Questions

4.2 Define the following

(i) Resultant Vector

(ii) Torque

(iii) Centre of mass

(iv) Centre of gravity

Ans:

(i) Resultant Vector

A resultant vector is a single vector that has the same effect as the combined effect of all the vectors to be added.

OR

The sum of two or more vector is a single vector, which has the same effect as the combined effect of all the vectors to be added. This single vector is called resultant vector.

(ii) Torque

The turning effect of a force is called torque or moment of the force.

Torque τ =F x L

Torque is a vector quantity and its direction can be found by using the right and rule.

Unit of torque

Unit of torque is Nm

(iii) Centre of Mass

Centre of mass of a system is such a point where an applied force causes the system to move without rotation.

(iv) Centre of Gravity

A point where the whole weight of the body appears to act vertically downward is called Centre of gravity of a body.

4.3 Differentiate between the following:

(i) Like and unlike forces

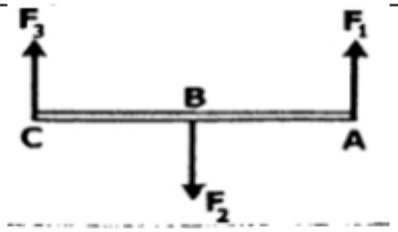
(ii) Torque and couple

(iii) Stable and neutral equilibrium

Ans:

(i) Difference between like and unlike forces:

Like parallel Force	**Unlike parallel force**
Like parallel forces are the forces that are parallel to each other and have the same direction	Unlike parallel forces are the forces thar are parallel but have directions opposite to each other.
Explanation: The forces F1, F2 and F3 are acting at points A, B and C respectively. Since the direction of the applied forces F1, F2 and F3 is the same, so these are like parallel forces. The applied forces F1, F2, F3 are acting in the opposite direction, so these are unlike parallel forces.	



(ii) Difference between Torque and Couple:

Torque is the special kind of force that has the capacity to rotate an object about an axis. While a force is described as the pull or push, it is better to think of torques as a twist

In a special case when applied force vectors add to zero, then the force is called a couple and their moment is called as torque. Thus, the rotational force that produces no moment of the tow forces. The moment of a couple is called a torque.

When a driver turns a steering wheel, he exerts two equal but opposite forces on it. The two forces form a couple. The turning effect of a couple is the sum of moment of the two forces. The moment of a couple is called Torque.

(iii)Difference between stable and neutral equilibrium

States of equilibrium:

There are three states of equilibrium

i- Stable equilibrium
ii- Unstable equilibrium
iii- Neutral equilibrium

(i) Stable equilibrium:

When the Centre of gravity of a body lies below point of the suspension or support, the body is said to be in Stable equilibrium. For example, a book lying on the table is in stable equilibrium.

Explanation:

A book lying on the horizontal surface is an example of stable equilibrium. If the book is lifted from one edge and then allowed to fall, it will come back to its original position. Other examples of stable equilibrium are bodies lying on the floor such as chair, table etc.

Reason of stability:

When the book is lifted, its center of gravity is raised. The line of action of weight passes through the base of the book. A torque due to the weight of the book brings it back to the original position.



(ii) Unstable Equilibrium:

When the Centre of gravity of a body lies above the point of suspension or support, the body is said to be in unstable equilibrium.

Example

Pencil standing on its pint or a stick in vertically standing position.

Explanation:

If a thin rod standing vertically is slightly disturbed from its position it will not come back to its original position. This type of equilibrium is called unstable

equilibrium, other example of unstable equilibrium are vertically standing cylinder and tunnel.

Reason of instability:

When the rod is slightly disturbed its Centre of gravity is lowered. The line of action of its weight lies outside the base of the rod. The torque due to weight of the rod toppled it down.



(iii)Neutral equilibrium:

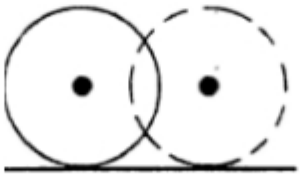
When the Centre of gravity of a body lies at the point of suspension or support, the body is said to be in neutral equilibrium.

Explanation:

If a ball is pushed slightly to roll, neither will it come back to its original position nor it will roll forward rather it will remain at rest. This type of equilibrium is called neutral equilibrium.

Reason of neutral equilibrium:

If a ball is rolled, its Centre of gravity is neither raised nor lowered. This means that its Centre of gravity is at same height as before.

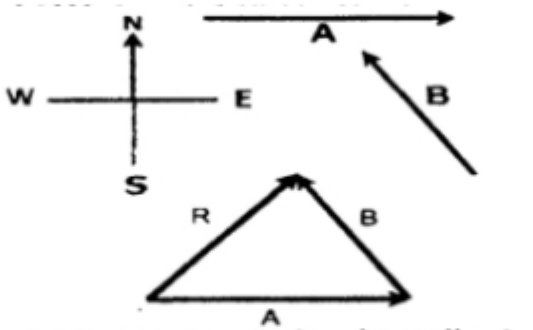


4.4 How head to tail rule helps to find the resultant of forces?

Ans:

Addition of vectors by head to tail rule:

To add the vectors, draw the representative lines of these vectors in such a way that the head of the first vector coincides with the tail of second vector. The line joining the tail of the first vector with the head of the second vector represents the resultant vector. The direction of the resultant vector is from the tail of the first vector towards the head of the second. This is called head to tail rule.



Adding vectors by head to tail rule

Note:

It should note that head to tail rule can be used to add any number of forces. The vector representing resultant force gives the magnitude and direction of the resultant force.

4.5 How a force be resolved into its rectangular components?

Ans:

Resolution of forces/vectors:

The process of splitting up vectors into their component forces is called resolution of forces.

OR

Splitting up of a force into two mutually perpendicular components is called resolution of that force. Vector resolution is reverse from vector addition.

Perpendicular component/rectangular components:

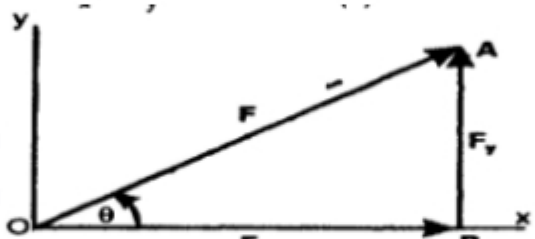
Consider a force **F** represented by line **OA** making an angle with x-axis. Draw a perpendicular **AB** on x-axis from **A.** According to head to tail rule, **OA** is the resultant vector represented by **OB** and **BA**.

Thus

OA=OB+BA..... (1)

From figure

F= F_x+F_y ..... (2)



Resolution of a force

Magnitude of horizontal component:

In right angled triangle OBA

Cosθ= base/hypotenuse= OB/OA

$$\frac{Fx}{F} = \text{Cos}\theta$$

$$F_x = F\,\text{Cos}\theta \text{..... (3)}$$

Magnitude of vertical component (F_y):

Sinθ= perpendicular/hypotenuse= BA/OA

$$\frac{Fy}{F} = \text{Sin}\theta$$

$$F_y = F\,\text{Sin}\theta \text{..... (4)}$$

Equations (3) and (4) gives the magnitude of horizontal and rectangular components.

4.6 Why a body is said to be in equilibrium?

Ans:

A body is said to be in equilibrium if no net force acts on it. A body in equilibrium thus remains at rest or moves with uniform velocity.

Examples:

A car moving with uniform velocity on a levelled road and an airplane flying in air with uniform velocity are example of bodies in equilibrium

Conditions of equilibrium:

In the above examples, we see that a body at rest or in uniform motion is in equilibrium if the resultant force acting on it is zero. For a body in equilibrium, it must satisfy certain conditions. There are two conditions of equilibrium.

4.7 Explain the first condition of equilibrium.

Ans:

First condition of equilibrium:

A body is said to satisfy the first condition of equilibrium if the resultant of all the forces acting on it is zero.

Explanation:

Let n number of forces F_1, F_2, F_3,....., F_n are acting on a body such that

$$F_1+F_2+F_3+.....+F_n = 0$$

Or

$$\sum \mathbf{F} = 0 \text{ ..... (1)}$$

The symbol ∑ is a Greek letter called Sigma used for summation. Equation (1)

Is called the first condition of equilibrium.

First condition of equilibrium can also be stated in terms of x and y components.

$$F_{1x}+F_{2x}+F_{3x}+.....+F_{nx} = 0$$

And

$$F_{1y}+F_{2y}+F_{3y}+.....+F_{ny} = 0$$

Or

$$\sum F_x = 0$$

And

$$\sum \mathbf{F_y} = 0$$

Examples:

A book lying on the table or a picture hanging on the wall, are at rest and thus satisfy first condition of equilibrium and is thus in equilibrium.

A paratrooper coming down with terminal velocity (constant velocity) also satisfies first condition for equilibrium and is thus in equilibrium.

4.8 Why there is a need of second condition of equilibrium if a body satisfies first condition of equilibrium?

Ans:

Case1:

First condition for equilibrium does not ensure that a body is in equilibrium.

Consider a body pulled by the forces F1 and F2. The two forces are equal but opposite to each other. Both are acting along the same line; hence, their

resultant will be zero. According to the first condition, the body will be in equilibrium.

Case2:

Now shift the location of the forces as shown in figure. In this situation, the body is not in equilibrium although the first condition of equilibrium is still satisfied.it is because the body has the tendency to rotate. This situation demands another condition for equilibrium in addition to the first condition i.e. second condition of equilibrium. According to this, a body satisfies second condition when resultant torque acting on it is zero.

$$\sum \tau = 0$$



(a) Two equal and opposite forces acting along the same lines (b) Two equal and opposite forces acting along different lines

4.9 What is second condition of equilibrium?

Second condition of equilibrium

Ans:

A body satisfies second condition for equilibrium when the resultant torque acting on its zero. Mathematically

$$\sum \tau = 0$$

4.10 Give an example of a moving body, which is in equilibrium.

Ans:

A car moving with uniform velocity on a levelled road and an airplane flying in air with uniform velocity are example of bodies in equilibrium

A paratrooper coming down with terminal velocity (constant velocity) also satisfies first condition for equilibrium and is thus in equilibrium.

4.11 Think of a body that is in rest but not in equilibrium.

Ans:

Rest implies stationary equilibrium implies a resultant force of zero. Therefore, a body in equilibrium could be moving. For example a skydiver at terminal velocity, where resistive forces are equal to the force of gravity. This means that a body can be in equilibrium and not at rest, but a body at rest must be in equilibrium. Otherwise, it would move so to answer the question: it is impossible.

ClassNotes

4.12 Why a body cannot be in equilibrium due to single force acting on it?

Ans:

No, with only a single force present, the body will accelerate infinitely in the direction of force.

Because the force that is alone applied will have, some direction and the object will try to move in this direction under its influence. However, if two opposite and equal forces take part it gives rise to a null vector force. The body can be in rotational equilibrium under the impact of a single force.

4.13 Why the height of the vehicles is kept as low as possible?

Ans:

As the whole the weight of the body acts on center of gravity so, in case of racing car center of gravity must be close to the earth so that there are less chances of overturning of the car.

If the car is high, it is easy to produce the torque in car due to large moment arm, and the car can take the somersault (forward roll)

4.14 Explain what is meant by stable, unstable and neutral equilibrium. Give on example of each.

Ans:

See Q#4.3(iii) from exercise.

ClassNotes