Important Properties of Planes and Solids Formulas PDF

Formulas
Examples
with Units

List of 49
Important Properties of Planes and Solids Formulas

1) Mass Moment of Inertia Formulas

1.1) Mass Moment of Inertia of Circular Plate about x-axis Passing through Centroid Formula

Evaluate Formula

Formula

$$I_{xx} = \frac{M \cdot r^2}{4}$$

Example with Units

$$11.7207\,\text{kg·m²} = \frac{35.45\,\text{kg} \cdot 1.15\,\text{m}^2}{4}$$

1.2) Mass Moment of Inertia of Circular Plate about y-axis Passing through Centroid Formula

Evaluate Formula

Formula

$$I_{yy} = \frac{M \cdot r^2}{4}$$

Example with Units

$$11.7207\,\text{kg·m²} = \frac{35.45\,\text{kg} \cdot 1.15\,\text{m}^2}{4}$$

1.3) Mass Moment of Inertia of Circular Plate about z-axis through Centroid, Perpendicular to Plate Formula

Evaluate Formula

Formula

$$I_{zz} = \frac{M \cdot r^2}{2}$$

Example with Units

$$23.4413\,\text{kg·m²} = \frac{35.45\,\text{kg} \cdot 1.15\,\text{m}^2}{2}$$

1.4) Mass Moment of Inertia of Cone about x-axis Passing through Centroid, Perpendicular to Base Formula

Evaluate Formula

Formula

$$I_{xx} = \frac{3}{10} \cdot M \cdot R_c^2$$

Example with Units

$$11.5028\,\text{kg·m²} = \frac{3}{10} \cdot 35.45\,\text{kg} \cdot 1.04\,\text{m}^2$$

1.5) Mass Moment of Inertia of Cone about y-axis Perpendicular to Height, Passing through Apex Point Formula

Evaluate Formula

Formula

$$I_{yy} = \frac{3}{20} \cdot M \cdot \left(R_c^2 + 4 \cdot H_c^2 \right)$$

Example with Units

$$11.614\,\text{kg·m}^2 = \frac{3}{20} \cdot 35.45\,\text{kg} \cdot \left(1.04\,\text{m}^2 + 4 \cdot 0.525\,\text{m}^2 \right)$$

1.6) Mass Moment of Inertia of Cuboid about x-axis Passing through Centroid, Parallel to Length Formula

Evaluate Formula

Formula

$$I_{xx} = \frac{M}{12} \cdot \left(w^2 + H^2 \right)$$

Example with Units

$$11.7243\,\text{kg·m}^2 = \frac{35.45\,\text{kg}}{12} \cdot \left(1.693\,\text{m}^2 + 1.05\,\text{m}^2 \right)$$

1.7) Mass Moment of Inertia of Cuboid about y-axis Passing through Centroid Formula

Evaluate Formula

Formula

$$I_{yy} = \frac{M}{12} \cdot \left(L^2 + w^2 \right)$$

Example with Units

$$11.7554\,\text{kg·m}^2 = \frac{35.45\,\text{kg}}{12} \cdot \left(1.055\,\text{m}^2 + 1.693\,\text{m}^2 \right)$$

1.8) Mass Moment of Inertia of Cuboid about z-axis Passing through Centroid Formula

Evaluate Formula

Formula

$$I_{zz} = \frac{M}{12} \cdot \left(L^2 + H^2 \right)$$

Example with Units

$$6.545\,\text{kg·m}^2 = \frac{35.45\,\text{kg}}{12} \cdot \left(1.055\,\text{m}^2 + 1.05\,\text{m}^2 \right)$$

1.9) Mass Moment of Inertia of Rectangular Plate about x-axis through Centroid, Parallel to Length Formula

Evaluate Formula

Formula

$$I_{xx} = \frac{M \cdot B^2}{12}$$

Example with Units

$$11.6988\,\text{kg·m}^2 = \frac{35.45\,\text{kg} \cdot 1.99\,\text{m}^2}{12}$$

1.10) Mass Moment of Inertia of Rectangular Plate about y-axis through Centroid, Parallel to Breadth Formula

Evaluate Formula

Formula

$$I_{yy} = \frac{M \cdot L_{rect}^2}{12}$$

Example with Units

$$11.9351\,\text{kg·m}^2 = \frac{35.45\,\text{kg} \cdot 2.01\,\text{m}^2}{12}$$

1.11) Mass Moment of Inertia of Rectangular Plate about z-axis through Centroid, Perpendicular to Plate Formula

Evaluate Formula

Formula

$$I_{zz} = \frac{M}{12} \cdot \left({L_{rect}}^2 + B^2 \right)$$

Example with Units

$$23.6339\,\text{kg·m}^2 = \frac{35.45\,\text{kg}}{12} \cdot \left({2.01\,\text{m}}^2 + {1.99\,\text{m}}^2 \right)$$

1.12) Mass Moment of Inertia of Rod about y-axis Passing through Centroid, Perpendicular to Length of Rod Formula

Evaluate Formula

Formula

$$I_{yy} = \frac{M \cdot {L_{rod}}^2}{12}$$

Example with Units

$$11.8167\,\text{kg·m}^2 = \frac{35.45\,\text{kg} \cdot {2\,\text{m}}^2}{12}$$

1.13) Mass Moment of Inertia of Rod about z-axis Passing through Centroid, Perpendicular to Length of Rod Formula

Evaluate Formula

Formula

$$I_{zz} = \frac{M \cdot {L_{rod}}^2}{12}$$

Example with Units

$$11.8167\,\text{kg·m}^2 = \frac{35.45\,\text{kg} \cdot {2\,\text{m}}^2}{12}$$

1.14) Mass Moment of Inertia of Solid Cylinder about x-axis through Centroid, Perpendicular to Length Formula

Evaluate Formula

Formula

$$I_{xx} = \frac{M}{12} \cdot \left(3 \cdot {R_{cyl}}^2 + {H_{cyl}}^2 \right)$$

Example with Units

$$11.8585\,\text{kg·m}^2 = \frac{35.45\,\text{kg}}{12} \cdot \left(3 \cdot {1.155\,\text{m}}^2 + {0.11\,\text{m}}^2 \right)$$

1.15) Mass Moment of Inertia of Solid Cylinder about y-axis through Centroid, Parallel to Length Formula

Evaluate Formula

Formula

$$I_{yy} = \frac{M \cdot {R_{cyl}}^2}{2}$$

Example with Units

$$23.6456\,\text{kg·m}^2 = \frac{35.45\,\text{kg} \cdot {1.155\,\text{m}}^2}{2}$$

1.16) Mass Moment of Inertia of Solid Cylinder about z-axis through Centroid, Perpendicular to Length Formula

Evaluate Formula

Formula

$$I_{zz} = \frac{M}{12} \cdot \left(3 \cdot {R_{cyl}}^2 + {H_{cyl}}^2 \right)$$

Example with Units

$$11.8585\,\text{kg·m}^2 = \frac{35.45\,\text{kg}}{12} \cdot \left(3 \cdot {1.155\,\text{m}}^2 + {0.11\,\text{m}}^2 \right)$$

1.17) Mass Moment of Inertia of Solid Sphere about x-axis Passing through Centroid Formula

Evaluate Formula

Formula

$$I_{xx} = \frac{2}{5} \cdot M \cdot {R_s}^2$$

Example with Units

$$11.7425\,\text{kg·m}^2 = \frac{2}{5} \cdot 35.45\,\text{kg} \cdot {0.91\,\text{m}}^2$$

1.18) Mass Moment of Inertia of Solid Sphere about y-axis Passing through Centroid Formula

Evaluate Formula

Formula

$$I_{yy} = \frac{2}{5} \cdot M \cdot R_s^2$$

Example with Units

$$11.7425\,\text{kg·m}^2 = \frac{2}{5} \cdot 35.45\,\text{kg} \cdot 0.91\,\text{m}^2$$

1.19) Mass Moment of Inertia of Solid Sphere about z-axis Passing through Centroid Formula

Evaluate Formula

Formula

$$I_{zz} = \frac{2}{5} \cdot M \cdot R_s^2$$

Example with Units

$$11.7425\,\text{kg·m}^2 = \frac{2}{5} \cdot 35.45\,\text{kg} \cdot 0.91\,\text{m}^2$$

1.20) Mass Moment of Inertia of Triangular Plate about x-axis Passing through Centroid, Parallel to Base Formula

Evaluate Formula

Formula

$$I_{xx} = \frac{M \cdot H_{tri}^2}{18}$$

Example with Units

$$11.6294\,\text{kg·m}^2 = \frac{35.45\,\text{kg} \cdot 2.43\,\text{m}^2}{18}$$

1.21) Mass Moment of Inertia of Triangular Plate about y-axis Passing through Centroid, Parallel to Height Formula

Evaluate Formula

Formula

$$I_{yy} = \frac{M \cdot b_{tri}^2}{24}$$

Example with Units

$$11.7464\,\text{kg·m}^2 = \frac{35.45\,\text{kg} \cdot 2.82\,\text{m}^2}{24}$$

1.22) Mass Moment of Inertia of Triangular Plate about z-axis through Centroid, Perpendicular to Plate Formula

Evaluate Formula

Formula

$$I_{zz} = \frac{M}{72} \cdot \left(3 \cdot b_{tri}^2 + 4 \cdot H_{tri}^2\right)$$

Example with Units

$$23.3757\,\text{kg·m}^2 = \frac{35.45\,\text{kg}}{72} \cdot \left(3 \cdot 2.82\,\text{m}^2 + 4 \cdot 2.43\,\text{m}^2\right)$$

2) Mass of Solids Formulas

2.1) Mass of Cone Formula

Evaluate Formula

Formula

$$M_{co} = \frac{1}{3} \cdot \pi \cdot \rho \cdot H_c \cdot R_c^2$$

Example with Units

$$593.4514\,\text{kg} = \frac{1}{3} \cdot 3.1416 \cdot 998\,\text{kg/m}^3 \cdot 0.525\,\text{m} \cdot 1.04\,\text{m}^2$$

2.2) Mass of Cuboid Formula

Evaluate Formula

Formula

$$M_{cu} = \rho \cdot L \cdot H \cdot w$$

Example with Units

$$1871.6699\,\text{kg} = 998\,\text{kg/m}^3 \cdot 1.055\,\text{m} \cdot 1.05\,\text{m} \cdot 1.693\,\text{m}$$

2.3) Mass of Rectangular Plate Formula

Evaluate Formula

Formula

$$M_{rp} = \rho \cdot B \cdot t \cdot L_{rect}$$

Example with Units

$$4790.2802\,\text{kg} = 998\,\text{kg/m}^3 \cdot 1.99\,\text{m} \cdot 1.2\,\text{m} \cdot 2.01\,\text{m}$$

2.4) Mass of Solid Cylinder Formula

Evaluate Formula

Formula

$$M_{sc} = \pi \cdot \rho \cdot H \cdot R_{cyl}^2$$

Example with Units

$$4391.7103\,\text{kg} = 3.1416 \cdot 998\,\text{kg/m}^3 \cdot 1.05\,\text{m} \cdot 1.155\,\text{m}^2$$

2.5) Mass of Solid Sphere Formula

Evaluate Formula

Formula

$$M_{ss} = \frac{4}{3} \cdot \pi \cdot \rho \cdot R_s^3$$

Example with Units

$$3150.2377\,\text{kg} = \frac{4}{3} \cdot 3.1416 \cdot 998\,\text{kg/m}^3 \cdot 0.91\,\text{m}^3$$

2.6) Mass of Triangular Plate Formula

Evaluate Formula

Formula

$$M_{tp} = \frac{1}{2} \cdot \rho \cdot b_{tri} \cdot H_{tri} \cdot t$$

Example with Units

$$4103.3369\,\text{kg} = \frac{1}{2} \cdot 998\,\text{kg/m}^3 \cdot 2.82\,\text{m} \cdot 2.43\,\text{m} \cdot 1.2\,\text{m}$$

3) Mechanics and Statistics of Materials Formulas

3.1) Inclination of Resultant of Two Forces Acting on Particle Formula

Evaluate Formula

Formula

$$\alpha = a\tan\left(\frac{F_2 \cdot \sin(\theta)}{F_1 + F_2 \cdot \cos(\theta)}\right)$$

Example with Units

$$2.6474^\circ = a\tan\left(\frac{12\,\text{N} \cdot \sin(16^\circ)}{60\,\text{N} + 12\,\text{N} \cdot \cos(16^\circ)}\right)$$

3.2) Moment of Couple Formula

Evaluate Formula

Formula

$$M_c = F \cdot r_{F\text{-}F}$$

Example with Units

$$12.5\,\text{N*m} = 2.5\,\text{N} \cdot 5\,\text{m}$$

3.3) Moment of Force Formula

Evaluate Formula

Formula

$$M_f = F \cdot r_{FP}$$

Example with Units

$$10\,\text{N*m} = 2.5\,\text{N} \cdot 4\,\text{m}$$

3.4) Moment of inertia given radius of gyration Formula

Evaluate Formula

Formula

$$I_r = A \cdot k_G^2$$

Example with Units

$$981.245\,\text{m}^4 = 50\,\text{m}^2 \cdot 4.43\,\text{m}^2$$

3.5) Moment of inertia of circle about diametrical axis Formula

Evaluate Formula

Formula

$$I_r = \frac{\pi \cdot d^4}{64}$$

Example with Units

$$981.0639\,\text{m}^4 = \frac{3.1416 \cdot 11.89\,\text{m}^4}{64}$$

3.6) Radius of gyration given moment of inertia and area Formula

Evaluate Formula

Formula

$$k_G = \sqrt{\frac{I_r}{A}}$$

Example with Units

$$4.4294\,\text{m} = \sqrt{\frac{981\,\text{m}^4}{50\,\text{m}^2}}$$

3.7) Resolution of Force with Angle along Horizontal Direction Formula

Evaluate Formula

Formula

$$F_H = F_\theta \cdot \cos(\theta)$$

Example with Units

$$11.5544\,\text{N} = 12.02\,\text{N} \cdot \cos(16^\circ)$$

3.8) Resolution of Force with Angle along Vertical Direction Formula

Evaluate Formula

Formula

$$F_v = F_\theta \cdot \sin(\theta)$$

Example with Units

$$3.3132\,\text{N} = 12.02\,\text{N} \cdot \sin(16^\circ)$$

3.9) Resultant of Two Forces Acting on Particle at 0 Degrees Formula

Evaluate Formula

Formula

$$R_{par} = F_1 + F_2$$

Example with Units

$$72\,\text{N} = 60\,\text{N} + 12\,\text{N}$$

3.10) Resultant of Two Forces Acting on Particle at 180 Degrees Formula

Evaluate Formula

Formula

$$R = F_1 - F_2$$

Example with Units

$$48\,\text{N} = 60\,\text{N} - 12\,\text{N}$$

3.11) Resultant of Two Forces Acting on Particle at 90 Degrees Formula

Evaluate Formula

Formula

$$R = \sqrt{F_1^2 + F_2^2}$$

Example with Units

$$61.1882\,\text{N} = \sqrt{60\,\text{N}^2 + 12\,\text{N}^2}$$

3.12) Resultant of Two Forces acting on Particle with Angle Formula

Evaluate Formula

Formula

$$R_{par} = \sqrt{F_1^2 + 2 \cdot F_1 \cdot F_2 \cdot \cos(\theta) + F_2^2}$$

Example with Units

$$71.6116\,\text{N} = \sqrt{60\,\text{N}^2 + 2 \cdot 60\,\text{N} \cdot 12\,\text{N} \cdot \cos(16^\circ) + 12\,\text{N}^2}$$

3.13) Resultant of Two like Parallel Forces Formula

Evaluate Formula

Formula

$$R_{par} = F_1 + F_2$$

Example with Units

$$72\,\text{N} = 60\,\text{N} + 12\,\text{N}$$

3.14) Resultant of Two Unlike Parallel Forces Unequal in Magnitude Formula

Evaluate Formula

Formula

$$R = F_1 - F_2$$

Example with Units

$$48\,\text{N} = 60\,\text{N} - 12\,\text{N}$$

4) Moment of Inertia in Solids Formulas

4.1) Moment of inertia of hollow circle about diametrical axis Formula

Evaluate Formula

Formula

$$I_s = \left(\frac{\pi}{64}\right) \cdot \left(d_c^4 - d_i^4\right)$$

Example with Units

$$9.5366\,\text{m}^4 = \left(\frac{3.1416}{64}\right) \cdot \left(3.999\,\text{m}^4 - 2.8\,\text{m}^4\right)$$

4.2) Moment of Inertia of Hollow Rectangle about Centroidal Axis x-x Parallel to Breadth Formula

Evaluate Formula

Formula

$$J_{xx} = \frac{\left(B \cdot L_{rect}^3\right) - \left(B_i \cdot L_i^3\right)}{12}$$

Example with Units

$$1.2246\,\text{m}^4 = \frac{\left(1.99\,\text{m} \cdot 2.01\,\text{m}^3\right) - \left(0.75\,\text{m} \cdot 1.25\,\text{m}^3\right)}{12}$$

4.3) Moment of inertia of rectangle about centroidal axis along x-x parallel to breadth Formula

Evaluate Formula

Formula

$$J_{xx} = B \cdot \left(\frac{L_{rect}^3}{12}\right)$$

Example with Units

$$1.3467\,\text{m}^4 = 1.99\,\text{m} \cdot \left(\frac{2.01\,\text{m}^3}{12}\right)$$

4.4) Moment of inertia of rectangle about centroidal axis along y-y parallel to length Formula

Evaluate Formula

Formula

$$J_{yy} = L_{rect} \cdot \frac{B^3}{12}$$

Example with Units

$$1.32\,\text{m}^4 = 2.01\,\text{m} \cdot \frac{1.99\,\text{m}^3}{12}$$

4.5) Moment of inertia of semicircular section about its base Formula

Evaluate Formula

Formula

$$I_s = 0.393 \cdot r_{sc}^4$$

Example with Units

$$9.2063\,\text{m}^4 = 0.393 \cdot 2.2\,\text{m}^4$$

4.6) Moment of inertia of semicircular section through center of gravity, parallel to base Formula

Evaluate Formula

Formula

$$I_s = 0.11 \cdot r_{sc}^4$$

Example with Units

$$2.5768\,\text{m}^4 = 0.11 \cdot 2.2\,\text{m}^4$$

4.7) Moment of inertia of triangle about centroidal axis x-x parallel to base Formula

Evaluate Formula

Formula

$$J_{xx} = \frac{b_{tri} \cdot H_{tri}^3}{36}$$

Example with Units

$$1.124\,\text{m}^4 = \frac{2.82\,\text{m} \cdot 2.43\,\text{m}^3}{36}$$

Variables used in list of Properties of Planes and Solids Formulas above

- **A** Area of Cross-Section *(Square Meter)*
- **B** Breadth of Rectangular Section *(Meter)*
- B_i Inner Breadth of Hollow Rectangular Section *(Meter)*
- b_{tri} Base of Triangle *(Meter)*
- **d** Diameter of Circle *(Meter)*
- d_c Outer Diameter of Hollow Circular Section *(Meter)*
- d_i Inner Diameter of Hollow Circular Section *(Meter)*
- **F** Force *(Newton)*
- F_1 First Force *(Newton)*
- F_2 Second Force *(Newton)*
- F_H Horizontal Component of Force *(Newton)*
- F_v Vertical component of force *(Newton)*
- F_θ Force at Angle *(Newton)*
- **H** Height *(Meter)*
- H_c Height of Cone *(Meter)*
- H_{cyl} Cylinder Height *(Meter)*
- H_{tri} Height of Triangle *(Meter)*
- I_r Rotational Inertia *(Meter⁴)*
- I_s Moment of Inertia for Solids *(Meter⁴)*
- I_{xx} Mass Moment of Inertia about X-axis *(Kilogram Square Meter)*
- I_{yy} Mass Moment of Inertia about Y-axis *(Kilogram Square Meter)*
- I_{zz} Mass Moment of Inertia about Z-axis *(Kilogram Square Meter)*
- J_{xx} Moment of Inertia about x-x axis *(Meter⁴)*
- J_{yy} Moment of Inertia about y-y axis *(Meter⁴)*
- k_G Radius of Gyration *(Meter)*
- **L** Length *(Meter)*

Constants, Functions, Measurements used in list of Properties of Planes and Solids Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- Functions: **atan**, atan(Number) *Inverse tan is used to calculate the angle by applying the tangent ratio of the angle, which is the opposite side divided by the adjacent side of the right triangle.*
- Functions: **cos**, cos(Angle) *Cosine of an angle is the ratio of the side adjacent to the angle to the hypotenuse of the triangle.*
- Functions: **sin**, sin(Angle) *Sine is a trigonometric function that describes the ratio of the length of the opposite side of a right triangle to the length of the hypotenuse.*
- Functions: **sqrt**, sqrt(Number) *A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.*
- Functions: **tan**, tan(Angle) *The tangent of an angle is a trigonometric ratio of the length of the side opposite an angle to the length of the side adjacent to an angle in a right triangle.*
- Measurement: **Length** in Meter (m) *Length Unit Conversion*
- Measurement: **Weight** in Kilogram (kg) *Weight Unit Conversion*
- Measurement: **Area** in Square Meter (m²) *Area Unit Conversion*
- Measurement: **Force** in Newton (N) *Force Unit Conversion*
- Measurement: **Angle** in Degree (°) *Angle Unit Conversion*
- Measurement: **Density** in Kilogram per Cubic Meter (kg/m³) *Density Unit Conversion*
- Measurement: **Torque** in Newton Meter (N*m) *Torque Unit Conversion*

- L_i Inner Length of Hollow Rectangle *(Meter)*
- L_{rect} Length of Rectangular Section *(Meter)*
- L_{rod} Length of Rod *(Meter)*
- **M** Mass *(Kilogram)*
- M_c Moment of Couple *(Newton Meter)*
- M_{co} Mass of Cone *(Kilogram)*
- M_{cu} Mass of Cuboid *(Kilogram)*
- M_f Moment of force *(Newton Meter)*
- M_{rp} Mass of Rectangular Plate *(Kilogram)*
- M_{sc} Mass of Solid Cylinder *(Kilogram)*
- M_{ss} Mass of Solid Sphere *(Kilogram)*
- M_{tp} Mass of Triangle Plate *(Kilogram)*
- **r** Radius *(Meter)*
- **R** Resultant force *(Newton)*
- R_c Radius of Cone *(Meter)*
- R_{cyl} Cylinder Radius *(Meter)*
- $r_{F\text{-}F}$ Perpendicular Distance between Two Forces *(Meter)*
- r_{FP} Perpendicular Distance between Force and Point *(Meter)*
- R_{par} Parallel Resultant Force *(Newton)*
- R_s Radius of Sphere *(Meter)*
- r_{sc} Radius of semi circle *(Meter)*
- **t** Thickness *(Meter)*
- **w** Width *(Meter)*
- **α** Inclination of Resultant forces *(Degree)*
- **θ** Angle *(Degree)*
- **ρ** Density *(Kilogram per Cubic Meter)*

- Measurement: **Moment of Inertia** in Kilogram Square Meter (kg·m²)
  Moment of Inertia Unit Conversion
- Measurement: **Second Moment of Area** in Meter⁴ (m⁴)
  Second Moment of Area Unit Conversion

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