University of Anbar
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Civil Engineering Department

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Strength of Materials I, Semester 1, 2022 **Dr. Dhafer K. Jadaan**

Syllabus

1. Equilibrium

2. Stresses

3. Strains

4. Mechanical Properties

5. Axial Load

6. Torsion

7. Shear and Bending diagrams

Introduction

International System of Units

TABLE 1–3 Prefixes

	Exponential Form	Prefix	SI Symbol
Multiple			
1 000 000 000	10^9	giga	G
1 000 000	10^6	mega	M
1 000	10^3	kilo	k
Submultiple			
0.001	10^{-3}	milli	m
0.000 001	10^{-6}	micro	μ
0.000 000 001	10^{-9}	nano	n

Example:

$$(50\text{ kN})(60\text{ nm}) = [50(10^3)\text{ N}][60(10^{-9})\text{ m}]$$
$$= 3000(10^{-6})\text{ N}\cdot\text{m} = 3(10^{-3})\text{ N}\cdot\text{m} = 3\text{ mN}\cdot\text{m}$$

Dimensional Homogeneity

$$s = vt + \frac{1}{2}at\text{^}2$$

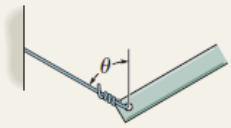
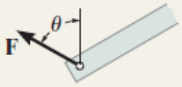
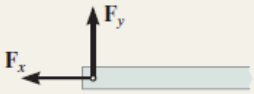
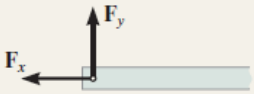
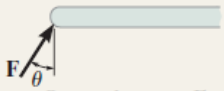
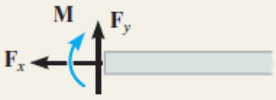
$$m = \frac{m}{\cancel{s}}\cancel{s} + \frac{1}{2}\frac{m}{\cancel{s^2}}\cancel{s^2}$$

Chapter One

Equilibrium

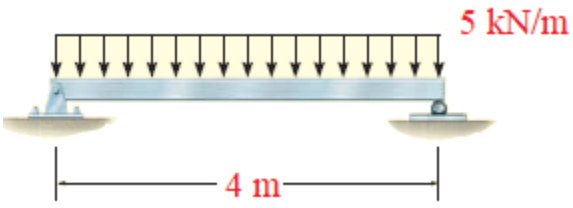
Support Reactions

TABLE 1–1

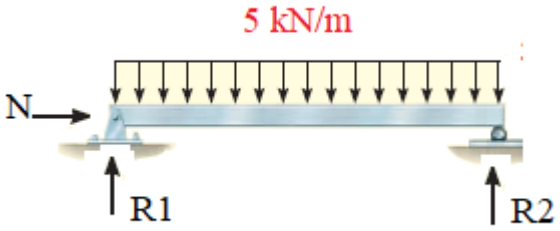
Type of connection	Reaction	Type of connection	Reaction
 Cable	 One unknown: F	 External pin	 Two unknowns: F_x, F_y
 Roller	 One unknown: F	 Internal pin	 Two unknowns: F_x, F_y
 Smooth support	 One unknown: F	 Fixed support	 Three unknowns: F_x, F_y, M

Examples

Determine the reactions of the simply supported beam.



Solution

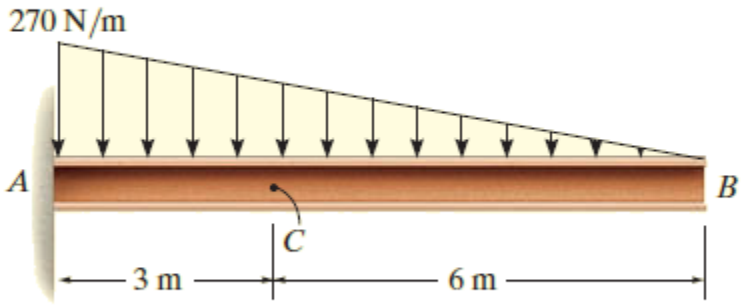


$$\Sigma F_x = 0 \rightarrow N = 0$$

$$\Sigma M_{R2} = 0 \rightarrow R_1 * 4 - 5 * 4 * 4/2 = 0 \rightarrow R_1 = 10\ kN$$

$$\Sigma F_y = 0 \rightarrow R_1 + R_2 - 5 * 4 = 0 \rightarrow R_2 = 10\ kN$$

Determine the resultant internal loadings acting on the cross section at *C* of the cantilevered beam shown in Fig. 1–4*a*.

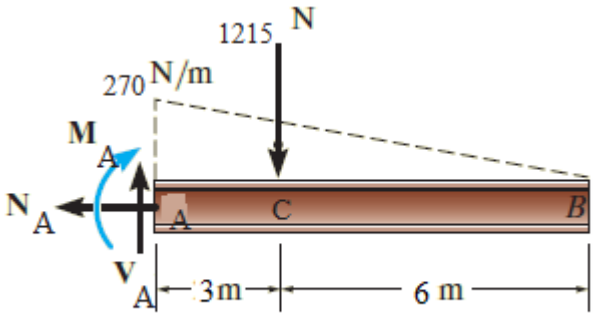


(a)

Fig. 1–4

Solution

Free-body diagram. From table 1-4, fixed support has three reactions



(b)

$$\stackrel{+}{\rightarrow}\Sigma F_x = 0; \qquad -N_A = 0$$

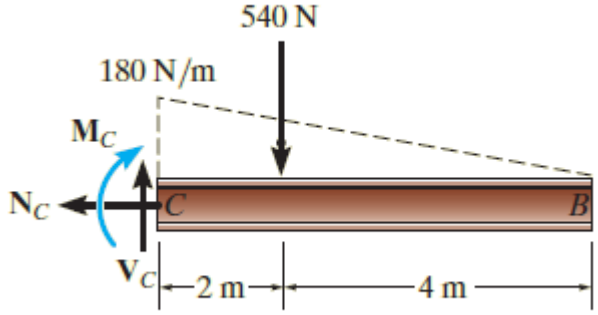
$$N_A = 0$$

$$+\uparrow \Sigma F_y = 0; \qquad V_A - 1215\text{N} = 0$$

$$V_A = 1215\text{N}$$

$$\circlearrowleft + \Sigma M_A = 0; \qquad -M_A - 1215\ \text{N}(3\ \text{m}) = 0$$

$$M_A = -3645\ \text{N}\cdot\text{m}$$



(b)

$$\stackrel{+}{\rightarrow}\Sigma F_x = 0; \qquad -N_C = 0$$

$$N_C = 0$$

$$+\uparrow \Sigma F_y = 0; \qquad V_C - 540\ \text{N} = 0$$

$$V_C = 540\ \text{N}$$

$$\circlearrowleft + \Sigma M_C = 0; \qquad -M_C - 540\ \text{N}(2\ \text{m}) = 0$$

$$M_C = -1080\ \text{N}\cdot\text{m}$$

Determine the horizontal and vertical components of reaction on the beam caused by the pin at B and the rocker at A as shown in Fig. 5–12*a*. Neglect the weight of the beam.

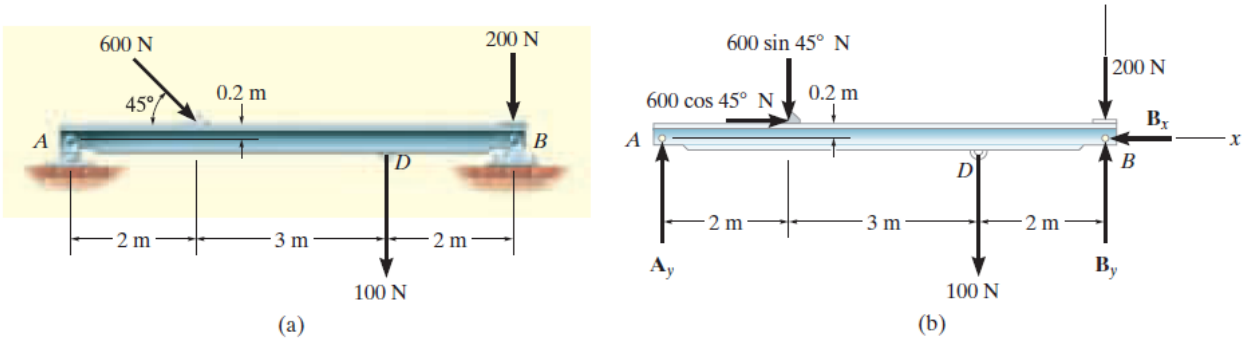
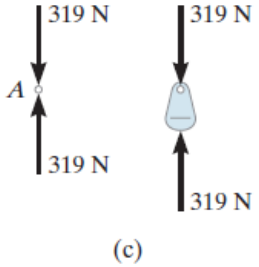


Fig. 5–12



SOLUTION

Free-Body Diagram. The supports are *removed*, and the free-body diagram of the beam is shown in Fig. 5–12*b*. (See Example 5.1.) For simplicity, the 600-N force is represented by its x and y components as shown in Fig. 5–12*b*.

Equations of Equilibrium. Summing forces in the x direction yields

$$\stackrel{+}{\rightarrow}\Sigma F_x = 0; \qquad 600\cos 45°\ \text{N} - B_x = 0$$

$$B_x = 424\ \text{N} \qquad \textit{Ans.}$$

A direct solution for $\mathbf{A}_y$ can be obtained by applying the moment equation $\Sigma M_B = 0$ about point B.

$$\circlearrowleft +\Sigma M_B = 0; \qquad 100\ \text{N}(2\ \text{m}) + (600\sin 45°\ \text{N})(5\ \text{m})$$

$$- (600\cos 45°\ \text{N})(0.2\ \text{m}) - A_y(7\ \text{m}) = 0$$

$$A_y = 319\ \text{N} \qquad \textit{Ans.}$$

Summing forces in the y direction, using this result, gives

$$+\uparrow\Sigma F_y = 0; \qquad 319\ \text{N} - 600\sin 45°\ \text{N} - 100\ \text{N} - 200\ \text{N} + B_y = 0$$

$$B_y = 405\ \text{N} \qquad \textit{Ans.}$$