a constant ratio to the normal reaction between the two contact surfaces.
         (Dynamic frictional force / Normal reaction) = a constant
      c. For moderate speeds, the force of friction remains constant. But it decreases at a slow rate with the increase of speed.
      d. The magnitude of dynamic friction is slightly less than that of static friction.
      e. The force of friction is independent of the velocity of sliding.

f. The coefficient of kinetic friction is slightly less than the coefficient of static friction.

7. **Define rolling resistance.**
   It is defined as the friction that occurs because of the deformation of the surface under a rolling load.
8. **If $x=3.5t^3 – 7t^2$, determine acceleration, velocity and position of the particle, when t = 5 sec.**

9. **State the principle of work and energy in a rigid body.**
   It states that $K.E._1 + W = K.E._2$
   Where, $K.E._1$ - The body's initial translational and rotational kinetic energy $K.E._2$ - The body's final translational and rotational kinetic energy W - Work done by the external forces.
10. **What is general plane motion?**
    It is the combination of the translation and rotation. If a body moves in such a way that a particle on the body translate through some distance and also displace through a certain angle, such a motion is termed as general plane motion.
11. **Define impending motion.**
    The state of motion of a body which is just about to move or slide is called Impending motion. When the maximum frictional force (i.e, Limiting friction) is attained and if the applied force exceeds the limiting friction, the body starts sliding or rolling. The state is called impending motion.
12. **Define angle of repose.**
    It is defined as the angle which an inclined plane makes with the horizontal when a body placed on it is just on the point of moving down is called angle of repose. ($\dot{\alpha}$)
13. **Define cone of friction.**
    The cone with the point of contact as the vertex and the normal at the point of contact as the axis, having semi-vertex angle (Φ) is known as the cone of friction.
14. **Define the following terms i) Ladder ii) Wedge iii) Belt drive.**
    i) Ladder: The ladder is a device for climbing or scaling on the roofs or walls. It is made by wood, iron or rope connected by a number of cross pieces called ladder.
    ii) Wedge: A wedge is a piece of wood or metal in the shape of a prism whose cross section is in the shape of triangle or trapezoid. It is used for lifting heavy loads and tightening fits.
    iii) Belt Drive: A belt drive is a power transmission device with belt and pulley arrangement in which the belt friction is used in the application of brakes to stop friction.