Chapter = 04

Turning Effect of Forces

Q1)Define like and unlike forces. Explain using examples

Like parallel forces

The forces that act along the same direction are called like parallel forces.

For Example

You might have seen many people pushing a car to move it Fig4.2. Why do all of them push it together in same direction? All of these forces are called like parallel forces because these are acting along same line.

Unlike parallel forces

The forces that act along opposite directions are called unlike parallel forces

For Example

A ceiling fan suspended in a hook through supporting rod. The forces acting on it are; weight of the fan acting vertically downwards and tension in the supporting rod pulling it vertically upwards. These two forces are also parallel but opposite to each other and acting along the same line. Thus, these forces are called unlike parallel forces.

Q2)What is meant by resolution of forces? How the direction and magnitude of a vector is obtained from its components?

Resolution of forces

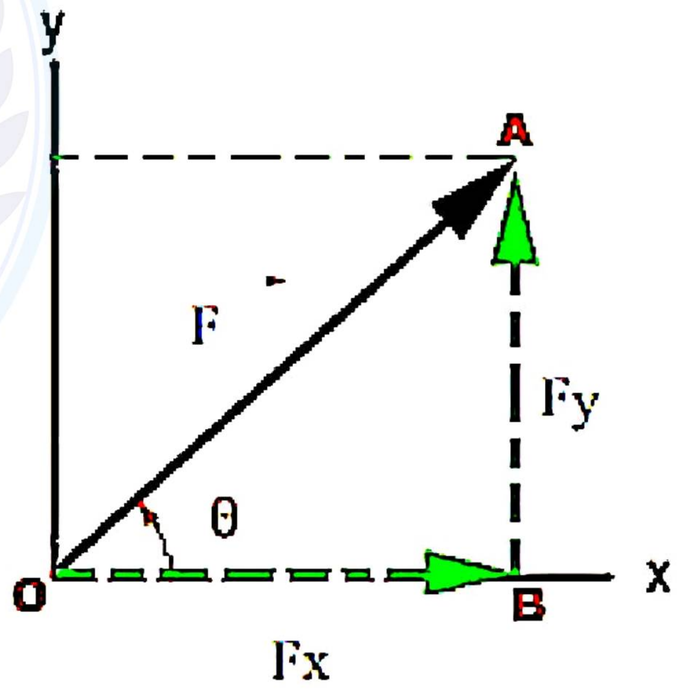
The process of splitting of a force into mutually perpendicular components is called resolution of force.

Mathematical Expression

Consider a vector $\vec{F}$ making and angle θ with positive X-axis. Vector $\vec{F}$ is represented by a line OA. From point A draw a perpendicular AB on X-axis. Suppose OB and BA represents two vectors. F_x and F_y respectively. Thus, F_x and F_y are the rectangular components of vector$F$.

Direction of resultant Vector

Consider right angled triangle ΔOAB



Using Pythagoras theorem

$Hyp^2 = Per^2 + Base^2$

$F^2 = Fx^2 + Fy^2$

$F = \sqrt{Fx^2 + Fy^2}$

Magnitude of vector

Consider right angled triangle ΔOAB

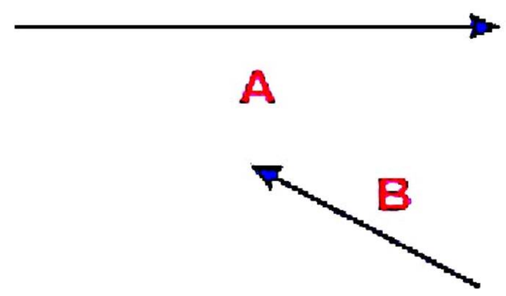
$$\text{Tan}\theta = \frac{Per}{Base}$$

$$\text{Tan}\theta = \frac{Fy}{Fx}$$

$$\theta = \tan^{-1}\left(\frac{OB}{OA}\right)$$

Q3)Which rule is used to find the resultant of more than two forces? Give Steps to add two vectors.

HEAD TO TAIL RULE

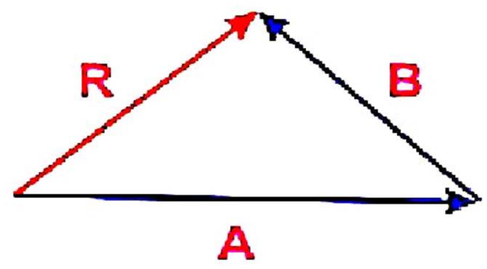


Step 1

Choose a suitable scale

Step 2

Draw all the force vectors according to scale. Vectors A and B in this case.



Step 3

Now take any vector as first vector and draw next vector in such a way that its tail coincides with head of the previous. If number of vectors is more than two, then continue the process till last vector is reached.

Step 4

Use a straight line with arrow pointed towards last vector to join the tail of first vector with the head of last vector. This is the resultant vector.

Q4)Define resolution of vector. Derive expression for rectangular component of vector.

Resolution of forces

The process of splitting of a vector into mutually perpendicular components is called resolution of vector.

Rectangular component of vector

Consider a vector $\vec{F}$ making and angle θ with positive X-axis. Vector $\vec{F}$ is represented by a line OA. From point A draw a perpendicular AB on X-axis. Suppose OB and BA represents two vectors. F_x and F_y respectively. Thus, F_x and F_y are the rectangular components of vector$F$.

HORIZONTAL COMPONENT

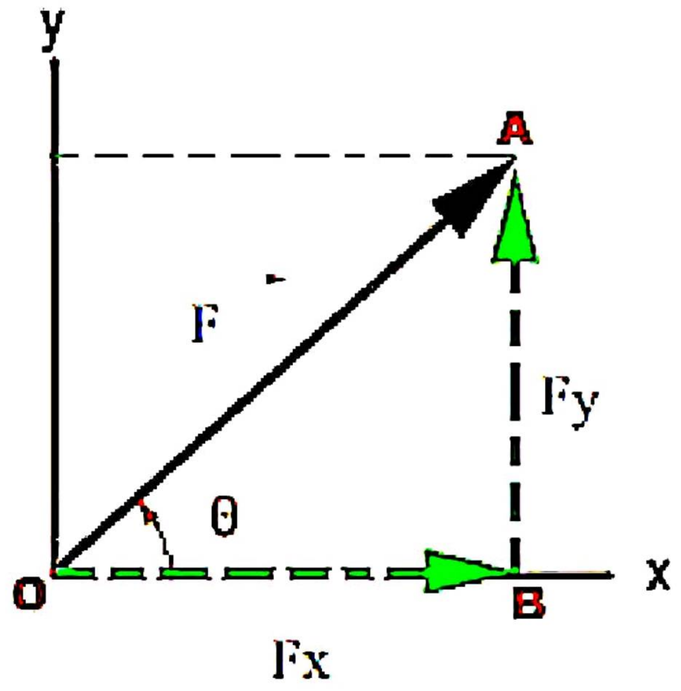
Consider right angled triangle ΔOAB

$\text{Cos}\theta = \frac{Base}{Hyp}$

$\text{Cos}\theta = \frac{OB}{OA}$

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

$F \cos\theta = Fx$



MAGNITUDE OF VERTICAL COMPONENT

Consider right angled triangle ΔOAB

$\text{Sin}\theta = \frac{per}{Hyp}$

$\text{Sin}\theta = \frac{AB}{OA}$

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

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

Q5)Define torque. Give its formula and unit. Also List the factors on which moment of force depends.

Torque

Turning effect of force is known as torque

Formula

Torque = force x moment arm

$\tau = F \times d$

Unit

Its S.I unit is N.m

It depends upon:

A. The magnitude of force.

B. The perpendicular distance of the point of application of force from the Pivot or fulcrum.

Q6)State principle of moment. Give three examples in which principle of moment is observed.

Principle of moment

The sum of the clockwise moments about a point is equal to the sum of the anticlockwise moments about that point.

Example

Sea saw

Opening a cap of bottle

To tightening or losing a screw

Q7)How is the see- saw balanced?

Two children playing on the see-saw. Fatima is sitting on right side and Faheem on the left side of the pivot. When the clockwise turning effect of Fatima is equal to the anticlockwise turning effect of Faheem, then see-saw balances. In this case they cannot swing. When the sum of all the clockwise moments on a body is balanced by the sum of all the anticlockwise moments, this is known as principle of moments.

Q8)What is center of gravity? Give center of gravity of some regular shape object.

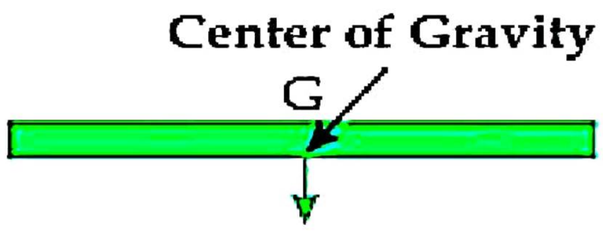
Centre of gravity

A body behaves as if its whole mass is concentrated at one point, called its centre of mass or centre of gravity

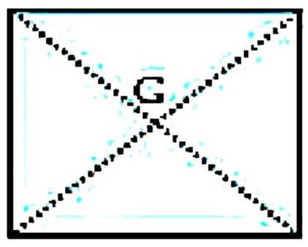
Center of Gravity of Some Regular Shaped objects

The Center of gravity of regular shaped uniform objects is their geometrical Center.

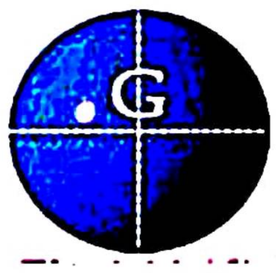
The Center of gravity of uniform rod is its midpoint



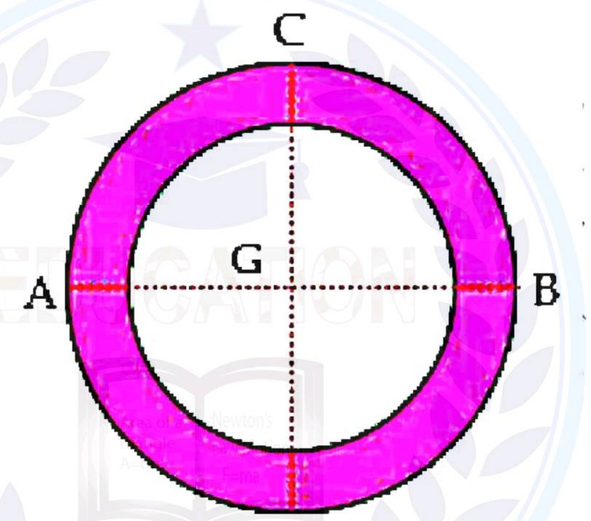
The Center of gravity of uniform square or a rectangular sheet is the point of intersection of its diagonals.



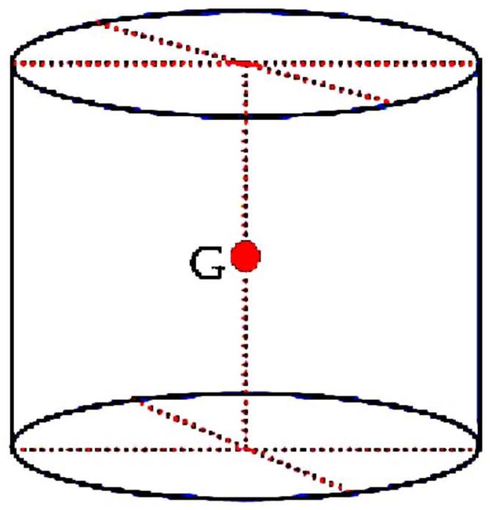
The Center of gravity of solid or hollow sphere is the Center of the sphere



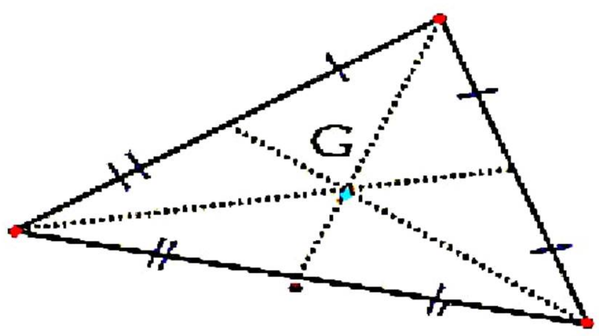
The Center of gravity of uniform circular ring is the Center of ring



The Center of gravity of a uniform solid or hollow cylinder is the mid-point on its axis



The Center of gravity of a uniform triangular sheet is the point of intersection of its medians



Q9)What is couple? Write three necessary conditions for two forces to form a couple.

Couple

Two unlike parallel forces of the same magnitude but not acting along the same line form a couple.

Conditions

1. To form a couple, two forces must be:
2. Equal in magnitude u Parallel, but opposite in direction
3. Separated by a distanced.

Q10) Define Equilibrium. Also discuss its types

Equilibrium

When a body does not possess any acceleration neither linear nor angular it is said to be in equilibrium.

For example,

A book lying on table in rest

A paratrooper moving downwards with terminal velocity

A chair lift hanging on supporting ropes

Types of equilibrium

There are two types of equilibrium.

1. Static Equilibrium
2. Dynamic Equilibrium

Static Equilibrium

A body at rest is said to be in static equilibrium.

Dynamic Equilibrium

A moving object that does not possess any acceleration neither linear nor angular is said to be in dynamic equilibrium.

Q11) State and explain Condition of equilibrium

Conditions for Equilibrium

A body must satisfy certain conditions to be in equilibrium. There are two conditions for equilibrium

First Condition for Equilibrium

According to this condition for equilibrium sum of the all forces acting on a body must be equal to zero.

$$F_1 + F_2 + F_3 + \ldots\ldots\ldots\ldots\ldots + F_n = 0$$

OR

$$\Sigma F = 0$$

In terms of x and y components of the forces acting on the body first condition for the equilibrium can be expressed as:

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

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

$$\Sigma F_x = 0$$

$$\Sigma F_y = 0$$

Second Condition of Equilibrium

Sum of all clockwise and anticlockwise torques acting on a body is zero. Mathematically,

$$\Sigma \tau = 0$$

Q12) What are states of equilibrium. Also write their conditions.

States of Equilibrium

There are three states of equilibrium:

1. Stable equilibrium
2. Unstable equilibrium and
3. Neutral equilibrium

Stable Equilibrium

A body is in stable equilibrium if when slightly displaced and then released it returns to its previous position.

Unstable Equilibrium

A body is said to be in unstable equilibrium when slightly tilted does not return back to its previous position.

Neutral Equilibrium

A body is said to be in neutral equilibrium when displaced from previous position remains in equilibrium in new position

Chapter = 04

Numerical problems

Numerical # 1

A pair of like parallel forces 15N each are acting on a body. Find their resultant.

F_1 = 15N

F_2 = 15N

F = ?

F = $F_1 + F_2$ (for like parallel forces)

F = 15 +15

F = 30 N

Practice of Numerical # 1

A pair of like parallel forces 28N each are acting on a body. Find their resultant.

Numerical # 2

A pair of like parallel forces 10N and 20 N each are acting on a body. Find their resultant.

F_1 = 10 N

F_2 = 20 N

F = ?

F = $F_1 + F_2$ (for like parallel forces)

F = 10 + 20

F = 30 N

Practice of Numerical # 2

A pair of like parallel forces 120N and 600 N each are acting on a body. Find their resultant.

Numerical # 3

Two unlike parallel forces 10 N each acting along same line. Find their resultant.

F_1 = 10 N

F_2 = 10 N

F = ?

F = $F_1 - F_2$ (for unlike parallel forces)

F = 10 – 10

F = 0

Practice of Numerical # 3

Two unlike parallel forces 9 N each acting along same line. Find their resultant.

Numerical # 4

Two unlike parallel forces 8 N and 5N each acting along same line. Find their resultant.

$F_1 = 8$ N

$F_2 = 5$ N

F = ?

$F = F_1 - F_2$ (for unlike parallel forces)

$F = 8 - 5$

$F = 3N$

Practice of Numerical # 4

Two unlike parallel forces 13 N and 10N each acting along same line. Find their resultant.

Numerical # 5

A gardener is driving a lawnmower with a force of 80 N that makes an angle of 40° with the ground.

i) Find its horizontal component ii) Find its vertical component (Cos45 0.707 , Sin45 = 0.707)

Data

F = 80N

$\theta = 40°$

Fx = ?

Fy = ?

Solution

$Fx = F\cos\theta$

$Fx = 80\text{Cos}45$

$Fx = 80 \times 0.707$

$Fx = 56.56$ N

$Fx = F\sin\theta$

$Fx = 80\sin45$

$Fx = 80 \times 0.707$

$Fx = 56.56$ N

Practice of Numerical # 5

A gardener is driving a lawnmower with a force of 90 N that makes an angle of 60° with the ground.

i) Find its horizontal component ii) Find its vertical component

Numerical # 6

Horizontal and vertical components of a force are 4 N and 3 N respectively. Find

i) Resultant force ii) Direction of resultant

Data

Fx = 4N

Fy = 3N

F = ?

θ = ?

Solution

$F = \sqrt{Fx^2 + Fy^2}$

$F = \sqrt{4^2 + 3^2}$

$F = \sqrt{16 + 9}$

$F = \sqrt{25}$

F = 5N

Practice of Numerical # 6

Horizontal and vertical components of a force are 8 N and 6 N respectively. Find

i) Resultant force ii) Direction of resultant

Numerical # 7

A spanner of 0.3 m length can produce a torque of 300Nm. i) determine the force applied on it

ii) What should be the length of the spanner if torque is to be increased to 500Nm with same applied force

Data

d = 0.3 m

τ = 300 N.m

F = ?

If τ = 500 N.m

d = ?

Solution

τ = Fd

300 = F x 0.3

F = 300/0.3

F = 1000 N

τ = Fd

500 = 1000 x d

$d = \frac{500}{1000}$

d = 0.5 m

Practice of Numerical # 7

A spanner of 0.5 m length can produce a torque of 450Nm. i) determine the force applied on it

ii) What should be the length of the spanner if torque is to be increased to 600Nm with same applied force

Numerical # 8

A mechanic uses a double arm spanner to turn a nut. He applies a force of 15 N at each end of the spanner and produces a torque of 60 Nm. What is the length of the moment arm of the couple? If he wants to produce a torque of 80Nm with same spanner then how much force he should apply?

Data

F = 15 N

τ = 60 N.m

d = ?

If, τ = 80 N.m

F = ?

Solution

$\tau = Fd$

60 = 15 x d

$d = \frac{60}{15}$

d = 4m

$\tau = Fd$

80 = F x 4

$F = \frac{80}{4}$

F = 20N