UNIT- II EQUILIBRIUM OF RIGID BODIES
Two Mark Question & Answers

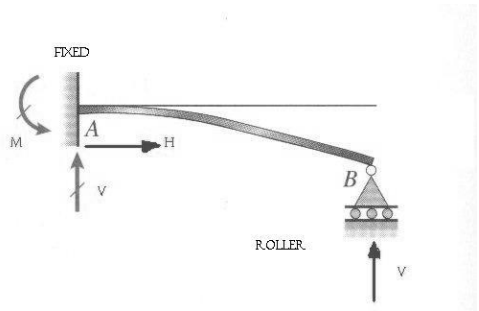
Syllabus

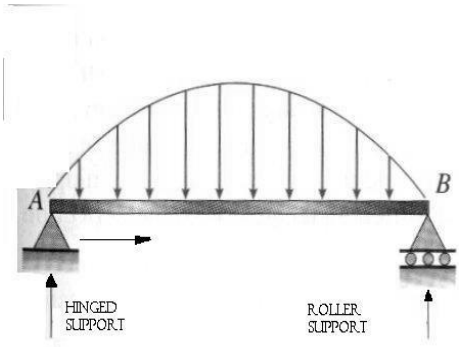
Free body diagram – Types of supports and their reactions – requirements of stable equilibrium – Moments and Couples – Moment of a force about a point and about an axis – Vectorial representation of moments and couples – Scalar components of a moment – Varignon's theorem – Equilibrium of Rigid bodies in two dimensions – Equilibrium of Rigid bodies in three dimensions – Examples

1. **State varignon's theorem**
   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.
2. **What is meant by equilibrium of a particle**
   When the resultant of a number of forces acting on a particle is zero, the particle is in equilibrium.

3. **State equilibrium forces**
   The set of forces where the resultant is zero and bring the body to its original position . Such a force is called equilibrium forces

4. **Write the equations which express the conditions for the equilibrium of a rigid body?**
   $\sum F_x = 0$ $\sum M_x = 0$
   $\sum F_y = 0$ & $\sum M_y = 0$
   $\sum F_z = 0$ $\sum M_z = 0$
5. **What are the different types of support?**
   a. Roller support b. hinged support c. fixed support





6. Define Concentrated or point load

Concentrated or point load

Any load acting at a point on a point on a load, is known as point load. In actual practice, it is not possible to apply a load at a point (ie. at a mathematical point) as it must have some contact area. But this area in comparison to the length of the beam is very small (or area is negligible).

7. Define Uniformly Distributed Load (UDL)

If a beam is loaded in such a way, that each unit length of the beam carries same intensity of the load, then that type of load is known as uniformly distributed load.

For finding the reactions the total uniformly distributed load is assumed to act at the Centre of Gravity (C.G.) of the load.

8.Define Uniformly Varying Load (UVL)

If a beam is loaded in such a way, that each unit length of the beam carries same intensity of the load, then that type of load is known as uniformly distributed load.

For finding the reactions the total uniformly distributed load is assumed to act at the Centre of Gravity (C.G.) of the load

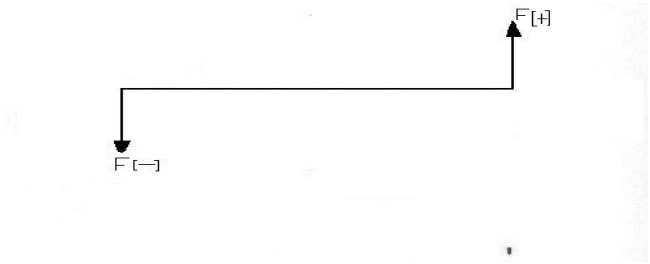
9. What are statically determinate?

A structure which can be completely analysed by static conditions of equilibrium alone say

$\sum H = 0, \sum V = 0, \sum M = 0$ are called statically determinate structure

10. **Define couple**

Couple is defined as two forces having the same magnitude , parallel lines of action and opposite sense are said to form a couple



11. **Define moment of a couple**

Moment of a couple is defined as the product of force and arm of the couple.

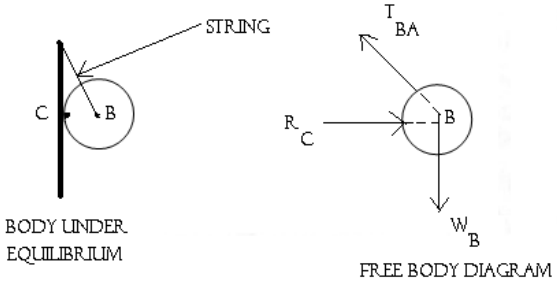
Moment of a couple = Force x arm of the couple

12. **State the difference between moment and a couple**

COUPLE	MOMENT
The couple is pure turning effect which may move anywhere in its own plane without change of its effect on the body	Moment of a force include a description of the reference axis about which the moment is taken

13. **What is free body diagram?**

The sketch showing all the forces both external forces and reactions and moments acting on the body and isolated from surrounding body is called free body diagram.

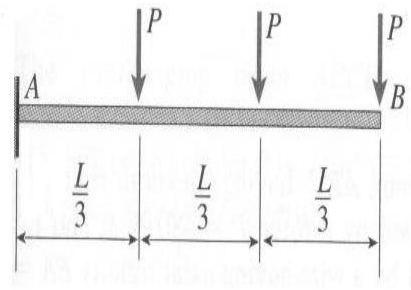


14. **State two force principle?**
    If a body is subjected to two forces, then the body will be in equilibrium if these two forces are collinear, equal and opposite. i.e. $F_1 = F_2$

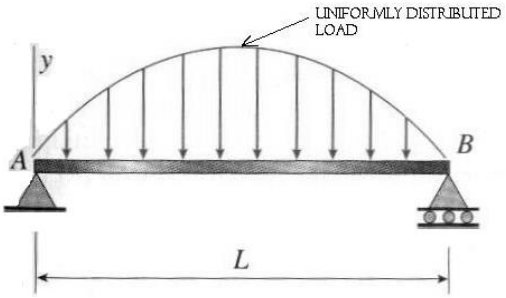
15. **State three force principle**
    If a body is subjected to three forces, then the body will be in equilibrium if the the resultant of any two forces is equal, opposite and collinear, with the third force

16. **State four –force principle**
    If a body is subjected to force forces, then the body will be in equilibrium if the resultant of any two forces is equal, opposite and collinear, with the resultant of the other two.

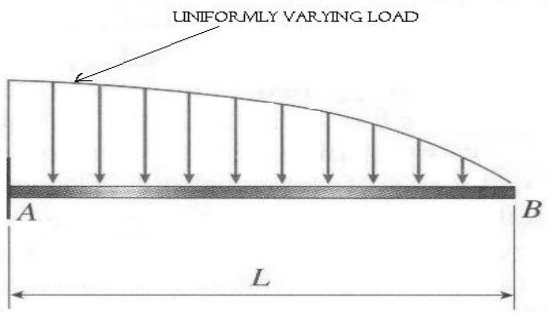
17. **What are the types of loads?**
    a) Point load
    b) Uniformly distributed load
    c) Uniformly varying load



. POINT LOAD



UNIFORMLY DISTRIBUTED LOAD



UNIFORMLY VARYING LOAD

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18. **What are the types of equilibrium**
    - ✓ Stable equilibrium
    - ✓ Unstable equilibrium
    - ✓ Neutral equilibrium

19. **What is meant by stable equilibrium?**
    A body is said to be in equilibrium when it comes back to its original position after it has been given a small displacement. This is known as stable equilibrium

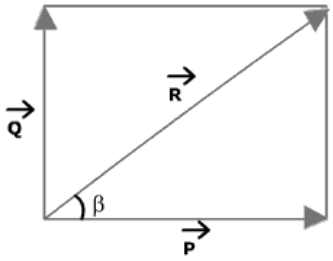
20. **What is meant by Unstable equilibrium**

If a body does not return back to its original position and moves further apart after being slightly displaced from its rest position, the body is said to be in unstable equilibrium. This condition arises when the additional force causes to move apart from its rest position.

21. **What is meant by Neutral equilibrium**

If a body occupies a position and remains at rest in this position after being slightly displaced from its rest position, the body is said to be in neutral equilibrium

22. **State triangular law**
    The law stats 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.



Triangular law

23. **A simply supported beam AB of span 6m carries point loads of 3kN and 6kN at a distance of 2m and 4m from the left end A. Find the reactions at A and B.**

Given data:

The given system is as shown in fig.

Span of the beam = 6m
R_A = Reaction at A
R_B = Reaction at B.

Solution:

As the beam is in equilibrium, the moments of all forces about any point should be zero.
Now, taking moment of all forces about A, and equating the resultant moment to zero, we get

$(R_B X6)-(3X2)-(6X4) = 0$

$6R_B = 6+24=30$

R_B = **5 kN.**

Also for equilibrium, $\sum F_y = 0$

$R_A + R_B = 3+6 = 9$

$R_A = 9 - R_B = 9-5 =$ **4 kN.**

Result:

Reaction at point A = R_A = **4 kN.**

Reaction at point B = R_B = **5 kN.**

24. **A force of 500 N forms angles 60°, 45°s and 120° respectively with X, Y and Z axis, write the force in vector form.**

Given data:

F = 500 N, $\theta_x = 60^o$, $\theta_y = 45^o$ and $\theta_Z = 120^o$

$$\vec{F} = FCos\theta_{xi} + FCos\theta_{yJ} + FCos\theta_{ZK}$$

$$= \left(500Cos60^o\right)i + \left(500Cos450^o\right)J + \left(500Cos120^o\right)K$$

$$\vec{F} = 250i + 353.55J - 250K$$

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

Solution:

B (1.4, 1.2, 0)

A (0.8, 0,1.2)

$\hat{F} = F\lambda$

$$= F\frac{(x_2 - x_1)i + (y_2 - y_1)j + (Z_2 - Z_1)K}{\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (Z_2 - Z_1)^2}}$$

$$= 750\left[\frac{(1.4 - 0.8)i + (1.2 - 0)j + (0 - 1.2)K}{(1.4 - 0.8)^2 + (1.2 - 0)^2 + (0 - 1.2)^2}\right]$$

$$= 750\left[\frac{0.6i + 1.2j - 1.2K}{\sqrt{0.6^2 + 1.2^2 - 1.2^2}}\right]$$

$$= 750\left[\frac{0.6i + 1.2j - 1.2K}{1.8}\right]$$

$$= 416.67\left[\frac{(0.6i + 1.2j - 1.2K)}{1.8}\right]$$

$$= 416.67(0.6i + 1.2j - 1.2k)$$

$$= 250i + 500J - 500k$$

26. A force $\vec{F} = 700i + 1500J$ is applied to a belt A. Determine the Magnitude of the force and the angle it forms with the horizontal (May 2004)

Solution:

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

$$= \sqrt{700^2 + 1500^2}$$

$$F = 1655.29\,N$$

Angle of the force with horizontal

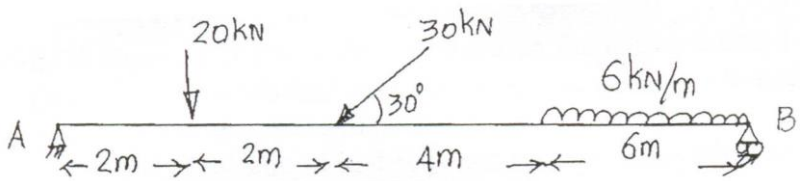
$$\theta x = Cos - 1\left[\frac{Fx}{F}\right]$$

$$= Cos - 1\left[\frac{700}{1655.29}\right]$$

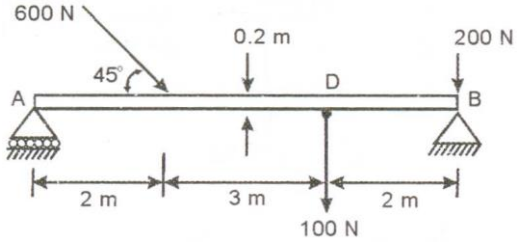
$$\theta_x = 64.98^o$$

Part-B

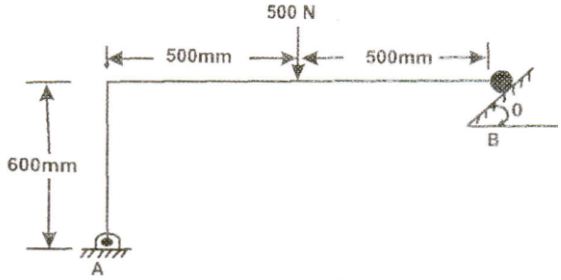
1. Determine the reactions at supports A and B of the simply supported beam shown in figure.



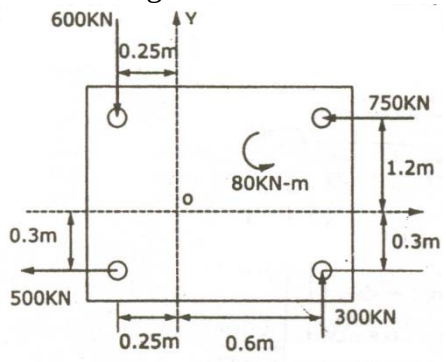
2. Determine the reactions at A and B from the figure.



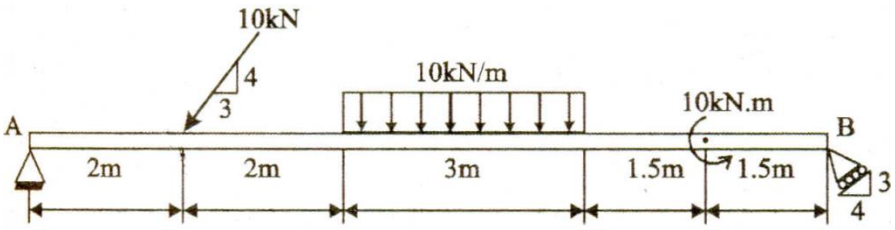
3. A frame supported at A and B is subjected to a force of 500 N as shown in figure. Compute the reactions at the support points for the cases of Θ = 0º, Θ = 60º and Θ = 90º



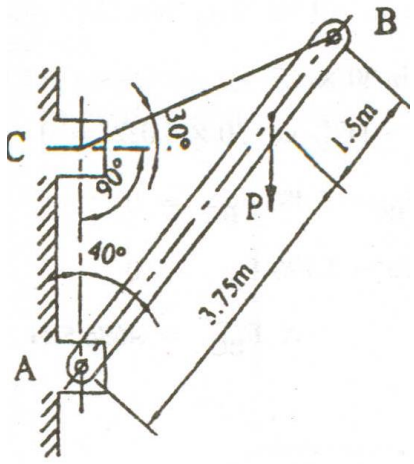
4. Four forces and a couple are applied to a rectangular plate as shown in figure below. Determine the magnitude and direction of the resultant force –couple system. Also determine the distance x from O along x-axis where the resultant intersects.



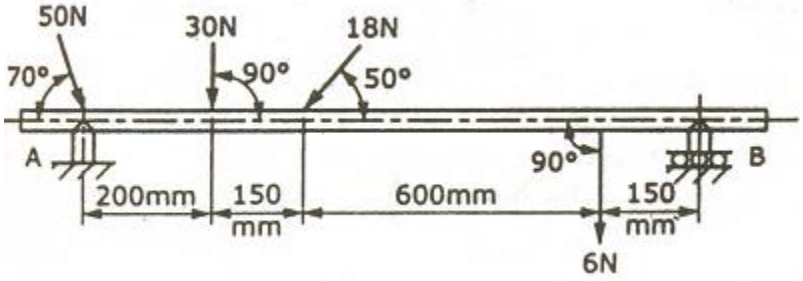
5. Find the reaction at the supports A and B for a beam as shown in figure.



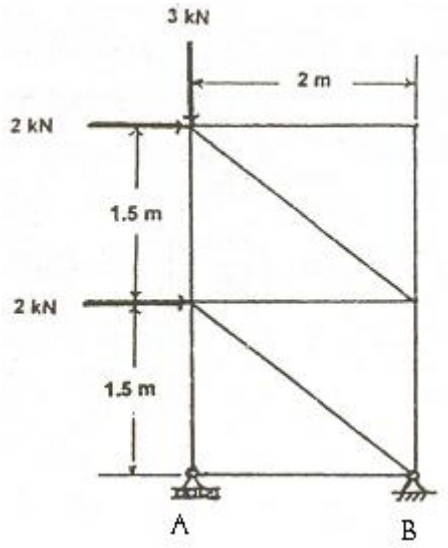
1. A Load P of 3500 N is acting on the boom, which is held by cable BC as shown in the Figure. The weight of the boom can be neglected.
   (a)Draw the free body diagrams of the boom
   (b) Find the tension in cable BC
   (c) Determine the reaction of A.



7. Determine the reaction at the support A and B from as shown figure.



8. Determine the reaction at the support A and B from as shown figure


3 kN
2 m
2 kN
1.5 m
2 kN
1.5 m
A
B