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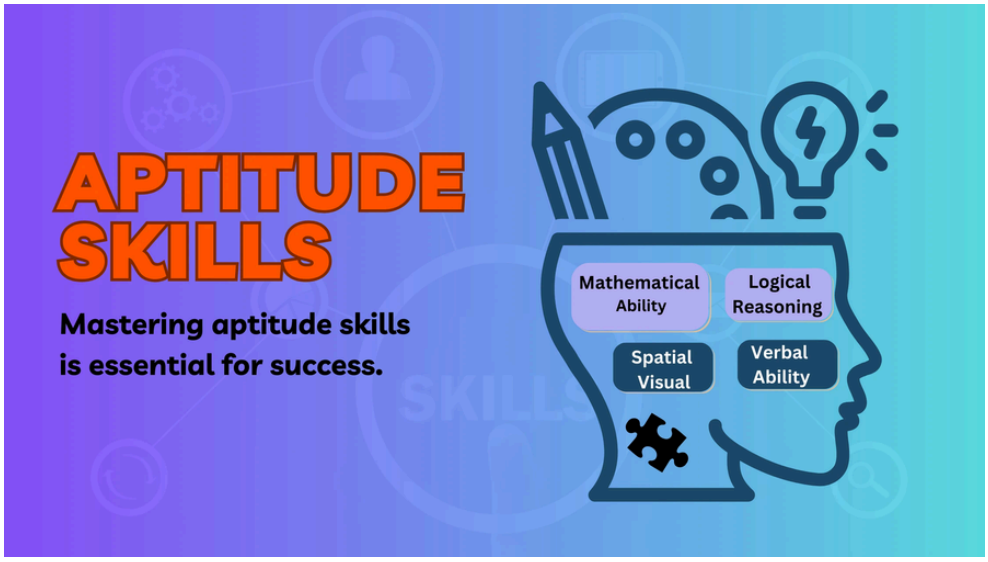

Aptitude Material

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MINISTRY OF CORPORATE AFFAIRS
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Aptitude Preparation Guide for Tech Students

1. Introduction to Aptitude for Tech Careers

- Importance of aptitude in technical placements
- Types of aptitude tests in IT sector
- Strategy for improving aptitude skills

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- Simple & Compound Interest
- Ratios & Proportions
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- Time & Work

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- Number Theory in Coding (GCD, LCM, Prime Numbers)
- Recursion & Backtracking
- String Manipulation Techniques

7.2 Algorithms & Data Structures

- Sorting & Searching Algorithms
- Arrays, Linked Lists, Stacks & Queues
- Graphs & Trees

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1. Introduction to Aptitude for Tech Careers

Importance of aptitude in technical placements

Aptitude plays a crucial role in technical placements as it assesses a candidate's problem-solving ability, logical reasoning, and numerical skills—key attributes for excelling in technical roles. Recruiters use aptitude tests as an initial screening tool to evaluate how well a candidate can think critically and handle challenges. Strong aptitude skills reflect a candidate's potential to learn new technologies, adapt to complex scenarios, and make data-driven decisions. These skills are essential in solving real-world problems in engineering, IT, or other technical domains. Excelling in aptitude tests increases the chances of securing interviews and advancing in the recruitment process.

Aptitude tests in the IT sector evaluate a candidate's technical and problem-solving abilities essential for success in the industry. Common types include logical reasoning tests, which assess analytical thinking and problem-solving skills; quantitative aptitude tests, focusing on mathematical concepts like algebra, statistics, and data interpretation; and verbal ability tests, which measure language proficiency and communication skills. Additionally, technical aptitude tests evaluate domain-specific knowledge, including programming, databases, and software concepts. Some tests may include situational judgment questions to assess decision-making in IT-related scenarios. Excelling in these tests helps candidates showcase their suitability for roles requiring technical expertise and analytical thinking.

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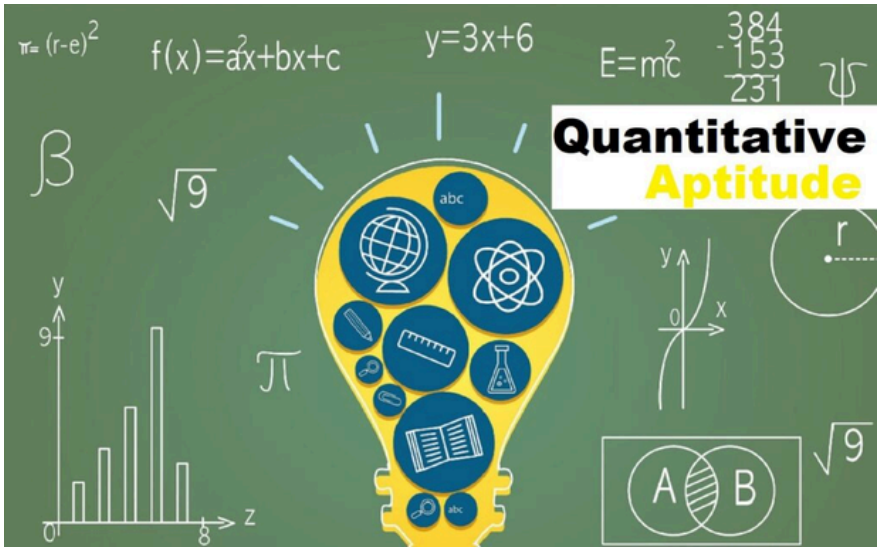
Strategy for improving aptitude skills

Improving aptitude skills requires consistent practice and a structured approach. Start by identifying weaker areas, such as logical reasoning, quantitative aptitude, or verbal ability, and focus on strengthening them. Practice regularly with mock tests, previous placement papers, and online resources to enhance speed and accuracy. Break down complex problems into smaller, manageable steps and use shortcuts or formulas to save time. Develop strong fundamentals in mathematics and reasoning techniques, and work on vocabulary and comprehension for verbal sections. Time management is crucial, so practice under timed conditions. Lastly, analyze mistakes to avoid repeating them and refine your problem-solving strategies.

2. Quantitative Aptitude

Quantitative aptitude refers to the ability to solve numerical and mathematical problems efficiently, making it a critical skill in competitive exams and placements. It assesses a candidate's proficiency in arithmetic, algebra, geometry, number systems, probability, and data interpretation. Strong quantitative aptitude demonstrates analytical thinking, logical reasoning, and problem-solving capabilities. To excel, candidates should focus on mastering basic mathematical concepts, practicing regularly with diverse problem sets, and learning shortcuts or tricks for quick calculations. It is often used as a key parameter in screening processes, as it reflects a candidate's ability to handle complex data and solve practical problems in real-world scenarios



2.1 Number System

The number system is a fundamental concept in mathematics that deals with representing and classifying numbers. It includes different types of numbers, such as natural numbers, whole numbers, integers, rational numbers, irrational numbers, and real numbers. Understanding concepts like divisibility rules, prime numbers, factors, multiples, remainders, and place value is essential. The number system forms the foundation for solving problems in quantitative aptitude, including topics like HCF, LCM, and modular arithmetic. Proficiency in the number system helps improve speed and accuracy in competitive exams and technical placements, as many questions require a strong grasp of numerical properties and operations.

Natural Numbers (Counting numbers starting from 1):

Examples: 1, 2, 3, 10, 50

1.Problem: What is the sum of 7 and 12?
Solution: 7+12=197 + 12 = 197+12=19

2.Problem: Multiply 9 and 5.
Solution: 9×5=459 \times 5 = 459×5=45

3.Problem: Find the first three natural numbers.
Solution: 1, 2, 3

4. Problem: What is the smallest natural number?
Solution: 1

5.Problem: Find the sum of the first 5 natural numbers.
Solution: 1+2+3+4+5=151 + 2 + 3 + 4 + 5 = 151+2+3+4+5=15

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Whole Numbers (W): Natural numbers including 000: 0,1,2,3,...0, 1, 2, 3, \dots0,1,2,3,....

Whole Numbers Problems:

1.What is 5+05 + 05+0?
Solution: ??
2.Is 000 a whole number?
Solution: ??
3.What is 9−49 - 49−4?
Solution: ??
4.What is the smallest whole number?
Solution: ??
5.What is 7×37 \times 37×3?
Solution: ??

Integers (Z): Whole numbers and their negatives: ...,−3,−2,−1,0,1,2,3,...\dots, -3, -2, -1, 0, 1, 2, 3, \dots...,−3,−2,−1,0,1,2,3,....

Integers Problems:

1.What is (−3)+5(-3) + 5(−3)+5?
Solution: ??
2.What is (−7)−(−2)(-7) - (-2)(−7)−(−2)?
Solution: ??
3.What is the opposite of −6-6−6?
Solution: ??
4.Find (−4)×3(-4) \times 3(−4)×3.
Solution:??
5.What is (−8)÷(−2)(-8) \div (-2)(−8)÷(−2)?
Solution: ??

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Rational Numbers (Q): Numbers that can be expressed as ab\frac{a}{b}ba (where a,b∈Za, b \in Za,b∈Z and b≠0b \neq 0b□=0), including fractions and terminating/repeating decimals.

Rational Numbers Problems:

1.Simplify 69\frac{6}{9}96.

Solution: 23\frac{2}{3}32.

2.What is 34+12\frac{3}{4} + \frac{1}{2}43+21?

Solution: 54 or 1.25\frac{5}{4} \text{ or } 1.2545 or 1.25.

3.Convert 0.750.750.75 to a fraction.

Solution: 34\frac{3}{4}43.

4.What is 56×23\frac{5}{6} \times \frac{2}{3}65×32?

Solution: 1018=59\frac{10}{18} = \frac{5}{9}1810=95.

5.Find 72÷34\frac{7}{2} \div \frac{3}{4}27÷43.

Solution: 72×43=286=143\frac{7}{2} \times \frac{4}{3} = \frac{28}{6} = \frac{14}{3}27 ×34=628=314

Divisibility rules

Divisible by 2: A number is divisible by 2 if its last digit is even (0, 2, 4, 6, 8).

- **Example: 363636 is divisible by 2 because the last digit is 666.**

Divisible by 3: A number is divisible by 3 if the sum of its digits is divisible by 3.

- **Example: 123123123 is divisible by 3 because 1+2+3=61 + 2 + 3 = 61+2+3=6, and 666 is divisible by 3.**

Divisible by 4: A number is divisible by 4 if the last two digits form a number divisible by 4.

- **Example: 312312312 is divisible by 4 because the last two digits, 121212, are divisible by 4.**

Divisible by 5: A number is divisible by 5 if its last digit is 000 or 555.

- **Example: 454545 is divisible by 5 because the last digit is 555.**

Divisible by 6: A number is divisible by 6 if it is divisible by both 2 and 3.

- Example: 545454 is divisible by 6 because it is divisible by 2 (last digit is even) and by 3 (5+4=95 + 4 = 95+4=9).

Divisible by 9: A number is divisible by 9 if the sum of its digits is divisible by 9.

- Example: 729729729 is divisible by 9 because 7+2+9=187 + 2 + 9 = 187+2+9=18, and 181818 is divisible by 9.

Divisible by 10: A number is divisible by 10 if its last digit is 000.

- Example: 808080 is divisible by 10 because the last digit is 000.

Divisibility by 2 Problems:

1.Is 484848 divisible by 2?
Solution: Yes, because the last digit (888) is even.
2.Is 737373 divisible by 2?
Solution: No, because the last digit (333) is odd.
3.Find if 124124124 is divisible by 2.
Solution: Yes, because the last digit (444) is even.

Divisibility by 3 Problems:

1.Is 818181 divisible by 3?
Solution: Yes, because 8+1=98 + 1 = 98+1=9, and 999 is divisible by 3.
2.Is 145145145 divisible by 3?
Solution: No, because 1+4+5=101 + 4 + 5 = 101+4+5=10, and 101010 is not divisible by
3.Check if 273273273 is divisible by 3.
Solution: Yes, because 2+7+3=122 + 7 + 3 = 122+7+3=12, and 121212 is divisible by 3.

Divisibility by 4 Problems:

1.Is 929292 divisible by 4?
Solution: Yes, because the last two digits (929292) are divisible by 4.
2.Is 153153153 divisible by 4?
Solution: No, because the last two digits (535353) are not divisible by 4.
3.Check if 216216216 is divisible by 4.
Solution: Yes, because the last two digits (161616) are divisible by 4.

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Divisibility by 5 Problems:

1.Is 656565 divisible by 5?

Solution: Yes, because the last digit is 555.

2.Is 989898 divisible by 5?

Solution: No, because the last digit (888) is neither 000 nor 555.

3.Check if 150150150 is divisible by 5.

Solution: Yes, because the last digit is 000

Divisibility by 6 Problems:

1.Is 424242 divisible by 6?

Solution: Yes, because 424242 is divisible by both 2 (even) and 3 (4+2=64 + 2 = 64+2=6).

2.Is 125125125 divisible by 6?

Solution: No, because 125125125 is not divisible by 2 (it is odd).

3.Check if 848484 is divisible by 6.

Solution: Yes, because 848484 is divisible by both 2 (even) and 3 (8+4=128 + 4 = 128+4=12).

Divisibility by 9 Problems:

1.Is 818181 divisible by 9?

Solution: Yes, because 8+1=98 + 1 = 98+1=9, and 999 is divisible by 9.

2.Is 134134134 divisible by 9?

Solution: No, because 1+3+4=81 + 3 + 4 = 81+3+4=8, and 888 is not divisible by 9.

3.Check if 243243243 is divisible by 9.

Solution: Yes, because 2+4+3=92 + 4 + 3 = 92+4+3=9, and 999 is divisible by 9.

Divisibility by 10 Problems:

1.Is 120120120 divisible by 10?

Solution: Yes, because the last digit is 000.

2.Is 147147147 divisible by 10?

Solution: No, because the last digit is 777.

3.Check if 250250250 is divisible by 10.

Solution: Yes, because the last digit is 000.

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LCM (Least Common Multiple):

The Least Common Multiple (LCM) of two or more numbers is the smallest positive number that is a multiple of all the given numbers. To find the LCM, list the multiples of each number and identify the smallest one common to all. Alternatively, the prime factorization method can be used, where the LCM is the product of the highest powers of all prime factors.

Examples:

1.Find the LCM of 444 and 666.

Solution: Multiples of 444: 4,8,12,...4, 8, 12, \dots4,8,12,...; Multiples of 666: 6,12,18,... 6, 12, 18, \dots6,12,18,.... LCM = 121212.

2.Find the LCM of 151515 and 202020.

Solution: Prime factors: 15=3×515 = 3 \times 515=3×5, 20=22×520 = 2^2 \times 520=22×5. LCM = 22×3×5=602^2 \times 3 \times 5 = 6022×3×5=60.

3.Find the LCM of 888 and 121212.

Solution: Multiples of 888: 8,16,24,...8, 16, 24, \dots8,16,24,...; Multiples of 121212: 12,24,36,...12, 24, 36, \dots12,24,36,.... LCM = 242424.

HCF (Highest Common Factor):

The Highest Common Factor (HCF), also known as the greatest common divisor (GCD), is the largest number that divides two or more numbers without leaving a remainder. It can be found using the prime factorization method (taking the lowest powers of common factors) or the division method.

Examples:

1.Find the HCF of 242424 and 363636.

Solution: Prime factors: 24=23×324 = 2^3 \times 324=23×3, 36=22×3236 = 2^2 \times 3^236=22×32. HCF = 22×3=122^2 \times 3 = 1222×3=12.

2.Find the HCF of 181818 and 272727.

Solution: Prime factors: 18=2×3218 = 2 \times 3^218=2×32, 27=3327 = 3^327=33. HCF = 32=93^2 = 932=9.

3.Find the HCF of 424242 and 565656.

Solution: Prime factors: 42=2×3×742 = 2 \times 3 \times 742=2×3×7, 56=23×756 = 2^3 \times 756=23×7. HCF = 2×7=142 \times 7 = 142×7=14.

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Remainder Theorem:

The Remainder Theorem states that when a polynomial f(x)f(x)f(x) is divided by x−cx - cx−c, the remainder is f(c)f(c)f(c). This means substituting ccc into the polynomial gives the remainder directly. It is useful for quickly finding remainders without performing full polynomial division.

Examples:

1.Find the remainder when f(x)=x2+3x+2f(x) = x^2 + 3x + 2f(x)=x2+3x+2 is divided by x−1x - 1x−1:

Solution:

- Let c=1c = 1c=1. Substitute x=1x = 1x=1 into f(x)f(x)f(x):
- f(1)=(1)2+3(1)+2=1+3+2=6f(1) = (1)^2 + 3(1) + 2 = 1 + 3 + 2
- = 6f(1)=(1)2+3(1)+2=1+3+2=6.
- Remainder = 666.

2.Find the remainder when f(x)=2x3−x2+4x−5f(x) = 2x^3 - x^2 + 4x - 5f(x)=2x3−x2+4x−5 is divided by x+2x + 2x+2:

Solution:

- Let c=−2c = -2c=−2. Substitute x=−2x = -2x=−2:
- f(−2)=2(−2)3−(−2)2+4(−2)−5=−16−4−8−5=−33f(-2)
- = 2(-2)^3 - (-2)^2 + 4(-2) - 5
- = -16 - 4 - 8 - 5
- = -33f(−2)=2(−2)3−(−2)2+4(−2)−5
- =−16−4−8−5=−33.
- Remainder = −33-33−33.

3.Find the remainder when f(x)=3x2−5x+7f(x) = 3x^2 - 5x + 7f(x)=3x2−5x+7 is divided by x−3x - 3x−3:

Solution:

- Let c=3c = 3c=3. Substitute x=3x = 3x=3:
- f(3)=3(3)2−5(3)+7=27−15+7=19f(3)
- = 3(3)^2 - 5(3) + 7 = 27 - 15 + 7 = 19f(3)=3(3)2−5(3)+7
- =27−15+7=19.
- Remainder = 191919.

2.2 Arithmetic

Arithmetic is the branch of mathematics that deals with numbers and their basic operations, including addition, subtraction, multiplication, and division. It forms the foundation of more advanced mathematical concepts and is essential in everyday life for problem-solving and calculations.

Addition (+): Combining two or more numbers to get a total or sum.

- **Example: 5+3=85 + 3 = 85+3=8.**

Subtraction (−): Finding the difference between two numbers by removing one from the other.

- **Example: 10−4=610 - 4 = 610−4=6.**

Multiplication (×): Repeated addition of the same number, resulting in a product.

- **Example: 4×3=124 \times 3 = 124×3=12.**

Division (÷): Splitting a number into equal parts, resulting in a quotient.

- **Example: 12÷4=312 \div 4 = 312÷4=3.**

Arithmetic also includes understanding properties of numbers such as even and odd, prime and composite, as well as working with decimals, fractions, and percentages. It helps in calculating averages, ratios, proportions, and more.

Modern arithmetic extends into solving equations and problems involving sequences, patterns, and order of operations (BODMAS/PEMDAS). Mastering arithmetic skills is crucial for applications in science, business, engineering, and daily life, such as budgeting or measuring quantities. It's the building block of all mathematical learning.

Percentages

A percentage is a way of expressing a number as a fraction of 100. It is denoted by the symbol "%\%%" and means "per hundred." Percentages are widely used to compare proportions, calculate discounts, interest rates, profit/loss, and other real-world scenarios.

To calculate percentages:

1. Convert fractions or decimals to percentages by multiplying by 100100100: Fraction or Decimal×100% \text{Fraction or Decimal} \times 100\%Fraction or Decimal×100%.
2. Convert percentages to fractions or decimals by dividing by 100100100: Percentage÷100 \text{Percentage} \div 100Percentage÷100.
3. To find the percentage of a number: Percentage×Number/100 \text{Percentage} \times \text{Number} / 100Percentage×Number/100.

Examples:

1.Find 25%25\%25% of 200200200:

Solution: 25×200/100=5000/100=5025 \times 200 / 100 = 5000 / 100 = 5025×200/100=5000/100=50.

Answer: 505050.

2.What percentage is 303030 out of 120120120?

Solution: (30/120)×100=0.25×100=25%(30 / 120) \times 100 = 0.25 \times 100 = 25\%(30/120)×100=0.25×100=25%.

Answer: 25%25\%25%.

3.A product costing ₹500₹500₹500 is on a 20%20\%20% discount. Find the discounted price:

Solution: Discount = 500×20/100=100500 \times 20 / 100 = 100500×20/100=100.

Discounted price = 500−100=400500 - 100 = 400500−100=400.

Answer: ₹400₹400₹400.

Percentages simplify comparisons and are essential in financial calculations, data analysis, and everyday transactions.

1.

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Profit & Loss

Profit and Loss are concepts in commerce that determine the financial outcome of a transaction. They are calculated based on the Cost Price (C.P.) and Selling Price (S.P.) of an item.

Profit: If the Selling Price is greater than the Cost Price, the seller makes a profit.

Formula:

Profit=S.P.−C.P.\text{Profit} = \text{S.P.} - \text{C.P.}Profit=S.P.−C.P.

Profit Percentage=(Profit/C.P.)×100\text{Profit Percentage} = (\text{Profit} / \text{C.P.}) \times 100Profit Percentage=(Profit/C.P.)×100

Loss: If the Selling Price is less than the Cost Price, the seller incurs a loss.

Formula:

Loss=C.P.−S.P.\text{Loss} = \text{C.P.} - \text{S.P.}Loss=C.P.−S.P.

Loss Percentage=(Loss/C.P.)×100\text{Loss Percentage} = (\text{Loss} / \text{C.P.}) \times 100Loss Percentage=(Loss/C.P.)×100

Examples:

1.A product is bought for ₹200 and sold for ₹250. Find the profit and profit percentage.

Solution:

Profit = 250−200=50250 - 200 = 50250−200=50.

Profit % = (50/200)×100=25%(50 / 200) \times 100 = 25\%(50/200)×100=25%.

Answer: Profit = ₹50, Profit % = 25%.

2.A chair is bought for ₹500 and sold for ₹450. Find the loss and loss percentage.

Solution:

Loss = 500−450=50500 - 450 = 50500−450=50.

Loss % = (50/500)×100=10%(50 / 500) \times 100 = 10\%(50/500)×100=10%.

Answer: Loss = ₹50, Loss % = 10%.

3.A product is bought for ₹600 and sold for ₹720. Find the profit and profit percentage.

Solution:

Profit = 720−600=120720 - 600 = 120720−600=120.

Profit % = (120/600)×100=20%(120 / 600) \times 100 = 20\%(120/600)×100=20%.

Answer: Profit = ₹120, Profit % = 20%

Profit and Loss calculations are crucial for financial planning and business management.

Simple & Compound Interest

Simple Interest (S.I.) is the extra amount paid or earned on a principal amount over a specific period of time at a fixed rate of interest. It is calculated using the formula:
S.I.=P×R×T100\text{S.I.} = \frac{P \times R \times T}{100}S.I.=100P×R×T
Where:

- P = Principal (amount of money borrowed or invested)
- R = Rate of Interest (per annum)
- T = Time (in years)

Solved Examples:

- Example 1:
  Find the Simple Interest on ₹5,000 at 8%8\%8% p.a. for 3 years.
  Solution:
  Given: P=5,000P = 5,000P=5,000, R=8R = 8R=8, T=3T = 3T=3.
  Formula: S.I.=P×R×T100\text{S.I.} = \frac{P \times R \times T}{100}S.I.=100P×R×T.
  S.I.=5,000×8×3100=120,000100=1,200\text{S.I.} = \frac{5,000 \times 8 \times 3}{100} = \frac{120,000}{100} = 1,200S.I.=1005,000×8×3=100120,000=1,200
  Answer: The Simple Interest is ₹1,200.

- Example 2:
  A person invests ₹10,000 at 6%6\%6% p.a. for 4 years. What is the total amount after 4 years?
- Solution:
  Given: P=10,000P = 10,000P=10,000, R=6R = 6R=6, T=4T = 4T=4.
  Simple Interest:
  S.I.=10,000×6×4100=240,000100=2,400\text{S.I.} = \frac{10,000 \times 6 \times 4}{100} = \frac{240,000}{100} = 2,400S.I.=10010,000×6×4=100240,000=2,400
  Total Amount = P+S.I.=10,000+2,400=12,400P + \text{S.I.} = 10,000 + 2,400 = 12,400P+S.I.=10,000+2,400=12,400.
  Answer: Total Amount = ₹12,400.

Compound Interest

Compound Interest (CI) is the interest calculated on the initial principal and the accumulated interest from previous periods. Unlike simple interest, which is calculated only on the principal amount, compound interest allows money to grow exponentially over time.

The formula for compound interest is:

A=P(1+rn)ntA = P \left(1 + \frac{r}{n} \right)^{nt}A=P(1+nr)nt

where:

- A = Final Amount
- P = Principal Amount
- r = Annual Interest Rate (in decimal)
- n = Number of times interest is compounded per year
- t = Number of years

Solved Examples

Example 1

Find the compound interest on $1000 at 5% annual interest, compounded annually for 3 years.

A=1000(1+5100)3A = 1000 \left(1 + \frac{5}{100} \right)^3A=1000(1+1005)3A=1000×(1.157625)=1157.63A = 1000 \times (1.157625) = 1157.63A=1000×(1.157625)=1157.63

CI = $157.63

Example 2

Find CI on $2000 at 10% per annum, compounded semi-annually for 2 years.

A=2000(1+102×100)2×2A = 2000 \left(1 + \frac{10}{2 \times 100} \right)^{2 \times 2}A=2000(1+2×10010)2×2A=2000×(1.215506)=2431.01A = 2000 \times (1.215506) = 2431.01A=2000×(1.215506)=2431.01

CI = $431.01

Example 3

Find CI on $5000 at 8% per annum, compounded quarterly for 1 year.

A=5000(1+84×100)4×1A = 5000 \left(1 + \frac{8}{4 \times 100} \right)^{4 \times 1}A=5000(1+4×1008)4×1A=5000×(1.082856)=5414.28A = 5000 \times (1.082856) = 5414.28A=5000×(1.082856)=5414.28

CI = $414.28

Ratios & Proportions

Ratio and Proportion are fundamental concepts in mathematics that compare values and maintain relationships between quantities.

1. Ratio

A ratio is a comparison of two quantities. It is written in the form a : b or a/b, where a and b are numbers. Ratios express how much of one quantity is present in relation to another.

For example, if there are 3 boys and 5 girls in a class, the ratio of boys to girls is 3:5.

2. Proportion

A proportion states that two ratios are equal. It is written as:

ab=cd\frac{a}{b} = \frac{c}{d}ba=dc

This means that the relationship between a and b is the same as that between c and d.

For example, if 4 pens cost $10, then 8 pens will cost $20, since 4:10 = 8:20.

Solved Examples

Example 1: Simplifying a Ratio

Simplify the ratio 20:30.

2030=23\frac{20}{30} = \frac{2}{3}3020=32

The simplified ratio is 2:3.

Example 2: Equivalent Ratios

Find an equivalent ratio of 5:7.

Multiplying both terms by 2, we get 10:14.

Example 3: Solving a Proportion

If 2/5 = x/15, find x.

Cross multiplying:

2×15=5×x2 \times 15 = 5 \times x2×15=5×x30=5x30 = 5x30=5xx=6x = 6x=6

Example 4: Finding a Missing Value

If A:B = 3:4 and B:C = 5:6, find A:C.

Multiplying the ratios:

A:C=(3/4)×(5/6)=15:24A:C = (3/4) \times (5/6) = 15:24A:C=(3/4)×(5/6)=15:24

Simplifying, A:C = 5:8.

Example 5: Word Problem

A bag contains red and blue balls in the ratio 3:2. If there are 30 red balls, find the number of blue balls.

redblue=32\frac{red}{blue} = \frac{3}{2}bluered=2330x=32\frac{30}{x} = \frac{3}{2}x30 =23

Cross multiplying:

3x=603x = 603x=60x=20x = 20x=20

So, there are 20 blue balls.

Averages & Mixtures

1. Averages

The average (or mean) is the sum of all values divided by the number of values. The formula is:

Average=Sum of all values Number of values\text{Average} = \frac{\text{Sum of all values}}{\text{Number of values}}Average=Number of values*Sum of all values

For example, the average of 4, 8, and 12 is:

4+8+123=243=8\frac{4 + 8 + 12}{3} = \frac{24}{3} = 834+8+12=324=82.

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Mixtures

A mixture problem involves mixing two or more substances with different quantities and prices (or values) to form a new mixture with a specific average value.
The weighted average formula is:
Weighted Average=∑(Quantity×Value)∑Quantity\text{Weighted Average} = \frac{\sum (Quantity \times Value)}{\sum \text{Quantity}}Weighted Average=∑Quantity∑(Quantity×Value)Solved Examples

Example 1: Average of Numbers

Find the average of 5, 10, 15, 20, and 25.
Average=5+10+15+20+255=755=15\text{Average} = \frac{5 + 10 + 15 + 20 + 25}{5} = \frac{75}{5} = 15Average=55+10+15+20+25=575=15

Example 2: Missing Number in Average

The average of 6, 9, 12, and x is 10. Find x.
6+9+12+x4=10\frac{6 + 9 + 12 + x}{4} = 1046+9+12+x=1027+x4=10\frac{27 + x}{4} = 10427+x =1027+x=4027 + x = 4027+x=40x=13x = 13x=13

Example 3: Mixing Two Items

A shopkeeper mixes 5 kg of sugar at $40/kg with 10 kg of sugar at $50/kg. Find the price per kg of the mixture.
Price per kg=(5×40)+(10×50)5+10\text{Price per kg} = \frac{(5 \times 40) + (10 \times 50)}{5 + 10}Price per kg=5+10(5×40)+(10×50)=200+50015=70015=46.67= \frac{200 + 500}{15} = \frac{700}{15} = 46.67=15200+500=15700=46.67
So, the price per kg of the mixture is $46.67.

Example 4: Water and Milk Mixture

A milkman mixes 3 liters of water with 12 liters of milk. Find the percentage of milk in the mixture.
\text{Milk %} = \frac{\text{Milk Quantity}}{\text{Total Quantity}} \times 100=1212+3×100=1215×100=80%= \frac{12}{12+3} \times 100 = \frac{12}{15} \times 100 = 80\%=12+312×100=1512×100=80%
So, the mixture is 80% milk.

Averages and mixtures help in solving real-life problems like calculating marks, mixing products, and managing costs!

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Time, Speed & Distance

1. Basic Formula:
   Speed=Distance/Time
   Time= Distance/speed
   Distance=Speed*Time

Speed is measured in km/h or m/s. The conversion between these units is:
1 km/h=518 m/s1 \text{ km/h} = \frac{5}{18} \text{ m/s}1 km/h=185 m/s1 m/s=185 km/h1 \text{ m/s} = \frac{18}{5} \text{ km/h}1 m/s=518 km/h

Types of Problems

Average Speed

Average Speed=Total DistanceTotal Time\text{Average Speed} = \frac{\text{Total Distance}}{\text{Total Time}}Average Speed=Total TimeTotal Distance

Relative Speed

- If two objects move towards each other: Relative Speed=S1+S2\text{Relative Speed} = S_1 + S_2Relative Speed=S1+S2
- If two objects move in the same direction: Relative Speed= ∣ S1−S2 ∣ \text{Relative Speed} = |S_1 - S_2|Relative Speed= ∣ S1−S2 ∣

Solved Examples

Example 1: Basic Calculation
A car travels 150 km in 3 hours. Find its speed.
Speed=1503=50 km/h\text{Speed} = \frac{150}{3} = 50 \text{ km/h}Speed=3150
=50 km/h

Example 2: Finding Time
A train is moving at 90 km/h. How much time will it take to cover 270 km?
Time=27090=3 hours\text{Time} = \frac{270}{90} = 3 \text{ hours}Time=90270
=3 hours

Example 3: Average Speed

A bus covers 120 km at 40 km/h and another 120 km at 60 km/h. Find its average speed.

Total Time=12040+12060=3+2=5 hours\text{Total Time} = \frac{120}{40} + \frac{120}{60} = 3 + 2 = 5 \text{ hours}Total Time=40120+60120=3+2=5 hoursAverage Speed=TotalDistanceTotalTime=2405=48 km/h\text{Average Speed} = \frac{\text{Total Distance}}{\text{Total Time}} = \frac{240}{5} = 48 \text{ km/h}Average Speed=TotalTimeTotalDistance=5240

=48 km/h

Example 4: Relative Speed

Two cars move towards each other at 50 km/h and 70 km/h. Find their relative speed.

Relative Speed=50+70=120 km/h\text{Relative Speed} = 50 + 70 = 120 \text{ km/h}Relative Speed=50+70

=120 km/h

Example 5: Train Crossing a Pole

A train of length 200 m moves at 40 m/s. How much time will it take to cross a pole?

Time=20040=5 seconds\text{Time} = \frac{200}{40} = 5 \text{ seconds}Time=40200=5 seconds

These concepts are useful in real-life scenarios like travel planning, racing, and logistics!

Time & Work

Time and Work problems deal with how long a person or a group of people take to complete a task. These problems use the concept of efficiency and unit work to determine time, workers required, or total work done.

Basic Formulae

Work Done

Work Done=Efficiency×Time

Work Done = \text{Efficiency} \times \text{Time}Work Done=Efficiency×Time

1. **Example If A alone can complete a work in X days, then A's work per day = 1X\frac{1}{X}X1**
1. **If A and B together can do a work in Y days, then their one day's work = 1A+1B=1Y\frac{1}{A} + \frac{1}{B} = \frac{1}{Y}A1+B1=Y1**

Solved Examples

Example 1: Individual Work

A can complete a task in 10 days. How much work does A complete in one day?
Work per day=110\text{Work per day} = \frac{1}{10}Work per day=101

Example 2: Work Done in Given Time

B can complete a task in 20 days. How much work does he complete in 5 days?
Work in 5 days=5×120=520=14\text{Work in 5 days} = 5 \times \frac{1}{20} = \frac{5}{20} = \frac{1}{4}Work in 5 days=5×201=205=41
So, B completes 1/4th of the work in 5 days.

Example 3: Combined Work

A can complete a work in 10 days, and B in 20 days. How long will they take together?
1/10+1/20=2/20+1/20=3/20
Total Time=3/20≈6.67 days

Example 4: More Workers, Less Time

If 5 workers complete a task in 8 days, how many days will 10 workers take?
Since work is constant, we use inverse proportion:
New Time=5/10×8=4
New Time=10/5×8=4 days

Example 5: Efficiency Ratio

A is twice as fast as B. If B alone can do a work in 12 days, how many days will A and B take together?
A's time = 12/2 = 6 days
1/6+1/12=2/12+1/12=3/12=1/4
So, they will finish in 4 days.

2.3 Algebra

Algebra is a branch of mathematics that deals with symbols and variables to solve equations and understand relationships between numbers. It helps in forming equations and solving real-world problems.

Basic Concepts

1.Variables & Constants

Variables: Symbols like x,y,zx, y, zx,y,z that represent unknown values.

Constants: Fixed numbers like 2, 5, -7, etc.

2.Expressions & Equations

An expression consists of variables, numbers, and operations, e.g., 3x+23x + 23x+2.

An equation is an expression set equal to a value, e.g., 3x+2=113x + 2 = 113x+2=11.

3. Solving Linear Equations

A linear equation has the form: ax+b=0ax + b = 0ax+b=0

The solution is found by isolating xxx.

4.Quadratic Equations

A quadratic equation has the form: ax2+bx+c=0ax^2 + bx + c = 0ax2+bx+c=0

It is solved using factorization, completing the square, or the quadratic formula: x=−b±b2−4ac2ax = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}x=2a−b±b2−4ac

Solved Examples

Example 1: Solving a Linear Equation

Solve 3x+5=11.

3x=11−5

3x=6

x=6/3=2

Example 2: Finding a Variable

If y=2x+3y = 2x + 3y=2x+3 and x=4x = 4x=4, find yyy.

y=2(4)+3=8+3=11y = 2(4) + 3 = 8 + 3

= 11y=2(4)+3=8+3=11

Example 3: Quadratic Equation

Solve x2−5x+6=0x^2 - 5x + 6 = 0x2−5x+6=0 using factorization.

(x−2)(x−3)=0

x - 2 = 0 or x - 3 = 0

x=2 or x=3

Example 4: Simplifying Algebraic Expressions

Simplify $(2x+3)+(4x-5$.

$$2x+3+4x-5$$
$$=6x-2$$

Example 5: Solving Two Linear Equations

Solve:

$$2x+y=10$$
$$x-y=2$$

Adding both equations:

$$(2x+y)+(x-y)=10+2$$
$$3x=12$$
$$x=4$$

Substituting $x=4$ in $x-y=2$

$$4-y=2$$
$$\Rightarrow y=2$$

So, $x=4$, $y=2$.

Algebra is widely used in physics, economics, engineering, and everyday problem-solving!

Basics of Algebraic Equations

An algebraic equation is a mathematical statement that shows the equality of two expressions using variables and constants. It consists of:

- Variables (e.g., x,y,zx, y, zx,y,z) – unknown values.
- Constants (e.g., 2, 5, -3) – fixed values.
- Operators (e.g., +, −, ×, ÷).

Types of Algebraic Equations:

Linear Equations – The highest power of the variable is 1. Example: $2x+3=72x + 3 = 72x+3=7$.

Quadratic Equations – The highest power of the variable is 2. Example: $x2-4x+4=0x^2 - 4x + 4 = 0x2-4x+4=0$.

Polynomial Equations – Involves higher powers (e.g., cubic, quartic).

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Solving Linear Equations:

We isolate the variable using inverse operations (addition, subtraction, multiplication, division).

Examples

Example 1: Solving a Linear Equation

Solve 3x−5=10

3x=10+5

3x=15

x=15/3=5

Example 2: Solving a Quadratic Equation

Solve x^2 - 9 = 0

x^2 = 9

Taking the square root on both sides:

x=±3

So, the solutions are x=3 or x=−3

Quadratic Equations

A quadratic equation is a second-degree algebraic equation of the form:

ax2+bx+c=0ax^2 + bx + c = 0ax2+bx+c=0

where:

- a,b,ca, b, ca,b,c are constants (a≠0a \neq 0a□=0),
- xxx is the variable,
- aaa is the coefficient of x2x^2x2,
- bbb is the coefficient of xxx,
- ccc is the constant term.

Methods to Solve Quadratic Equations

Factorization Method – Expressing the quadratic equation as a product of two binomials.

Quadratic Formula – Using the formula: x=−b±b2−4ac2ax = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}x=2a−b±b2−4ac where b2−4acb^2 - 4acb2−4ac is called the discriminant (D).

Completing the Square Method – Converting the equation into a perfect square trinomial.

Solved Examples

Example 1: Solving by Factorization

Solve x2−5x+6=0x^2 - 5x + 6 = 0x2−5x+6=0.

Step 1: Find two numbers whose product is 6 and sum is -5

Numbers: -2 and -3

Step 2: Split the middle term

x2−2x−3x+6=0

Step 3: Factorize

x(x−2)−3(x−2)=0

(x−2)(x−3)=0

Step 4: Solve for x

x−2=0⇒x=2

x−3=0⇒x=3

Solution: x=2,3.

Example 2: Solving by Quadratic Formula

Solve 2x2+3x−2=02x^2 + 3x - 2 = 02x2+3x−2=0.

Step 1: Identify coefficients

a=2,b=3,c=−2

Step 2: Compute the discriminant

D=b^2−4ac

=(3)2−4(2)(−2) = 9+16 = 25

Step 3: Apply the quadratic formula

x=−3±sqrt25/2(2)

x=−3±5/4

Step 4: Solve for x

x=−3+5/4=2/4=1/2

x=−3−5/4=-8/4=−2

Solution: x=0.5,−2.

Example 3: Solving by Completing the Square

Solve x^2 + 6x + 5 = 0

Step 1: Move the constant to the other side

x^2 + 6x = -5

Step 2: Add (6/2)^2=9 to both sides

x^2 + 6x + 9 = -5 + 9

Step 3: Write as a perfect square

$(x + 3)^2 = 4$

Step 4: Take the square root

$x+3=\pm2$

Step 5: Solve for x

$x=-3+2=-1$

$x=-3-2=-5$

Solution: $x=-1,-5$

Summary

- **Factorization works best when roots are rational.**
- **Quadratic Formula is useful when the equation is complex.**
- **Completing the Square is useful in deriving formulas and solving specific problems**

Progressions: AP, GP, and HP

A progression is a sequence of numbers following a specific pattern. The three main types are:

- **Arithmetic Progression (AP) – A sequence where the difference between consecutive terms is constant.**
- **Geometric Progression (GP) – A sequence where the ratio between consecutive terms is constant.**
- **Harmonic Progression (HP) – A sequence whose reciprocals form an AP.**

1. Arithmetic Progression (AP)

Definition

An AP has a constant difference d between consecutive terms.

- **General form: $a,a+d,a+2d,a+3d,...$**
- **nth term: $T_n=a+(n-1)d$**
- **Sum of first n terms: $S_n = n/2[2a+(n-1)d]$**

Solved Examples for AP

Example 1: Find the 10th term of AP

Given: $a=3,d=5$ find T_{10}

$T_{10} = 3+(10-1)\times5 = 3+45 = 48$

.

Example 2: Find the sum of the first 15 terms of AP

Given: a=2,d=3,n=15 find S15.

S15=15/2[2(2)+(15−1)(3)]1)(3)]

=15/2[4+42]

=15/2×46=345

Example 3: Find the number of terms in AP

Given: a=5,d=2,Tn=4 find n

47=5+(n−1)×2

42=(n−1)×2

n−1=21⇒n=22

Geometric Progression (GP)

Definition

A GP has a constant ratio rrr between consecutive terms.

- **General form: a,ar,ar^2,ar^3,...**
- **nth term: Tn=ar^(n−1)**
- **Sum of first n terms: Sn=a(1−r^n)/1−r , r≠1**

Solved Examples for GP

Example 1: Find the 6th term of GP

Given: a=2 , r=3 find T6.

T6=2×3^(6−1) = 2×243 = 486

Example 2: Find the sum of first 4 terms of GP

Given: a=3 , r=2 , n=4 find S4.

S4=3(1−2^4)/1−2

=−3(1−16)=−3(−15)=45

Example 3: Find the common ratio

Given: 2,6,18,54 find r

r=6/2=3

3. Harmonic Progression (HP)

Definition

A HP is a sequence where the reciprocals form an AP.

- **General form: 1/a , 1/a+d , 1/a+2d,...**
- **nth term of HP is the reciprocal of the nth term of the corresponding AP: Tn=1/a+(n−1)d**

Solved Examples for HP

Example 1: Find the 5th term of HP

Given the AP: 2,4,6,8,... find the 5th term of HP.

Step 1: Find the 5th term of AP:

T5= 2+(5−1)×2 = 2+8 = 10

Step 2: Take reciprocal:

T5=1/10

Example 2: Find the sum of first 3 terms of HP

Given AP: 2,4,62, 4, 62,4,6, find the sum of corresponding HP terms.

Step 1: Find reciprocals:

1/2 , 1/4 , 1/6

Step 2: Find the sum:

S = 1/2+1/4+1/6

=6/12+3/12+2/12 = 11/12

Example 3: Check if a sequence is HP

Given: 1,13,151, \frac{1}{3}, \frac{1}{5}1,31,51, check if it is an HP.

Step 1: Find reciprocals:

1,3,5

Since 1, 3, 5 is an AP (common difference = 2), the given sequence is an HP.

Conclusion

- **AP: Constant difference between terms.**
- **GP: Constant ratio between terms.**
- **HP: Reciprocal of an AP**

2.4 Geometry & Mensuration

Geometry

Geometry is the study of shapes, sizes, and properties of figures and spaces. It is one of the oldest branches of mathematics and is classified into two main types:

Plane Geometry – Deals with two-dimensional (2D) shapes like triangles, circles, squares, and rectangles.

Solid Geometry – Deals with three-dimensional (3D) shapes like cubes, spheres, cylinders, and pyramids.

In geometry, different properties such as angles, symmetry, congruence, and similarity are studied. Some fundamental concepts include:

- Points, Lines, and Angles: A point represents a position in space, a line is a straight path that extends infinitely, and angles are formed when two lines meet.
- Triangles: Classified into different types based on sides (equilateral, isosceles, scalene) and angles (acute, right, obtuse). The sum of the interior angles of a triangle is always 180°.
- Quadrilaterals: Shapes with four sides, including squares, rectangles, parallelograms, and trapeziums.
- Circles: Defined by radius, diameter, and circumference, with key formulas like circumference = $2\pi r$ and area = πr^2.

Mensuration

Mensuration is a branch of mathematics that deals with the measurement of length, area, volume, and surface area of different geometrical shapes. It applies geometric formulas to find the dimensions of objects in real life, such as buildings, fields, and containers.

Mensuration in 2D (Plane Figures)

- Perimeter: The total length around a shape.
  - Perimeter of a rectangle = $2(l + b)$
  - Perimeter of a square = $4a$
- Area: The space enclosed within a shape.
  - Area of a rectangle = $l \times b$
  - Area of a square = a^2
  - Area of a triangle = $\frac{1}{2} \times \text{base} \times \text{height}$
  - Area of a circle = πr^2

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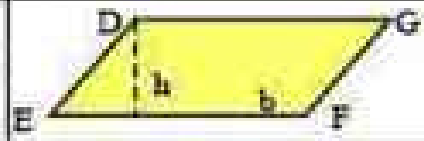
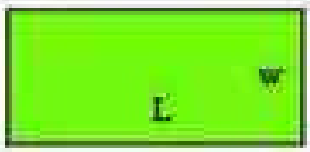
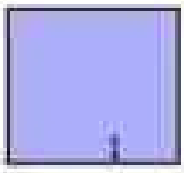
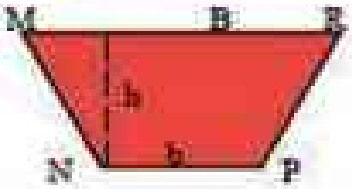
NAME	FIGURE	AREA	PERIMETER CIRCUMFERENCE
TRIANGLE		$A=\frac{b\times h}{2}$	$P=MN+NP+PM$
PARALLELOGRAM		$A=b\times h$	$P=DE+EF+FG+GD$
RHOMBUS		$A=b\times h$	$P=b+b+b+b$ $P=4b$
RECTANGLE		$A=L\times w$	$P=L+w+L+w$ $P=2L+2w$
SQUARE		$A=l^2$	$P=l+l+l+l$ $P=4l$
TRAPEZOID		$A=\frac{(B+b)\times h}{2}$	$P=MN+NP+PR+RM$
CIRCLE		$A=\pi r^2$	$C=2\pi r=\pi d$

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Mensuration in 3D (Solid Figures)

- **Volume:** The amount of space occupied by a solid.
  - Volume of a cube = a^3
  - Volume of a cuboid = $l \times b \times h$
  - Volume of a cylinder = $\pi r^2 h$
- **Surface Area:** The total area covering a solid shape.
  - Surface area of a sphere = $4\pi r^2$
  - Surface area of a cylinder = $2\pi r(h + r)$

Properties of Triangles, Circles, Quadrilaterals

Properties of Triangles

A triangle is a three-sided polygon with three angles. The sum of its interior angles is always 180°.

Properties:

Types of Triangles:

- Based on sides: Equilateral (all sides equal), Isosceles (two sides equal), Scalene (no sides equal).
- Based on angles: Acute (all angles < 90°), Right (one angle = 90°), Obtuse (one angle > 90°).

Pythagoras Theorem (for right triangles): a^2 + b^2 = c^2.

Heron's Formula (for area): A=s(s−a)(s−b)(s−c)A = \sqrt{s(s-a)(s-b)(s-c)}A=s(s−a)(s−b)(s−c), where s=a+b+c2s = \frac{a+b+c}{2}s=2a+b+c.

Exterior Angle Property: An exterior angle equals the sum of two opposite interior angles.

Sum of Two Sides: The sum of any two sides is always greater than the third side.

Solved Examples:

1.Find the area of a triangle with base = 10 cm and height = 6 cm.

Solution: A=1/2×10×6 = 30 cm².

2.Find the hypotenuse of a right triangle with sides 6 cm and 8 cm.

Solution: c=sqrt{6^2 + 8^2} = sqrt{36 + 64} =10 cm.

3.If a triangle has sides 7 cm, 8 cm, and 9 cm, find its area using Heron's formula.

Solution: s=7+8+9/2=12

A=sqrt{12(12−7)(12−8)(12−9)}=sqrt(12×5×4×3)=28 cm².

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Properties of Circles

A circle is a set of points equidistant from a fixed center point.

Properties:

1. **Radius (r): Distance from center to any point on the circle.**
2. **Diameter (d): Twice the radius, d=2r**
3. **Circumference: C=2πr.**
4. **Area: A=πr^2**
5. **Chord: A line segment joining any two points on the circle.**
6. **Tangent: A line touching the circle at only one point.**
7. **Arc: A portion of the circle's circumference.**
8. **Sector: A region enclosed by two radii and the arc.**

Solved Examples:

1. **Find the circumference of a circle with radius 7 cm.**
   - **Solution: C=2π(7)=14π ≈ 43.96cm**
2. **Find the area of a circle with diameter 14 cm.**
   - **Solution: r=14/2=7**
   - **A=π(7)^2 = 49π≈153.94 cm².**
3. **Find the length of an arc subtending a 60° angle in a circle of radius 10 cm.**
   - **Solution: Arc length = θ/360×2πr**
   - **=60/360×2π(10)=1/6×20π≈10.47cm**

Properties of Quadrilaterals

A quadrilateral is a four-sided polygon. The sum of its interior angles is always 360°.

Properties:

1. **Parallelogram: Opposite sides and angles are equal, diagonals bisect each other.**
2. **Rectangle: Opposite sides are equal, all angles = 90°, diagonals are equal.**
3. **Square: All sides equal, all angles = 90°, diagonals bisect at right angles.**
4. **Rhombus: All sides equal, opposite angles are equal, diagonals bisect at 90°.**
5. **Trapezium: One pair of opposite sides is parallel.**

Solved Examples:

1. **Find the area of a rectangle with length 12 cm and width 5 cm.**
   - **Solution: A=l×b=12×5 = 60 cm².**
2. **Find the perimeter of a square with side 9 cm.**
   - **Solution: P=4×9 = 36 cm.**
3. **Find the area of a trapezium with bases 8 cm and 10 cm and height 5 cm.**
   - **Solution: A=1/2(a+b)h=1/2(8+10)5=1/2(18)5=45cm**

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Area, Volume & Surface Area of 2D and 3D figures

Area of 2D Figures

The area of a two-dimensional (2D) shape is the amount of space enclosed within its boundaries. It is measured in square units (e.g., cm^2, m^2).

Common 2D Figures and Their Areas:

1. Square: A= a^2 (where a is the side length)
2. Rectangle: A=l×b (where l is length and b is breadth)
3. Triangle: A=1/2×base×height
4. Circle: A=πr^2A (where r is the radius)
5. Trapezium: A=1/2(a+b)h (where a,b are parallel sides, and h is height)

Solved Examples:

1. Find the area of a rectangle with length 12 cm and width 8 cm.
   - Solution: $A=12\times8=96\ cm^2$.
2. Find the area of a circle with radius 7 cm.
   - Solution: $A=\pi(7)^2 = 49\pi \approx 153.94\ cm^2$.
3. Find the area of a triangle with base 10 cm and height 5 cm.
   - Solution: $A = 1/2\times10\times5 = 25\ cm^2$.

Volume of 3D Figures

The volume of a three-dimensional (3D) object is the amount of space it occupies. It is measured in cubic units (e.g., cm^3, m^3).

Common 3D Figures and Their Volumes:

1. Cube: V= a^3
2. Cuboid: V=l×b×h
3. Cylinder: V=πr^2h
4. Sphere: V=4/3πr^3
5. Cone: V=1/3πr^2h

Solved Examples:

1. Find the volume of a cube with side 5 cm.
   - Solution: $V=5^3=125\ cm^3$.
2. Find the volume of a cylinder with radius 7 cm and height 10 cm.
   - Solution: $V=\pi(7)^2(10)=490\pi\approx1539.38\ cm^3$.
3. Find the volume of a cone with radius 6 cm and height 9 cm.
   - Solution: $V=1/3\pi(6)^2(9)=108\pi \approx 339.29 cm^3$.

Surface Area of 3D Figures

The surface area of a 3D shape is the total area of all its faces. It is measured in square units (e.g., cm^2, m^2).

Common 3D Figures and Their Surface Areas:

1. Cube: SA=6a^2
2. Cuboid: SA=2(lb+bh+hl)
3. Cylinder: SA=2πr(h+r)
4. Sphere: SA=4πr^2
5. Cone: SA=πr(l+r) (where l is slant height)

Solved Examples:

1. Find the surface area of a cube with side 4 cm.
   - Solution: SA=6(4)^2=96 cm^2.
2. Find the surface area of a sphere with radius 5 cm.
   - Solution: SA=4π(5)^2=100π ≈ 314.16 cm^2.
3. Find the surface area of a cylinder with radius 3 cm and height 7 cm.
   - Solution: SA=2π(3)(7+3)=60π≈188.4 cm^2.

Understanding area, volume, and surface area is crucial for solving real-world problems in construction, packaging, and design.

2.5 Probability & Statistics

Probability

Probability is the branch of mathematics that deals with the likelihood or chance of an event occurring. It is measured on a scale from 0 to 1, where 0 means an impossible event and 1 means a certain event.

Basic Probability Formula

P(E)=Number of favorable outcomes/Total number of possible outcomes
where P(E) is the probability of an event E

Types of Events in Probability:

Independent Events – The occurrence of one event does not affect the other (e.g., rolling two dice).

Dependent Events – The occurrence of one event affects the probability of the other (e.g., drawing cards without replacement).

Mutually Exclusive Events – Two events that cannot happen at the same time (e.g., flipping a coin and getting both heads and tails at once).

Complementary Events – The probability of an event not occurring is 1−P(E)1 - P(E)1−P(E).

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Statistics

Statistics is the branch of mathematics that deals with collecting, analyzing, interpreting, and presenting data. It helps in making informed decisions based on numerical data.

Types of Statistics:

1. **Descriptive Statistics – Summarizes data using measures like mean, median, mode, and standard deviation.**
2. **Inferential Statistics – Draws conclusions from sample data and applies them to a larger population.**

Measures of Central Tendency:

- **Mean (Average): Mean=∑X/N**
- **Median: The middle value in an ordered data set.**
- **Mode: The most frequently occurring value.**

Measures of Dispersion:

- **Range: Difference between the highest and lowest values.**
- **Variance: Measures how much data varies from the mean.**
- **Standard Deviation: Square root of variance, representing data spread**

Solved Examples

Example 1: Probability of Rolling a Die

Question: What is the probability of rolling a 5 on a fair six-sided die?

Solution:

Total outcomes = 6 (1, 2, 3, 4, 5, 6)

Favorable outcomes = 1 (rolling a 5)

$P(5)=1/6\approx0.1667$ or 16.67%

Example 2: Finding the Mean

Question: Find the mean of the following numbers: 5, 8, 10, 12, 15.

Solution:

$Mean=5+8+10+12+15/5=50/5=10$

Example 3: Probability of Drawing a Red Card

Question: A standard deck of 52 playing cards has 26 red cards. What is the probability of drawing a red card?

Solution:

$P(Red)=26/52=1/2=0.5$ or 50%

- **Conclusion**

Probability and statistics are essential in decision-making, risk assessment, and real-world applications like finance, medicine, and sports analytics. Probability helps predict chances of events, while statistics helps analyze and interpret data effectively

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Basics of Probability

Probability is a branch of mathematics that deals with measuring the likelihood of an event occurring. It is expressed as a number between 0 and 1, where 0 represents an impossible event and 1 represents a certain event.

Basic Probability Formula

P(E)=Number of favorable outcomes/Total number of possible outcomes
where P(E) is the probability of an event EEE.

Types of Probability Events:

1. **Certain Event – Probability is 1 (e.g., the sun rising tomorrow).**
2. **Impossible Event – Probability is 0 (e.g., rolling a 7 on a six-sided die).**
3. **Equally Likely Events – All outcomes have the same chance of occurring (e.g., flipping a fair coin).**
4. **Independent Events – The outcome of one event does not affect the other (e.g., tossing two coins).**
5. **Dependent Events – The outcome of one event affects the probability of the next (e.g., drawing cards without replacement).**
6. **Mutually Exclusive Events – Two events cannot occur together (e.g., rolling a die and getting both a 2 and a 5 at the same time).**

Solved Examples

Example 1: Rolling a Die
Question: What is the probability of rolling an even number on a fair six-sided die?
Solution:

- **Possible outcomes: 1, 2, 3, 4, 5, 6 (Total = 6)**
- **Favorable outcomes (even numbers): 2, 4, 6 (Total = 3)**

P(E) = 3/6 = 12=0.5 or 50%

Example 2: Drawing a King from a Deck of Cards
Question: What is the probability of drawing a King from a standard deck of 52 playing cards?
Solution:

- **Total cards: 52**
- **Kings in the deck: 4**

P(King)=4/52=1/13 ≈ 0.077 or 7.7%

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Permutations & Combinations

Introduction

Permutations and combinations are mathematical techniques used to count different ways of arranging or selecting objects. Both are part of combinatorics, but they are used in different situations.

Permutations

A permutation is an arrangement of objects in a specific order. The order of objects matters.

Formula for Permutations:

For arranging r objects out of n available objects, the formula is:

$$P(n,r)=n!/(n-r)!$$

where n! (n factorial) is the product of all positive integers up to n ,i.e.,

$$n!=n\times(n-1)\times(n-2)\times\ldots\times1$$

Types of Permutations:

1. **Without Repetition: Each object is used only once (e.g., arranging people in a line).**
2. **With Repetition: Objects can be repeated (e.g., forming words from letters where some letters repeat).**

Combinations

A combination is a selection of objects where the order does not matter.

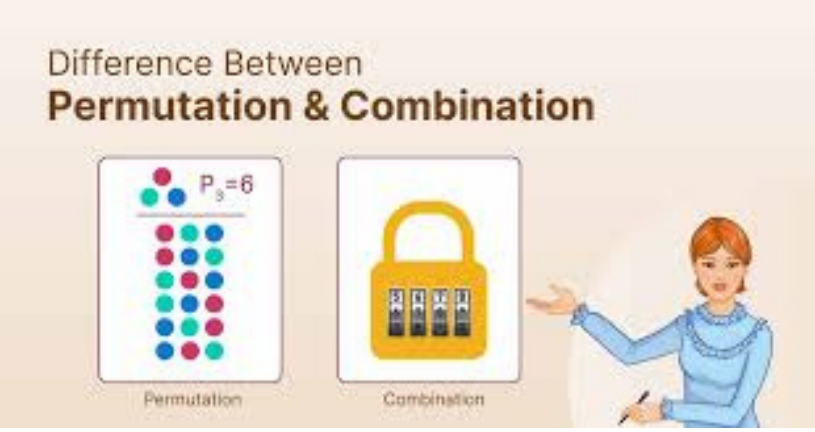
Formula for Combinations:

For selecting r objects out of n without considering the order, the formula is:

$$C(n,r)=n!/r!(n-r)!$$

Types of Combinations:

1. **Without Repetition: Objects are selected only once (e.g., choosing a team).**
2. **With Repetition: Objects can be repeated in selections (e.g., selecting flavors of ice cream).**



Solved Examples

Example 1: Arranging Books on a Shelf (Permutation)

Question: How many ways can 4 books be arranged on a shelf from a total of 6 books?

Solution:

$P(6,4) = 6!/(6-4)! = 6!/2!$

$= 6 \times 5 \times 4 \times 31 = 360$

Answer: 360 ways

Example 2: Selecting a Team (Combination)

Question: How many ways can a team of 3 be selected from 7 people?

Solution:

$C(7,3) = 7!/3!(7-3)! = 7!/3!4!$

$= 7 \times 6 \times 5/3 \times 2 \times 1 = 35$

Answer: 35 ways

Example 3: Arranging Letters in a Word (Permutation with Repetition)

Question: How many ways can the letters in the word "APPLE" be arranged?

Solution: The word "APPLE" has 5 letters, with P repeating twice. The formula for permutations with repetition is:

$P = 5!/2! = 5 \times 4 \times 3 \times 2 \times 1/2 \times 1$

$= 60$

Answer: 60 ways

Example 4: Choosing Fruits (Combination with Repetition)

Question: How many ways can you choose 3 fruits from apples, bananas, and oranges if repetition is allowed?

Solution: The formula for combination with repetition is:

$C(n+r-1,r) = C(3+3-1,3) = C(5,3) = 5!/3!(5-3)! = 5 \times 4/2 \times 1 = 10$

Answer: 10 ways

Conclusion

- **Use permutations when order matters (e.g., seating arrangements, passwords).**
- **Use combinations when order does not matter (e.g., forming teams, selecting items).**
- **Understanding permutations and combinations helps solve real-world problems in probability, cryptography, and logistics.**

Mean, Median, and Mode

Mean, median, and mode are measures of central tendency used in statistics to describe the center of a data set. Each measure provides different insights into the data, depending on its distribution and characteristics.

1. Mean (Arithmetic Mean)

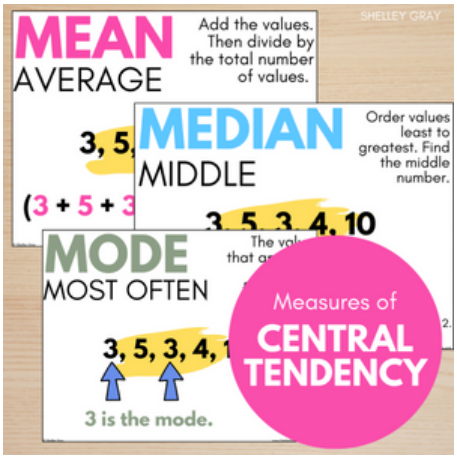
The mean, also called the average, is the sum of all values in a data set divided by the total number of values. It is commonly used for finding the central value of a set of numbers.

Formula for Mean:

Mean=∑X/N

where:

- **∑X is the sum of all data values**
- **N is the total number of values**



Example : Finding the Mean

Question: Find the mean of the numbers: 5, 10, 15, 20, 25.

Solution:

Mean=5+10+15+20+25/5

=75/5=15

Answer: The mean is 15.

2. Median

The median is the middle value in an ordered data set. If the number of values is odd, the median is the middle number. If the number of values is even, the median is the average of the two middle numbers.

Steps to Find the Median:

1. **Arrange the data in ascending order.**
2. **Identify the middle value:**
   - **If N is odd, the median is the middle number.**
   - **If N is even, the median is the average of the two middle numbers.**

Example : Finding the Median

Case 1: Odd Number of Values

Question: Find the median of 3, 7, 10, 12, 18.

Solution:

Ordered data: 3, 7, 10, 12, 18

The middle value is 10.

Answer: The median is 10.

Case 2: Even Number of Values

Question: Find the median of 4, 8, 11, 15, 19, 22.

Solution:

Ordered data: 4, 8, 11, 15, 19, 22

The middle numbers are 11 and 15.

Median=11+15/2

=26/2=13

Answer: The median is 13.

3. Mode

The mode is the number that appears most frequently in a data set. A data set can have:

- No mode (if all numbers appear the same number of times).
- One mode (unimodal).
- Two modes (bimodal).
- More than two modes (multimodal).

Example : Finding the Mode

Case 1: Unimodal

Question: Find the mode of 3, 7, 7, 9, 10, 12.

Solution: The number 7 appears twice, more than any other number.

Answer: The mode is 7.

Case 2: Bimodal

Question: Find the mode of 4, 4, 6, 7, 7, 9, 10.

Solution: The numbers 4 and 7 both appear twice.

Answer: The data set is bimodal, and the modes are 4 and 7.

Conclusion

- The mean gives an overall idea of the data but is affected by outliers.
- The median is useful when the data is skewed or has extreme values.
- The mode is helpful when analyzing the most frequent occurrence, especially in categorical data.

These measures help in summarizing and analyzing data in various fields like business, economics, and science.

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Variance & Standard Deviation

Introduction

Variance and standard deviation are measures of dispersion that describe how data points spread out from the mean. These measures help in understanding data variability, consistency, and reliability.

- **Variance measures the average squared deviation from the mean.**
- **Standard deviation is the square root of variance and provides a measure of spread in the same units as the data.**

1. Variance

Definition

Variance (σ^2 for a population, s^2 for a sample) quantifies how far each data point is from the mean.

Formula for Variance

Population Variance:

σ^2=∑(Xi−μ)^2/N

where:

- **Xi = each data point**
- **μ = population mean**
- **N = total number of data points**

Sample Variance:

s^2=∑(Xi−X¯)^2/n−1

where:

- **X¯ = sample mean**
- **n = number of sample data points**

2. Standard Deviation

Definition

The standard deviation (σ\sigmaσ for a population, sss for a sample) is the square root of variance. It shows the average distance of data points from the mean in original units.

Formula for Standard Deviation

σ=sqrt{sigma^2}

s = sqrt{s^2}

A small standard deviation means data points are close to the mean, while a large standard deviation means data points are more spread out.

Solved Examples

Example 1: Population Variance and Standard Deviation

Question: Find the variance and standard deviation for the data set 4, 8, 6, 5, 10.

Solution:

Find the Mean:μ=4+8+6+5+10/5=33/5=6.6

Find Squared Deviations from the Mean:(4−6.6)^2=(−2.6)^2=6.76

(8−6.6)^2=(1.4)^2=1.96

(6−6.6)^2=(−0.6)^2=0.36

(5−6.6)2=(−1.6)2=2.56

(10−6.6)^2=(3.4)^2=11.56

Find Variance:σ^2=6.76+1.96+0.36+2.56+11.56/5=23.2/5=4.64

Find Standard Deviation:

σ=sqrt{4.64} ≈2.15

Answer: Variance = 4.64, Standard Deviation = 2.15

Example 2: Sample Variance and Standard Deviation

Question: Find the sample variance and standard deviation for 3, 7, 5, 9.

Solution:

1. **Find the Mean:$\bar{X}$=3+7+5+9/4=24/4=6**
2. **Find Squared Deviations:(3−6)^2=9 , (7−6)^2=1 , (5−6)^2=1 , (9−6)^2=9**
3. **Find Sample Variance:s^2=9+1+1+9/4−1=20/3≈6.67**
4. **Find Standard Deviation:s=sqrt{6.67} ≈2.58**

Answer: Sample Variance = 6.67, Standard Deviation = 2.58

Example 3: Real-Life Application

Question: A company tracks delivery times for two shipping services.

- **Service X: Mean delivery time = 2 days, Standard deviation = 0.5 days**
- **Service Y: Mean delivery time = 2 days, Standard deviation = 2 days**

Which service is more reliable?

Answer: Service X is more consistent (smaller standard deviation). Service Y has a higher variability, meaning some deliveries may take much longer.

3. Logical Reasoning

Introduction

Logical reasoning is the process of using structured thinking to analyze information, identify patterns, and draw conclusions. It is widely used in competitive exams, problem-solving, decision-making, and artificial intelligence.

Logical reasoning is generally divided into two main types:

1. **Deductive Reasoning – Drawing specific conclusions from general statements.**
2. **Inductive Reasoning – Making general conclusions from specific observations.**

Types of Logical Reasoning

1. Deductive Reasoning

- **In deductive reasoning, conclusions are based on given premises and must be logically correct if the premises are true.**
- **Example:**
  - **Premise 1: All humans are mortal.**
  - **Premise 2: Socrates is a human.**
  - **Conclusion: Socrates is mortal.**

2. Inductive Reasoning

- **In inductive reasoning, conclusions are drawn from patterns or observations but may not always be 100% true.**
- **Example:**
  - **The sun has risen in the east every day.**
  - **Therefore, the sun will rise in the east tomorrow.**

3. Analytical Reasoning

- **Involves solving puzzles, seating arrangements, and complex relationships.**
- **Example: John sits to the left of Mike. Mike sits to the right of Lisa. Who is in the middle?**
  - **Answer: Mike**

4. Critical Reasoning

- **Evaluating arguments and determining their validity.**
- **Example: If pollution increases, global temperatures will rise. Pollution has increased. What follows?**
  - **Answer: Global temperatures will rise.**

5. Non-Verbal Reasoning

- **Includes pattern recognition, sequences, and spatial reasoning.**
- **Example: Which shape completes the sequence? (Common in IQ tests).**

3.1 Coding-Decoding

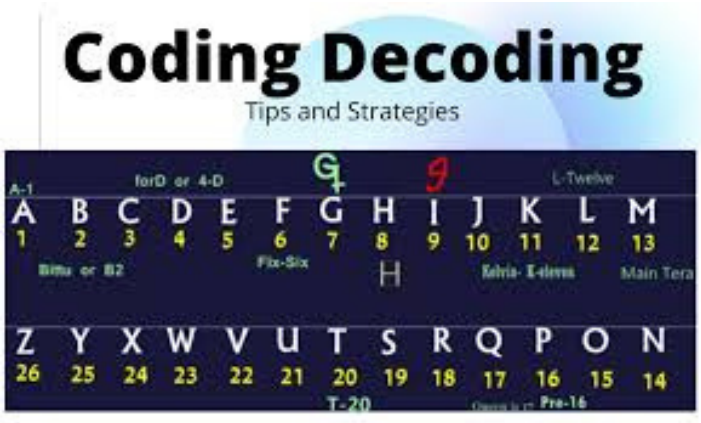
Introduction

Coding-Decoding is a type of logical reasoning where words, numbers, or symbols are encoded using a particular pattern or rule. The challenge is to decode the given information based on the observed pattern. This type of reasoning is commonly tested in competitive exams.

Types of Coding-Decoding

1. Letter Coding

A word is coded by replacing its letters using a specific rule, such as shifting letters forward or backward in the alphabet.



2. Number Coding

Words or letters are represented by numbers following a specific rule.

Example :

Question: If HELLO is coded as 8-5-12-12-15, how is WORLD coded?

Solution:

Each letter is replaced with its position in the alphabet:

- **W = 23, O = 15, R = 18, L = 12, D = 4**
- **Answer: 23-15-18-12-4**

3. Substitution Coding

Words are substituted with other words, and the pattern needs to be identified.

Example :

Question: If "Apple" is called "Mango," "Mango" is called "Banana," and "Banana" is called "Orange," what is the color of "Banana"?

Solution: The actual color of Banana is Yellow, but in the given code, "Banana" is called "Orange."

Answer: Orange

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1. Letter Shifting (Simple Alphabet Coding)

Question: If ROSE is coded as URVH, how is LILY coded?

Solution:

- **Each letter is shifted +3 in the alphabet:**
  - **R → U, O → R, S → V, E → H**
- **Applying the same shift to LILY:**
  - **L → O, I → L, L → O, Y → B**
  - **Answer: OLOB**

2. Reverse Letter Coding

Question: If GREAT is coded as TGAER, how is SMART coded?

Solution:

- **The letters of the word are reversed:**
  - **GREAT → TGAER**
  - **SMART → TRAMS**
  - **Answer: TRAMS**

3. Number Coding (Position in Alphabet)

Question: If DOG is coded as 4-15-7, how is CAT coded?

Solution:

Each letter is replaced by its position in the alphabet:

- **D = 4, O = 15, G = 7**
- **C = 3, A = 1, T = 20**
- **Answer: 3-1-20**

4. Substitution Coding

Question: If **"Blue" is coded as "Green," "Green" is coded as "Yellow," "Yellow" is coded as "Red," and "Red" is coded as "Blue," what is the color of the sun?

Solution:

- **The sun is actually Yellow, but according to the code, "Yellow" is called "Red."**
- **Answer: Red**

5. Vowel & Consonant Swapping

Question: If MANGO is coded as NBNHP, how is APPLE coded?

Solution:

- **Vowels (+1) → A → B, O → P**
- **Consonants (-1) → M → N, N → B, G → H**
- **Applying the same to APPLE:**
  - **A → B, P → O, P → O, L → M, E → F**
  - **Answer: BOOMF**

6. Mathematical Coding

Question: If PEN = 44, BOOK = 58, find the code for LAMP.

Solution:

- **Assign numerical values: P(16) + E(5) + N(14) = 35 × 2 = 44**
- **B(2) + O(15) + O(15) + K(11) = 43 × 2 = 58**
- **L(12) + A(1) + M(13) + P(16) = 42 × 2 = 56**
- **Answer: 56**

7. Pair Letter Coding

Question: If CAKE is coded as XZPV, how is LION coded?

Solution:

- **Letters are replaced with their opposite letters (A → Z, B → Y, etc.):**
  - **C → X, A → Z, K → P, E → V**
  - **L → O, I → R, O → L, N → M**
  - **Answer: ORLM**

8. Letter Skipping Pattern

Question: If CODE is coded as EOGF, how is HELP coded?

Solution:

- **C → E (+2), O → O (no change), D → G (+3), E → F (+1)**
- **Applying the same pattern to HELP:**
  - **H → J (+2), E → E (no change), L → O (+3), P → Q (+1)**
  - **Answer: JEOQ**

9. Sentence Coding

Question: In a certain language:

- **"She is happy" is written as "X3 Y5 Z7"**
- **"He is kind" is written as "W4 Y5 U6"**
- **What is the code for "is"?**

Solution:

- **"is" appears in both sentences and is coded as Y5.**
- **Answer: Y5**

10. Symbol Coding

Question: If A = #, B = %, C = @, D = !, how is ABCD coded?

Solution:

- **A → #, B → %, C → @, D → !**
- **Answer: #%@!**

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Letter Shifting in Coding-Decoding

Letter shifting is a common type of coding-decoding where letters in a word are shifted forward or backward in the alphabet based on a specific pattern. The shift can be uniform (each letter is moved by the same number of places) or non-uniform (each letter follows a different rule).

For example, if DOG is shifted by +2, it becomes FQI (D → F, O → Q, G → I).

Solved examples

Example 1
Q: If BALL is coded as EDOO, how is HAND coded?
A: (Shift +3) → KDQG

Example 2
Q: If CAT is coded as FDW, how is DOG coded?
A: (Shift +3) → GRJ

Example 3
Q: If FISH is coded as HKUJ, how is WATER coded?
A: (Shift +2) → YCVGT

Example 4
Q: If LION is coded as MJPO, how is TIGER coded?
A: (Shift +1) → UJHFS

Example 5
Q: If TABLE is coded as UZFOD, how is CHAIR coded?
A: (Shift +2) → EJCKT

Example 6
Q: If MANGO is coded as NBMHP, how is ORANGE coded?
A: (Shift +1) → PSBOHF

Example 7
Q: If APPLE is coded as DOORH, how is MOUSE coded?
A: (Shift +3) → PRXVH

Example 8
Q: If RAT is coded as TCR, how is DOG coded?
A: (Shift +2) → FQI

Example 9
Q: If GAME is coded as IBOH, how is WORD coded?
A: (Shift +2) → YQTF

Example 10
Q: If HELLO is coded as JGNNQ, how is WORLD coded?
A: (Shift +2) → YQTNF

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Number & Symbol-Based Coding

Number & Symbol-based coding is a type of coding-decoding where letters, words, or phrases are represented using numbers or symbols following a specific rule. These patterns can involve letter positions, mathematical operations, or symbolic substitutions.

Types of Number & Symbol-Based Coding:

1. **Alphabet Position Coding – Each letter is replaced by its position in the alphabet (A = 1, B = 2, C = 3, etc.).**
2. **Mathematical Operations – The sum, difference, or multiplication of letter positions is used for coding.**
3. **Symbol Substitution – Letters or numbers are replaced with special symbols.**

Solved Examples

Example 1: Alphabet Position Coding
Q: If DOG is coded as 4-15-7, how is CAT coded?
A: 3-1-20
Example 2: Reverse Position Coding
Q: If BAT is coded as 25-1-7, how is PEN coded?
A: 11-22-13 (26 - letter position)
Example 3: Mathematical Coding
Q: If LION is coded as 12 × 9 × 15 × 14 = 22680, how is TIGER coded?
A: 20 × 9 × 7 × 5 × 18 = 12600
Example 4: Addition Coding
Q: If SUN = 19 + 21 + 14 = 54, how is MOON coded?
A: 13 + 15 + 15 + 14 = 57
Example 5: Symbol-Based Coding
Q: If A = #, B = %, C = @, D = !, how is CABD coded?
A: @#%!
Example 6: Letter-Number Pairing
Q: If APPLE is coded as A1-P16-P16-L12-E5, how is ORANGE coded?
A: O15-R18-A1-N14-G7-E5
Example 7: Position Sum Coding
Q: If DOG is coded as (4+15+7) = 26, how is CAT coded?
A: (3+1+20) = 24
Example 8: Symbol-Based Arithmetic Coding
Q: If A = +, B = -, C = ×, D = ÷, how is 3C4A5B2 decoded?
A: 3 × 4 + 5 - 2 = 15

Example 9: Mixed Number-Symbol Coding
Q: If HELLO is coded as H#L#O, how is WORLD coded?
A: W#R#D (Vowels replaced by #)
Example 10: Alternate Number Coding
Q: If A = 2, B = 4, C = 6, then what is the code for FACE?
A: 6-2-6-10 (Each letter's position × 2)

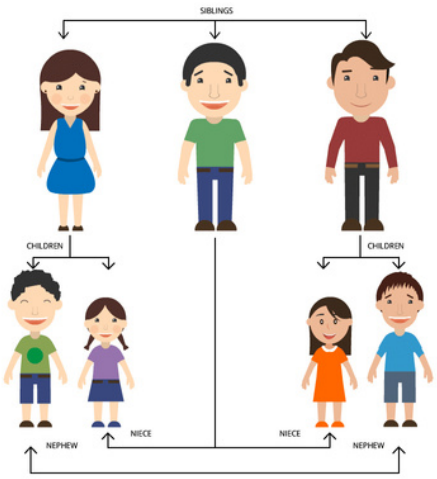
3.2 Blood Relations

Blood Relations in Logical Reasoning

Blood relation problems test a person's ability to analyze family relationships based on given information. These questions involve terms like father, mother, brother, sister, uncle, aunt, nephew, niece, etc.

Common Relationships & Notations

1. **Father's son/daughter → Brother/Sister**
2. **Mother's brother → Uncle**
3. **Father's father → Grandfather**
4. **Sister's son → Nephew**
5. **Brother's daughter → Niece**
6. **Father's sister → Aunt**
7. **Son's wife → Daughter-in-law**
8. **Wife's father → Father-in-law**



Solved Examples

Example 1
Q: Pointing to a man, Rahul said, "He is the father of my mother." How is the man related to Rahul?
A: Grandfather
Example 2
Q: Introducing a woman, Ramesh said, "She is the wife of my father's only son." How is the woman related to Ramesh?
A: Mother
Example 3
Q: A is the brother of B, B is the mother of C. How is A related to C?
A: Maternal Uncle

Example 4
Q: Pointing to a girl, Ravi said, "She is the daughter of my sister." How is the girl related to Ravi?
A: Niece
Example 5
Q: A is the son of B, B is the sister of C, and C is the son of D. How is A related to D?
A: Grandson
Example 6
Q: If A is the father of B, and B is the mother of C, what is A to C?
A: Grandfather
Example 7
Q: X is the son of Y, Y is the daughter of Z. How is Z related to X?
A: Grandparent
Example 8
Q: If P is the sister of Q and Q is the father of R, how is P related to R?
A: Paternal Aunt
Example 9
Q: A's father is B's son. B's father is C. How is A related to C?
A: Grandson
Example 10
Q: Pointing to a boy, Raj said, "He is the only son of my mother's father." How is the boy related to Raj?
A: Uncle

Family Tree Problems in Logical Reasoning

Family tree problems involve analyzing relationships between different family members based on given information. These problems test logical thinking and understanding of terms like father, mother, brother, sister, uncle, aunt, cousin, nephew, niece, grandfather, and grandmother.

How to Solve Family Tree Problems?

1. **Identify the given relationships.**
2. **Break down statements into individual links.**
3. **Draw a family tree to visualize connections.**
4. **Use gender clues (e.g., father, mother, son, daughter).**
5. **Determine direct and indirect relationships.**

Solved Examples

Example 1
Q: A is B's father. B is C's brother. How is A related to C?
A: Father
Example 2
Q: A is the mother of B, and B is the father of C. How is A related to C?
A: Grandmother
Example 3
Q: X is the son of Y. Y is the daughter of Z. How is Z related to X?
A: Grandfather or Grandmother
Example 4
Q: P is Q's father. Q is R's sister. How is P related to R?
A: Father
Example 5
Q: Pointing to a girl, Raj said, "She is the only daughter of my father's only son." How is the girl related to Raj?
A: Daughter
Example 6
Q: A's father is B's son. B's father is C. How is A related to C?
A: Grandson
Example 7
Q: A is the brother of B, B is the mother of C. How is A related to C?
A: Maternal Uncle
Example 8
Q: Pointing to a boy, Ravi said, "He is the son of my father's only son." How is the boy related to Ravi?
A: Son
Example 9
Q: If A is the sister of B, B is the father of C, and C is the brother of D, how is A related to D?
A: Paternal Aunt
Example 10
Q: If X is the wife of Y and Y is the brother of Z, how is Z related to X?
A: Brother-in-law or Sister-in-law

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Coded Relations in Logical Reasoning

Coded relations involve family relationships represented using symbols like +, −, ×, ÷, @, #, $, etc.. The challenge is to decode the given symbols and determine the correct relationship.

Common Symbols & Their Meanings

- **A + B → A is the father of B**
- **A − B → A is the mother of B**
- **A × B → A is the brother of B**
- **A ÷ B → A is the sister of B**

Solved Examples

Example 1
Q: If A + B means A is the father of B, then what does P + Q + R mean?
A: P is the grandfather of R
Example 2
Q: If A - B means A is the mother of B, and B × C means B is the brother of C, then how is A related to C?
A: Mother
Example 3
Q: If A × B means A is the brother of B, and B − C means B is the mother of C, how is A related to C?
A: Maternal Uncle
Example 4
Q: If P + Q − R means P is the father of Q, and Q is the mother of R, then how is P related to R?
A: Grandfather
Example 5
Q: If A ÷ B means A is the sister of B, and B × C means B is the brother of C, how is A related to C?
A: Sister
Example 6
Q: If A × B means A is the brother of B, B + C means B is the father of C, how is A related to C?
A: Uncle

Example 7
Q: If P ÷ Q means P is the sister of Q, and Q − R means Q is the mother of R, how is P related to R?
A: Maternal Aunt
Example 8
Q: If A + B means A is the father of B, and B × C means B is the brother of C, how is A related to C?
A: Father
Example 9
Q: If X × Y means X is the brother of Y, and Y + Z means Y is the father of Z, how is X related to Z?
A: Uncle
Example 10
Q: If A − B means A is the mother of B, and B ÷ C means B is the sister of C, how is A related to C?
A: Mother

3.3 Syllogisms & Logical Deductions

Syllogisms & Logical Deductions
Syllogisms and logical deductions are essential concepts in logical reasoning. They help evaluate arguments and determine whether a conclusion logically follows from given statements. These problems are widely used in competitive exams, interviews, and cognitive ability tests.

1. Understanding Syllogisms

A syllogism is a form of reasoning where a conclusion is drawn from two or more given statements (premises). The conclusion must logically follow from the premises.

Key Components of a Syllogism:

1. **Premises – Given statements (e.g., "All cats are animals.")**
2. **Conclusion – The logical deduction based on the premises.**
3. **Venn Diagrams – A method to visualize relationships between different entities.**

2. Types of Statements in Syllogisms

1. **Universal Affirmative (A-type): All A are B (e.g., "All dogs are mammals.")**
2. **Universal Negative (E-type): No A is B (e.g., "No birds are reptiles.")**
3. **Particular Affirmative (I-type): Some A are B (e.g., "Some cats are white.")**
4. **Particular Negative (O-type): Some A are not B (e.g., "Some fruits are not apples.")**

3. Logical Deductions

Logical deductions involve drawing conclusions based on the given facts. It requires an understanding of how different statements relate to one another. Common techniques for logical deductions include:

- **Using Venn diagrams**
- **Applying logical rules**
- **Identifying direct and indirect relationships**

Solved Examples

Example 1:

Statements:

1. **All cats are animals.**
2. **All animals are living beings.**

Conclusion:

1. **All cats are living beings. ✅ (Correct conclusion)**
2. **Some animals are cats. ✅ (Correct conclusion)**
3. **Some living beings are not animals. ❌ (Incorrect conclusion)**

Explanation: Using a Venn diagram, we see that "cats" are a subset of "animals," and "animals" are a subset of "living beings." So, "All cats are living beings" is valid. The third statement is incorrect because it contradicts the given premises.

Example 2:

Statements:

1. **Some men are doctors.**
2. **All doctors are intelligent.**

Conclusion:

1. **Some men are intelligent. ✅ (Correct conclusion)**
2. **All intelligent people are doctors. ❌ (Incorrect conclusion)**

Explanation: The first conclusion follows because some men are doctors, and all doctors are intelligent. However, the second conclusion is incorrect because the premises do not state that all intelligent people must be doctors.

Example 3:

Statements:

1. **No books are newspapers.**
2. **Some newspapers are magazines.**

Conclusion:

1. **Some magazines are not books. ❌ (Incorrect conclusion)**
2. **No newspapers are books. ✅ (Correct conclusion)**

Explanation: From the first statement, "No books are newspapers," we can deduce that "No newspapers are books" (conversion of the universal negative statement). However, the first conclusion is invalid because magazines were never related to books in the premises.

4. Tips to Solve Syllogisms & Logical Deductions

- Use Venn diagrams for better visualization.
- Understand the types of statements (A, E, I, O).
- Do not assume extra information beyond what is given.
- Check for converse relationships in universal negative statements.

Conclusion

Mastering syllogisms and logical deductions improves analytical thinking and reasoning skills, making it easier to solve logical puzzles and reasoning-based problems effectively.

Statements & Conclusions

Statements and Conclusions is a critical topic in logical reasoning that involves analyzing a given statement and determining which conclusions logically follow. These problems test analytical thinking and the ability to differentiate between valid and invalid conclusions.

1. Understanding Statements & Conclusions

A statement is a given fact, assumption, or observation. A conclusion is a logical inference that follows from the statement. The goal is to determine whether the given conclusion is valid based on the provided statement.

Types of Statements:

1. Factual Statements: Based on facts or observations (e.g., "All birds have wings.").
2. Opinion-Based Statements: Express personal viewpoints (e.g., "Exercise is the best way to stay fit.").
3. Conditional Statements: Contain "if-then" conditions (e.g., "If it rains, the ground gets wet.").

How to Evaluate Conclusions:

- The conclusion must be directly supported by the statement.
- No assumptions beyond the given statement should be made.
- Use logical deduction techniques (Venn diagrams, elimination method).

Solved Examples

Example 1:

Statement: "All apples are fruits."

Conclusions:

1. **Some fruits are apples. ✅ (Correct conclusion)**
2. **All fruits are apples. ❌ (Incorrect conclusion)**

Explanation: The first conclusion is correct because if all apples are fruits, then some fruits must be apples. The second conclusion is incorrect because the statement does not say that all fruits are apples.

Example 2:

Statement: "Smoking is harmful to health."

Conclusions:

1. **All unhealthy people smoke. ❌ (Incorrect conclusion)**
2. **Smoking causes health problems. ✅ (Correct conclusion)**

Explanation: The first conclusion is incorrect because the statement does not say that only smoking causes health problems. The second conclusion is valid as it aligns with the statement.

Key Takeaways:

- **A conclusion must be directly derived from the statement.**

Venn Diagram Approach

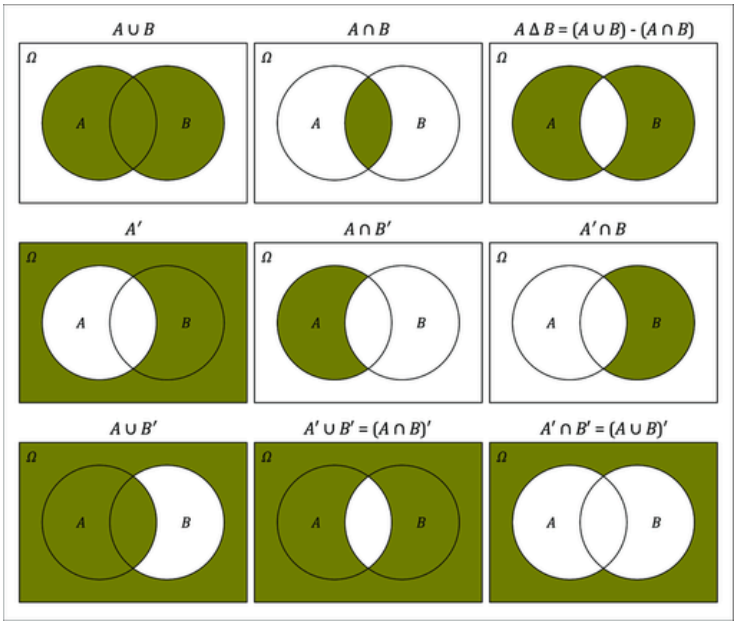
The Venn Diagram approach is a powerful method used to solve logical reasoning problems, particularly in Syllogisms, Statements & Conclusions, and Set Theory. It visually represents relationships between different sets using overlapping circles.

Why Use Venn Diagrams?

- **Helps visualize inclusions, exclusions, and intersections between sets.**
- **Eliminates confusion and reduces chances of incorrect conclusions.**
- **Makes complex relationships simpler and more understandable.**

Basic Venn Diagram Representations:

1. **All A are B → A is completely inside B.**
2. **Some A are B → A and B have an overlapping region.**
3. **No A is B → A and B are separate circles (no overlap).**
4. **Some A are not B → A has a part outside B.**



Solved Examples

Example 1:
Statement: All dogs are animals.
Venn Diagram: A circle representing "dogs" inside a bigger circle of "animals."
Conclusion: All dogs are animals ✅
Example 2:
Statement: Some fruits are apples.
Venn Diagram: Two overlapping circles – one for "fruits" and one for "apples."
Conclusion: Some apples are fruits ✅
Example 3:
Statement: No cats are birds.
Venn Diagram: Two separate circles (no overlap) for "cats" and "birds."
Conclusion: No birds are cats ✅
Example 4:
Statements:

1. **All students are intelligent.**
2. **Some intelligent people are scientists.**
3. **Venn Diagram: A circle of "students" inside "intelligent," with "scientists" partially overlapping "intelligent."**
4. **Conclusion: Some students may be scientists ❌ (Not necessarily true)**

Example 5:
Statements:

1. **Some doctors are teachers.**
2. **Some teachers are writers.**
3. **Venn Diagram: Three overlapping circles for "doctors," "teachers," and "writers."**
4. **Conclusion: Some doctors are writers ❌ (Not necessarily true)**

Key Takeaways:

- **Venn Diagrams simplify logical reasoning by showing clear relationships.**
- **Always check if a conclusion must be true before accepting it.**
- **Avoid assumptions beyond the given statements.**

Using Venn Diagrams makes solving logical reasoning problems faster and more accurate!

3.4 Seating Arrangements

Seating Arrangement problems are a common part of logical reasoning where individuals are arranged in a specific order based on given conditions. These problems test analytical thinking and spatial visualization skills.

Types of Seating Arrangements

1. **Linear Arrangement – People are seated in a row (either facing the same direction or opposite).**
2. **Circular Arrangement – People are seated in a circle (facing either inward or outward).**
3. **Square/Rectangular Arrangement – People are seated around a square or rectangular table (facing inward or outward).**
4. **Complex Arrangement – Combination of different seating styles with additional conditions.**

Key Techniques to Solve Seating Arrangements

- **Identify directions (e.g., Left-Right for linear, Clockwise/Counterclockwise for circular).**
- **Fix a reference point (e.g., A is at one end or X is sitting to the left of Y).**
- **Use diagrams to visualize seating positions.**
- **Apply given conditions step by step.**
- **Avoid assumptions not mentioned in the question.**

Solved Examples

Example 1: Linear Arrangement

Question: A, B, C, D, and E are sitting in a row. B is to the left of C. D is at the extreme right. A is between B and C. Who is sitting at the leftmost position?

Solution:

- **D is at the extreme right.**
- **A is between B and C.**
- **B is to the left of C.**

Seating Order: B - A - C - E - D

Answer: B is at the leftmost position. ✅

Example 2: Circular Arrangement

Question: Five people (P, Q, R, S, and T) sit in a circle, all facing the center. Q is to the immediate left of R. T is between Q and S. Who is sitting to the right of S?

Solution:

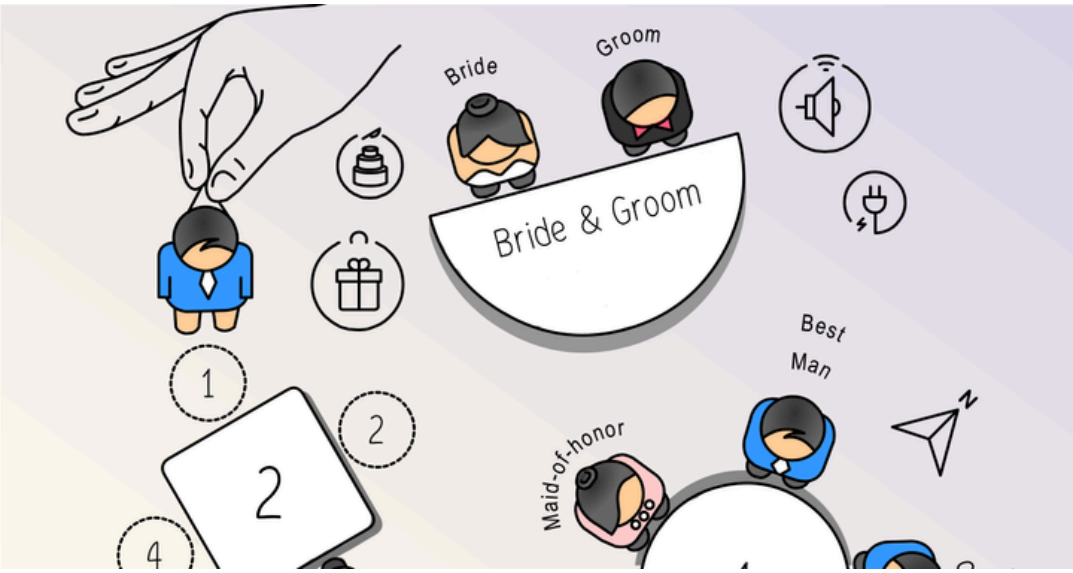
- **Q is to the left of R.**
- **T is between Q and S.**

Seating Order: P - Q - T - S - R

Answer: R is to the right of S. ✅

Key Takeaways:

- **Use diagrams for clarity.**
- **Place fixed positions first.**
- **Proceed step by step to avoid errors.**



:1. Circular Arrangement

In a circular arrangement, people are seated in a circle, facing either inward (toward the center) or outward (away from the center). The direction affects left and right positioning.

Rules to Solve:

- If facing inward, the left is clockwise, and the right is counterclockwise.
- If facing outward, the left is counterclockwise, and the right is clockwise.
- Fix one person's position and place others accordingly.

Solved Examples

Example 1:

Question: A, B, C, D, and E sit in a circle facing inward. B is to the immediate left of C, and D is between A and B. Who is to the right of A?

Solution:

Seating Order: A - D - B - C - E

Answer: E is to the right of A. ✅

Example 2:

Question: Six people sit in a circle facing outward. If X is to the right of Y, and Z is to the left of Y, what is the direction of movement?

Solution: Since they are facing outward, right is clockwise, and left is counterclockwise. ✅

Example 3:

Question: In a circular arrangement of 8 people facing inward, who is third to the right of A?

Solution: Move three places clockwise from A. ✅

2. Linear Arrangement

In a linear arrangement, people sit in a straight line, either facing the same or opposite directions.

Rules to Solve:

- If facing the same direction, left and right remain the same.
- If facing opposite directions, left and right reverse for some people.

:Solved Examples

Example 1:

Question: A, B, C, D, and E sit in a row facing north. B is to the left of C. D is at the rightmost position. A is between B and C. Who is at the leftmost position?

Solution:

Seating Order: B - A - C - E - D

Answer: B is at the leftmost position. ✅

Example 2:

Question: Five people sit in a row. P is second from the left, and Q is at the extreme right. Who is third from the right?

Solution: Determine the positions step by step. ✅

Example 3:

Question: A, B, C, D, and E sit in a row, all facing south. Who is to the right of B?

Solution: Since they are facing south, right is reversed. ✅

3. Square/Rectangular Arrangement

In a square/rectangular arrangement, people sit at the corners or sides of a table. They can face inward or outward, affecting left-right positioning.

Rules to Solve:

- Corner people have two immediate neighbors.
- Side people have one person on each side.
- Facing inward: Left is anticlockwise, right is clockwise.
- Facing outward: Left is clockwise, right is anticlockwise.

Solved Examples

Example 1:

Question: Four people (A, B, C, D) sit at the corners of a square facing inward. Who is to the left of B?

Solution: Move anticlockwise from B. ✅

Example 2:

Question: Eight people sit around a rectangular table. If P is opposite Q and R is to the right of P, who is opposite R?

Solution: Place P opposite Q and check conditions. ✅

Example 3:

Question: Six people sit around a rectangular table, all facing outward. Who is to the left of A?

Solution: Move clockwise from A. ✅

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Complex Puzzles

Complex puzzles involve multiple conditions, relationships, or arrangements that require logical reasoning and systematic problem-solving. These puzzles are commonly seen in competitive exams, interviews, and brain teasers.

Types of Complex Puzzles

1. **Seating Arrangement Puzzles – Advanced linear, circular, or square seating arrangements with multiple conditions.**
2. **Blood Relation Puzzles – Involving family members with indirect relationships.**
3. **Scheduling/Arrangement Puzzles – Assigning people, objects, or tasks based on conditions.**
4. **Direction-Based Puzzles – Analyzing movements in different directions.**
5. **Mathematical/Logical Puzzles – Finding missing numbers, patterns, or logical sequences.**

Approach to Solve Complex Puzzles

1. **Break Down Information: Identify key statements and note constraints.**
2. **Use a Diagram/Table: Visual representation simplifies relationships.**
3. **Eliminate Incorrect Options: Apply conditions step by step.**
4. **Check for Contradictions: Ensure all conditions are satisfied.**

Solved Examples

Example 1: Seating Arrangement

Question: Seven friends (A, B, C, D, E, F, and G) sit in a row. B is to the left of C. D is between A and F. E is to the immediate right of C. Who sits at the leftmost end?
Solution: Arranging step by step, the order is:
B - A - D - F - C - E - G
Answer: B sits at the leftmost position. ✅

Example 2: Blood Relation Puzzle

Question: A is the father of B. B is the mother of C. C is the sister of D. How is A related to D?
Solution: A is B's father → B is C's mother → C is D's sister.
Thus, A is D's maternal grandfather. ✅

Example 3: Scheduling Puzzle

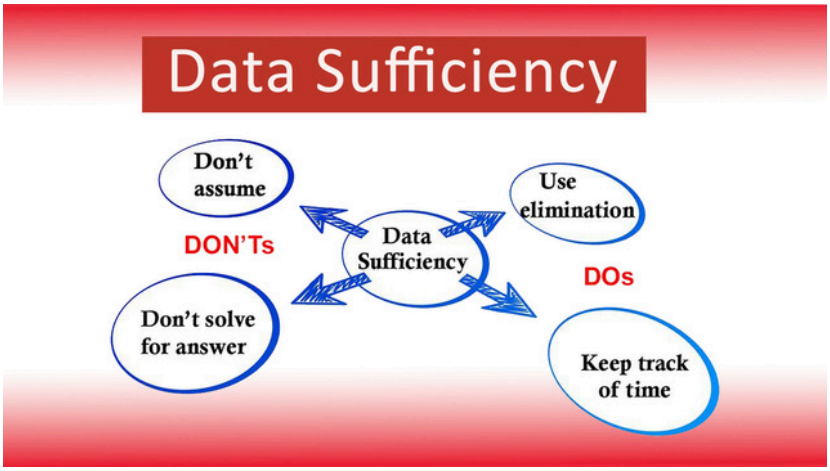
Question: Five people (P, Q, R, S, T) work on different days (Monday to Friday). P works before Q. R works on Wednesday. S works after T. Who works on Tuesday?
Solution: Arranging based on conditions:
Monday - T, Tuesday - P, Wednesday - R, Thursday - Q, Friday - S
Answer: P works on Tuesday. ✅

3.5 Data Sufficiency

Data Sufficiency is a type of problem commonly found in logical reasoning sections of competitive exams. It tests your ability to determine whether the provided information is enough to answer a specific question. Rather than solving the problem directly, you must evaluate whether the data given in the statements is sufficient to answer the question.

Approach to Solve Data Sufficiency Problems

1. **Read the Question Carefully: Understand exactly what is being asked.**
2. **Evaluate Each Statement: Check if each individual statement provides enough information to answer the question.**
3. **Combine the Statements: If neither statement alone is sufficient, see if combining the two statements resolves the problem.**
4. **Use the Answer Choices: Typically, in data sufficiency problems, there are five answer choices:**
   - **(A) Statement 1 alone is sufficient.**
   - **(B) Statement 2 alone is sufficient.**
   - **(C) Both statements together are sufficient.**
   - **(D) Each statement alone is insufficient.**
   - **(E) Both statements together are insufficient.**



Solved Examples

Example 1:
Question: Is x>5x > 5x>5?
Statement 1: x=4x = 4x=4
Statement 2: x=6x = 6x=6
Solution:

- **Statement 1: x=4x = 4x=4 → This is not enough to answer the question since xxx is not greater than 5.**
- **Statement 2: x=6x = 6x=6 → This is sufficient, as xxx is greater than 5.**

Answer: Statement 2 alone is sufficient. ✅
Example 2:
Question: What is the value of x+yx + yx+y?
Statement 1: x=5x = 5x=5
Statement 2: y=3y = 3y=3Solution:
Combined: Both statements provide the values of x and y, so x+y=5+3=8x + y = 5 + 3 = 8x+y=5+3=8.
Answer: Both statements together are sufficient. ✅
Example 3:
Question: Is x an even number?
Statement 1: x is divisible by 4.
Statement 2: x is a positive integer.
Solution:

- **Statement 1: If x is divisible by 4, it must be even. This is sufficient to answer the question.**
- **Statement 2: Tells us x is positive, but does not provide any information about its evenness.**

Answer: Statement 1 alone is sufficient. ✅

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Logical Approach to Problem-Solving

Problem-solving is a skill that involves identifying the issue, evaluating possible solutions, and selecting the most effective course of action. A logical approach emphasizes using structured reasoning and systematic steps to reach a solution, making it essential in both academic and real-world situations.

Steps for Logical Problem-Solving

1. **Understand the Problem:**
   - **Read the problem carefully and identify what is being asked.**
   - **Break down the problem into smaller, manageable parts if necessary.**
2. **Identify Given Information:**
   - **List all the known facts, assumptions, and constraints provided in the problem.**
   - **Be clear about what information is available and what needs to be determined.**
3. **Formulate a Plan:**
   - **Think of possible approaches to solve the problem.**
   - **Choose a strategy (e.g., algebraic solution, diagramming, or using logical rules) that fits the problem type.**
4. **Solve Step-by-Step:**
   - **Follow a structured approach, solving the problem incrementally.**
   - **Avoid jumping to conclusions—make sure each step logically follows from the previous one.**
5. **Check for Consistency and Validity:**
   - **Once a solution is reached, revisit the problem to check if the solution satisfies all conditions.**
   - **Look for any contradictions or overlooked details that might invalidate the answer.**
6. **Evaluate the Solution:**
   - **Assess if the solution is the simplest and most efficient.**
   - **Consider alternative solutions and verify that the chosen solution is optimal.**

Key Logical Techniques for Problem-Solving

- **Deductive Reasoning: Drawing conclusions from general facts or premises.**
- **Inductive Reasoning: Making generalized conclusions based on specific observations or patterns.**
- **Elimination Method: Ruling out impossible or illogical solutions to narrow down the correct one.**
- **Visualization (Diagrams, Tables, Venn Diagrams): Helps in breaking down complex problems into simpler, visual forms.**

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Problem: John's father is older than Tom. Tom is younger than Jack. Jack is younger than John. Who is the oldest?

Solution:

1. John's father is older than Tom. → John's father > Tom.
2. Tom is younger than Jack. → Jack > Tom.
3. Jack is younger than John. → John > Jack.
4. Combining the statements, we get:
   - John's father > Jack > Tom.
   - John > Jack > Tom.
5. Therefore, John's father is the oldest.
6. Answer: John's father is the oldest. ✅

Problem: A person is facing east. He walks 30 meters, turns left, walks 40 meters, turns left again, and walks 30 meters. In which direction is he now facing?

Solution:

1. The person starts facing east.
2. After walking 30 meters, he turns left (to north).
3. After walking 40 meters, he turns left again (to west).
4. He walks 30 meters and does not turn again, so he is still facing west.
5. Answer: The person is facing west. ✅

Problem: At 3:00 PM, the hour hand and minute hand of a clock are aligned. How much time will pass before they align again?

Solution:

1. The minute hand moves 360 degrees every hour, while the hour hand moves 30 degrees per hour (360°/12 hours).
2. The hands align every time the minute hand gains 360° over the hour hand.
3. In one hour, the minute hand moves 360°, while the hour hand moves 30°. So, the minute hand gains 330° every hour.
4. To gain a full 360° over the hour hand

Answer: The hands align again after 1 hour and 5.45 minutes. ✅

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How to Determine if Data is Sufficient

In data sufficiency problems, the goal is to evaluate whether the given statements provide enough information to answer a question. Instead of solving the question directly, you assess whether the data is adequate to determine the answer. This skill is crucial in logical reasoning sections of competitive exams.

Approach to Data Sufficiency Problems

1. **Understand the Question:**
   - Read the question carefully and identify what you are asked to determine.
   - Identify the key variables and relationships mentioned.
2. **Analyze the Statements:**
   - Evaluate each statement independently to see if it provides enough information to answer the question.
   - If both statements are provided, check if combining them gives a complete picture.
3. **Use the Answer Choices:**
   - Typically, there are five options in data sufficiency problems:
     - (A) Statement 1 alone is sufficient.
     - (B) Statement 2 alone is sufficient.
     - (C) Both statements together are sufficient.
     - (D) Each statement alone is insufficient.
     - (E) Both statements together are insufficient.

Solved Examples

Example 1:

Question: What is the value of xxx?

Statement 1: 2x=102x = 102x=10

Statement 2: xxx is a positive integer.

Solution:

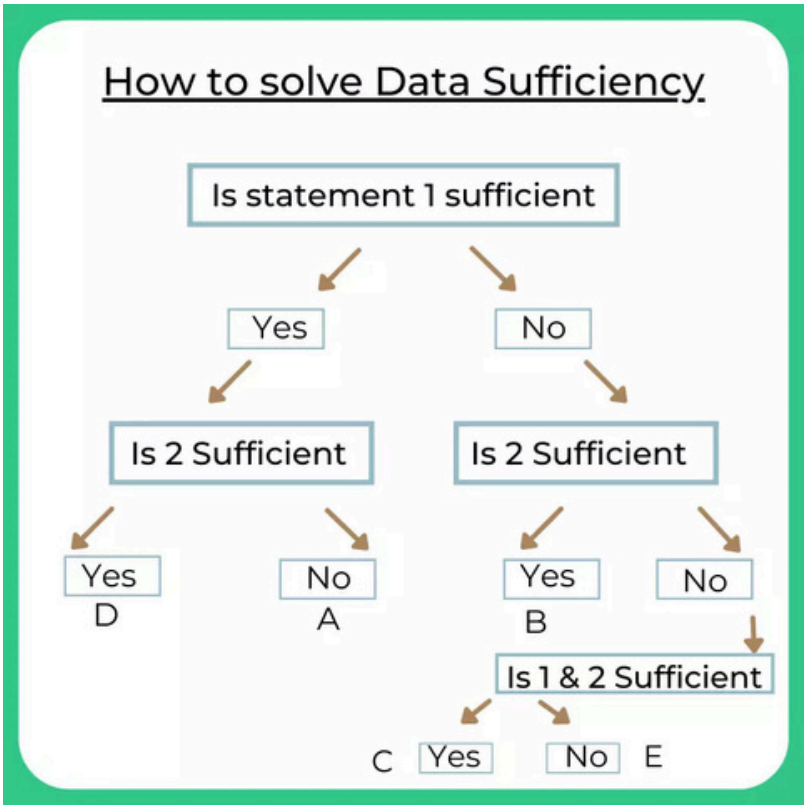
- **Statement 1: 2x=102x = 102x=10, solving gives x=5x = 5x=5.**
- **Statement 2: xxx is positive, but Statement 1 already gives x=5x = 5x=5.**
- **Answer: Statement 1 alone is sufficient. ✅**

Example 2:
Question: Is xxx an even number?
Statement 1: x=6x = 6x=6.
Statement 2: xxx is a positive integer.
Solution:

- **Statement 1: x=6x = 6x=6 clearly states that xxx is even.**
- **Statement 2: Doesn't help determine whether xxx is even, as we already know from Statement 1.**
- **Answer: Statement 1 alone is sufficient. ✅**

Example 3:
Question: What is the age of Mr. X?
Statement 1: Mr. X's age is twice the age of his son.
Statement 2: Mr. X's son is 15 years old.
Solution:

- **Statement 1: We know Mr. X is twice his son's age, but we still need the son's age.**
- **Statement 2: The son is 15, so Mr. X's age is 2×15=302 \times 15 = 302×15=30.**
- **Answer: Both statements together are sufficient. ✅**



4. Verbal Ability

Verbal Ability refers to the skills related to understanding and reasoning using concepts framed in words. It includes comprehension, vocabulary, grammar, and sentence structuring. It is often tested in competitive exams, interviews, and aptitude tests to assess a person's ability to process language, interpret information, and communicate effectively.

Key Components of Verbal Ability:

1. Reading Comprehension:
2. Involves reading a passage and answering questions based on its content. It assesses how well a person can understand and analyze written material.
3. Vocabulary:
4. Tests knowledge of words and their meanings, including synonyms, antonyms, and contextual usage. This helps gauge a person's command over language.
5. Grammar:
6. Assesses the understanding of language rules, such as sentence structure, verb tenses, subject-verb agreement, and punctuation.
7. Sentence Completion and Correction:
8. Involves completing a sentence or correcting errors in a given sentence based on grammar rules and logical reasoning.
9. Analogies:
10. Identifying the relationship between two pairs of words and applying it to another pair.

Solved Examples:

Example 1: Vocabulary

Question: Select the word most similar in meaning to "EXUBERANT".

Options:

a) Sad

b) Cheerful

c) Angry

d) Lazy

Solution:

"Exuberant" means full of energy, excitement, and cheerfulness. The most similar word is cheerful.

Answer: b) Cheerful

Example 2: Reading Comprehension

Passage:
"Despite the great advancements in technology, the reliance on traditional methods of communication remains strong in many rural areas."
Question: What is the main point of the passage?
Options:
a) Technology is not advancing fast enough.
b) Rural areas depend on traditional communication.
c) Modern methods are universally used.
d) Technology hinders communication.
Solution:
The passage emphasizes the continued dependence on traditional communication in rural areas despite technological advancements.
Answer: b) Rural areas depend on traditional communication.

Example 3: Grammar

Question: Choose the correct sentence.
a) She don't like chocolate.
b) She doesn't likes chocolate.
c) She doesn't like chocolate.
d) She not like chocolate.
Solution:
The correct form is "She doesn't like chocolate" as "doesn't" is used with the base form of the verb.
Answer: c) She doesn't like chocolate.

Example 4: Sentence Completion

Question: He walked to the store, _____ he forgot his wallet.
Options:
a) so
b) but
c) because
d) although
Solution:
The correct word is "but" as it contrasts the two actions.
Answer: b) but

Example 5: Analogy

Question: Book is to Reading as Fork is to:
a) Drawing
b) Writing
c) Eating
d) Cooking
Solution:
A book is used for reading, and a fork is used for eating.
Answer: c) Eating

4.1 Vocabulary

Vocabulary refers to the set of words known and used by a person. In competitive exams, a strong vocabulary is essential for effective communication and comprehension. Vocabulary-based questions often test a candidate's understanding of word meanings, usage, synonyms, antonyms, and contextual meanings. Mastering vocabulary improves reading comprehension, communication skills, and overall performance in verbal ability sections.

Types of Vocabulary Questions:

1.Synonyms:

Questions that ask for words with similar meanings. These test the breadth of your vocabulary and ability to identify relationships between words.

2.Antonyms:

Questions that ask for words with opposite meanings. This tests your understanding of the nuances and contrasts in language.

3.Contextual Vocabulary:

In these questions, you choose a word based on the context provided in the sentence or passage.

4.Word Usage:

These questions ask how a word is used in a particular sentence, testing whether you understand its correct application.

5.Analogies:

These questions assess your ability to identify the relationship between two words and apply it to another pair.

Solved Examples:

Example 1: Synonym

Question: Select the word most similar in meaning to "APPEASE".

Options:

a) Anger

b) Satisfy

c) Ignore

d) Criticize

Solution:

"Appease" means to calm or satisfy, which is similar to "Satisfy."

Answer: b) Satisfy

Example 2: Antonym

Question: Select the word most opposite in meaning to "ALTRUISM".

Options:

a) Selfishness

b) Generosity

c) Kindness

d) Sympathy

Solution:

"Altruism" refers to selfless concern for others, and the opposite would be "Selfishness."

Answer: a) Selfishness

Example 3: Contextual Vocabulary

Question: The manager's comments were extremely _____, causing everyone in the meeting to feel uncomfortable.

Options:

a) Pleasant

b) Hostile

c) Enthusiastic

d) Neutral

Solution:

Based on the context of discomfort, the correct word is "Hostile," which means unfriendly or aggressive.

Answer: b) Hostile

Example 4: Word Usage

Question: Choose the correct word to fill in the blank:
"The detective's _____ instincts led him to the hidden evidence."
Options:
a) Dull
b) Keen
c) Lazy
d) Weak
Solution:
"Keen" means sharp or perceptive, which fits the context of a detective's instincts.
Answer: b) Keen

Example 5: Analogy

Question: Book is to Read as Knife is to:
a) Eat
b) Cut
c) Cook
d) Carve
Solution:
A book is used to read, and a knife is used to cut.
Answer: b) Cut

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Synonyms & Antonyms

Synonyms are words that have similar meanings. They help in enhancing vocabulary and improving communication by providing alternative ways to express the same idea. For example, "happy" and "joyful" are synonyms because they both convey a positive emotional state.

Antonyms are words that have opposite meanings. They are useful for understanding word contrasts and refining language skills. For example, "hot" and "cold" are antonyms because they represent opposing temperature conditions.

Synonyms and antonyms are commonly tested in verbal ability exams through direct word association, sentence completions, and analogy-based questions. Expanding vocabulary through regular reading and practice can improve performance in such questions.

Solved Examples

Example 1: Synonym

Question: Select the synonym of "Benevolent".

Options:

a) Cruel

b) Generous

c) Arrogant

d) Harsh

Solution:

"Benevolent" means kind and charitable. The closest synonym is "Generous".

Answer: b) Generous ✅

Example 2: Antonym

Question: Select the antonym of "Hostile".

Options:

a) Friendly

b) Aggressive

c) Rude

d) Harsh

Solution:

"Hostile" means unfriendly or aggressive. The opposite is "Friendly".

Answer: a) Friendly ✅

Example 3: Synonym

Question: Select the synonym of "Melancholy".
Options:
a) Happy
b) Joyful
c) Sad
d) Excited
Solution:
"Melancholy" means sadness or gloominess. The closest synonym is "Sad".
Answer: c) Sad ✅

Example 4: Antonym

Question: Select the antonym of "Abundant".
Options:
a) Plentiful
b) Scarce
c) Excessive
d) Ample
Solution:
"Abundant" means plentiful or in large quantity. The opposite is "Scarce".
Answer: b) Scarce ✅
By mastering synonyms and antonyms, one can improve vocabulary, comprehension, and verbal reasoning skills.

Word Formation

Word formation is the process of creating new words from existing words or roots by adding prefixes, suffixes, or combining words. It helps expand vocabulary and understand word meanings based on structure.

Types of Word Formation:

1. **Prefixes – Added at the beginning of a word to modify its meaning (e.g., unhappy, rewrite).**
2. **Suffixes – Added at the end of a word to change its form (e.g., hopeful, action).**
3. **Compounding – Combining two words to form a new word (e.g., notebook, blackboard).**
4. **Conversion – Changing a word's grammatical category without adding a prefix or suffix (e.g., "Google" (noun) → "to google" (verb)).**
5. **Clipping & Blending – Shortening words (e.g., info from "information") or merging words (e.g., brunch = breakfast + lunch).**

Solved Examples

Example 1: Prefix Addition
Question: Add a prefix to make "legal" mean "not legal".
Answer: Illegal ✅
Example 2: Suffix Addition
Question: Add a suffix to "act" to form a noun.
Answer: Action ✅
Example 3: Compounding
Question: Combine "rain" and "coat" to form a new word.
Answer: Raincoat ✅
Example 4: Conversion
Question: Use "Google" as a verb in a sentence.
Answer: "I will google the answer." ✅
Example 5: Clipping
Question: What is the clipped form of "influenza"?
Answer: Flu ✅

4.2 Grammar & Sentence Correction

Grammar is the set of rules that govern the structure of sentences, including word order, punctuation, and syntax. Sentence correction involves identifying and fixing errors related to grammar, spelling, punctuation, or clarity. Both are crucial for effective communication and are frequently tested in competitive exams and language proficiency tests.

Key Areas of Grammar & Sentence Correction:

Subject-Verb Agreement – The verb must agree with the subject in number and person.

- **Incorrect: She go to school every day.**
- **Correct: She goes to school every day.**

Tense Consistency – The sentence should maintain the correct tense.

- **Incorrect: Yesterday, he goes to the market.**
- **Correct: Yesterday, he went to the market.**

Pronoun Usage – The pronoun must match the noun it replaces.

- **Incorrect: Each of the boys took their book.**
- **Correct: Each of the boys took his book.**

Prepositions – Using the right preposition is essential for sentence clarity.

- Incorrect: She is married with a doctor.
- Correct: She is married to a doctor.

Word Order & Clarity – The sentence must be clear and logical.

- Incorrect: I only have ten dollars.
- Correct: I have only ten dollars.

Solved Examples

Example 1: Subject-Verb Agreement

Question: Identify the error.
"The dog and the cat is playing in the garden."
Solution: The subject is plural ("dog and cat"), so the verb should be "are."
Corrected Sentence: "The dog and the cat are playing in the garden." ✅

Example 2: Tense Consistency

Question: Identify the incorrect verb.
"I was watching TV when she calls me."
Solution: "Calls" (present tense) should be in past tense for consistency.
Corrected Sentence: "I was watching TV when she called me." ✅

Example 3: Pronoun Usage

Question: Correct the error.
"Everyone should do their best in the exam."
Solution: "Everyone" is singular, so use "his or her" instead of "their."
Corrected Sentence: "Everyone should do his or her best in the exam." ✅

Example 4: Prepositions

Question: Find and correct the preposition error.
"He is addicted in video games."
Solution: The correct preposition is "to," not "in."
Corrected Sentence: "He is addicted to video games." ✅

Example 5: Word Order

Question: Identify and fix the error.
"She hardly not speaks to anyone."
Solution: "Hardly" is a negative word, so "not" is unnecessary.
Corrected Sentence: "She hardly speaks to anyone." ✅

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Subject-Verb Agreement

Subject-verb agreement is a fundamental rule in English grammar that ensures the verb agrees with the subject in number and person. This means:

- **A singular subject takes a singular verb (e.g., He writes a letter).**
- **A plural subject takes a plural verb (e.g., They write a letter).**

Errors in subject-verb agreement often occur when:

1. **Subjects are separated from verbs by words or phrases.**
2. **Collective nouns are used (e.g., team, committee).**
3. **Indefinite pronouns (e.g., everyone, somebody) are used.**
4. **Compound subjects (joined by "and" or "or") appear.**
5. **The sentence has inverted word order (e.g., There is a problem).**

Rules & Examples

Example 1: Singular vs. Plural Subjects

Incorrect: The boy play football every evening.
Correct: The boy plays football every evening. ✅

Example 2: Compound Subjects

Incorrect: My brother and sister is coming to visit.
Correct: My brother and sister are coming to visit. ✅

Example 3: Collective Nouns

Incorrect: The committee are deciding on the new policy.
Correct: The committee is deciding on the new policy. ✅ (Treated as a single unit.)

Example 4: Indefinite Pronouns

Incorrect: Everybody know the rules.
Correct: Everybody knows the rules. ✅ (Indefinite pronouns are singular.)

Example 5: Inverted Sentences

Incorrect: There is many problems in the report.
Correct: There are many problems in the report. ✅ (The subject "problems" is plural, so the verb must be "are.")

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Articles, Prepositions & Tenses

Articles, prepositions, and tenses are fundamental aspects of English grammar that help in constructing clear and meaningful sentences.

1. Articles

Articles (a, an, the) are used before nouns to define them as specific or general.

- **Definite Article ("the") – Refers to specific nouns.**
  - **Example: The sun rises in the east.**
- **Indefinite Articles ("a" and "an") – Refer to non-specific nouns.**
  - **Example: I saw a dog in the park.**
  - **"An" is used before vowels: He ate an apple.**

2. Prepositions

Prepositions show the relationship between a noun and another word in a sentence.

- **Types of Prepositions:**
  - **Time: in, on, at (e.g., We met on Monday.)**
  - **Place: in, on, at (e.g., The book is on the table.)**
  - **Direction: to, from, into (e.g., She went to school.`**

3. Tenses

Tenses indicate the time of an action.

- **Present Tense: Describes current actions.**
  - **Example: She reads books daily.**
- **Past Tense: Describes completed actions.**
  - **Example: They went to the zoo yesterday.**
- **Future Tense: Describes upcoming actions.**
  - **Example: I will visit my grandmother tomorrow.**

Solved Examples

Example 1: Articles

Question: Choose the correct article.
"I saw ___ elephant at the zoo."
Answer: "I saw an elephant at the zoo." ✅

Example 2: Prepositions

Question: Fill in the blank with the correct preposition.
"The keys are ___ the table."
Answer: "The keys are on the table." ✅

Example 3: Present Tense

Question: Choose the correct verb form.
"She always ___ to school on time."
Options: (a) go (b) goes (c) going
Answer: "She always goes to school on time." ✅

Example 4: Past Tense

Question: Correct the tense error.
"Yesterday, he drives to work."
Correct Answer: "Yesterday, he drove to work." ✅

Example 5: Future Tense

Question: Fill in the blank with the future tense.
"They ___ a movie tomorrow."
Answer: "They will watch a movie tomorrow." ✅

Active & Passive Voice

In reasoning and verbal ability, understanding active and passive voice helps in sentence transformation, logical deductions, and comprehension-based questions. Some exams test sentence conversion from active to passive and vice versa, requiring a strong grasp of sentence structure.

What is Active & Passive Voice in Reasoning?

- **Active Voice: The subject performs the action. (More direct and clear.)**
  - **Example: The teacher explained the topic.**
- **Passive Voice: The subject receives the action. (Used when the doer is unknown or less important.)**
  - **Example: The topic was explained by the teacher.**

Rules for Voice Conversion in Reasoning:

1. **Identify the subject, verb, and object in the sentence.**
2. **Move the object to the subject position.**
3. **Use the correct form of 'to be' with the past participle of the verb.**
4. **Add 'by' + the original subject (optional).**

Solved Examples

Example 1: Simple Present Tense

Active: The manager reviews the reports.
Passive: The reports are reviewed by the manager. ✅

Example 2: Simple Past Tense

Active: She wrote a novel.
Passive: A novel was written by her. ✅

Example 3: Present Continuous Tense

Active: They are solving the puzzle.
Passive: The puzzle is being solved by them. ✅

Example 4: Future Tense

Active: The company will launch a new product.
Passive: A new product will be launched by the company. ✅

Example 5: Question Form

Active: Did he complete the assignment?
Passive: Was the assignment completed by him? ✅

4.2 Reading Comprehension

Reading Comprehension (RC) is a crucial part of reasoning and verbal ability. It tests a person's ability to understand, analyze, and interpret a given passage. Questions based on RC evaluate skills such as finding the main idea, identifying supporting details, making inferences, and understanding the author's tone and purpose.

Types of Reading Comprehension Questions:

1. **Direct Questions: Based on facts from the passage.**
   - **Example: "What is the main topic of the passage?"**
2. **Inference-Based Questions: Require understanding beyond the given text.**
   - **Example: "What can be inferred about the author's opinion?"**
3. **Vocabulary-Based Questions: Ask for the meaning of words/phrases in context.**
   - **Example: "What does the word 'resilient' mean in the passage?"**
4. **True/False or Cause-Effect Questions: Ask about relationships between ideas.**
   - **Example: "Which of the following statements is true based on the passage?"**
5. **Tone and Theme Questions: Identify the author's attitude or the central idea.**
   - **Example: "What is the tone of the passage?"**

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Solved Examples

Passage:

"Climate change is a pressing issue that affects ecosystems, weather patterns, and human health. Rising temperatures have led to more frequent natural disasters, such as hurricanes and wildfires. Governments worldwide are taking measures to reduce carbon emissions and promote sustainable living."

Example 1: Direct Question

Q: What is the primary focus of the passage?
A: Climate change and its effects. ✅

Example 2: Inference-Based Question

Q: What can be inferred about the author's perspective on climate change?
A: The author views climate change as a serious issue requiring urgent action. ✅

Example 3: Vocabulary-Based Question

Q: What does "sustainable living" mean in the passage?
A: Living in a way that conserves resources and protects the environment. ✅

Example 4: True/False Question

Q: Rising temperatures have not contributed to natural disasters. (True/False)
A: False ✅

Example 5: Tone & Theme Question

Q: What is the tone of the passage?
A: Concerned and informative. ✅

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Speed Reading Techniques

Speed reading is the ability to read and comprehend text quickly. It involves techniques that help increase reading speed while maintaining comprehension and accuracy. Mastering speed reading is beneficial for competitive exams, research, and daily reading.

Key Speed Reading Techniques:

Skimming: Quickly glancing over the text to grasp the main idea.

- Example: Reading headlines and subheadings before the full article.

Scanning: Looking for specific information like names, dates, or keywords.

- Example: Searching for a particular date in a history book.

Eliminating Sub vocalization: Reducing the habit of silently pronouncing words while reading.

- Example: Instead of mentally saying “the sun is shining,” just recognize it as an image.

Using Peripheral Vision: Expanding your vision to read multiple words at a time instead of one-by-one.

- Example: Instead of reading "The cat sat on the mat" word by word, seeing it as a phrase.

Chunking Words: Reading words in groups rather than individually.

- Example: Instead of reading "New York is a big city" as five separate words, process it as "New York | is a big city."

Solved Examples of Speed Reading Techniques

Example 1: Skimming

Question: What is the main idea of a news article?

Solution: Read the headline, first and last paragraphs, and bolded words to grasp the main idea quickly. ✅

Example 2: Scanning

Question: Find the year "Independence was declared" in a long historical text.

Solution: Scan the paragraphs for numbers and key terms like "declaration" or "freedom." ✅

Example 3: Eliminating Sub vocalization

Question: Read a 500-word article in under 2 minutes.

Solution: Avoid pronouncing each word mentally—focus on absorbing phrases and meanings visually. ✅

Example 4: Using Peripheral Vision

Question: How can you read a page faster?
Solution: Use side vision to take in whole lines or groups of words instead of focusing on one word at a time. ✅

Example 5: Chunking Words

Question: How do you speed up reading while maintaining comprehension?
Solution: Instead of reading individual words, process groups of words together, e.g., "The sun is bright today" as one phrase. ✅

Critical Reasoning & Inference-Based Questions

Critical reasoning involves analyzing, evaluating, and drawing logical conclusions from given information. It tests a person's ability to think logically, identify assumptions, and infer hidden meanings. Inference-based questions require readers to deduce information that is not explicitly stated but is implied in the passage.

Types of Critical Reasoning Questions:

1. **Assumption-Based Questions: Identify unstated premises that support the argument.**
2. **Inference-Based Questions: Draw logical conclusions from the given information.**
3. **Strengthening/Weakening Arguments: Determine what strengthens or weakens the logic of an argument.**
4. **Cause-Effect Relationships: Analyze the link between actions and outcomes.**
5. **Evaluating Arguments: Judge the validity and logical flow of an argument.**

Solved Examples of Critical Reasoning & Inference-Based Questions

Example 1: Assumption-Based Question

Statement: "Regular exercise improves mental health."
Question: What is an assumption in the argument?
Options:
a) Mental health issues are caused by a lack of exercise.
b) People who exercise regularly have better mental health.
c) Exercise is the only way to improve mental health.
Answer: (b) People who exercise regularly have better mental health. ✅

Example 2: Inference-Based Question
Statement: "All students in the class passed the exam."
Question: What can be inferred?
Options:
a) No student failed.
b) The exam was easy.
c) Some students scored full marks.
Answer: (a) No student failed. ✅ (Directly inferred from the statement.)

Example 3: Strengthening the Argument
Statement: "Drinking more water improves skin health."
Question: Which statement strengthens the argument?
Options:
a) People who drink more water have clearer skin.
b) Skincare products are essential for good skin.
c) Exercise is also important for skin health.
Answer: (a) People who drink more water have clearer skin. ✅

Example 4: Cause-Effect Question
Statement: "Many people fell sick after drinking contaminated water."
Question: What is the most likely cause?
Options:
a) The weather changed suddenly.
b) The water contained harmful bacteria.
c) People were stressed.
Answer: (b) The water contained harmful bacteria. ✅ (Logical cause-effect relationship.)

Example 5: Evaluating an Argument
Statement: "Schools should ban junk food to improve student health."
Question: Which statement evaluates this argument?
Options:
a) Junk food is cheaper than healthy food.
b) Many students bring junk food from home.
c) Junk food affects students' concentration and health.
Answer: (c) Junk food affects students' concentration and health. ✅ (It provides logical reasoning for the argument.)

5. Data Interpretation & Analysis

Data Interpretation & Analysis (DIA) refers to the process of examining, understanding, and making sense of numerical or visual data to draw meaningful conclusions. It is a key skill in reasoning and quantitative aptitude sections of competitive exams and professional assessments. Effective data interpretation helps in analyzing information, making predictions, and making informed decisions based on facts and figures.

Types of Data in Data Interpretation:

1. Tabular Data: Data presented in the form of tables, where information is organized in rows and columns.
   - Example: A table showing the sales of different products over a period of time.
2. Graphical Data: Data represented visually in graphs such as bar charts, line graphs, pie charts, and histograms.
   - Example: A pie chart showing the percentage of market share of different companies.
3. Pictorial Data: Data represented through images or pictures.
   - Example: A bar graph where each bar is represented by an icon or a picture.
4. Textual Data: Data represented in the form of written information, often used in case studies or reports.
   - Example: A paragraph describing the trends in the stock market.

Steps in Data Interpretation & Analysis:

Reading the Data Carefully: The first step is to understand the data presented. Whether it's a table, graph, or chart, it’s important to examine the axis, units, and labels to fully grasp the context.

Identifying Key Information: Identify what the question is asking for and what data is relevant to solving it. Look for specific values, trends, or relationships that can provide the answer.

Analyzing Relationships: Look for relationships or trends within the data. For example, in a bar graph, observe how different categories compare to each other, or in a line graph, observe whether the trend is increasing, decreasing, or fluctuating.

Performing Calculations: Many data interpretation questions require basic arithmetic calculations such as averages, percentages, totals, and ratios. You may need to add or subtract values, calculate the mean, or compare values to answer the question.

Drawing Conclusions: Based on the analysis, draw logical conclusions. Identify any patterns or outliers that can help in making an accurate interpretation.

Types of Data Interpretation Questions:

Percentage-Based Questions: Questions that require calculating the percentage of a given quantity from the data presented.

- Example: "What is the percentage increase in sales from January to February?"

Average/Mean Calculation: Questions that require calculating the average or mean of a set of data.

- Example: "What is the average expenditure of all departments?"

Ratio & Proportion: Questions asking to compare two or more quantities and find their ratio.

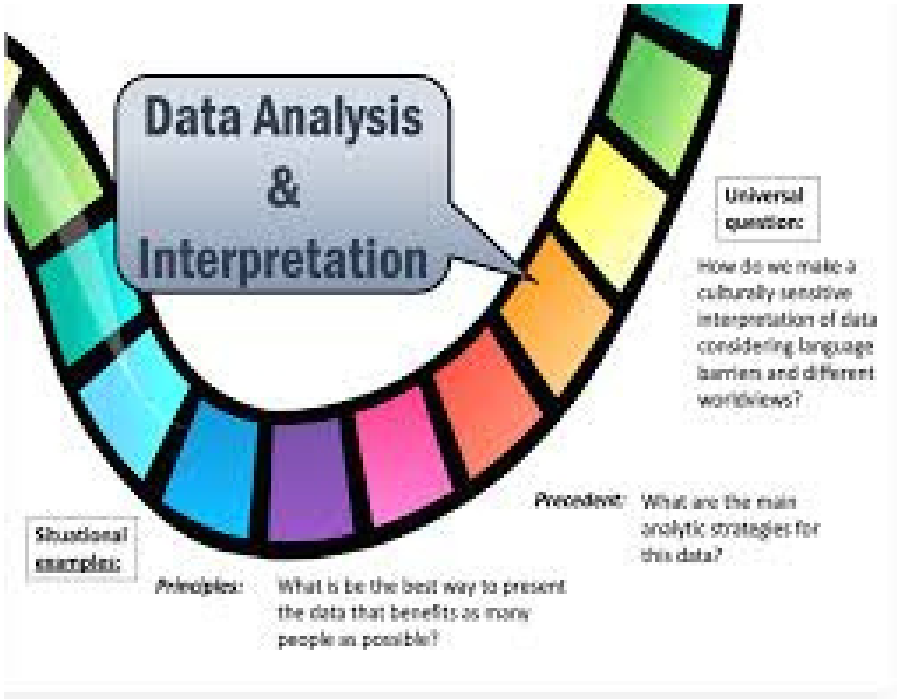
- Example: "If the number of men to women in a group is 2:3, and there are 30 women, how many men are there?"

Comparative Analysis: Questions where you compare different sets of data presented in tables or graphs to identify trends or differences.

- Example: "Which product had the highest sales in Q3?"

Time-Based Analysis: Questions that analyze data over different periods (like months, years, or quarters).

- Example: "How much was the total revenue for the year



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Pie Charts, Bar Graphs, Line Graphs

Data visualization is crucial for understanding trends, comparisons, and distributions. Among the most common types of graphs used for this purpose are pie charts, bar graphs, and line graphs. Each of these has unique applications and advantages.

1. Pie Charts

A pie chart is a circular graph divided into slices, where each slice represents a proportion of the total. It is most useful for showing percentage distributions or parts of a whole. The total value of all slices adds up to 100%.

Example 1: Distribution of Expenses

A person's monthly budget is divided as follows: Rent (40%), Food (25%), Transport (15%), Savings (10%), and Entertainment (10%). A pie chart visually represents these categories as proportional slices.

2. Bar Graphs

A bar graph displays categorical data using rectangular bars. The height (or length) of each bar is proportional to the value it represents. Bar graphs can be horizontal or vertical and are useful for comparing quantities across categories.

Example 2: Student Performance in Subjects

A student scores the following marks: Math (90), Science (80), English (85), History (75), and Art (95). A vertical bar graph shows each subject on the x-axis and marks on the y-axis, helping compare performance across subjects.

Example 3: Sales Comparison of Products

A store sells four products: Product A (500 units), Product B (700 units), Product C (400 units), and Product D (600 units). A bar graph allows easy comparison of sales figures among products.

3. Line Graphs

A line graph represents data points connected by a line. It is mainly used to show trends over time, such as changes in stock prices, temperature variations, or population growth.

Example 4: Temperature Changes Over a Week

The temperature at noon over a week is recorded: Monday (30°C), Tuesday (32°C), Wednesday (31°C), Thursday (29°C), Friday (28°C), Saturday (27°C), and Sunday (29°C). A line graph with time (days) on the x-axis and temperature on the y-axis shows how temperature fluctuates.

Example 5: Company's Monthly Revenue

A company records its revenue over six months: January ($10,000), February ($12,000), March ($15,000), April ($13,000), May ($16,000), and June ($18,000). A line graph helps visualize the revenue trend.

Each of these charts is essential for data representation and analysis, making complex data easier to understand. Pie charts highlight proportions, bar graphs compare values, and line graphs show trends over time.

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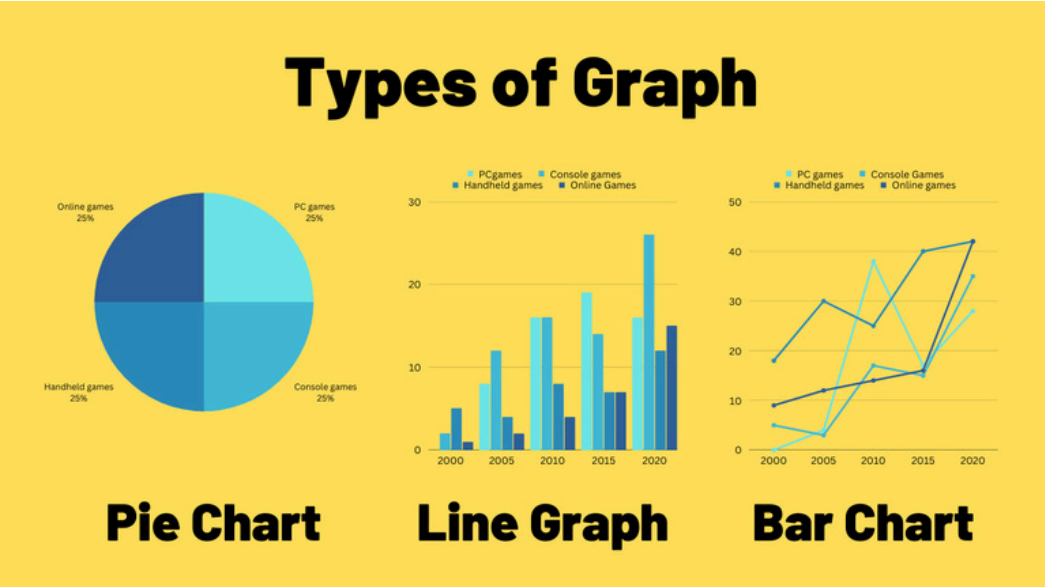

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Tabular Data & Capelets

The phrase "Tabular Data & Capelets" combines two distinct concepts: tabular data, which relates to structured datasets, and capelets, which are fashion accessories resembling short capes.

Tabular Data

Tabular data is information organized into rows and columns, commonly found in spreadsheets, databases, and tables. It is widely used for storing, analyzing, and visualizing structured information. Each row typically represents an individual record, while columns represent attributes.

Examples of tabular data:

1. Sales Reports – A table listing product names, sales figures, and revenue by month.
2. Student Grades – A spreadsheet with student names, subjects, and scores for performance tracking.
3. Employee Database – A table containing employee IDs, names, departments, and salaries.
4. Weather Data – A dataset listing daily temperature, humidity, and precipitation levels.
5. Stock Market Data – A table showing stock prices, opening/closing values, and daily volume.

Capelets

Capelets are short capes that cover the shoulders and upper arms, often used for fashion or warmth. They are popular in both modern and historical clothing, adding elegance and style to outfits.

Examples of capelets:

1. Bridal Capelets – Delicate lace or satin capelets worn over wedding dresses.
2. Winter Capelets – Wool or fur-trimmed capelets providing warmth in cold weather.
3. Victorian Capelets – Embroidered or velvet capelets inspired by 19th-century fashion.
4. Superhero Capelets – Mini capes worn as part of comic book or cosplay costumes.
5. Casual Capelets – Lightweight fabric capelets for layering over everyday outfits.

Though unrelated, both tabular data and capelets are structured in their own ways—one in a logical format for organization, the other in a fashion-oriented design.

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Ratio & Percentage-Based Data Interpretation (DI) Questions

Ratio and percentage-based Data Interpretation (DI) questions are crucial in competitive exams and analytical problem-solving. These questions assess one's ability to analyze numerical data efficiently.

Ratio-Based DI Questions

Ratio-based DI questions involve comparing quantities in proportion. Ratios express the relationship between two or more numbers, making it easier to understand distributions and comparisons.

Key Concepts in Ratio-Based DI:

- **Basic Ratio Formula: If two quantities are in the ratio of A:B, it means for every A units of the first quantity, there are B units of the second.**
- **Proportion: If A:B = C:D, then A × D = B × C.**
- **Conversion: Ratios can be converted into actual values using total quantity or additional given data.**

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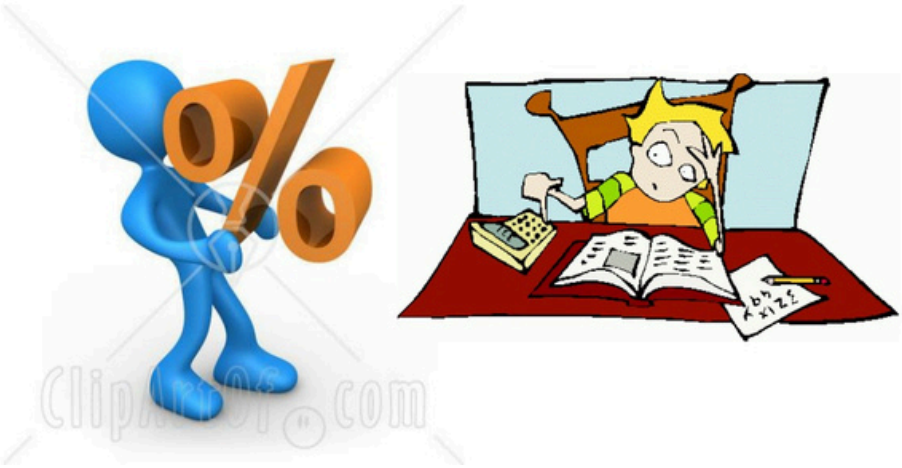
Ratio and Percentages



Examples of Ratio-Based DI Questions

Classroom Students Ratio

- The ratio of boys to girls in a classroom is 5:3. If the total number of students is 80, how many boys and girls are there?
- Solution: Boys = (5/8) × 80 = 50, Girls = (3/8) × 80 = 30.

Company Workforce Distribution

- A company's employees are in a ratio of 4:5:6 in departments A, B, and C. If there are 300 employees in total, how many are in each department?

Investment Ratio in a Business

- Two partners invest in a business in a 3:2 ratio. If the total investment is $50,000, how much did each invest?

Speed Ratio of Two Trains

- The speeds of two trains are in a 5:7 ratio. If the first train's speed is 50 km/h, find the second train's speed.

Age Ratio Problem

- The ages of A and B are in a ratio of 7:5. If A is 28 years old, find B's age.

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Percentage-Based DI Questions

Percentage-based DI questions involve calculating increases, decreases, comparisons, or compositions of values using percentage formulas.

- **Key Concepts in Percentage-Based DI:**
- **Basic Formula: Percentage = (Part/Whole) × 100**
- **Increase/Decrease: New Value = Old Value ± (Old Value × Percentage Change / 100)**
- **Comparative Percentage: Percentage difference = [(New Value - Old Value) / Old Value] × 100**

Examples of Percentage-Based DI Questions

Salary Increment Calculation

An employee's salary is $40,000. If it increases by 20%, what is the new salary?
Solution: New salary = 40,000 + (40,000 × 20/100) = $48,000.

- **Discount on a Product**
- **A product priced at $500 has a 15% discount. What is the final price?**
- **Population Growth**
- **Population Growth**
- **A town's population is 1,00,000. If it grows by 10% annually, what will be the population after one year?**
- **Exam Score Analysis**
  - **A student scored 80 marks in an exam. If the total marks were 100, what percentage did they score?**
- **Profit and Loss Calculation**
  - **A shopkeeper buys an item for $250 and sells it for $300. What is the percentage profit?**

These questions are essential for banking, finance, and competitive exams as they test logical reasoning and numerical aptitude.

6.Puzzles & Critical Thinking

Puzzles and critical thinking go hand in hand, as solving puzzles requires logical reasoning, analytical skills, and problem-solving abilities. These activities help enhance cognitive functions, improve decision-making, and develop a structured approach to tackling challenges.

Puzzles

Puzzles are problems or games that require logical thinking, pattern recognition, or creative problem-solving to reach a solution. They come in various forms, such as word puzzles, number puzzles, logic puzzles, and visual puzzles.

Key Benefits of Solving Puzzles:

- **Enhances memory and cognitive abilities.**
- **Improves problem-solving skills.**
- **Develops patience and attention to detail.**
- **Encourages out-of-the-box thinking.**

Examples of Puzzles:

1. Sudoku
   - **A number puzzle played on a 9×9 grid where each row, column, and 3×3 subgrid must contain numbers 1 to 9 without repetition.**
2. Crossword Puzzle
   - **A word puzzle where clues are given, and words must be filled into an intersecting grid.**
3. Jigsaw Puzzle
   - **A visual puzzle where pieces must be arranged to form a complete picture.**
4. Riddles
   - **Example: I speak without a mouth and hear without ears. I have no body, but I come alive with the wind. What am I? (Answer: An Echo)**
5. Logic Grid Puzzle
   - **A problem where given clues help determine relationships between different subjects. Example: "Three friends ordered different drinks. Find out who ordered what based on given conditions."**

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Critical Thinking

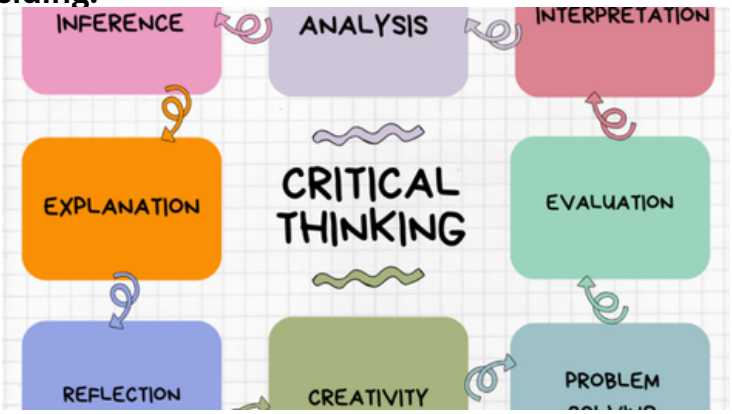
Critical thinking is the ability to analyze information objectively, identify patterns, and make reasoned decisions. It involves logical reasoning, questioning assumptions, and evaluating evidence.

Key Aspects of Critical Thinking:

- **Analysis – Breaking down information into parts.**
- **Inference – Drawing logical conclusions from given facts.**
- **Evaluation – Assessing the credibility of information.**
- **Problem-Solving – Finding solutions based on reasoning.**

Examples of Critical Thinking in Action:

- **Detective Problem-Solving**
  - **A detective finds a body in a locked room with no signs of forced entry. By analyzing the clues, he deduces that the killer was inside all along and staged it as a suicide.**
- **Business Decision-Making**
  - **A company must choose between two investment options. By evaluating market trends and financial data, they make an informed decision.**
- **Mathematical Problem-Solving**
  - **A farmer has a limited budget to buy animals. Given the cost of each type of animal, he must determine how many of each he can buy within his budget.**
- **Scientific Hypothesis Testing**
  - **A scientist observes an unusual chemical reaction. Instead of assuming a cause, they test multiple hypotheses and evaluate the results.**
- **Everyday Decision-Making**
  - **You have two job offers: one with a higher salary but long hours, another with lower pay but better work-life balance. Using critical thinking, you weigh the pros and cons before deciding.**



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Sudoku & Non-Verbal Reasoning Puzzles

Sudoku

Sudoku is a logic-based number puzzle played on a 9×9 grid, divided into nine 3×3 sub grids. The objective is to fill the grid so that each row, column, and 3×3 box contains the numbers 1 to 9, without repetition.

Key Rules of Sudoku:

1. **Each row must contain numbers 1 to 9 without repetition.**
2. **Each column must contain numbers 1 to 9 without repetition.**
3. **Each 3×3 sub grid must contain numbers 1 to 9 without repetition.**

5 Solved Examples of Sudoku (Easy Level)

Example 1: Missing Number in a Row

- **Given: A row has numbers 1, 2, _, 4, 5, 6, 7, 8, 9.**
- **Solution: The missing number is 3, as it is the only number missing from 1-9.**

Example 2: Missing Number in a Column

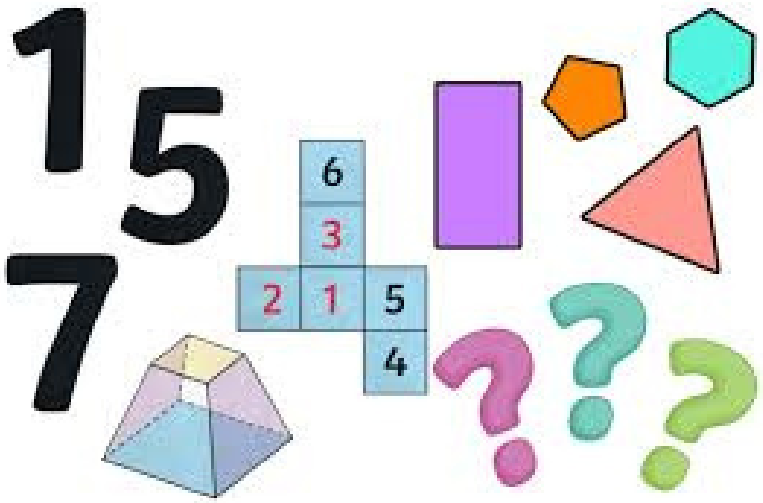
- **Given: A column has 5, _, 3, 6, 7, 2, 9, 8, 1.**
- **Solution: The missing number is 4, as it is the only missing digit from 1-9.**

Example 3: Missing Number in a 3×3 Box

- **Given: A 3×3 box contains 1, 2, 3, 4, 5, 6, 8, 9, _.**
- **Solution: The missing number is 7, since each box must contain 1-9.**

Example 4: Using Cross-Checking

- **Given: A row has _, 2, 3, 4, _, 6, _, 8, 9, and a column has 1, _, _, 4, 5, _, 7, _, 9.**
- **Solution: By checking which numbers are missing in both, we can logically place the missing numbers.**



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Non-Verbal Reasoning Puzzles

Non-verbal reasoning puzzles involve identifying patterns, sequences, and logical relationships between shapes, figures, or symbols. These puzzles test spatial awareness, pattern recognition, and logical thinking.

Types of Non-Verbal Reasoning Puzzles:

1. **Series Completion – Identifying the next shape in a sequence.**
2. **Odd One Out – Finding the figure that does not belong.**
3. **Mirror Image & Water Image – Identifying reflections of given figures.**
4. **Paper Folding & Cutting – Predicting the outcome after folding and cutting.**
5. **Figure Matrix & Analogies – Completing a pattern-based puzzle grid.**

5 Solved Examples of Non-Verbal Reasoning Puzzles

Example 1: Series Completion

- **Given: 🔺 → 🔷 → 🔺 → 🔷 → ?**
- **Solution: The missing shape is 🔺, as the pattern alternates between triangle and diamond.**

Example 2: Odd One Out

- **Given: ⭕, ⭕, ⭕, 🔲**
- **Solution: The odd one out is 🔲 (square) because all others are circles.**

Example 3: Mirror Image

- **Given: "L" shape → Find its mirror reflection.**
- **Solution: The correct answer is a flipped "L" facing the opposite direction.**

Example 4: Paper Folding & Cutting

- **Given: A square sheet is folded twice and a small hole is cut. Predict the unfolded pattern.**
- **Solution: The final shape will have symmetrically placed holes based on the number of folds.**

Example 5: Figure Matrix

- **Given: A 2×2 grid with three completed patterns and one missing pattern.**
- **Solution: Identify the transformation in the first three and apply it to find the missing pattern.**

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Logical Pattern Recognition

Logical pattern recognition is the ability to identify, analyze, and predict sequences, trends, or structures in data, symbols, numbers, or shapes. It plays a crucial role in problem-solving, reasoning, and decision-making. Patterns can be numerical, alphabetical, visual, or symbolic, and recognizing them helps in critical thinking, mathematical reasoning, and artificial intelligence development.

Types of Logical Patterns:

1. Number Patterns – Recognizing sequences in numbers.
2. Alphabet Patterns – Identifying patterns in letter arrangements.
3. Visual/Shape Patterns – Detecting transformations in shapes.
4. Behavioral Patterns – Analyzing trends in data or events.
5. Coding-Decoding Patterns – Understanding hidden relationships between symbols.

5 Examples of Logical Pattern Recognition

Example 1: Number Series

- Given: 2, 4, 8, 16, ?
- Solution: The pattern follows ×2. The missing number is 32.

Example 2: Alphabet Series

- Given: A, C, E, G, ?
- Solution: The pattern skips one letter each time (A, (B), C, (D), E...). The missing letter is I.

Example 3: Shape Rotation

- Given: A triangle pointing up, right, down, ?
- Solution: The pattern follows 90° clockwise rotation. The missing shape is a triangle pointing left.

Example 4: Coding-Decoding

- Given: If CAT = 3120, what is DOG?
- Solution: Assign A=1, B=2... Z=26. C=3, A=1, T=20 → 3120. Similarly, D=4, O=15, G=7 → 4157.

Example 5: Missing Figure

- Given: A sequence of squares with increasing diagonal lines, predict the next.
- Solution: The pattern adds one more diagonal line each time, so the missing figure should have four diagonal lines.

Pattern recognition enhances problem-solving skills, AI development, and logical reasoning abilities, making it essential in various fields like mathematics, computing, and cognitive sciences.

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Brain Teasers

Brain teasers are puzzles or riddles designed to test logic, problem-solving ability, and lateral thinking. They often require thinking outside the box and applying creativity rather than straightforward calculations. These puzzles enhance critical thinking, memory, and cognitive flexibility, making them popular in educational settings, job interviews, and IQ tests.

Types of Brain Teasers:

1. **Logical Puzzles – Require deductive reasoning.**
2. **Mathematical Teasers – Involve number-based problem-solving.**
3. **Riddles – Use wordplay and indirect clues.**
4. **Visual Puzzles – Focus on recognizing patterns or optical illusions.**
5. **Lateral Thinking Puzzles – Require unconventional reasoning.**

5 Brain Teasers with Solutions

1. The Missing Dollar Puzzle (Logical Puzzle)

- **Three friends split a $30 hotel bill, each paying $10. Later, the manager finds the bill was actually $25 and gives $5 back. The bellboy keeps $2 and gives $1 to each friend. Now, each friend has paid $9 ($27 in total), and the bellboy has $2. Where is the missing $1?**
- **Solution: There is no missing dollar. The trick lies in misleading addition. The $27 includes the bellboy's $2, so the total is still $30.**

2. The Classic River Crossing Puzzle (Logical Thinking)

- **A farmer must take a wolf, a goat, and a cabbage across a river. The boat can only carry one item at a time, and the wolf cannot be left alone with the goat, nor the goat with the cabbage.**
- **Solution:**
  a. **Take the goat across.**
  b. **Return alone and take the wolf across.**
  c. **Bring the goat back.**
  d. **Take the cabbage across.**
  e. **Finally, take the goat across.**

3. The Two Rope Problem (Mathematical + Logical Thinking)

- **You have two ropes, each burning for exactly 60 minutes, but they burn irregularly. How do you measure exactly 45 minutes?**
- **Solution:**
  a. **Light one rope at both ends and the other at one end.**
  b. **When the first rope completely burns (30 min), light the other end of the second**

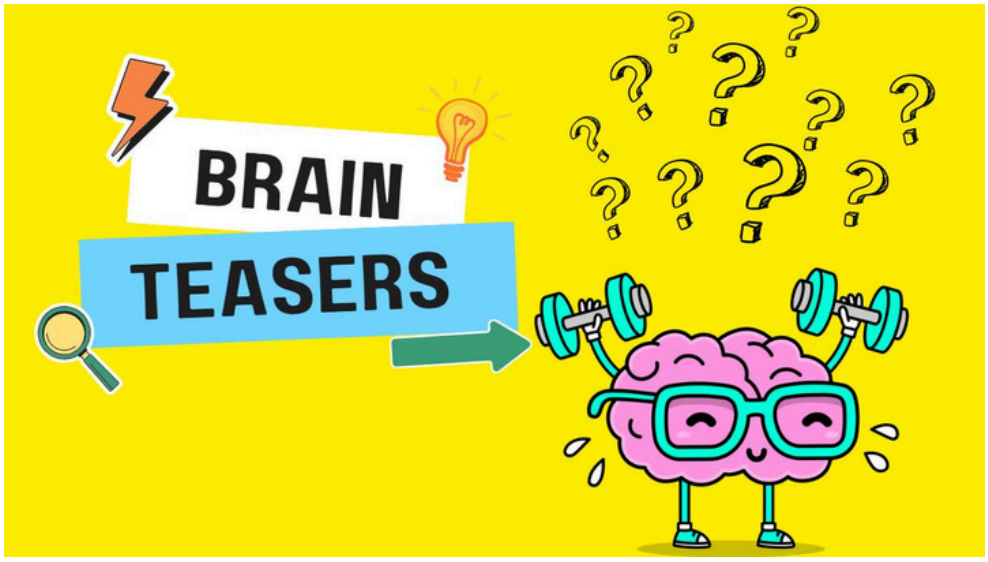
- The remaining rope burns in 15 minutes. Total: 45 minutes.

4. The Man in the Elevator (Lateral Thinking Puzzle)

- A man lives on the 10th floor. He takes the elevator to the ground floor daily but returns home by taking the elevator to the 7th floor and then walking the rest of the way up. Why?
- Solution: He is short and cannot reach the button for the 10th floor, so he presses the highest button he can (7th) and walks up.

5. The Stolen Money Puzzle (Riddle)

- A shopkeeper has a $100 bill. A customer buys an item worth $70 and pays with a fake bill. The shopkeeper unknowingly exchanges the fake bill for a real one from another customer and gives $30 change. How much did the shopkeeper lose?
- Solution: He lost $70. The fake bill is worthless, so he loses the value of the goods sold.



Conclusion

Brain teasers sharpen the mind by challenging conventional thinking and improving cognitive abilities. They are used in education, IQ tests, and problem-solving exercises across various fields. Regularly solving brain teasers enhances creativity, logic, and decision-making skills.

7.Technical Aptitude (for Coding Interviews)

Introduction

Technical aptitude refers to the ability to understand and apply programming concepts, data structures, algorithms, problem-solving techniques, and system design principles in coding interviews. It is essential for software engineers, developers, and computer science graduates preparing for technical job interviews at companies like Google, Amazon, Microsoft, and startups.

A strong technical aptitude involves:

Programming Skills – Writing clean, efficient, and bug-free code.

Data Structures & Algorithms (DSA) – Knowledge of arrays, linked lists, stacks, queues, trees, graphs, sorting, and searching.

Problem-Solving Ability – Logical reasoning, breaking problems into smaller parts, and optimizing solutions.

System Design – Designing scalable and efficient software architectures.

Debugging & Optimization – Identifying and fixing bugs and improving code performance.

Key Topics in Technical Aptitude

1. Data Structures & Algorithms (DSA)

Efficient data structures and algorithms help in solving problems optimally.

✅ Example: Find the first non-repeating character in a string

💡 Solution (Using HashMap in Python)

```
from collections import Counter

def first_non_repeating(s):
    count = Counter(s)
    for char in s:
        if count[char] == 1:
            return char
    return Noneprint(first_non_repeating("aabbccdeff"))  # Output: d
```

🔹 Concept Used: Hashing (O(n) time complexity).

List Manipulation (O(n) time complexity).

2. Problem-Solving & Logical Thinking

Breaking problems into steps and using brute force, greedy, or dynamic programming approaches.

✅ Example: Find the missing number in an array of 1 to N numbers

💡 Solution (Using Sum Formula in Python)

```
def find_missing_number(arr, n):
 total = n * (n + 1) // 2return total - sum(arr)

print(find_missing_number([1, 2, 3, 5], 5)) # Output: 4
```

🔹 Concept Used: Mathematical Formula (O(n) time complexity).

3. Time & Space Complexity Analysis

Understanding Big O notation helps in evaluating the efficiency of code.

✅ Example: What is the time complexity of binary search?

💡 Answer: O(log N) because the search space is divided by 2 in each step.

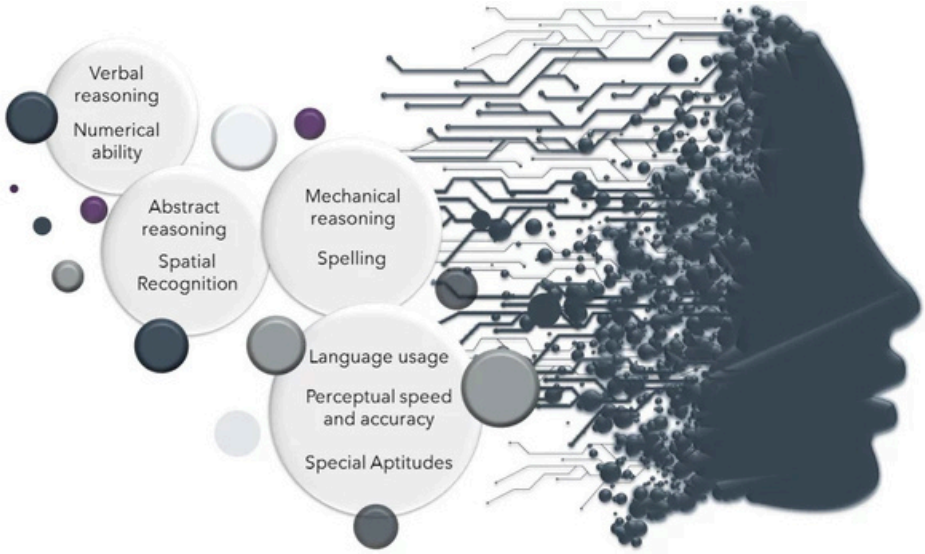
4. System Design & Scalability

Designing large-scale systems for high availability, fault tolerance, and efficiency.

✅ Example: How would you design a URL shortener like Bitly?

💡 Key Concepts:

- Database: Use NoSQL (e.g., Redis) for quick lookups.
- Hashing: Convert long URLs to short keys using Base62 encoding.
- Load Balancing: Distribute traffic across multiple servers.



5. Coding Challenges & Competitive Programming

Practicing on LeetCode, CodeChef, HackerRank, and Codeforces improves problem-solving speed.

✅ Example: Reverse a Linked List

💡 Solution (Using Iteration in Python)

```
class ListNode:
 def __init__(self, val=0, next=None):
 self.val = val
 self.next = nextdef reverse_list(head):
 prev, curr = None, head
 while curr:
 temp = curr.next
 curr.next = prev
 prev = curr
 curr = temp
 return prev
```

🔹 Concept Used: Linked List Manipulation (O(n) time complexity).

Conclusion

Technical aptitude is critical for acing coding interviews. A well-rounded candidate must master coding, problem-solving, system design, and optimization techniques. Consistently practicing on real-world problems enhances logical thinking and coding efficiency, leading to better performance in interviews and real-world projects.

7.1 Mathematical & Logical Programming

Mathematical & Logical Programming

Introduction

Mathematical and logical programming focuses on solving computational problems using mathematical concepts, logical reasoning, and efficient algorithms. It is an essential skill for coding interviews, competitive programming, and real-world software development.

Mathematical and logical programming includes:

- **Mathematical reasoning – Using formulas, number theory, and optimization techniques.**
- **Logical problem-solving – Applying structured thinking, condition-based logic, and decision-making.**
- **Algorithmic efficiency – Finding optimal solutions using techniques like recursion, dynamic programming, and divide-and-conquer.**

These concepts are widely used in game development, artificial intelligence, cryptography, and data analysis.

Key Areas of Mathematical & Logical Programming

1. Number Theory & Arithmetic Algorithms

- **Prime numbers, GCD, LCM, factorials, Fibonacci sequences, permutations, and combinations.**
- **Example: Finding GCD (Greatest Common Divisor) using the Euclidean algorithm.**

2. Logical & Boolean Operations

- **Bitwise operations, conditional statements, truth tables, and logical puzzles.**
- **Example: Checking if a number is a power of 2 using bitwise AND.**

3. Pattern Recognition & Series

- **Arithmetic & geometric progressions, matrix operations, Pascal's Triangle, etc.**
- **Example: Finding the nth Fibonacci number using matrix exponentiation.**

4. Probability & Combinatorics

- **Used in AI, machine learning, and cryptography.**
- **Example: Finding the number of ways to arrange objects in a sequence.**

5. Optimization & Approximation Algorithms

- **Dynamic programming, greedy algorithms, and mathematical modeling for efficiency.**
- **Example: The Knapsack Problem, where we maximize the value of selected items within a weight limit.**

Example 1: Finding the GCD of Two Numbers (Mathematical Programming)

💡 **Problem: Find the GCD of two numbers a and b using the Euclidean algorithm.**

Solution (Python Implementation)

```
def gcd(a, b):
    while b:
        a, b = b, a % b
    return a

print(gcd(48, 18))  # Output: 6
```

🔹 **Explanation:**

1. **The function uses modulo division to repeatedly replace the larger number with the remainder.**
2. **When the remainder becomes 0, the last non-zero remainder is the GCD.**
3. **Time Complexity: O(log(min(a, b))), making it much faster than brute force**

.

Example 2: Checking if a Number is a Power of 2 (Logical Programming)

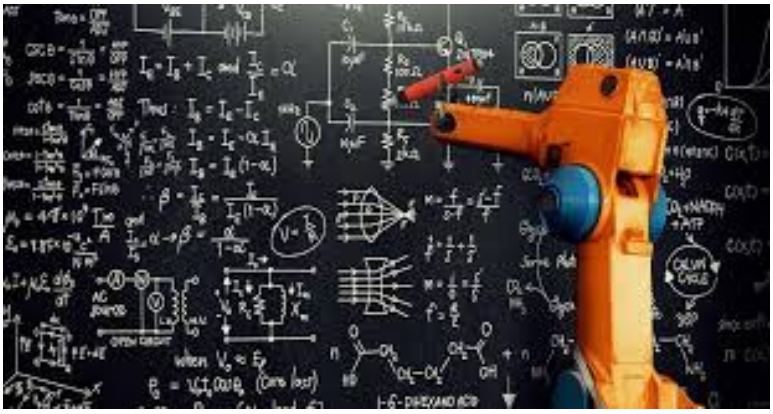
💡 **Problem: Write a function to check if a given number is a power of 2.**

Solution (Python Implementation Using Bitwise Operations)

```
def is_power_of_two(n):
        return n > 0 and (n & (n - 1)) == 0print(is_power_of_two(16))  # Output: Trueprint(is_power_of_two(18))  # Output: False
```

🔹 **Explanation:**

1. **A power of 2 has only one bit set in binary (e.g., 16 = 10000 in binary).**
2. **n & (n - 1) == 0 works because:**
   - **16 (10000) & 15 (01111) = 00000 → True**
   - **18 (10010) & 17 (10001) = 10000 → False**
3. **Time Complexity: O(1) (Constant time).**



Number Theory in Coding (GCD, LCM, Prime Numbers)

Introduction

Number theory is a branch of mathematics that deals with properties and relationships of numbers, particularly integers. In coding, number theory concepts are used in cryptography, competitive programming, optimization algorithms, and mathematical computations.

The three most important number theory concepts in coding are:

1. **GCD (Greatest Common Divisor) – The largest number that divides two or more integers without a remainder.**
2. **LCM (Least Common Multiple) – The smallest number that is a multiple of two or more integers.**
3. **Prime Numbers – Numbers greater than 1 that have exactly two factors: 1 and themselves.**

Understanding these concepts helps in solving problems efficiently using efficient algorithms like Euclidean algorithm, Sieve of Eratosthenes, and prime factorization.

1. Greatest Common Divisor (GCD)

The GCD of two numbers is the largest number that divides both without leaving a remainder.

Efficient Algorithm: Euclidean Algorithm

The Euclidean algorithm states that:

GCD(a,b)=GCD(b,amod b)GCD(a, b) = GCD(b, a \mod b)GCD(a,b)=GCD(b,amodb)

Repeat until b becomes 0. The remaining value of a is the GCD.

Example 1: Finding GCD Using Euclidean Algorithm

💡 **Problem: Find the GCD of 48 and 18.**

✅ **Solution (Python Implementation)**

```
def gcd(a, b):
    while b:
        a, b = b, a % b
    return a

print(gcd(48, 18))  # Output: 6

        return Falsefor i in range(2, int(n**0.5) + 1):
        if n % i == 0:
            return Falsereturn Trueprint(is_prime(29))  # Output: True
```

🔹 Explanation:

- 48 % 18 = 12 → Compute GCD(18, 12)
- 18 % 12 = 6 → Compute GCD(12, 6)
- 12 % 6 = 0 → GCD is 6

Example 2: GCD of Multiple Numbers

💡 Problem: Find the GCD of 48, 18, and 30.

✅ Solution (Using Python's math.gcd)

```
import math
from functools import reduce

def gcd_multiple(numbers):
 return reduce(math.gcd, numbers)

print(gcd_multiple([48, 18, 30])) # Output: 6
```

🔹 Explanation: The reduce() function applies the gcd() function iteratively to multiple numbers.

2. Least Common Multiple (LCM)

The LCM of two numbers is the smallest number that is a multiple of both.

Efficient Formula for LCM

LCM(a,b)= ∣ a×b ∣ GCD(a,b)LCM(a, b) = \frac{|a \times b|}{GCD(a, b)}LCM(a,b)=GCD(a,b) ∣ a×b ∣

This ensures efficiency by leveraging the GCD.

Example 1: Finding LCM Using GCD

💡 Problem: Find the LCM of 12 and 15.

✅ Solution (Python Implementation)

```
python
Copy
def lcm(a, b):
 return abs(a * b) // gcd(a, b)

print(lcm(12, 15)) # Output: 60
```

Example 2: LCM of Multiple Numbers

💡 **Problem: Find the LCM of 4, 5, and 6.**

✅ **Solution (Using Python's math.gcd)**

```
def lcm_multiple(numbers):
    return reduce(lambda x, y: lcm(x, y), numbers)

print(lcm_multiple([4, 5, 6]))  # Output: 60
```

🔹 **Explanation: Uses reduce() to iteratively compute the LCM of multiple numbers.**

3. Prime Numbers

A prime number is a number greater than 1 that has exactly two factors: 1 and itself.

Efficient Algorithm: Sieve of Eratosthenes

For finding all prime numbers up to N, the Sieve of Eratosthenes is an efficient algorithm with O(N log log N) complexity.

Example 1: Checking if a Number is Prime

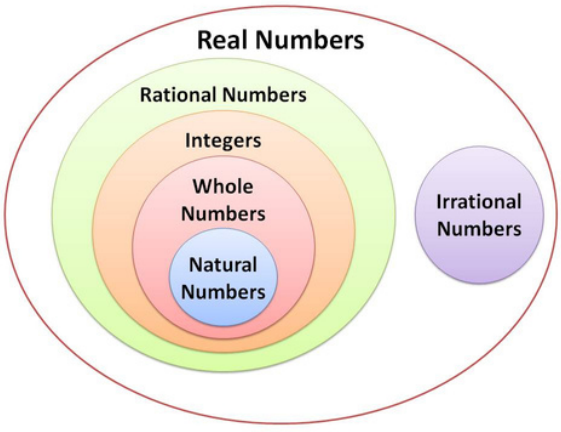
💡 **Problem: Check if 29 is prime.**

✅ **Solution (Python Implementation)**

```
def is_prime(n):
    if n < 2:
        return Falsefor i in range(2, int(n**0.5) + 1):
        if n % i == 0:
            return Falsereturn Trueprint(is_prime(29))  # Output: True
```

🔹 **Explanation:**

- **Only checks divisibility up to √n for efficiency.**
- **29 has no divisors except 1 and itself, so it is prime.**



Example 2: Finding All Prime Numbers Up to N

💡 **Problem: Find all prime numbers up to 30.**

✅ **Solution (Using Sieve of Eratosthenes)**

```
def sieve_of_eratosthenes(n):
    primes = [True] * (n + 1)
    p = 2while p * p <= n:
        if primes[p]:
            for i in range(p * p, n + 1, p):
                primes[i] = False
        p += 1return [i for i in range(2, n + 1) if primes[i]]

print(sieve_of_eratosthenes(30))  # Output: [2, 3, 5, 7, 11, 13, 17, 19, 23, 29]
```

🔹 **Explanation:**

1. **Mark all numbers as prime initially.**
2. **Eliminate multiples of each prime starting from 2.**
3. **Remaining numbers are prime.**

Conclusion

Number theory is essential for coding challenges and real-world applications like cryptography, AI, and data science. Efficient algorithms like Euclidean GCD, LCM using GCD, and Sieve of Eratosthenes optimize problem-solving and improve runtime efficiency.

Recursion & Backtracking

Introduction

Recursion and Backtracking are powerful problem-solving techniques widely used in coding interviews, competitive programming, and real-world applications like game development, AI, and optimization problems.

Recursion

Recursion is a technique where a function calls itself to solve a smaller subproblem of the original problem. It has two key parts:

1. **Base Case – The stopping condition that prevents infinite recursion.**
2. **Recursive Case – The function calls itself with a reduced problem size.**

Backtracking

Backtracking is an extension of recursion used to explore all possible solutions in constraint-based problems. It follows the principle of:

1. **Try a solution**
2. **Check if it is valid**
3. **If valid, continue; if not, backtrack and try another option**

Backtracking is useful for solving mazes, puzzles, permutations, combinations, and constraint satisfaction problems like Sudoku and N-Queens.

Example 1: Factorial Calculation (Recursion)

💡 **Problem: Find the factorial of a number n using recursion.**

✅ **Solution (Python Implementation)**

```
def factorial(n):
    if n == 0 or n == 1:  # Base casereturn 1return n * factorial(n - 1)  # Recursive caseprint(factorial(5))  # Output: 120
```

🔹 **Explanation:**

1. **Base Case: factorial(0) = 1, factorial(1) = 1.**
2. **Recursive Case: factorial(n) = n * factorial(n - 1).**
3. **Steps:**
   - **factorial(5) = 5 * factorial(4)**
   - **factorial(4) = 4 * factorial(3)**
   - **factorial(3) = 3 * factorial(2)**
   - **factorial(2) = 2 * factorial(1)**
   - **factorial(1) = 1 (Base Case)**

Time Complexity: O(n) (linear recursion).

Example 2: Solving N-Queens Problem (Backtracking)

💡 **Problem: Place N queens on an N × N chessboard so that no two queens attack each other.**

✅ **Solution (Python Implementation)**

```
def is_safe(board, row, col, n):
    for i in range(row):
        if board[i] == col or abs(board[i] - col) == abs(i - row):
            return Falsereturn Truedef solve_n_queens(board, row, n):
    if row == n:
        print(board)
        returnfor col in range(n):
        if is_safe(board, row, col, n):
            board[row] = col
            solve_n_queens(board, row + 1, n)
            board[row] = -1  # Backtrackdef n_queens(n):
    board = [-1] * n
    solve_n_queens(board, 0, n)

n_queens(4)
```

🔹 **Explanation:**

1. **Recursive Placement: Place queens one by one, checking if it is safe.**
2. **Backtrack if Conflict: If a queen placement leads to conflict, remove it and try another position.**
3. **Print solutions: Outputs valid placements of queens on the board.**

🔹 **For N = 4, valid solutions are:**

[1, 3, 0, 2]
[2, 0, 3, 1]

Time Complexity: O(N!) (exponential growth due to permutations).

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String Manipulation Techniques

Introduction

String manipulation is a fundamental concept in programming that involves modifying, analyzing, or transforming strings efficiently. Since strings are immutable in languages like Python, Java, and JavaScript, optimizing operations like concatenation, searching, and pattern matching is crucial for performance.

Some common string manipulation techniques include:

1. **Concatenation & Formatting – Merging multiple strings.**
2. **Substring Extraction – Extracting specific portions of a string.**
3. **Reversal & Palindrome Check – Checking if a string reads the same forward and backward.**
4. **Searching & Pattern Matching – Finding substrings using algorithms like KMP and Rabin-Karp.**
5. **Character Frequency & Anagram Checking – Useful for text processing and cryptography.**

Example 1: Reversing a String

💡 **Problem: Given a string, reverse it without using built-in functions.**

✅ **Solution (Python Implementation)**

```
def reverse_string(s):
   return s[::-1]  # Slicing techniqueprint(reverse_string("hello"))  # Output: "olleh"
```

🔹 **Explanation:**

- **s[::-1] creates a new string by iterating backward over the original string.**
- **Time Complexity: O(n) (traverses the string once).**

Example 2: Checking if a String is a Palindrome

💡 **Problem: Check if a given string reads the same forward and backward.**

✅ **Solution (Python Implementation)**

```
def is_palindrome(s):
                return s == s[::-1]      # Compare original and reversed stringprint(is_palindrome("madam"))  # Output: Trueprint(is_palindrome("hello"))  # Output: False
```

🔹 **Explanation:**

- **A palindrome is a word that remains the same when reversed ("madam", "racecar").**
- **We compare the original and reversed string for equality.**
- **Time Complexity: O(n).**

Example 3: Checking if Two Strings are Anagrams

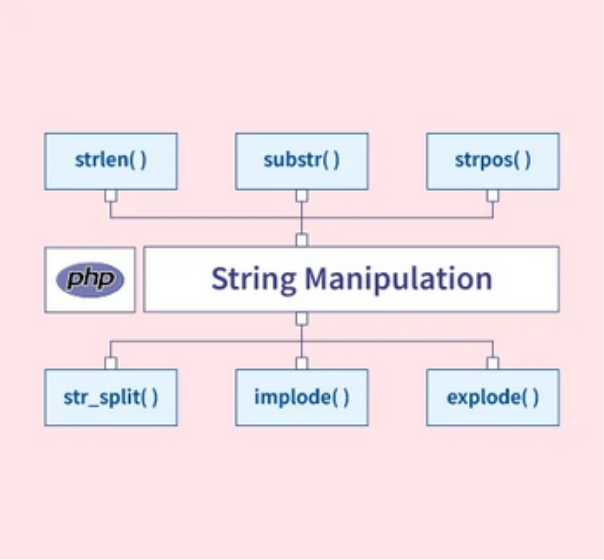
💡 **Problem: Two strings are anagrams if they contain the same characters but in a different order.**

✅ **Solution (Python Implementation)**

```
def is_anagram(s1, s2):
    return sorted(s1) == sorted(s2) # Sort both strings and compareprint(is_anagram("listen", "silent")) # Output: Trueprint(is_anagram("hello", "world")) # Output: False
```

🔹 **Explanation:**

- **Sorting rearranges both strings in alphabetical order, allowing for direct comparison.**
- **Time Complexity: O(n log n) due to sorting.**



Conclusion

String manipulation is essential for text processing, data parsing, and problem-solving in competitive programming. Mastering techniques like reversal, palindrome checking, and anagram validation improves coding efficiency and prepares developers for real-world challenges.

7.2 Algorithms & Data Structures

Introduction

Algorithms and Data Structures are the foundation of computer science and software development. An algorithm is a step-by-step procedure to solve a problem, while a data structure organizes and stores data efficiently.

Efficient use of algorithms and data structures optimizes performance, reduces computational time, and improves problem-solving skills, which are essential for coding interviews, competitive programming, and software engineering.

Types of Data Structures

1. Linear Data Structures

- **Arrays – Store elements in contiguous memory locations.**
- **Linked Lists – A sequence of nodes where each node points to the next.**
- **Stacks – Follows LIFO (Last In, First Out) principle.**
- **Queues – Follows FIFO (First In, First Out) principle.**

2. Non-Linear Data Structures

- **Trees – Hierarchical structures used in searching, sorting, and parsing.**
- **Graphs – Nodes (vertices) connected by edges, used in networks and pathfinding.**

Types of Algorithms

1. Sorting Algorithms

- **Quick Sort – Uses divide-and-conquer for fast sorting (O(n log n)).**
- **Merge Sort – Recursively splits and merges arrays (O(n log n)).**

2. Searching Algorithms

- **Binary Search – Searches in a sorted array in O(log n) time.**
- **Linear Search – Checks each element one by one (O(n)).**

3. Graph Algorithms

- **Dijkstra's Algorithm – Finds the shortest path in a graph.**
- **Depth-First Search (DFS) & Breadth-First Search (BFS) – Used for traversal.**

Example 1: Binary Search (Efficient Searching Algorithm)

💡 **Problem: Find an element in a sorted array using Binary Search.**

✅ **Solution (Python Implementation)**

```
def binary_search(arr, target):
  left, right = 0, len(arr) - 1while left <= right:
    mid = left + (right - left) // 2if arr[mid] == target:
      return mid
    elif arr[mid] < target:
      left = mid + 1else:
      right = mid - 1return -1

arr = [10, 20, 30, 40, 50]
print(binary_search(arr, 30))  # Output: 2
```

🔹 **Explanation:**

- Uses divide-and-conquer by checking the middle element.
- Reduces search space by half in each step.
- Time Complexity: O(log n).

Example 2: Implementing a Stack (Using Python List)

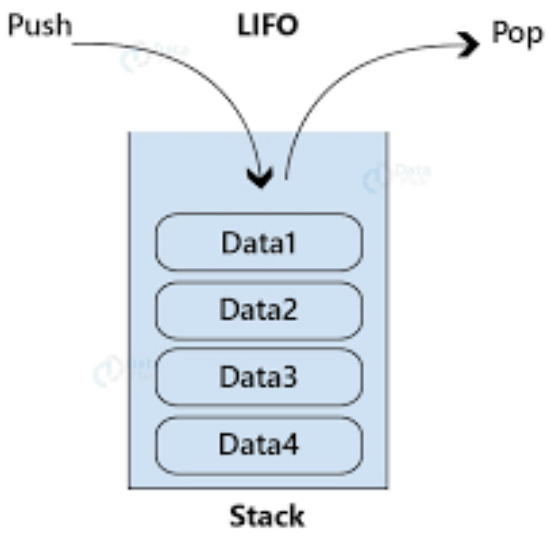
💡 **Problem: Implement a stack using a Python list.**

✅ **Solution (Python Implementation)**

```
class Stack:
  def __init__(self):
    self.stack = []

  def push(self, item):
    self.stack.append(item)

  def pop(self):
    if not self.is_empty():
      return self.stack.pop()
    return Nonedef is_empty(self):
    return len(self.stack) == 0
```



```
s = Stack()
s.push(10)
s.push(20)
print(s.pop()) # Output: 20
```

🔹 Explanation:

- Push: Adds an element to the top.
- Pop: Removes the top element (LIFO order).
- Time Complexity: O(1).

Example 3: BFS Traversal in a Graph

💡 Problem: Traverse a graph using Breadth-First Search (BFS).

✅ Solution (Python Implementation Using Queue)

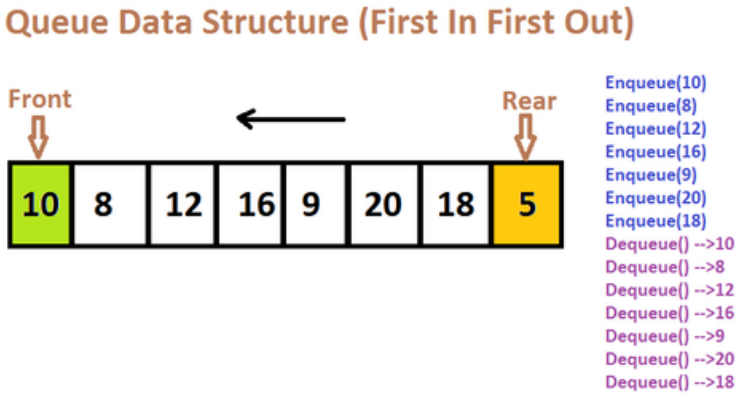
```
from collections import deque

def bfs(graph, start):
    visited = set()
    queue = deque([start])

    while queue:
        node = queue.popleft()
        if node not in visited:
            print(node, end=" ")
            visited.add(node)
            queue.extend(graph[node])

graph = {
    'A': ['B', 'C'],
    'B': ['A', 'D', 'E'],
    'C': ['A', 'F'],
    'D': ['B'],
    'E': ['B', 'F'],
    'F': ['C', 'E']
}

bfs(graph, 'A')  # Output: A B C D E F
```



🔹 Explanation:

- Uses a queue (FIFO) to visit nodes level by level.
- Time Complexity: O(V + E) (Vertices + Edges).

Sorting & Searching Algorithms

Introduction

Sorting and searching algorithms are fundamental in computer science and are widely used in databases, data analysis, and optimization problems. Sorting arranges elements in a specific order (ascending or descending), while searching finds an element in a dataset efficiently.

Sorting Algorithms

Sorting algorithms are classified based on time complexity, space complexity, and stability.

1. Quick Sort (Efficient Sorting - O(n log n))

💡 **Problem: Sort an array using Quick Sort.**

✅ **Solution (Python Implementation)**

```
def quick_sort(arr):
    if len(arr) <= 1:
        return arr
    pivot = arr[len(arr) // 2]
    left = [x for x in arr if x < pivot]
    middle = [x for x in arr if x == pivot]
    right = [x for x in arr if x > pivot]
    return quick_sort(left) + middle + quick_sort(right)

print(quick_sort([3, 6, 8, 10, 1, 2, 1]))
# Output: [1, 1, 2, 3, 6, 8, 10]
```

🔹 **Explanation:**

- **Uses a pivot to divide the array into smaller subarrays.**
- **Recursively sorts them.**
- **Time Complexity: O(n log n) in average case.**

Searching Algorithms

Searching algorithms help locate elements efficiently in large datasets.

2. Binary Search (Efficient Searching - O(log n))

💡 Problem: Find an element in a sorted array using Binary Search.

✅ Solution (Python Implementation)

```
def binary_search(arr, target):
   left, right = 0, len(arr) - 1while left <= right:
      mid = left + (right - left) // 2if arr[mid] == target:
         return mid
      elif arr[mid] < target:
         left = mid + 1else:
         right = mid - 1return -1

arr = [1, 2, 3, 4, 5, 6]
print(binary_search(arr, 4))  # Output: 3
```

🔹 Explanation:

- Checks the middle element and reduces search space.
- Time Complexity: O(log n).

Arrays, Linked Lists, Stacks & Queues

Introduction

Data structures help store and manage data efficiently. Arrays, Linked Lists, Stacks, and Queues are fundamental data structures used for different purposes in programming and software development. Understanding them is crucial for solving problems related to memory management, processing sequences, and optimizing performance.

1. Arrays

An array is a fixed-size, contiguous memory data structure that stores elements of the same data type.

Example: Finding the Maximum Element in an Array

💡 Problem: Find the maximum element in an array.

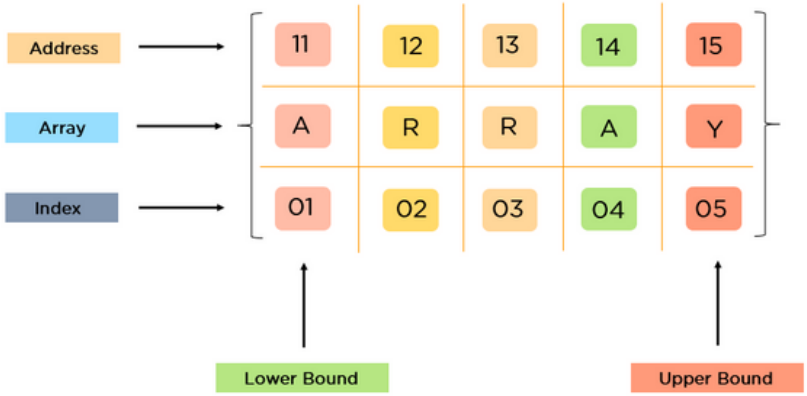
✅ Solution (Python Implementation)

python

Copy

```
def find_max(arr):
    max_val = arr[0]
    for num in arr:
        if num > max_val:
            max_val = num
    return max_val

arr = [10, 5, 20, 8, 15]
print(find_max(arr))  # Output: 20
```



🔹 Key Points:

- Access time: O(1) (Direct access using index).
- Insertion/Deletion: O(n) (Shifting required).
- Best for: Fixed-size data storage.

Example 2: Inserting an Element in an Array

Problem Statement:
Insert an element at a given position in an array.
Solution:

```
def insert_element(arr, element, pos):
   arr.insert(pos, element)  # Using built-in insert functionreturn arr

arr = [10, 20, 30, 40, 50]
new_element = 25
position = 2print("Array after insertion:", insert_element(arr, new_element, position))
```

Output:
pgsql
Copy
Array after insertion: [10, 20, 25, 30, 40, 50]

Linked Lists

Introduction
A linked list is a dynamic data structure in which elements (nodes) are linked using pointers. Each node consists of two parts:

1. **Data – The actual value.**
2. **Next – A pointer/reference to the next node.**

Types of Linked Lists

1. **Singly Linked List – Each node points to the next node.**
2. **Doubly Linked List – Each node has two pointers (next and previous).**
3. **Circular Linked List – The last node points back to the first node.**

Advantages of Linked Lists

1. **Dynamic Size – No need to define the size in advance.**
2. **Efficient Insertions/Deletions – Adding or removing elements does not require shifting (O(1) at the beginning, O(n) at the end).**

Example 1: Implementing a Singly Linked List

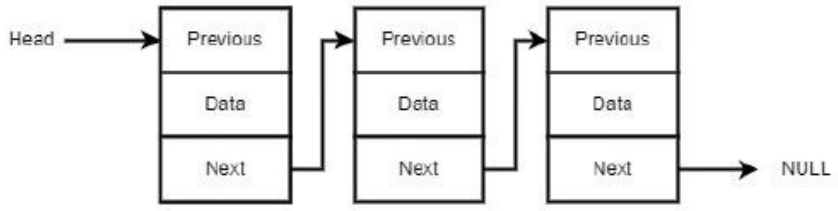
Problem Statement:
Create a singly linked list and traverse it.
Solution:

```
class Node:
 def __init__(self, data):
 self.data = data
 self.next = Noneclass LinkedList:
 def __init__(self):
 self.head = Nonedef append(self, data):
 new_node = Node(data)
 if not self.head:
 self.head = new_node
 return
 temp = self.head
 while temp.next:
 temp = temp.next
 temp.next = new_node

 def print_list(self):
 temp = self.head
 while temp:
 print(temp.data, end=" -> ")
 temp = temp.nextprint("None")

ll = LinkedList()
ll.append(10)
ll.append(20)
ll.append(30)
ll.print_list()
```

Single Linked List



Double Linked List

Output:
rust
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10 -> 20 -> 30 -> None

Stacks

Introduction

A stack is a linear data structure that follows the Last In, First Out (LIFO) principle. The element added last is removed first.

Operations on Stack

1. Push – Insert an element at the top.
2. Pop – Remove the top element.
3. Peek – Get the top element without removing it.
4. isEmpty – Check if the stack is empty.

Example 1: Implementing Stack Using List

```
class Stack:
    def __init__(self):
        self.stack = []

    def push(self, data):
        self.stack.append(data)

    def pop(self):
        if not self.is_empty():
            return self.stack.pop()
        return "Stack is empty"def peek(self):
        return self.stack[-1] if not self.is_empty() else "Stack is empty"def is_empty(self):
        return len(self.stack) == 0

s = Stack()
s.push(10)
s.push(20)
s.push(30)
print("Top Element:", s.peek())
print("Popped Element:", s.pop())
```

Output:
Top Element: 30Popped Element: 30

Queues

Introduction

A queue is a linear data structure that follows the First In, First Out (FIFO) principle. The element added first is removed first.

Operations on Queue

- **Enqueue – Insert an element at the rear.**
- **Dequeue – Remove an element from the front.**
- **Peek – Get the front element without removing it.**
- **isEmpty – Check if the queue is empty.**

Example 1: Implementing Queue Using List

```
class Queue:
 def __init__(self):
 self.queue = []

 def enqueue(self, data):
 self.queue.append(data)

 def dequeue(self):
 if not self.is_empty():
 return self.queue.pop(0)
 return "Queue is empty"def peek(self):
 return self.queue[0] if not self.is_empty() else "Queue is empty"def is_empty(self):
 return len(self.queue) == 0

q = Queue()
q.enqueue(10)
q.enqueue(20)
q.enqueue(30)
print("Front Element:", q.peek())
print("Dequeued Element:", q.dequeue())
```

Output:
Front Element: 10
Dequeued Element: 10
This covers Arrays, Linked Lists, Stacks, and Queues with explanations, characteristics, advantages, and two solved examples for each. Let me know if you need more details!

Graphs & Trees

Graphs

Introduction

A graph is a non-linear data structure that consists of nodes (vertices) and edges that connect them. It is widely used to model real-world problems such as social networks, transportation systems, and the internet.

Types of Graphs

1. **Directed Graph (Digraph) – Edges have a direction, indicating one-way connections.**
2. **Undirected Graph – Edges do not have direction, meaning connections are bidirectional.**
3. **Weighted Graph – Each edge has a weight or cost associated with it.**
4. **Unweighted Graph – Edges have no weight.**
5. **Cyclic Graph – Contains cycles (loops).**
6. **Acyclic Graph – No cycles are present (like trees).**

Graph Representation

1. **Adjacency Matrix – A 2D array where matrix[i][j] = 1 if there is an edge between vertex i and j.**
2. **Adjacency List – A list where each vertex stores a list of connected vertices (more space-efficient).**

Common Graph Traversal Algorithms

1. **Breadth-First Search (BFS) – Explores all neighbors before moving to the next level (uses a queue).**
2. **Depth-First Search (DFS) – Explores as far as possible along one branch before backtracking (uses a stack).**

Example 1: Graph Representation using Adjacency List

Problem Statement:

Represent a graph using an adjacency list and print it.

Solution

```
class Graph:
    def __init__(self):
        self.graph = {}

    def add_edge(self, u, v):
        if u not in self.graph:
            self.graph[u] = []
        self.graph[u].append(v)

    def print_graph(self):
        for node in self.graph:
            print(node, "->", " -> ".join(map(str, self.graph[node])))

g = Graph()
g.add_edge(0, 1)
g.add_edge(0, 2)
g.add_edge(1, 3)
g.add_edge(1, 4)
g.add_edge(2, 5)
g.print_graph()
```

Output:

rust

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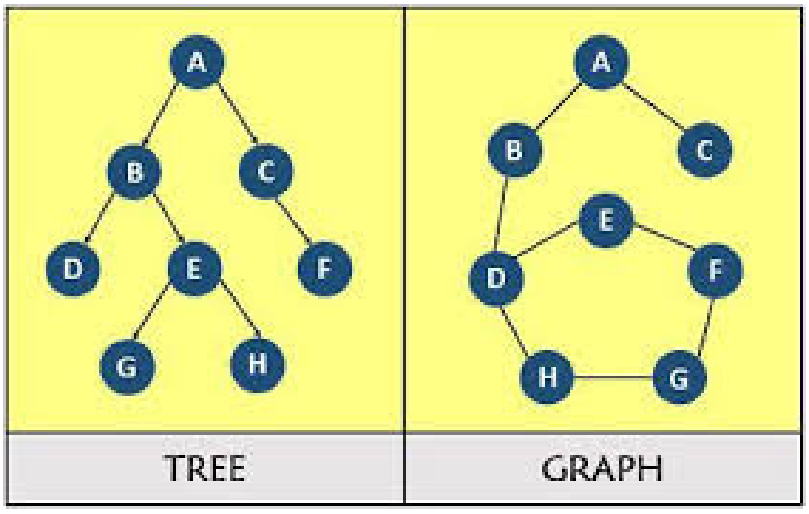
0 -> 1 -> 21 -> 3 -> 42 -> 5



Example 2: BFS Traversal of a Graph

Problem Statement:
Perform Breadth-First Search (BFS) traversal starting from node 0.
Solution:

```
from collections import deque

def bfs(graph, start):
 visited = set()
 queue = deque([start])
 while queue:
      node = queue.popleft()
      if node not in visited:
        print(node, end=" ")
        visited.add(node)
        queue.extend(graph.get(node, []))

graph = {
   0: [1, 2],
   1: [3, 4],
   2: [5],
   3: [],
   4: [],
   5: []
}

print("BFS Traversal:")
bfs(graph, 0)
```

Output:
yaml
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BFS Traversal:0 1 2 3 4 5

Trees

Introduction

A tree is a hierarchical data structure consisting of nodes, where each node has a parent and zero or more children. It is a special case of a graph (an acyclic, connected graph).

Tree Terminology

- Root – The topmost node.
- Parent & Child – A node connected to another node above it is a parent, and below it is a child.
- Leaf Node – A node with no children.
- Depth – Number of edges from the root to a node.
- Height – Number of edges on the longest path from a node to a leaf.
- Binary Tree – A tree where each node has at most two children.
- Binary Search Tree (BST) – A binary tree where left child < parent < right child.

Common Tree Traversal Techniques

1. Inorder Traversal (Left, Root, Right) – Used in BSTs to retrieve elements in sorted order.
2. Preorder Traversal (Root, Left, Right) – Used for creating a copy of the tree.
3. Postorder Traversal (Left, Right, Root) – Used in deletion operations.
4. Level Order Traversal (BFS in Trees) – Nodes are visited level by level.

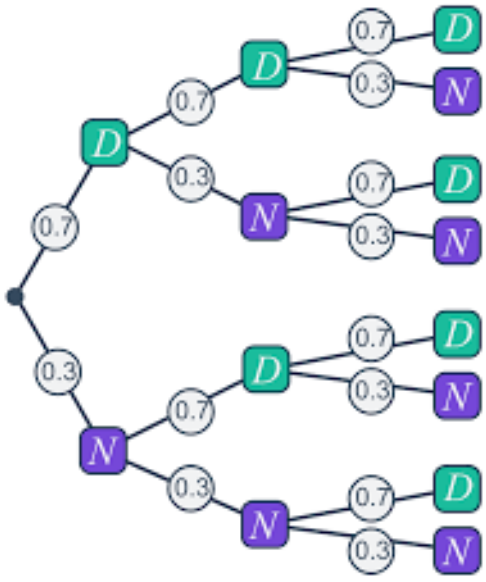
Example 1: Implementing a Binary Tree and Traversals

Problem Statement:

Create a binary tree and perform Inorder, Preorder, and Postorder traversals.

Solution:

```
class Node:
    def __init__(self, key):
        self.left = None
        self.right = None
        self.val = key
```



```
def inorder(root):
 if root:
 inorder(root.left)
 print(root.val, end=" ")
 inorder(root.right)

def preorder(root):
 if root:
 print(root.val, end=" ")
 preorder(root.left)
 preorder(root.right)

def postorder(root):
 if root:
 postorder(root.left)
 postorder(root.right)
 print(root.val, end=" ")

# Creating a sample tree
root = Node(1)
root.left = Node(2)
root.right = Node(3)
root.left.left = Node(4)
root.left.right = Node(5)

print("Inorder Traversal:")
inorder(root)

print("\nPreorder Traversal:")
preorder(root)

print("\nPostorder Traversal:")
postorder(root)
```

Output:
Inorder Traversal: 4 2 5 1 3
Preorder Traversal: 1 2 4 5 3
Postorder Traversal: 4 5 2 3 1

Example 2: Checking if a Binary Search Tree (BST) is Valid

Problem Statement:
Verify if a given tree is a valid Binary Search Tree (BST).
Solution:

```
import sys

class Node:
   def __init__(self, val):
      self.left = None
      self.right = None
      self.val = val

def is_valid_bst(root, min_val=-sys.maxsize, max_val=sys.maxsize):
   if not root:
      return Trueif not (min_val < root.val < max_val):
      return Falsereturn is_valid_bst(root.left, min_val, root.val) and is_valid_bst(root.right,
root.val, max_val)

# Creating a BST
root = Node(10)
root.left = Node(5)
root.right = Node(15)
root.right.left = Node(12)
root.right.right = Node(20)

print("Is valid BST?", is_valid_bst(root))
```

Output:

```
pgsql
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Is valid BST? True
```

This material is for reference to gain basic knowledge ; don't rely solely on it, and also refer to other internet resources for competitive exams. Thank you from CodTech.