WIKIPEDIA

List of second moments of area

The following is a **list of second moments of area** of some shapes. The second moment of area, also known as area moment of inertia, is a geometrical property of an area which reflects how its points are distributed with regard to an arbitrary axis. The unit of dimension of the second moment of area is length to fourth power, L^4, and should not be confused with the mass moment of inertia. If the piece is thin, however, the mass moment of inertia equals the area density times the area moment of inertia.

Contents

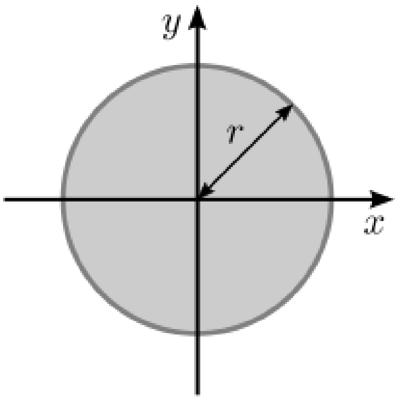
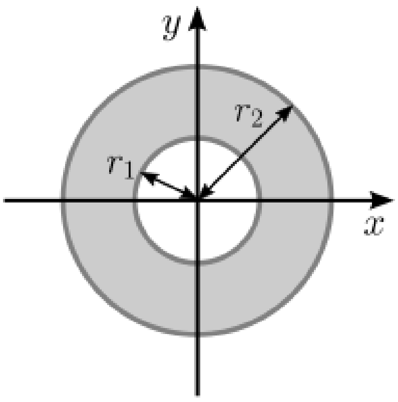
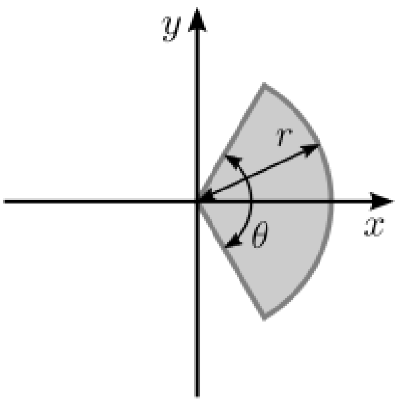
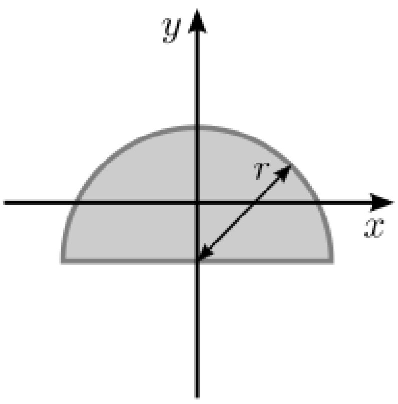
Second moments of area

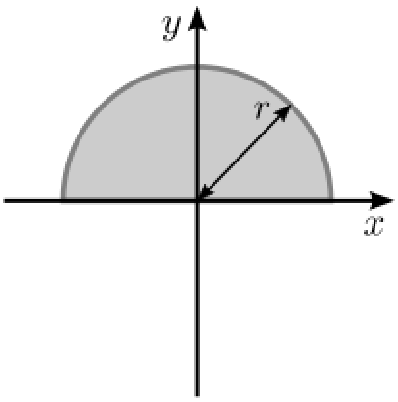
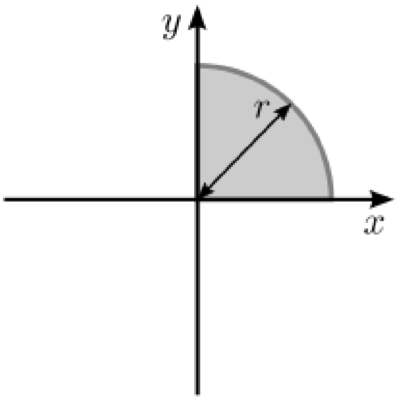
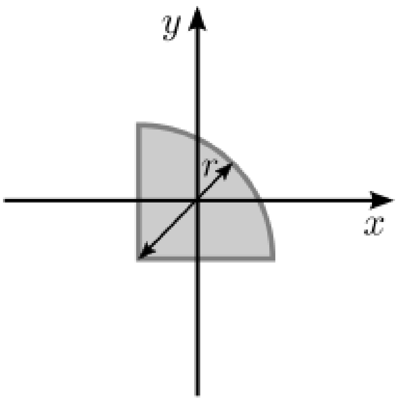
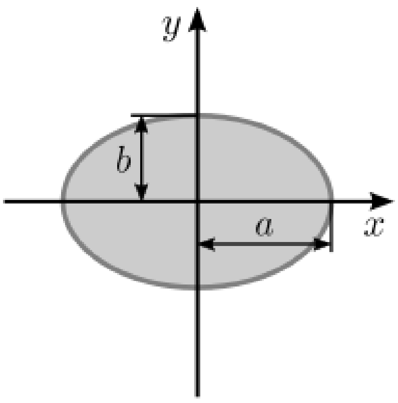
Please take into account that in the following equations,

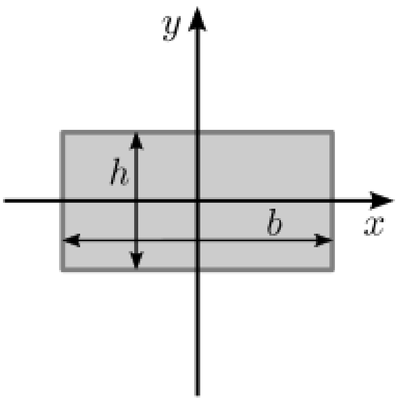
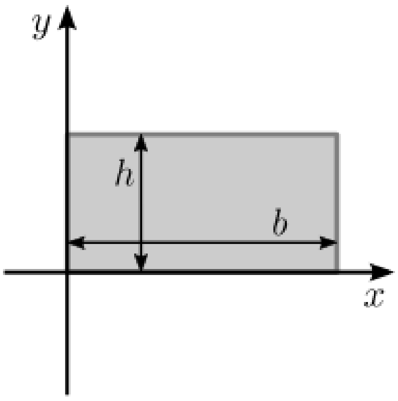
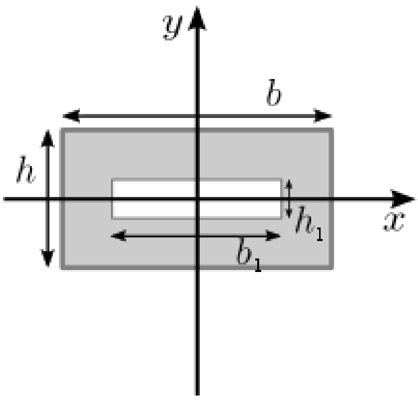
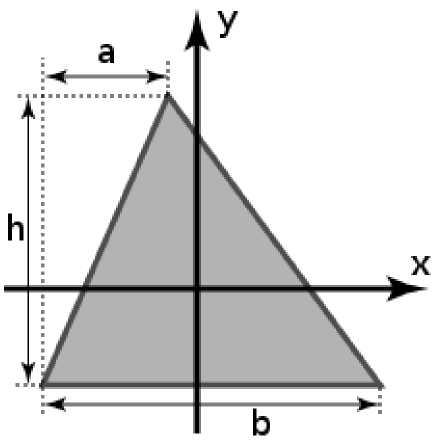
$$I_x = \iint_A y^2\, dx dy$$

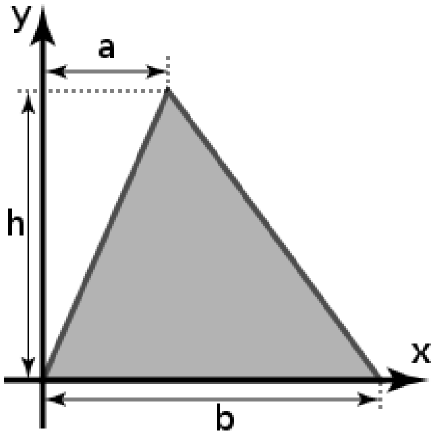
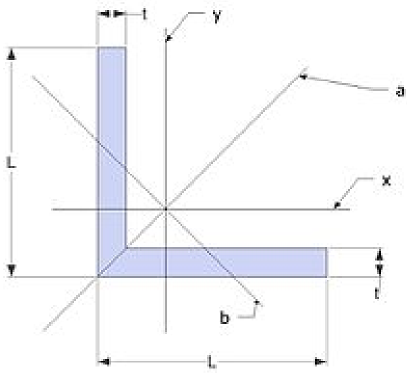
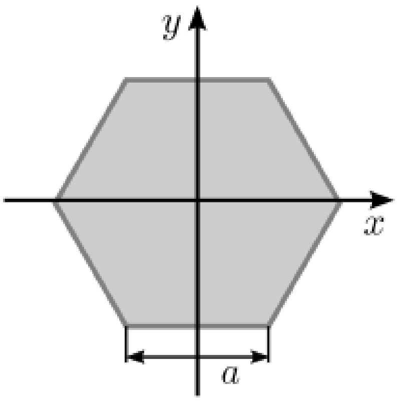
and

$$I_y = \iint_A x^2\, dx dy.$$

Description	Figure	Area moment of inertia	Comment
A filled circular area of radius *r*		$I_x = \frac{\pi}{4} r^4$ $I_y = \frac{\pi}{4} r^4$ $I_z = \frac{\pi}{2} r^4$ [1]	I_z is the Polar moment of inertia.
An annulus of inner radius r_1 and outer radius r_2		$I_x = \frac{\pi}{4} \left({r_2}^4 - {r_1}^4 \right)$ $I_y = \frac{\pi}{4} \left({r_2}^4 - {r_1}^4 \right)$ $I_z = \frac{\pi}{2} \left({r_2}^4 - {r_1}^4 \right)$	For thin tubes, $r \equiv r_1 \approx r_2$ and $r_2 \equiv r_1 + t$. So, for a thin tube, $I_x = I_y \approx \pi r^3 t$. I_z is the Polar moment of inertia.
A filled circular sector of angle *θ* in radians and radius *r* with respect to an axis through the centroid of the sector and the center of the circle		$I_x = (\theta - \sin\theta) \frac{r^4}{8}$	This formula is valid only for 0 ≤ θ ≤ 2π
A filled semicircle with radius *r* with respect to a horizontal line passing through the centroid of the area		$I_x = \left(\frac{\pi}{8} - \frac{8}{9\pi} \right) r^4 \approx 0.1098 r^4$ $I_y = \frac{\pi r^4}{8}$ [2]	
A filled semicircle as above but with respect to an axis		$I_x = \frac{\pi r^4}{8}$ $I_y = \frac{\pi r^4}{8}$ [2]	I_x: This is a consequence of the parallel axis theorem and the fact

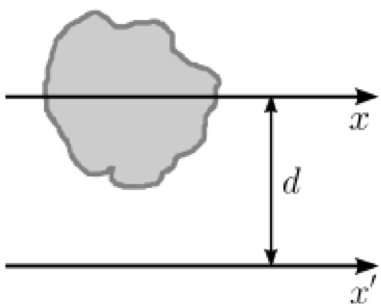
collinear with the base			that the distance between the x axes of the previous one and this one is $\frac{4r}{3\pi}$
A filled quarter circle with radius *r* with the axes passing through the bases		$I_x = \frac{\pi r^4}{16}$ $I_y = \frac{\pi r^4}{16}$ [3]	
A filled quarter circle with radius *r* with the axes passing through the centroid		$I_x = \left(\frac{\pi}{16} - \frac{4}{9\pi}\right) r^4 \approx 0.0549 r^4$ $I_y = \left(\frac{\pi}{16} - \frac{4}{9\pi}\right) r^4 \approx 0.0549 r^4$ [3]	This is a consequence of the parallel axis theorem and the fact that the distance between these two axes is $\frac{4r}{3\pi}$
A filled ellipse whose radius along the *x*-axis is *a* and whose radius along the *y*-axis is *b*		$I_x = \frac{\pi}{4} ab^3$ $I_y = \frac{\pi}{4} a^3 b$	
A filled rectangular area with a base width of *b* and height *h*		$I_x = \frac{bh^3}{12}$ $I_y = \frac{b^3 h}{12}$ [4]	

			
A filled rectangular area as above but with respect to an axis collinear with the base		$I_x = \frac{bh^3}{3}$ $I_y = \frac{b^3h}{3}$ [4]	This is a result from the parallel axis theorem
A hollow rectangle with an inner rectangle whose width is b_1 and whose height is h_1		$I_x = \frac{bh^3 - b_1 {h_1}^3}{12}$ $I_y = \frac{b^3h - {b_1}^3 h_1}{12}$	
A filled triangular area with a base width of b, height h and top vertex displacement a, with respect to an axis through the centroid		$I_x = \frac{bh^3}{36}$ $I_y = \frac{b^3h - b^2ha + bha^2}{36}$ [5]	
A filled triangular area as above but with respect to an axis collinear with the base		$I_x = \frac{bh^3}{12}$ $I_y = \frac{b^3h + b^2ha + bha^2}{12}$ [5]	This is a consequence of the parallel axis theorem

			
An equal legged angle, commonly found in engineering applications		$I_x = I_y = \frac{t(5L^2 - 5Lt + t^2)(L^2 - Lt + t^2)}{12(2L - t)}$ $I_{(xy)} = \frac{L^2 t(L - t)^2}{4(t - 2L)}$ $I_a = \frac{t(2L - t)(2L^2 - 2Lt + t^2)}{12}$ $I_b = \frac{t(2L^4 - 4L^3 t + 8L^2 t^2 - 6Lt^3 + t^4)}{12(2L - t)}$	$I_{(xy)}$ is the often unused product of inertia, used to define inertia with a rotated axis
A filled regular hexagon with a side length of *a*		$I_x = \frac{5\sqrt{3}}{16}a^4$ $I_y = \frac{5\sqrt{3}}{16}a^4$	The result is valid for both a horizontal and a vertical axis through the centroid, and therefore is also valid for an axis with arbitrary direction that passes through the origin.

Parallel axis theorem

The parallel axis theorem can be used to determine the second moment of area of a rigid body about any axis, given the body's moment of inertia about a parallel axis through the object's center of mass and the perpendicular distance (d) between the axes.



$$I_{x'} = I_x + Ad^2$$

See also

- List of moments of inertia
- List of centroids
- Polar moment of inertia

References

1. "Circle" (http://www.efunda.com/math/areas/Circle.cfm). eFunda. Retrieved 2006-12-30.
2. "Circular Half" (http://www.efunda.com/math/areas/CircleHalf.cfm). eFunda. Retrieved 2006-12-30.
3. "Quarter Circle" (http://www.efunda.com/math/areas/CircleQuarter.cfm). eFunda. Retrieved 2006-12-30.
4. "Rectangular area" (http://www.efunda.com/math/areas/rectangle.cfm). eFunda. Retrieved 2006-12-30.
5. "Triangular area" (http://www.efunda.com/math/areas/triangle.cfm). eFunda. Retrieved 2006-12-30.