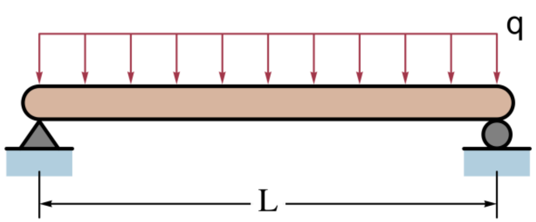
STRESS

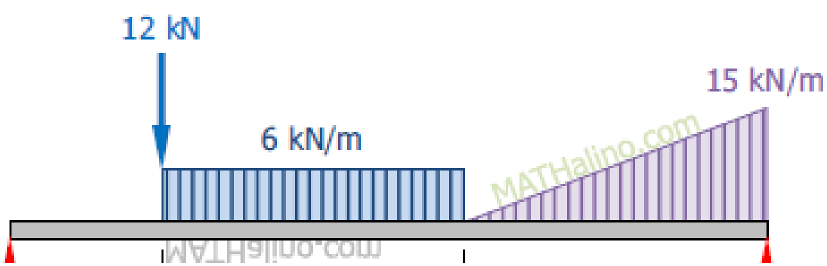
1
Stress 3

✓ **External Loads.** A body is subjected to only two types of external loads; namely, surface forces and body forces, Fig. 1–1 .

❖ ***Surface forces*** **:-** are caused by the direct contact of one body with the surface of another.

- *concentrated force*
- *distributed load* (measured by their intensity).
    - Uniform load (Rectangular load, triangular load)
    - Linear distributed load.





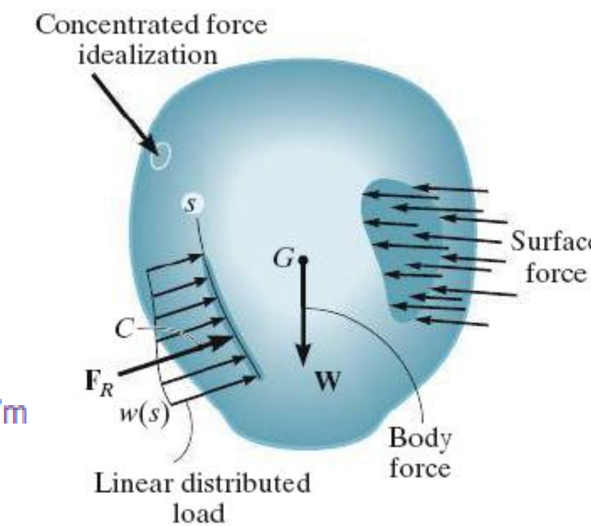


Fig. 1–1

Equations of Equilibrium.

Equilibrium of a body requires both a ***balance of forces*** , to prevent the body from translating or having accelerated motion along a straight or curved path, and a ***balance of moments*** , to prevent the body from rotating. These conditions can be expressed mathematically by two vector equations.

Equilibrium of a body:

$$\Sigma F_x = 0 \quad \Sigma F_y = 0 \quad \Sigma F_z = 0$$
$$\Sigma M_x = 0 \quad \Sigma M_y = 0 \quad \Sigma M_z = 0 \qquad (1\text{–}2)$$

For coplanar forces : There are three equations of equilibrium

$$\Sigma F_x = 0$$
$$\Sigma F_y = 0$$
$$\Sigma M_O = 0 \qquad (1\text{–}3)$$

✓ Internal loadings:

1. These internal loading acting on a specific region within the body can be attained by the ***Method of Section***.
2. ***Method of Section***: Imaginary cut is made through the body in the region where the internal loading is to be determined.
3. The two parts are separated and a free body diagram of one of the parts is drawn. Point O is often chosen as the centroid of the sectioned area

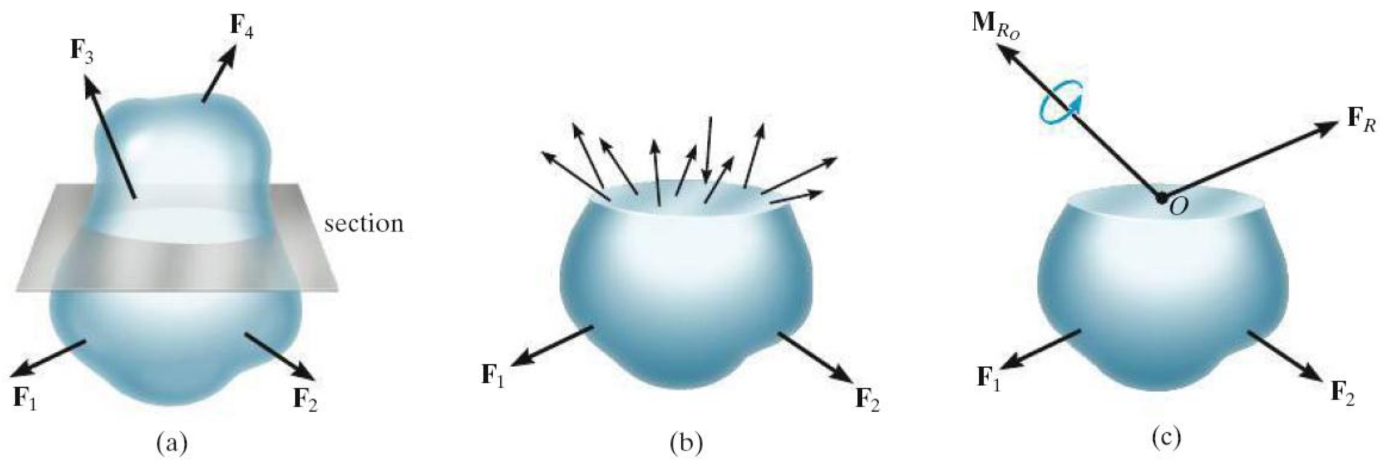


Fig. 1–2

Apply Equilibrium at this stage

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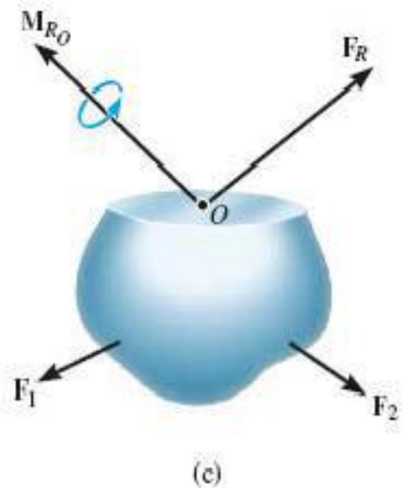
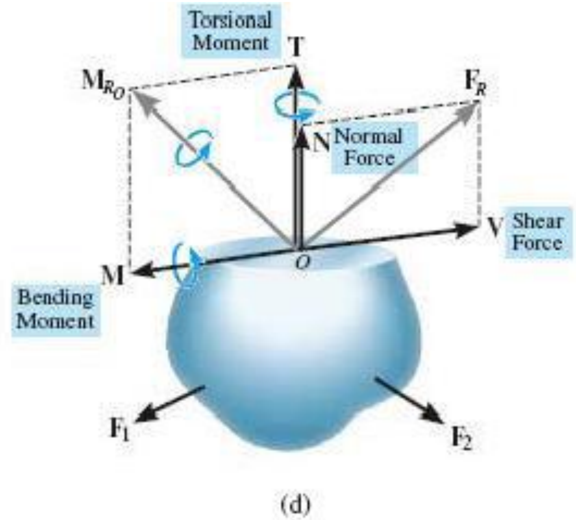
Four types of internal loadings can be defined:



(c)



(d)

Normal force (N). This force act perpendicular to the area.
Shear Force (V). This force lies in the plane of the area (parallel) **Torsional Moment (T).** This torque is developed when the external loads tend to twist one segment of the body with respect to the other
Bending Moment (M). This moment is developed when the external loads tend to bend the body.

Ex1:- Determine the resultant internal loadings acting on the cross section at *C* of the cantilevered beam shown in Fig. 1–4 *a* .

Determine the internal loading at C A cut will be made through C and the right part will be studied.

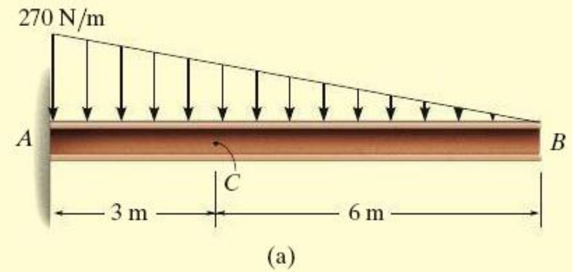


Fig. 1–4

Equations of Equilibrium. Applying the equations of equilibrium we have

$\xrightarrow{+} \Sigma F_x = 0;$ $\quad -N_C = 0$

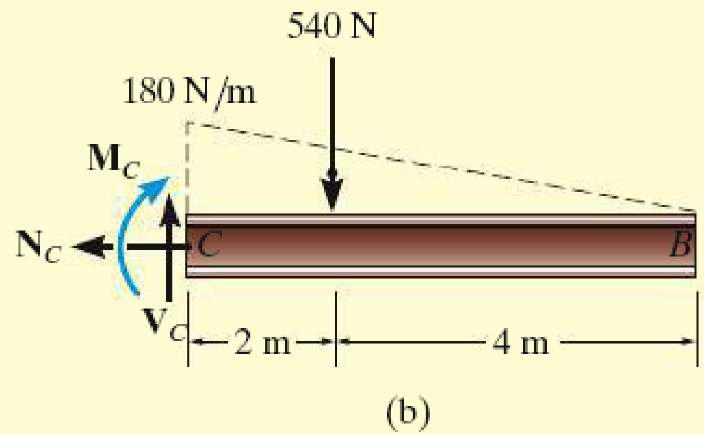
$N_C = 0$ *Ans.*

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

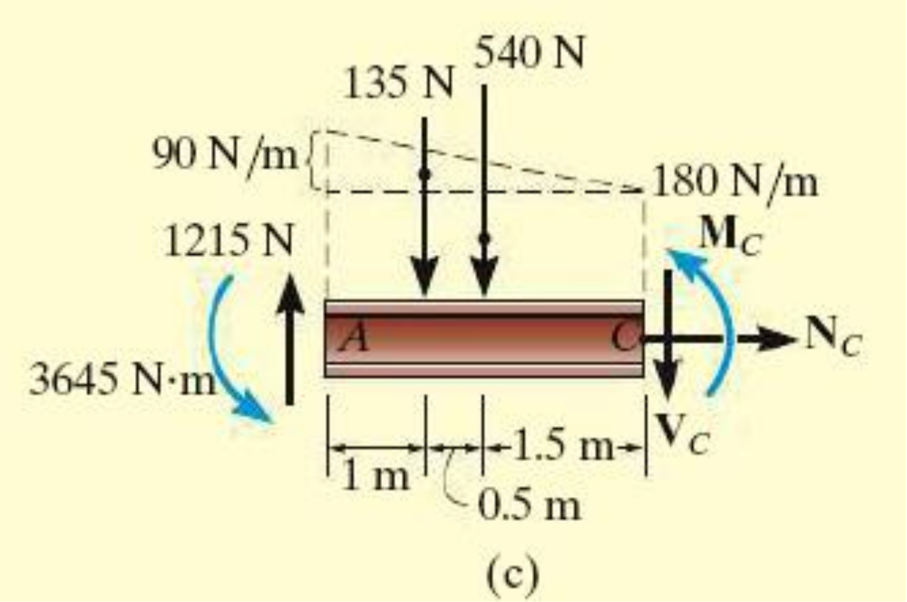
$V_C = 540\text{ N}$ *Ans.*

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

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



If the cut was made at C and the left part was taken First a free body diagram for the entire body is made and equilibrium is applied to get the support reactions.



Ex2:- The **500-kg** engine is suspended from the crane boom in Fig. 1–5 *a.* Determine the resultant internal loadings acting on the cross section of the boom at point ***E*** **.**

$\circlearrowleft + \Sigma M_A = 0;\qquad F_{CD}\left(\frac{3}{5}\right)(2\text{ m}) - [500(9.81)\text{ N}](3\text{ m}) = 0$

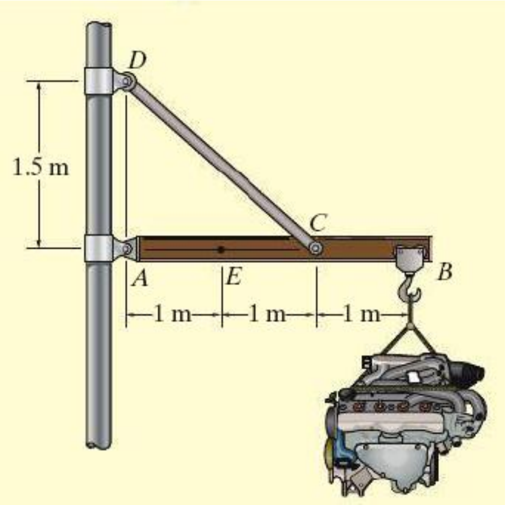
$F_{CD} = 12\,262.5\text{ N}$

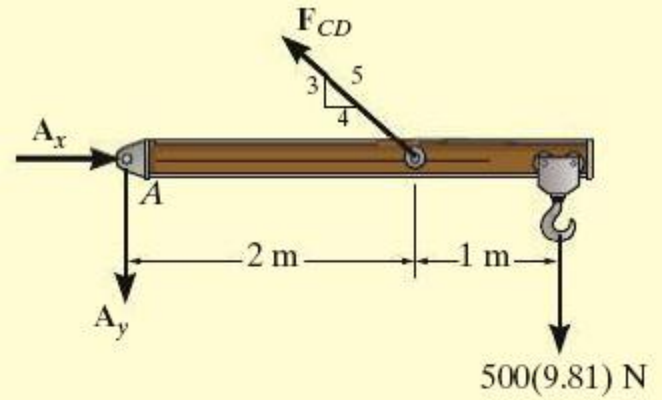
$\xrightarrow{+} \Sigma F_x = 0;\qquad A_x - (12\,262.5\text{N})\left(\frac{4}{5}\right) = 0$

$A_x = 9810\text{ N}$

$+\uparrow \Sigma F_y = 0;\qquad -A_y + (12\,262.5\text{ N})\left(\frac{3}{5}\right) - 500(9.81)\text{ N} = 0$

$A_y = 2452.5\text{ N}$





Free-Body Diagram. The free-body diagram of segment AE is shown in Fig. 1–5 c.

Equations of Equilibrium.

$\xrightarrow{+} \Sigma F_x = 0;$ $\quad N_E + 9810 \text{ N} = 0$

$N_E = -9810 \text{ N} = -9.81 \text{ kN}$

$+\uparrow \Sigma F_y = 0;$ $\quad -V_E - 2452.5 \text{ N} = 0$

$V_E = -2452.5 \text{ N} = -2.45 \text{ kN}$

$\circlearrowleft + \Sigma M_E = 0;$ $\quad M_E + (2452.5 \text{ N})(1 \text{ m}) = 0$

$M_E = -2452.5 \text{ N} \cdot \text{m} = -2.45 \text{ kN} \cdot \text{m}$