

Trigonometry

Sides and Angles of a Triangle

Basics of a Triangle

What is a Triangle?

- A **triangle** is a polygon with **three sides and three angles**. The sum of the internal angles of any triangle is always:

$$\angle A + \angle B + \angle C = 180^\circ$$

Each triangle has:

- **Three sides** (denoted as a, b, c)
- **Three angles** (denoted as A, B, C)
 - Angle A is opposite side a
 - Angle B is opposite side b
 - Angle C is opposite side c

Classification of Triangles

A. Based on Sides

- **Equilateral Triangle**: All three sides are equal and all angles are 60° .
- **Isosceles Triangle**: Two sides are equal; base angles are equal.
- **Scalene Triangle**: All three sides and all three angles are different.

B. Based on Angles

- **Acute Triangle**: All angles are less than 90° .
- **Right Triangle**: One angle is exactly 90° .
- **Obtuse Triangle**: One angle is greater than 90° .
- In trigonometry, we often focus especially on **right triangles**, but general triangles are also addressed through special rules and laws.

Elements of a Triangle

- Let's denote a triangle as $\triangle ABC$ with corresponding sides:
 - Side a : opposite angle A
 - Side b : opposite angle B
 - Side c : opposite angle C
- Key elements:

- **Angle:** The amount of rotation between two intersecting sides.
- **Side:** The length of the segment connecting two vertices.
- **Height (Altitude):** Perpendicular segment from a vertex to the opposite side.
- **Base:** Usually referred to one side (commonly side b) used as a reference.

Angle Notation and Measurement

- Angles can be measured in:
 - **Degrees ($^{\circ}$):** 360° in a full circle.
 - **Radians:** π radians = 180° .
- Conversion:

$$\text{Radians} = \frac{\pi}{180} \times \text{Degrees}$$

Basic Trigonometric Ratios (Right-Angled Triangle)

- For a right triangle with angle θ , and sides defined as:
 - **Hypotenuse:** Side opposite the right angle (longest side).
 - **Opposite:** Side opposite the angle θ .
 - **Adjacent:** Side next to angle θ (not hypotenuse).
- Then the **basic trigonometric ratios** are:

Ratio	Definition	Formula
Sine ($\sin \theta$)	Opposite to Hypotenuse	$\frac{\text{Opposite}}{\text{Hypotenuse}}$
Cosine ($\cos \theta$)	Adjacent to Hypotenuse	$\frac{\text{Adjacent}}{\text{Hypotenuse}}$
Tangent ($\tan \theta$)	Opposite to Adjacent	$\frac{\text{Opposite}}{\text{Adjacent}}$

- **Reciprocal Ratios:**

Ratio	Formula
Cosecant ($\csc \theta$)	$\frac{1}{\sin \theta} = \frac{\text{Hypotenuse}}{\text{Opposite}}$
Secant ($\sec \theta$)	$\frac{1}{\cos \theta} = \frac{\text{Hypotenuse}}{\text{Adjacent}}$
Cotangent ($\cot \theta$)	$\frac{1}{\tan \theta} = \frac{\text{Adjacent}}{\text{Opposite}}$

Pythagoras Theorem (Right Triangle Only)

$$\text{Hypotenuse}^2 = \text{Opposite}^2 + \text{Adjacent}^2$$

$$c^2 = a^2 + b^2$$

- This fundamental relationship is used to find unknown sides in right-angled triangles.

Trigonometric Identities

- These are universally true expressions involving trigonometric ratios:

1. Pythagorean Identity:

$$\sin^2 \theta + \cos^2 \theta = 1$$

2. From this, we derive:

$$1 + \tan^2 \theta = \sec^2 \theta$$

$$1 + \cot^2 \theta = \csc^2 \theta$$

Angle Relationships and Quadrants

Complementary Angles:

$$\sin(90^\circ - \theta) = \cos \theta, \cos(90^\circ - \theta) = \sin \theta$$

Supplementary Angles:

$$\sin(180^\circ - \theta) = \sin \theta, \cos(180^\circ - \theta) = -\cos \theta$$

ASTC Rule (All Students Take Calculus):

- In the 1st Quadrant: All ratios are positive.
- In the 2nd Quadrant: Only sine and cosecant are positive.
- In the 3rd Quadrant: Only tangent and cotangent are positive.
- In the 4th Quadrant: Only cosine and secant are positive.

Trigonometric Ratios of Standard Angles

Angle	sin	cos	tan
0°	0	1	0
30°	1/2	$\sqrt{3}/2$	$1/\sqrt{3}$
45°	$\sqrt{2}/2$	$\sqrt{2}/2$	1
60°	$\sqrt{3}/2$	1/2	$\sqrt{3}$
90°	1	0	Undefined

- These values are foundational for solving triangles efficiently.

Definition of a Triangle

- A triangle is a closed figure made up of three sides and three angles.
- The sum of the internal angles of any triangle is always 180 degrees.

Types of triangles (based on angles):

- **Acute Triangle:** All angles $< 90^\circ$
- **Right Triangle:** One angle $= 90^\circ$
- **Obtuse Triangle:** One angle $> 90^\circ$

Types of triangles (based on sides):

- **Equilateral Triangle:** All sides equal, all angles $= 60^\circ$
- **Isosceles Triangle:** Two sides equal
- **Scalene Triangle:** All sides different

Basic Trigonometric Ratios (Right-Angled Triangle)

- Let's consider a **right triangle** with:
 - Angle θ
 - Hypotenuse = longest side (opposite the right angle)
 - Opposite = side opposite to θ
 - Adjacent = side next to θ (not the hypotenuse)
- The **primary trigonometric ratios** are:

Ratio Name	Formula	Description
Sine ($\sin \theta$)	$\frac{\text{Opposite}}{\text{Hypotenuse}}$	Ratio of opposite side to hypotenuse
Cosine ($\cos \theta$)	$\frac{\text{Adjacent}}{\text{Hypotenuse}}$	Ratio of adjacent side to hypotenuse
Tangent ($\tan \theta$)	$\frac{\text{Opposite}}{\text{Adjacent}}$	Ratio of opposite side to adjacent

- There are also **reciprocal ratios**:

Ratio Name	Formula	Reciprocal Of
Cosecant ($\csc \theta$)	$\frac{1}{\sin \theta}$	Sine
Secant ($\sec \theta$)	$\frac{1}{\cos \theta}$	Cosine
Cotangent ($\cot \theta$)	$\frac{1}{\tan \theta}$	Tangent



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