Plane and Solid Geometry Formulas

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Plane and Solid Geometry by RTFVerterra © October 2003

PLANE GEOMETRY

PLANE AREAS

Triangle

Given base b and altitude h
$$A = \tfrac{1}{2}bh$$

Given two sides a and b and included angle θ:
$$A = \tfrac{1}{2}ab\sin\theta$$

Given three sides a, b, and c (Hero's Formula):
$$A = \sqrt{s(s-a)(s-b)(s-c)}$$
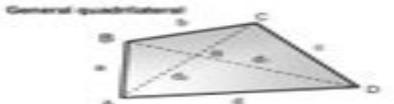$$s = \frac{a+b+c}{2}$$

The area under this condition can also be solved by finding one angle using cosine law and apply the formula for two sides and included angle.

Given three angles A, B, and C and one side a:
$$A = \frac{a^2 \sin B \sin C}{2\sin A}$$

The area under this condition can also be solved by finding one side using sine law and apply the formula for two sides and included angle.

Rectangle

Area, $A = ab$
Perimeter, $P = 2(a+b)$
Diagonal, $d = \sqrt{a^2 + b^2}$

Square

Area, $A = a^2$
Perimeter, $P = 4a$
Diagonal, $d = a\sqrt{2}$

General quadrilateral

Given diagonals d_1 and d_2 and included angle θ:
$$A = \tfrac{1}{2}d_1 \cdot d_2 \sin\theta$$

Given four sides a, b, c, d, and sum of two opposite angles:
$$A = \sqrt{(s-a)(s-b)(s-c)(s-d) - abcd\cos^2\theta}$$
$$s = \frac{a+b+c+d}{2}$$
$$\theta = \frac{\angle A + \angle C}{2} \text{ or } \theta = \frac{\angle B + \angle D}{2}$$

Given four sides a, b, c, d, and two opposite angles B and D:

Divide the area into two triangles.
$$A = \tfrac{1}{2}ab\sin B + \tfrac{1}{2}cd\sin D$$

Parallelogram

Given diagonals d_1 and d_2 and included angle θ:
$$A = \tfrac{1}{2}d_1 \cdot d_2 \sin\theta$$

Given two sides a and b and one angle A:
$$A = ab\sin A$$

Rhombus

Given diagonals d_1 and d_2:
$$A = \tfrac{1}{2}d_1 \cdot d_2$$

Given side a and one angle A:
$$A = a^2 \sin A$$

Trapezoid

$$A = \frac{a+b}{2}h$$

Cyclic Quadrilateral

A cyclic quadrilateral is a quadrilateral whose vertices lie on the circumference of a circle.

$$\angle A + \angle C = 180°$$
$$\angle B + \angle D = 180°$$
$$Area = \sqrt{(s-a)(s-b)(s-c)(s-d)}$$
$$s = \frac{a+b+c+d}{2}$$

Ptolemy's theorem

For any cyclic quadrilateral, the product of the diagonals equals the sum of the products of the opposite sides.
$$d_1 \cdot d_2 = ac + bd$$

POLYGONS

There are two basic types of polygons, a convex and a concave polygon. A convex polygon is one in which no side, when extended, will pass inside the polygon, otherwise it called concave polygon. The following figure is a convex polygon.

Polygons are classified according to the number of sides. The following are some names of polygons.

sides	name
3 sides	triangle
4 sides	quadrangle or quadrilateral
5 sides	pentagon
6 sides	hexagon
7 sides	heptagon or septagon
8 sides	octagon
9 sides	nonagon

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sides	name
10 sides	decagon
11 sides	undecagon
12 sides	dodecagon
15 sides	quindecagon
16 sides	hexadecagon

Sum of interior angles
The sum of interior angles θ of a polygon of n sides is:
$$Sum, \; \Sigma\theta = (n-2) \times 180°$$

Sum of exterior angles
The sum of exterior angles β is equal to 360°.
$$\Sigma\beta = 360°$$

Number of diagonals, D
The diagonal of a polygon is the line segment joining two non-adjacent sides. The number of diagonals is given by:
$$D = \frac{n}{2}(n-3)$$

Regular polygons

Polygons whose sides are equal are called equilateral polygons. Polygons with equal interior angles are called equiangular polygons. Polygons that are both equilateral and equiangular are called regular polygons. The area of a regular polygon can be found by considering one segment, which has the form of an isosceles triangle.

- a = side
- θ = angle subtended by the side from the center
- R = radius of circumscribing circle
- r = radius of inscribed circle, also called the apothem
- n = number of sides

$$\theta = 360°/n$$
$$Area, \; A = \tfrac{1}{2}R^2 \sin\theta \times n = \tfrac{1}{2}xr \times n$$
$$Perimeter, \; P = n \times a$$
$$Interior\ angle = \frac{n-2}{n} \times 180°$$
$$Exterior\ angle = 360°/n$$

Circle

$$Circumference = 2\pi r = \pi D$$
$$Area, \; A = \pi r^2 = \frac{\pi}{4}D^2$$

Sector of a circle

$$Arc, \; C = r\cdot r = \theta_{radians} = \frac{\pi \theta}{180°}$$
$$Area = \tfrac{1}{2}r^2 \theta_{radians} = \frac{\pi r^2 \theta}{360°}$$
$$Area = \tfrac{1}{2}C \times r$$

Note: 1 radian is the angle θ such that C = r.

Segment of a circle

$$Area = A_{sector} - A_{triangle}$$
$$Area = \tfrac{1}{2}r^2\theta - \tfrac{1}{2}r^2 \sin\theta$$
$$Area = \tfrac{1}{2}r^2(\theta - \sin\theta)$$

θ = angle in radians.

$$Area = A_{sector} + A_{triangle}$$
$$Area = \tfrac{1}{2}r^2\theta + \tfrac{1}{2}r^2 \sin\theta$$
$$Area = \tfrac{1}{2}r^2(\theta + \sin\theta)$$

Parabolic segment

$$Area = \frac{2}{3}bh$$

Ellipse

$$Area = \pi a b$$
Perimeter, P
$$P = 2\pi \sqrt{\frac{a^2 + b^2}{2}}$$

RADIUS OF CIRCLES

Circle circumscribed about a triangle (Circumcircle)

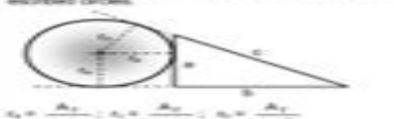A circle is circumscribed about a triangle if it passes through the vertices of the triangle.

$$r = \frac{abc}{4A_t}$$

A_t = area of the triangle

Circle inscribed in a triangle (Incircle)
A circle is inscribed in a triangle if it is tangent to the three sides of the triangle.

$$r = \frac{A_t}{s}$$
$$s = \tfrac{1}{2}(a+b+c)$$

Circles escribed about a triangle (Excircles)

A circle is escribed about a triangle if it is tangent to one side and to the prolongation of the other two sides. A triangle has three escribed circles.

$$r_a = \frac{A_t}{s-a}; \; r_b = \frac{A_t}{s-b}; \; r_c = \frac{A_t}{s-c}$$

Circle circumscribed about a quadrilateral

A circle is circumscribed about a quadrilateral if it passes through the vertices of the quadrilateral.

$$r = \frac{\sqrt{(ab+cd)(ac+bd)(ad+bc)}}{4A_{quad}}$$
$$A_{quad} = \sqrt{(s-a)(s-b)(s-c)(s-d)}$$
$$s = \tfrac{1}{2}(a+b+c+d)$$

Circle inscribed in a quadrilateral

A circle is inscribed in a quadrilateral if it is tangent to the three sides of the quadrilateral.

$$r = \frac{A_{quad}}{s}; \quad s = \tfrac{1}{2}(a+b+c+d)$$
$$A_{quad} = \sqrt{abcd}$$

SOLID GEOMETRY

POLYHEDRONS

A polyhedron is a closed solid whose faces are polygons.

PRISM

A prism is a polyhedron whose bases are equal polygons in parallel planes and whose sides are parallelograms.

Prisms are classified according to their bases. Thus, a hexagonal prism is one whose base is a...

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