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Chris Haslego
President
Cheresources, Inc.

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*Content Based
Chemical Engineering*

Properties of Sections - Solid Centered Square

SERVICE:

----- **Definition of Symbols** -----

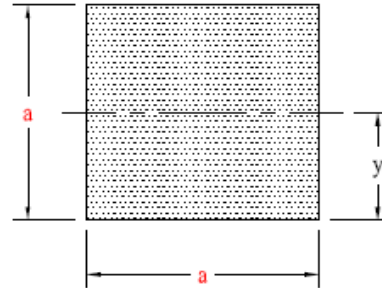
A = Area, in.²
 I = Moment of inertia, in.⁴
 r = Radius of gyration, $\sqrt{I/A}$
 y = Distance from neutral axis to extreme fiber, in.
 Z = Section modulus, I/y, in.³

----- **User Input** -----

a = in.

----- **Calculated Properties** -----

$A = a^2 =$ in.²
 $y = \frac{1}{2}a =$ in.
 $I = \frac{a^4}{12} =$ in.⁴
 $Z = \frac{a^3}{6} =$ in.³
 r = 0.289a = in.



Properties of Sections - Solid Offset Square

SERVICE:

----- **Definition of Symbols** -----

- A = Area, in.²
 I = Moment of inertia, in.⁴
 r = Radius of gyration, $\sqrt{I/A}$
 y = Distance from neutral axis to extreme fiber, in.
 Z = Section modulus, I/y, in.³

----- **User Input** -----

a = in.

----- **Calculated Properties** -----

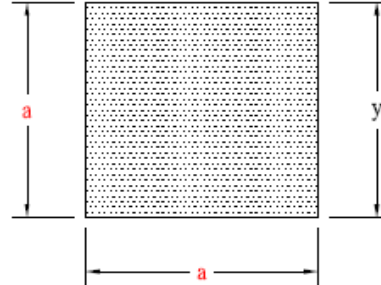
$$A = a^2 = \quad \text{in.}^2$$

$$y = a = \quad \text{in.}$$

$$I = \frac{a^4}{3} = \quad \text{in.}^4$$

$$Z = \frac{a^3}{3} = \quad \text{in.}^3$$

$$r = 0.577a = \quad \text{in.}$$



Properties of Sections - Solid Rotated Square

SERVICE:

----- **Definition of Symbols** -----

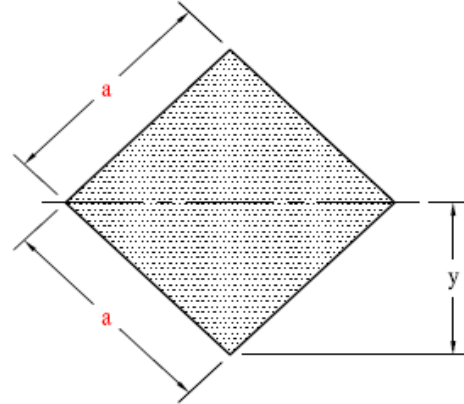
A = Area, in.²
 I = Moment of inertia, in.⁴
 r = Radius of gyration, $\sqrt{I/A}$
 y = Distance from neutral axis to extreme fiber, in.
 Z = Section modulus, I/y, in.³

----- **User Input** -----

a = in.

----- **Calculated Properties** -----

$A = a^2 =$ in.²
 $y = 0.707a =$ in.
 $I = \frac{a^4}{12} =$ in.⁴
 $Z = 0.118a^3 =$ in.³
 $r = 0.289a =$ in.



Properties of Sections - Hollow Centered Square

SERVICE:

----- **Definition of Symbols** -----

A = Area, in.²
 I = Moment of inertia, in.⁴
 r = Radius of gyration, $\sqrt{I/A}$
 y = Distance from neutral axis to extreme fiber, in.
 Z = Section modulus, I/y, in.³

----- **User Input** -----

a = in.
 b = in.

----- **Calculated Properties** -----

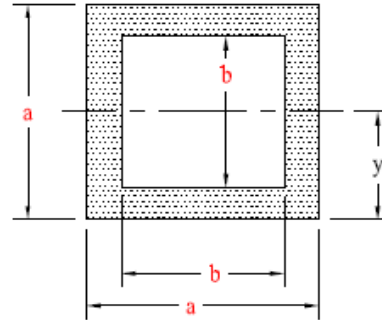
$$A = a^2 - b^2 = \quad \text{in.}^2$$

$$y = \frac{1}{2}a = \quad \text{in.}$$

$$I = \frac{a^4 - b^4}{12} = \quad \text{in.}^4$$

$$Z = \frac{a^4 - b^4}{6a} = \quad \text{in.}^3$$

$$r = 0.289\sqrt{a^2 + b^2} = \quad \text{in.}$$



Properties of Sections - Hollow Rotated Square

SERVICE:

----- **Definition of Symbols** -----

A = Area, in.²
 I = Moment of inertia, in.⁴
 r = Radius of gyration, $\sqrt{I/A}$
 y = Distance from neutral axis to extreme fiber, in.
 Z = Section modulus, I/y, in.³

----- **User Input** -----

a = in.
 b = in.

----- **Calculated Properties** -----

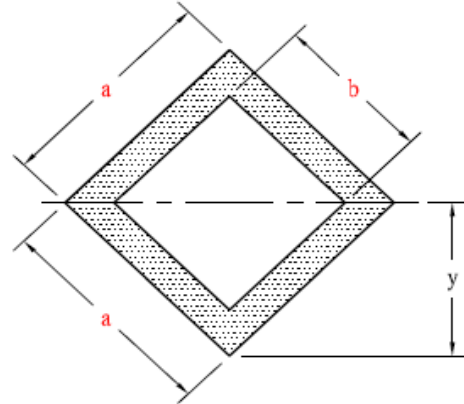
$$A = a^2 - b^2 = \quad \text{in.}^2$$

$$y = 0.707a = \quad \text{in.}$$

$$I = \frac{a^4 - b^4}{12} = \quad \text{in.}^4$$

$$Z = \frac{0.118a^4 - b^4}{a} = \quad \text{in.}^3$$

$$r = 0.289\sqrt{a^2 + b^2} = \quad \text{in.}$$



Properties of Sections - Solid Centered Rectangle

SERVICE:

----- **Definition of Symbols** -----

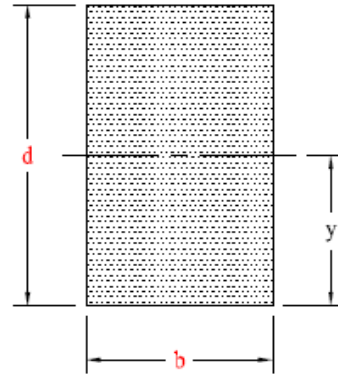
A = Area, in.²
 I = Moment of inertia, in.⁴
 r = Radius of gyration, $\sqrt{I/A}$
 y = Distance from neutral axis to extreme fiber, in.
 Z = Section modulus, I/y, in.³

----- **User Input** -----

b = in.
 d = in.

----- **Calculated Properties** -----

A = bd = in.²
 $y = \frac{1}{2}d =$ in.
 $I = \frac{bd^3}{12} =$ in.⁴
 $Z = \frac{bd^2}{6} =$ in.³
 r = 0.289d = in.



Properties of Sections - Solid Offset Rectangle

SERVICE:

----- **Definition of Symbols** -----

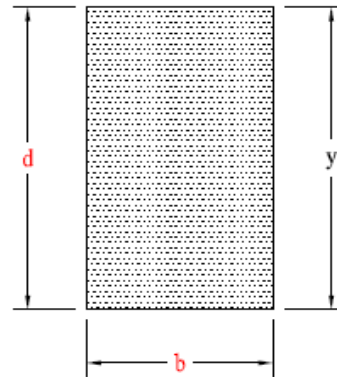
A = Area, in.²
 I = Moment of inertia, in.⁴
 r = Radius of gyration, $\sqrt{I/A}$
 y = Distance from neutral axis to extreme fiber, in.
 Z = Section modulus, I/y, in.³

----- **User Input** -----

b = in.
 d = in.

----- **Calculated Properties** -----

A = bd = in.²
 y = d = in.
 $I = \frac{b \cdot d^3}{3} =$ in.⁴
 $Z = \frac{b \cdot d^2}{3} =$ in.³
 r = 0.577d = in.



Properties of Sections - Solid Rotated Square

SERVICE: _____

----- **Definition of Symbols** -----

A = Area, in.²
 I = Moment of inertia, in.⁴
 r = Radius of gyration, $\sqrt{I/A}$
 y = Distance from neutral axis to extreme fiber, in.
 Z = Section modulus, I/y, in.³

----- **User Input** -----

a = °
 b = in.
 d = in.

----- **Calculated Properties** -----

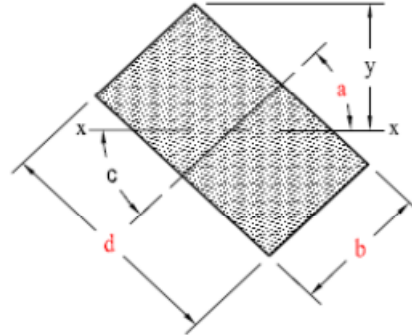
A = bd = in.²
 c = °

$$y = \frac{b \cdot \sin \cdot a + d \cdot \cos \cdot a}{2} = \text{in.}$$

$$I = \frac{b \cdot d \cdot (b^2 \cdot \sin^2 \cdot a + d^2 \cdot \cos^2 \cdot a)}{12} = \text{in.}^4$$

$$Z = \frac{b \cdot d \cdot (b^2 \cdot \sin^2 \cdot a + d^2 \cdot \cos^2 \cdot a)}{6(b \cdot \sin \cdot a + d \cdot \cos \cdot a)} = \text{in.}^3$$

$$r = \sqrt{\frac{b^2 \cdot \sin^2 \cdot a + d^2 \cdot \cos^2 \cdot a}{12}} = \text{in.}$$



Properties of Sections - Hollow Centered Rectangle

SERVICE:

----- **Definition of Symbols** -----

A = Area, in.²
 I = Moment of inertia, in.⁴
 r = Radius of gyration, $\sqrt{I/A}$
 y = Distance from neutral axis to extreme fiber, in.
 Z = Section modulus, I/y, in.³

----- **User Input** -----

b = in.
 d = in.
 h = in.
 k = in.

----- **Calculated Properties** -----

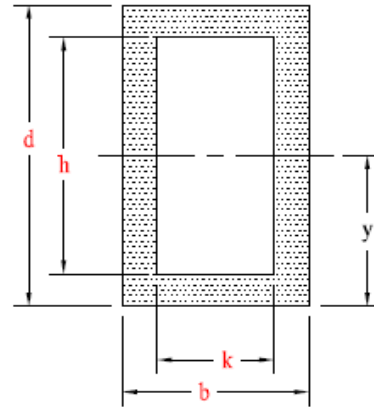
$$A = bd - hk = \text{in.}^2$$

$$y = \frac{1}{2}d = \text{in.}$$

$$I = \frac{bd^3 - hk^3}{12} = \text{in.}^4$$

$$Z = \frac{bd^3 - hk^3}{6d} = \text{in.}^3$$

$$r = 0.289 \sqrt{\frac{bd^3 - hk^3}{bd - hk}} = \text{in.}$$

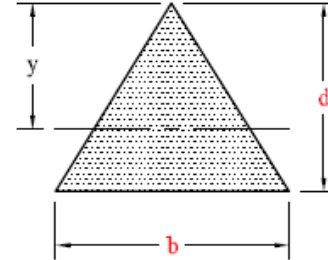


Properties of Sections - Centered Triangle

SERVICE:

----- **Definition of Symbols** -----

A = Area, in.²
 I = Moment of inertia, in.⁴
 r = Radius of gyration, $\sqrt{I/A}$
 y = Distance from neutral axis to extreme fiber, in.
 Z = Section modulus, I/y, in.³



----- **User Input** -----

b = in.
 d = in.

----- **Calculated Properties** -----

$A = \frac{1}{2}bd =$ in.²
 $y = \frac{2}{3}d =$ in.
 $I = \frac{bd^3}{36} =$ in.⁴
 $Z = \frac{bd^2}{24} =$ in.³
 r = 0.236d = in.

Properties of Sections - Offset Triangle

SERVICE:

----- **Definition of Symbols** -----

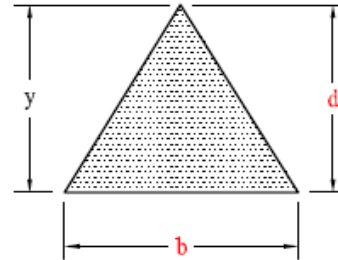
A = Area, in.²
 I = Moment of inertia, in.⁴
 r = Radius of gyration, $\sqrt{I/A}$
 y = Distance from neutral axis to extreme fiber, in.
 Z = Section modulus, I/y, in.³

----- **User Input** -----

b = in.
 d = in.

----- **Calculated Properties** -----

$A = \frac{1}{2}bd =$ in.²
 y = d = in.
 $I = \frac{bd^3}{12} =$ in.⁴
 $Z = \frac{bd^2}{12} =$ in.³
 r = 0.408d = in.



Properties of Sections - Trapezoid

SERVICE:

----- **Definition of Symbols** -----

A = Area, in.²
 I = Moment of inertia, in.⁴
 r = Radius of gyration, $\sqrt{I/A}$
 y = Distance from neutral axis to extreme fiber, in.
 Z = Section modulus, I/y, in.³

----- **User Input** -----

a = in.
 b = in.
 d = in.

----- **Calculated Properties** -----

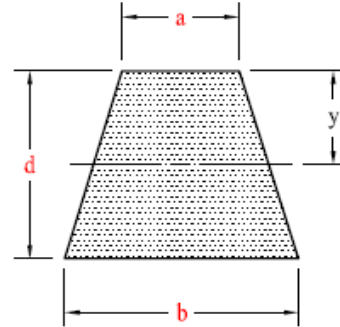
$$A = \frac{d(a + b)}{2} = \quad \text{in.}^2$$

$$y = \frac{d(a + 2b)}{3(a + b)} = \quad \text{in.}$$

$$I = \frac{d^3 \cdot (a^2 + 4ab + b^2)}{36(a + b)} = \quad \text{in.}^4$$

$$Z = \frac{d^2(a^2 + 4ab + b^2)}{12(a + 2b)} = \quad \text{in.}^3$$

$$r = \sqrt{\frac{I}{A}} = \quad \text{in.}$$



Properties of Sections - Circle

SERVICE:

----- **Definition of Symbols** -----

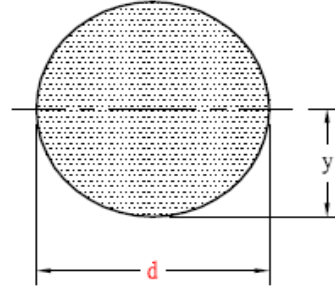
A = Area, in.²
 I = Moment of inertia, in.⁴
 r = Radius of gyration, $\sqrt{I/A}$
 y = Distance from neutral axis to extreme fiber, in.
 Z = Section modulus, I/y, in.³

----- **User Input** -----

d = in.

----- **Calculated Properties** -----

A = $0.7854d^2$ = in.²
 y = $\frac{d}{2}$ = in.
 I = $0.049d^4$ = in.⁴
 Z = $0.098d^3$ = in.³
 r = $\frac{d}{4}$ = in.



Properties of Sections - Donut

SERVICE:

----- **Definition of Symbols** -----

A = Area, in.²
 I = Moment of inertia, in.⁴
 r = Radius of gyration, $\sqrt{I/A}$
 y = Distance from neutral axis to extreme fiber, in.
 Z = Section modulus, I/y, in.³

----- **User Input** -----

D = in.
 d = in.

----- **Calculated Properties** -----

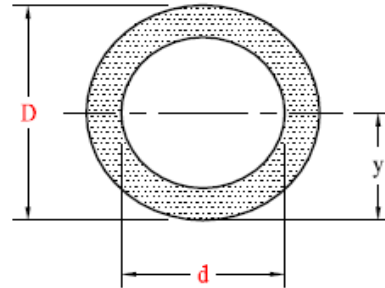
$$A = 0.7854(D^2 - d^2) = \quad \text{in.}^2$$

$$y = \frac{D}{2} = \quad \text{in.}$$

$$I = 0.049(D^4 - d^4) = \quad \text{in.}^4$$

$$Z = \frac{0.098(D^4 - d^4)}{D} = \quad \text{in.}^3$$

$$r = \sqrt{D^2 + \frac{d^2}{4}} = \quad \text{in.}$$



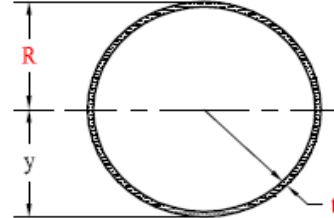
Properties of Sections - Thin-Walled Cylinder

For Section of thin walled cylinder when $R > 10t$

SERVICE:

----- Definition of Symbols -----

- $A =$ Area, in.²
 $I =$ Moment of inertia, in.⁴
 $r =$ Radius of gyration, $\sqrt{I/A}$
 $y =$ Distance from neutral axis to extreme fiber, in.
 $Z =$ Section modulus, I/y , in.³



----- User Input -----

$R =$ in.
 $t =$ in.

----- Calculated Properties -----

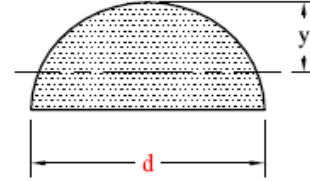
$A = 2R\pi t =$ in.²
 $y = R =$ in.
 $I = R^3 t\pi =$ in.⁴
 $Z = R^2 t\pi =$ in.³
 $r = 0.707R =$ in.

Properties of Sections - Half Circle

SERVICE:

----- **Definition of Symbols** -----

A = Area, in.²
 I = Moment of inertia, in.⁴
 r = Radius of gyration, $\sqrt{I/A}$
 y = Distance from neutral axis to extreme fiber, in.
 Z = Section modulus, I/y, in.³



----- **User Input** -----

d = in.

----- **Calculated Properties** -----

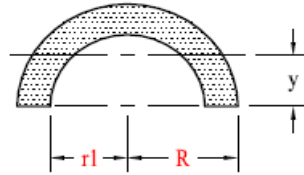
A = 0.393d² = in.²
 y = 0.288d = in.
 I = 0.007d⁴ = in.⁴
 Z = 0.024d³ = in.³
 r = 0.132d = in.

Properties of Sections - Half Donut

SERVICE:

----- Definition of Symbols -----

- A = Area, in.²
 I = Moment of inertia, in.⁴
 r = Radius of gyration, $\sqrt{I/A}$
 y = Distance from neutral axis to extreme fiber, in.
 Z = Section modulus, I/y, in.³



----- User Input -----

- R = in.
 r1 = in.

----- Calculated Properties -----

$$A = 1.5708(R^2 - r1^2) = \quad \text{in.}^2$$

$$y = 0.424 \frac{R^3 - r1^3}{R^2 - r1^2} = \quad \text{in.}$$

$$I = 0.1098(R^4 - r1^4) - \frac{0.283R^2 r1^2(R-r1)}{R + r1} = \quad \text{in.}^4$$

$$Z = \frac{I}{y} = \quad \text{in.}^3$$

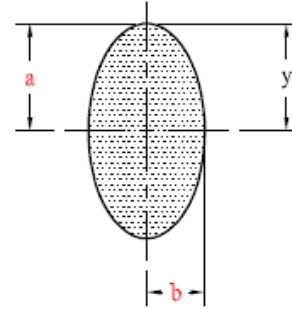
$$r = \sqrt{\frac{I}{A}} = \quad \text{in.}$$

Properties of Sections - Ellipse

SERVICE:

----- **Definition of Symbols** -----

A = Area, in.²
 I = Moment of inertia, in.⁴
 r = Radius of gyration, $\sqrt{I/A}$
 y = Distance from neutral axis to extreme fiber, in.
 Z = Section modulus, I/y, in.³



----- **User Input** -----

a = in.
 b = in.

----- **Calculated Properties** -----

A = 3.1416ab = in.²
 y = a = in.
 I = 0.7854a³b = in.⁴
 Z = 0.7854a²b = in.³
 r = $\frac{a}{2}$ = in.

Properties of Sections - Structural Tee

SERVICE: _____

----- **Definition of Symbols** -----

- A = Area, in.²
- I = Moment of inertia, in.⁴
- r = Radius of gyration, $\sqrt{I/A}$
- y = Distance from neutral axis to extreme fiber, in.
- Z = Section modulus, I/y, in.³

----- **User Input** -----

- b = in.
- d = in.
- h = in.
- s = in.
- t = in.

----- **Calculated Properties** -----

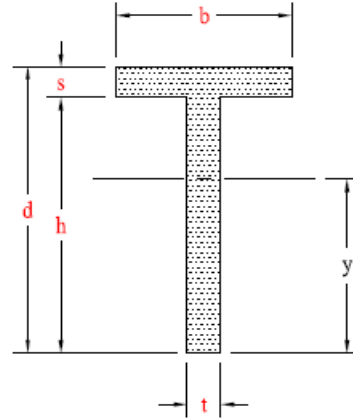
A = $bs + ht =$ in.²

y = $d - \frac{d^2t + s^2(b - t)}{2(bs + ht)} =$ in.

I = $\frac{1}{3}[ty^3 + b(d - y)^3 - (b - t)(d - y - s)^2] =$ in.⁴

Z = $\frac{I}{y} =$ in.³

r = $\sqrt{\frac{I}{A}} =$ in.



Properties of Sections - Welded Tee Plate Width

SERVICE:

----- **Definition of Symbols** -----

A = Area, in.²
 I = Moment of inertia, in.⁴
 r = Radius of gyration, $\sqrt{I/A}$
 y = Distance from neutral axis to extreme fiber, in.
 Z = Section modulus, I/y , in.³
 F_y = Yield strength of sheet in K
 K = 1,000 psi (ie 36,000 psi = 36K)

----- **User Input** -----

s = in.
 h = in.
 t = in.
 F_y = K

----- **Calculated Variables** -----

$$b = s \cdot \frac{95}{\sqrt{F_y}} = \quad \text{in.}$$

$$d = \quad \text{in.}$$

----- **Calculated Properties** -----

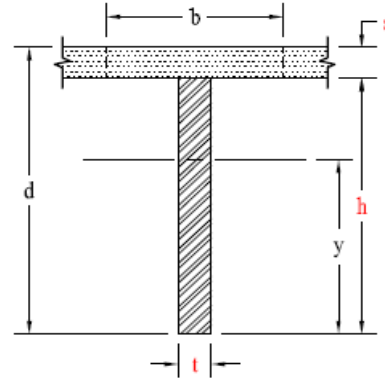
$$A = bs + ht = \quad \text{in.}^2$$

$$y = d - \frac{d^2t + s^2(b-t)}{2(bs + ht)} = \quad \text{in.}$$

$$I = \frac{1}{3}[ty^3 + b(d-y)^3 - (b-t)(d-y-s)^2] = \quad \text{in.}^4$$

$$Z = \frac{I}{y} = \quad \text{in.}^3$$

$$r = \sqrt{\frac{I}{A}} = \quad \text{in.}$$



Properties of Sections - Equal 'L'

SERVICE:

----- **Definition of Symbols** -----

- A = Area, in.²
- I = Moment of inertia, in.⁴
- r = Radius of gyration, $\sqrt{I/A}$
- y = Distance from neutral axis to extreme fiber, in.
- Z = Section modulus, I/y, in.³

----- **User Input** -----

a = in.
 t = in.

----- **Calculated Properties** -----

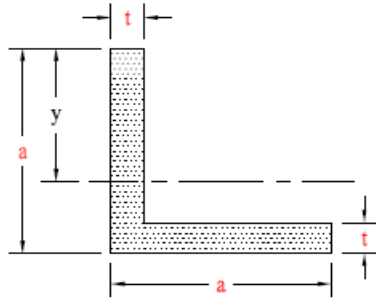
$$A = t(2a-t) = \text{in.}^2$$

$$y = a - \frac{a^2 + at - t^2}{2(2a - t)} = \text{in.}$$

$$I = \frac{1}{3}[ty^3 + a(a-y)^3 - (a-t)(b-y-t)^3] = \text{in.}^4$$

$$Z = \frac{I}{y} = \text{in.}^3$$

$$r = \sqrt{\frac{I}{A}} = \text{in.}$$



Properties of Sections - Unequal 'L'

SERVICE: _____

----- **Definition of Symbols** -----

- A = Area, in.²
- I = Moment of inertia, in.⁴
- r = Radius of gyration, $\sqrt{I/A}$
- y = Distance from neutral axis to extreme fiber, in.
- Z = Section modulus, I/y, in.³

----- **User Input** -----

- a = in.
- b = in.
- d = in.
- t = in.

----- **Calculated Properties** -----

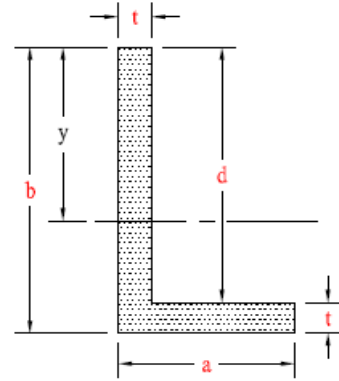
$$A = t(a + b - t) = \text{in.}^2$$

$$y = b - \frac{t(2d + a) + d^2}{2(d + a)} = \text{in.}$$

$$I = \frac{1}{8}[ty^3 + a(b - y)^3 - (a - t)(b - y - t)^3] = \text{in.}^4$$

$$Z = \frac{I}{y} = \text{in.}^3$$

$$r = \sqrt{\frac{I}{A}} = \text{in.}$$

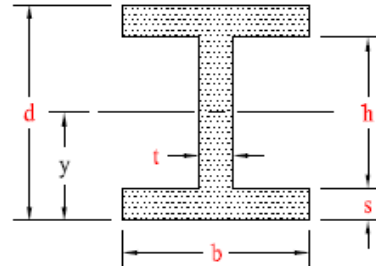


Properties of Sections - Vertical 'I'

SERVICE: _____

----- Definition of Symbols -----

A = Area, in.²
 I = Moment of inertia, in.⁴
 r = Radius of gyration, $\sqrt{I/A}$
 y = Distance from neutral axis to extreme fiber, in.
 Z = Section modulus, I/y, in.³



----- User Input -----

b = _____ in.
 d = _____ in.
 h = _____ in.
 s = _____ in.
 t = _____ in.

----- Calculated Properties -----

$$A = bd - h(b - t) \quad \text{in.}^2$$

$$y = \frac{d}{2} = \quad \text{in.}$$

$$I = \frac{bd^3 - h^3(b - t)}{12} = \quad \text{in.}^4$$

$$Z = \frac{bd^3 - h^3(b - t)}{6d} = \quad \text{in.}^3$$

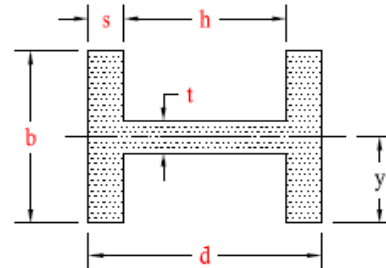
$$r = \sqrt{\frac{I}{A}} = \quad \text{in.}$$

Properties of Sections - Horizontal 'I'

SERVICE: _____

----- **Definition of Symbols** -----

A = Area, in.²
 I = Moment of inertia, in.⁴
 r = Radius of gyration, $\sqrt{I/A}$
 y = Distance from neutral axis to extreme fiber, in.
 Z = Section modulus, I/y, in.³



----- **User Input** -----

b = _____ in.
 d = _____ in.
 h = _____ in.
 s = _____ in.
 t = _____ in.

----- **Calculated Properties** -----

$$A = bd - h(b - t) \quad \text{in.}^2$$

$$y = \frac{b}{2} = \quad \text{in.}$$

$$I = \frac{2sb^3 + ht^3}{12} = \quad \text{in.}^4$$

$$Z = \frac{2sb^3 + ht^3}{6b} = \quad \text{in.}^3$$

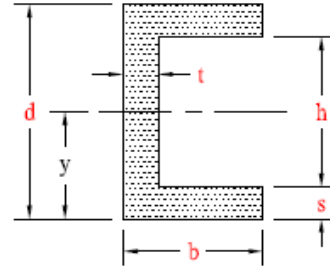
$$r = \sqrt{\frac{I}{A}} = \quad \text{in.}$$

Properties of Sections - Vertical Channel

SERVICE: _____

----- Definition of Symbols -----

A = Area, in.²
 I = Moment of inertia, in.⁴
 r = Radius of gyration, $\sqrt{I/A}$
 y = Distance from neutral axis to extreme fiber, in.
 Z = Section modulus, I/y, in.³



----- User Input -----

b = _____ in.
 d = _____ in.
 h = _____ in.
 s = _____ in.
 t = _____ in.

----- Calculated Properties -----

$$A = bd - h(b - t) \quad \text{in.}^2$$

$$y = \frac{d}{2} = \quad \text{in.}$$

$$I = \frac{bd^3 - h^3(b - t)}{12} = \quad \text{in.}^4$$

$$Z = \frac{bd^3 - h^3(b - t)}{6d} = \quad \text{in.}^3$$

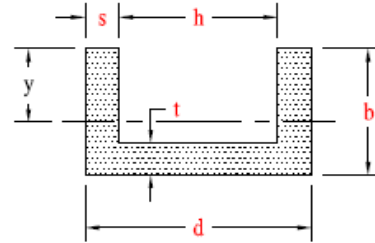
$$r = \sqrt{\frac{bd^3 - h^3(b - t)}{12(bd - h(b - t))}} = \quad \text{in.}$$

Properties of Sections - Horizontal Channel

SERVICE: _____

----- Definition of Symbols -----

A = Area, in.²
 I = Moment of inertia, in.⁴
 r = Radius of gyration, $\sqrt{I/A}$
 y = Distance from neutral axis to extreme fiber, in.
 Z = Section modulus, I/y , in.³



----- User Input -----

b = _____ in.
 d = _____ in.
 h = _____ in.
 s = _____ in.
 t = _____ in.

----- Calculated Properties -----

$$A = bd - h(b - t) = \text{in.}^2$$

$$y = b - \frac{2b^2s + ht^2}{2bd - 2h(b - t)} = \text{in.}$$

$$I = (2sb^3 + ht^3)/[3 - A(b - y)^2] = \text{in.}^4$$

$$Z = \frac{I}{y} = \text{in.}^3$$

$$r = \sqrt{\frac{I}{A}} = \text{in.}$$

Properties of Sections

BASIS : This program is for calculating the properties of sections.

NOTE : Always begin a new case by retrieving the original file. Direct entry of data in cells that originally contain table lookups could cause functions to be lost and/or incorrect calculations. Cells that require data entry are colored **RED**; calculated values are black.

REFERENCES :

- 1) *Pressure Vessel Handbook - 11th Edition*
- 2) *Manual of Steel Construction - Allowable Stress Design - A.I.S.C. 9th Edition*

◊-◊-◊-◊-◊ **ProcSafety May 2011, by Mark Roote** ◊-◊-◊-◊-◊

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