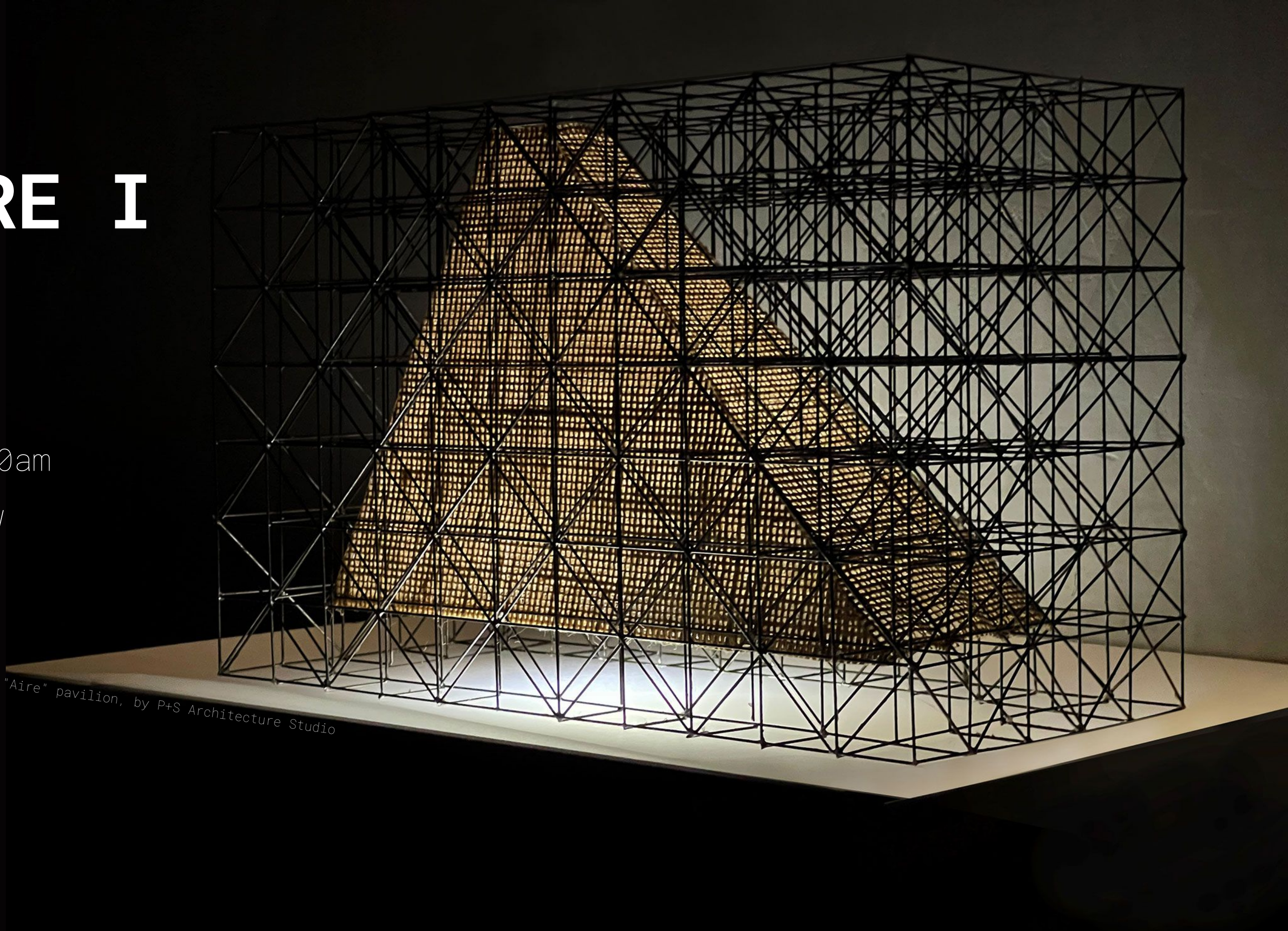
STRUCTURE I

ARCH-314

9:30am - 10:30am

East Review



"Aire" pavilion, by P+S Architecture Studio

Today:

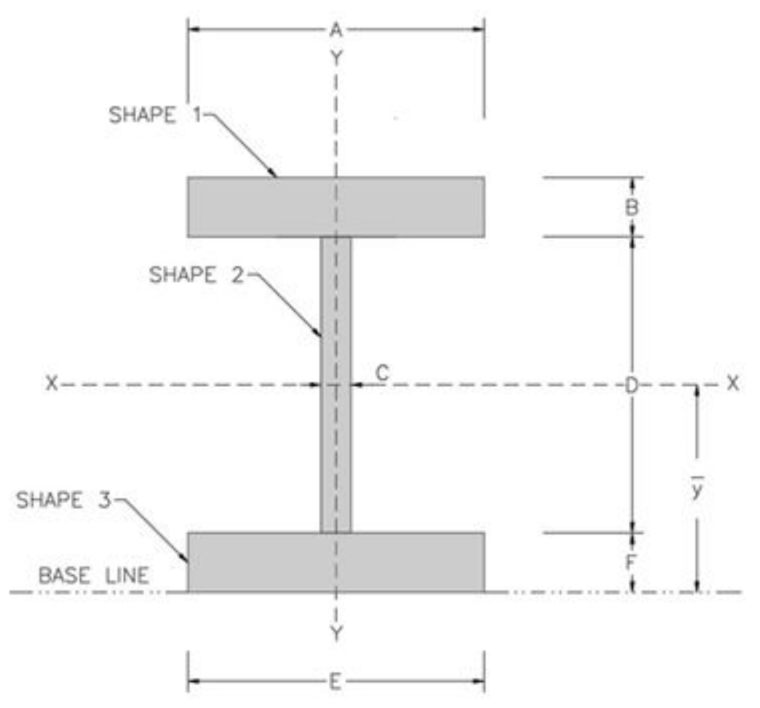
- Problem No.11: Moment of Inertia
- Lab 09: Moment of Inertia

PROBLEM NO.11

Use the Parallel Axis Theorem to find the moments of inertia about both the x-x and y-y axes of the compound section.

DATASET: 1 -2- -3-

Dimension A	8 IN
Dimension B	2 IN
Dimension C	1 IN
Dimension D	8 IN
Dimension E	4 IN
Dimension F	1 IN



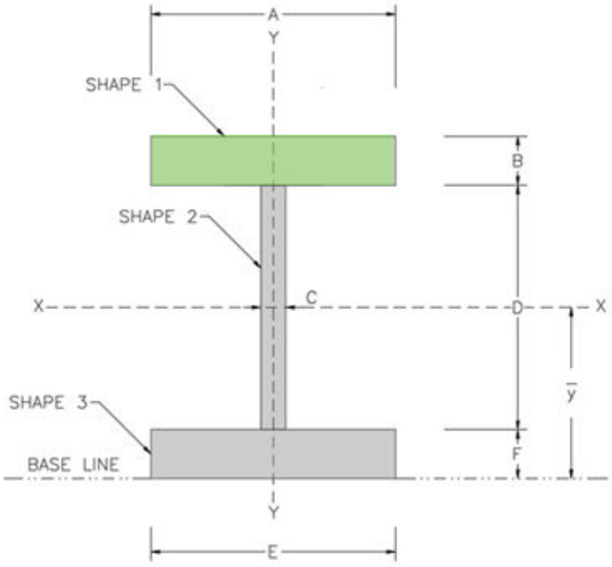
PROBLEM NO.11

Question 1: **Moment of Inertia of shape 1 about their own centroid (Ixx)**

$$Ixx_1 = \frac{A \times B^3}{12}$$

$$Ixx_1 = \frac{8 \times 2^3}{12}$$

$$\boxed{Ixx_1 = 5.3\ in}^4$$



Use the Parallel Axis Theorem to find the moments of inertia about both the x-x and y-y axes of the compound section.

DATASET: 1 -2- -3-

Dimension A	8 IN
Dimension B	2 IN
Dimension C	1 IN
Dimension D	8 IN
Dimension E	4 IN
Dimension F	1 IN

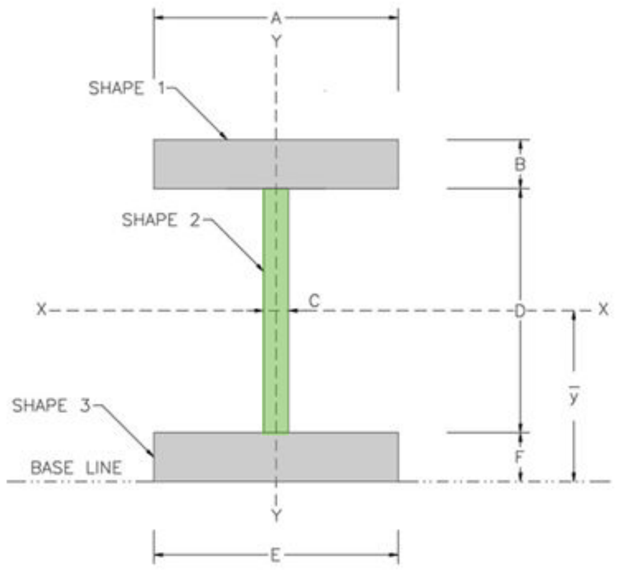
PROBLEM NO.11

Question 2: **Moment of Inertia of shape 2 about their own centroid (Ixx)**

$$Ixx_2 = \frac{C \times D^3}{12}$$

$$Ixx_2 = \frac{1 \times 8^3}{12}$$

$$\boxed{Ixx_2 = 42.66\ in}^4$$



Use the Parallel Axis Theorem to find the moments of inertia about both the x-x and y-y axes of the compound section.

DATASET: 1 -2- -3-

Dimension A	8 IN
Dimension B	2 IN
Dimension C	1 IN
Dimension D	8 IN
Dimension E	4 IN
Dimension F	1 IN

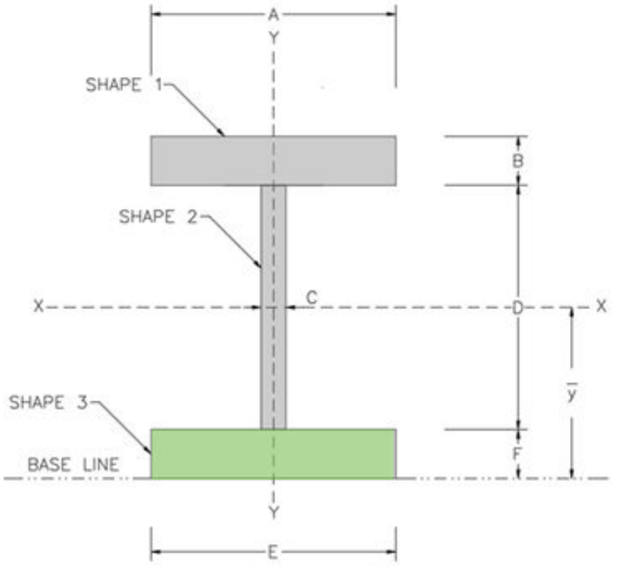
PROBLEM NO.11

Question 3: Moment of Inertia of shape 3 about their own centroid (Ixx)

$$Ixx_3 = \frac{E \times F^3}{12}$$

$$Ixx_3 = \frac{4 \times 1^3}{12}$$

$$Ixx_3 = 0.33\ in^4$$



Use the Parallel Axis Theorem to find the moments of inertia about both the x-x and y-y axes of the compound section.

DATASET: 1 -2- -3-

Dimension A	8 IN
Dimension B	2 IN
Dimension C	1 IN
Dimension D	8 IN
Dimension E	4 IN
Dimension F	1 IN

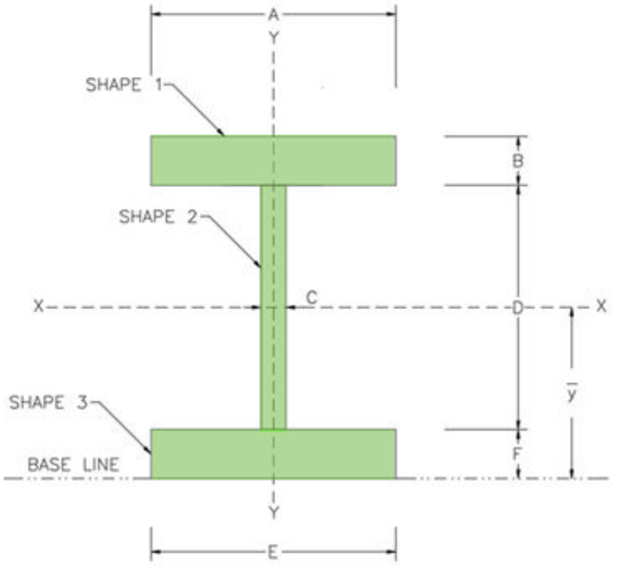
PROBLEM NO.11

Question 4: Summation of x-x Moments of Inertia of all shapes (SUM Ixx)

$$\sum_{I_{xx}} = I_{xx_1}(Question1) + I_{xx_2}(Question2) + I_{xx_3}(Question3)$$

$$\sum_{I_{xx}} = 5.3 + 42.66 + 0.33$$

$$\boxed{\sum_{I_{xx}} = 48.29\ in^4}$$



Use the Parallel Axis Theorem to find the moments of inertia about both the x-x and y-y axes of the compound section.

DATASET: 1 -2- -3-

Dimension A	8 IN
Dimension B	2 IN
Dimension C	1 IN
Dimension D	8 IN
Dimension E	4 IN
Dimension F	1 IN

PROBLEM NO.11

Question 5: Distance from the centroid of shape 1 to the centroid of the whole shape

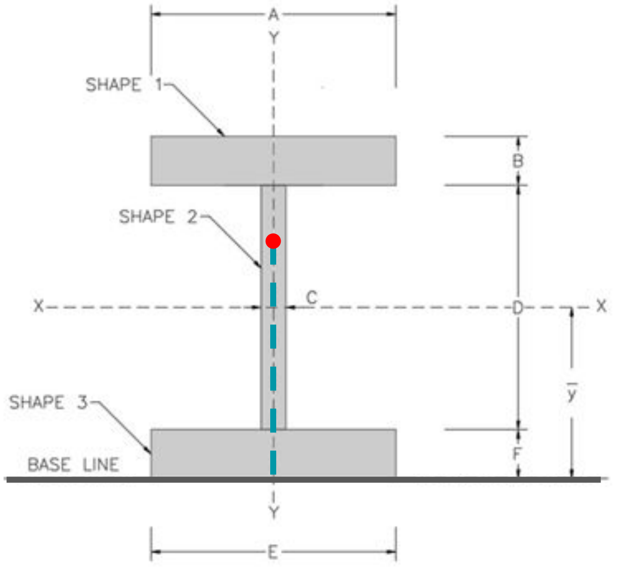
centroid of the whole shape:

$$\bar{x} = \frac{\sum_{A \times y}}{\sum_{A}} = \frac{A_1 \times y_1 + A_2 \times y_2 + A_3 \times y_3}{A_1 + A_2 + A_3}$$

$$\bar{x} = \frac{16 \times \left(\frac{2}{2} + 8 + 1\right) + 8 \times \left(\frac{8}{2} + 1\right) + 4 \times \left(\frac{1}{2}\right)}{16 + 8 + 4}$$

$$\bar{x} = \frac{160 + 40 + 2}{28}$$

$$\bar{x} = 7.214\ in$$



Use the Parallel Axis Theorem to find the moments of inertia about both the x-x and y-y axes of the compound section.

DATASET: 1 -2- -3-

Dimension A	8 IN
Dimension B	2 IN
Dimension C	1 IN
Dimension D	8 IN
Dimension E	4 IN
Dimension F	1 IN

PROBLEM NO.11

Question 5: **Distance from the centroid of shape 1 to the centroid of the whole shape**

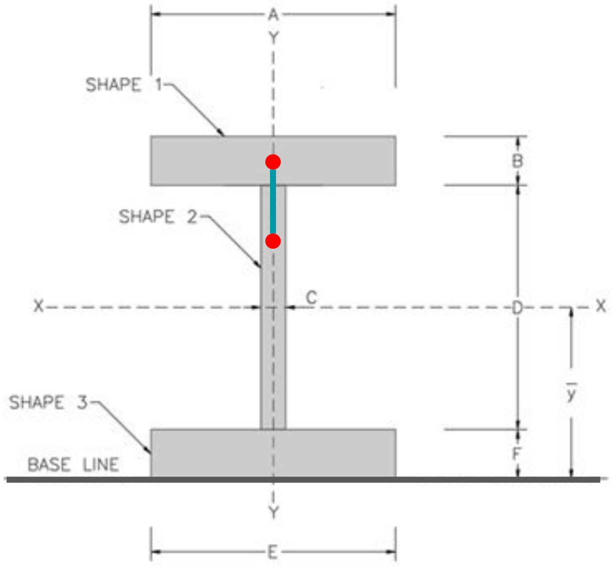
$$\bar{x} = 7.214\ in\ (\ Centroid\ of\ \ whole\ shape)$$

$$y_{n1} = \frac{B}{2} + (\ D - (\ \bar{x} - F)\ )$$

$$y_{n1} = \frac{2}{2} + (\ 8 - (\ 7.214 - 1)\ )$$

$$y_{n1} = 1 + 1.786$$

$$\boxed{y_{n1} = 2.786\ in}$$



Use the Parallel Axis Theorem to find the moments of inertia about both the x-x and y-y axes of the compound section.

DATASET: 1 -2- -3-

Dimension A	8 IN
Dimension B	2 IN
Dimension C	1 IN
Dimension D	8 IN
Dimension E	4 IN
Dimension F	1 IN

PROBLEM NO.11

Question 6: Distance from the centroid of shape 2 to the centroid of the whole shape

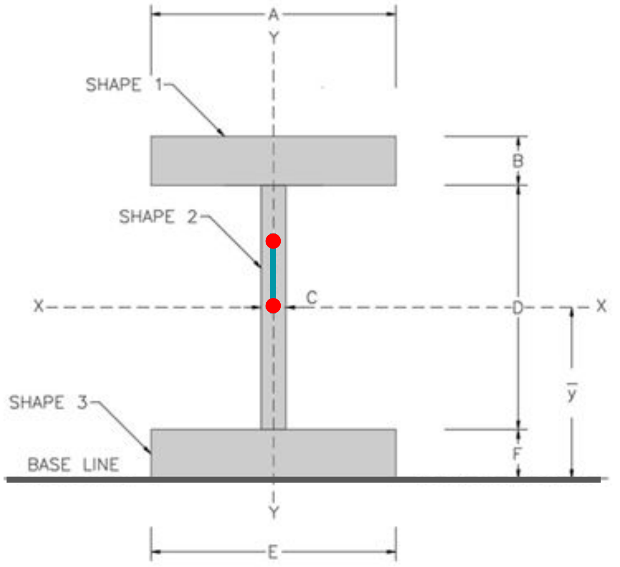
$$\bar{x} = 7.214\ in\ (\ Centroid\ of\ \ whole\ shape)$$

$$y_{n2} = \left(\bar{x} - F - \frac{D}{2}\right)$$

$$y_{n2} = 7.214 - 1 - \frac{8}{2}$$

$$y_{n2} = 6.214 - 4$$

$$y_{n1} = 2.214\ in$$



Use the Parallel Axis Theorem to find the moments of inertia about both the x-x and y-y axes of the compound section.

DATASET: 1 -2- -3-

Dimension A	8 IN
Dimension B	2 IN
Dimension C	1 IN
Dimension D	8 IN
Dimension E	4 IN
Dimension F	1 IN

PROBLEM NO.11

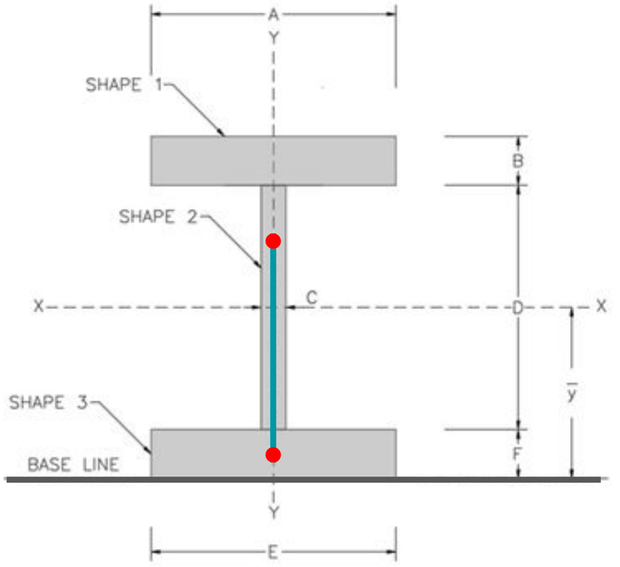
Question 7: **Distance from the centroid of shape 3 to the centroid of the whole shape**

$$\bar{x} = 7.214\ in\ (\ Centroid\ of\ \ whole\ shape)$$

$$y_{n3} = \left(\bar{x} - \frac{F}{2}\right)$$

$$y_{n3} = 7.214 - \frac{1}{2}$$

$$\boxed{y_{n3} = 6.714\ in}$$



Use the Parallel Axis Theorem to find the moments of inertia about both the x-x and y-y axes of the compound section.

DATASET: 1 -2- -3-

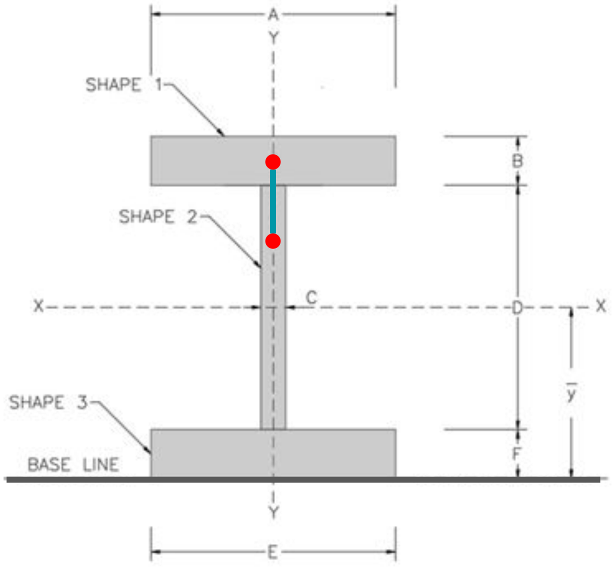
Dimension A	8 IN
Dimension B	2 IN
Dimension C	1 IN
Dimension D	8 IN
Dimension E	4 IN
Dimension F	1 IN

PROBLEM NO.11

Question 8: **2nd Moment of area 1 about centroid of whole shape x dist. to centroid**

$$A_1 \times y_{n1}^2$$

$$16 \times 2.786^2 = 124.188\ in^4$$



Use the Parallel Axis Theorem to find the moments of inertia about both the x-x and y-y axes of the compound section.

DATASET: 1 -2- -3-

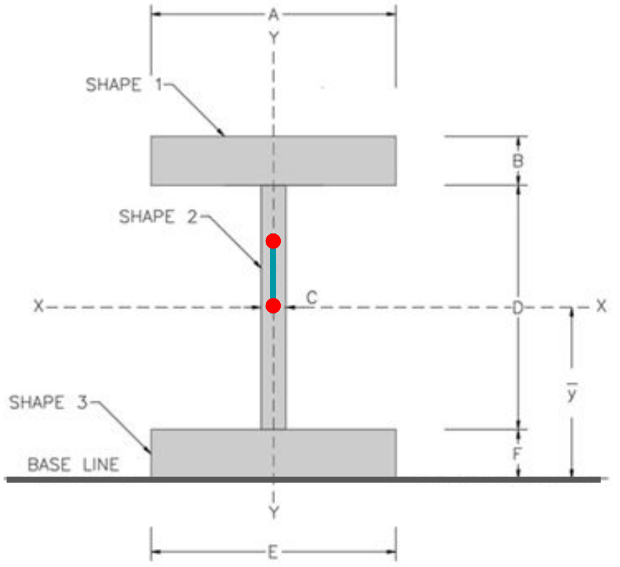
Dimension A	8 IN
Dimension B	2 IN
Dimension C	1 IN
Dimension D	8 IN
Dimension E	4 IN
Dimension F	1 IN

PROBLEM NO.11

Question 9: 2nd Moment of area 2 about centroid of whole shape x dist. to centroid

$$A_2 \times {y_{n2}}^2$$

$$8 \times 2.214^2 = 39.214\ in^4$$



Use the Parallel Axis Theorem to find the moments of inertia about both the x-x and y-y axes of the compound section.

DATASET: 1 -2- -3-

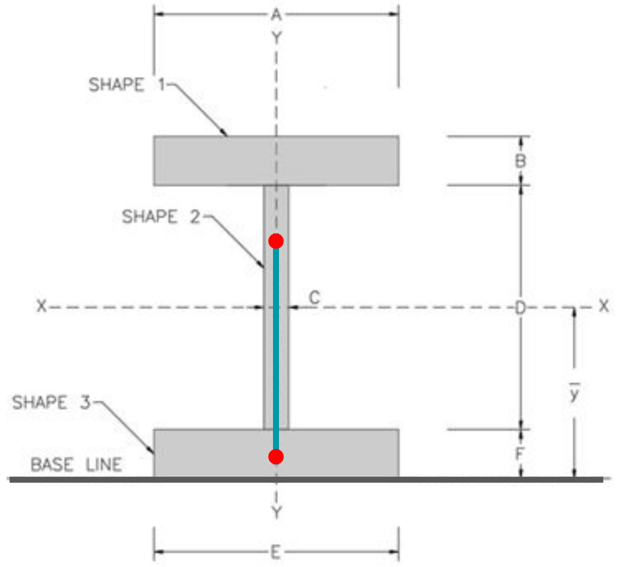
Dimension A	8 IN
Dimension B	2 IN
Dimension C	1 IN
Dimension D	8 IN
Dimension E	4 IN
Dimension F	1 IN

PROBLEM NO.11

Question 10: **2nd Moment of area 3 about centroid of whole shape x dist. to centroid**

$$A_3 \times y_{n3}^{\ 2}$$

$$4 \times 6.714^2 = \boxed{180.311\ in^4}$$



Use the Parallel Axis Theorem to find the moments of inertia about both the x-x and y-y axes of the compound section.

DATASET: 1 -2- -3-

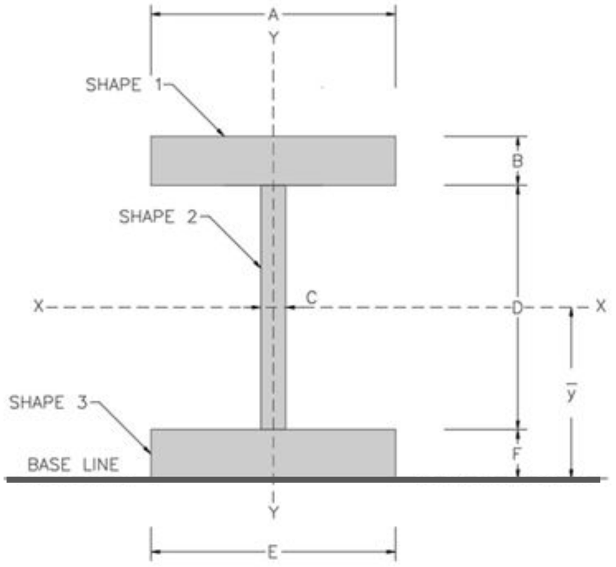
Dimension A	8 IN
Dimension B	2 IN
Dimension C	1 IN
Dimension D	8 IN
Dimension E	4 IN
Dimension F	1 IN

PROBLEM NO.11

Question 11: Summation of moments of areas times distances to centroid (SUM Ad^2)

$$A_1 \times y_{n1}^2 + A_2 \times y_{n2}^2 + A_3 \times y_{n3}^2$$

$$124.188 + 39.214 + 180.311 = \boxed{343.713\ in^4}$$



Use the Parallel Axis Theorem to find the moments of inertia about both the x-x and y-y axes of the compound section.

DATASET: 1 -2- -3-

Dimension A	8 IN
Dimension B	2 IN
Dimension C	1 IN
Dimension D	8 IN
Dimension E	4 IN
Dimension F	1 IN

PROBLEM NO.11

Question 12: **Moment of Inertia about the x-x axis for the whole shape (Ix)**

$$Ix_1 = Ixx_1(Question1) + \left(A_1 \times y_{n1}^2\right)(Question8)$$

$$Ix_1 = 5.3 + 124.188 = 129.488\ in^4$$

$$Ix_2 = Ixx_2(Question2) + \left(A_2 \times y_{n2}^2\right)(Question9)$$

$$Ix_2 = 42.66 + 39.214 = 81.874\ in^4$$

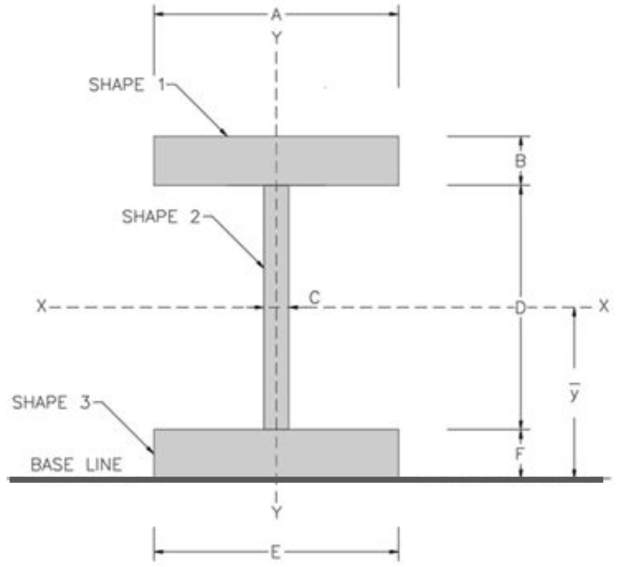
$$Ix_3 = Ixx_3(Question3) + \left(A_3 \times y_{n3}^2\right)(Question10)$$

$$Ix_3 = 0.33 + 180.311 = 180.641\ in^4$$

$$\sum_{Ix} = Ix_1 + Ix_2 + Ix_3$$

$$\sum_{Ix} = 129.488 + 81.874 + 180.641$$

$$\sum_{Ix} = 392.003\ in^4$$



Use the Parallel Axis Theorem to find the moments of inertia about both the x-x and y-y axes of the compound section.

DATASET: 1 -2- -3-

Dimension A	8 IN
Dimension B	2 IN
Dimension C	1 IN
Dimension D	8 IN
Dimension E	4 IN
Dimension F	1 IN

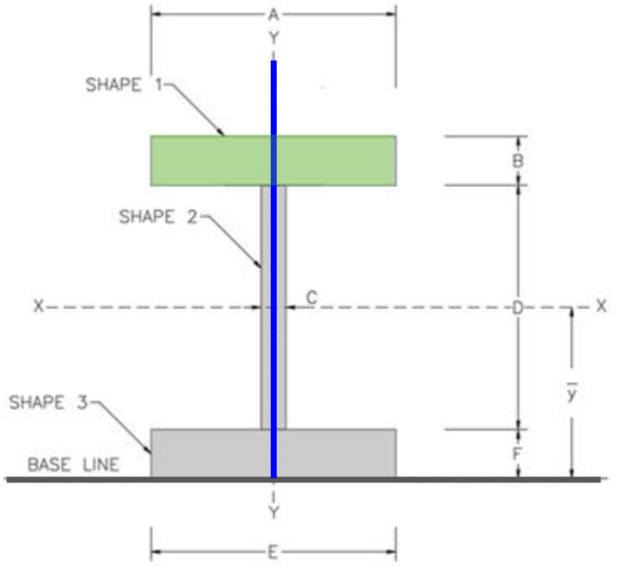
PROBLEM NO.11

Question 13: y-y Moment of Inertia of shape 1 about its own centroid (Iyy)

$$Iyy_1 = \frac{B \times A^3}{12}$$

$$Iyy_1 = \frac{2 \times 8^3}{12}$$

$$Iyy_1 = 85.33\ in^4$$



Use the Parallel Axis Theorem to find the moments of inertia about both the x-x and y-y axes of the compound section.

DATASET: 1 -2- -3-

Dimension A	8 IN
Dimension B	2 IN
Dimension C	1 IN
Dimension D	8 IN
Dimension E	4 IN
Dimension F	1 IN

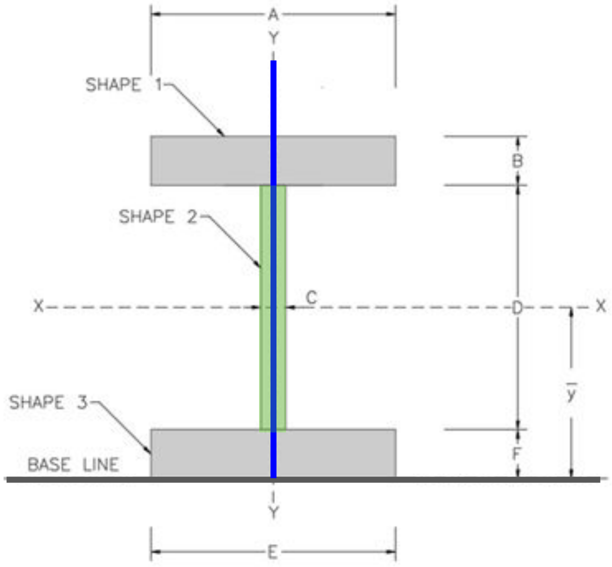
PROBLEM NO.11

Question 14: y-y Moment of Inertia of shape 2 about its own centroid (Iyy)

$$Iyy_2 = \frac{D \times C^3}{12}$$

$$Iyy_2 = \frac{8 \times 1^3}{12}$$

$$Iyy_2 = 0.66\ in^4$$



Use the Parallel Axis Theorem to find the moments of inertia about both the x-x and y-y axes of the compound section.

DATASET: 1 -2- -3-

Dimension A	8 IN
Dimension B	2 IN
Dimension C	1 IN
Dimension D	8 IN
Dimension E	4 IN
Dimension F	1 IN

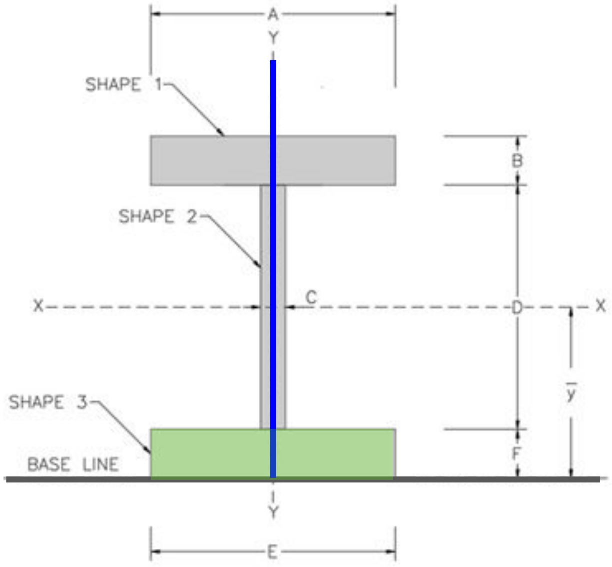
PROBLEM NO.11

Question 15: y-y Moment of Inertia of shape 3 about its own centroid (Iyy)

$$Iyy_3 = \frac{F \times E^3}{12}$$

$$Iyy_3 = \frac{1 \times 4^3}{12}$$

$$Iyy_3 = 5.33\ in^4$$



Use the Parallel Axis Theorem to find the moments of inertia about both the x-x and y-y axes of the compound section.

DATASET: 1 -2- -3-

Dimension A	8 IN
Dimension B	2 IN
Dimension C	1 IN
Dimension D	8 IN
Dimension E	4 IN
Dimension F	1 IN

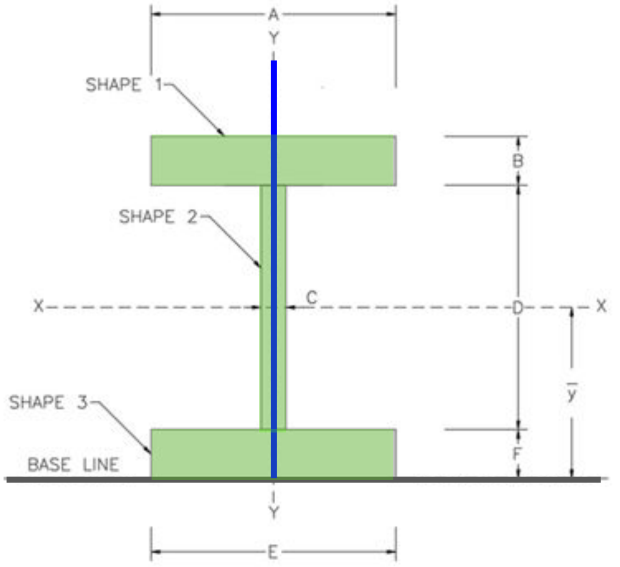
PROBLEM NO.11

Question 16: Summation of y-y Moments of Inertia of all shapes (SUM Iyy)

$$\sum_{Iyy} = Iyy_1 + Iyy_2 + Iyy_3$$

$$\sum_{Iyy} = 85.33 + 0.66 + 5.33$$

$$\sum_{Iyy} = \boxed{91.32\ in^4}$$



Use the Parallel Axis Theorem to find the moments of inertia about both the x-x and y-y axes of the compound section.

DATASET: 1 -2- -3-

Dimension A	8 IN
Dimension B	2 IN
Dimension C	1 IN
Dimension D	8 IN
Dimension E	4 IN
Dimension F	1 IN

PROBLEM NO.11

Question 17: **Moment of Inertia about the y-y axis for the whole shape (Iy)**

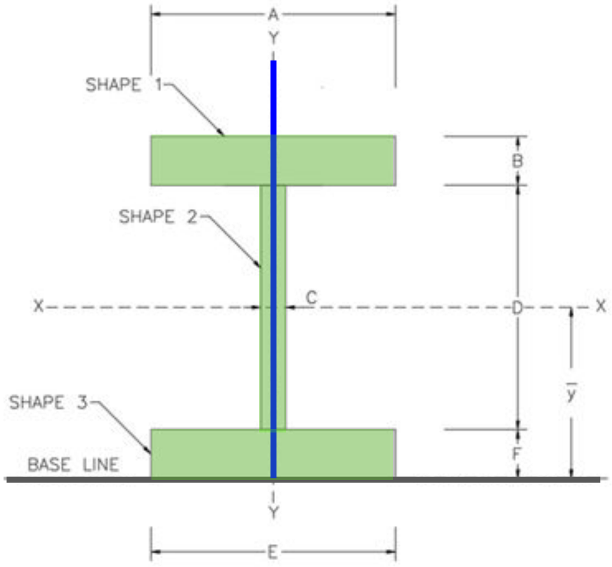
$$(d = distance\ from\ the\ centroid\ of\ each\ shape\ to\ Y\ axis)$$

$$Centroids\ of\ all\ shapes\ are\ located\ on\ Y\ axis$$

$$Iy = Iyy + A \times d^2 \rightarrow d = 0 \rightarrow Iy = Iyy$$

$$\sum_{Iy} = \sum_{Iyy} (Question\ 16)$$

$$\sum_{Iy} = \boxed{91.32\ in^4}$$



Use the Parallel Axis Theorem to find the moments of inertia about both the x-x and y-y axes of the compound section.

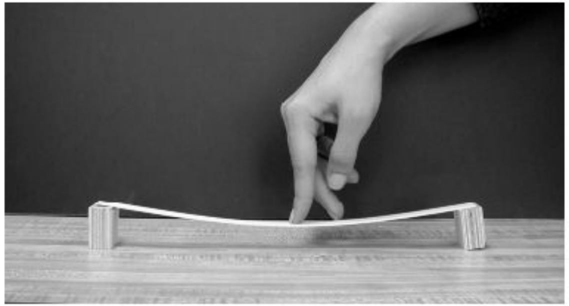
DATASET: 1 -2- -3-

Dimension A	8 IN
Dimension B	2 IN
Dimension C	1 IN
Dimension D	8 IN
Dimension E	4 IN
Dimension F	1 IN

Lab 09: Moment of Inertia

Procedure

1. Span the given 1/16" x 1/2" basswood stick flatwise between two supports.
2. Load the 'beam' at mid span with your finger to cause about 1/2" deflection.
3. Now rotate the stick 90° so that it is on the narrow edge, and hold it in place.
4. Again with your finger apply about the same load as before, and notice how much stiffer the beam has become.
5. Now calculate the moment of inertia for both orientations – flatwise and on edge.
6. Compare the two numbers and observe how they relate to the actual stiffness you felt with your finger.



Moment of Inertia
of a rectangle

$$I = \frac{bd^3}{12}$$

$$Moment\ of\ \ Inertia = \frac{b \times d^3}{12}$$