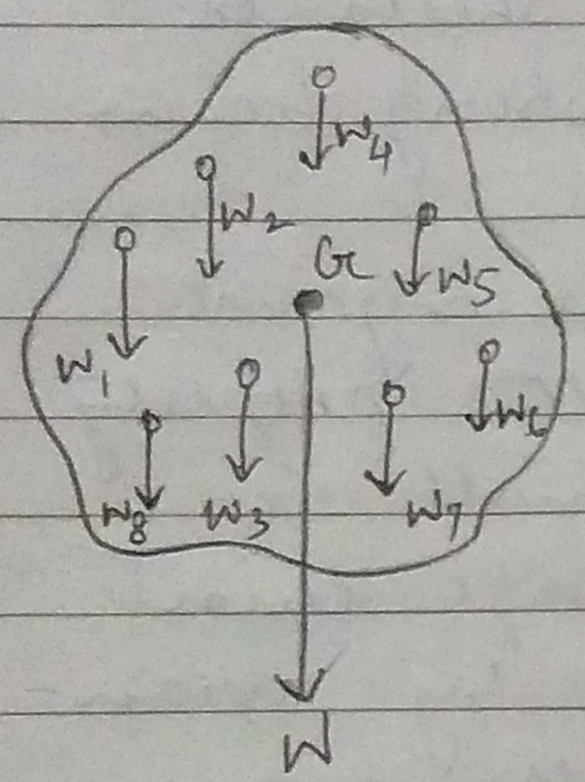
FORCE

Centre of gravity :- The centre of gravity (C.G) of a body is the point about which the algebraic sum of moments of weights of all the particles constituting the body is zero. The entire weight of the body can be considered to act at this point howsoever the body is placed.

explanation :- A body can be considered to be made of a large number of particles of weight $w_1, w_2, w_3 \ldots$. All these weights acting in vertically downwards towards the centre of the earth. These can be replaced by a single force W, where

$$W = w_1 + w_2 + w_3 + \ldots$$



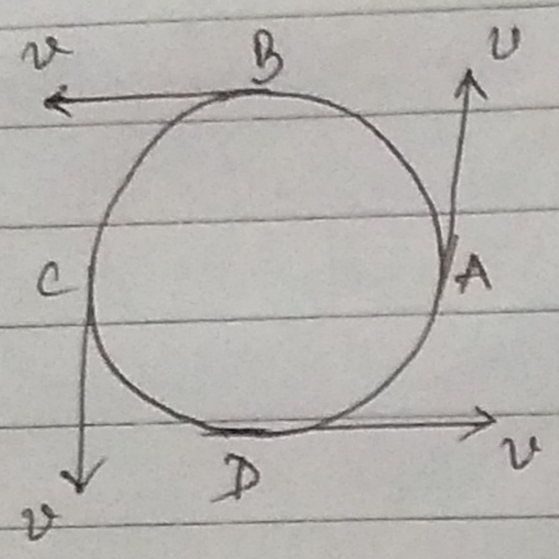
The weight W is considered to act at a point G such that the algebraic sum of moments due to weights w_1, w_2, $w_3 \ldots$ of each particle about the point G is zero. The point G is called the centre of gravity of the body.

Centre of gravity of some objects :

object	Position of C.G.
1. Rod	Mid-point of rod.
2. Circular disc	Geometric centre.
3. Solid or hollow sphere	geometric centre
4. Solid or hollow cylinder	mid point on the axis of cylinder
5. Solid cone	At height h/4 from the base, on axis
6. Hollow cone	At a height h/3 from base, on axis
7. Circular ring	centre of ring

8. Triangular lamina – The point of intersection of medians.
9. Parallelogram, rectangular lamina, square or rhombus – The point of intersection of diagonals.

* Uniform circular motion :- When a particle moves with a constant speed in a circular path its motion is said to be the uniform circular motion.



→ The continuous change in the direction of motion implies that the velocity of the particle is non-uniform i.e. the motion is accelerated.

→ At any point, the direction of motion is along the tangent drawn at that point of the circular path.

→ Though the speed is uniform the velocity is non-uniform.

Centripital force : Centripital force is the force acting on a body moving in a circular path in a direction towards the centre of circular path.

Centrifugal force : A force assumed by an observer moving with the body to act on the body in direction away from the centre of circular path is called the centrifugal force.

→ It is not the force of reaction of the centripital force.
→ It is a fictitious force.

3. Which type of motions are exhibited by a vehicle and its wheels?

Ans. The motion of vehicle is translatory and the motion of wheels is rotatory.

4. What do you mean by axis of rotation?

Ans. Axis of rotation is the line or point about which the object rotates. It may be within the object or outside the object.

5. Can the couple acting on a rigid object produce translatory motion?

Ans. No, the couple acting on a rigid object cannot produce translatory motion, it can cause only rotatory motion.

6. Name the device used for measuring: (*a*) mass (*b*) weight. **[2010]**

Ans. (*a*) Beam balance or Physical balance.

(*b*) Spring balance.

7. Can the moment of a force be zero even if the force is not zero? If so, when?

Ans. Yes, if the line of action passes through the point about which moment is to be calculated.

8. What is the purpose of adding ballast in the ocean freighters carrying a light cargo? Where would it be placed?

Ans. In ocean freighters, ballast is added to its lowest deck to lower centre of gravity.

9. (*a*) What is meant by the term 'moment of force'?

(*b*) If the moment of force is assigned a negative sign then will the turning tendency of the force be clockwise or anticlockwise? **[2012]**

Ans. (*a*) Moment of force produced by a force about an axis is equal to the product of the magnitude of force and its lever arm about the axis. It is represented by τ (tau).

$$\text{Torque } (\tau) = \text{Force } (F) \times \text{Lever arm } (d_{\perp})$$

(*b*) If the moment of force is assigned a negative sign, the turning tendency of the force will be clockwise.

10. Where does the position of centre of gravity lie for:

(*a*) a circular lamina, (*b*) a triangular lamina? **[2011]**

Ans. (*a*) The position of centre of gravity for a circular lamina lies at the geometric centre.

(*b*) For a triangular lamina, the position of centre of gravity lies at the centroid or point of intersection of medians.

11. Give a few examples of couple.

Ans. The rotation of an object is due to couple.

Few examples of couple are: turning a water tap, tightening of the cap of an inkpot, winding a clock with the key, steering of a four wheeler, driving the pedal of a bicycle, opening of a door (rotation is produced by the force we exert and an equal and opposite reaction at the hinge).

12. If a large force is acting on an object such that its line of action passes through the point about which the object can rotate. What will be your inference about the approximate magnitude of the moment of force?

Ans. As we know, torque (τ) = force (F) × perpendicular distance (d) from the axis of rotation

Here $d = 0 \Rightarrow \tau = 0$, i.e. moment of force will be zero.

13. Why are the passengers not allowed to stand in a small boat while crossing a river?

Ans. Passengers are not allowed to stand in a small boat because standing raises the centre of gravity of the boat, due to which line joining the centre of gravity and the centre of the earth may fall outside the base of the boat crossing the river. Thus, boat can capsize.

14. Why are passengers travelling in a double-decker bus allowed to stand on the lower deck but not on the upper deck?

Ans. Passengers travelling in the double-decker bus are allowed to sit or stand only on the lower deck which ensures lowering of the centre of gravity. On the other hand, if the passengers are standing on the upper deck, the centre of gravity of the bus will be raised to the extent that the line joining the centre of gravity of the bus and the centre of the earth can fall outside the base of bus along the sharp turns and hence it can topple over.

15. Explain why a rope walker holds a long pole in his hands.

Ans. When a rope walker walks on the tight rope, he holds a long pole in his hands to stay on the rope. For this the line joining the centre of gravity and centre of earth must fall with the rope. When rope walker feels he is falling towards right, he then shifts pole towards left by keeping his centre of gravity undisturbed. Thus, he can balance himself on the rope.

16. Explain why does one lean forward while climbing up a hill.

Ans. When a person climbs up a hill, he bends himself in the forward direction and adjusts his centre of gravity in such a way that the vertical line joining the centre of gravity and the centre of the earth falls within the base of his feet. Thus, the condition of stable equilibrium is satisfied and the person does not fall.

Due to similar reason a person coming down a hill bends backwards.

17. Why is heavy luggage loaded near the bottom of a ship?

Ans. Ship is loaded with heavy luggage near the bottom to lower down the centre of gravity. Hence the line joining the centre of gravity and the centre of earth does not fall outside the base of the ship when it pitches or rolls in the sea. Thus, it stays in stable equilibrium.

18. Why does a coolie carrying load on his back bend forward?

Ans. A coolie carrying load on his back has to lean forward to bring down the centre of gravity of the load and himself as low as possible and to keep the vertical line passing through the centre of gravity of the whole system between his feet. Hence he remains in stable equilibrium.

19. Why is a cart loaded with hay more likely to be upset than one loaded with steel?

Ans. When a cart/truck is loaded with hay its centre of gravity is sufficiently raised. While the centre of gravity of cart/truck loaded with steel is lowered. When the hay loaded cart will take sharp turn/or moves on uneven road, vertical line passing through its centre of gravity may go outside the base of the cart/truck and it is more likely to topple than the cart loaded with steel.

20. Why do we use a long handle with a screw jack?

Ans. In a screw jack, a long handle helps us to apply less force F at a good distance from the axis of rotation making $d_{\perp}$ large so as to give a large turning effect.

21. Why are the racing cars very broad and very low?

Ans. Racing car is specially designed with a very broad base and very low in height which keeps its centre of gravity very low. Thus, when this car takes sharp turn, at very high speed, the vertical line joining its centre of gravity and centre of the earth always falls within its base, which keeps it in stable equilibrium.

22. Why is it easy to carry two buckets in one hand each, rather than to carry only one bucket in one hand?

Ans. When a person carries only one bucket in his one hand, his centre of gravity shifts towards the bucket and vertical line passing through its centre of gravity may fall outside his feet. However, if in both the hands buckets are carried, the centre of gravity is lowered and it falls within the feet due to which a person stays in stable equilibrium.

EXERCISE–1(C)

1. Explain the meaning of uniform circular motion. Give *one* example of such motion.

2. Draw a neat labelled diagram for a particle moving in a circular path with a constant speed. In your diagram show the direction of velocity at any instant.

3. Is it possible to have an accelerated motion with a constant speed ? Name such type of motion.

   Ans. Yes, uniform circular motion

4. Give an example of motion in which speed remains uniform, but the velocity changes.

   Ans. Circular motion

5. A uniform circular motion is an accelerated motion. Explain it. State whether the acceleration is uniform or variable ? Name the force responsible to cause this acceleration. What is the direction of force at any instant ? Draw diagram in support of your answer.

6. Differentiate between a uniform linear motion and a uniform circular motion.

7. Name the force required for circular motion. State its direction. **Ans.** Centripetal force

8. What is a centripetal force ?

9. Explain the motion of a planet around the sun in a circular path.

10. (a) How does a centripetal force differ from a centrifugal force with refrence to the direction in which they act ?
    (b) Is centrifugal force the force of reaction of the centripetal force ?
    (c) Compare the magnitudes of centripetal and centrifugal force.

    Ans. (a) They act in opposite directions (b) No (c) 1 : 1

11. Is centrifugal force a real force ? **Ans.** No

12. A small pebble tied at one end of a string is placed near the periphery of a circular disc, at the centre of which the other end of the string is tied to a peg. The disc is rotating about an axis passing through its centre.
    (a) What will be your observation when you are standing outside the disc ? Explain.
    (b) What will be your observation when you are standing at the centre of the disc ? Explain.

    Ans. (a) The pebble moves in a circular path because the tension in the string provides the required centripetal force. (b) The pebble is stationary just in front because the centrifugal force on the pebble balances the tension in the string.

13. A piece of stone tied at the end of a thread is whirled in a horizontal circle with uniform speed with the help of hand. Answer the following questions :
    (a) Is the velocity of stone uniform or variable ?
    (b) Is the acceleration of stone uniform or variable?
    (c) What is the direction of acceleration of stone at any instant ?
    (d) What force does provide the centripetal force required for circular motion ?
    (e) Name the force and its direction which acts on the hand.

    Ans. (a) variable (b) variable (c) towards the centre of the circular path (d) tension in the string (e) the reaction of tension away from the centre of the circular path.

14. State *two* differences between the centripetal and centrifugal force.

15. State whether the following statements are true or false by writing T/F against them.
    (a) The earth moves around the sun with a uniform velocity.
    (b) The motion of moon around the earth in circular path is an accelerated motion.
    (c) A uniform linear motion is unaccelerated, while a uniform circular motion is an accelerated motion.
    (d) In a uniform circular motion, the speed continuously changes because the direction of motion changes.
    (e) A boy experiences a centrifugal force on his hand when he rotates a piece of stone tied at one end of a string, holding the other end in the hand. **Ans.** (a) F (b) T (c) T (d) F (e) F

MULTIPLE CHOICE TYPE

1. Which of the following quantity remains constant in a uniform circular motion :
   (a) velocity (b) speed
   (c) acceleration (d) both velocity and speed.

   Ans. (b) speed

2. The centrifugal force is :
   (a) a real force
   (b) the force of reaction of centripetal force
   (c) a fictitous force
   (d) directed towards the centre of circular path

   Ans. (c) a fictitous force