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Volume - 2

Mathematics, Logical Ability, and General Science

SIERRA INNOVATIONS

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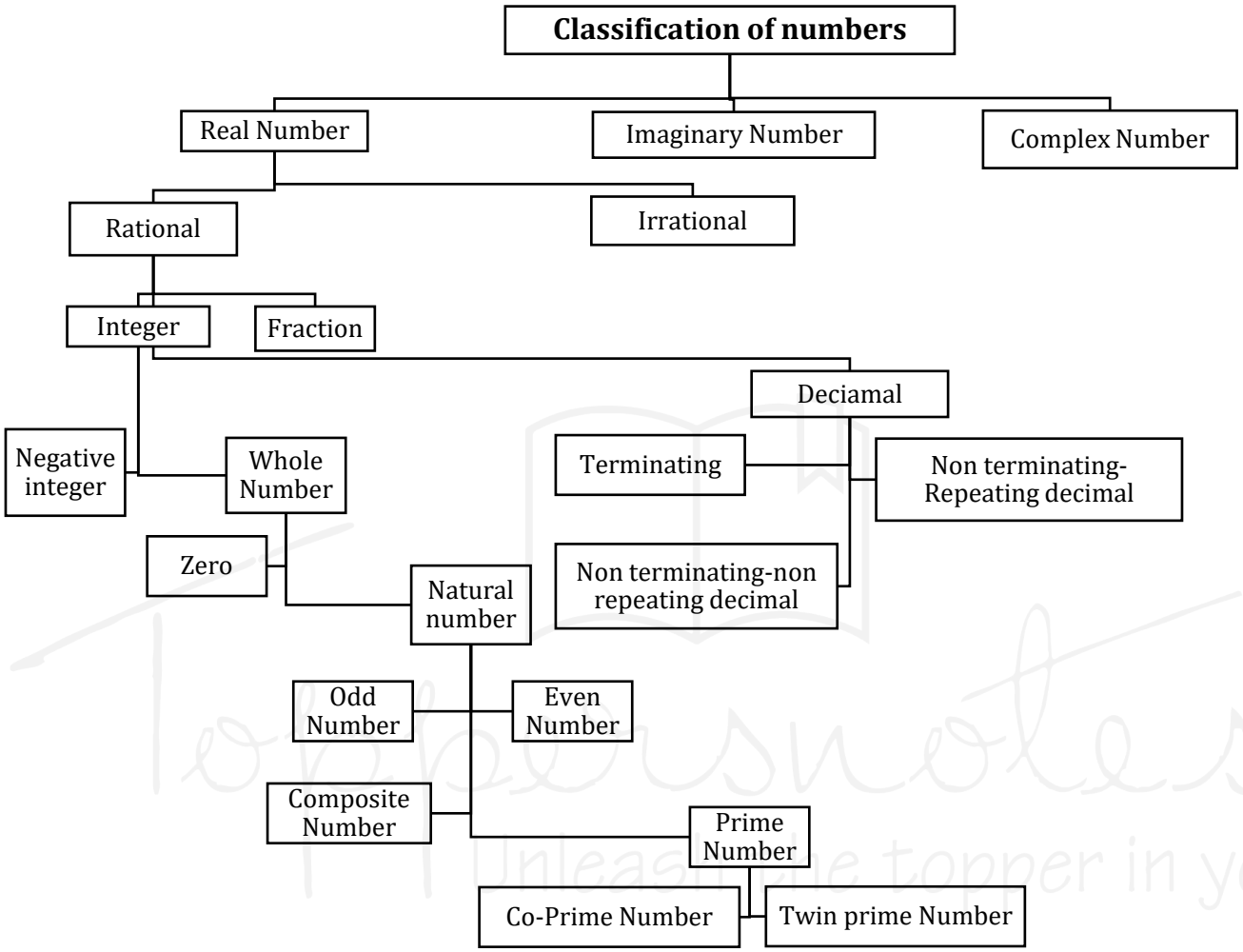
1 CHAPTER Number System

- **Number System**: A number system is a **method of representing and working with numbers** using a defined set of symbols and rules.



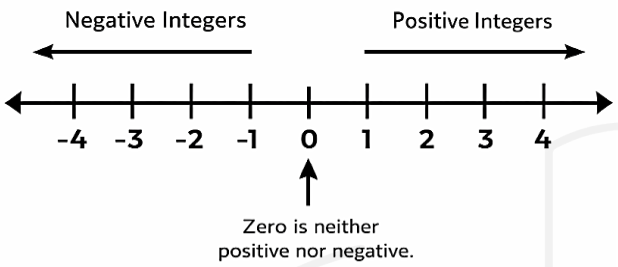
Types	Definition
Real Number	A real number is any number that can be represented on the number line. A real number is a number that includes all rational and irrational numbers and can be expressed as a point on the number line.
Rational Number	A rational number is a number that can be expressed in the form $\frac{p}{q}$, where p and q are integers and $q \neq 0$.
Irrational Number	An irrational number is a number that cannot be expressed in the form $\frac{p}{q}$, where p and q are integers and $q \neq 0$
Fraction	A fraction is a number that represents a part of a whole or a ratio of two quantities. It is written in the form $\frac{a}{b}$.
Integer	An integer is a whole number that can be positive, negative, or zero, and does not include any fractional or decimal part

Negative Integer	Negative integers are whole numbers with a negative sign, such as $-1, -2, -3, \ldots$
Whole Number	A whole number is a non-negative integer, including zero.
Natural number	Natural numbers are the numbers starting from 1 and increasing by 1 each time. 1,2,3, 4,…
Odd Number	An odd number is a natural number that is not divisible by 2 or in the form of $2n + 1$
Even Numbers	An even number is a natural number that is completely divisible by 2 or in the form of $2n$.
Prime number	A prime number is a natural number greater than 1 that has exactly two distinct factors: 1 and the number itself. 2,3,5, 7. ➢ 2 is the smallest prime number. ➢ 2 is only even prime number. ➢ All prime number (except 2 and 3) can be written in the form of $6n + 1$ or $6n + 5$ where n is natural number however, the converse is not true. ➢ (3,5,7) is only group of three primes, which are consecutive odds. ➢ 101 is smallest 3-digit prime number. ➢ 997 is largest 3-digit prime number.
Composite Number	A composite number is a natural number greater than 1 that has more than two factors. A composite number can be divided exactly by 1, itself, and at least one other number. 4,6,8,9,10,12, 14… ➢ The smallest composite number is 4. ➢ The smallest odd composite number is 9 If a and b are any two odd primes then $a^2 + b^2$ and $a^2 - b^2$ is composite numbers.

Co-Prime Numbers	Two or more numbers are called co-prime (or relatively prime) if their only common factor (HCF) is 1. ➢ 1 is neither prime or composite.
Twin Prime Numbers	Twin numbers (twin primes) are a pair of prime numbers whose difference is exactly 2. ➢ 5 is only prime which is in 2 twin prime pairs. (3, 5) (5, 7) ➢ Sum of twin prime number (expect 3 and 5) is always divisible by 12.
Decimal Number	A decimal number is a number that has a decimal point (.) and consists of a whole part and a fractional part. Ex- 3.5,12.75 etc
Terminating Decimal	A terminating decimal is a decimal number that ends after a finite number of digits after the decimal point. Ex- 2.5,0.75
Non-Terminating Repeating Decimal	A non-terminating repeating decimal is a decimal number that does not end and in which one or more digits repeat continuously after the decimal point. Ex- 0. 333..,0. 1212
Non-Terminating Non-Repeating Decimal	A non-terminating non-repeating decimal is a decimal number that does not end and does not repeat any digit or pattern after the decimal point. Ex- 1.1412,3.14
Imaginary Number	An imaginary number is a number that can be written in the form $= bi$ b is a real number i is the imaginary unit, defined by

Complex Number	A complex number is a number that consists of two parts—a real part and an imaginary part—and can be expressed in the standard form $z = a + ib$ a is a real number, called the real part of z b is a real number, called the imaginary part of z i is the imaginary unit, defined by the property

Integer Number Line



How to check the given number is prime or not?

- To determine whether a number is prime, first find its square root and round it down to the nearest whole number. Then check whether the number is divisible by any prime number up to this value. If it is not divisible by any of them, the number is a prime number.

Between	Number or prime number
1-50	15
1-100	25
1-200	46

Ramanujan number

A Ramanujan number is a number that can be expressed as the sum of two positive cubes in two different ways. It is also known as the Hardy–Ramanujan number or taxi-cab number.

Smallest Ramanujan number = 1729

$1729 = 1^3 + 12^3 = 9^3 + 10^3$

Perfect number

A perfect number is a natural number that is equal to the sum of its proper divisors (that is, all its positive divisors excluding the number itself).

Ex: 4 is divisible by 1 and 2, so $1 + 2 = 3 \neq 4$; therefore,4 is not a perfect number.

6 is divisible by 1,2 and 3, so, $1 + 2 + 3 = 6 = 6$; therefore, 6 is a perfect number.

Key points

Even + Even = Even

Even × Even = Even

Even + Odd = odd

Even × Odd = Even

Odd + odd = Even

Odd × Odd = Odd

Sum Of 'n' odd number is odd, if n is odd.

Sum of 'n' odd number is even, if n is even.

Type 1: Question based on definitions

Ex: 173 is prime number of not?

Sol: The Square root of 173 is approximately 13.

The Prime number less than or equal to 13 are 2,3,5,7,11 and 13,

Since 173 is not divisible by any number, it is a prime number.

Ex: x, y and z are distinct prime number where $x < y < z$ if $x + y + z = 70$, then what is the value of z?

Sol: Now, sum is 70, means at least one of the numbers is even. A we know, only one even prime number exists, and that is 2.

2 is also the smallest prime number.

Means $x = 2$

Now, $70 - 2 = 68 = y + z$

By substituting the values of different prime numbers, we obtain the result.

$y = 31 \; and \; x = 37$

Ex: How many composite numbers are there from 53 to 97?

Sol: If we find the total number of integers between 53 and 97 and then subtract the number of prime numbers between them, we obtain the number of composite numbers.

Total number = $97 - 53 + 1 = 45 (+1$ when both numbers are included)

Total prime number from 53 to 97 is 10

So, composite number = 45 – 10 = 35

Ex: Which one of the following is TRUE?
(A) All irrational numbers are real
(B) All real numbers are irrational.
(C) Rational numbers are not real.
(D) Integers are not rational.
Sol: Irrational numbers form a subset of real numbers, so all irrational numbers are real.
Not all real numbers are irrational;
rational numbers are also real.
Rational numbers are real numbers.
Integers are a subset of rational numbers since any integer can be written as $\frac{p}{q}$(e.g., $5 = \frac{5}{1}$).
So, Answer is (A).

Special concept: based on sum of digits for special types of numbers

Number	Square	Sum of digits
11^2	121	3
111^2	12321	9
So, on		
111111111^2	123456789 8 7654321	81

Ex: Each digit of a 9-digit number is 1. It is multiplied by itself. What is the sum of digit of the resulting number.
Sol- using the concept
$111111111^2 =\gg 81$

Type 2: Unit digit based

To find the units digit of an expression, consider only the unit digits of the numbers instead of evaluating the entire expression.
Unit digit of (a + b) = unit digit of a + unit digit of b
Unit digit of (a − b) = unit digit of a − unit digit of b
Unit digit of a × b = unit digit of a × unit digit of b

Ex: What are the unit digit of 435×433 .
Sol:Unit digit of a × b = unit digit of a × unit digit of b
$5 \times 3 = 15$ so, unit digit is 5

Cyclicity

Cyclicity in the number system means the repeating pattern of digits or remainders when a number is raised to higher powers. The unit digit remains unchanged for all powers.
$0 \rightarrow 0$ $1 \rightarrow 1$
$5 \rightarrow 5$ $6 \rightarrow 6$
Cycle of Length 2-The unit digit alternates between two values.
$4 \rightarrow 4, 6$
When the power is odd, the unit digit is 4, and when the power is even, the unit digit is 6.
$9 \rightarrow 9, 1$
When the power is odd, the unit digit is 9, and when the power is even, the unit digit is 1.
Cycle of Length 4- The unit digit repeats after four powers.
$2 \rightarrow 2, 4, 8, 6$ $3 \rightarrow 3, 9, 7, 1$
$7 \rightarrow 7, 9, 3, 1$ $8 \rightarrow 8, 4, 2, 6$
Let $N = x^y$
To find the unit digit of (N), we only need to consider the unit digit of the base number (x). The unit digit of an exponential expression can be determined by finding the remainder when the power is divided by 4.

Type 3: Cyclicity - Unit Digit Based on Arithmetic Equations

Ex: If $x = (164)^{169} + (333)^{337} - (727)^{726}$ then what is the unit digit of x?
Sol: In the expression, the **first term** has an odd power of 4, so the unit digit of the first term is 4. For the **second term**, dividing 337 by 4 gives a remainder of 1 so the unit digit of the second term is 3. For the **third term**, dividing 726 by 4 gives a remainder of 2; hence, the unit digit of the third term is 9.
So, unit digit of the expression $4 + 3 - 9 = -2$
If the unit digit comes out negative, add 10 to obtain the correct unit digit.Unit digit is $10 - 2 = 8$

Ex: What is the unit digit of $1^5 + 2^5 + 3^5 + 4^5 + \cdots + 20^5$
Sol: In each term, the cyclicity is 1. Therefore, for every term, the units digit is the same as the number itself.
The Unit digit for 1 to 10 is zero.
$= (1 + 2 + 2.. + 9 + 0)$
$+ (1 + 2 + 3.. + 9 + 0) = 0$

Ex: Find the unit digit $x = 187^{280} \times 529^{320} \times 343^{236}$

Sol: If remainder is 0 then put power equal to the 4.

For the first terms – 7^4 cyclicity is 1

For the second terms – power of 9 is even so the unit digit is 1

For the third terms - 3^4 cyclicity is 1

$Unit\ digit\ is\ = 1 \times 1 \times 1 = 1$

Ex: What is the unit digit in the expansion of $(57242)^{9\times7\times5\times3\times1}$?

Sol: We only check only for digit 2. Power will be divided by 4.

$= 2^{1\times(-1)\times1\times(-1)\times1} = 2^1$

So, the unit digit is 2

Type 4: Counting based Questions (a digit or page counting or key stokes)

1 to 9 → required digit is = 9

10 to 99 → 90×2 = 180

Ex: What is the number of digits required for numbering a book with 428 pages?

Sol: 1 to 9 → required digit is = 9

10 to 99 → 90×2 = 180

100 to 428 = (428-100+1) = 329→329×3=987

Total number of digits required = 9 +180 + 987 =1176

Type 5: Perfect Square Based Questions

How to check if a number is a perfect square (it shows the possibility)

1. The last two digits of any perfect square number must be among the squares from 1 to 24.
2. The units digit should not be 2, 3, 7, or 8.
3. The number of zeros in the number and the denominator should both be even.
4. After dividing a perfect square by 9, the remainder must be 0, 1, 4, or 7.

Ex: Is it possible that 562576 is a perfect square or not?

Sol: The number ends in 76, which is possible for a perfect square. The unit digit is 6, so it is possible for the number to be a perfect square.

Sum of digit of $562576 = 21$

after dividing remainder is 3.

So, this number is not perfect.

Type 6 Decimal to fraction conversion

- The number of zeros in the denominator is equal to the number of digits after the decimal point.

  $0.abc = \frac{abc}{1000}$
- The number of 9 in the denominator is equal to the number of digits after the decimal point.

  $0.\overline{abc} = \frac{abc}{999}$
- When some digits are not covered by the overline

  $0.a\overline{bc} = \frac{abc - a}{990}$

  $0.ab\overline{cd} = \frac{abcd - ab}{9900}$
- Mix concept

  $a.b\overline{cd} = a + \frac{bcd - b}{990} = \frac{abcd - ab}{990}$

Ex: If $A = 0.3\overline{12}$, $B = 0.4\overline{15}$ and $C = 0.30\overline{9}$ what is the value of $A + B + C$.

Sol:

$$A + B + C = \frac{312 - 3}{990} + \frac{415 - 4}{990} + \frac{309 - 30}{900}$$

$$A + B + C = \frac{720}{999} + \frac{279}{900}$$

$$A + B + C = \frac{10269}{9900} = \frac{1141}{1100}$$

Type 7: Number of zeros

- Zeros at the end of a number are determined by the number of 10s and in its factorization, primarily based on the pairs of 5s and 2s.
- **Factorial** is a mathematical operation defined for non-negative integers.

- **For** a positive integer n, the factorial of n, denoted by $n!$, is the product of all positive integers from 1 to n.
  $n! = n \times (n-1) \times (n-2) \times \cdots \times 1$
  $0! = 1,\ 1! = 1$
  - ✓ The unit digit of numbers after 4! is zero.
  - ✓ 4! and all factorials after it are divisible by 4.
  - ✓ Product of 'n' consecutive natural number is divisible by n
- **Power of number contained in a factorial:** Highest power of a prime number 'p' contained in n! is given by
  $= \left[\frac{n}{p}\right] + \left[\frac{n}{p^2}\right] + \left[\frac{n}{p^3}\right] + \cdots$
- The product of n consecutive natural number is always divisible by n!

Ex: The three numbers 24, 25, and 26 are divisible by.

Sol: The product of n consecutive natural number is always divisible by n!
Means 24,25,26 is divisible by 3!

Ex: Find the number of trailing zeros in 100!

Sol: In 100! factors of 2 are abundant, we only count factors of 5.
Each multiple of 5 contributes at least one factor of 5. Numbers like 25, 50, 75, 100 contain an extra factor of 5 because $25 = 5^2$.

$$\left[\frac{100}{5}\right] + \left[\frac{100}{25}\right] + \left[\frac{100}{125}\right] = 20 + 4 + 0 = 24$$

Number of trailing zeros $= 24$

Ex: Find the number of trailing zeros in 2×4×6…×250.

Sol: factors of 2 are abundant, we only count factors of 5.

$2 \times 4 \times 6 \ldots \times 250$
$= (2 \times 1) \times (2 \times 2) \ldots . (2 \times 125)$
$(2 \times 1) \times (2 \times 2) \ldots . (2 \times 125)$
$= 2^{125}(1 \times 2 \times \ldots 125)$
$2^{125}(1 \times 2 \times \ldots 125) = 2^{125} \times 125!$

$$\left[\frac{125}{5}\right] + \left[\frac{125}{25}\right] + \left[\frac{125}{125}\right] = 25 + 5 + 1 = 31$$

Number of trailing zeros $= 31$

Divisibility

Number	Divisibility Rule
2	Last digit is 0, 2, 4, 6, 8
3	Sum of digits divisible by 3
4	Last two digits form a number divisible by 4
5	Last digit is 0 or 5
25	Last two digit is 00 or divisibly by 25
6	Number divisible by both 2 and 3
7	Subtract twice the last digit from the remaining; result divisible by 7
8	Last three digits divisible by 8
9	Sum of digits divisible by 9
11	Difference between sum of digits at even and odd places is 0 or divisible by 11

Special cases

1. $1001 = 7 \times 11 \times 13$
   $1001 \times abc = abcabc$
2. $10101 = 3 \times 7 \times 13 \times 37$
   $10101 \times ab = ababab$

Type 8: Based on Divisibility rules

Ex: A number N is formed by writing 9 for 99 times. What is the remainder if N is divided by 13?

Sol: When any number is repeated n times, the combination of the 6-digit number is divisible by 7, 11, and 13.
96 times 9 will be divisible by 13, and only three 9s will remain.

$$= \frac{999}{13} \Rightarrow R \rightarrow 11$$

Ex: Find the greatest possible value of $(a + b)$ for which the 8-digit number 143b203a is divisible by 15.

Sol: Divisibility of 3 - if sum of its digits is divisible by 3.
Divisibility of 5- if the last number is either 0 or 5, the entire no. is divisible by 5.
Factors of $15 = (3 \times 5)$ Hence, the number should be divisible by both 3 and 5.
So, a can be 0 or 5. But since the question asks for greatest value, a must be 5.
After that sum of the number is = 18+b
For greatest = b=9
So, $(a + b) = (9 + 5) = 14$

Ex: If the 9-digit number $72x8431y4$ is divisible by 36, find the value of $\left(\frac{x}{y}-\frac{y}{x}\right)$ for the smallest possible value of y, where x and y are natural numbers.

Sol: The divisibility rule of 36 is that the number must be divisible by 4 and 9.

Last two-digit number $= y4$, on putting $y = 2$, the last two-digit number becomes 24,

Therefore, the value of $y = 2$. (y is the smallest possible value)

For divisibility rule of 9,

sum of number $= 31 + x$

So, $x = 5$

Now the value

$$\left(\frac{x}{y}-\frac{y}{x}\right)=\left(\frac{5}{2}-\frac{2}{5}\right)=2\frac{1}{10}$$

Type 9: Divisibility of expressions

Expression	'n' is odd	'n' is even
$x^n - y^n$	$(x-y)$	$(x+y)(x-y)$
$x^n + y^n$	$(x+y)$	$Can't\ say$

Ex: What is the remainder if $(17^{26} - 11^{26})$ is divided by 42?

Sol: n is even. So, $(x+y)(x-y)$

$$=\frac{(17+11)(17-11)}{42}=\frac{28\times 6}{42},$$

$Remainder = 0$

Key Point: If 'n' is odd and $a, b, c \ldots z$ are consecutive natural number then $(a^n + b^n + \cdots + z^n)$ is divisible by $(a + b + c \ldots z)$

Ex: $11^5 + 12^5 + 13^5$ is divisible by?

Sol- using concept

11+12+13 = 36

So, the expression is divisible by 36

Type 10: Digit and its Reverse Form 2-digit and 3 digit and its reverse form

1. **For 2-digit**

   Let, two-digit original number $= 10x + y$, Reversed number $= 10y + x$

   Sum of original and reserved number $(10x + y) + (10y + x) = 11(x + y)$

   Difference of original and reversed number $(10x + y) - (10y + x) = 9(x - y)$

2. **For 3-digit**

   Let, Hundred digit $= x$, Tenth digit $= y$, Unit digit $= z$ So,

   original number $= 100x + 10y + z$

   Hundred and unit digits interchange, new number $= 100z + 10y + x$

   Difference of original and reverse number $= 99(x - z)$

Ex: The sum of the two-digit number and the number obtained by inter-changing the digit is 99. If the difference of digits is 1, then the number is;

Sol: Let, number $= 10x + y$

$(10x + y) + (10y + x) = 99$

$x + y = 9$

$x - y = 1$

After the equation $x = 5, y = 4$

So, the number is

$= 10 \times 5 + 4 = 54$

Ex: What will be the smallest natural number to be filled in the blank for the number $23x45678$ to be divisible by 22.

Sol: The divisibility rule for 22 is based on divisibility by both 2 and 11. A number is divisible by 11 if the difference between the sum of its digits in odd positions and the sum of its digits in even positions is divisible by 11.

Odd positions sum: $3 + 4 + 6 + 8 = 21$

Even positions sum: $2 + x + 5 + 7 = 14 + x$

$21 - (14 + x) = 7 - x$

$7 - x = 11k$, for some integer k

For the smallest x, let's try $k = 0$

$7 - x = 0 \Rightarrow x = 7$

Thus, the smallest value of x that makes the number $23x45678$ divisible by 22 is 5.

Ex: How many numbers are there from 700 to 950 (including both) which are neither divisible by 3 nor by 7?

Sol:

Neither divisible by 3 nor by 7

$=$ Total $-$ (Divisible by 3 or 7) $=$ Total $-$ [N(3) + N(7) $-$ N(21)]

Total number from 700 to 950 = 251

Divisible by $3 = \frac{251}{3} \approx 83$

Divisible by $7 = \frac{251}{7} \approx 35$

Divisible by $21 = \frac{251}{21} \approx 11$

Required number

$= 251 - (83 + 35 - 11) = 144$

Factorization

A factor of a number is a whole number that can be multiplied by another whole number to result in the original number. In other words, a factor divides the number evenly without leaving any remainder.

Let $N = a^p \times b^q \times c^r$

Total number of factors $= (p+1)(q+1)(r+1)$

Total number of even factors $= p(q+1)(r+1)$

Total number of odd factors $= (q+1)(r+1)$

Sum of all factors $= (a^0 + a^1 + \cdots a^p)(b^0 + b^1 + \cdots b^q)(c^0 + c^1 + \cdots + c^q)$

Sum of even factors $= (2^1 + 2^2 + \cdots + 2^p)(b^0 + b^1 + \cdots + b^q)(c^0 + c^1 + \cdots + c^r)$

Sum of odd factors $= 2^0(b^1 + b^2 + \cdots + b^q)(c^1 + c^2 + \cdots + c^r)$

Average of factor $= \frac{\text{sum of factor}}{\text{number of factor}}$

Sum of reciprocal of factors $= \frac{sum\ of\ factor}{given\ number}$

Number of prime factors $= p + q + r$

Number of distinct prime factor $= no\ of\ prime\ \ number\ in\ factor$

Number of composite numbers $= total - distinct\ prime\ number\ - 1$

- Every number has positive and negative factors.
- All numbers in the form $(prime)^2$ have 3 factors.

Type 11: Find the Number of Factors Based

Ex: Find all types of factors and the sum of all types of factors for $N = 3600$.

Sol: $N = 3600 = 2^4 \times 3^2 \times 5^2$

- Total number of factors $= 5 \times 3 \times 3 = 45$
- Number of even factors
  $2 \times (1800) = 2(2^3 \times 3^2 \times 5^2)$
  $= 4 \times 3 \times 3 = 36$
- Number of odd factors $= 3 \times 3 = 9$
- Number of prime factors $= 4 + 2 + 2 = 8$
- Number of distinct Prime factor (visible in factorization) $= 1 + 1 + 1 = 3$
- Number of Composite numbers
  $= 45 - 3 - 1 = 41$
- Perfect square $= (2^2)^2(3^2)^1(5^2)^1$
  $= 3 \times 2 \times 2 = 12$
- Perfect cube $= (2^3)^1 = (1+1) = 2$
- Sum of all factor
  $= (2^0 + 2^1 + 2^2 + 2^3 + 2^4)(3^0 + 3^1 + 3^2)(5^0 + 5^1 + 5^2)$
  $= 12493$
- Sum of even factor
  $= (2^1 + 2^2 + 2^3 + 2^4)(3^0 + 3^1 + 3^2)(5^0 + 5^1 + 5^2) = 12090$
- Sum of odd factor
  $= (3^0 + 3^1 + 3^2)(5^0 + 5^1 + 5^2) = 403$
- Sum of prime $= 2 + 3 + 5 = 10$
- Sum of composite number
  $= total\ sum - (sum\ of\ prime + 1) = 12493 - 10 - 1 = 12482$
- Perfect square
  $= (2^0 + 2^2 + 2^4)(3^0 + 3^2)(5^0 + 5^1) = 5460$

Ex: Calculate the total number of prime factors in the expression $(4^{11} \times 5^5 \times 3^2 \times 13^2)$

Sol:

$(4^{11} \times 5^5 \times 3^2 \times 13^2) = 2^{22} \times 3^2 \times 5^5 \times 13^2$

Total number of prime factors

$= 22 + 2 + 5 + 2 = 31$

Ex: How many factors of $(30^{16} \times 16^{18} \times 20^{21})$ are perfect square as well as perfect cube?

Sol: $30^{16} \times 16^{18} \times 20^{21} = 2^{130} \times 3^{16} \times 5^{37}$

When asked to check for a perfect square or perfect cube, check if the power is a multiple of 6.

$2^{130} \times 3^{16} \times 5^{37}$

$= 2^{126} \times 2^4 \times 3^{12} \times 3^4 \times 5^{36} \times 5^1$

$2^{126} \times 2^4 \times 3^{12} \times 3^4 \times 5^{36} \times 5^1$

$= (2^6)^{21} \times 2^4 \times (3^6)^2 \times 3^4 \times (5^6)^6 \times 5^1$

The total number of factors that are both perfect squares and perfect cubes

$= (21+1)(2+1)(6+1) = 462$

Ex: How many factors of the number $2^8 \times 3^6 \times 5^4 \times 10^5$ are multiple of 120.

Sol: $N = 2^8 \times 3^6 \times 5^4 \times 10^5 = 2^{13} \times 3^6 \times 5^9$

$\frac{N}{120} = \frac{2^{13} \times 3^6 \times 5^9}{2^3 \times 3^1 \times 5^1} = 2^{10} \times 3^5 \times 5^8$

Number of factors $= 11 \times 6 \times 9 = 594$

Remainder

Let suppose number N when divided by divisor D, leaves the remainder as R and quotient as Q.

$N = D \times Q + R$

Dividend = Divisor × quotient + Remainder

If a gives r remainder when divided by n, then ka gives kr remainder when divided by n.

If a and b give r_1 and r_2 remainders respectively when divided by n then.

$a + b$ divided by n, gives remainder $r_1 + r_2$

$a \times b$ divided by n, gives remainder $r_1 + r_2$

Type 12: Question based on remainder theorem

Ex: A number being divided by 52 gives a remainder 45. If the number is divided by 13, the remainder will be?

Sol: Since 13 is a multiple of 52, we can directly divide the remainder of one by the divisor.

$$= \frac{45}{13} \Rightarrow R \to 6$$

Ex: A number when divided by 12 leaves 5 remainder. What is the remainder if square of this number is divided by 8.

Sol: When a mathematical operation is performed on a number, the same operation can also be performed on the remainder.

$$= \frac{5^2}{8} = \frac{25}{8} \Rightarrow R \to 1$$

Ex: If the dividend is 45, the divisor is 8, and the quotient is 5, find the remainder.

Sol- $N = D \times Q + R$

$45 = 8 \times 5 + Remainder$

Remainder $= 45 - 40 = 5$

Type 13: Important concept of remainder

$$\frac{(x+a)^n}{x} \Rightarrow R \to a^n$$

$$\frac{(x+1)^n}{x} \Rightarrow R \to 1$$

$$\frac{(x-1)^n}{x} \Rightarrow R \to (1)^n$$

$R = 1$ *when n is even*

$R = -1$ *when n is odd*

Special case:

$$\frac{4}{6} \Rightarrow R \to 4$$

$$\frac{4^n}{6} \Rightarrow R \to 4$$

Ex: What is the remainder when 2^{75} is divided by 14?

Sol:

$$\frac{2^{75}}{15} = \frac{(2^4)^{18}.2^3}{15} = \frac{(16-1)^{18} \times 8}{15} \Rightarrow R \to 8$$

Ex: What is the remainder if 2^{192} is divided by 6?

Sol: Using the concept

$$\frac{2^{192}}{6} = \frac{4^{96}}{6} \Rightarrow R \to 4$$

Ex: What is the remainder when 37^{47} is divided by 19.

Sol:

$$\frac{37^{47}}{19} = \frac{(38-1)^{47}}{19} \Rightarrow R \to -1$$

Remainder cannot be negative, so the remainder is subtracted from the divisor.

$R \to -1 \Rightarrow R \to 19 - 1 = 18$

Type 14: Fermat's little theorem

$$If\ \frac{a^{P-1}}{P}, \quad \Rightarrow R \to 1$$

Conditions

1. P is prime number.
2. a, P are co-prime.

Ex: What is the remainder when 21^{47} is divided by 47?

Sol: 21 and 47 are coprime number so we can use Fermat's little theorem.

$$\frac{21^{47}}{47} = \frac{21^{46} \times 21}{47} \Rightarrow R \to 21$$

Type 15: Euler's (totient) theorem

$$\frac{A^X}{d} \Rightarrow R \to 1$$

Where A and d are co-prime.

$X -$ number of numbers less than d and co-prime to d.

$$X = d\left(1 - \frac{1}{P^1}\right)\left(1 - \frac{1}{P^2}\right) \ldots\ldots\ldots$$

Where P^1 and P^2 are distinct prime factors of d.

Ex: If φ is the Euler's totient functions, then $\varphi(92)$ is.

Sol: $92 = 2^2 \times 23$

$$\varphi(92) = 92\left(1-\frac{1}{2}\right)\times\left(1-\frac{1}{23}\right) = 44$$

Ex: 7^{82} is divided by 11, R=?

Sol: To find the remainder when $7^{82}$is divided by 11, we can use Fermat's Little Theorem, which states that if p is a prime number and $a$is an integer not divisible by p, then

$$\varphi(11) = 11\left(1-\frac{1}{11}\right) = 10$$

82 is divided by 10, and the remainder is

$2.\frac{7^2}{11} \Rightarrow R \to 5$

Type 16: Wilson's theorem

If P is prime number, then,

$\frac{(P-1)!}{P} \quad \Rightarrow R \to P-1$

$\frac{(P-2)!}{P} \quad \Rightarrow R \to 1$

Ex: What will be the remainder when 568! is divided by 569.

Sol- Using the Wilson theorem

$$\frac{568!}{596} = \frac{(569-1)!}{P} \quad \Rightarrow R \to 569-1$$

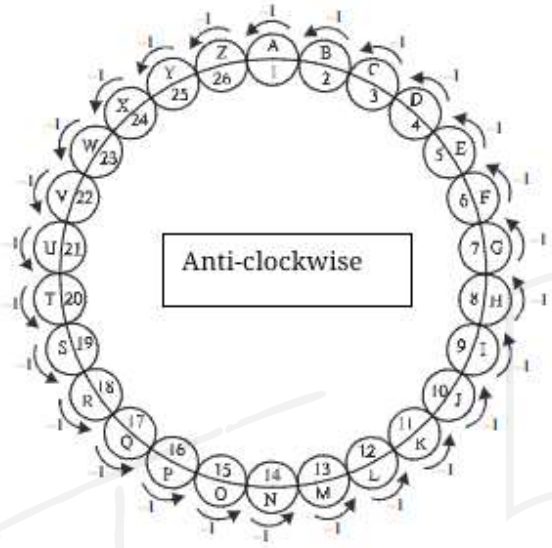
$$= 568$$

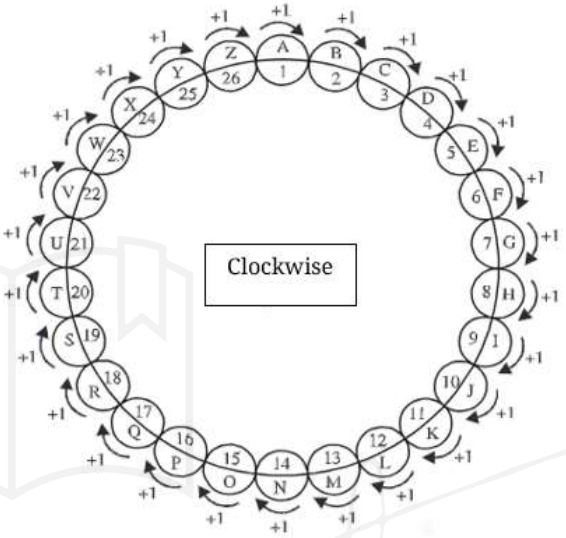
12 CHAPTER

Coding and Decoding

- Coding-decoding is a way of changing a message into a secret form before sending it, so that anyone who doesn't know the key can't understand it.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26



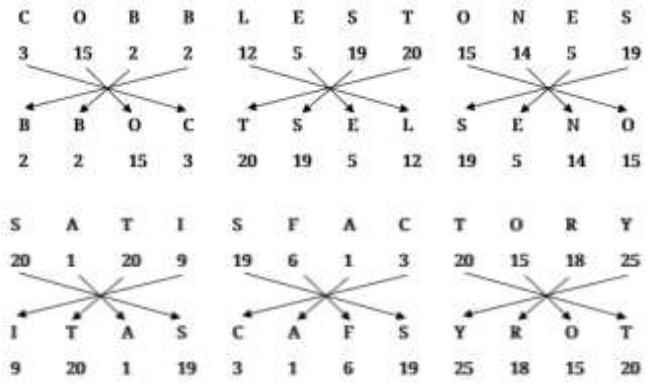


Letter Coding

Type-1 Letter Position Change Based Coding

Ex: In a specific code language, the word "COBBLESTONES" is written as "BBOCTSELSENO" and "SATISFACTORY" as "ITASCAFSYROT." How will the word "TACHYCARDIAS" be written in that same code language?

Ans: To decode the pattern:



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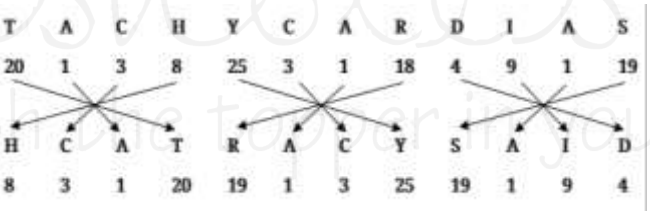


Hence, "HCATRACYSAID" is the correct answer.

Type-2 Opposite Letter Based Coding

Ex: In a specific code, if FLING is coded as UORMT, how will STICK be coded?

Ans:

- FLING → UORMT
  - ✓ F → U (Reverse of 6th letter of the alphabet)
  - ✓ L → O (Reverse of 12th letter of the alphabet)

- ✓ I → R (Reverse of 9th letter of the alphabet)
- ✓ N → M (Reverse of 14th letter of the alphabet)
- ✓ G → T (Reverse of 7th letter of the alphabet)

Now applying this same logic to STICK:

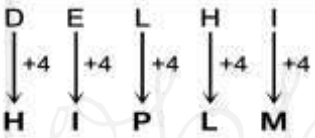
- ➢ STICK
  - ✓ S → H (Reverse of 19th letter of the alphabet)
  - ✓ T → G (Reverse of 20th letter of the alphabet)
  - ✓ I → R (Reverse of 9th letter of the alphabet)
  - ✓ C → X (Reverse of 3rd letter of the alphabet)
  - ✓ K → P (Reverse of 11th letter of the alphabet)

Thus, STICK will be coded as HGXRP.

Type-3 Forward Order Letter Coding

Ex: If DELHI is coded as HIPLM, what will be the code for QEHVEW?

Ans:



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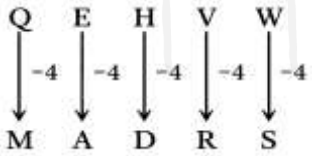


Type-4 Ascending Order Letter Coding

Ex: In a certain code language, 'BEHOLD' is written as 'BDEHLO' and 'INDEED' is written as 'DDEEIN'. How will 'COURSE' be written in that language?

Ans:

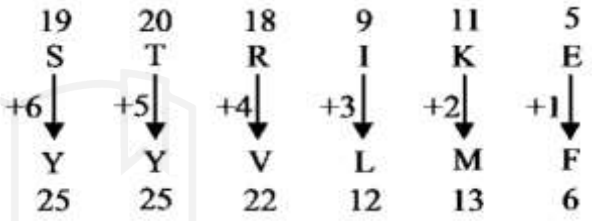
- ➢ BEHOLD → BDEHLO: The letters are rearranged by sorting the letters in ascending order: B, D, E, H, L, O:
  Rearranged output is: BDEHLO
- ➢ INDEED → DDEEIN: Rearranged output: DDEEIN

Now, following this pattern, COURSE will be written as CEORSU.

Type-5 Descending Order Letter Coding

Ex: In a certain code language, if 'STRIKE' is written as 'YYVLMF', how will 'GARDEN' be written in that language?

Ans: The first, second, third, fourth, fifth, and sixth letters of the word 'STRIKE' are in an increasing order of six, five, four, three, two, and one, but in a descending sequence.



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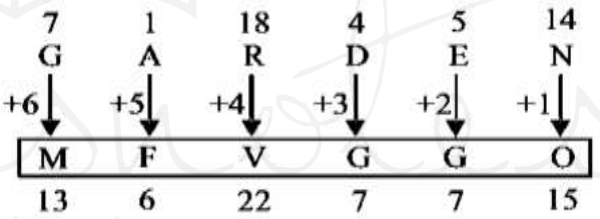


Type-6 Consecutive Even Number Pattern Coding

Ex: In a certain code language, the word 'CLAIM' is written as 'EPGQW'. What will be the code for the word 'FIGHT' in the same code language?

Ans: The change from each letter of "CLAIM" to "EPGQW" follows a particular pattern:

1. C → E: C + 2 → E
2. L → P: L + 4 → P
3. A → G: A + 6 → G
4. I → Q: I + 8 → Q
5. M → W: M + 10 → W

Now, applying the same pattern to the word 'FIGHT':

1. F → H: F + 2 → H
2. I → M: I + 4 → M
3. G → M: G + 6 → M
4. H → P: H + 8 → P
5. T → D: T + 10 → D

So, the code for 'FIGHT' is 'HMMPD'.

Type-7 Decreasing Order Letter Coding

Ex: In a certain code language, if the word 'TRAIN' is coded as 'SQZHM', how will the word 'DATE' be coded in the same code language?

Ans:

Let's analyse the pattern used to encode the word "TRAIN" as "SQZHM":

1. T → S: T - 1 → S
2. R → Q: R - 1 → Q
3. A → Z: A - 1 → Z
4. I → H: I - 1 → H
5. N → M: N - 1 → M

So, each letter is shifted by -1 (decreased by 1).

Now, applying the same pattern to the word 'DATE':

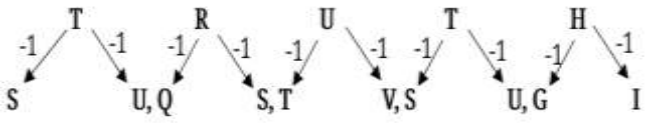
1. D → C: D - 1 → C
2. A → Z: A - 1 → Z
3. T → S: T - 1 → S
4. E → D: E - 1 → D

Thus, the word "DATE" will be coded as 'CZSD'.

Type-8 Pair of Letters Based Coding

Ex: If the word 'TRUTH' is coded as 'SUQSTVSUGI', what will be the code for 'LIES' in the same code language?

Ans:



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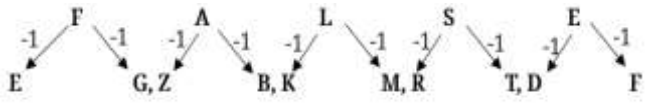


Type-9 Number Coding

Ex: In a certain code, if 'HOTEL' is coded as 300, what will be the code for 'HOSTEL'?

Ans:

Code = (sum of positional value of alphabets) x (number of alphabets)

HOTEL = (8 + 15 + 20 + 5 + 12) × (5) = 60 ×5 = 300

HOSTEL = (8 + 15 + 19 + 20 + 5 + 12) × (6) = 79 ×6 = 474

So, code for HOSTEL is 474.

Type-10 Word Coding

Ex: If "wall" is called "window," "window" is called "door," "door" is called "floor," "floor" is called "ceiling," and "ceiling" is called "ventilator," where will a person be standing?

Ans: The chain of transformations is as follows:

Wall → Window → Door → Floor → Ceiling → Ventilator.

So, a person would be standing where the ceiling is called "ventilator." Thus, the correct answer is Ceiling.

Ex: If "eraser" is called "box," "box" is called "pencil," "pencil" is called "bag," and "bag" is called "book," then what will a student use for writing?

Ans: The chain of transformations is as follows:

Eraser → Box → Pencil → Bag → Book.

The student writes with a pencil, which is now called "bag." Hence, the correct answer is Bag.

Type-11 Symbol Coding

Ex: In the given code language, 'this is done' is written as 'koj mor soj', 'that is okay' is written as 'loj roj mor', and 'you are okay' is written as 'hok nok loj'. What is the code for 'that' in this code language?

Ans: Form the sentence 2 and 3 okay = loj

From the sentence 1 and 2 is = mor

In sentence 2, the remaining code corresponds to "that" and is represented by "roj".

Ex: Direction: Study the following information carefully and answer the given questions.

'fate red mobile peace' is coded as 'ka la ho ga'

'prepare and honour fate' is coded as 'mo ta pa ka'

'peace values hero prepare' is coded as 'zi la ne mo'

'prepare values honour fate' is coded as 'zi mo ka ta'

Ex: What is the code for 'fate' in the given code language?

1. ta 2. Ka 3. zi 4. Mo

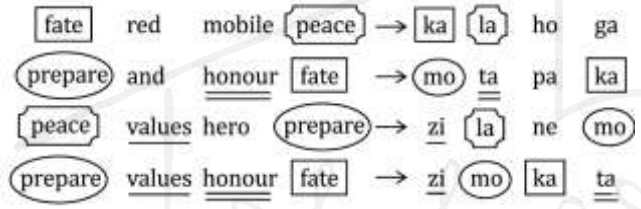
Ex: What is the code for 'peace' in the given code language?

1. ta 2. Mo 3. la 4.Either pa or mo

Ex: What is the code for 'prepare' in the given code language?

1. mo 2. Ta 3. pa 4. ka

Ans:



1. Code for fate is “ka”.
2. Code for peace is “la”.
3. Code for prepare is “mo”.

Ex: In a certain code language, 'MOST' is written as '134' and 'FUR' is written as '90'. How will 'SUCCESS' be written in that language?

Ans:

Logic: Addition of alphabet positional value × 2 = Code

'MOST' is written as '134'

M (13) + O (15) + S (19) + T (20) = 67 × 2 = 134

And, 'FUR' is written as '90'

F (6) + U (21) + R (18) = 45 × 2 = 90

Similarly, 'SUCCESS' be written as

S (19) + U (21) + C (3) + C (3) + E (5) + S (19) + S (19) = 89 × 2 = 178

Hence, the correct answer is "178".

Ex: In a certain code language, 'LIBERTY' is coded as '4221824364050'. How will 'SLAVERY' be coded in that language?

Ans:

Step 1: Arrange letters according to the alphabet’s series.

Step 2: All consonant place values multiply by 2 and it is coded as numeric values.

Step 3: Opposite letter place values of vowels are coded as numeric values.

'LIBERTY' is coded as '4221824364050'.

Step 1: LIBERTY Alphabetical order → BEILRTY.

Step 2: All consonant place values multiply by 2 and it is coded as numeric values.

Step 3: Opposite letter place values of vowels are coded as numeric values.

SLAVERY Alphabetical order - AELRSVY.

Hence, the correct answer is "26222436384450".

Ex: N = 28 and ORE = 76, then how will you code PALE?

Ans: N = 14; 14 × 2 = 28

ORE 15+18+5 38: 38×2 = 76

Similarly. PALE 16+1+12+5= 34; 34 × 2 = 68

Type-12 Analogy Based Coding

Column I contains some words, and their corresponding codes are given in Column II. In the code, it is not necessary that the letters are in the same order as they appear in the words they represent. Each letter has only one code. Carefully study both columns and answer the following questions.

Column I	Column II
(1) HEAD	(a) hlonqsx
(2) ROUTINE	(b) dhpqrs
(3) ENOUGH	(c) efnqr
(4) GHOST	(d) efhnox
(5) MASTER	(e) adeh
(6) NOSE	(f) hnor

Alphabet	N	M	E	H	A	D	G	I	O	R	S	T	U
Code	o	p	h	e	d	a	f	l	n	s	r	q	x

1. The code for D is a.
2. The code for E is h.
3. The code for G is f.
4. The code for I is l.
5. The code for M is p.

21 CHAPTER

Biology

The Cell

- **Simplest and most basic unit** of life.
- **Discovered:** Robert Hooke (1665)
- All living things made up of cells- **structural, functional, and biological unit of life**.
- Has the **ability to duplicate itself** on its own.
- aka **"building blocks of life.**"

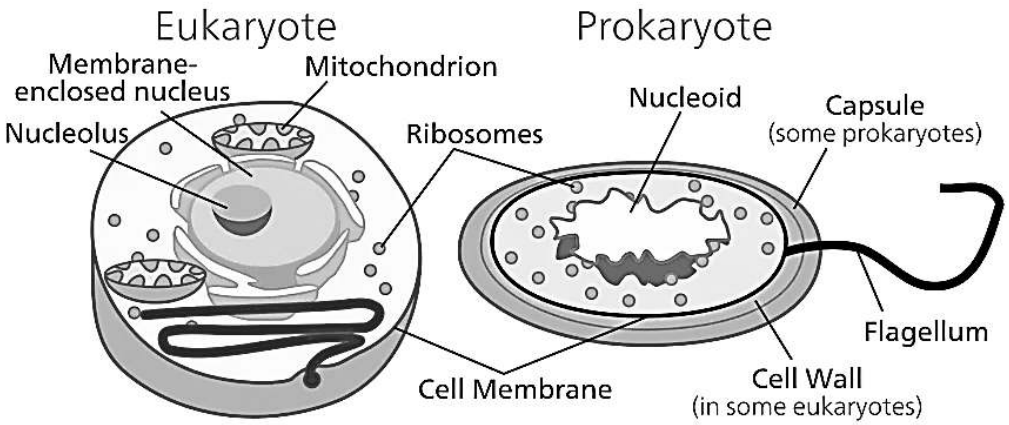
Cell Structure and its components

Cell Organelles

- Present within a cell & **perform certain specific functions to carry out life's processes.**

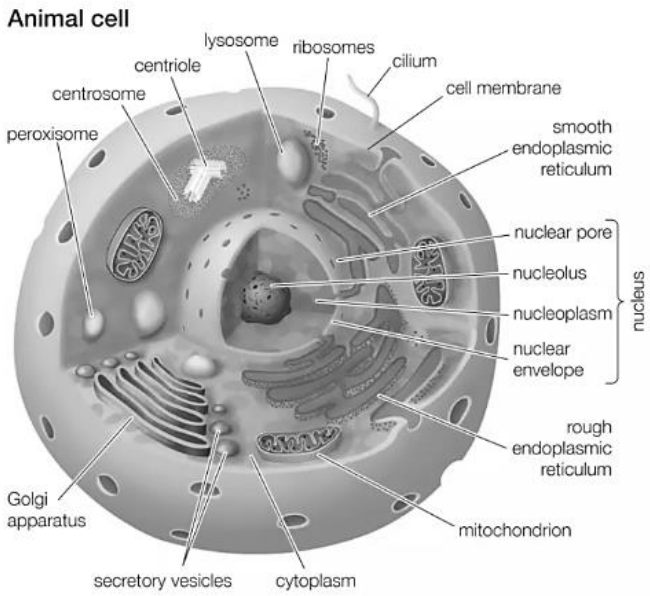
Plasma / Cell Membrane	● **Outermost covering** of the cell ● **Separates contents of cell** from its **external environment.** ● **A selectively permeable membrane** as it allows entry and exit of some materials in and out of the cell.
Cell Wall	● **ONLY** in **plants** ● **Outside** the **plasma membrane.** ● Mainly **composed of cellulose.** ○ **Cellulose:** A complex substance - provides structural strength to plants.
Cytoplasm	● **Jelly-like substance** present between **cell membrane & nucleus.** ● **Fluid content inside plasma membrane.** ● **Contains** many specialised **cell organelles** (mitochondria, golgi bodies, ribosomes, etc)
Nucleus	● **Contains chromosomes** that contain **information** for **inheritance** of features from parents to next generation in form of DNA ● Plays a **central role** in **cellular reproduction**. ● **Nuclear membrane**- a **double-layered** covering on nucleus. ○ **Allows transfer** of **material** from **inside** nucleus **to its outside**, i.e., to cytoplasm.
Nucleolus	● **Ribosome synthesis site regulating cellular activity** and **reproduction**.
Gene	● **Unit of inheritance** in living organisms.
Protoplasm	● **Entire content of a living cell** [cytoplasm + nucleus]. ● aka **living substance of the cell.**
Chromosomes	● **Rod-shaped structures** ● Visible **only when** the **cell is about to divide**. ● Contain **information for inheritance of features** from parents to next generation in the form of DNA (deoxyribo nucleic acid) ● **Composed** of **DNA** and **Protein**.
DNA molecules	● Contains **information necessary for constructing and organising cells**. ● Functional segments of DNA - **genes.**

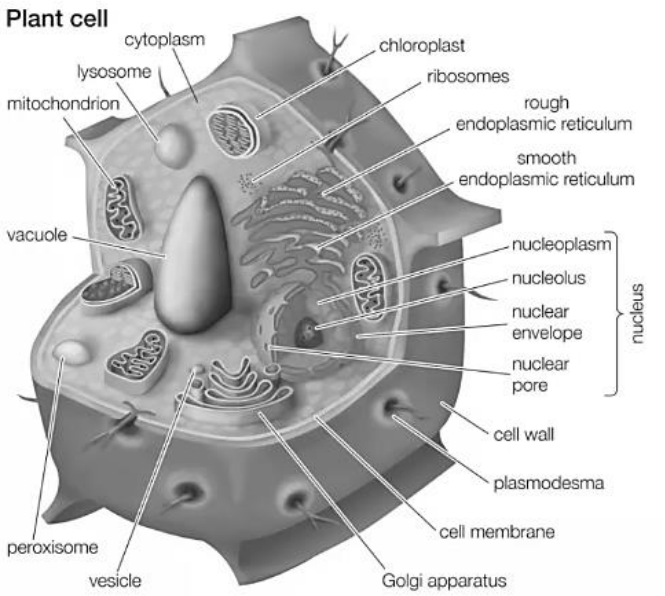
Vacuoles	● **Empty structure in cytoplasm** ● Act as storage sacs for solid or liquid contents. ● **Common in plant cells.** ● **Smaller in animal cells**. ● **Substances stored-** amino acids, sugars, various organic acids and some proteins.
Endoplasmic Reticulum	● A **large network of membrane-bound tubes and sheets**. ● **2 types :** **1. Rough endoplasmic reticulum [RER]** o **Has ribosomes** attached to its surface. o **Ribosomes** - sites of **protein manufacture**. **2. Smooth endoplasmic reticulum** o Helps in the **manufacture of fat molecules**, or lipids, important for cell function. o Some of these proteins and lipids **help in building the cell membrane k/a membrane biogenesis.** ● Serve as **channels for transport of materials** between various regions of cytoplasm or between the cytoplasm and the nucleus. ● Also functions as **a cytoplasmic framework** providing a **surface for some biochemical activities of cells.**
Golgi Apparatus/ Complex	● A **system of membrane-bound vesicles** arranged **parallel** to each other in **stacks** called **cisterns**. ● **Packages** and **dispatches material synthesised near ER** to **various targets** inside and outside the cell. ● **Stores**, **modifies** and **packages products** in vesicles. ● Involved in the **formation** of **lysosomes**. o **Membrane-bound sacs** filled with digestive enzymes. o Kind of **waste disposal system** of the cell. o **Help** to **keep** the **cell clean** by **digesting** any **foreign material** as well as **worn-out cell organelles**.
Mitochondria	● Aka **powerhouse of the cell.** ● **Energy required** for various chemical activities **is released** by mitochondria in the form of **ATP** (Adenosine Triphosphate) molecules. ● 2 **membranes:** o **Outer membrane- porous** o **Inner membrane - deeply folded.** ■ **Folds** create a **large surface area** for **ATP-generating chemical reactions**.
ATP	● aka **energy currency of the cell.** ● **Body uses energy** stored in **ATP** for **making new chemical compounds** and for mechanical work.
Ribosomes	● **Site of protein synthesis.** ● **Polyribosomes or Polysomes:** Several **ribosomes may attach to a single mRNA and form a chain.** ● **Prokaryotes- ribosomes are associated with the plasma membrane of the cell.**
Cilia and Flagella Cilia	● **Hair-like outgrowths of the cell membrane.** ● **Cilia** - **small structures which work like oars**, **causing** the **movement of either the cell or the surrounding fluid.** ● **Flagella** - comparatively **longer** and responsible for cell movement. ● **Prokaryotic bacteria have flagella but structurally different from eukaryotic flagella.**
Centrosome and Centrioles	● Centrosome- **an organelle** usually containing 2 **cylindrical structures called centrioles.** ● **Surrounded by amorphous pericentriolar materials**. ● **Both** the **centrioles** in a centrosome **lie perpendicular** to each other



Prokaryotic Cell	Eukaryotic Cell
● **Primitive/undeveloped nucleus.**	● Has **true or developed nucleus**
● **Size** - 0.2 - 2.0 micrometers	● **Size**- 10- 100 micrometers.
● **Simpler** in **structure**	● **More complex**
● **Organelles not membrane-bound**	● **Organelles membrane bound** & specific in function.
● **DNA** arranged in **circular** shape	● **DNA linear** in shape
● **Cytoplasm present**, but **lacks** in most **cell organelles**.	● Consists of **both cytoplasm** and **organelles**
● **Cell wall present**. ● Made of mucopeptide or peptidoglycan	● Usually, **absence of cell** wall here. ● Made of cellulose
● **Cell division** - binary fission, transduction, conjugation, and transformation	● **Cell division** - mitosis
● **Mitochondria absent**	● Mitochondria **present**.
● **Endoplasmic reticulum not present**.	● Endoplasmic reticulum **present**.
● **Ribosome present**	● Ribosome **present**
● **Plasmids** commonly **found**. ○ A **small, circular, double-stranded DNA** molecule **distinct** from a **cell's chromosomal DNA**. ○ **Naturally exist in bacterial cells.**	● **Plasmids** very **rarely found**
● **Only asexual reproduction**.	● **Both sexual** and **asexual** reproduction.
● Have a **single origin** of **replication**	● Have **multiple origins** of **replication**
● Only 1 **chromosome**.	● **Many chromosomes** present
● **Eg.** Bacteria and Archaea.	● **Eg**. Plant and animal cells.

Plant and Animal Cells





	Animal Cell	Plant Cell
Nucleus	Present	Present
Cilia	Present	Very rare
Shape	Round (irregular shape)	Rectangular (fixed shape)
Chloroplast	NO chloroplasts	Chloroplasts present
Cytoplasm	Present	Present
Endoplasmic Reticulum	Present	Present
Ribosomes	Present	Present
Mitochondria	Present	Present
Vacuole	One or more small vacuoles (much smaller than plant cells).	One large central vacuole taking up 90% of cell volume.

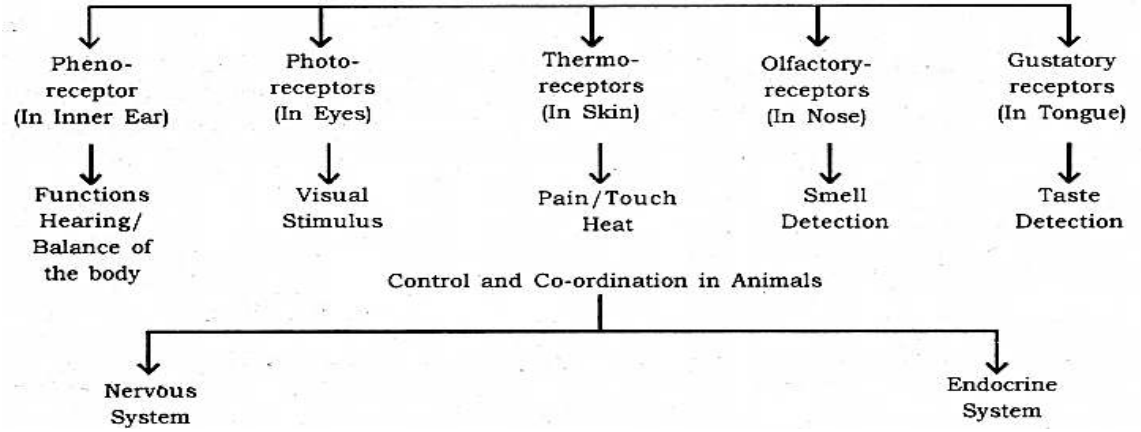
Control and Coordination

In animals

Nervous system and hormonal system are **responsible** for **control** and **coordination**.

Receptors:

- **Specialized tips of nerve fibres** that **collect information** to be **conducted by nerves**.
- **In** the **sense organs** of the animals.



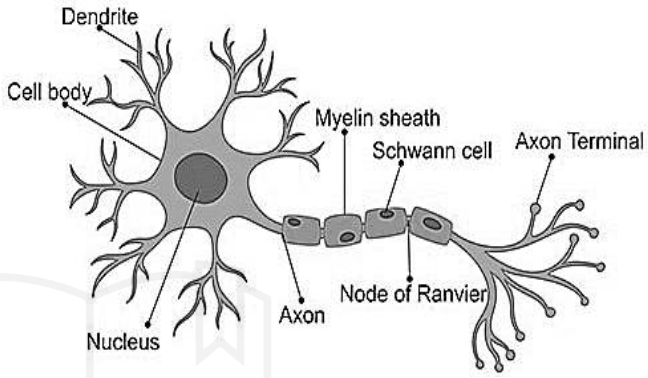
- **Types**:

1. **Nervous System**

- A **highly complex regulatory system** in animals.
- **Coordinates actions** & **transmits sensory information** and **signals** to/from the different parts of body.
- **Neuron** - **structural** and **functional unit** of entire system.
- **Functions:**
  - **Receives information** from the **environment**.
  - Receive the information from the **various body parts**.
  - **Act accordingly** through muscles and glands.
- **Movement**- **ability** of an organism **to move** a **particular body part**.
- **Locomotion** - **ability** of an organism **to move** its **whole body** from one place to another.

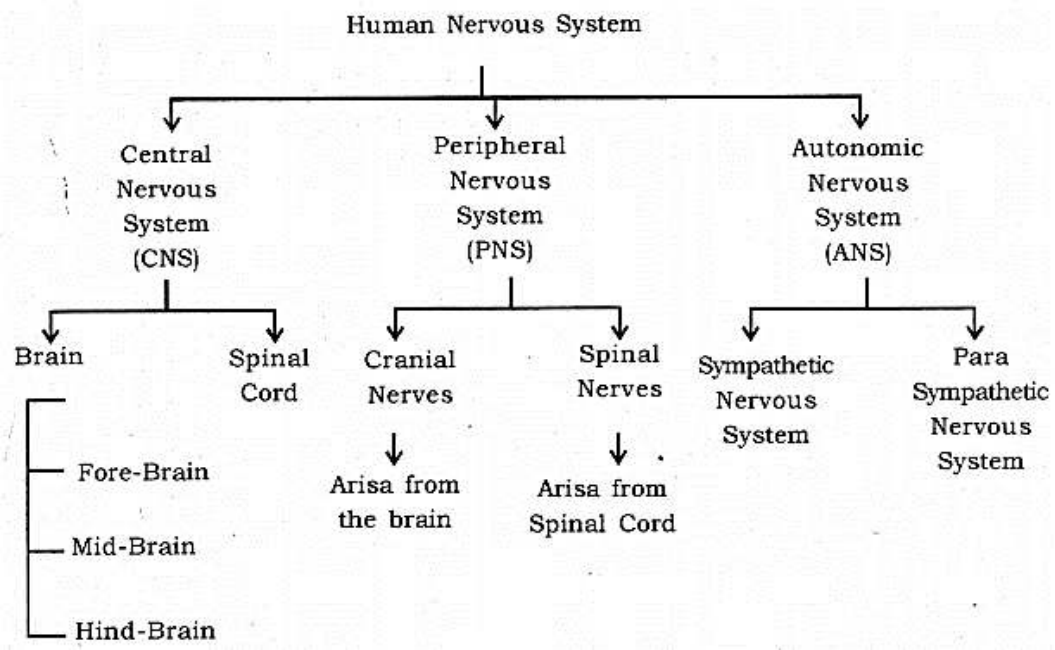
Neuron

- **Structural and functional unit of the nervous system**
- **Coordinates and controls the complex actions** in animals.
- **Specialized cells** responsible for **transmission** of **nerve** impulses.
- **3 parts-**
  1. **Axon-**
     - **Tail** of the **neuron**.
     - **Ends** in **fine hair-like structures** k/a **axon terminals** which rely on nerve impulses
     - **Axons** - **myelinated** or **unmyelinated**.
     - **Impulse transmission is** faster in **myelinated neurons**.
  2. **Cyton/soma/cell body-**
     - **Star-shaped** having various **hair-like structures** k/a **dendrites** which **receive** the **nerve impulses**
  3. **Myelin Sheath-**
     - An **insulating sheath** on **axon**.
     - **Insulates axon against nerve impulse** from its **surroundings**.
     - **Dendrites receive** the **impulse** from other neurons.
     - **Cyton** or Soma cells **process** the **impulse**- **transmitted** to the **Axon**. Gets transmitted either to other neurons or to muscles for taking necessary action.



- **Types :**
  1. **Sensory** neurons- Receive the signals from a sense organ
  2. **Motor** neurons- Send the signals to a gland or muscle
  3. **Relay** or association neuron- Relay signals between a motor neuron and sensory neuron.
- **Synapse**
  - A **microscopic gap** between **two adjacent neurons**.
  - A **point contact between terminal branches** of **axon** of one neuron and with the dendrite of another neuron.
  - **Convert electric signals** into **chemicals** that can cross over gap between axon and dendrite.
  - **Chemical message** is **passed** to **next neuron** and **converted back** to the **electrical signal** for **interpretation**.
- **Neuromuscular Junction:**
  - **Point where** a **muscle fibre comes** in **contact with** a **motor neuron** carrying nerve impulse from the control nervous system.

Human nervous system

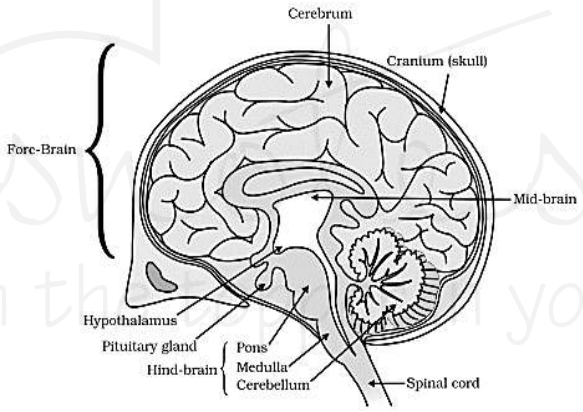


1. **Central Nervous System:**

- **Brain + spinal cord.**
- **Brain controls** all the **functions** in the human body.
- **Spinal cord** works as **relay channel** for **signals between brain** and **peripheral nervous system**.

Human Brain

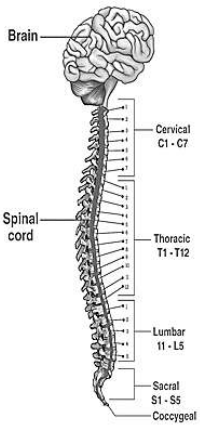
- A **highly complex organ** mainly **composed** of **nervous tissue**.
- **Tissues highly folded** to **accommodate** a **large surface area** in **less space**.
- **Covered by** a **3-layered system** of **membranes** k/a **meninges**.
- **Cerebrospinal fluid** filled **between meninges cushions** the **brain** against mechanical shocks.



- **3 parts:**
  1. **Fore-brain:**
     - **Composed** of the **cerebrum**.
     - **Cerebrum**- **Largest part** in human brains.
     - Divided into **2 hemispheres** k/a cerebral hemispheres.
     - **Functions**:
       - **Controls voluntary** motor actions.
       - **Site** of **sensory perceptions**, like tactile and auditory perceptions.
       - **Site** of **learning** and **memory**.
  2. **Mid-brain:**
     - **Composed** of the **hypothalamus**.
     - **Hypothalamus**- lies at the **base** of the **cerebrum**.
     - **Controls sleep** and **wake cycle** (circadian rhythm) of the body.
     - **Controls** the urges for **eating** and **drinking**.
  3. **Hind-brain:**
     - **Composed** of **cerebellum**, **pons**, **medulla**, **oblongata**.
     - **Cerebellum**- lies **below cerebrum** and at back of whole structure.
       - **Coordinates** the **motor functions**.
       - **Eg**. riding a bicycle, ensures perfect coordination between pedalling and steering control.
       - **Controls posture** and **balance**.
       - **Controls** the **precision** of **voluntary action**.

- **Medulla**: **Forms brain stem**, along with the pons.
  - **Lies at the base of brain** and **continues** into **spinal cord**.
  - **Controls** various **involuntary functions**, like hear beat respiration, etc.
  - **Controls involuntary actions**.
  - **Eg**: Blood pressure, salivation, vomiting.
- **Pons**:
  - **Relays impulses** between **lower cerebellum** and **spinal cord**
  - **Regulates respiration**.

Spinal cord:



1. **Controls reflex actions** and conducts messages between different parts of body and brain.
2. **Reflex Action**:
3. **Sudden** and **involuntary response** to **stimuli**.
4. **Helps organisms** to **quickly adapt** to an **adverse circumstance** that could cause bodily harm or even death.
5. **Eg**. Pulling our hands away immediately after touching a hot or cold object.
6. **Reflex Arc**:
7. **Path** through which nerves signals, **involved** in a **reflex action**, travel.
   Receptor → **Sensory neuron** → **Relay neuron** → **Motor neuron** → **Effector** (muscle)
2. **Peripheral Nervous System:**
   - **Cranial nerves** + **spinal nerves**.
   - **12 pairs** of **cranial nerves** coming out of brain and go to the organs in the head region.
   - **31 pairs** of **spinal nerves** coming out of spinal cord and go to the organs which are below the head region.
3. **Autonomous Nervous System:**
   - **Composed** of a **chain of nerve ganglion** which **runs along spinal cord**.
   - **Controls** all the **involuntary actions** in the **human body**.
     - **2 parts** :

     A. Sympathetic Nervous System:
     - **Increases activity** of an **organ** as required.
     - **Eg.** during running, there is an increased demand for oxygen by the body - fulfilled by an increased breathing rate and increased heart rate.

     B. Parasympathetic Nervous System:
     - **Decreases** the **activity** of an organ and thus has a calming effect.
     - **Eg.** during sleep, breathing rate slows down and so does the heart rate.
     - Helps in the **conservation of energy**.

Endocrine System

- **Made** up **of interconnected glands** that create **hormones.**
- Almost **every cell, organ, and function in our body is influenced by the endocrine system.**
- **Aids -** regulation of mood, growth and development**,** tissue function, metabolism, and sexual and reproductive functions.
- Also k/a **ductless system** as the endocrine glands **secrete** their **hormones** directly into **bloodstream**.