Structural Steel Design

Custom Cross Sections

NAME

REFERENCE

Using ASTM A36 steel, $F_y = 36$ ksi and $E = 29.6 \times 10^3$ ksi.

Using ASTM A992 steel, $F_y = 50$ ksi and $E = 29.6 \times 10^3$ ksi.

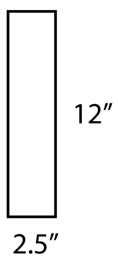
Centroid location: $\bar{x} = \dfrac{\sum_{i=1}^{n} \bar{x}_i A_i}{A}$ $\quad \bar{y} = \dfrac{\sum_{i=1}^{n} \bar{y}_i A_i}{A}$

For rectangular sections: $I_x = \dfrac{bd^3}{12}$

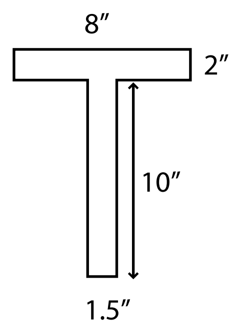
Parallel axis theorem: $I'_x = I_x + Ad^2$

FOR THE FOLLOWING SHAPES, SOLVE FOR THE MOMENT OF INERTIA (AROUND THE X-AXIS ONLY).

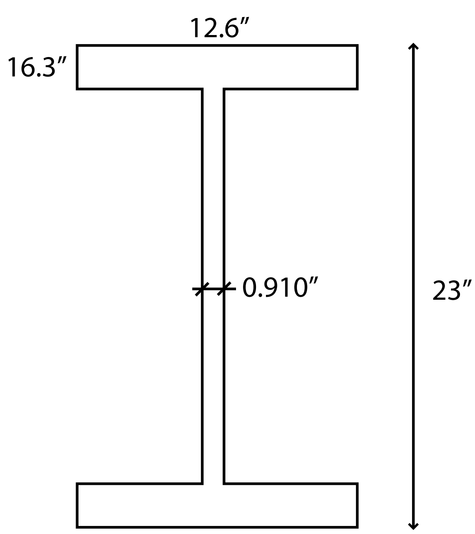
1 Generic rectangular section.



2 Generic T-section.

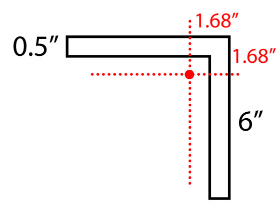


3 Steel wide-flange section. This essentially asks you to verify the value for I_x in AISC Table 1-1.

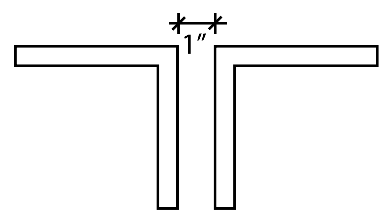


W21x201

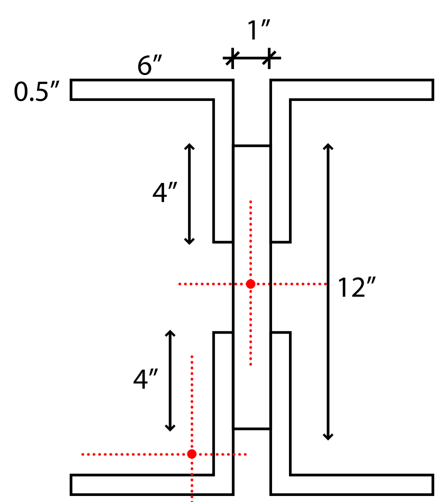
4 Steel built-up sections. Try each one.



Steel angle, by itself.
Centroid is given.



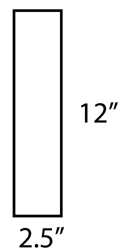
Double angle.



Built-up section. Centroids are given.

SOLUTIONS

1 Generic rectangular section.

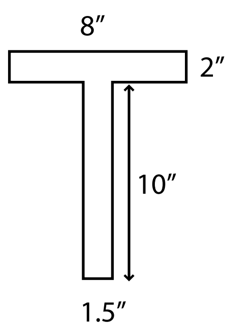


All we need is the equation for I_x for rectangular sections

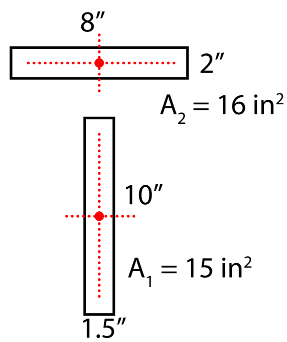
$$I_x = \frac{bd^3}{12} = \frac{(2.5")(12")^3}{12} = \boxed{360\ in^4}$$

b = 2.5″, d = 12″

2 Generic T-section.

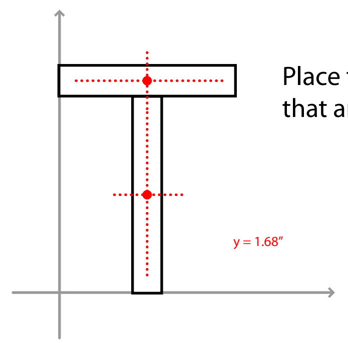


First step is to divide the section into parts for which we know the moment of inertia. Note the centroids and areas.



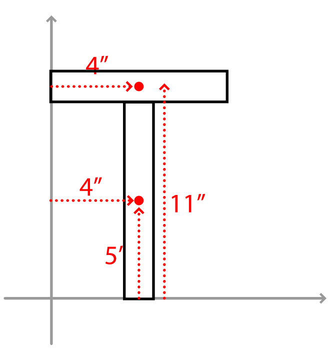
$A = 15\ in^2 + 16\ in^2 = 31\ in^2$

Find the new centroid.



Place the section on axes that are easy to deal with.

Note where the centroids are relative to the new coordinate system.

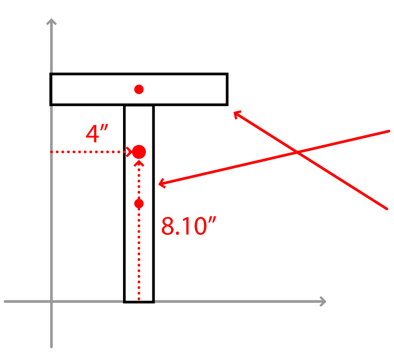


Calculate the x-coordinate of the new centroid.

$$\bar{x} = \frac{\sum_{i=1}^{n} \bar{x}_i A_i}{A} = \frac{(4")(15") + (4")(16")}{31\ in^2} = \frac{124\ in^2}{31\ in^2} = 4\ in^2$$

Calculate the y-coordinate of the new centroid.

$$\bar{y} = \frac{\sum_{i=1}^{n} \bar{y}_i A_i}{A} = \frac{(5")(15") + (11")(16")}{31\ in^2} = \frac{251\ in^2}{31\ in^2} = 8.10\ in^2$$



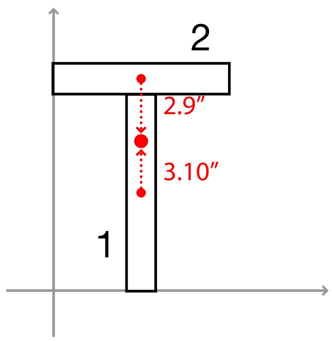
Draw the new centroid. Calculate I_x for each shape.

$$I_{x1} = \frac{bd^3}{12} = \frac{(1.5")(10")^3}{12} = 125\ in^4$$

$$I_{x2} = \frac{bd^3}{12} = \frac{(8")(2")^3}{12} = 5.33\ in^4$$

SOLUTIONS

Calculate the displaced moments of inertia using the parallel axis theorem.



$$I_x' = I_x + Ad^2$$

Calculate the distances from the part centroids to the overall centroid.

Place the values that you need in a table, one row per part.

	I_x	A	d	$I_x + Ad^2$
1	125 in^4	15 in^2	3.10″	269.15 in^4
2	5.33 in^4	16 in^2	2.9″	139.89 in^4

Calculate the values of $I_x + Ad^2$. Then add them together to get the final answer. **409.04 in^4**

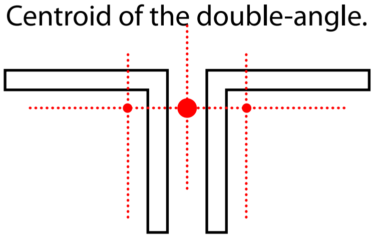
3 Steel wide-flange section.

The process for the steel wide flange section is the same as the previous, with just different parts. There are class notes as well online that show hints as to how to do this.

Final answer = **5310 in^4**

4 Steel built-up sections.

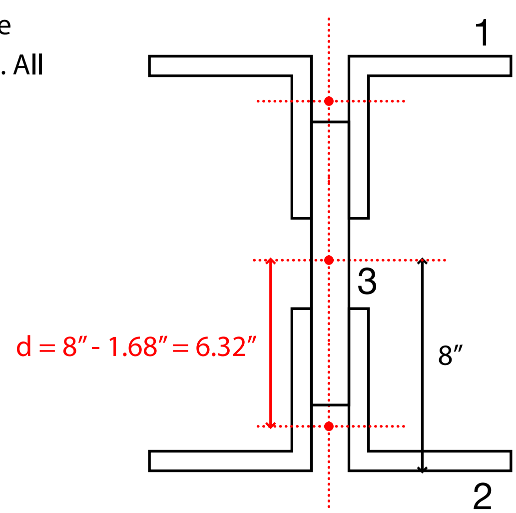
Centroid of the double-angle.



The lecture notes cover how to calculate I_x for the single angle. All we have to do for the double angle is double the value of I_x, since the are not offset from each other in the vertical direction. Thus, d = 0 for both parts in the parallel axis formula!

Single I_x = 19.91 in^4, double Ix = 39.82 in^4

Since we know the moment of inertia of the double-angle, we can treat each double-angle as a *single part* in the big section. All we need are the values d for the displacements.



	I_x	A	d	$I_x + Ad^2$
1	39.2 in^4	11.5 in^2	6.32″	499.16 in^4
2	39.2 in^4	11.5 in^2	6.32″	499.16 in^4
3	144 in^4	12 in^2	0″	144 in^4

1142.3 in^4