Strength of Materials:

Lecture 2

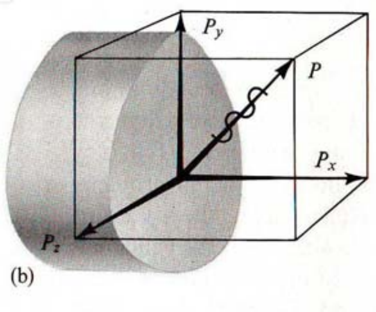
1-Axial Force, Shear Force, and Bending Moment Diagrams:

The positive sense of the **force components** on the cut section viewed toward the origin coincides with the positive direction of the coordinate axes as shown in Fig. (b).

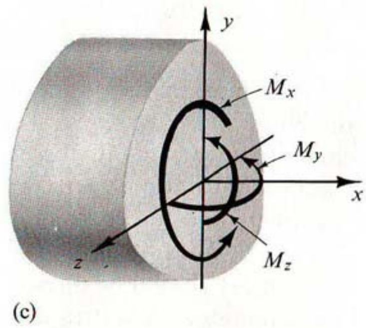
The three **components of moment** which can occur at a section of a member act around the three coordinate axes Fig. (c).

The quantities shown in Fig.(c) will be represented alternatively by double headed vectors as in fig. (d). The sense of these vectors follows the right-hand screw rule.

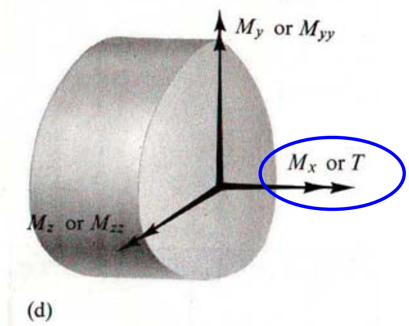
*Mx is the torque = T



(b)

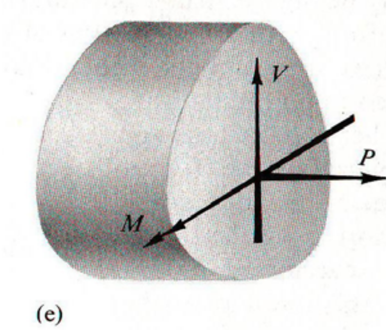


(c)

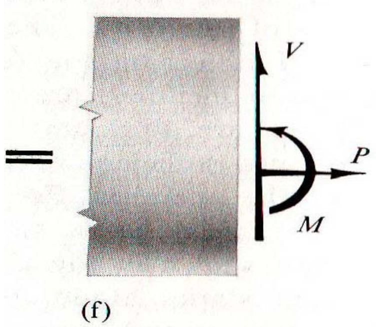


(d)

For planar problems the notation for and the **diagrammatic representation** of the forces components are shown in Fig. (e and f).



(e)



(f)

Side view of forces acts on the body;
P (axial force), V (shear force), and the M (moment).

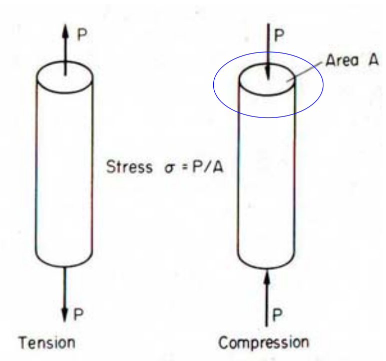
From the drawing shown before (P = F):

F_x: Axial Force ⇒ σ (normal or direct stress) $= \dfrac{P}{A}$ --- (1)

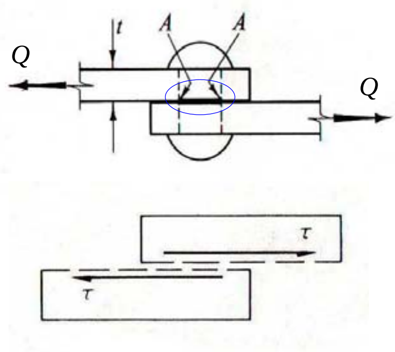
F_y, F_z: Shear Force ⇒ τ (shear force) $= \dfrac{VQ}{It}$ --- (2)

M_x: Twisting Moment or Torsion ⇒ $T = \dfrac{T.R}{J}$ --- (3)

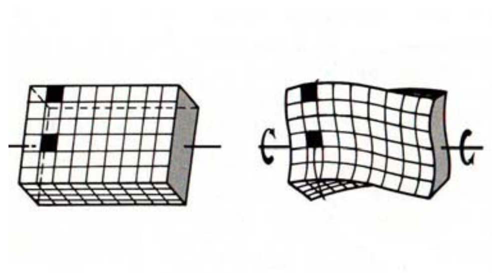
M_y, M_z: Bending Moment ⇒ $\sigma = \dfrac{M\,c}{I}$ --- (4)



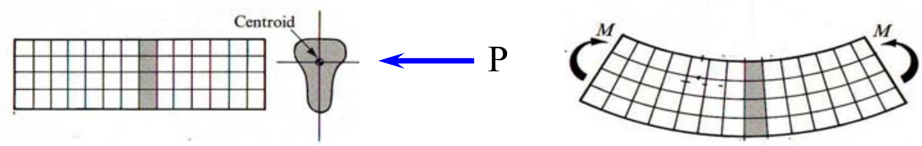
a) Axial Force



b) Shear Force



c) Torsion Force



d) Bending Moment

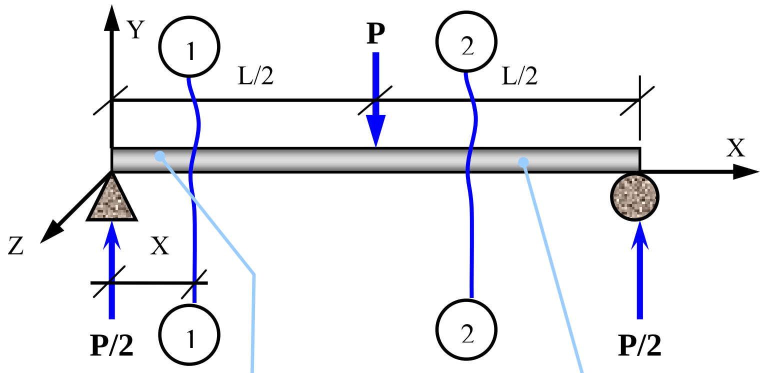
Sign Conventions:

1) **SHEAR** is considered **Positive** at section when it tends to **Rotate** the portion of the beam. In The **Clock Wise Direction** about an axis through @ point in side the force and normal to the plane of loading, otherwise it is negative.

For concreteness consider a beam, such as shown in Fig. (1-a). Any part of this beam to either side of an imaginary cut, as (1-1), which is made perpendicular to the x-axis of the member, can treated as a free body.

Simply supported beam with

Concentrated force in the middle.

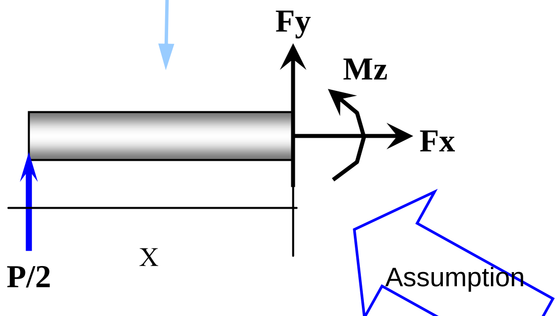


(a)

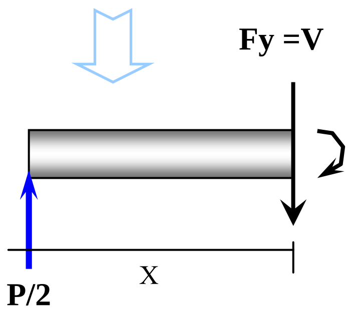
To maintain a segment of a beam such as shown in Fig. (1-b) in equilibrium there must be an internal vertical force **Fy** at the cut to satisfy the equation $\sum Fy = 0$. This force is called; "Shear *force*, v". The shear is numerically equal to the algebraic sum of all the vertical components of the external forces the external forces acting on the isolated segment, but it opposite in direction.

By apply: $+\uparrow \sum Fy = 0$

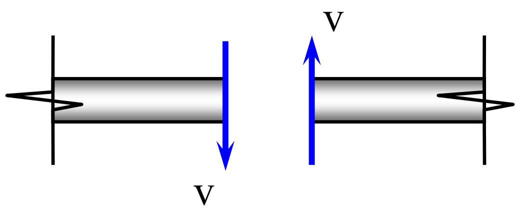
Fy = P/2



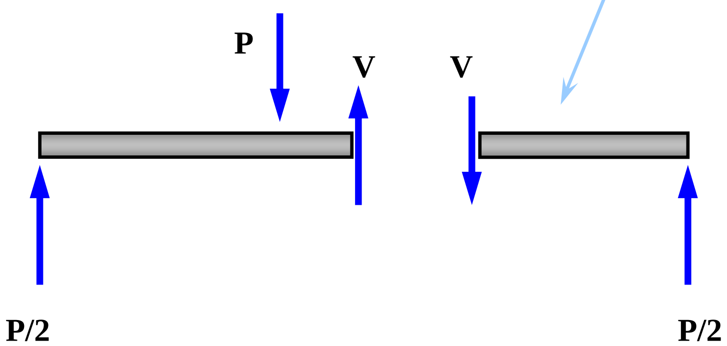
(b) Section 1-1



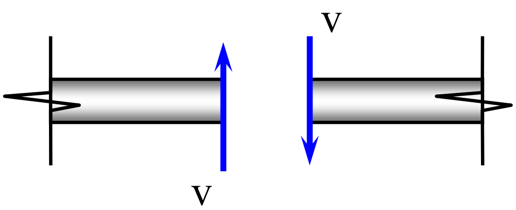
(c)



(+ v) Shear



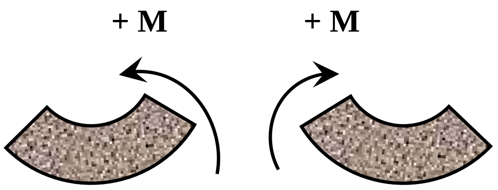
(d) Section 2-2



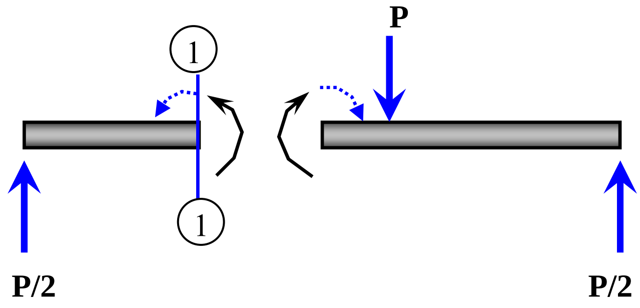
(- v) Shear

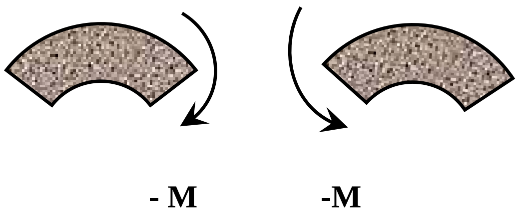
Figure (1) Simply Supported Beam

2) **Bending Moment** is considered **<u>Positive</u>** at section when it tends to **<u>bend</u>** the member **<u>Con @ + ve upward</u>**; <u>otherwise</u> it is negative.

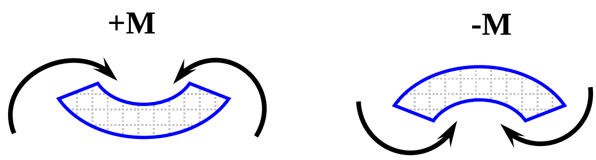


(+) Moment

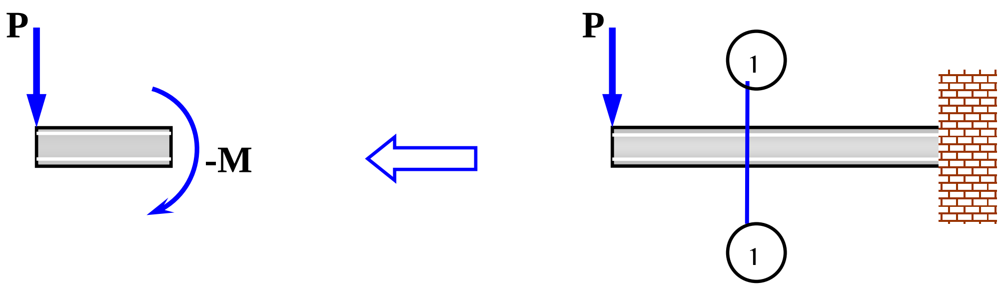




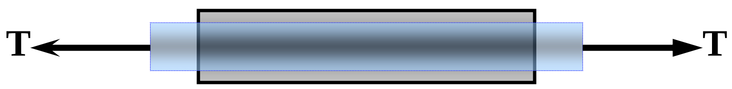
(-) Moment



<u>Ex1:</u>



3) **AXIAL FORCE**



T=Tension **(+)**, Increase in LENGTH

C = Compression **(-)**, decrease in LENGTH

1- Methods of Sections

Ex2: Draw A.F., S.F & B.M. Diagrams?

$\xrightarrow{+} \sum Fx = 0$ --- (1)

$R_{AX} - 6 = 0$

$\therefore R_{AX} = \underline{6\ kN}$ →

$\circlearrowleft + \sum M_A = 0$ --- (2)

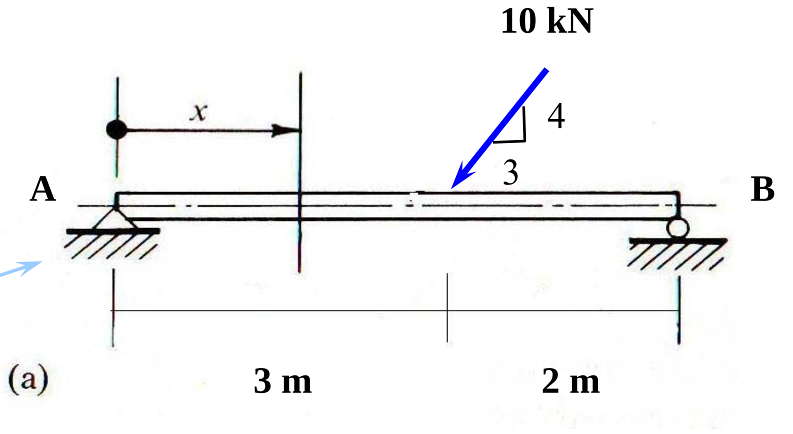
$8 \times 3 - R_{BY} \times 5 = 0$

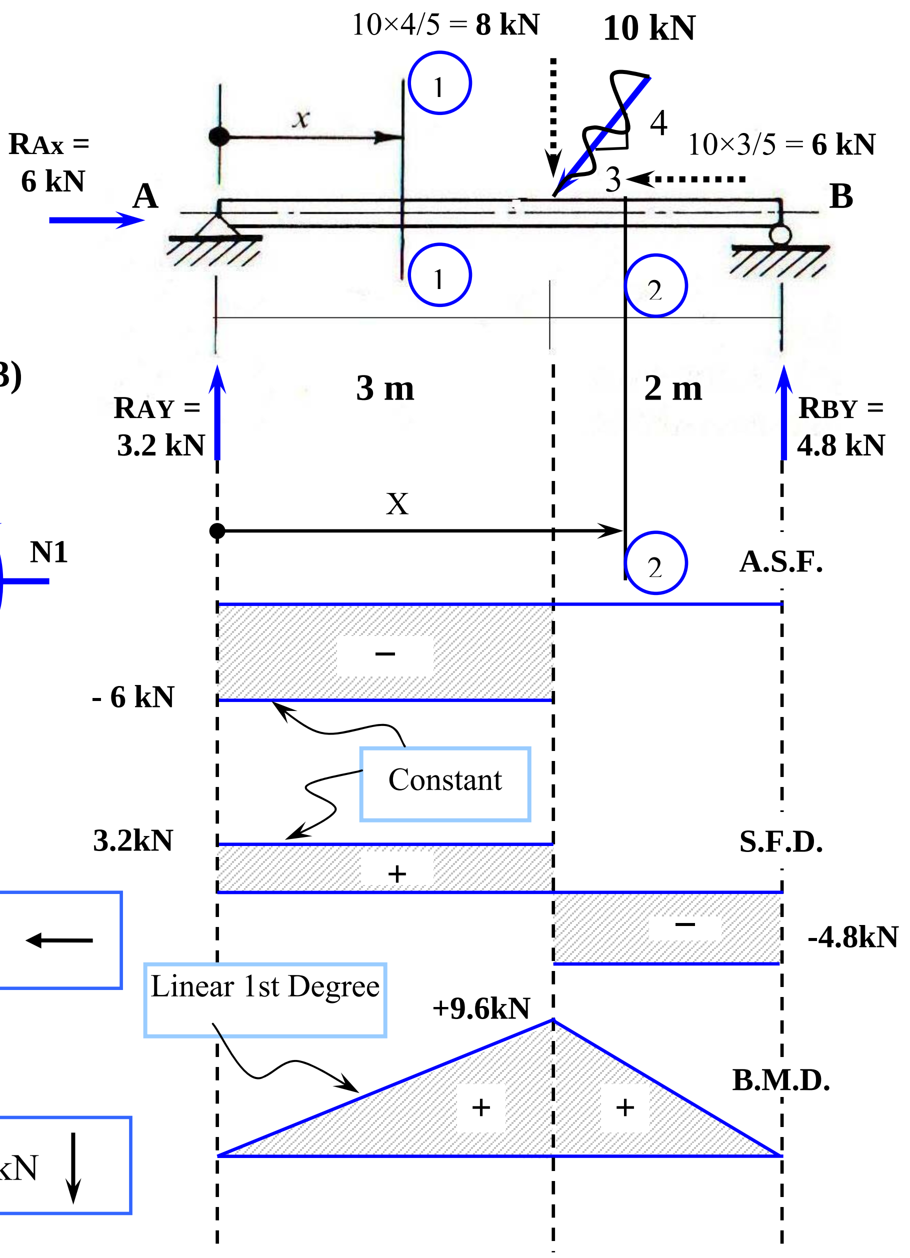
$\therefore R_{BY} = \underline{4.8\ kN}$ ↑

$+\uparrow \sum Fy = 0$ --- (3)

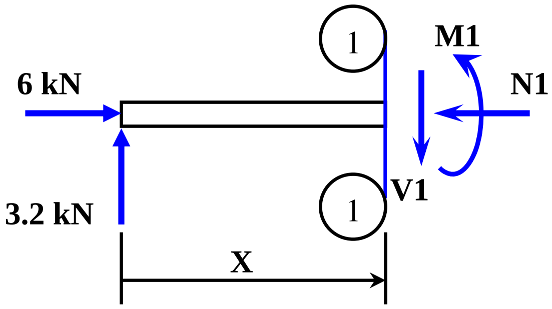
$+ R_{AY} - 8 + 4.8 = 0$

$\therefore R_{AY} = \underline{3.2\ kN}$ ↑





For Section 1-1: **($0 \le X \le 3$)**



$\xrightarrow{+} \sum Fx = 0$

$6 - N_1 = 0$

$\therefore N_1 = 6\ kN$ ←

$+\uparrow \sum Fy = 0$

$+ 3.2 - V_1 = 0$

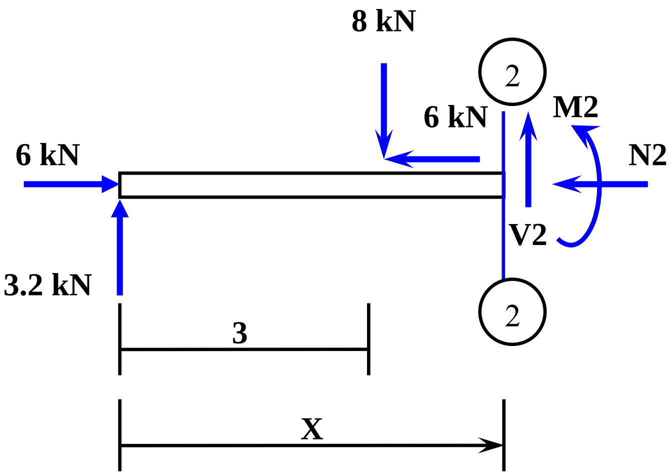
$\therefore V_1 = 3.2\ kN$ ↓

$\curvearrowleft + \sum M_A = 0$

$+3.2 * X - M_1 = 0$ $\quad \therefore M = +3.2X\ kN$ ↻

Variable to X-1st Degree

<u>For Section 2-2:</u> $(3 \le X \le 5)$



$\xrightarrow{+} \sum F_x = 0$

$6 - 6 - N_2 = 0$ $\quad \therefore N_2 = 0$ ←

$+\uparrow \sum F_y = 0$

$+3.2 - 8 + V_2 = 0$ $\quad \therefore V_2 = 4.8\ kN$ ↑

$\curvearrowleft + \sum M_A = 0$

$+3.2 * X_2 - 8(X_2 - 3) - M_2 = 0$ $\quad \therefore M_2 = -4.8X_2 + 24$ ↻

Just for Checking:

Where X = 5m ⇒ $M = -4.8 \times 5 + 24 = 0$

Where X = 3m ⇒ $M = -4.8 \times 3 + 24 = 9.6$

Note: $\frac{dM}{dx} = V$, $\frac{dV}{dx} = P$