SNS COLLEGE OF TECHNOLOGY

Coimbatore-35

An Autonomous Institution

Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A++' Grade
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF AEROSPACE ENGINEERING

23AST205 Aerospace Structures

II YEAR III SEM

SHEAR FLOW IN OPEN SECTIONS

SHEAR FLOW AND SHEAR CENTER

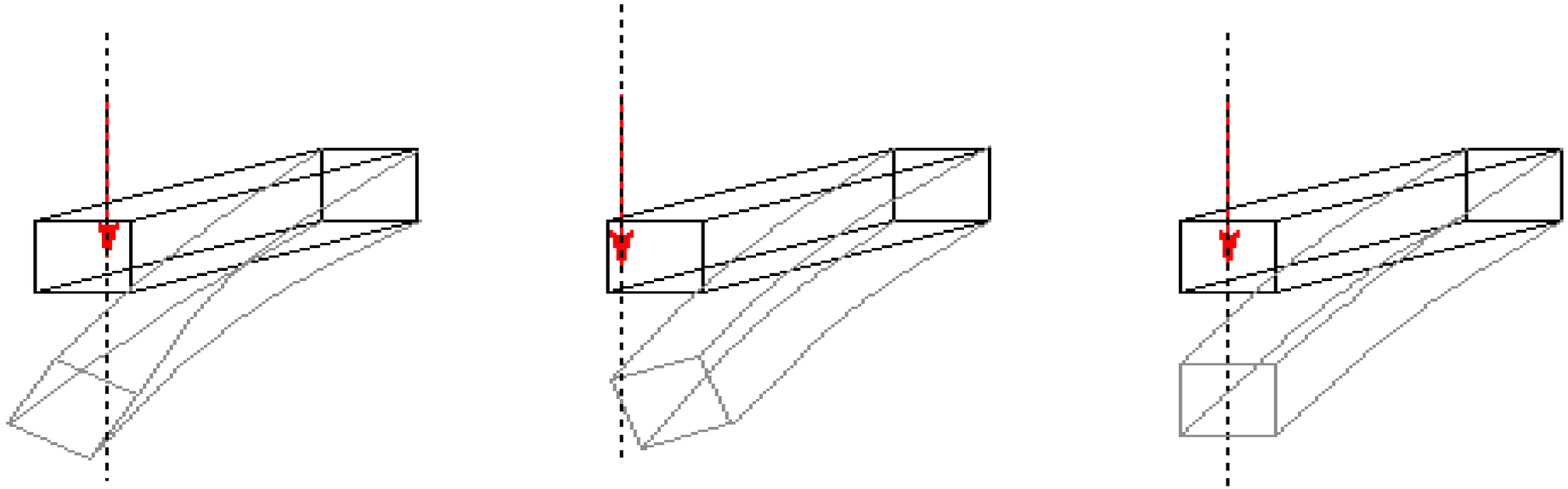
Restrictions:

1. Shear stress at every point in the beam must be less than the elastic limit of the material in shear.
2. Normal stress at every point in the beam must be less than the elastic limit of the material in tension and in compression.
3. Beam's cross section must contain at least one axis of symmetry.
4. The applied transverse (or lateral) force(s) at every point on the beam must pass through the elastic axis of the beam. Recall that elastic axis is a line connecting cross-sectional shear centers of the beam.
5. The length of the beam must be much longer than its cross sectional dimensions.
6. The beam's cross section must be uniform along its length.

SHEAR CENTER

- If the line of action of the force passes through the **Shear Center** of the beam section, then the beam will only bend without any twist. Otherwise, twist will accompany bending.
- The shear center is in fact the *centroid of the internal shear force system.* Depending on the beam's cross-sectional shape along its length, the location of shear center may vary from section to section.
- A line connecting all the shear centers is called the **elastic axis** of the beam. When a beam is under the action of a more general lateral load system, then to prevent the beam from twisting, the load must be centered along the elastic axis of the beam.

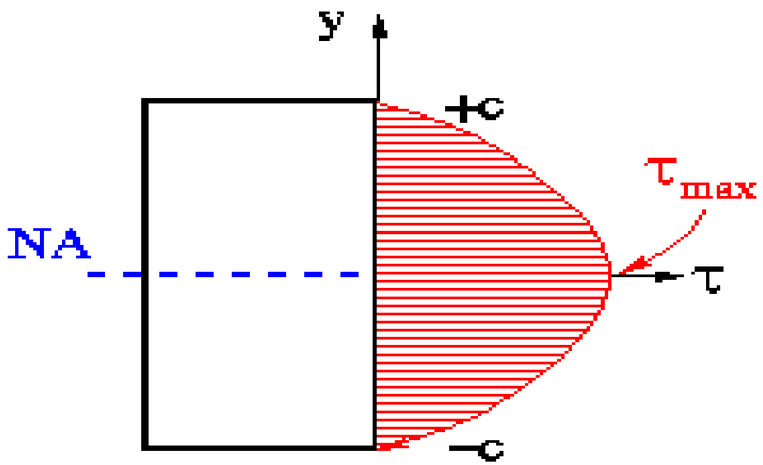
SHEAR CENTER



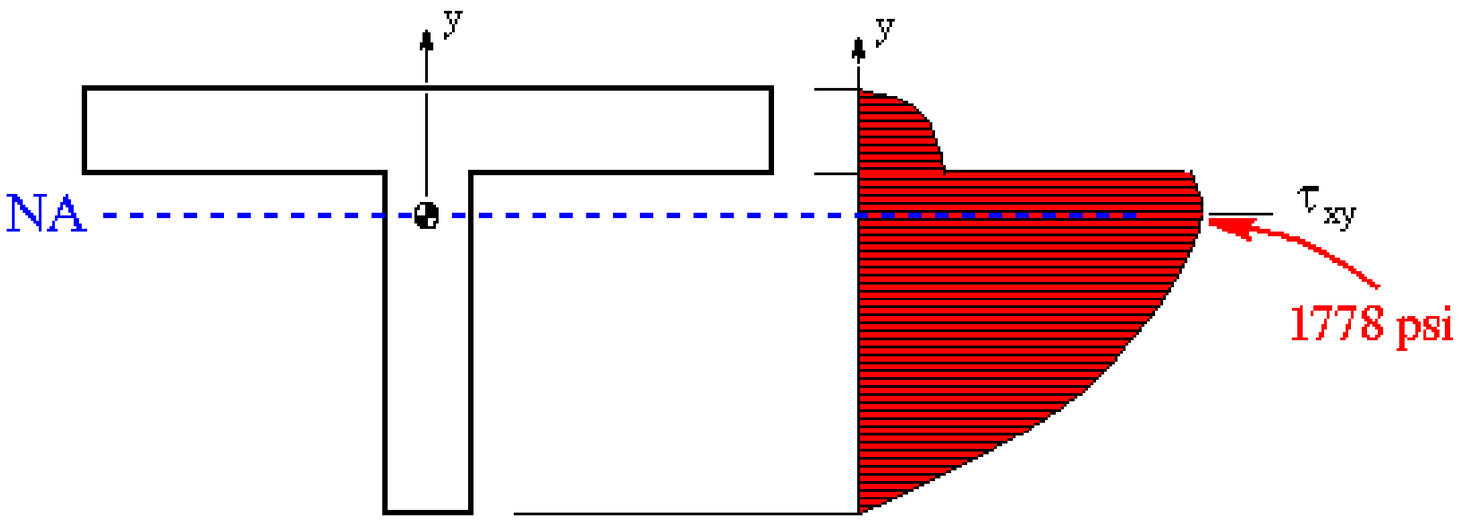
- The two following points facilitate the determination of the shear center location.
- The shear center always falls on a cross-sectional axis of symmetry.
- If the cross section contains two axes of symmetry, then the shear center is located at their intersection.
- Notice that this is the only case where shear center and centroid coincide.

SHEAR STRESS DISTRIBUTION

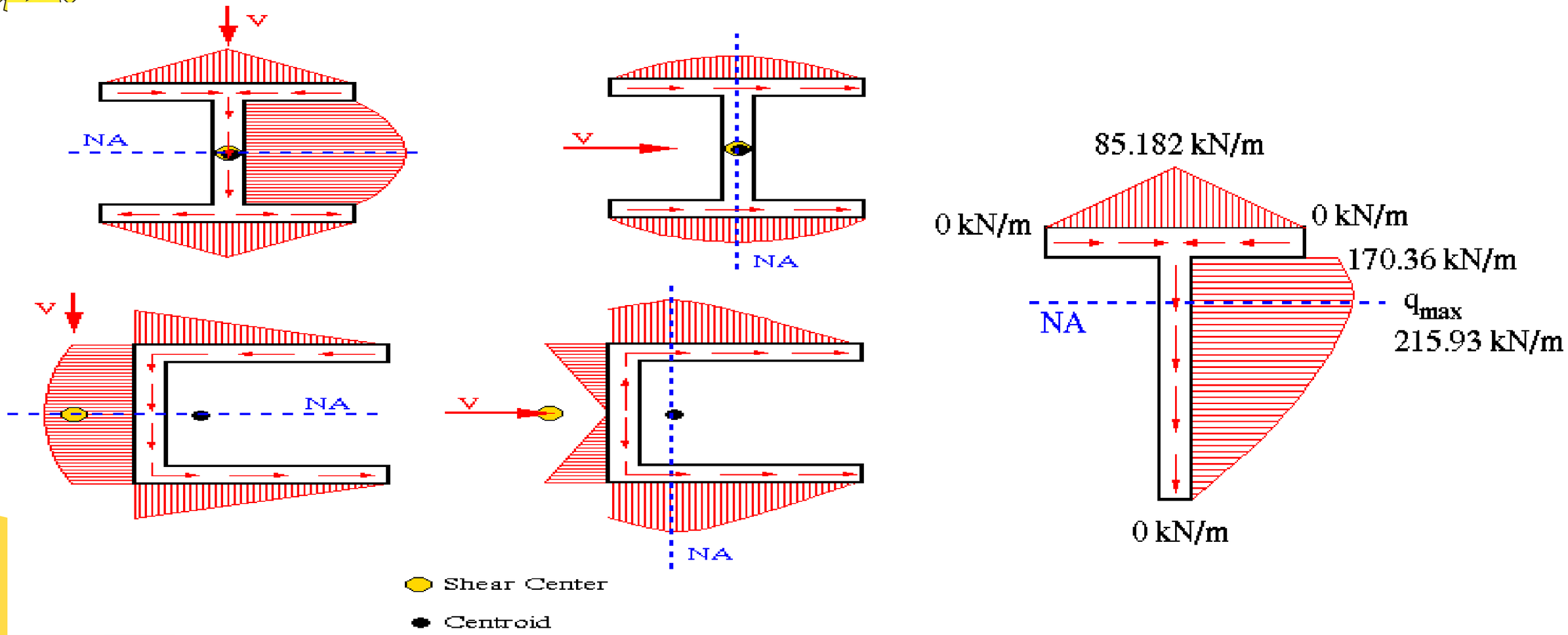
RECTANGLE



T-SECTION



SHEAR FLOW DISTRIBUTION

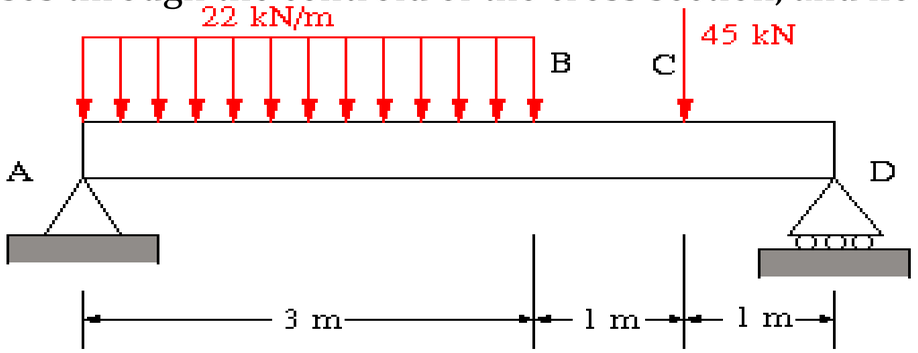


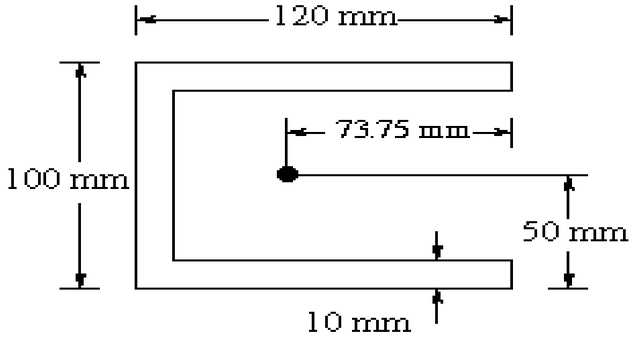
EXAMPLES

- For the beam and loading shown, determine:

(a) the location and magnitude of the maximum transverse shear force 'Vmax',
(b) the shear flow 'q' distribution due the 'Vmax',
(c) the 'x' coordinate of the shear center measured from the centroid,
(d) the maximun shear stress and its location on the cross section.

Stresses induced by the load do not exceed the elastic limits of the material. **NOTE:**In this problem the applied transverse shear force passes through the centroid of the cross section, and not its shear center.





FOR ANSWER REFER

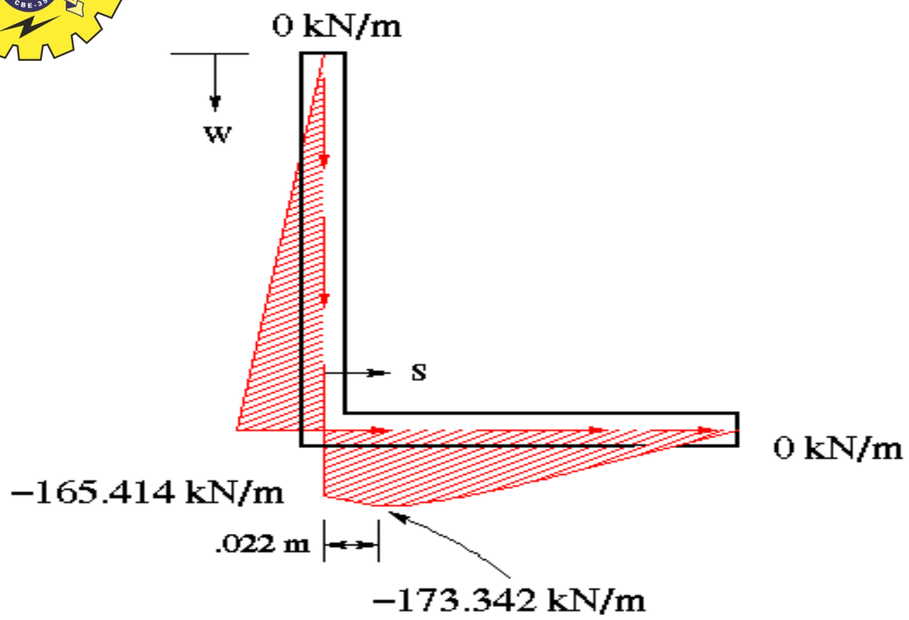
http://www.ae.msstate.edu/~masoud/Teaching/exp/A14.7_ex3.html

SHEAR FLOW ANALYSIS FOR UNSYMMETRIC BEAMS

- SHEAR FOR EQUATION FOR UNSUMMETRIC SECTION IS

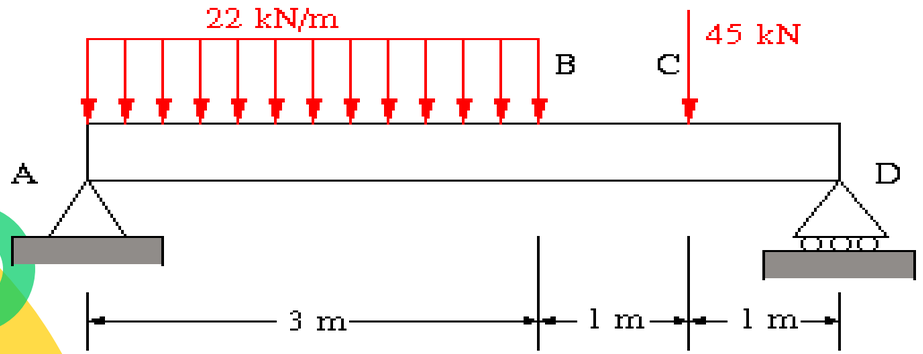
$$q = -\left(\frac{I_x V_x - I_{xy} V_y}{I_x I_y - I_{xy}^2}\right) \sum xA - \left(\frac{I_y V_y - I_{xy} V_x}{I_x I_y - I_{xy}^2}\right) \sum yA$$

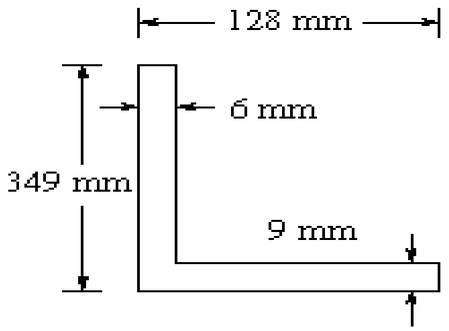
SHEAR FLOW DISTRIBUTION



- For the beam and loading shown, determine:
- (a) the location and magnitude of the maximum transverse shear force,
- (b) the shear flow 'q' distribution due to 'Vmax',
- (c) the 'x' coordinate of the shear center measured from the centroid of the cross section.
- Stresses induced by the load do not exceed the elastic limits of the material. The transverse shear force is applied through the shear center at every section of the beam. Also, the length of each member is measured to the middle of the adjacent member.

- ANSWER REFER
- http://www.ae.msstate.edu/~masoud/Teaching/exp/A14.8_ex1.htm





Beams with Constant Shear Flow Webs

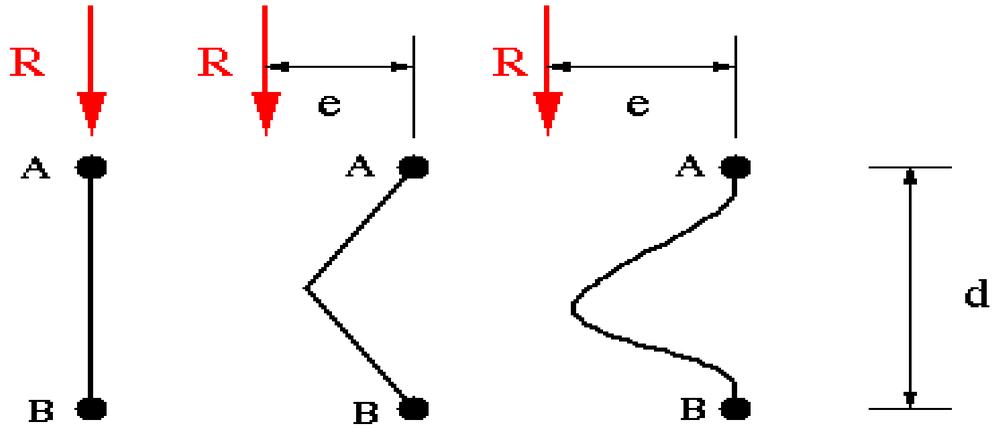
Assumptions:

1. Calculations of **centroid, symmetry, moments of area and moments of inertia** are based totally on the **areas and distribution** of beam stiffeners.
2. A web does not change the shear flow between two adjacent stiffeners and as such would be in the state of constant shear flow.

3. The stiffeners carry the entire bending-induced normal stresses, while the web(s) carry the entire shear flow and corresponding shear stresses.

Analysis

- Let's begin with a simplest thin-walled stiffened beam. Such a beam can only support a transverse force that is parallel to a straight line drawn through the centroids of two stiffeners. Examples of such a beam are shown below
- The reason the shear flows are equal is that the distance between two adjacent stiffeners is shown to be 'd' in all cases, and the applied force is shown to be equal to 'R' in all cases. The shear flow along the web can be determined by the following relationship



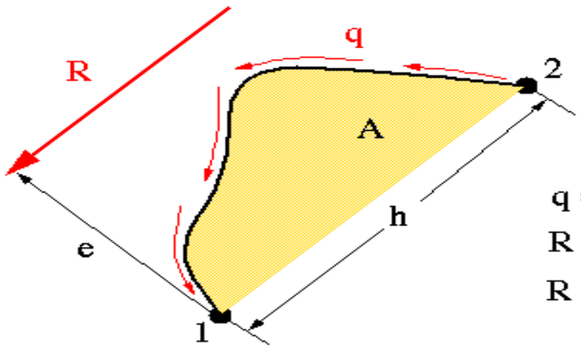
$$R = qd$$

IMPORTANT FEATURES OF TWO-STIFFENER

1. Shear flow between two adjacent stiffeners is constant.
2. The **magnitude** of the resultant shear force is only a function of the straight line between the two adjacent stiffeners, and is absolutely independent of the web shape.
3. The **direction** of the resultant shear force is parallel to the straight line connecting the adjacent stiffeners.

SINGLE-WEB BEAMS:

1. The **location** of the resultant shear force is a function of the enclosed area (between the web, the stringers at each end and the arbitrary point 'O'), and the straight distance between the adjacent stiffeners.
2. This is the only quantity that depends on the shape of the web connecting the stiffeners.
3. The line of action of the resultant force passes through the **shear center** of the section.



q = constant

R = qh (magnitude)

R is parallel to h (direction)

$e = \frac{2A}{h}$ (location)

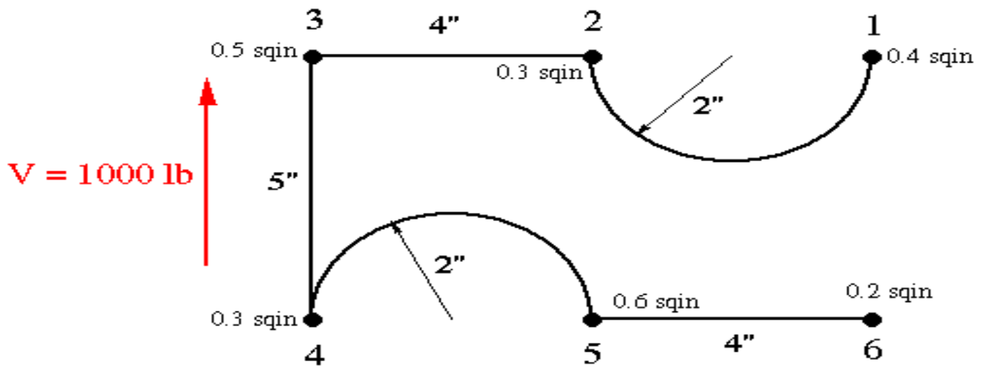
EXAMPLE

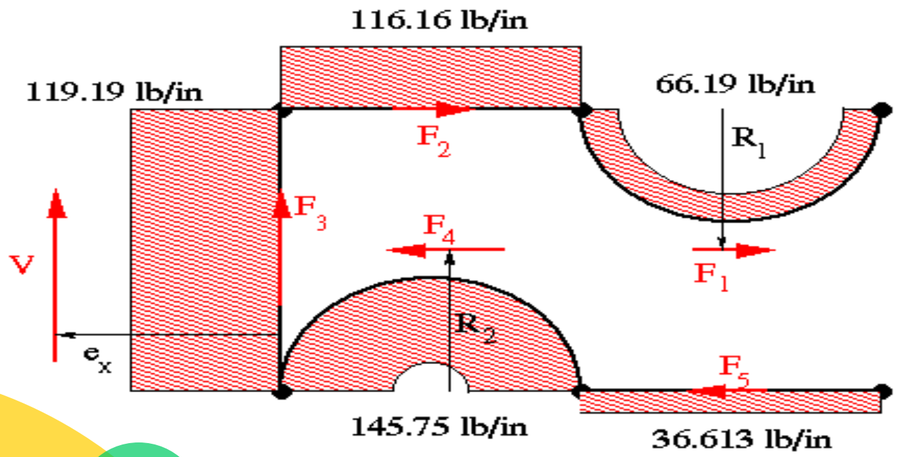
- For the multi-web, multi-stringer open-section beam shown, determine

(a) the shear flow distribution,

(b) the location of the shear center

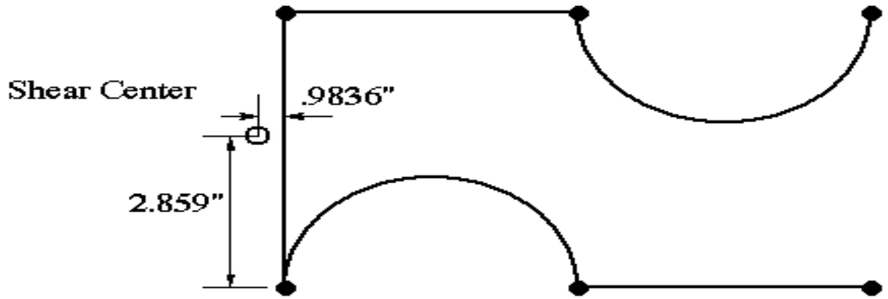
- Answer





$$R_1 = R_2 = \frac{2A}{d} = \frac{2(\pi/2\ (2)^2)}{4}$$

$$= \pi$$



S.NO	QUESTION	ANSWER
1	The ability to resist applied load is called	
2	The force required to produce unit deflection is called	
3	The materials having same properties in all directions are called	

OPTION		
	A	Isotropic materials
	B	Strength
	C	Stiffness