

NEW

Semester - II

Engineering Mechanics

UNIT

2

Equilibrium (संतुलन)

UNIT-II Equilibrium

Equilibrium and Equilibrant, Free body and free body diagram, Analytical and graphical methods of analysing equilibrium. Lami's Theorem statement and explanation, Application for various engineering problems.

Beam- Types of beam, supports (simple, hinged, roller and fixed) and loads acting on beam (vertical and inclined point load, uniformly distributed load, couple), Beam reaction for cantilever, simply supported beam with or without overhang - subjected to combination of Point load and uniformly distributed load.

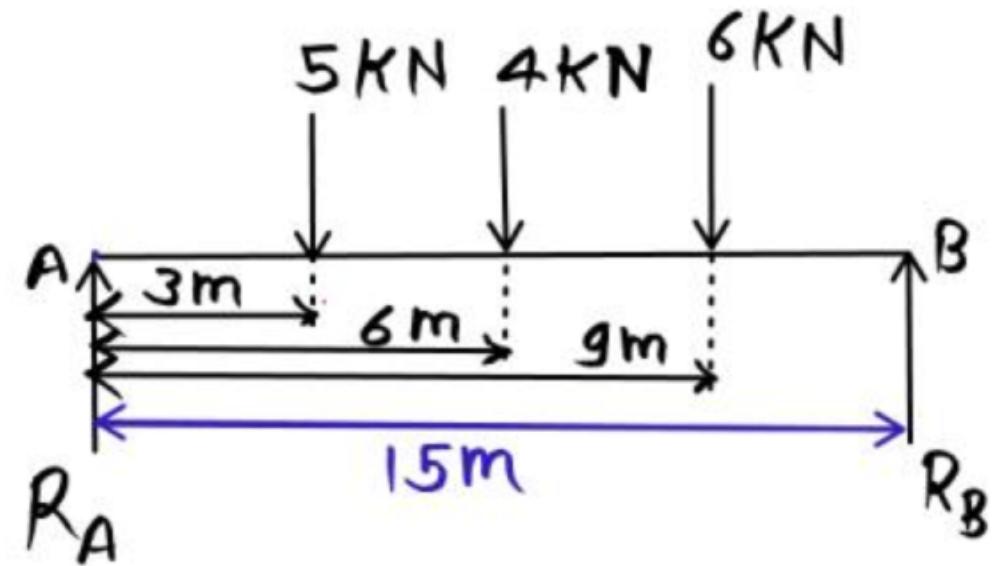
Q.1

15 मी. लम्बे दोनों किनारों पर सरल आधारित एक बीम पर 5 KN, 6 KN तथा 4 KN के लोड बायं सपोर्ट से क्रमशः 3मी., 9मी. और 6मी. की दूरी पर क्रिप्ताशील हैं। दोनों सपोर्ट पर उत्तिक्रिप्त क्षात्र कीजिए।

"Loads 5 KN, 6 KN and 4 KN acts on a simply supported beam of length 15m at distance 3m, 9m and 6m from Left support.
Find out the reactions on both supports." (H.W.)

$$R_A = 8.8 \text{ KN}$$

$$R_B = 6.2 \text{ KN.}$$



संतुलन के समी०

$$\sum F_y = 0 \text{ से}$$

$$R_A + R_B - 5 - 4 - 6 = 0$$

$$R_A + R_B = 15 \text{ KN} \quad \text{--- } ①$$

$$\sum M_A = 0 \text{ से}$$

taking moment about Point A

$$R_B \times 15 - 6 \times 9 - 4 \times 6 - 5 \times 3 + R_A \times 0 = 0$$

$$15R_B - 54 - 24 - 15 = 0$$

$$15R_B - 93 = 0$$

$$R_B = \frac{93}{15}$$

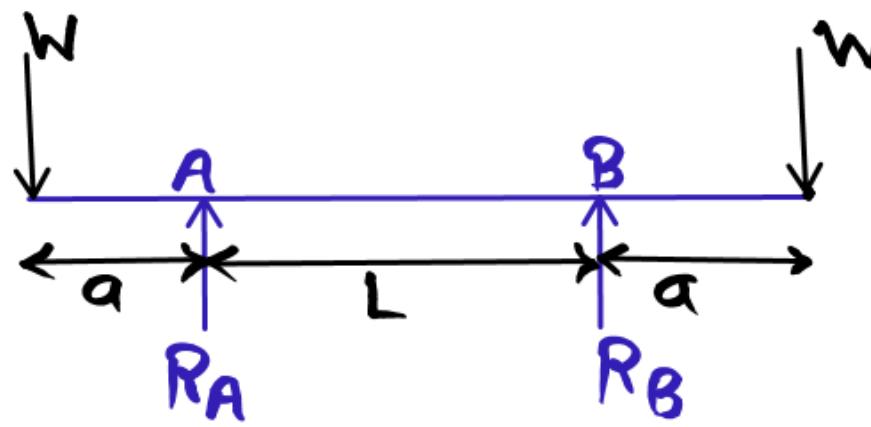
$$\Rightarrow R_B = 6.2 \text{ KN}$$

समी० ① में लगाने पर

$$R_A + 6.2 = 15$$

$$R_A = 8.8 \text{ KN}$$

Reaction for overhanging beam (प्रलंबी धरन के लिए प्रतिक्रिया) :-



सन्तुलन के समी० (Equilibrium equation)

$$\sum F_y = 0 \text{ से}$$

$$R_A + R_B - W - W = 0$$

$$R_A + R_B = 2W \quad \text{--- } ①$$

$$\sum M_A = 0 \text{ से}$$

$$-W \times (a+L) + R_B \times L + R_A \times 0 + W \times a = 0$$

$$-Wa - WL + L \cdot R_B + 0 + Wa = 0$$

$$L \cdot R_B = WL$$

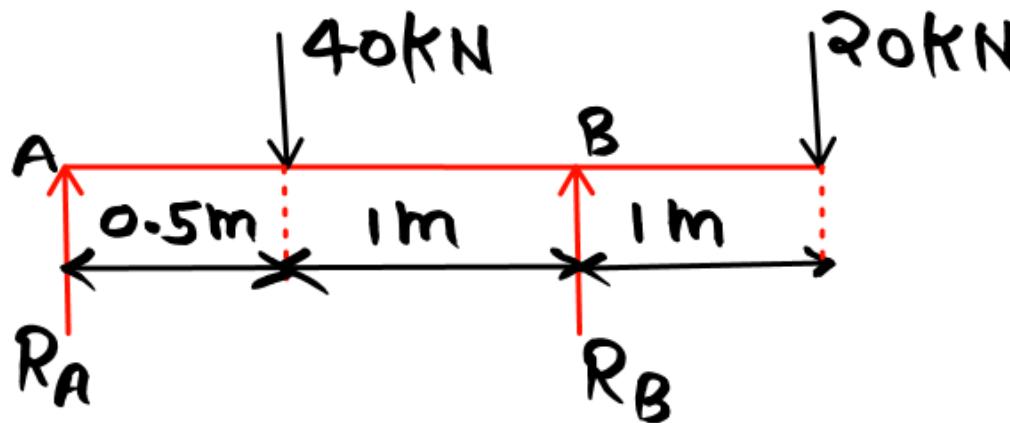
$$R_B = W \quad \text{समी } ① \text{ के रखने पर}$$

$$R_A + W = 2W$$

$$R_A = 2W - W$$

$$R_A = W$$

Q.



सनुलन के समी०

$$\sum F_y = 0 \text{ से}$$

$$R_A + R_B - 40 - 20 = 0$$

$$R_A + R_B = 60\text{KN} \quad \text{--- } ①$$

$$\sum M_A = 0 \text{ से}$$

taking moment about Point A

$$-20 \times 2.5 + R_B \times 1.5 - 40 \times 0.5 + R_A \times 0 = 0$$

$$-50 + 1.5 R_B - 20 = 0$$

$$1.5 R_B - 70 = 0$$

$$1.5 R_B = 70$$

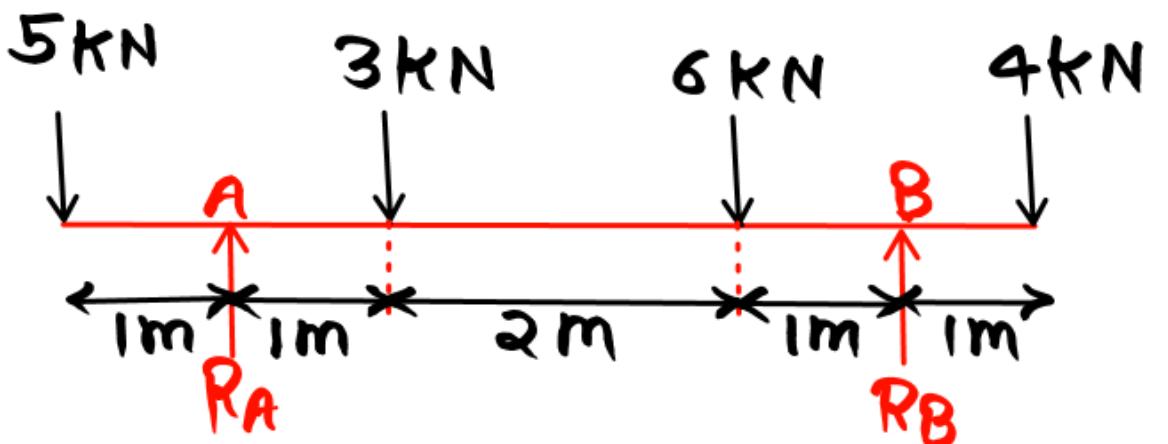
$$R_B = \frac{70}{1.5}$$

$$R_B = 46.67 \text{ kN}$$

समी० ① के स्वेच्छ पर

$$R_A + 46.67 = 60$$

$$R_A = 13.33 \text{ kN}$$



सनुलन के समी०

$$\sum F_y = 0 \text{ से}$$

$$R_A + R_B - 5 - 3 - 6 - 4 = 0$$

$$R_A + R_B = 18 \text{ kN} \quad \text{--- } ①$$

$$\sum M_A = 0 \text{ से}$$

taking moment about Point A.

$$-4 \times 5 + R_B \times 4 - 6 \times 3 - 3 \times 1 + R_A \times 0 + 5 \times 1 = 0$$

$$-20 + 4R_B - 18 - 3 + 0 + 5 = 0$$

$$4R_B - 36 = 0$$

$$4R_B = 36$$

$$R_B = 9 \text{ kN}$$

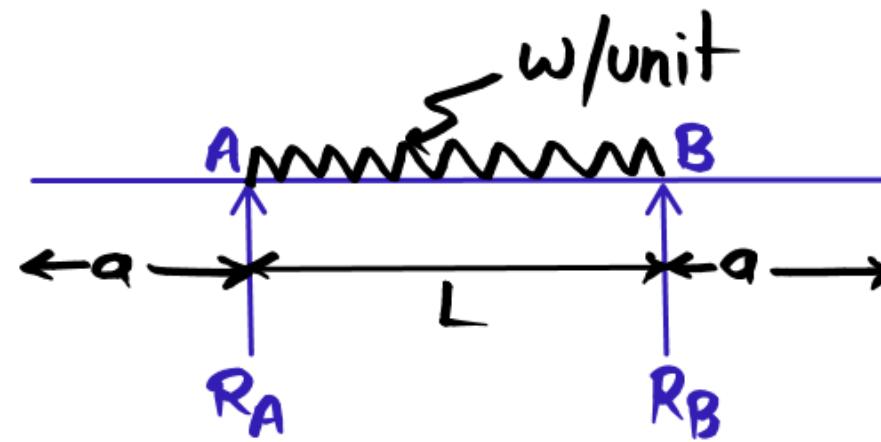
समी० ① मे० स्वेच्छा पर

$$R_A + 9 = 18$$

$$R_A = 9 \text{ kN}$$

Reaction for overhanging beam subjected to U.D.L.

(जब प्रत्यक्षी धरन पर U.D.L. पड़ा है तो उसकी प्रतिक्रिया) :-



समुलन के समी०

$$\sum F_y = 0 \text{ से}$$

$$R_A + R_B - w \cdot L = 0$$

$$R_A + R_B = w \cdot L \quad \text{--- (1)}$$

for U.D.L.

$$\text{total Load} = \text{U.D.L} \times \text{Length}$$

$$\text{Moment} = \frac{\text{total Load} \times \text{Length}}{2}$$

$\sum M_A = 0$ से (Taking moment about Point A)

$$R_B \times L - wL \times \frac{L}{2} + R_A \times 0 = 0$$

$$L \cdot R_B - \frac{wL^2}{2} = 0$$

$$L \cdot R_B = \frac{wL^2}{2}$$

$$R_B = \frac{wL}{2}$$

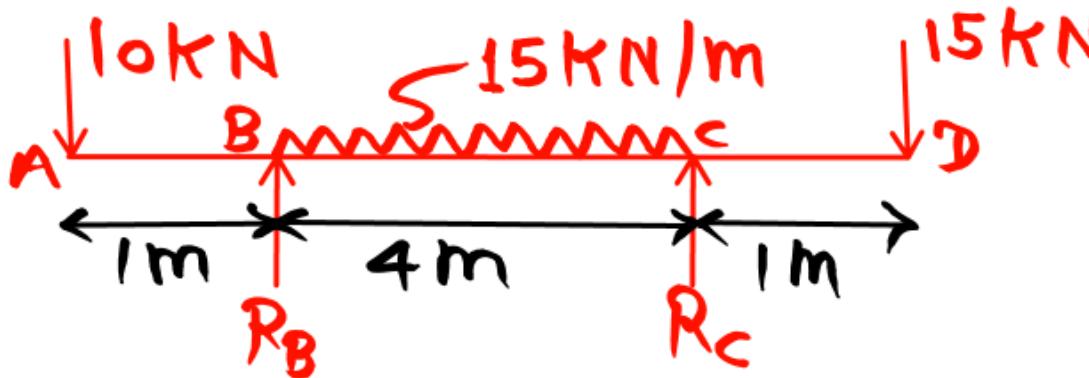
समी० (1) में इसका प्रयोग

$$R_A + \frac{wL}{2} = wL$$

$$R_A = wL - \frac{wL}{2}$$

$$R_A = \frac{wL}{2}$$

Q.



सनुलग के समी०

$$\sum F_y = 0 \text{ से}$$

$$R_B + R_C - 10 - 15 - (15 \times 4) = 0$$

$$R_B + R_C - 10 - 15 - 60 = 0$$

$$R_B + R_C = 85 \text{ KN} \quad \text{--- } ①$$

$$\sum M_B = 0 \text{ से}$$

taking moment about Point B

$$-15 \times 5 + R_C \times 4 - 60 \times 2 + R_B \times 0 + 10 \times 1 = 0$$

$$\Rightarrow -75 + 4R_C - 120 + 10 = 0$$

$$\Rightarrow 4R_C - 185 = 0$$

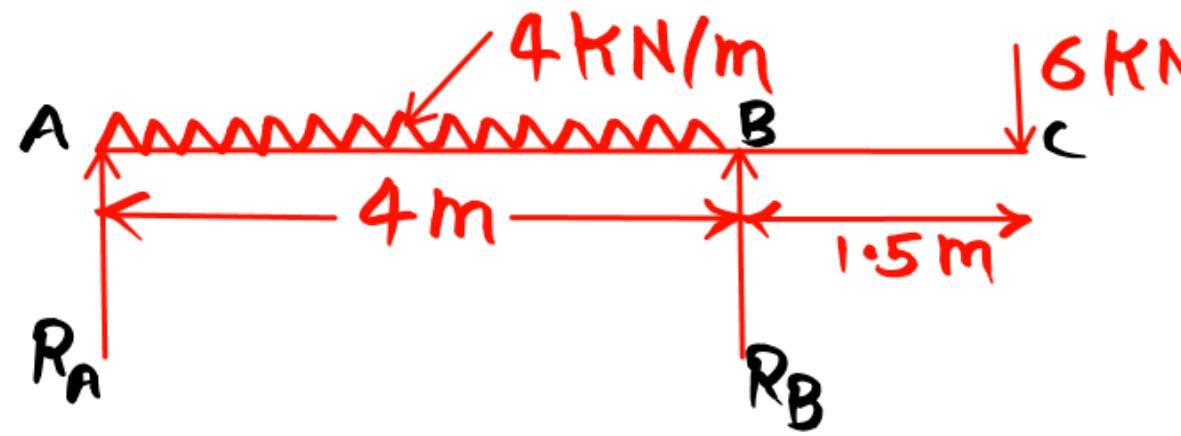
$$\Rightarrow 4R_C = 185$$

$$\Rightarrow R_C = 46.25 \text{ KN} \quad \text{Put in Eq. } ①$$

$$\Rightarrow R_B + 46.25 = 85$$

$$\Rightarrow R_B = 38.75 \text{ KN}$$

Q.



सनुलन के समूह

$$\sum F_y = 0 \text{ से}$$

$$R_A + R_B - 6 - 4 \times 4 = 0$$

$$R_A + R_B = 22 \text{ kN} \quad \text{--- } ①$$

$$\sum M_A = 0 \text{ से}$$

Taking moment about Point A

$$-6 \times 5.5 + R_B \times 4 - 16 \times 2 + R_A \times 0 = 0$$

$$-33.0 + 4R_B - 32 = 0$$

$$4R_B - 65 = 0$$

$$4R_B = 65$$

$$R_B = 16.25 \text{ kN}$$

Put in Eq ①

$$R_A + 16.25 = 22$$

$$R_A = 5.75 \text{ kN}$$