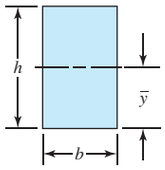
APPENDIX B

Properties of Sections and Solids

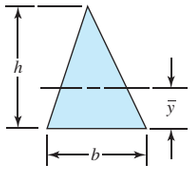
Appendix B-1a *Properties of Sections*

A = area, in.^{2}
I = moment of inertia, in.^{4}
J = polar moment of inertia, in.^{4}
Z = section modulus, in.^{3}
ρ = radius of gyration, in.
$\bar{y}$ = centroidal distance, in.



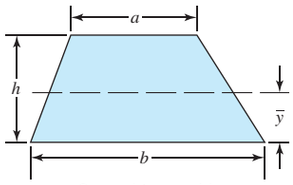
Rectangle

$$A = bh \qquad \rho = 0.289h$$
$$I = \frac{bh^3}{12} \qquad \bar{y} = \frac{h}{2}$$
$$Z = \frac{bh^2}{6}$$



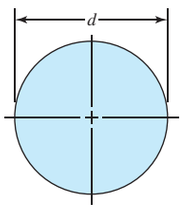
General triangle

$$A = \frac{bh}{2} \qquad \rho = 0.236h$$
$$I = \frac{bh^3}{36} \qquad \bar{y} = \frac{h}{3}$$
$$Z = \frac{bh^2}{24}$$



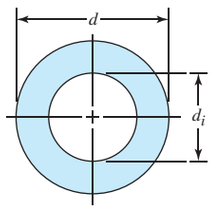
General trapezoid

$$A = \frac{h}{2}(a + b) \qquad \rho = \frac{h}{6}\sqrt{2 + \frac{4ab}{(a + b)^2}}$$
$$I = \frac{h^3(a^2 + 4ab + b^2)}{36(a + b)} \qquad \bar{y} = \frac{h}{3}\frac{(2a + b)}{(a + b)}$$
$$Z = \frac{h^2}{12}\frac{(a^2 + 4ab + b^2)}{(a + 2b)}$$



Circle

$$A = \frac{\pi d^2}{4} \qquad J = \frac{\pi d^4}{32}$$
$$I = \frac{\pi d^4}{64} \qquad \rho = \frac{d}{4}$$
$$Z = \frac{\pi d^3}{32}$$

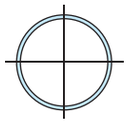


Hollow circle

$$A = \frac{\pi}{4}(d^2 - d_i^2) \qquad J = \frac{\pi}{32}(d^4 - d_i^4)$$
$$I = \frac{\pi}{64}(d^4 - d_i^4) \qquad \rho = \sqrt{\frac{d^2 + d_i^2}{16}}$$
$$Z = \frac{\pi}{32d}(d^4 - d_i^4)$$

Appendix B-1b *Dimensions and Properties of Steel Pipe and Tubing Sections*

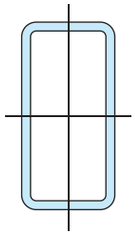
A = area, in.^{2} Z = section modulus, in.^{3}
I = moment of inertia, in.^{4} ρ = radius of gyration, in.



Standard Weight Pipe
Dimensions and Properties

Dimensions				Properties				
Nominal Diameter (in.)	**Outside Diameter (in.)**	**Inside Diameter (in.)**	**Wall Thickness (in.)**	**Weight per Foot (lb) Plain Ends**	***A*** **(in.^{2})**	***I*** **(in.^{4})**	***Z*** **(in.^{3})**	***ρ*** **(in.)**
$\frac{1}{2}$	.840	.622	.109	.85	.250	.017	.041	.261
$\frac{3}{4}$	1.050	.824	.113	1.13	.333	.037	.071	.334
1	1.315	1.049	.133	1.68	.494	.087	.133	.421
$1\frac{1}{4}$	1.660	1.380	.140	2.27	.669	.195	.235	.540
$1\frac{1}{2}$	1.900	1.610	.145	2.72	.799	.310	.326	.623
2	2.375	2.067	.154	3.65	1.07	.666	.561	.787
$2\frac{1}{2}$	2.875	2.469	.203	5.79	1.70	1.53	1.06	.947
3	3.500	3.068	.216	7.58	2.23	3.02	1.72	1.16
4	4.500	4.026	.237	10.79	3.17	7.23	3.21	1.51
5	5.563	5.047	.258	14.62	4.30	15.2	5.45	1.88

Appendix B-1b *(continued)*



Square and Rectangular Structural Tubing Dimensions and Properties

Dimensions			Properties[b]						
Nominal[a] Size (in.)	**Wall Thickness (in.)**	**Weight per Foot (lb)**	***A*** **(in.^{2})**	I_x **(in.^{4})**	Z_x **(in.^{3})**	ρ_x **(in.)**	I_y **(in.^{4})**	Z_y **(in.^{3})**	ρ_y **(in.)**
2 × 2	$\frac{3}{16}$	4.32	1.27	0.668	0.668	0.726			
	$\frac{1}{4}$	5.41	1.59	0.766	0.766	0.694			
2.5 × 2.5	$\frac{3}{16}$	5.59	1.64	1.42	1.14	0.930			
	$\frac{1}{4}$	7.11	2.09	1.69	1.35	0.899			
3 × 2	$\frac{3}{16}$	5.59	1.64	1.86	1.24	1.06	0.977	0.977	0.771
	$\frac{1}{4}$	7.11	2.09	2.21	1.47	1.03	1.15	1.15	0.742
3 × 3	$\frac{3}{16}$	6.87	2.02	2.60	1.73	1.13			
	$\frac{1}{4}$	8.81	2.59	3.16	2.10	1.10			
4 × 2	$\frac{3}{16}$	6.87	2.02	3.87	1.93	1.38	1.29	1.29	0.798
	$\frac{1}{4}$	8.81	2.59	4.69	2.35	1.35	1.54	1.54	0.770
4 × 4	$\frac{3}{16}$	9.42	2.77	6.59	3.30	1.54			
	$\frac{1}{4}$	12.21	3.59	8.22	4.11	1.51			
	$\frac{3}{8}$	17.27	5.08	10.7	5.35	1.45			
	$\frac{1}{2}$	21.63	6.36	12.3	6.13	1.39			
5 × 3	$\frac{3}{16}$	9.42	2.77	9.1	3.62	1.81	4.08	2.72	1.21
	$\frac{1}{4}$	12.21	3.59	11.3	4.52	1.77	5.05	3.37	1.19
	$\frac{3}{8}$	17.27	5.08	14.7	5.89	1.70	6.48	4.32	1.13
	$\frac{1}{2}$	21.63	6.36	16.9	6.75	1.63	7.33	4.88	1.07
5 × 5	$\frac{3}{16}$	11.97	3.52	13.4	5.36	1.95			
	$\frac{1}{4}$	15.62	4.59	16.9	6.78	1.92			
	$\frac{3}{8}$	22.37	6.58	22.8	9.11	1.86			
	$\frac{1}{2}$	28.43	8.36	27.0	10.8	1.80			

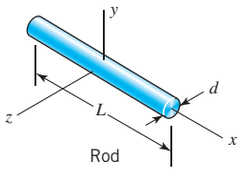
[a] Outside dimensions across flat sides.

[b] Properties are based upon a nominal outside corner radius equal to two times the wall thickness.

Source: Manual of Steel Construction, American Institute of Steel Construction, Chicago, Illinois, 1980.

Appendix B-2 *Mass and Mass Moments of Inertia of Homogeneous Solids*

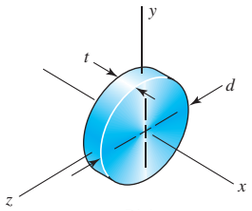
ρ = mass density



Rod

$$m = \frac{\pi d^2 L \rho}{4}$$

$$I_y = I_z = \frac{mL^2}{12}$$

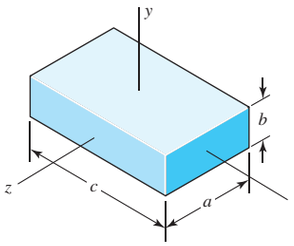


Disk

$$m = \frac{\pi d^2 t \rho}{4}$$

$$I_x = \frac{md^2}{8}$$

$$I_y = I_z = \frac{md^2}{16}$$



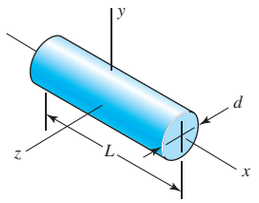
Rectangular prism

$$m = abc\rho$$

$$I_x = \frac{m}{12}(a^2 + b^2)$$

$$I_y = \frac{m}{12}(a^2 + c^2)$$

$$I_z = \frac{m}{12}(b^2 + c^2)$$

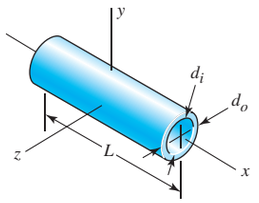


Cylinder

$$m = \frac{\pi d^2 L \rho}{4}$$

$$I_x = \frac{md^2}{8}$$

$$I_y = I_z = \frac{m}{48}(3d^2 + 4L^2)$$



$$m = \frac{\pi L \rho}{4}(d_o^2 - d_i^2)$$

$$I_x = \frac{m}{8}(d_o^2 + d_i^2)$$

$$I_y = I_z = \frac{m}{48}(3d_o^2 + 3d_i^2 + 4L^2)$$