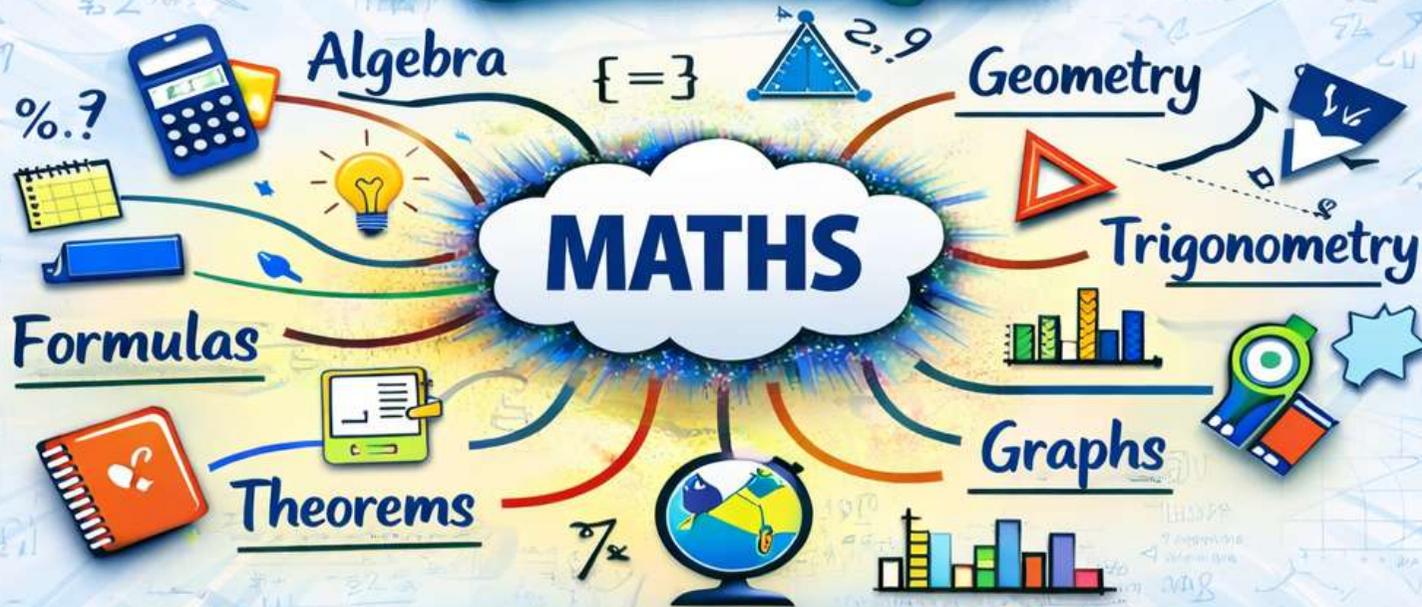


From the author of *Mathmission* series books

# MATHEMATICS

## CLASS 10

### Mind Maps



**O.P. GUPTA**

Indira Award Winner

# REAL NUMBERS

## Fundamental Theorem of Arithmetic (FTA)

Every composite number can be expressed (factorized) uniquely as a product of prime numbers except for order.

☑ Applications :

- Prime factorization
- Finding HCF and LCM

## Applications of HCF and LCM

- HCF : Greatest number dividing two or more numbers
- LCM : Smallest number divisible by two or more numbers
- Relationship :  $\text{HCF}(a, b) \times \text{LCM}(a, b) = a \times b$
- Real life application based word problems on grouping or periodic events, time

- HCF = Product of common prime factors with lowest exponents
- LCM = Product of all prime factors with highest exponents
- HCF is the divisor of LCM.
- HCF of two coprime numbers is always 1.
- LCM of two coprime numbers is equal to the product of those two numbers.

**Check whether  $a^n$  can end with the digit 0, where 'a' and 'n' are any natural numbers?**

- For  $a^n$  to end with the digit 0, the prime factorization of 'a' must include '2' and '5' both.

## Type of Numbers (Number System)

- Natural numbers (**N**) : 1, 2, 3, ...
- Whole numbers (**W**) : 0, 1, 2, 3, ...
- Integers (**Z**) : 0,  $\pm 1$ ,  $\pm 2$ ,  $\pm 3$ , ...
- Rational numbers (**Q**) :  $\frac{7}{5}$ ,  $-\frac{1}{4}$ ,  $\frac{13}{19}$ , 9 i.e.,  $\frac{9}{1}$ ,  $\frac{16}{3}$ , ...
- Irrational numbers (**T**) :  $\sqrt{3}$ ,  $1 - \sqrt{7}$ ,  $4\sqrt{2}$ ,  $2 + 3\sqrt{5}$ ,  $\frac{\sqrt{11}}{5}$ , e, 0.1212212221..., 0.030030003..., etc.
- Real numbers (**R**) : -3, 0, 1, 2,  $-\frac{1}{5}$ ,  $\frac{6}{11}$ ,  $\sqrt{7}$  etc.

## Revisiting Irrational Numbers

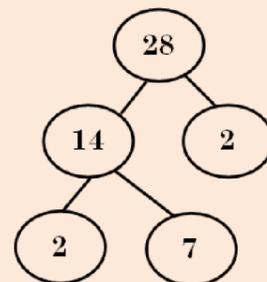
**Def.** Irrational numbers cannot be expressed as a ratio of two integers i.e., they cannot be written in the form of  $\frac{p}{q}$ ,  $q \neq 0$ . Irrational numbers are non-terminating and have non-repeating decimal expansion.

Examples:  $\sqrt{2}$ ,  $\sqrt{3}$ ,  $5 - 2\sqrt{7}$ ,  $\pi$  etc.

## Proof of irrationality

- Prove that  $\sqrt{3}$  is irrational.
- Prove that  $3 - 5\sqrt{11}$  is irrational.
- If  $\sqrt{2}$  is given as an irrational number, then prove that  $(5 - 2\sqrt{2})$  is an irrational number.

## Factor Tree



**Def.** A factor tree is a visual method of representing the prime factorization of a number by expressing it as a product of prime numbers. Refer the adjacent figure which illustrates the prime factorization of 28.

Clearly,  $28 = 2 \times 2 \times 7$

**Prime numbers** : A prime number is a natural number greater than 1 that has exactly two distinct positive divisors, 1 and the number itself.

In other words, we can say a prime number can be divided only by 1 and itself, not by any other number.

- 2 is the only even prime number.
- 1 is NOT a prime number.

**Coprime numbers** : Two numbers are said to be coprime (or relatively prime) if their HCF is 1. Coprime numbers do not have any common factor other than 1.

- **Terminating rational numbers** :  $\frac{1}{2}$  i.e., 0.5,  $\frac{71}{100}$  i.e., 0.71 etc.

- **Non-terminating rational numbers with the repeating decimal expansion** :  $\frac{1}{3}$  i.e., 0.333..., 0.4232323... etc.

- **Irrational numbers with Non-Terminating and Non-Repeating Decimal expansion** : 0.101001000100001..., 1.1101001000100001... etc.



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# POLYNOMIALS

## General form of a polynomial

A polynomial is defined as an algebraic expression of the following form

$$p(x) = a_0 + a_1x^1 + a_2x^2 + a_3x^3 + \dots + a_nx^n, a_n \neq 0,$$

where all the exponents (i.e., powers) are non-negative integers and  $a_0, a_1, a_2, \dots, a_n$  are real nos. (s.t.  $a_n \neq 0$ ).

## Type of Polynomials & their standard forms

- Constant :  $p(x) = c$ , where  $c$  is any non-zero real no.
- Zero :  $p(x) = 0$  (sometimes treated as a special case of constant polynomial)
- Linear :  $p(x) = ax + b, a \neq 0$
- Quadratic :  $p(x) = ax^2 + bx + c, a \neq 0$
- Cubic :  $p(x) = ax^3 + bx^2 + cx + d, a \neq 0$
- Biquadratic :  $p(x) = ax^4 + bx^3 + cx^2 + dx + e, a \neq 0$
- Quintic :  $p(x) = ax^5 + bx^4 + cx^3 + dx^2 + ex + f, a \neq 0$

For a quadratic polynomial,  $p(x) = ax^2 + bx + c, a \neq 0$

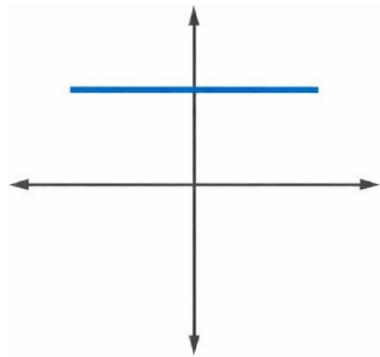
- Sum of zeroes (S) :  $-\frac{b}{a}$
- Product of zeroes (P) :  $\frac{c}{a}$

## Forming a quadratic polynomial

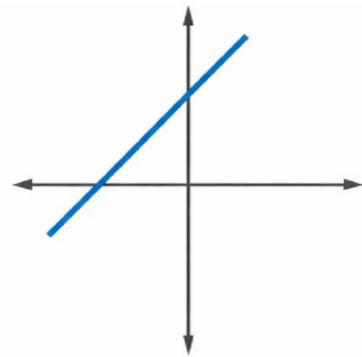
$x^2 - Sx + P$  or  $k(x^2 - Sx + P)$  where  $k$  is any non-zero real number.

**Note that,** S : Sum of zeroes of quadratic polynomial and P : Product of zeroes of quadratic polynomial

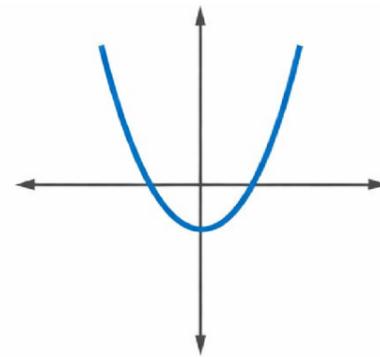
Constant polynomial, degree : 0



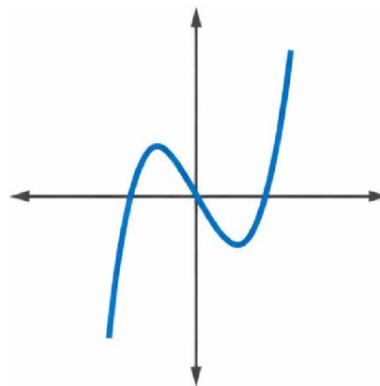
Linear polynomial, degree : 1



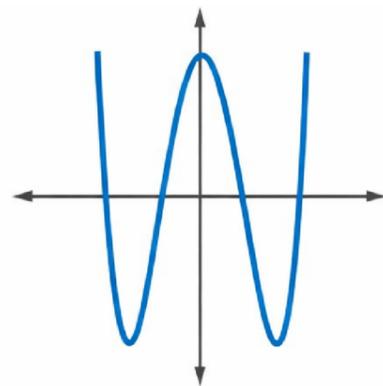
Quadratic polynomial, degree : 2



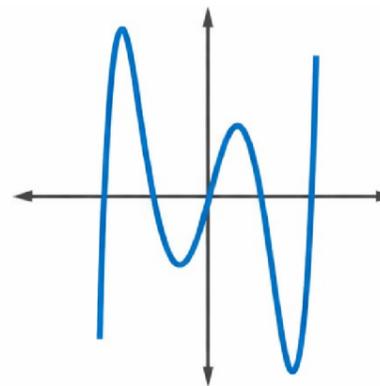
Cubic polynomial, degree : 3



Biquadratic polynomial, degree : 4



Quintic polynomial, degree : 5



## Algebraic Identities

- $(a \pm b)^2 = a^2 \pm 2ab + b^2$
- $a^2 - b^2 = (a + b)(a - b)$
- $(a \pm b)^3 = a^3 \pm 3ab(a \pm b) \pm b^3$

**Note that,**  $a^2 + b^2 = (a + b)^2 - 2ab$ ,  $(a + b)^4 = [(a + b)^2]^2$ ,  $(a + b)^6 = [(a + b)^3]^2$  etc.

## Nature of biquadratic polynomial

**Degree :** 4

**Graph :** W-shaped or U-shaped

**No. of zeroes :** Four zeroes (at most four *real* zeroes), cuts x-axis at four points on graph in the case of *all* real zeroes

## Nature of cubic polynomial

**Degree :** 3

**Graph :** Inverted S-shaped

**No. of zeroes :** Three zeroes (at most three *real* zeroes), cuts x-axis thrice on graph in the case of *all* real zeroes

## Nature of quadratic polynomial

**Degree :** 2

**Graph :** Parabolic

**No. of zeroes :** Two zeroes (at most two *real* zeroes), cuts x-axis twice on graph in the case of *all* real zeroes

## Nature of linear polynomial

**Degree :** 1

**Graph :** Straight line

**No. of zeroes :** One *real* zero, cuts x-axis once on graph

## Nature of zero polynomial

**Degree :** Not defined

**Graph :** Coincident on x-axis (i.e., x-axis itself)

**No. of zeroes :** Infinitely many zeroes

## Nature of constant polynomial

**Degree :** 0

**Graph :** Straight line parallel to x-axis

**No. of zeroes :** No zeroes (0 count of zeroes)



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# PAIR OF LINEAR EQUATIONS IN TWO VARIABLES

## Word Problems (Applications based problems)

- We normally find problems based on
- Numbers
  - Ages
  - Geometry
  - Money
  - Speed, distance & time

**Def.** A pair of linear equations in two variables is a set of **two equations**, each of **degree 1**, involving the **same two variables** (usually x and y).

✪ General form :  $a_1x + b_1y + c_1 = 0$ ,  $a_2x + b_2y + c_2 = 0$ , where  $a_1, b_1, a_2, b_2 \neq 0$  and  $a_1, b_1, c_1, a_2, b_2, c_2$  are real nos.

## How to solve the given system of linear equations in two variables?

### Graphical method

In this method, we draw the graphs of both equations on the same Cartesian plane. The **point of intersection** gives the solution (x, y).

#### Important points to note :

- Intersecting lines → one solution
- Coincident lines → infinitely many solutions
- Parallel lines → no solution

### Algebraic method

#### I. Substitution method

1. Express one variable in terms of the other from one equation
2. Substitute this expression (obtained above) into the second equation
3. Solve for one variable
4. Substitute the obtained value of one variable back into any one equation to find the value of other variable

#### II. Elimination method

1. Make the coefficients of one variable equal in both equations
2. Add or subtract the equations to eliminate one variable
3. Solve the resulting equation to get value of one variable
4. Substitute the obtained value of one variable into any one equation to get the value of second variable

## Conditions of Consistency and inconsistency of the pair of lines / Graphical representation

Pair of Equations	Comparing the Ratio	Graphical meaning	Algebraic Interpretations
$a_1x + b_1y + c_1 = 0$ and $a_2x + b_2y + c_2 = 0$	$\frac{a_1}{a_2} \neq \frac{b_1}{b_2}$	Intersecting Lines 	Unique Solution (Consistent system)
	$\frac{a_1}{a_2} = \frac{b_1}{b_2} = \frac{c_1}{c_2}$	Coincident Lines 	Infinitely Many Solutions (Consistent system)
	$\frac{a_1}{a_2} = \frac{b_1}{b_2} \neq \frac{c_1}{c_2}$	Parallel Lines 	No Solution (Inconsistent system)

### Special case when Coefficient of x and y are interchanged in the two equations

Consider the two equations as  $ax + by = m$  and  $bx + ay = n$ .

Now do as per the following steps.

1. Add the two equations to obtain  $(a + b)x + (b + a)y = m + n$   
 $\Rightarrow (a + b)(x + y) = m + n$   
 $\Rightarrow x + y = \frac{m + n}{a + b} \quad \dots(i)$
2. Subtract the second equation from the first equation to obtain  $(a - b)x + (b - a)y = m - n$   
 $\Rightarrow (a - b)(x - y) = m - n$   
 $\Rightarrow x - y = \frac{m - n}{a - b} \quad \dots(ii)$
3. Add (i) and (ii) to obtain the value of x and then subtract (ii) from (i) to obtain value of y.

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# QUADRATIC EQUATIONS

For a quadratic equation,  $ax^2 + bx + c = 0$ ,  $a \neq 0$

- Sum of roots (S) :  $-\frac{b}{a}$
- Product of roots (P) :  $\frac{c}{a}$

**Forming a quadratic equation**

$x^2 - Sx + P = 0$  or  $k(x^2 - Sx + P) = 0$  where  $k$  is any non-zero real number.

**Note that**, S : Sum of roots of quadratic equation and P : Product of roots of quadratic equation

**Word Problems (Applications based problems)**

We normally find problems based on

- Numbers
- Ages
- Geometry
- Speed, distance & time

**General form of a Quadratic equation**

An equation of the form  $ax^2 + bx + c = 0$ , where  $a$ ,  $b$  and  $c$  are real numbers such that  $a \neq 0$  is called a quadratic equation.

**Solutions (roots) of a quadratic equation**

Since  $ax^2 + bx + c = 0$  is of degree 2, so it shall have two roots (including real and/or imaginary roots). Let  $x = \alpha$  and  $x = \beta$  be the roots of given quadratic equation  $ax^2 + bx + c = 0$ ,  $a \neq 0$ . Then we shall have  $a\alpha^2 + b\alpha + c = 0$  and  $a\beta^2 + b\beta + c = 0$ .

**Methods of solving quadratic equations**

**(a) Factorization method:**

Firstly factorize  $ax^2 + bx + c = 0$ ,  $a \neq 0$  into a product of two linear factors say  $(x - \alpha)(x - \beta) = 0$  by splitting the middle term. Then equate each factor to zero and get the values of  $x$  as  $x = \alpha$  and  $x = \beta$ . These values of  $x$  (i.e.,  $\alpha$  and  $\beta$ ) are called **roots of the given quadratic equation**.

**(b) Quadratic formula method or Discriminant method:**

Obtain the discriminant (D) of quadratic equation  $ax^2 + bx + c = 0$ ,  $a \neq 0$  that is,  $D = b^2 - 4ac$ . Then the roots of the given quadratic equation are  $\frac{-b + \sqrt{D}}{2a}$  and  $\frac{-b - \sqrt{D}}{2a}$  (i.e.,  $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ ).

The Quadratic formula method is also called **Sridharacharya method**, after the name of famous Indian mathematician Sridhara (or, Sridharacharya) who derived this formula.

**Discriminant and nature of roots of quadratic equation  $ax^2 + bx + c = 0$ ,  $a \neq 0$**

We calculate  $b^2 - 4ac$ , which is called Discriminant (D). The discriminant (D) helps us in deciding the **nature of roots** of the quadratic equation without actually solving it. Thus a quadratic equation  $ax^2 + bx + c = 0$  has

- *real solutions if  $D \geq 0$ .*
- *two distinct real roots if  $D > 0$ .*
- *two equal and real roots if  $D = 0$ .*
- *no real roots if  $D < 0$ .*

**Note** that, the equal roots of quadratic equation are also known as the **Coincident roots**.

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# ARITHMETIC PROGRESSION

## Properties of A.P.

- (a) If the same number is added to, or subtracted from, all the terms of an A.P. then the resulting progression is also an A.P. with the **same common difference** as that of the original A.P.
- (b) If the corresponding terms of two Arithmetic progressions be added or subtracted, the resulting progression is also an A.P. with common difference  $d_1 + d_2$  or  $d_1 - d_2$  (or,  $d_2 - d_1$ ) as the case may be of addition or subtraction of arithmetic progressions respectively.
- (c) If all the terms of an A.P. be multiplied or divided by the same quantity (non-zero number), the resulting progression is also an A.P. with common difference  $kd$  or  $\frac{d}{k}$  as the case may be of multiplication or division respectively.

- If  $a, b, c$  are in A.P., then  $2b = a + c$  i.e.,  $b = \frac{a+c}{2}$ .  
Also the number 'b' is called the **Arithmetic Mean (A.M.)** between  $a$  and  $c$ .
- Any three numbers in A.P. can be considered as:  $a - d, a, a + d$ .
- Any four numbers in A.P. can be considered as:  $a - 3d, a - d, a + d, a + 3d$ .
- Any five numbers in A.P. can be considered as:  $a - 2d, a - d, a, a + d, a + 2d$ .

## Def. of Arithmetic Progression

A succession of numbers is said to be in A.P. if the difference between any term and the term preceding it is constant throughout. That is, an A.P. is a sequence in which the difference between consecutive terms is constant. This constant is called as the **Common difference** of the arithmetic progression (A.P.) and is represented by the lower case letter 'd'.

Thus, if  $a_1, a_2, a_3, \dots, a_n$  represent the  $n$  terms of an A.P., then  $a_2 - a_1 = a_3 - a_2 = \dots = a_n - a_{n-1}$ . Also, the number obtained by  $a_2 - a_1$  or  $a_3 - a_2$  i.e.,  $a_n - a_{n-1}$  is called the common difference (denoted by 'd').

Thus,  $d = a_2 - a_1$ , and in general  $d = a_n - a_{n-1}$ .

Clearly, the general form of an A.P. can be written as  $a, a + d, a + 2d, a + 3d, \dots$

- $a$  : first term,  $d$  : common difference of A.P.

## Sum of $n$ terms of A.P. ( $S_n$ )

Consider  $a_1, a_2, a_3, \dots, a_n$  represent an A.P. with  $n$  terms. Let  $S_n = a_1 + a_2 + a_3 + \dots + a_n$ . Then the sum of  $n$  terms of A.P. will be given by

- $S_n = \frac{n}{2} [2a + (n-1)d]$
- $S_n = \frac{n}{2} (a + a_n) = \frac{n}{2} (\text{first term} + \text{last term})$

## Important points to note :

- Expression involving sum of  $n$  terms of an A.P. is always **quadratic**.
- $S_1 = a_1$
- $a_n = S_n - S_{n-1}$
- $S_n = 1 + 2 + 3 + \dots + n = \frac{n(n+1)}{2}$   
= Sum of first  $n$  natural numbers

## General term i.e., $n^{\text{th}}$ term of A.P.

If an A.P. has  $n$  terms with first term 'a' and the common difference 'd', then its  $n^{\text{th}}$  term is given as  $a_n = a + (n-1)d$ . Remember that  $a_n$  is called the **last term** and  $n^{\text{th}}$  term of the A.P. as well.

## Important points to note :

- Expression involving  $n^{\text{th}}$  term of an A.P. is always **linear**.

## $p^{\text{th}}$ term of an A.P. from the end

Consider an A.P. having  $n$  terms with first term and common difference as 'a' and 'd' respectively. Then,  $p^{\text{th}}$  term from end =  $(n - p + 1)^{\text{th}}$  term from beginning.

Hence,  $a_{n-p+1} = a + ((n - p + 1) - 1)d = a + (n - p)d$ .

Further,  $p^{\text{th}}$  term from end =  $a_n + (p-1)(-d)$ .

Also we can **use the following algorithm** too to find the  $p^{\text{th}}$  term of an A.P. from end.

**STEP 1** Consider the given A.P. as  $a_1, a_2, a_3, \dots, a_n$ .

**STEP 2** Reverse the A.P. to obtain a new A.P. as  $a_n, a_{n-1}, a_{n-2}, \dots, a_2, a_1$ .

**STEP 3** Now consider  $a_n$  as the first term of this newly obtained A.P. with  $d = a_{n-1} - a_n$ .

**STEP 4** Find  $p^{\text{th}}$  term from the beginning of this new A.P. This will give the  $p^{\text{th}}$  term from the end for the original arithmetic progression.

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# TRIANGLES

## Pythagoras Theorem

In a right-angled triangle (i.e., one angle is of  $90^\circ$ ), we always have  $(\text{Hypotenuse})^2 = (\text{Base})^2 + (\text{Perpendicular})^2$ .

## Converse of Pythagoras Theorem

If  $(\text{Longest side})^2 = \text{Sum of squares of other two sides}$ , then the triangle is right-angled.

## Ratio of Corresponding Sides in Similar Triangles

If two triangles are **similar**, then **all their corresponding linear dimensions are in the same ratio**. That is, in two similar triangles, the **ratio of corresponding sides is equal** to the ratio of their

- corresponding medians
- corresponding altitudes
- corresponding angle bisectors

### Explanation :

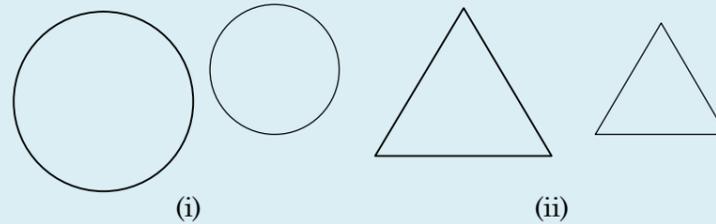
Let  $\triangle ABC \sim \triangle DEF$ , then  $\frac{AB}{DE} = \frac{BC}{EF} = \frac{CA}{FD}$ .

- 1. Ratio of medians :** If AM and DN are medians of  $\triangle ABC$  and  $\triangle DEF$  respectively, then  $\frac{AM}{DN} = \frac{AB}{DE}$ .
- 2. Ratio of altitudes :** If AL and DP are altitudes of  $\triangle ABC$  and  $\triangle DEF$  respectively, then  $\frac{AL}{DP} = \frac{AB}{DE}$ .
- 3. Ratio of angle bisectors :** If AQ and DR are angle bisectors of corresponding angles in  $\triangle ABC$  and  $\triangle DEF$  respectively, then  $\frac{AQ}{DR} = \frac{AB}{DE}$ .

**Note :** Above results can be used directly to answer the MCQs.

## Similar figures

If two figures are given, having the same shape but *not necessarily* the same size, then they are called the similar figures. Refer the following figures.



- All the congruent figures are similar but the converse is not necessarily true.
- Two polygons of the same number of sides are similar, if
  - (i) their corresponding angles are equal and
  - (ii) their corresponding sides are in same ratio.

## Thales Theorem i.e., Basic Proportionality Theorem (B. P. T.)

If a line is drawn parallel to one side of a triangle to intersect the other two sides in distinct points, the other two sides are divided in the same ratio.

☛ Proof is important.

## Converse of B. P. T. i.e., Converse of Thales Theorem

If a line divides any two sides of a triangle in the same ratio, then the line is parallel to the third side.

☛ Result is important (proof is not important).

## Important Applications

- Finding unknown sides
- Verifying similarity
- Finding heights and distances
- Solving real-life problems

## Common mistakes to avoid

- Mixing congruence and similarity
- Incorrect correspondence of sides

## Similar triangles

Two triangles are said to be similar, if

- their **corresponding angles are equal**
- their **corresponding sides are proportional** i.e., the **corresponding sides are in the same ratio**.

## Criterion for Similarity of triangles

### (a) A. A. A. Similarity (Angle-Angle-Angle) or A. A. Similarity (Angle-Angle)

If all three angles of one triangle are equal to the three angles of another triangle, then the triangles are similar i.e.,  $\triangle ABC \sim \triangle PQR$ , when  $\angle A = \angle P$ ,  $\angle B = \angle Q$  and  $\angle C = \angle R$ .

### Or, A. A. Similarity (Angle-Angle)

If two angles of one triangle are equal to two angles of another triangle, then the triangles are similar i.e.,  $\triangle ABC \sim \triangle PQR$ , when  $\angle A = \angle P$  and  $\angle B = \angle Q$ .

**Note :** If two angles in both triangles are same, then the third angle will also be same.

### (b) S. A. S. Similarity (Side-Angle-Side)

If the ratio of two sides is equal and included angle is equal, then the triangles are similar i.e.,  $\triangle ABC \sim \triangle PQR$ , when we

have  $\angle A = \angle P$  and  $\frac{AB}{PQ} = \frac{AC}{PR}$ .

### (c) S. S. S. Similarity (Side-Side-Side)

If the corresponding sides are proportional, then the triangles are similar i.e.,  $\triangle ABC \sim \triangle PQR$ , when we have

$\frac{AB}{PQ} = \frac{BC}{QR} = \frac{AC}{PR}$ .

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# COORDINATE GEOMETRY

## Cartesian Coordinate System

- X-axis (horizontal)
- Y-axis (vertical)
- Both axes intersect at **Origin (0, 0)**

## Coordinates of a Point is written as (x, y)

- x → Abscissa
- y → Ordinate

- ⊕ Y coordinate of any point on x-axis is 0 i.e., (x, 0).
- ⊕ X coordinate of any point on y-axis is 0 i.e., (0, y).

## Quadrants and sign conventions

Quadrant	Sign of x	Sign of y	Sign of (x, y)
Quadrant I	Positive	Positive	(+, +)
Quadrant II	Negative	Positive	(-, +)
Quadrant III	Negative	Negative	(-, -)
Quadrant IV	Positive	Negative	(+, -)

## Some useful facts

In order to prove that a given figure is

- an isosceles triangle, prove that its two sides are equal.
- an equilateral triangle, prove that all of its three sides are equal.
- a square, prove that the four sides are equal and the diagonals are also equal.
- a rhombus, prove that the four sides are equal.
- a rectangle, prove that the opposite sides are equal and the diagonals are also equal.
- a parallelogram, prove that the opposite sides are equal.
- a parallelogram but not a rectangle, prove that its opposite sides are equal but diagonals are not equal.
- a rhombus but not a square, prove that its all sides are equal but the diagonals are not equal.

## Section Formula

Consider a line segment PQ such that their coordinates are P(x<sub>1</sub>, y<sub>1</sub>) and Q(x<sub>2</sub>, y<sub>2</sub>).

Also assume that a point A(x, y) which lies somewhere in between PQ, then A must divide PQ in some ratio m : n say.



$$PA : QA = m : n$$

(Internal division)

$$\text{Then } A(x, y) = A\left(\frac{mx_2 + nx_1}{m+n}, \frac{my_2 + ny_1}{m+n}\right).$$

**Note :** If A is the **midpoint** of line-segment PQ, that implies A divides PQ in 1 : 1, then  $A\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right)$ .

## Distance Formula

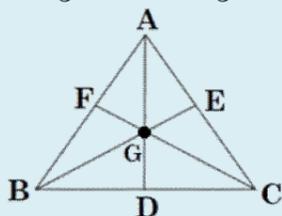
If points are A(x<sub>1</sub>, y<sub>1</sub>) and B(x<sub>2</sub>, y<sub>2</sub>), then the distance between the points A and B is,  $AB = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$ .

## Some Special Cases

- Distance of (x, y) from x-axis = |y|
- Distance of (x, y) from y-axis = |x|
- Distance of (x, y) from origin =  $\sqrt{x^2 + y^2}$

## Centroid (Centre of gravity)

It is the point of intersection of the medians of triangle. Let the coordinates of the  $\Delta ABC$  be A(x<sub>1</sub>, y<sub>1</sub>), B(x<sub>2</sub>, y<sub>2</sub>) and C(x<sub>3</sub>, y<sub>3</sub>). Then in order to locate the coordinates of the centroid, we use **section formula** with the fact that medians AD, BE and CF intersect at G (say) each other in the ratio 2 : 1. Hence,  $G\left(\frac{x_1 + x_2 + x_3}{3}, \frac{y_1 + y_2 + y_3}{3}\right)$  is the centroid of  $\Delta ABC$ .



## To prove three points as collinear

By collinear points we mean that they lie on the same line. Suppose three points under consideration are given as A(x<sub>1</sub>, y<sub>1</sub>), B(x<sub>2</sub>, y<sub>2</sub>) and C(x<sub>3</sub>, y<sub>3</sub>).

Then in order to prove that they are collinear we can do any of the followings.

- Prove that the sum of the distances between two pairs of points is equal to the third pair of points. That is  $AB + BC = AC$  or,  $AC + BC = AB$  or,  $AC + AB = BC$ .
- If B lies on AC, then it must divide AC in some ratio which can be found by the help of section formula. Similarly in cases of other points it can be checked if the point lies on the join of remaining two points.

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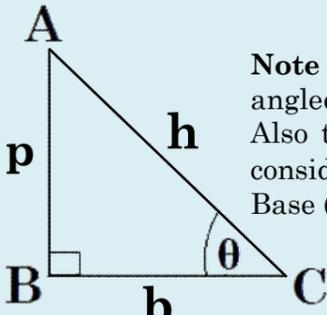
# INTRODUCTION TO TRIGONOMETRY

**Trigonometric ratios of Standard angles**

Angles T-Ratios	0°	30°	45°	60°	90°
sin	0	$\frac{1}{2}$	$\frac{1}{\sqrt{2}}$	$\frac{\sqrt{3}}{2}$	1
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{1}{\sqrt{2}}$	$\frac{1}{2}$	0
tan	0	$\frac{1}{\sqrt{3}}$	1	$\sqrt{3}$	Not defined
cosec	Not defined	2	$\sqrt{2}$	$\frac{2}{\sqrt{3}}$	1
sec	1	$\frac{2}{\sqrt{3}}$	$\sqrt{2}$	2	Not defined
cot	Not defined	$\sqrt{3}$	1	$\frac{1}{\sqrt{3}}$	0

- Common mistakes to avoid**
- Mixing up sin, cos, and tan ratios
  - Using Pythagoras identity incorrectly
  - Not identifying the right angle in triangle problems
  - Forgetting reciprocal identities, e.g.  $\sec \theta = \frac{1}{\cos \theta}$
  - Wrong values of trigonometric ratios for standard angles
  - Not writing the angles with trigonometric ratios, e.g.  $\sin^2 + \cos^2 = 1$ .

**Understanding a right angled triangle**  
Let  $\Delta ABC$  be a right angled triangle with  $\angle B = 90^\circ$ .  
Let  $\angle ACB = \theta$  (an acute angle);  $AB = \text{Perpendicular (p)}$ ,  $BC = \text{Base (b)}$  and,  $CA = \text{Hypotenuse (h)}$ .



**Note :** The longest side in the right angled triangle is Hypotenuse (h). Also the angle  $\theta$  (i.e., the angle in consideration) is always between the Base (b) and Hypotenuse (h).

**Pythagoras Theorem**  
In a right-angled triangle (i.e., one angle is of  $90^\circ$ ), we always have  $(\text{Hypotenuse})^2 = (\text{Base})^2 + (\text{Perpendicular})^2$ .  
That is,  $h^2 = b^2 + p^2$  for  $\Delta ABC$  shown above.

- Behavior of trigonometric ratios in a right angled triangle**
- As angle  $\theta$  increases from  $0^\circ$  to  $90^\circ$ , the value of  $\sin \theta$ ,  $\tan \theta$  and  $\sec \theta$  increases.
  - As angle  $\theta$  increases from  $0^\circ$  to  $90^\circ$ , the value of  $\cos \theta$ ,  $\cot \theta$  and  $\text{cosec} \theta$  decreases.

**Trigonometric Ratios of Complementary Angles**

- $\sin(90^\circ - \theta) = \cos \theta$  and  $\cos(90^\circ - \theta) = \sin \theta$
- $\tan(90^\circ - \theta) = \cot \theta$  and  $\cot(90^\circ - \theta) = \tan \theta$
- $\sec(90^\circ - \theta) = \text{cosec} \theta$  and  $\text{cosec}(90^\circ - \theta) = \sec \theta$

**Note :** This concept is **not** in syllabus for 2025-26, however if required, you may use these to answer the MCQs.

**Trigonometric ratios**  
Refer the  $\Delta ABC$  shown adjacent.

- $\sin \theta = \frac{AB}{CA} = \frac{p}{h}$
- $\cos \theta = \frac{BC}{CA} = \frac{b}{h}$
- $\tan \theta = \frac{AB}{BC} = \frac{p}{b}$
- $\text{cosec} \theta = \frac{CA}{AB} = \frac{h}{p}$
- $\sec \theta = \frac{CA}{BC} = \frac{h}{b}$
- $\cot \theta = \frac{BC}{AB} = \frac{b}{p}$

⚡ Note the following abbreviations which we prefer to use.

- Sine  $\rightarrow$  sin
- Cosine  $\rightarrow$  cos
- Tangent  $\rightarrow$  tan
- Cosecant  $\rightarrow$  cosec
- Secant  $\rightarrow$  sec
- Cotangent  $\rightarrow$  cot

**Relationship between trigonometric ratios**

(a)  $\text{cosec} \theta = \frac{1}{\sin \theta}$       (b)  $\sec \theta = \frac{1}{\cos \theta}$

(c)  $\tan \theta = \frac{\sin \theta}{\cos \theta}$       (d)  $\cot \theta = \frac{\cos \theta}{\sin \theta}$

(e)  $\tan \theta = \frac{1}{\cot \theta}$  or,  $\cot \theta = \frac{1}{\tan \theta}$

**Trigonometric Identities**

- $\sin^2 \theta + \cos^2 \theta = 1$
- $\sec^2 \theta = 1 + \tan^2 \theta$
- $\text{cosec}^2 \theta = 1 + \cot^2 \theta$



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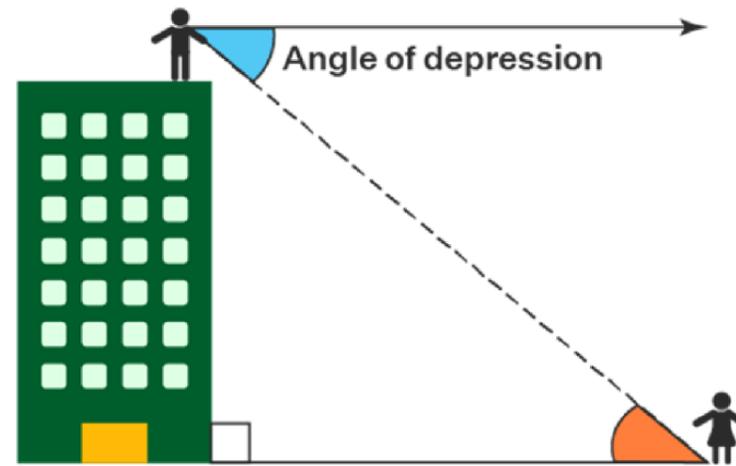
**SOME APPLICATIONS OF TRIGONOMETRY**

**Line of Sight**

- The line joining the **observer's eye** and the **object**
- Forms an angle with the horizontal

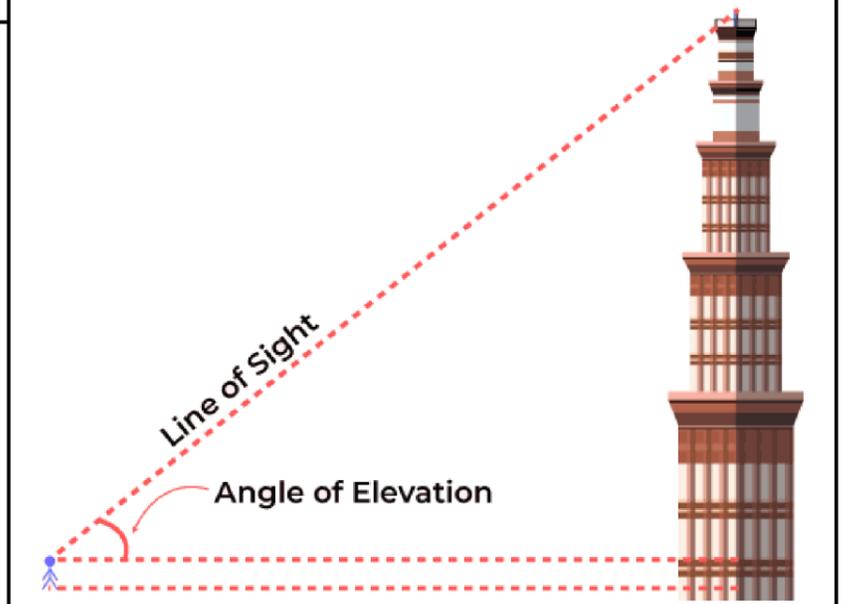
**Angle of Depression**

- Angle between the **line of sight** and the **horizontal**, when the object is **below** eye level
- For example: Looking down from the top of a building



**Angle of Elevation**

- Angle between the **line of sight** and the **horizontal**, when the object is **above** eye level
- For example: Looking at the top of a tower



**Steps to solve problems**

1. Draw a **neat labelled diagram**
2. Identify angle (elevation / depression)
3. Choose suitable **trigonometric ratio**
4. Substitute correct values of trigonometric ratios
5. Solve and write **units**

**Right-angled triangle formation**

- Horizontal line through the observer's eye
- Vertical object (tower, tree, building, hill)
- Perpendicular dropped from the object to the ground

**Most commonly used trigonometric ratios**

- $\tan \theta = \frac{\text{Height}}{\text{Distance}}$
- $\sin \theta = \frac{\text{Height}}{\text{Slant distance}}$
- $\cos \theta = \frac{\text{Distance}}{\text{Slant distance}}$

**Common mistakes to avoid**

- Confusing elevation and depression
- Ignoring height of observer
- Using wrong trigonometric ratio
- Missing units in final answer

**Important tips for the board exams**

- Draw a neat and labelled diagram
- Approximation only if required
- Use standard trigonometric values only
- Memorize  $\sqrt{2} = 1.414$ ,  $\sqrt{3} = 1.732$ ,  $\sqrt{5} = 2.236$

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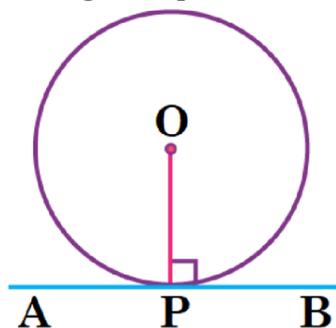


# CIRCLES

## Theorems on Tangents

### Theorem 1

The tangent at any point of a circle is perpendicular to the radius through the point of contact.

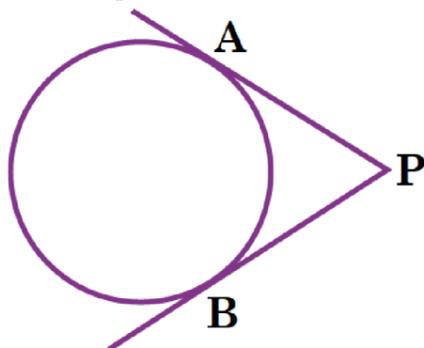


That is,  $OP \perp AB$

☛ Proof is important.

### Theorem 2

The lengths of tangents drawn from an external point to a circle are equal.



That is,  $PA = PB$

☛ Proof is important.

## Basic introduction

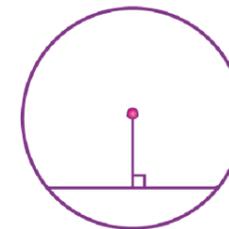
- A **circle** is the set of all points in a plane at a fixed distance from a fixed point
- Fixed point → **Centre**
- Fixed distance → **Radius**
- **Radius (r)** : Distance from centre to any point on the circle
- **Diameter (2r)** : Longest chord of the circle, passes through centre
- **Chord** : Line segment joining any two points on the circle
- **Arc** : Part of the circumference
- **Circumference** : Perimeter of the circle
- **Secant** : A line intersecting the circle at **two points**
- **Tangent** : A line which touches the circle at **exactly one point**, this point is called **Point of contact**

## Important tips for exams

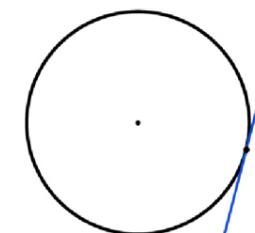
- Draw neat, labelled diagrams
- Mention theorem in problems
- Identify the point of contact accurately

## Important facts

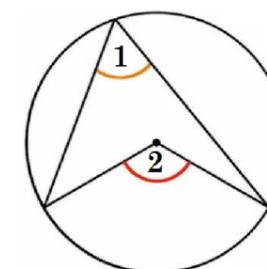
- A perpendicular from centre bisects the chord into two equal parts.



- Only one tangent can pass through a point on the circle



- The angle subtended by an arc at the centre of a circle is **twice** the angle subtended at any point on the circumference



That is,  $\angle 2 = 2\angle 1$

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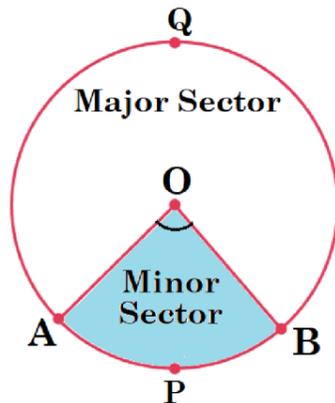


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# AREAS RELATED TO CIRCLES

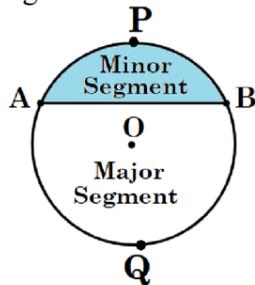
## Sector of a circle

It is that portion or part of the circle which is enclosed by two radii and the corresponding arc.



## Segment of a circle

It is that portion of the circle which is enclosed between a chord and the corresponding arc.

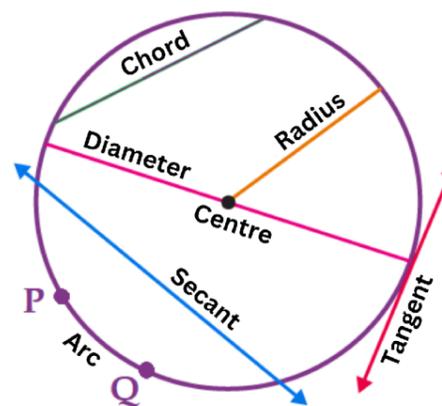


In a clock, the

- Angle made by minute-hand in 1 minute =  $6^\circ$
- Angle made by hour-hand in 1 minute =  $0.5^\circ$

## Basic introduction

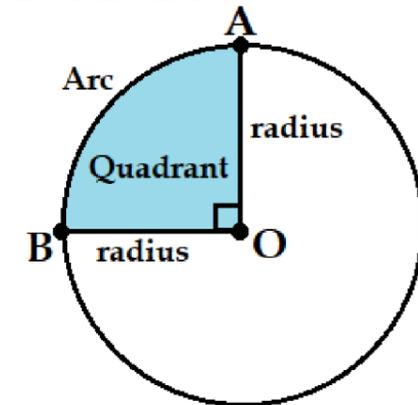
- A **circle** is the set of all points in a plane at a fixed distance from a fixed point
- Fixed point → **Centre**
- Fixed distance → **Radius**
- **Radius (r)** : Distance from centre to any point on the circle
- **Diameter (2r)** : Longest chord of the circle, passes through centre
- **Chord** : Line segment joining any two points on the circle
- **Arc** : Part of the circumference (PQ)
- **Secant** : A line intersecting the circle at **two points**
- **Tangent** : A line which touches the circle at **exactly one point**, this point is called **Point of contact**
- **Semi-circle** : Diameter of circle divides it into two equal parts (or, two equal arcs). Each part is called a semi-circle



## Common mistakes to avoid

- Confusing sector and segment
- Forgetting to subtract triangle area in segment
- Missing units ( $\text{cm}^2$ ,  $\text{m}^2$ )
- Forgetting to put correct value of  $\pi$ , as directed

**Quadrant of a circle** : One fourth part of a circle is called the quadrant of the circle



**Circumference of a circle** : The distance covered by travelling once around a circle is its perimeter, which is usually called its circumference.

That is, Circumference (arc length of semicircle of radius r) is given by  $C = 2\pi r$ .

Further, note that **Perimeter of semi-circle** of radius  $r = \pi r + 2r = \pi r + d$ , where d is the diameter.

## Some important formulae

- Area of circle =  $\pi r^2$
- Area of the sector of angle  $\theta = \frac{\theta}{360} \times \pi r^2$
- Length of the arc of a sector of angle  $\theta = \frac{\theta}{360} \times 2\pi r$
- Area of the segment of a circle  
= Area of the corresponding sector  
- Area of corresponding triangle  
 $= \frac{\theta}{360} \times \pi r^2 - r^2 \sin \frac{\theta}{2} \cos \frac{\theta}{2} = \frac{\theta}{360} \times \pi r^2 - \frac{1}{2} r^2 \sin \theta$
- Perimeter of equilateral triangle =  $3a$
- Area of equilateral triangle =  $\frac{\sqrt{3}}{4} a^2$
- Area of rhombus =  $\frac{1}{2}$  (Product of diagonals)
- Area of Parallelogram = Base  $\times$  Corresponding height
- Area of trapezium  
 $= \frac{1}{2} \left[ (\text{Sum of parallel sides}) \times \left( \frac{\text{Distance between}}{\text{parallel sides}} \right) \right]$



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# SURFACE AREAS & VOLUMES

**Surface areas of solid bodies**  
Surface area of a solid body is the area of all of its surfaces together. It is measured in square units.

**Volume of solid bodies**  
Volume of a solid body is the space occupied by it. It is measured in cubic units.

**Some important formulae**

**Cuboid**  
Lateral surface area =  $2(l+b)h$   
Total surface area =  $2(lb+bh+hl)$   
Volume =  $lbh$

**Cube**  
Lateral surface area =  $4a^2$   
Total surface area =  $6a^2$   
Volume =  $a^3$

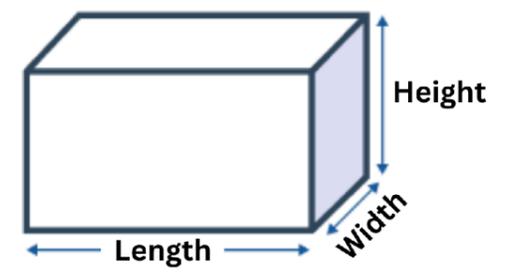
**Sphere**  
Surface area =  $4\pi r^2$   
Volume =  $\frac{4}{3}\pi r^3$

**Hemisphere**  
Curved surface area =  $2\pi r^2$   
Surface area =  $3\pi r^2$   
Volume =  $\frac{2}{3}\pi r^3$

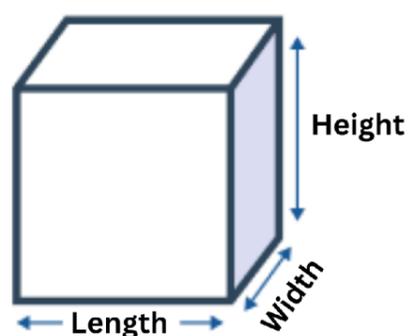
**Cylinder**  
Curved surface area =  $2\pi rh$   
Total surface area =  $2\pi r^2 + 2\pi rh$   
Volume =  $\pi r^2 h$

**Cone**  
Curved surface area =  $\pi rl$ , where  $l^2 = r^2 + h^2$   
Total surface area =  $\pi r^2 + \pi rl$   
Volume =  $\frac{1}{3}\pi r^2 h$

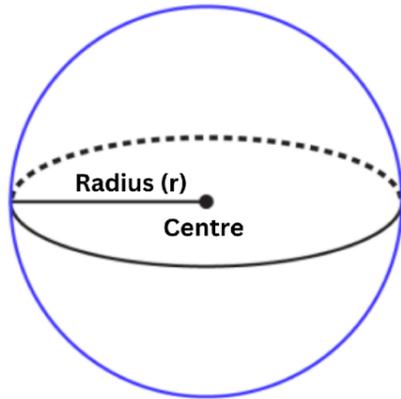
**Some important solid bodies**



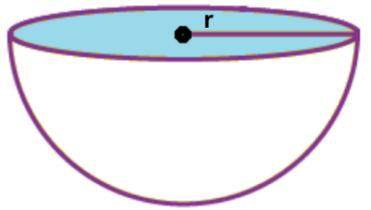
Cuboid



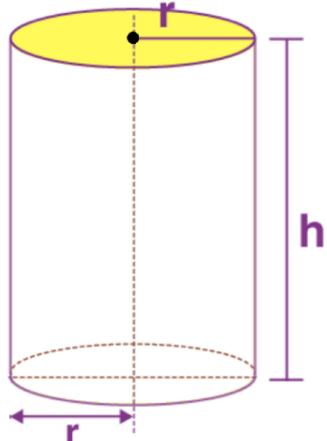
Cube



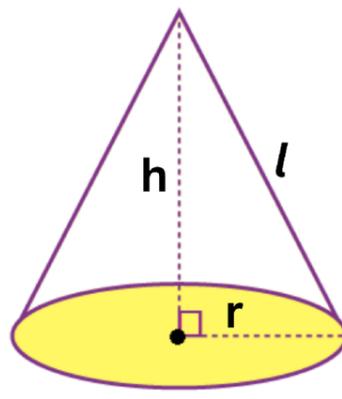
Sphere



Hemisphere



Cylinder



Cone

**Important exam tips**

- Avoid confusion between CSA and TSA
- Use slant height ( $l$ ) for CSA of cone
- Avoid unit mismatch
- Make diagram while solving the problems, as it improves presentation
- Use the value of  $\pi = 3.14$  or  $\pi = \frac{22}{7}$ , as directed

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# STATISTICS

## Median

It is the middle most or the central observation, when the given set of observations are arranged in an order.

### • Cumulative frequency

The cumulative frequency of a class is the frequency obtained by adding the frequencies of all the classes preceding the given class.

### • Median class

A class having cumulative frequency just greater than half the sum of all the frequencies (popularly termed as the  $\frac{N}{2}$  value) is called the median class. In other words, the median class is obtained by marking that class interval which corresponds to the cumulative frequency which is just greater than the  $\frac{N}{2}$  value.

### ◆ Median of Discrete Frequency Distribution

**STEP 1** Find the cumulative frequency.

**STEP 2** Find  $N = \sum f_i$  and, then  $\frac{N}{2}$ .

**STEP 3** Observe the cumulative frequency which is **just greater than the  $\frac{N}{2}$  value** and find out the corresponding value of the variable  $x$ .

**STEP 4** The value of the variable obtained in the **STEP 3** is the required Median.

### ◆ Median of Grouped Data or Continuous Frequency Distribution

$$\bullet \text{ Median} = l + \left( \frac{\frac{N}{2} - C}{f} \right) \times h$$

where  $l$  = lower limit of the median-class,  $N = \sum f_i$  = number of observations,  $C$  = cumulative frequency of the class preceding the median class,  $f$  = frequency of the median-class,  $h$  = class-size.

## Mean of Grouped Data

In general, it is obtained by dividing the sum of all observations by the total number of observations. It is denoted by  $\bar{x}$ .

$$(a) \text{ Direct method : } \bar{x} = \frac{\sum f_i x_i}{\sum f_i}$$

where  $x_i$  represents the variates (class-marks) and  $f_i$  their corresponding frequencies.

$$(b) \text{ Assumed mean method : } \bar{x} = a + \frac{\sum f_i d_i}{\sum f_i}$$

where 'a' is the **assumed mean** and  $d_i = x_i - a$  is the deviation of 'a' from each of the variates  $x_i$ .

$$(c) \text{ Step deviation method : } \bar{x} = a + \frac{\sum f_i u_i}{\sum f_i} \times h$$

where 'a' is the **assumed mean** and 'h' is the class-width. Also  $u_i = \frac{x_i - a}{h}$ .

◆ Assumed mean and step deviation methods are known as **Short-cut method** also.

## Mode of Grouped Data

The value of observation having maximum frequency is the mode of the given data.

$$\bullet \text{ Mode} = l + \left( \frac{f_1 - f_0}{2f_1 - f_0 - f_2} \right) \times h$$

where  $l$  = lower limit of the modal-class,

$h$  = size of the class interval,

$f_1$  = frequency of the modal-class,

$f_0$  = frequency of the class preceding the modal-class,

$f_2$  = frequency of the class succeeding the modal-class.

**Note :** The **modal-class** is that class which has got the maximum frequency.

**Empirical relationship between the three measures of Central Tendency**

$$3 \text{ Median} = \text{Mode} + 2 \text{ Mean}$$



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# PROBABILITY

## Description of the Playing Cards

- Total no. of playing cards : 52
- Total no. of Red cards : 26
- Total no. of Black cards : 26 (so,  $26 + 26 = 52$ )
- No. of Ace cards : 4 (2 Black and 2 Red)
- Three Face cards are : Jack, Queen, King
- No. of Face cards : 4 Jacks, 4 Queens, 4 Kings (so, total face cards :  $4 \times 3 = 12$ )
- No. of Red coloured Face cards : 6 (Two from each of the faces)
- No. of Black coloured Face cards : 6 (Two from each of the faces)
- Four Suits are : Club, Spade (Both black); Heart, Diamond (Both red)
- No. of cards in each suit : 13 (so,  $13 \times 4 = 52$ )
- **Numbering on the cards** is done from 2 to 10. Sometimes Ace is numbered as 1 but if so, then it will be mentioned in the question. Thus we have four cards with each numbers from 2 to 10 from each of the four suits.



## Important terms

### Experiment

It is an activity which results in some well-defined outcomes (results).

### Trial

It is an activity performed once which results in one or several outcomes.

### Random experiment

It is an experiment with **uncertain outcome**. That is, an experiment in which all the possible outcomes are known in advance but exactness of outcome cannot be predicted.

### Elementary event

An outcome of a random experiment is called an elementary event.

### Occurrence of an event

An event E associated to a random experiment is said to occur if any one of the elementary events associated to the event E is an outcome.

### Non-occurrence of an event

An event E associated to a random experiment is said to be non-occurring if there is no outcome associated to the event E.

### Favourable elementary event

An elementary event E is said to be favourable if it is as per the definition of the event.

### Impossible event

An event is said to be impossible if it can never happen. The probability of an impossible event is 0 i.e., zero.

### Sure event

If an event is bound to happen, then it is a sure event. The sure event is also called as **Certain event**. The probability of an impossible event is 1.

### Sample space

It is the collection (i.e., set) of all the possible outcomes in an experiment. Usually it is symbolized by the upper case letter S. And the elements of the set is put into the brackets {...}.

- Total number of outcomes in n throws of a coin =  $2^n$
- Total number of outcomes in n throws of a die =  $6^n$

## Common mistakes to avoid

- Confusing sector and segment
- Ignoring 'favourable' vs 'total' outcomes logic
- Not simplifying final answers into fractions
- Misinterpreting 'at least' or 'not' type questions

## Probability of an event

$$P(E) = \frac{\text{Number of outcomes favourable to event E}}{\text{Number of all possible outcomes of the experiment}}$$

## Important properties

- $0 \leq P(E) \leq 1$
- $P(E) + P(\text{not } E) = 1$  i.e.,  $P(E) + P(\bar{E}) = 1$

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