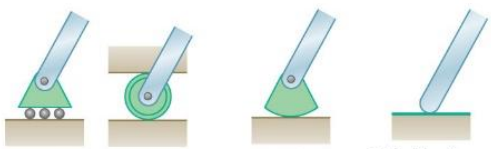
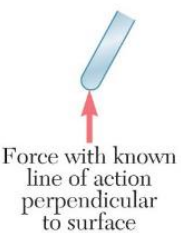
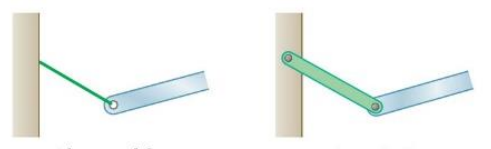
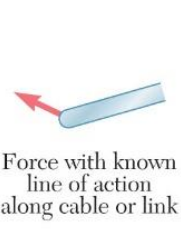
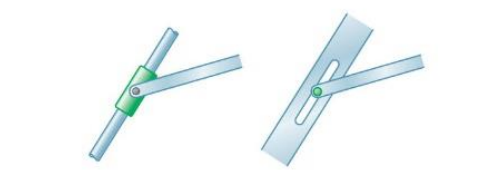
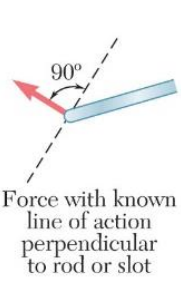

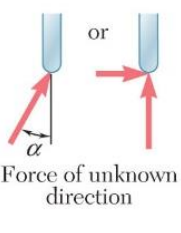

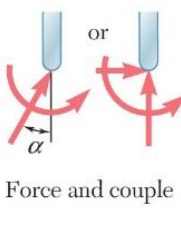


Support or Connection	Reaction	Number of Unknowns
 <p>Rollers Rocker Frictionless surface</p>	 <p>Force with known line of action perpendicular to surface</p>	1
 <p>Short cable Short link</p>	 <p>Force with known line of action along cable or link</p>	1
 <p>Collar on frictionless rod Frictionless pin in slot</p>	 <p>Force with known line of action perpendicular to rod or slot</p>	1
 <p>Frictionless pin or hinge Rough surface</p>	 <p>Force of unknown direction</p>	2
 <p>Fixed support</p>	 <p>Force and couple</p>	3



This rocker bearing supports the weight of a bridge. The convex surface of the rocker allows the bridge to move slightly horizontally.



Links are often used to support suspended spans of highway bridges.



Force applied to the slider exerts a normal force on the rod, causing the window to open.

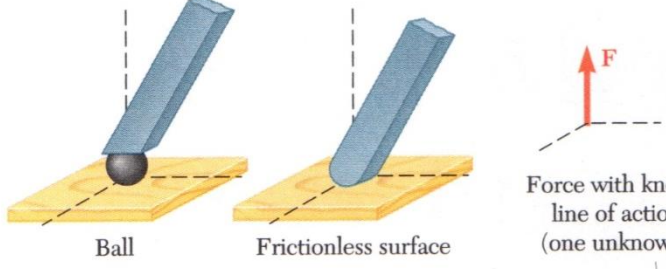
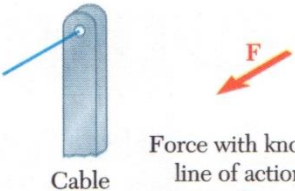
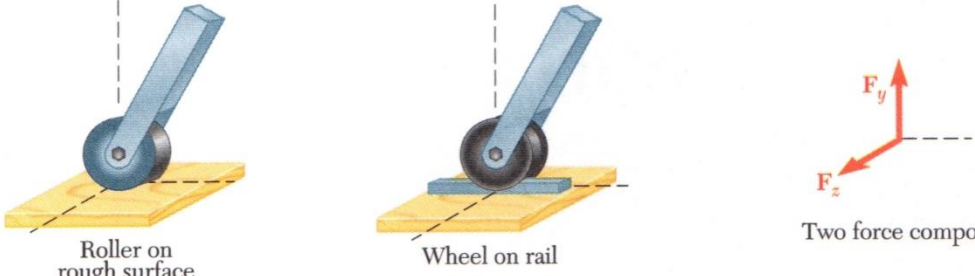
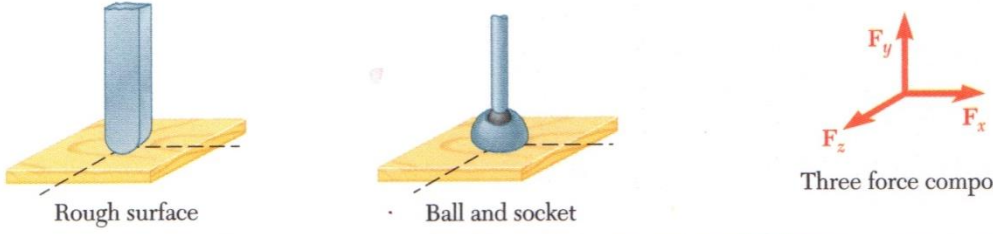
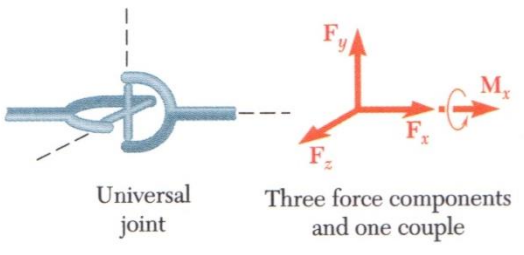
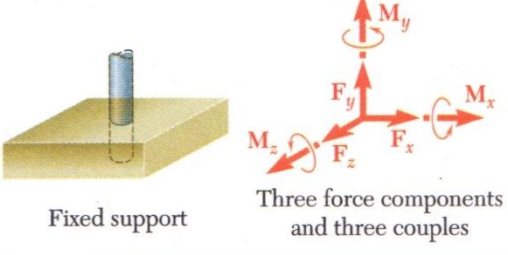

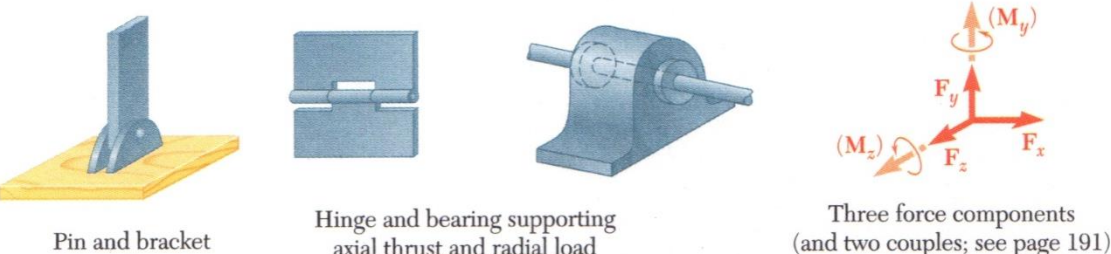


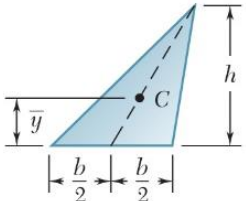
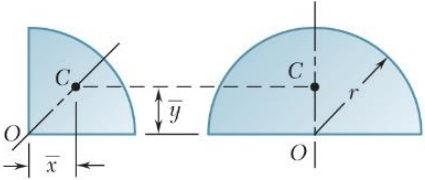
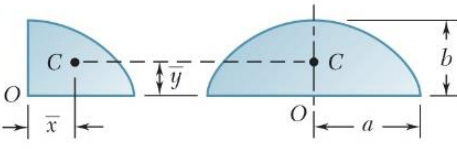
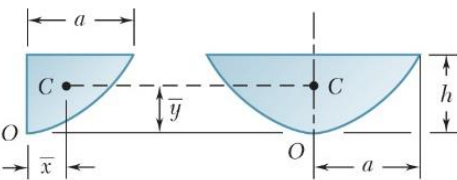
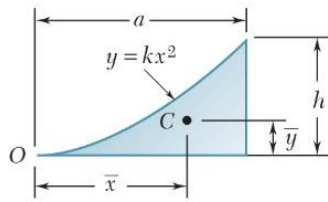
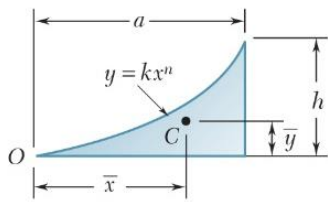
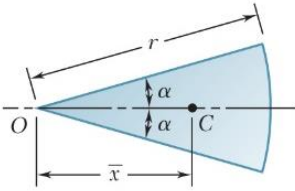
Pin supports are common on bridges and overpasses.



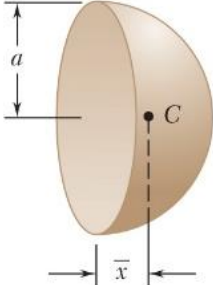
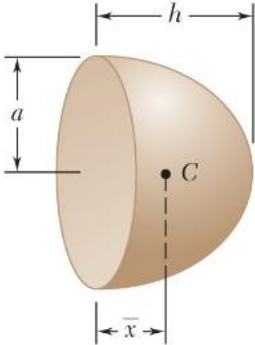
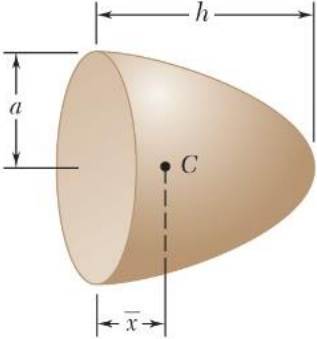
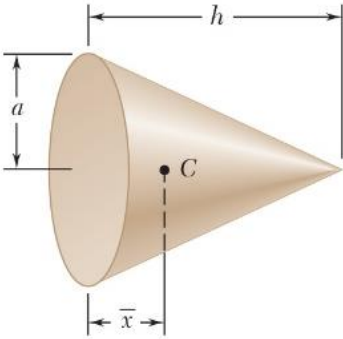
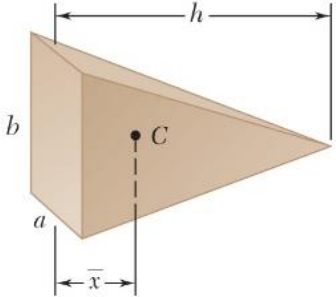
This cantilever support is fixed at one end and extends out into space at the other end.

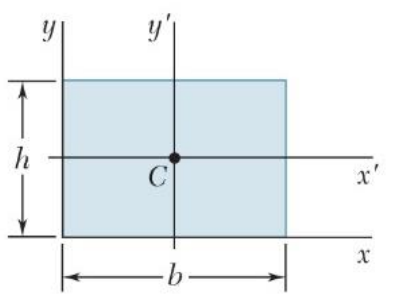
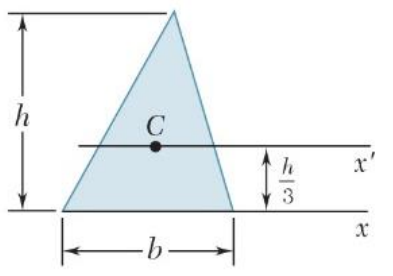
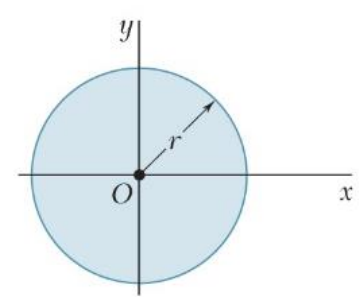
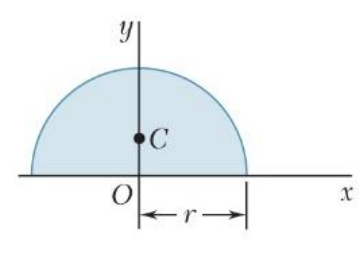
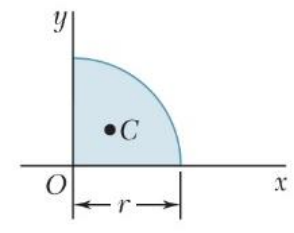
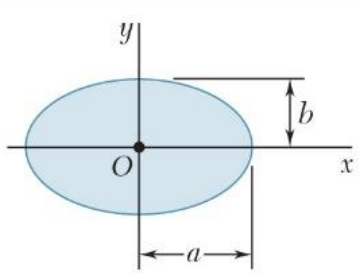
Reactions at Supports and Connections for a Three-Dimensional Structure

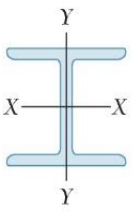
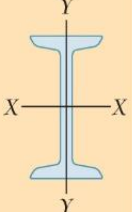
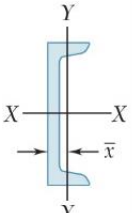
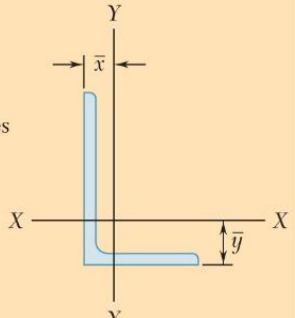
 <p>Ball Frictionless surface</p> <p>Force with known line of action (one unknown)</p>	 <p>Cable</p> <p>Force with known line of action (one unknown)</p>
 <p>Roller on rough surface Wheel on rail</p> <p>Two force components</p>	
 <p>Rough surface Ball and socket</p> <p>Three force components</p>	
 <p>Universal joint</p> <p>Three force components and one couple</p>	 <p>Fixed support</p> <p>Three force components and three couples</p>
 <p>Hinge and bearing supporting radial load only</p> <p>Two force components (and two couples; see page 191)</p>	
 <p>Pin and bracket Hinge and bearing supporting axial thrust and radial load</p> <p>Three force components (and two couples; see page 191)</p>	

Shape		\bar{x}	\bar{y}	Area
Triangular area			$\frac{h}{3}$	$\frac{bh}{2}$
Quarter-circular area		$\frac{4r}{3\pi}$	$\frac{4r}{3\pi}$	$\frac{\pi r^2}{4}$
Semicircular area		0	$\frac{4r}{3\pi}$	$\frac{\pi r^2}{2}$
Quarter-elliptical area		$\frac{4a}{3\pi}$	$\frac{4b}{3\pi}$	$\frac{\pi ab}{4}$
Semielliptical area		0	$\frac{4b}{3\pi}$	$\frac{\pi ab}{2}$
Semiparabolic area		$\frac{3a}{8}$	$\frac{3h}{5}$	$\frac{2ah}{3}$
Parabolic area		0	$\frac{3h}{5}$	$\frac{4ah}{3}$
Parabolic spandrel		$\frac{3a}{4}$	$\frac{3h}{10}$	$\frac{ah}{3}$
General spandrel		$\frac{n+1}{n+2}a$	$\frac{n+1}{4n+2}h$	$\frac{ah}{n+1}$
Circular sector		$\frac{2r \sin \alpha}{3\alpha}$	0	αr^2

Shape		\bar{x}	\bar{y}	Length
Quarter-circular arc		$\frac{2r}{\pi}$	$\frac{2r}{\pi}$	$\frac{\pi r}{2}$
Semicircular arc		0	$\frac{2r}{\pi}$	πr
Arc of circle		$\frac{r \sin \alpha}{\alpha}$	0	$2\alpha r$

Shape		\bar{x}	Volume
Hemisphere		$\frac{3a}{8}$	$\frac{2}{3}\pi a^3$
Semiellipsoid of revolution		$\frac{3h}{8}$	$\frac{2}{3}\pi a^2 h$
Paraboloid of revolution		$\frac{h}{3}$	$\frac{1}{2}\pi a^2 h$
Cone		$\frac{h}{4}$	$\frac{1}{3}\pi a^2 h$
Pyramid		$\frac{h}{4}$	$\frac{1}{3}abh$

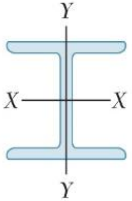
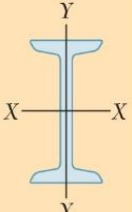
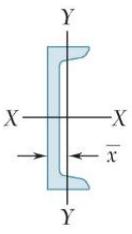
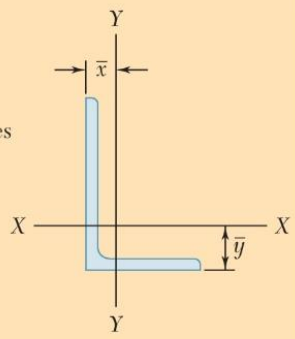
Rectangle		$\bar{I}_{x'} = \frac{1}{12}bh^3$ $\bar{I}_{y'} = \frac{1}{12}b^3h$ $I_x = \frac{1}{3}bh^3$ $I_y = \frac{1}{3}b^3h$ $J_C = \frac{1}{12}bh(b^2 + h^2)$
Triangle		$\bar{I}_{x'} = \frac{1}{36}bh^3$ $I_x = \frac{1}{12}bh^3$
Circle		$\bar{I}_x = \bar{I}_y = \frac{1}{4}\pi r^4$ $J_O = \frac{1}{2}\pi r^4$
Semicircle		$I_x = I_y = \frac{1}{8}\pi r^4$ $J_O = \frac{1}{4}\pi r^4$
Quarter circle		$I_x = I_y = \frac{1}{16}\pi r^4$ $J_O = \frac{1}{8}\pi r^4$
Ellipse		$\bar{I}_x = \frac{1}{4}\pi ab^3$ $\bar{I}_y = \frac{1}{4}\pi a^3b$ $J_O = \frac{1}{4}\pi ab(a^2 + b^2)$

	Designation	Area in ²	Depth in.	Width in.	Axis X-X			Axis Y-Y		
					\bar{I}_x , in ⁴	\bar{k}_x , in.	\bar{y} , in.	\bar{I}_y , in ⁴	\bar{k}_y , in.	\bar{x} , in.
W Shapes (Wide-Flange Shapes) 	W18 × 76†	22.3	18.2	11.0	1330	7.73		152	2.61	
	W16 × 57	16.8	16.4	7.12	758	6.72		43.1	1.60	
	W14 × 38	11.2	14.1	6.77	385	5.87		26.7	1.55	
	W8 × 31	9.12	8.00	8.00	110	3.47		37.1	2.02	
S Shapes (American Standard Shapes) 	S18 × 54.7†	16.0	18.0	6.00	801	7.07		20.7	1.14	
	S12 × 31.8	9.31	12.0	5.00	217	4.83		9.33	1.00	
	S10 × 25.4	7.45	10.0	4.66	123	4.07		6.73	0.950	
	S6 × 12.5	3.66	6.00	3.33	22.0	2.45		1.80	0.702	
C Shapes (American Standard Channels) 	C12 × 20.7†	6.08	12.0	2.94	129	4.61		3.86	0.797	0.698
	C10 × 15.3	4.48	10.0	2.60	67.3	3.87		2.27	0.711	0.634
	C8 × 11.5	3.37	8.00	2.26	32.5	3.11		1.31	0.623	0.572
	C6 × 8.2	2.39	6.00	1.92	13.1	2.34		0.687	0.536	0.512
Angles 	L6 × 6 × 1‡	11.0			35.4	1.79	1.86	35.4	1.79	1.86
	L4 × 4 × 1/2	3.75			5.52	1.21	1.18	5.52	1.21	1.18
	L3 × 3 × 1/4	1.44			1.23	0.926	0.836	1.23	0.926	0.836
	L6 × 4 × 1/2	4.75			17.3	1.91	1.98	6.22	1.14	0.981
	L5 × 3 × 1/2	3.75			9.43	1.58	1.74	2.55	0.824	0.746
	L3 × 2 × 1/4	1.19			1.09	0.953	0.980	0.390	0.569	0.487

*Courtesy of the American Institute of Steel Construction, Chicago, Illinois

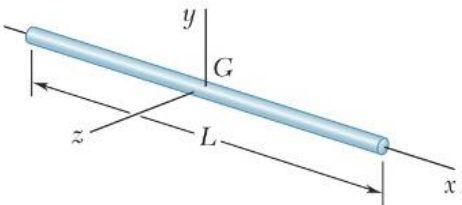
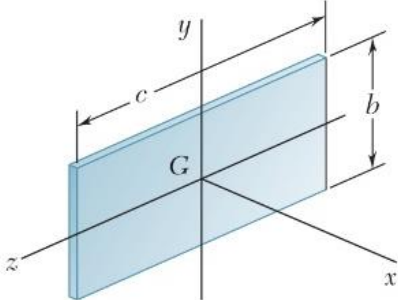
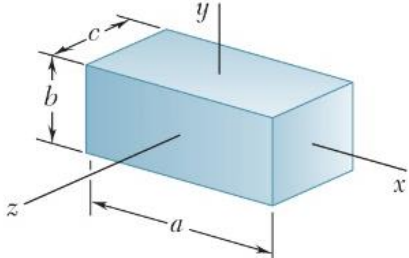
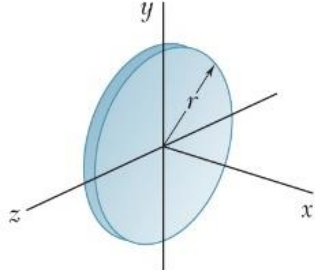
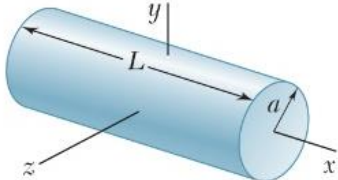
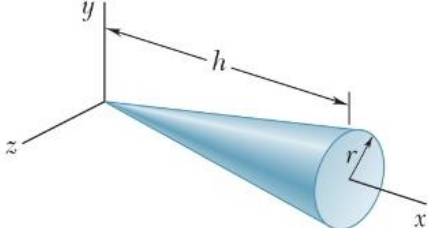
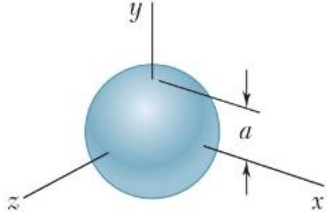
†Nominal depth in inches and weight in pounds per foot

‡Depth, width, and thickness in inches

	Designation	Area mm ²	Depth mm	Width mm	Axis X-X			Axis Y-Y			
					\bar{I}_x 10 ⁶ mm ⁴	\bar{k}_x mm	\bar{y} mm	\bar{I}_y 10 ⁶ mm ⁴	\bar{k}_y mm	\bar{x} mm	
W Shapes (Wide-Flange Shapes)		W460 × 113†	14 400	462	279	554	196	63.3	66.3		
		W410 × 85	10 800	417	181	316	171	17.9	40.6		
		W360 × 57.8	7230	358	172	160	149	11.1	39.4		
		W200 × 46.1	5880	203	203	45.8	88.1	15.4	51.3		
S Shapes (American Standard Shapes)		S460 × 81.4†	10 300	457	152	333	180	8.62	29.0		
		S310 × 47.3	6010	305	127	90.3	123	3.88	25.4		
		S250 × 37.8	4810	254	118	51.2	103	2.80	24.1		
		S150 × 18.6	2360	152	84.6	9.16	62.2	0.749	17.8		
C Shapes (American Standard Channels)		C310 × 30.8†	3920	305	74.7	53.7	117	1.61	20.2	17.7	
		C250 × 22.8	2890	254	66.0	28.0	98.3	0.945	18.1	16.1	
		C200 × 17.1	2170	203	57.4	13.5	79.0	0.545	15.8	14.5	
		C150 × 12.2	1540	152	48.8	5.45	59.4	0.286	13.6	13.0	
Angles		L152 × 152 × 25.4‡	7100			14.7	45.5	47.2	14.7	45.5	47.2
		L102 × 102 × 12.7	2420			2.30	30.7	30.0	2.30	30.7	30.0
		L76 × 76 × 6.4	929			0.512	23.5	21.2	0.512	23.5	21.2
		L152 × 102 × 12.7	3060			7.20	48.5	50.3	2.59	29.0	24.9
		L127 × 76 × 12.7	2420			3.93	40.1	44.2	1.06	20.9	18.9
		L76 × 51 × 6.4	768			0.454	24.2	24.9	0.162	14.5	12.4

†Nominal depth in millimeters and mass in kilograms per meter

‡Depth, width, and thickness in millimeters

Slender rod		$I_y = I_z = \frac{1}{12} mL^2$
Thin rectangular plate		$I_x = \frac{1}{12} m(b^2 + c^2)$ $I_y = \frac{1}{12} mc^2$ $I_z = \frac{1}{12} mb^2$
Rectangular prism		$I_x = \frac{1}{12} m(b^2 + c^2)$ $I_y = \frac{1}{12} m(c^2 + a^2)$ $I_z = \frac{1}{12} m(a^2 + b^2)$
Thin disk		$I_x = \frac{1}{2} mr^2$ $I_y = I_z = \frac{1}{4} mr^2$
Circular cylinder		$I_x = \frac{1}{2} ma^2$ $I_y = I_z = \frac{1}{12} m(3a^2 + L^2)$
Circular cone		$I_x = \frac{3}{10} ma^2$ $I_y = I_z = \frac{3}{5} m\left(\frac{1}{4} a^2 + h^2\right)$
Sphere		$I_x = I_y = I_z = \frac{2}{5} ma^2$