# APPENDIX
# SECTIONS AND SHAPES—TABULAR DATA

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**A.1 CENTROIDS AND CENTER OF GRAVITY / A.1**
**A.2 SECOND MOMENTS OF AREAS / A.11**
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## *A.1 CENTROIDS AND CENTER OF GRAVITY*

When forces are distributed over a line, an area, or a volume, it is often necessary to determine where the resultant force of such a system acts. To have the same effect, the resultant must act at the centroid of the system. The *centroid* of a system is a point at which a system of distributed forces may be considered concentrated with exactly the same effect.

Figure A.1 shows four weights $W_1$, $W_2$, $W_4$, and $W_5$ attached to a straight horizontal rod whose weight $W_3$ is shown acting at the center of the rod. The centroid of this *weight* or *point group* is located at $G$, which may also be called the *center of gravity* or the *center of mass* of the point group. The total weight of the group is

$$W = W_1 + W_2 + W_3 + W_4 + W_5$$

This weight, when multiplied by the *centroidal distance* $\bar{x}$, must balance or cancel the sum of the individual weights multiplied by their respective distances from the left end. In other words,

$$W\bar{x} = W_1 l_1 + W_2 l_2 + W_3 l_3 + W_4 l_4 + W_5 l_5$$

or

$$\bar{x} = \frac{W_1 l_1 + W_2 l_2 + W_3 l_3 + W_4 l_4 + W_5 l_5}{W_1 + W_2 + W_3 + W_4 + W_5}$$

A similar procedure can be used when the point groups are contained in an area such as Fig. A.2. The centroid of the group at $G$ is now defined by the two centroidal

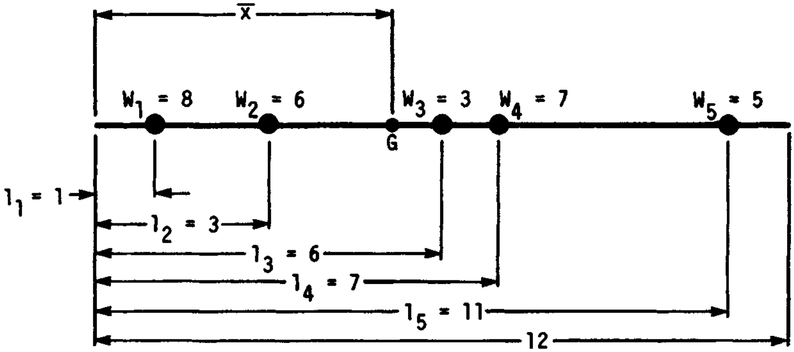



**FIGURE A.1** The centroid of this point group is located at $G$, a distance of $\bar{x}$ from the left end.

distances $\bar{x}$ and $\bar{y}$, as shown. Using the same procedure as before, we see that these must be given by the equations

$$\bar{x} = \sum_{i=1}^{i=N} A_i x_i \Big/ \sum_{i=1}^{i=N} A_i \qquad \bar{y} = \sum_{i=1}^{i=N} A_i y_i \Big/ \sum_{i=1}^{i=N} A_i \tag{A.1}$$

A similar procedure is used to locate the centroids of a group of lines or a group of areas. Area groups are often composed of a combination of circles, rectangles, triangles, and other shapes. The areas and locations of the centroidal axes for many such shapes are listed in Table A.1. For these, the $x_i$ and $y_i$ of Eqs. (A.1) are taken as the distances to the centroid of each area $A_i$.

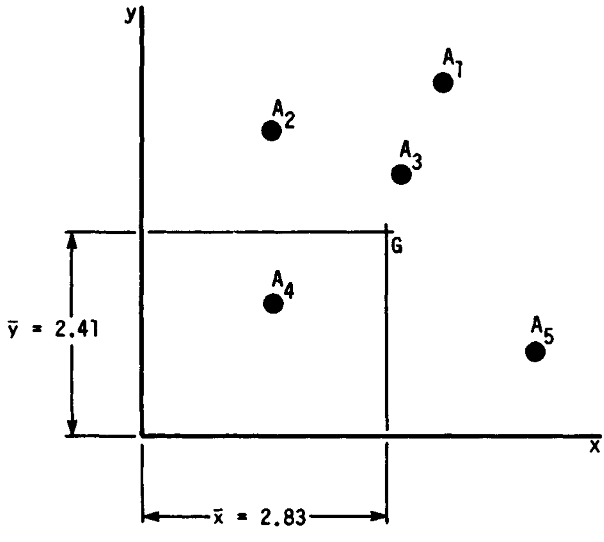
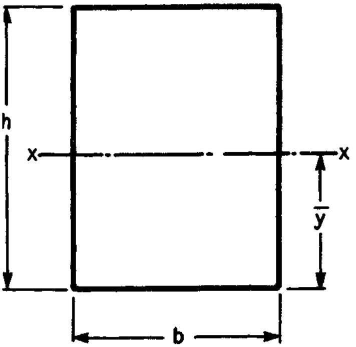



**FIGURE A.2** The weightings and coordinates of the points are designated as $A_i$ $(x_i, y_i)$; they are $A_1 = 0.5(3.5, 4.0)$, $A_2 = 0.5(1.5, 3.5)$, $A_3 = 0.5(3.0, 3.0)$, $A_4 = 0.7(1.5, 1.5)$, and $A_5 = 0.7(4.5, 1.0)$.

**TABLE A.1** Properties of Sections†

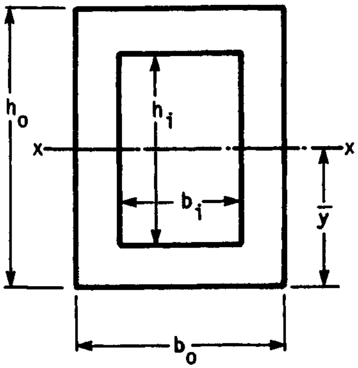
## 1. Rectangle




$$A = bh \qquad I_x = \frac{bh^3}{12}$$

$$k_x = 0.289h \qquad \bar{y} = \frac{h}{2}$$

## 2. Hollow rectangle



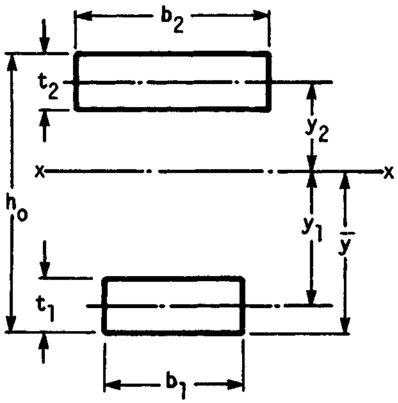

$$A = b_o h_o - b_i h_i$$

$$I_x = \frac{1}{12}(b_o h_o^3 - b_i h_i^3)$$

$$k_x = \left(\frac{I}{A}\right)^{1/2}$$

$$\bar{y} = \frac{h_o}{2}$$

## 3. Two rectangles




$$A = b_1 t_1 + b_2 t_2$$

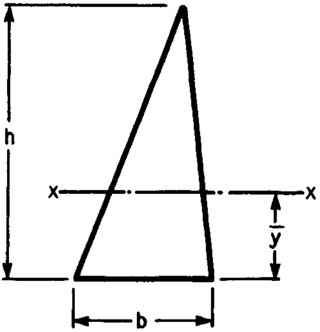
$$I_x = \frac{b_1 t_1^3}{12} + b_1 t_1 y_1^2 + \frac{b_2 t_2^3}{12} + b_2 t_2 y_2^2$$

$$k_x = \left(\frac{I_x}{A}\right)^{1/2}$$

$$\bar{y} = \frac{b_1 t_1^2 + 2b_1 t_2 h_o - b_2 t_2^2}{2(b_1 t_1 + b_2 t_2)}$$

†List of symbols: $A$ = area; $I$ = second area moment about principal axis; $J_O$ = second polar area moment with respect to $O$; $k$ = radius of gyration; and $\bar{x}$, $\bar{y}$ = centroidal distances.

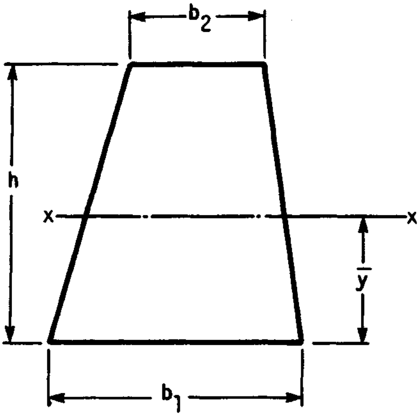
### 4. Triangle




$$A = \frac{bh}{2} \qquad I_x = \frac{bh^3}{36}$$

$$k = 0.236h \qquad \bar{y} = \frac{h}{3}$$

### 5. Trapezoid



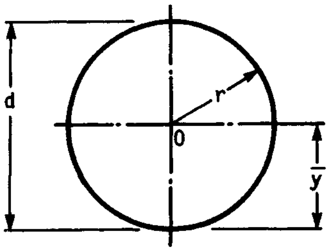

$$A = \frac{h}{2}(b_1 + b_2)$$

$$I_x = \frac{h^3(b_1^2 + 4b_1b_2 + b_2^2)}{36(b_1 + b_2)}$$

$$k_x = \frac{h[2(b_1^2 + 4b_1b_2 + b_2^2)]^{1/2}}{6(b_1 + b_2)}$$

$$\bar{y} = \frac{h(b_1 + 2b_2)}{3(b_1 + b_2)}$$

### 6. Circle

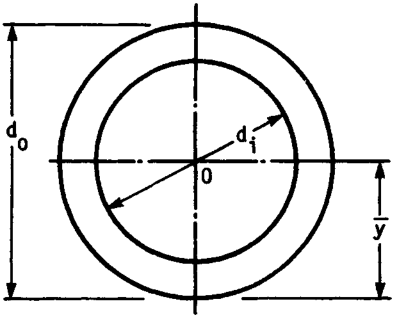



$$A = \pi r^2 = \frac{\pi d^2}{4}$$

$$I = \frac{\pi r^4}{4} = \frac{\pi d^4}{64} \qquad J_O = \frac{\pi r^4}{2}$$

$$k = \frac{r}{2} = \frac{d}{4} \qquad \bar{y} = r = \frac{d}{2}$$

### 7. Hollow circle




$$A = \frac{\pi}{4}(d_o^2 - d_i^2)$$

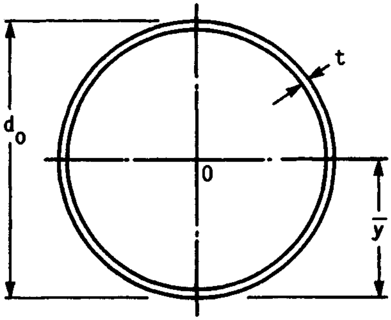
$$I = \frac{\pi}{64}(d_o^4 - d_i^4)$$

$$J_O = \frac{\pi}{32}(d_o^4 - d_i^4)$$

$$k = \frac{1}{4}(d_o^2 + d_i^2)^{1/2}$$

$$\bar{y} = \frac{d_o}{2}$$

### 8. Thin ring (annulus)

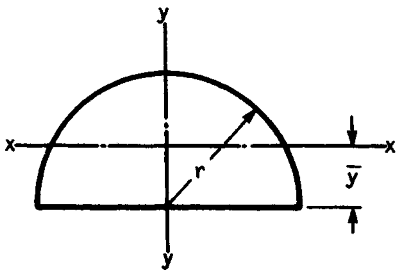



$$A = \pi d_o t \qquad I = \frac{\pi d_o^3 t}{8}$$

$$J_O = \frac{\pi d_o^3 t}{4}$$

$$k = 0.353 d_o \qquad \bar{y} = \frac{d_o}{2}$$

### 9. Semicircle

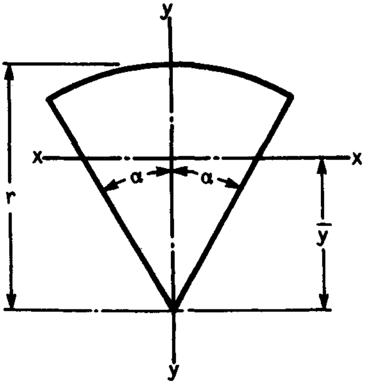



$$A = \frac{\pi r^2}{2} \qquad I_x = 0.1098 r^4$$

$$I_y = \frac{\pi r^4}{8} \qquad k_x = 0.264 r$$

$$k_y = \frac{r}{2} \qquad \bar{y} = 0.424 r$$

**10. Circular sector**




$$A = \alpha r^2$$

$$I_x = \frac{r^4}{4}\left(\alpha + \sin\alpha\cos\alpha - \frac{16}{9\alpha}\sin^2\alpha\right)$$

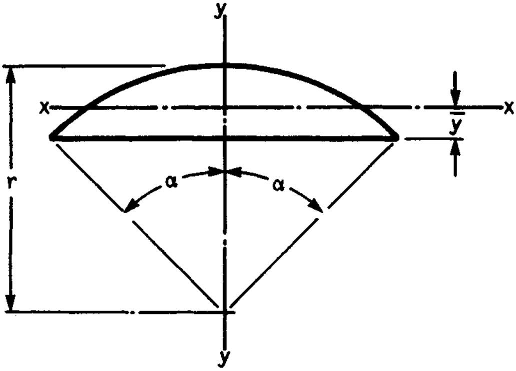
$$I_y = \frac{r^4}{4}(\alpha - \sin\alpha\cos\alpha)$$

$$k_x = \frac{r}{2}\left(1 + \frac{\sin\alpha\cos\alpha}{\alpha} - \frac{16}{9\alpha}\sin^2\alpha\right)^{1/2}$$

$$k_y = \frac{r}{2}\left(\frac{\alpha - \sin\alpha\cos\alpha}{\alpha}\right)^{1/2}$$

$$\bar{y} = \frac{2r\sin\alpha}{3\alpha}$$

**11. Circular segment**



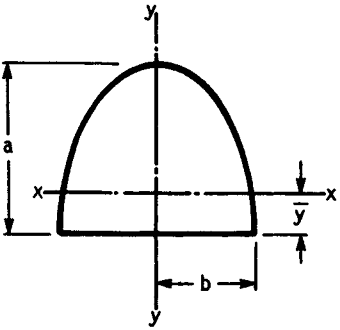

$$A = \frac{r^2}{2}(2\alpha - \sin 2\alpha)$$

$$I_x = r^4\left[\left(\frac{2\alpha - \sin 2\alpha}{8}\right)\left(1 + \frac{2\sin^3\alpha\cos\alpha}{\alpha - \sin\alpha\cos\alpha}\right) - \frac{8\sin^6\alpha}{9(2\alpha - \sin 2\alpha)}\right]$$

$$k_x = \frac{r}{2}\left[1 + \frac{2\sin^3\alpha\cos\alpha}{\alpha - \sin\alpha\cos\alpha} - \frac{64\sin^6\alpha}{9(2\alpha - \sin 2\alpha)^2}\right]^{1/2}$$

$$\bar{y} = \frac{4r\sin^3\alpha}{6\alpha - 3\sin 2\alpha} - r\cos\alpha$$

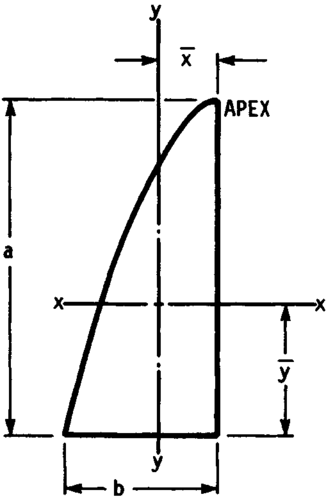
### 12. Parabola




$$A = \frac{4ab}{3} \qquad I_x = \frac{16a^3b}{175}$$

$$I_y = \frac{4ab^3}{15} \qquad \bar{y} = \frac{a}{5}$$

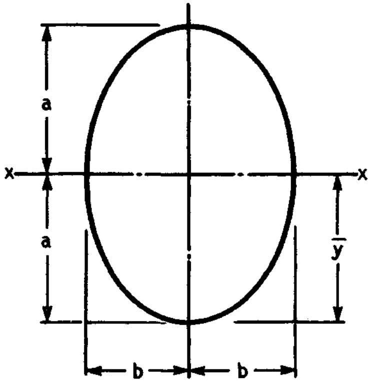
### 13. Semiparabola




$$A = \frac{2ab}{3} \qquad I_x = \frac{8a^3b}{175}$$

$$I_y = \frac{19ab^3}{480} \qquad \bar{y} = \frac{2a}{5} \qquad \bar{x} = \frac{3b}{8}$$

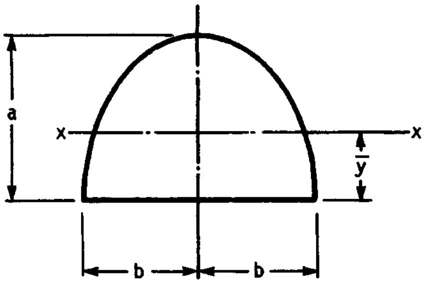
### 14. Ellipse




$$A = \pi ab \qquad I_x = \frac{\pi a^3 b}{4}$$

$$k_x = \frac{a}{2} \qquad \bar{y} = a$$

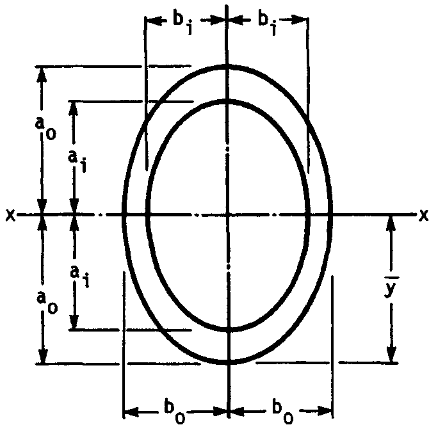
### 15. Semiellipse




$$A = \frac{\pi ab}{2} \qquad I_x = a_3 b\left(\frac{\pi}{8} - \frac{8}{9\pi}\right)$$

$$k_x = \frac{b}{6\pi}(9\pi^2 - 64)^{1/2} \qquad \bar{y} = \frac{4a}{3\pi}$$

### 16. Hollow ellipse

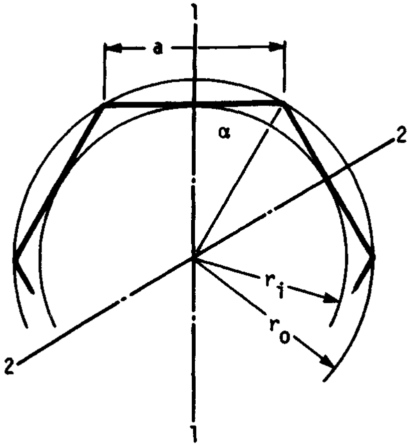



$$A = \pi(a_o b_o - a_i b_i)$$

$$I_x = \frac{\pi(a_o^3 b_o - a_i^3 b_i)}{4}$$

$$k_x = \frac{1}{2}\left(\frac{a_o^3 b_o - a_i^3 b_i}{a_o b_o - a_i b_i}\right)^{1/2} \qquad \bar{y} = a_o$$

**17. Regular polygon (*N* sides)**

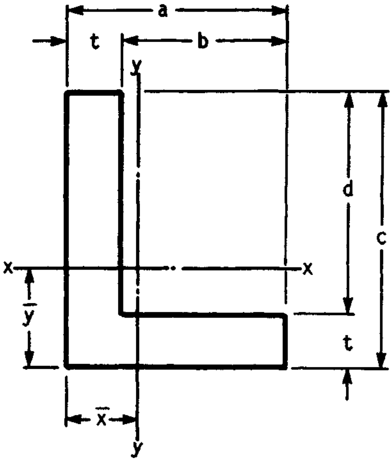



$$A = \frac{Nr_o^2 \sin 2\alpha}{2} = Nr_i^2 \tan \alpha$$

$$I_1 = \frac{A(6r_o^2 - a^2)}{24} \qquad I_2 = \frac{A(12r_i^2 + a^2)}{48}$$

$$k_1 = \left(\frac{6r_o^2 - a^2}{24}\right)^{1/2} \qquad k_2 = \left(\frac{12r_i^2 + a^2}{48}\right)^{1/2}$$

**18. Angle**



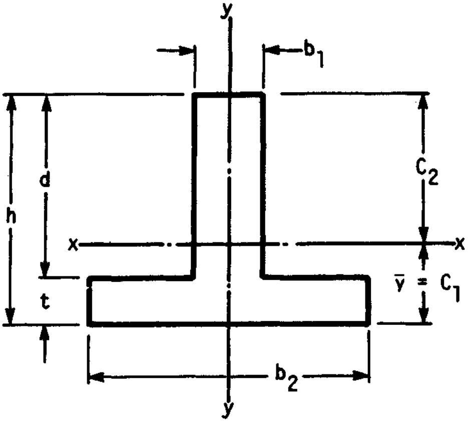

$$A = t(a + d)$$

$$\bar{y} = \frac{c^2 + bt}{2(a + d)} \qquad \bar{x} = \frac{a^2 + dt}{2(a + d)}$$

$$I_x = \frac{1}{3}[t(c - \bar{y})^3 + a\bar{y}^3 - b(\bar{y} - t)^3]$$

$$I_y = \frac{1}{3}[t(a - \bar{x})^3 + c\bar{x}^3 - d(\bar{x} - t)^3]$$

## 19. T section



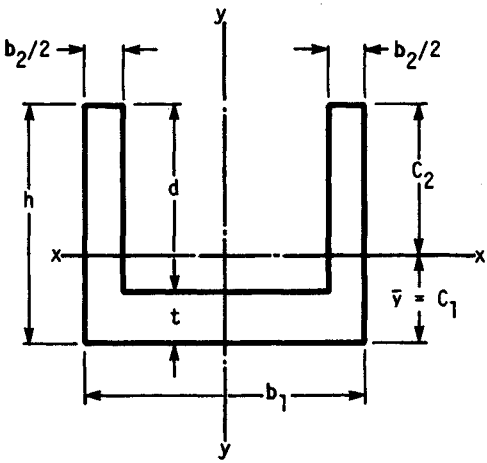

$$A = b_1 t + b_2 d$$

$$\bar{y} = \frac{b_1 t^2 + 2b_2 t d + b_2 d^2}{2A}$$

$$I_x = \frac{b_1 c_1^3 - (b_1 - b_2)(c_1 - t)^3 + b_2 c_2^3}{3}$$

$$I_y = \frac{t b_1^3 + d b_2^3}{12}$$

## 20. U Section




$$A = b_1 t + b_2 d$$

$$\bar{y} = \frac{b_1 t^2 + 2b_2 t d + b_2 d^2}{2A}$$

$$I_x = \frac{b_1 c_1^3 - (b_1 - b_2)(c_1 - t)^3 + b_2 c_2^3}{3}$$

$$I_y = \frac{h b_1^3 - d(b_1 - b_2)^3}{12}$$

Equations (A.1) can easily be solved on an ordinary calculator using the Σ key twice, once for the denominator and again for the numerator. The equations are also easy to program. Practice these techniques using the data and results in Figs. A.1, A.2, and A.3.

By substituting integration signs for the summation signs in Eqs. (A.1), we get the more general form of the relations as

$$\bar{x} = \frac{\int x'\, dA}{\int dA} \qquad \bar{y} = \frac{\int y'\, dA}{\int dA}$$

These reduce to

$$\bar{x} = \frac{1}{A}\int x'\, dA \qquad \bar{y} = \frac{1}{A}\int y'\, dA \tag{A.2}$$

where $x'$ and $y'$ = coordinate distances to the centroid of the element $dA$. These equations can be solved by

- Finding expressions for $x'$ and $y'$ and then performing the integration analytically.
- Approximate integration using the routines described in the programming manual of your programmable calculator or computer.
- Using numerical integration routines.

## *A.2 SECOND MOMENTS OF AREAS*

The expression $A\bar{x} = \int x' dA$ from Eqs. (A.2) is a *first moment of an area.* A *second moment of an area* is obtained when the element of area is multiplied by the square of a distance to some stated axis. Thus the expressions

$$\int x^2\, dA \qquad \int y^2\, dA \qquad \int r^2\, dA \tag{A.3}$$

are all second moments of areas. Such formulas resemble the equation for *moment of inertia,* which is

$$\int \rho^2\, dm \tag{A.4}$$

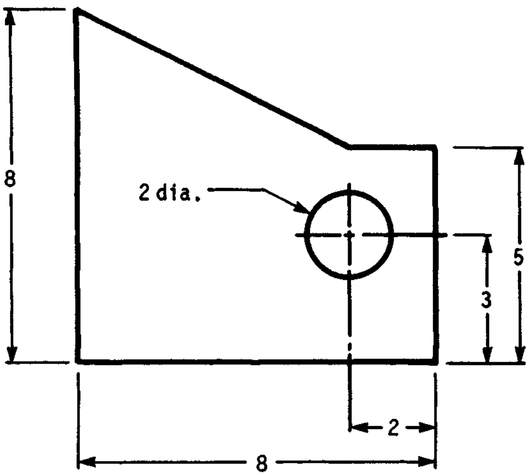
where $\rho$ = distance to some axis and $dm$ = an element of mass. Because of the resemblance, Eqs. (A.3) are often called the equations for moment of inertia too, but this is a misnomer because an area cannot have inertia.

We can find the second moment of an area about rectangular axes by using one of the formulas

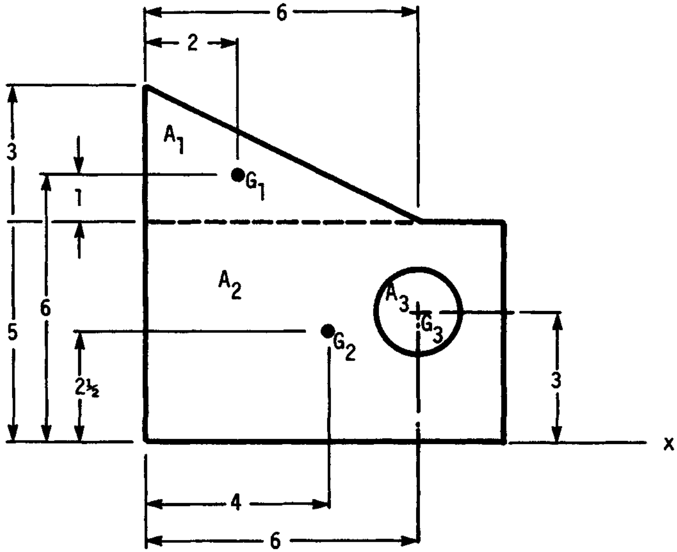
$$I_x = \int y^2\, dA \qquad I_y = \int x^2\, dA \tag{A.5}$$

***Example 1.*** Find the second moment of area of the rectangle in Fig. A.4 about the $x$ axis.

*Solution.* Select an element of area $dA$ such that it is everywhere $y$ units from $x$. Substituting appropriate terms into Eqs. (A.5) gives




(a)




(b)

**FIGURE A.3** A composite shape consisting of a rectangle, a triangle, and a circular hole. The centroidal distances are found to be $\bar{x} = 3.47$ and $\bar{y} = 3.15$.

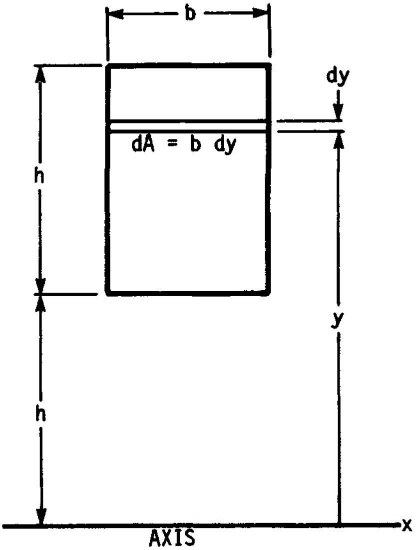



**FIGURE A.4** Second area moment of a rectangle.

$$I_x = \int y^2\, dA = \int_h^{2h} y^2 b\, dy = \left.\frac{by^3}{3}\right|_h^{2h} = \frac{7bh^3}{3}$$

The *polar second moment of an area* is the second moment taken about an axis *normal to the plane* of an area. The equation is

$$J = \int \rho^2\, dA \qquad \text{(A.6)}$$

***Example 2.*** Find the polar second moment of the area of a circle about its centroidal axis.

*Solution.* Let the radius of the circle be $r$. Define a thin elemental ring of thickness $d\rho$ at radius $\rho$. Then $dA = 2\pi\rho\, d\rho$. We now have

$$J = \int \rho^2\, dA = \int_0^r \rho^2(2\pi\rho)\, d\rho = 2\pi \left.\frac{\rho^4}{4}\right|_0^r = \frac{\pi r^4}{2}$$

### A.2.1 Radius of Gyration

If we think of the second moment of an area as the total area times the square of a fictitious distance, then

$$I_x = \int y^2\, dA = k_x^2 A \qquad \text{or} \qquad k_x = \sqrt{\frac{I_x}{A}} \qquad \text{(A.7)}$$

In polar form,

$$J_z = \int \rho^2\, dA = k_z^2 A \qquad \text{or} \qquad k_z = \sqrt{\frac{J_z}{A}} \qquad \text{(A.8)}$$

In each case, $k$ is called the *radius of gyration.*

### A.2.2 Transfer Formula

In Fig. A.5, suppose we know the second moment of the area about $x$ to be $I_x$. We can find the second moment of the area about some new axis that is parallel to the old using the transfer formula. Thus the second moment of the area in Fig. A.5 about the $x'$ axis is

$$I' = I_G + d^2 A \qquad \text{(A.9)}$$

where $I_G$ = second moment about the centroidal axis and $d$ = transfer distance. Using this formula and the second moments from Table A.1 makes it possible to compute the second moments of sections made up of a combination of shapes. The procedure has much in common with the example in Fig. A.3.

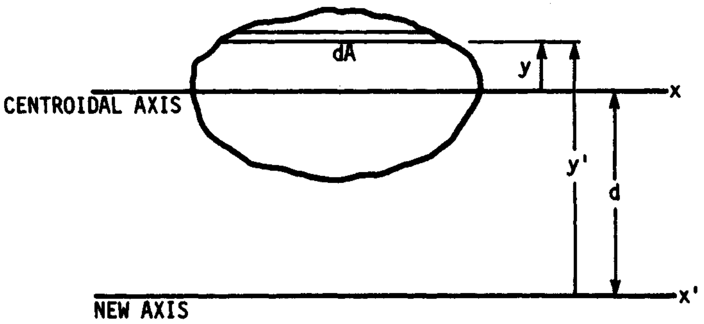



**FIGURE A.5** Use of the transfer formula.

### A.2.3 Principal Axes

Sometimes we encounter the integral

$$I_{xy} = \int xy \, dA \tag{A.10}$$

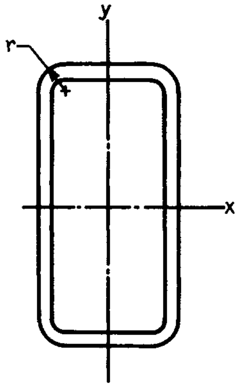
which is called the *product moment of an area.* This integral can be either positive or negative because $x$ and $y$ can have positive or negative values.

If one of the axes of an area, say $y$, is an axis of symmetry, then every element of area $dA$ located by a positive $x$ will have a twin, symmetrically located, having a corresponding negative $x$. These will sum to zero in the integration, and so the product moment is always zero when either $x$ or $y$ is an axis of symmetry. Since $I_{xy}$ can be either positive or negative, there must be some orientation of rectangular axes where $I_{xy} = 0$. The two axes corresponding to this zero position are called the *principal axes.* If such axes intersect at the centroid of a section, then they are called the *centroidal principal axes.*

## A.3 STRUCTURAL SHAPES

An assortment of various shapes used in structural steel works and their sizes and properties are tabulated in Tables A.2 to A.6. These are probably the most useful sizes for machine-design purposes, but other sizes are available or can be obtained on special order. Generally, aluminum shapes are available in a larger range of sizes, especially the smaller ones.

**TABLE A.2** Properties of Square and Rectangular Structural Steel Tubing†




| Size, in | Weight, lb/ft | Area $A$, in$^2$ | Radius‡ $r$, in | $I_x$, in$^4$ | $I_y$, in$^4$ |
|---|---|---|---|---|---|
| 2 × 2 × $\frac{3}{16}$ | 4.32 | 1.27 | $\frac{3}{8}$ | 0.668 | |
| $\frac{1}{4}$ | 5.41 | 1.59 | $\frac{1}{2}$ | 0.766 | |
| 3 × 2 × $\frac{3}{16}$ | 5.59 | 1.64 | $\frac{3}{8}$ | 1.24 | 0.977 |
| $\frac{1}{4}$ | 7.11 | 2.09 | $\frac{1}{2}$ | 2.21 | 1.15 |
| 3 × 3 × $\frac{3}{16}$ | 6.87 | 2.02 | $\frac{3}{8}$ | 2.60 | |
| $\frac{1}{4}$ | 8.81 | 2.59 | $\frac{1}{2}$ | 3.16 | |
| $\frac{5}{16}$ | 10.58 | 3.11 | $\frac{5}{8}$ | 3.58 | |
| 4 × 2 × $\frac{3}{16}$ | 6.87 | 2.02 | $\frac{3}{8}$ | 3.87 | 1.29 |
| $\frac{1}{4}$ | 8.81 | 2.59 | $\frac{1}{2}$ | 4.69 | 1.54 |
| $\frac{5}{16}$ | 10.58 | 3.11 | $\frac{5}{8}$ | 5.32 | 1.71 |
| 4 × 3 × $\frac{3}{16}$ | 8.15 | 2.39 | $\frac{3}{8}$ | 5.23 | 3.34 |
| $\frac{1}{4}$ | 10.51 | 3.09 | $\frac{1}{2}$ | 6.45 | 4.10 |
| $\frac{5}{16}$ | 12.70 | 3.73 | $\frac{5}{8}$ | 7.45 | 4.71 |
| 4 × 4 × $\frac{3}{16}$ | 9.42 | 2.77 | $\frac{3}{8}$ | 6.59 | |
| $\frac{1}{4}$ | 12.21 | 3.59 | $\frac{1}{2}$ | 8.22 | |
| $\frac{5}{16}$ | 14.83 | 4.36 | $\frac{5}{8}$ | 9.58 | |
| $\frac{3}{8}$ | 17.27 | 5.08 | $\frac{3}{4}$ | 10.7 | |
| $\frac{1}{2}$ | 21.63 | 6.36 | 1 | 12.3 | |
| 5 × 3 × $\frac{1}{4}$ | 12.21 | 3.59 | $\frac{1}{2}$ | 11.3 | 5.05 |
| $\frac{5}{16}$ | 14.83 | 4.36 | $\frac{5}{8}$ | 13.2 | 5.85 |
| $\frac{3}{8}$ | 17.27 | 5.08 | $\frac{3}{4}$ | 14.7 | 6.48 |
| $\frac{1}{2}$ | 21.63 | 6.36 | 1 | 16.9 | 7.33 |
| 5 × 4 × $\frac{1}{4}$ | 13.91 | 4.09 | $\frac{1}{2}$ | 14.1 | 9.98 |
| $\frac{5}{16}$ | 16.96 | 4.98 | $\frac{5}{8}$ | 16.6 | 11.7 |
| $\frac{3}{8}$ | 19.82 | 5.83 | $\frac{3}{4}$ | 18.7 | 13.2 |

**TABLE A.2** Properties of Square and Rectangular Structural Steel Tubing† (*Continued*)

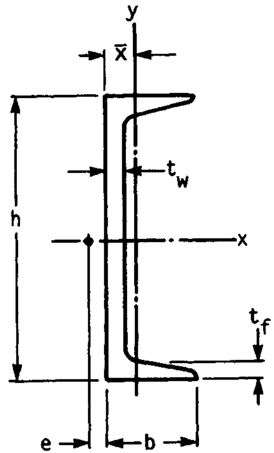
| Size, in | Weight, lb/ft | Area $A$, in$^2$ | Radius‡ $r$, in | $I_x$, in$^4$ | $I_y$, in$^4$ |
|---|---|---|---|---|---|
| $5 \times 5 \times \frac{1}{4}$ | 15.62 | 4.59 | $\frac{1}{2}$ | 16.9 | |
| $\frac{5}{16}$ | 19.08 | 5.61 | $\frac{5}{8}$ | 20.1 | |
| $\frac{3}{8}$ | 22.37 | 6.58 | $\frac{3}{4}$ | 22.8 | |
| $\frac{1}{2}$ | 28.43 | 8.36 | 1 | 27.0 | |
| $6 \times 3 \times \frac{1}{4}$ | 13.91 | 4.09 | $\frac{1}{2}$ | 17.9 | 6.00 |
| $\frac{5}{16}$ | 16.96 | 4.98 | $\frac{5}{8}$ | 21.1 | 6.98 |
| $\frac{3}{8}$ | 19.82 | 5.83 | $\frac{3}{4}$ | 23.8 | 7.78 |
| $6 \times 4 \times \frac{1}{4}$ | 15.62 | 4.59 | $\frac{1}{2}$ | 22.1 | 11.7 |
| $\frac{5}{16}$ | 19.08 | 5.61 | $\frac{5}{8}$ | 26.2 | 13.8 |
| $\frac{3}{8}$ | 22.37 | 6.58 | $\frac{3}{4}$ | 29.7 | 15.6 |
| $\frac{1}{2}$ | 28.43 | 8.36 | 1 | 35.3 | 18.4 |
| $6 \times 6 \times \frac{1}{4}$ | 19.02 | 5.59 | $\frac{1}{2}$ | 30.3 | |
| $\frac{5}{16}$ | 23.34 | 6.86 | $\frac{5}{8}$ | 36.3 | |
| $\frac{3}{8}$ | 27.48 | 8.08 | $\frac{3}{4}$ | 41.6 | |
| $\frac{1}{2}$ | 35.24 | 10.4 | 1 | 50.5 | |
| $8 \times 4 \times \frac{5}{16}$ | 23.34 | 6.86 | $\frac{5}{8}$ | 53.9 | 18.1 |
| $\frac{3}{8}$ | 27.48 | 8.08 | $\frac{3}{4}$ | 61.9 | 20.6 |
| $\frac{1}{2}$ | 35.24 | 10.4 | 1 | 75.1 | 24.6 |
| $8 \times 6 \times \frac{5}{16}$ | 27.59 | 8.11 | $\frac{5}{8}$ | 72.4 | 46.4 |
| $\frac{3}{8}$ | 32.58 | 9.58 | $\frac{3}{4}$ | 83.7 | 53.5 |
| $\frac{1}{2}$ | 42.05 | 12.4 | 1 | 103. | 65.7 |
| $8 \times 8 \times \frac{5}{16}$ | 31.84 | 9.36 | $\frac{5}{8}$ | 90.9 | |
| $\frac{3}{8}$ | 37.69 | 11.1 | $\frac{3}{4}$ | 106. | |
| $\frac{1}{2}$ | 48.85 | 14.4 | 1 | 131. | |
| $\frac{5}{8}$ | 59.32 | 17.4 | $1\frac{1}{4}$ | 153. | |

†Size expressed by outside dimensions and wall thickness; other sizes are available (see Ref. [A.2]).
‡Tolerance is three times the wall thickness.

Seamless mechanical steel tubing is available in a great range of sizes, from about 3⁄16 in outside diameter with a wall thickness of no. 24 gauge B and W up to a wall thickness of 1 in and an outside diameter of 12 in or over. Welded tubing is made from strip steel, either hot rolled with a bright finish or cold rolled. Tubing is also available cold drawn and may be obtained with a high-quality inside finish for certain applications.

The wall thickness of tubing is usually specified in gauge sizes or in fractions of an inch when USCS units are used. The tolerances of tubing are generally specified for the outside diameter and the wall thickness. This means that the inside diameter takes all the variation. However, tubing can be ordered using an inside-diameter specification.

**TABLE A.3** Properties of American Standard Channels†




| Designation | Area $A$, in$^2$ | $t_w$, in | $b$, in | $t_f$, in | $D$, in | $\bar{x}$, in | $e$, in | $I_x$, in$^4$ | $I_y$, in$^4$ |
|---|---|---|---|---|---|---|---|---|---|
| C 3 × 4.1 | 1.26 | 0.170 | 1.410 | 0.273 | ... | 0.436 | 0.461 | 1.66 | 0.197 |
| 3 × 5 | 1.47 | 0.258 | 1.498 | 0.273 | ... | 0.438 | 0.392 | 1.85 | 0.247 |
| 3 × 6 | 1.76 | 0.356 | 1.596 | 0.273 | ... | 0.455 | 0.322 | 2.07 | 0.305 |
| C 4 × 5.4 | 1.59 | 0.184 | 1.584 | 0.296 | ... | 0.457 | 0.502 | 3.85 | 0.319 |
| 4 × 7.25 | 2.13 | 0.321 | 1.721 | 0.296 | $\frac{5}{8}$ | 0.459 | 0.386 | 4.59 | 0.433 |
| C 5 × 6.7 | 1.97 | 0.190 | 1.750 | 0.320 | ... | 0.484 | 0.552 | 7.49 | 0.479 |
| 5 × 9 | 2.64 | 0.325 | 1.885 | 0.320 | $\frac{5}{8}$ | 0.478 | 0.427 | 8.90 | 0.632 |

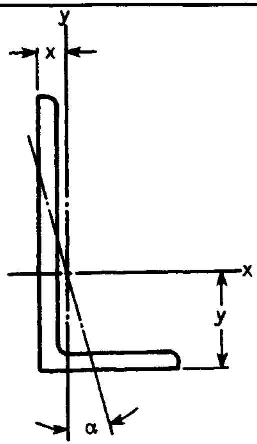
**TABLE A.3** Properties of American Standard Channels† (*Continued*)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| C 6 × 8.2 | 2.40 | 0.200 | 1.920 | 0.343 | 5/8 | 0.511 | 0.599 | 13.1 | 0.693 |
| 6 × 10.5 | 3.09 | 0.314 | 2.034 | 0.343 | 5/8 | 0.499 | 0.486 | 15.2 | 0.866 |
| 6 × 13 | 3.83 | 0.437 | 2.157 | 0.343 | 5/8 | 0.514 | 0.380 | 17.4 | 1.05 |
| C 7 × 9.8 | 2.87 | 0.210 | 2.090 | 0.366 | 5/8 | 0.540 | 0.647 | 21.3 | 0.968 |
| 7 × 12.25 | 3.60 | 0.314 | 2.194 | 0.366 | 5/8 | 0.525 | 0.538 | 24.2 | 1.17 |
| 7 × 14.75 | 4.33 | 0.419 | 2.299 | 0.366 | 5/8 | 0.532 | 0.441 | 27.2 | 1.38 |
| C 8 × 11.5 | 3.38 | 0.220 | 2.260 | 0.390 | 3/4 | 0.571 | 0.697 | 32.6 | 1.32 |
| 8 × 13.75 | 4.04 | 0.303 | 2.343 | 0.390 | 3/4 | 0.553 | 0.604 | 36.1 | 1.53 |
| 8 × 18.75 | 5.51 | 0.487 | 2.527 | 0.390 | 3/4 | 0.565 | 0.431 | 44.0 | 1.98 |
| C 9 × 13.4 | 3.94 | 0.233 | 2.433 | 0.413 | 3/4 | 0.601 | 0.743 | 47.9 | 1.76 |
| 9 × 15 | 4.41 | 0.285 | 2.485 | 0.413 | 3/4 | 0.586 | 0.682 | 51.0 | 1.93 |
| 9 × 20 | 5.88 | 0.448 | 2.648 | 0.413 | 3/4 | 0.583 | 0.515 | 60.9 | 2.42 |
| C 10 × 15.3 | 4.49 | 0.240 | 2.600 | 0.436 | 3/4 | 0.634 | 0.796 | 67.4 | 2.28 |
| 10 × 20 | 5.88 | 0.379 | 2.739 | 0.436 | 3/4 | 0.606 | 0.637 | 78.9 | 2.81 |
| 10 × 25 | 7.35 | 0.526 | 2.886 | 0.436 | 3/4 | 0.617 | 0.494 | 91.2 | 3.36 |
| 10 × 30 | 8.82 | 0.673 | 3.033 | 0.436 | 3/4 | 0.649 | 0.369 | 103 | 3.94 |
| C 12 × 20.7 | 6.09 | 0.282 | 2.942 | 0.501 | 7/8 | 0.698 | 0.870 | 129 | 3.88 |
| 12 × 25 | 7.35 | 0.387 | 3.047 | 0.501 | 7/8 | 0.674 | 0.746 | 144 | 4.47 |
| 12 × 30 | 8.82 | 0.510 | 3.170 | 0.501 | 7/8 | 0.674 | 0.618 | 162 | 5.14 |
| C 15 × 33.9 | 9.96 | 0.400 | 3.400 | 0.650 | 1 | 0.787 | 0.896 | 315 | 8.13 |
| 15 × 40 | 11.8 | 0.520 | 3.520 | 0.650 | 1 | 0.777 | 0.767 | 349 | 9.23 |
| 15 × 50 | 14.7 | 0.716 | 3.716 | 0.650 | 1 | 0.798 | 0.583 | 404 | 11.0 |

†The designation is the channel depth and the unit weight in pounds per foot: $D$ = diameter of maximum flange fastener, and $e$ = location of shear center.

SOURCE: Ref. [A.2]. All the sizes listed here are generally available in aluminum alloys. For these, the unit weight is obtained by multiplying the area by 0.829.

**TABLE A.4** Properties of Angles†




| Size, in | $w$, lb/ft | Area $A$, in$^2$ | $y$, in | $I_x$, in$^4$ | $x$, in | $I_y$, in$^4$ | Tan $\alpha$ |
|---|---|---|---|---|---|---|---|
| L 2 × 2 × $\frac{1}{8}$ | 1.65 | 0.484 | 0.546 | 0.190 | 0.546 | 0.190 | 1.000 |
| × $\frac{3}{16}$ | 2.44 | 0.715 | 0.569 | 0.272 | 0.569 | 0.272 | 1.000 |
| × $\frac{1}{4}$ | 3.19 | 0.938 | 0.592 | 0.348 | 0.592 | 0.348 | 1.000 |
| × $\frac{5}{16}$ | 3.92 | 1.15 | 0.614 | 0.416 | 0.614 | 0.416 | 1.000 |
| × $\frac{3}{8}$ | 4.7 | 1.36 | 0.636 | 0.479 | 0.636 | 0.479 | 1.000 |
| L $2\frac{1}{2}$ × 2 × $\frac{3}{16}$ | 2.75 | 0.809 | 0.764 | 0.509 | 0.514 | 0.291 | 0.631 |
| × $\frac{1}{4}$ | 3.62 | 1.06 | 0.787 | 0.654 | 0.537 | 0.372 | 0.626 |
| × $\frac{5}{16}$ | 4.5 | 1.31 | 0.809 | 0.788 | 0.559 | 0.446 | 0.620 |
| × $\frac{3}{8}$ | 5.3 | 1.55 | 0.831 | 0.912 | 0.581 | 0.514 | 0.614 |
| L $2\frac{1}{2}$ × $2\frac{1}{2}$ × $\frac{3}{16}$ | 3.07 | 0.902 | 0.694 | 0.547 | .... | .... | 1.000 |
| × $\frac{1}{4}$ | 4.10 | 1.19 | 0.717 | 0.703 | .... | .... | 1.000 |
| × $\frac{5}{16}$ | 5.00 | 1.46 | 0.740 | 0.849 | .... | .... | 1.000 |
| × $\frac{3}{8}$ | 5.9 | 1.73 | 0.762 | 0.984 | .... | .... | 1.000 |

**TABLE A.4** Properties of Angles† (*Continued*)

| Size, in | $w$, lb/ft | Area $A$, in$^2$ | $y$, in | $I_x$, in$^4$ | $x$, in | $I_y$, in$^4$ | Tan $\alpha$ |
|---|---|---|---|---|---|---|---|
| L $3 \times 2 \times \frac{3}{16}$ | 3.07 | 0.902 | 0.970 | 0.842 | 0.470 | 0.307 | 0.446 |
| L $3 \times 2 \times \frac{1}{4}$ | 4.1 | 1.19 | 0.993 | 1.09 | 0.493 | 0.392 | 0.440 |
| $\times \frac{5}{16}$ | 5.0 | 1.46 | 1.02 | 1.32 | 0.516 | 0.470 | 0.435 |
| $\times \frac{3}{8}$ | 5.9 | 1.73 | 1.04 | 1.53 | 0.539 | 0.543 | 0.428 |
| L $3 \times 2\frac{1}{2} \times \frac{3}{16}$ | 3.39 | 0.996 | 0.888 | 0.907 | 0.638 | 0.577 | 0.688 |
| $\times \frac{1}{4}$ | 4.5 | 1.31 | 0.911 | 1.17 | 0.661 | 0.743 | 0.684 |
| $\times \frac{3}{8}$ | 6.6 | 1.92 | 0.956 | 1.66 | 0.706 | 1.04 | 0.676 |
| L $3 \times 3 \times \frac{3}{16}$ | 3.71 | 1.09 | 0.820 | 0.962 | .... | .... | 1.000 |
| $\times \frac{1}{4}$ | 4.9 | 1.44 | 0.842 | 1.24 | .... | .... | 1.000 |
| $\times \frac{5}{16}$ | 6.1 | 1.78 | 0.865 | 1.51 | .... | .... | 1.000 |
| $\times \frac{3}{8}$ | 7.2 | 2.11 | 0.888 | 1.76 | .... | .... | 1.000 |
| $\times \frac{1}{2}$ | 9.4 | 2.75 | 0.932 | 2.22 | .... | .... | 1.000 |
| L $3\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{4}$ | 4.9 | 1.44 | 1.11 | 1.80 | 0.614 | 0.777 | 0.506 |
| $\times \frac{5}{16}$ | 6.1 | 1.78 | 1.14 | 2.19 | 0.637 | 0.939 | 0.501 |
| $\times \frac{3}{8}$ | 7.2 | 2.11 | 1.16 | 2.56 | 0.660 | 1.09 | 0.496 |
| L $3\frac{1}{2} \times 3 \times \frac{1}{4}$ | 5.4 | 1.56 | 1.04 | 1.91 | 0.785 | 1.30 | 0.727 |
| $\times \frac{5}{16}$ | 6.6 | 1.93 | 1.06 | 2.33 | 0.808 | 1.58 | 0.724 |
| L $3\frac{1}{2} \times 3 \times \frac{3}{8}$ | 7.9 | 2.30 | 1.08 | 2.72 | 0.830 | 1.85 | 0.721 |
| L $3\frac{1}{2} \times 3\frac{1}{2} \times \frac{1}{4}$ | 5.8 | 1.69 | 0.968 | 2.01 | .... | .... | 1.000 |
| $\times \frac{5}{16}$ | 7.2 | 2.09 | 0.990 | 2.45 | .... | .... | 1.000 |
| $\times \frac{3}{8}$ | 8.5 | 2.48 | 1.01 | 2.87 | .... | .... | 1.000 |
| L $4 \times 3 \times \frac{1}{4}$ | 5.8 | 1.69 | 1.24 | 2.77 | 0.736 | 1.36 | 0.558 |
| $\times \frac{5}{16}$ | 7.2 | 2.09 | 1.26 | 3.38 | 0.759 | 1.65 | 0.554 |
| $\times \frac{3}{8}$ | 8.5 | 2.48 | 1.28 | 3.96 | 0.782 | 1.92 | 0.551 |
| $\times \frac{1}{2}$ | 11.1 | 3.25 | 1.33 | 5.05 | 0.827 | 2.42 | 0.543 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| L 4 × 3$\frac{1}{2}$ × $\frac{1}{4}$ | 6.2 | 1.81 | 1.16 | 2.91 | 0.909 | 2.09 | 0.759 |
| × $\frac{5}{16}$ | 7.7 | 2.25 | 1.18 | 3.56 | 0.932 | 2.55 | 0.757 |
| × $\frac{3}{8}$ | 9.1 | 2.67 | 1.21 | 4.18 | 0.955 | 2.95 | 0.755 |
| × $\frac{1}{2}$ | 11.9 | 3.50 | 1.25 | 5.32 | 1.00 | 3.79 | 0.750 |
| L 4 × 4 × $\frac{1}{4}$ | 6.6 | 1.94 | 1.09 | 3.04 | .... | .... | 1.000 |
| × $\frac{5}{16}$ | 8.2 | 2.40 | 1.12 | 3.71 | .... | .... | 1.000 |
| × $\frac{3}{8}$ | 9.8 | 2.86 | 1.14 | 4.36 | .... | .... | 1.000 |
| × $\frac{1}{2}$ | 12.8 | 3.75 | 1.18 | 5.56 | .... | .... | 1.000 |
| L 4 × 4 × $\frac{5}{8}$ | 15.7 | 4.61 | 1.23 | 6.66 | .... | .... | 1.000 |
| × $\frac{3}{4}$ | 18.6 | 5.44 | 1.27 | 7.67 | .... | .... | 1.000 |
| L 5 × 3 × $\frac{1}{4}$ | 6.6 | 1.94 | 1.66 | 5.11 | 0.657 | 1.44 | 0.371 |
| × $\frac{5}{16}$ | 8.2 | 2.40 | 1.68 | 6.26 | 0.681 | 1.75 | 0.368 |
| × $\frac{3}{8}$ | 9.8 | 2.86 | 1.70 | 7.37 | 0.704 | 2.04 | 0.364 |
| × $\frac{1}{2}$ | 12.8 | 3.75 | 1.75 | 9.45 | 0.750 | 2.58 | 0.357 |
| L 5 × 3$\frac{1}{2}$ × $\frac{5}{16}$ | 8.7 | 2.56 | 1.59 | 6.60 | 0.838 | 2.72 | 0.489 |
| × $\frac{3}{8}$ | 10.4 | 3.05 | 1.61 | 7.78 | 0.861 | 3.18 | 0.486 |
| × $\frac{1}{2}$ | 13.6 | 4.00 | 1.66 | 9.99 | 0.906 | 4.05 | 0.479 |
| × $\frac{3}{4}$ | 19.8 | 5.81 | 1.75 | 13.9 | 0.996 | 5.55 | 0.464 |
| L 5 × 5 × $\frac{5}{16}$ | 10.3 | 3.03 | 1.37 | 7.42 | .... | .... | 1.000 |
| × $\frac{3}{8}$ | 12.3 | 3.61 | 1.39 | 8.74 | .... | .... | 1.000 |
| × $\frac{1}{2}$ | 16.2 | 4.75 | 1.43 | 11.3 | .... | .... | 1.000 |
| × $\frac{3}{4}$ | 23.6 | 6.94 | 1.52 | 15.7 | .... | .... | 1.000 |
| × $\frac{7}{8}$ | 27.2 | 7.98 | 1.57 | 17.8 | .... | .... | 1.000 |
| L 6 × 3$\frac{1}{2}$ × $\frac{5}{16}$ | 9.8 | 2.87 | 2.01 | 10.9 | 0.763 | 2.85 | 0.352 |
| × $\frac{3}{8}$ | 11.7 | 3.42 | 2.04 | 12.9 | 0.787 | 3.34 | 0.350 |
| L 6 × 4 × $\frac{3}{8}$ | 12.3 | 3.61 | 1.94 | 13.5 | 0.941 | 4.90 | 0.446 |
| × $\frac{1}{2}$ | 16.2 | 4.75 | 1.99 | 17.4 | 0.987 | 6.27 | 0.440 |
| × $\frac{5}{8}$ | 20.0 | 5.86 | 2.03 | 21.1 | 1.03 | 7.52 | 0.435 |
| × $\frac{3}{4}$ | 23.6 | 6.94 | 2.08 | 24.5 | 1.08 | 8.68 | 0.428 |

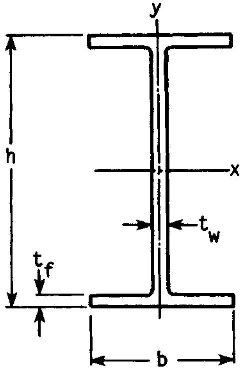
**TABLE A.4** Properties of Angles† (*Continued*)

| Size, in | $w$, lb/ft | Area $A$, in$^2$ | $y$, in | $I_x$, in$^4$ | $x$, in | $I_y$, in$^4$ | Tan $\alpha$ |
|---|---|---|---|---|---|---|---|
| L $6 \times 6 \times \frac{3}{8}$ | 14.9 | 4.36 | 1.64 | 15.4 | .... | .... | 1.000 |
| $\times \frac{1}{2}$ | 19.6 | 5.75 | 1.68 | 19.9 | .... | .... | 1.000 |
| $\times \frac{5}{8}$ | 24.2 | 7.11 | 1.73 | 24.2 | .... | .... | 1.000 |
| $\times \frac{3}{4}$ | 28.7 | 8.44 | 1.78 | 28.2 | .... | .... | 1.000 |
| $\times \frac{7}{8}$ | 33.1 | 9.73 | 1.82 | 31.9 | .... | .... | 1.000 |
| $\times 1$ | 37.4 | 11.0 | 1.86 | 35.5 | .... | .... | 1.000 |
| L $7 \times 4 \times \frac{3}{8}$ | 13.6 | 3.98 | 2.37 | 20.6 | 0.870 | 5.10 | 0.340 |
| $\times \frac{1}{2}$ | 17.9 | 5.25 | 2.42 | 26.7 | 0.917 | 6.53 | 0.335 |
| $\times \frac{3}{4}$ | 26.2 | 7.69 | 2.51 | 37.8 | 1.01 | 9.05 | 0.324 |
| L $8 \times 4 \times \frac{1}{2}$ | 19.6 | 5.75 | 2.86 | 38.5 | 0.859 | 6.74 | 0.267 |
| $\times \frac{3}{4}$ | 28.7 | 8.44 | 2.95 | 54.9 | 0.953 | 9.36 | 0.258 |
| $\times 1$ | 37.4 | 11.0 | 3.05 | 69.6 | 1.05 | 11.6 | 0.247 |
| L $8 \times 6 \times \frac{1}{2}$ | 23.0 | 6.75 | 2.47 | 44.3 | 1.47 | 21.7 | 0.558 |
| $\times \frac{3}{4}$ | 33.8 | 9.94 | 2.56 | 63.4 | 1.56 | 30.7 | 0.551 |
| $\times 1$ | 44.2 | 13.0 | 2.65 | 80.8 | 1.65 | 38.8 | 0.543 |
| L $8 \times 8 \times \frac{1}{2}$ | 26.4 | 7.75 | 2.19 | 48.6 | .... | .... | 1.000 |
| $\times \frac{5}{8}$ | 32.7 | 9.61 | 2.23 | 59.4 | .... | .... | 1.000 |
| $\times \frac{3}{4}$ | 38.9 | 11.4 | 2.28 | 69.7 | .... | .... | 1.000 |
| $\times \frac{7}{8}$ | 45.0 | 13.2 | 2.32 | 79.6 | .... | .... | 1.000 |
| $\times 1$ | 51.0 | 15.0 | 2.37 | 89.0 | .... | .... | 1.000 |
| $\times 1\frac{1}{8}$ | 56.9 | 16.7 | 2.41 | 98.0 | .... | .... | 1.000 |

†Size is the length of each leg and the thickness; unit weight for steel is $w$.

SOURCE: Ref. [A.2]. Angles up to 6 in inclusive are also available in aluminum alloys. For these, the unit weight is obtained by multiplying the area by 0.829. Sizes in structural steel larger than those listed are available on special order.

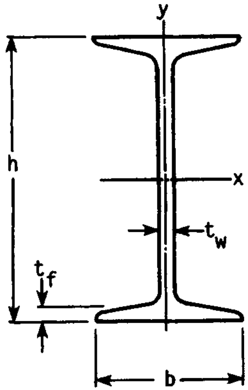
**TABLE A.5** Properties of W Shapes†




| Designation | Area $A$, in$^2$ | $h$, in | $t_w$, in | $b$, in | $t_f$, in | $I_x$, in$^4$ | $I_y$, in$^4$ |
|---|---|---|---|---|---|---|---|
| W 4 × 13 | 3.83 | 4.16 | 0.280 | 4.060 | 0.345 | 11.3 | 3.86 |
| W 5 × 16 | 4.68 | 5.01 | 0.240 | 5.000 | 0.360 | 21.3 | 7.51 |
| 5 × 19 | 5.54 | 5.15 | 0.270 | 5.030 | 0.430 | 26.2 | 9.13 |
| W 6 × 9 | 2.68 | 5.90 | 0.170 | 3.940 | 0.215 | 16.4 | 2.19 |
| 6 × 12 | 3.55 | 6.03 | 0.230 | 4.000 | 0.280 | 22.1 | 2.99 |
| 6 × 16 | 4.74 | 6.28 | 0.260 | 4.030 | 0.405 | 32.1 | 4.43 |
| 6 × 15 | 4.43 | 5.99 | 0.230 | 5.990 | 0.260 | 29.1 | 9.32 |
| 6 × 20 | 5.87 | 6.20 | 0.260 | 6.020 | 0.365 | 41.4 | 13.3 |
| 6 × 25 | 7.34 | 6.38 | 0.320 | 6.080 | 0.455 | 53.4 | 17.1 |
| W 8 × 10 | 2.96 | 7.89 | 0.170 | 3.940 | 0.205 | 30.8 | 2.09 |
| 8 × 13 | 3.84 | 7.99 | 0.230 | 4.000 | 0.255 | 39.6 | 2.73 |
| 8 × 15 | 4.44 | 8.11 | 0.245 | 4.015 | 0.315 | 48.0 | 3.41 |
| 8 × 18 | 5.26 | 8.14 | 0.230 | 5.25 | 0.330 | 61.9 | 7.97 |
| 8 × 21 | 6.16 | 8.28 | 0.250 | 5.27 | 0.400 | 75.3 | 9.77 |
| 8 × 24 | 7.08 | 7.93 | 0.245 | 6.495 | 0.400 | 82.8 | 18.3 |
| 8 × 28 | 8.25 | 8.06 | 0.285 | 6.535 | 0.465 | 98.0 | 21.7 |
| 8 × 31 | 9.13 | 8.00 | 0.285 | 7.995 | 0.435 | 110 | 37.1 |
| 8 × 35 | 10.3 | 8.12 | 0.310 | 8.020 | 0.495 | 127 | 42.6 |
| 8 × 40 | 11.7 | 8.25 | 0.360 | 8.070 | 0.560 | 146 | 49.1 |
| 8 × 48 | 14.1 | 8.50 | 0.400 | 8.110 | 0.685 | 184 | 60.9 |
| 8 × 58 | 17.1 | 8.75 | 0.510 | 8.220 | 0.810 | 228 | 75.1 |
| 8 × 67 | 19.7 | 9.00 | 0.570 | 8.280 | 0.935 | 272 | 88.6 |
| W 10 × 12 | 3.54 | 9.87 | 0.190 | 3.960 | 0.210 | 53.8 | 2.18 |
| 10 × 15 | 4.41 | 9.99 | 0.230 | 4.000 | 0.270 | 68.9 | 2.89 |
| 10 × 17 | 4.99 | 10.11 | 0.240 | 4.010 | 0.330 | 81.9 | 3.56 |
| 10 × 19 | 5.62 | 10.24 | 0.250 | 4.020 | 0.395 | 96.3 | 4.29 |
| W 10 × 22 | 6.49 | 10.17 | 0.240 | 5.75 | 0.360 | 118 | 11.4 |
| 10 × 26 | 7.61 | 10.33 | 0.260 | 5.770 | 0.440 | 144 | 14.1 |
| 10 × 30 | 8.84 | 10.47 | 0.300 | 5.810 | 0.510 | 170 | 16.7 |
| W 10 × 33 | 9.71 | 9.73 | 0.290 | 7.960 | 0.435 | 170 | 36.6 |
| 10 × 39 | 11.5 | 9.92 | 0.315 | 7.985 | 0.530 | 209 | 45.0 |
| 10 × 45 | 13.3 | 10.10 | 0.350 | 8.020 | 0.620 | 248 | 53.4 |

†The designation is the nominal depth, and the unit weight for steel is in pounds per foot. Larger sizes are available from W 10 × 49 to W 36 × 300. See Ref. [A.2]. Some of the sizes 8 in and under are available in aluminum alloys which are then called H sections.

**TABLE A.6** Properties of S Shapes†




| Designation | | Area $A$, in² | $h$, in | $t_w$, in | $b$, in | $t_f$, in | $D$, in | $I_x$, in⁴ | $I_y$, in⁴ |
|---|---|---|---|---|---|---|---|---|---|
| S | 3 × 5.7 | 1.67 | 3.00 | 0.170 | 2.330 | 0.260 | ... | 2.52 | 0.455 |
| | 3 × 7.5 | 2.21 | 3.00 | 0.349 | 2.509 | 0.260 | ... | 2.93 | 0.586 |
| S | 4 × 7.7 | 2.26 | 4.00 | 0.193 | 2.663 | 0.293 | ... | 6.08 | 0.764 |
| | 4 × 9.5 | 2.79 | 4.00 | 0.326 | 2.796 | 0.293 | ... | 6.79 | 0.903 |
| S | 5 × 10 | 2.94 | 5.00 | 0.214 | 3.004 | 0.326 | ... | 12.3 | 1.22 |
| | 5 × 14.75 | 4.34 | 5.00 | 0.494 | 3.284 | 0.326 | ... | 15.2 | 1.67 |
| S | 6 × 12.5 | 3.67 | 6.00 | 0.232 | 3.332 | 0.359 | ... | 22.1 | 1.82 |
| | 6 × 17.25 | 5.07 | 6.00 | 0.465 | 3.565 | 0.359 | $\frac{5}{8}$ | 26.3 | 2.31 |
| S | 7 × 15.3 | 4.50 | 7.00 | 0.252 | 3.662 | 0.392 | $\frac{5}{8}$ | 36.7 | 2.64 |
| | 7 × 20 | 5.88 | 7.00 | 0.450 | 3.860 | 0.392 | $\frac{5}{8}$ | 42.4 | 3.17 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| S 8 × 18.4 | 5.41 | 8.00 | 0.271 | 4.001 | 0.426 | $\frac{3}{4}$ | 57.6 | 3.73 |
| 8 × 23 | 6.77 | 8.00 | 0.441 | 4.171 | 0.426 | $\frac{3}{4}$ | 64.9 | 4.31 |
| S 10 × 25.4 | 7.46 | 10.00 | 0.311 | 4.661 | 0.491 | $\frac{3}{4}$ | 124 | 6.79 |
| 10 × 35 | 10.3 | 10.00 | 0.594 | 4.944 | 0.491 | $\frac{3}{4}$ | 147 | 8.36 |
| S 12 × 31.8 | 9.35 | 12.00 | 0.350 | 5.000 | 0.544 | $\frac{3}{4}$ | 218 | 9.36 |
| 12 × 35 | 10.3 | 12.00 | 0.428 | 5.078 | 0.544 | $\frac{3}{4}$ | 229 | 9.87 |
| S 12 × 40.8 | 12.0 | 12.00 | 0.462 | 5.252 | 0.659 | $\frac{3}{4}$ | 272 | 13.6 |
| 12 × 50 | 14.7 | 12.00 | 0.687 | 5.477 | 0.659 | $\frac{3}{4}$ | 305 | 15.7 |
| S 15 × 42.9 | 12.6 | 15.00 | 0.411 | 5.501 | 0.622 | $\frac{3}{4}$ | 447 | 14.4 |
| 15 × 50 | 14.7 | 15.00 | 0.550 | 5.640 | 0.622 | $\frac{3}{4}$ | 486 | 15.7 |
| S 18 × 54.7 | 16.1 | 18.00 | 0.461 | 6.001 | 0.691 | $\frac{7}{8}$ | 804 | 20.8 |
| 18 × 70 | 20.6 | 18.00 | 0.711 | 6.251 | 0.691 | $\frac{7}{8}$ | 926 | 24.1 |
| S 20 × 66 | 19.4 | 20.00 | 0.505 | 6.255 | 0.795 | $\frac{7}{8}$ | 1190 | 27.7 |
| 20 × 75 | 22.0 | 20.00 | 0.635 | 6.385 | 0.795 | $\frac{7}{8}$ | 1280 | 29.8 |
| S 20 × 86 | 25.3 | 20.30 | 0.660 | 7.060 | 0.920 | 1 | 1580 | 46.8 |
| 20 × 96 | 28.2 | 20.30 | 0.800 | 7.200 | 0.920 | 1 | 1670 | 50.2 |
| S 24 × 80 | 23.5 | 24.00 | 0.500 | 7.000 | 0.870 | 1 | 2100 | 42.2 |
| 24 × 90 | 26.5 | 24.00 | 0.625 | 7.125 | 0.870 | 1 | 2250 | 44.9 |
| 24 × 100 | 29.3 | 24.00 | 0.745 | 7.245 | 0.870 | 1 | 2390 | 47.4 |

†The designation is the nominal depth and the unit weight for steel is in pounds per foot; $D$ = diameter of maximum flange fastener.

SOURCE: Ref. [A.2]. Many of the sizes in this table up to and including 12 in are also available in aluminum alloys. Multiply the area by 0.829 to get the weight of these shapes.

## REFERENCES

A.1 *Steel Products Manual,* American Iron and Steel Institute, Washington, D.C.

A.2 *Manual of Steel Construction,* American Institute of Steel Construction, Inc., Chicago, Illinois.