

Mathematics (Standard) 2025, Set 30/2/1

Q.P. Code 30/2/1 · Series EGFH2 · 80 marks · 3 hours · March 2025. Questions are from the official CBSE paper. Step-by-step solutions are written by CogniGuru and checked against CBSE's published answer key. Where the key itself disagrees with the arithmetic, the solution says so.

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Section A: Multiple choice

20 questions, 1 mark each. MCQs (Q1 to Q18) and assertion-reason (Q19, Q20).

Q1 · TRIGONOMETRY · 1 MARK

If $7 \cos^2 \theta + 3 \sin^2 \theta = 4$, then the value of θ is:

- (A) 30° (B) 45°
(C) 60° (D) 90°

SOLUTION

Write $7 \cos^2 \theta + 3 \sin^2 \theta = 3(\cos^2 \theta + \sin^2 \theta) + 4 \cos^2 \theta = 3 + 4 \cos^2 \theta$.

So $3 + 4 \cos^2 \theta = 4$, which gives $\cos^2 \theta = \frac{1}{4}$ and $\cos \theta = \frac{1}{2}$ (taking the acute angle).

$\cos 60^\circ = \frac{1}{2}$, so $\theta = 60^\circ$.

Answer: (C) 60°

Common mistake: Trying the options one by one. Using $\sin^2 \theta + \cos^2 \theta = 1$ gets the answer in two lines.

Q2 · PROBABILITY · 1 MARK

The probability of drawing an even prime number out of numbers from 1 to 30 is:

- (A) $\frac{1}{30}$ (B) $\frac{4}{15}$
(C) $\frac{7}{30}$ (D) 0

SOLUTION

The only even prime number is 2, so there is 1 favourable outcome.

There are 30 equally likely numbers, so the probability is $\frac{1}{30}$.

Answer: (A) $\frac{1}{30}$

Common mistake: Counting all even numbers (15) or all primes (10). The number has to be both even and prime.

Q3 · QUADRATIC EQUATIONS · 1 MARK

The quadratic equation whose roots are 7 and $\frac{1}{7}$ is:

- (A) $7x^2 - 50x + 7 = 0$ (B) $7x^2 - 50x + 1 = 0$
(C) $7x^2 + 50x - 7 = 0$ (D) $7x^2 + 50x - 1 = 0$

SOLUTION

Sum of roots $= 7 + \frac{1}{7} = \frac{50}{7}$ and product of roots $= 7 \times \frac{1}{7} = 1$.

The equation is $x^2 - (\text{sum})x + \text{product} = 0$, that is $x^2 - \frac{50}{7}x + 1 = 0$.

Multiply by 7: $7x^2 - 50x + 7 = 0$.

Answer: (A) $7x^2 - 50x + 7 = 0$

Common mistake: Using a plus sign in front of $50x$. The middle term is minus the sum of the roots.

Q4 · REAL NUMBERS · 1 MARK

The least number which is a perfect square and is divisible by each of 16, 20 and 50, is:

(A) 1200

(B) 100

(C) 3600

(D) 2400

SOLUTION

$16 = 2^4$, $20 = 2^2 \times 5$, $50 = 2 \times 5^2$.

LCM $= 2^4 \times 5^2 = 400$. Every common multiple is a multiple of 400, so the least number divisible by all three is 400.

$400 = 20^2$ is already a perfect square, so the answer is 400.

None of the four options is 400, so the question as printed has no correct option. CBSE's answer key says the same and awards the mark to every candidate.

Answer: 400 (not among the options; CBSE awarded the mark to all)

Common mistake: Multiplying the LCM by another factor to "make it a square". Check first whether the LCM is already a perfect square.

Q5 · COORDINATE GEOMETRY · 1 MARK

The coordinates of the end points of a diameter of a circle are $(5, -2)$ and $(5, 2)$. The length of the radius of the circle is:

(A) ± 2

(B) ± 4

(C) 4

(D) 2

SOLUTION

Both points have $x = 5$, so the diameter is vertical. Its length is $2 - (-2) = 4$.

Radius $= \frac{4}{2} = 2$. A length cannot be negative, so it is not ± 2 .

Answer: (D) 2

Q6 · COORDINATE GEOMETRY · 1 MARK

The points $(-5, 0)$, $(5, 0)$ and $(0, 4)$ are the vertices of a triangle which is a/an:

(A) right-angled triangle

(B) isosceles triangle

(C) equilateral triangle

(D) scalene triangle

SOLUTION

Let $A(-5, 0)$, $B(5, 0)$, $C(0, 4)$. $AB = 10$.

$AC = \sqrt{5^2 + 4^2} = \sqrt{41}$ and $BC = \sqrt{5^2 + 4^2} = \sqrt{41}$.

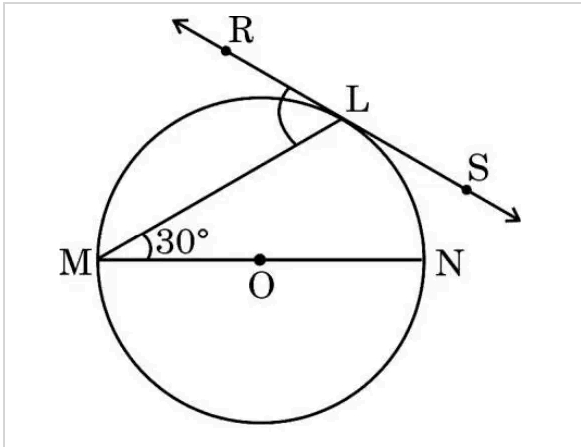
Two sides are equal and the third is different, so it is isosceles. It is not right-angled because $AC^2 + BC^2 = 82 \neq 100 = AB^2$.

Answer: (B) isosceles triangle

Common mistake: Stopping at "the base is on the x-axis" and calling it right-angled. Check with the distance formula.

Q7 · CIRCLES · 1 MARK

In the given figure, RS is the tangent to the circle at the point L and MN is the diameter. If $\angle NML = 30^\circ$, then $\angle RLM$ is:



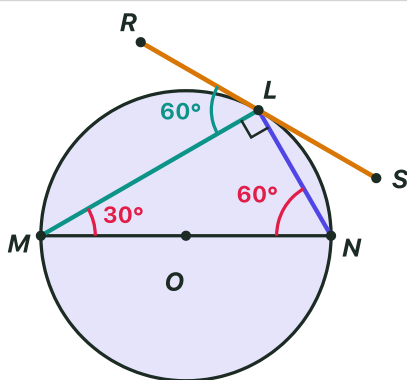
(A) 30°

(B) 60°

(C) 90°

(D) 120°

SOLUTION



Angle in a semicircle = 90° , so $\angle LNM = 60^\circ$. The tangent-chord angle $\angle RLM$ equals $\angle LNM$.

MN is a diameter, so the angle in a semicircle $\angle MLN = 90^\circ$.

In $\triangle MLN$: $\angle LNM = 180^\circ - 90^\circ - 30^\circ = 60^\circ$.

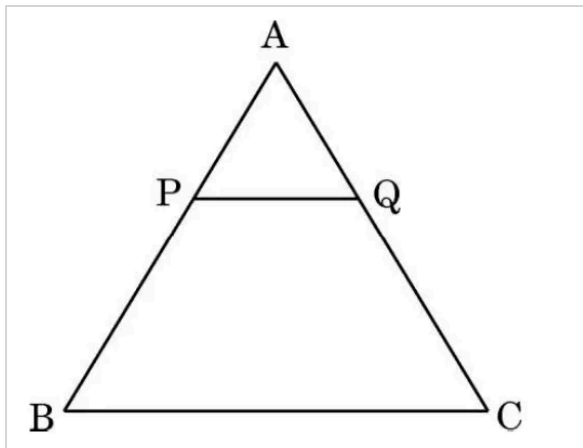
The angle between a tangent and a chord equals the angle in the alternate segment: $\angle RLM = \angle LNM = 60^\circ$.

Answer: (B) 60°

Common mistake: Answering 30° , the angle at M . The tangent-chord angle matches the angle on the opposite side of the chord, at N .

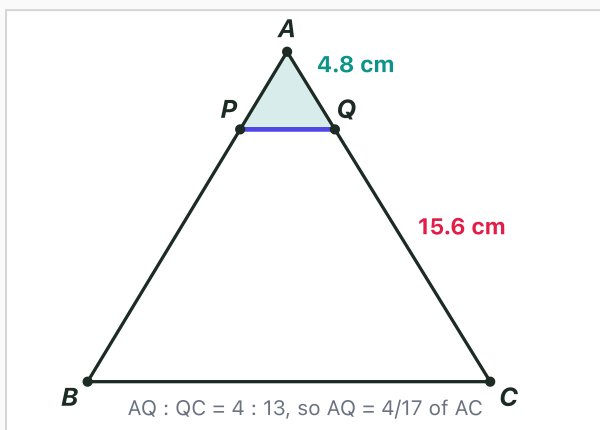
Q8 · TRIANGLES · 1 MARK

In the given figure, $PQ \parallel BC$. If $\frac{AP}{PB} = \frac{4}{13}$ and $AC = 20.4$ cm, then the length of AQ is:



- (A) 2.8 cm (B) 5.8 cm
(C) 3.8 cm (D) 4.8 cm

SOLUTION



$PQ \parallel BC$, so by the Basic Proportionality Theorem $\frac{AQ}{QC} = \frac{AP}{PB} = \frac{4}{13}$.

So AQ is 4 parts and QC is 13 parts out of $4 + 13 = 17$ parts of AC : $\frac{AQ}{AC} = \frac{4}{17}$.

$$AQ = \frac{4}{17} \times 20.4 = 4 \times 1.2 = 4.8 \text{ cm.}$$

Answer: (D) 4.8 cm

Common mistake: Using $\frac{4}{13} \times 20.4$. The ratio 4 : 13 is for $AQ : QC$, not for $AQ : AC$.

Q9 · TRIANGLES · 1 MARK

Which of the following statements is incorrect?

- (A) Two congruent figures are always similar. (B) A square and a rhombus of the same area are always similar.
(C) Two equilateral triangles are always similar. (D) Two similar triangles need not be congruent.

SOLUTION

Congruent figures have the same shape and size, so they are similar. (A) is correct.

A square and a rhombus can have the same area, but a rhombus can have angles other than 90° . Similar figures need equal angles, so they are not always similar. (B) is incorrect.

All angles of an equilateral triangle are 60° , so any two are similar. (C) is correct.

Similar triangles can have different sizes, so they need not be congruent. (D) is correct.

Answer: (B) A square and a rhombus of the same area are always similar.

Common mistake: Thinking equal area means same shape. Similarity is about equal angles and proportional sides.

Q10 · REAL NUMBERS · 1 MARK

The sum of the exponents of prime factors in the prime factorisation of 4004 is:

- (A) 5 (B) 4
(C) 3 (D) 2

SOLUTION

$$4004 = 4 \times 1001 = 2^2 \times 1001 \text{ and } 1001 = 7 \times 143 = 7 \times 11 \times 13.$$

$$\text{So } 4004 = 2^2 \times 7^1 \times 11^1 \times 13^1.$$

The exponents are 2, 1, 1, 1 and their sum is 5.

Answer: (A) 5

Common mistake: Counting the number of prime factors (four) instead of adding their exponents.

Q11 · PROBABILITY · 1 MARK

In a cricket match, a batsman hits the boundary 7 times out of the 42 balls he plays. The probability of his not hitting a boundary is:

- (A) $\frac{1}{7}$ (B) $\frac{2}{7}$
(C) $\frac{5}{6}$ (D) $\frac{1}{6}$

SOLUTION

Balls without a boundary: $42 - 7 = 35$.

$$P(\text{no boundary}) = \frac{35}{42} = \frac{5}{6}.$$

$$\text{Check: } P(\text{boundary}) = \frac{7}{42} = \frac{1}{6}, \text{ and } \frac{1}{6} + \frac{5}{6} = 1.$$

Answer: (C) $\frac{5}{6}$

Common mistake: Giving $\frac{1}{6}$, the probability of hitting a boundary. The question asks for NOT hitting one.

Q12 · AREAS RELATED TO CIRCLES · 1 MARK

If a large circular pizza is divided into 5 equal sectors, then the central angle of each sector will be:

- (A) 60° (B) 90°
(C) 45° (D) 72°

SOLUTION

A full circle is 360° at the centre. Five equal sectors share it equally.

$$\text{Each angle} = \frac{360^\circ}{5} = 72^\circ.$$

Answer: (D) 72°

Q13 · TRIGONOMETRY · 1 MARK

If $\sin 30^\circ \tan 45^\circ = \frac{\sec 60^\circ}{k}$, then the value of k is:

- (A) 4 (B) 3
(C) 2 (D) 1

SOLUTION

$$\sin 30^\circ = \frac{1}{2}, \tan 45^\circ = 1, \sec 60^\circ = 2.$$

$$\text{So } \frac{1}{2} \times 1 = \frac{2}{k}, \text{ which gives } k = 4.$$

Answer: (A) 4

Q14 · LINEAR EQUATIONS · 1 MARK

The line represented by the equation $x - y = 0$ is:

- (A) parallel to x-axis (B) parallel to y-axis
(C) passing through the origin (D) passing through the point (3, 2)

SOLUTION

$x - y = 0$ is the same as $y = x$, a line at 45° to the axes. It is not parallel to either axis.

Put (0, 0): $0 - 0 = 0$ ✓, so it passes through the origin.

Put (3, 2): $3 - 2 = 1 \neq 0$, so it does not pass through (3, 2).

Answer: (C) passing through the origin

Q15 · ARITHMETIC PROGRESSIONS · 1 MARK

The 10th term of the AP 5, $\frac{19}{4}$, $\frac{9}{2}$, $\frac{17}{4}$, ... is:

- (A) $\frac{11}{4}$ (B) $\frac{4}{11}$
(C) $\frac{13}{4}$ (D) $\frac{4}{13}$

SOLUTION

Write all terms over 4: $\frac{20}{4}$, $\frac{19}{4}$, $\frac{18}{4}$, $\frac{17}{4}$, ... So $a = 5$ and $d = -\frac{1}{4}$.

$$a_{10} = a + 9d = 5 - \frac{9}{4} = \frac{20 - 9}{4} = \frac{11}{4}.$$

Answer: (A) $\frac{11}{4}$

Common mistake: Using $10d$ instead of $9d$. The n th term is $a + (n - 1)d$.

Q16 · POLYNOMIALS · 1 MARK

If -4 is a zero of the polynomial $p(x) = x^2 - x - (2 + 2k)$, then the value of k is:

- (A) 3 (B) 9
(C) 6 (D) -9

SOLUTION

A zero makes the polynomial 0: $p(-4) = (-4)^2 - (-4) - (2 + 2k) = 0$.

$16 + 4 - 2 - 2k = 0$, so $18 - 2k = 0$ and $k = 9$.

Answer: (B) 9

Common mistake: Losing a sign: $-(-4) = +4$, and the bracket $(2 + 2k)$ is subtracted as a whole.

Q17 · COORDINATE GEOMETRY · 1 MARK

The equation of a line parallel to the x -axis and at a distance of 3 units below x -axis is:

- (A) $x = 3$ (B) $x = -3$
(C) $y = -3$ (D) $y = 3$

SOLUTION

A line parallel to the x -axis is horizontal, so every point on it has the same y value: its equation is $y = c$.

Below the x -axis means y is negative, and the distance is 3, so $y = -3$.

Answer: (C) $y = -3$

Common mistake: Writing $x = -3$. That is a vertical line, parallel to the y -axis.

Q18 · REAL NUMBERS · 1 MARK

The HCF of 40, 110 and 360 is:

- (A) 40 (B) 110
(C) 360 (D) 10

SOLUTION

$40 = 2^3 \times 5$, $110 = 2 \times 5 \times 11$, $360 = 2^3 \times 3^2 \times 5$.

Common prime factors with the smallest powers: $2^1 \times 5^1 = 10$.

Answer: (D) 10

Q19 · ARITHMETIC PROGRESSIONS · 1 MARK

Assertion (A): Common difference of the AP: $5, 1, -3, -7, \dots$ is 4.

Reason (R): Common difference of the AP: $a_1, a_2, a_3, \dots, a_n$ is obtained by $d = a_n - a_{n-1}$.

- (A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true, but R is not the correct explanation of A
(C) A is true, but R is false
(D) A is false, but R is true

SOLUTION

$d = a_2 - a_1 = 1 - 5 = -4$ (and $-3 - 1 = -4$, $-7 - (-3) = -4$). The common difference is -4 , not 4. So the assertion is false.

The reason gives the correct rule, $d = a_n - a_{n-1}$, so it is true.

Answer: (D) A is false, R is true

Common mistake: Dropping the minus sign. The terms are going down, so d is negative.

Q20 · LINEAR EQUATIONS · 1 MARK

Assertion (A): The pair of linear equations $px + 3y + 59 = 0$ and $2x + 6y + 118 = 0$ will have infinitely many solutions if $p = 1$.

Reason (R): If the pair of linear equations $px + 3y + 19 = 0$ and $2x + 6y + 157 = 0$ has a unique solution, then $p \neq 1$.

(A) Both A and R are true and R is the correct explanation of A

(B) Both A and R are true, but R is not the correct explanation of A

(C) A is true, but R is false

(D) A is false, but R is true

SOLUTION

(A) For infinitely many solutions we need $\frac{p}{2} = \frac{3}{6} = \frac{59}{118}$. Here $\frac{3}{6} = \frac{1}{2}$ and $\frac{59}{118} = \frac{1}{2}$, so we need $\frac{p}{2} = \frac{1}{2}$, i.e. $p = 1$. The assertion is true.

(R) A unique solution needs $\frac{p}{2} \neq \frac{3}{6}$, i.e. $p \neq 1$. The reason is true.

But the reason is about a different pair of equations (constants 19 and 157) and a different case (unique solution). It does not explain why $p = 1$ gives infinitely many solutions in the assertion. So R is not the explanation of A.

Answer: (B) Both true, but R is not the correct explanation of A

Common mistake: Choosing (A) because both statements mention $p = 1$. Check whether the reason actually explains the assertion.

Section B: Very short answer

5 questions, 2 marks each.

Q21 · POLYNOMIALS · 2 MARKS

If p and q are zeroes of the polynomial $p(y) = 21y^2 - y - 2$, then find the value of $(1 - p)(1 - q)$.

SOLUTION

For $21y^2 - y - 2$: sum of zeroes $p + q = -\frac{-1}{21} = \frac{1}{21}$ and product $pq = \frac{-2}{21}$.

$$\begin{aligned}(1 - p)(1 - q) &= 1 - (p + q) + pq = 1 - \frac{1}{21} - \frac{2}{21} \\ &= \frac{21 - 1 - 2}{21} = \frac{18}{21} = \frac{6}{7}.\end{aligned}$$

Answer: $\frac{6}{7}$

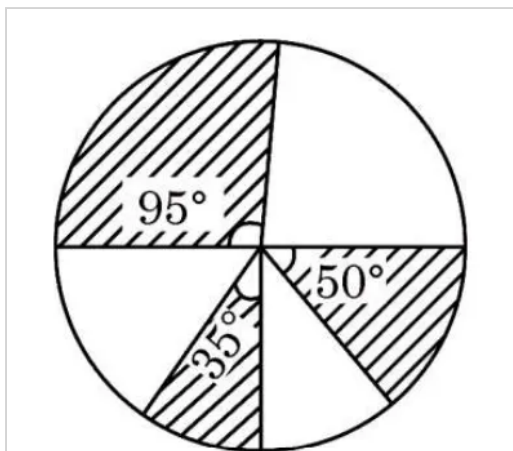
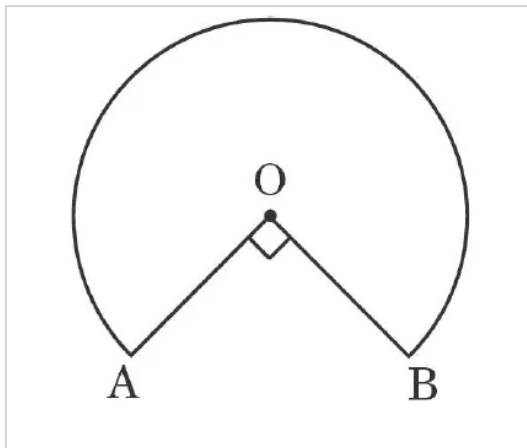
Common mistake: Expanding with $-(p + q)$ but then using $+\frac{b}{a}$ for the sum. The sum of zeroes is $-\frac{b}{a}$.

Q22 · AREAS RELATED TO CIRCLES · 2 MARKS

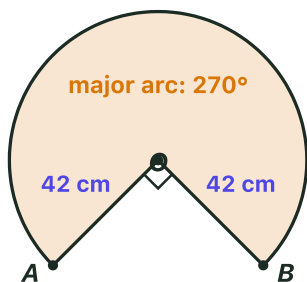
(a) In the given figure, the shape of the top of a table is that of a sector of a circle with centre O and $\angle AOB = 90^\circ$. If $AO = OB = 42$ cm, then find the perimeter of the top of the table.

OR

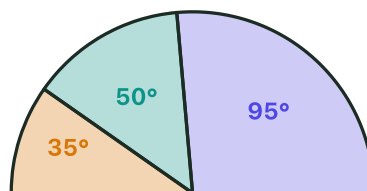
(b) In the given figure, three sectors of a circle of radius 5 cm, making angles 35° , 50° and 95° at the centre are shaded. Find the area of the shaded region. [Use $\pi = \frac{22}{7}$]



SOLUTION



The top is the major sector: $360^\circ - 90^\circ = 270^\circ$.



$95^\circ + 50^\circ + 35^\circ = 180^\circ$: half the circle

Rearranged side by side, the three sectors make exactly half of the circle.

(a) The table top is the circle with the 90° wedge AOB cut out, so the top is the major sector with angle $360^\circ - 90^\circ = 270^\circ$ and radius 42 cm.

$$\text{Length of the curved edge (major arc)} = \frac{270}{360} \times 2\pi r = \frac{3}{4} \times 2 \times \frac{22}{7} \times 42 = \frac{3}{4} \times 264 = 198 \text{ cm.}$$

The straight edges are the two radii, $42 + 42 = 84$ cm. Perimeter = $198 + 84 = 282$ cm.

(b) The three shaded sectors have the same radius, so their angles add: $95^\circ + 50^\circ + 35^\circ = 180^\circ$.

$$\text{Area} = \frac{180}{360} \times \pi r^2 = \frac{1}{2} \times \frac{22}{7} \times 5 \times 5 = \frac{275}{7} \text{ cm}^2 \approx 39.29 \text{ cm}^2.$$

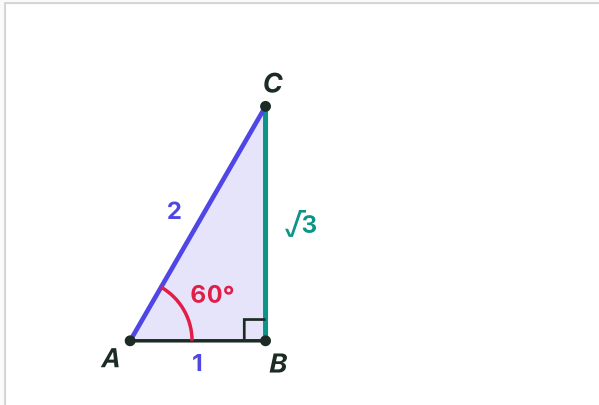
Answer: (a) 282 cm (b) $\frac{275}{7} \approx 39.29 \text{ cm}^2$

Common mistake: In (a), using the 90° angle for the arc. The table top is the big part, 270° , and the perimeter also needs the two radii.

Q23 · TRIGONOMETRY · 2 MARKS

If $\tan A = \sqrt{3}$, where A is an acute angle, then find the value of $\frac{\sin^2 A}{1 + \cos^2 A}$.

SOLUTION



$\tan A = \sqrt{3} = \tan 60^\circ$, so $A = 60^\circ$.

$$\sin^2 60^\circ = \left(\frac{\sqrt{3}}{2}\right)^2 = \frac{3}{4} \text{ and } \cos^2 60^\circ = \left(\frac{1}{2}\right)^2 = \frac{1}{4}.$$

$$\frac{\sin^2 A}{1 + \cos^2 A} = \frac{3/4}{1 + 1/4} = \frac{3/4}{5/4} = \frac{3}{5}.$$

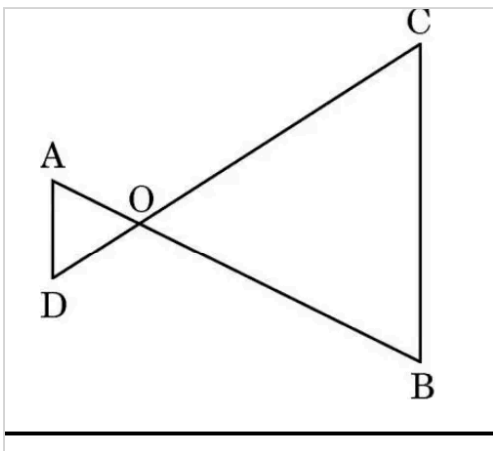
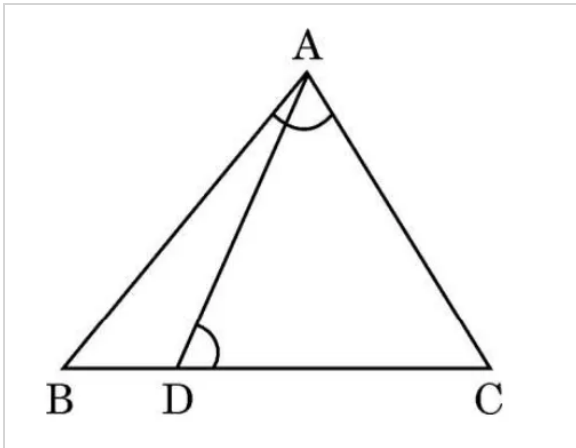
Answer: $\frac{3}{5}$

Q24 · TRIANGLES · 2 MARKS

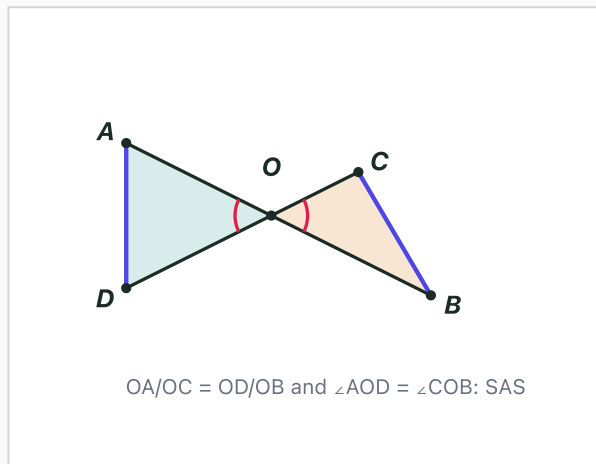
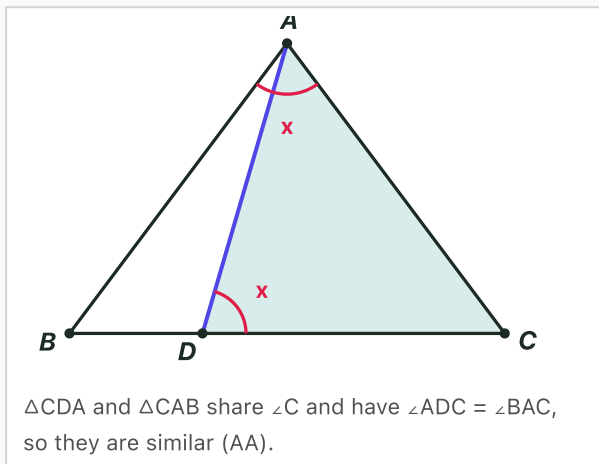
(a) In the given figure, D is a point on the side BC of $\triangle ABC$ such that $\angle ADC = \angle BAC$. Show that $CA^2 = CD \cdot CB$.

OR

(b) In the given figure, $OA \cdot OB = OC \cdot OD$. Show that $\angle A = \angle C$ and $\angle B = \angle D$.



SOLUTION



(a) In $\triangle CDA$ and $\triangle CAB$: $\angle ADC = \angle BAC$ (given) and $\angle C$ is common.

So $\triangle CDA \sim \triangle CAB$ by AA similarity.

Corresponding sides are proportional: $\frac{CD}{CA} = \frac{CA}{CB}$, so $CA^2 = CD \cdot CB$.

(b) $OA \cdot OB = OC \cdot OD$ gives $\frac{OA}{OC} = \frac{OD}{OB}$.

In $\triangle AOD$ and $\triangle COB$: $\frac{OA}{OC} = \frac{OD}{OB}$ and $\angle AOD = \angle COB$ (vertically opposite angles).

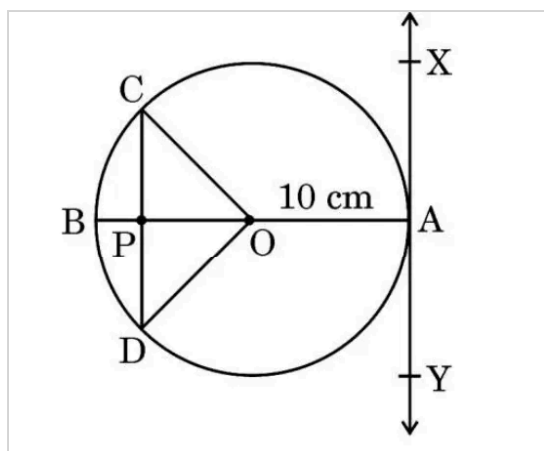
So $\triangle AOD \sim \triangle COB$ by SAS similarity, with $A \leftrightarrow C$ and $D \leftrightarrow B$. Hence $\angle A = \angle C$ and $\angle D = \angle B$.

Answer: (a) $CA^2 = CD \cdot CB$ (b) $\angle A = \angle C$, $\angle B = \angle D$

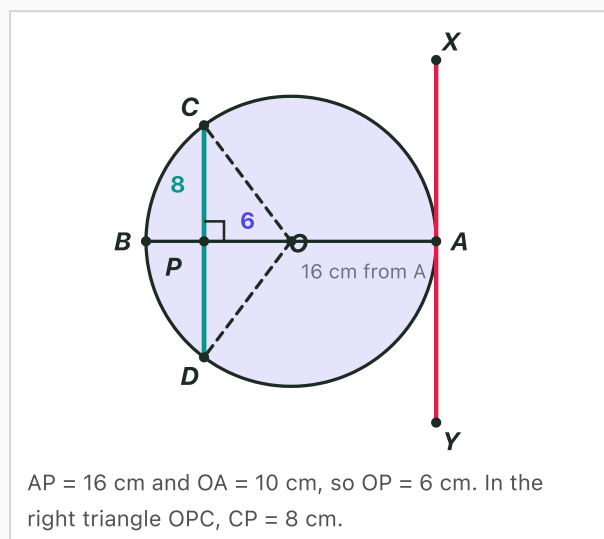
Common mistake: In (b), matching the vertices in the wrong order. The ratio $\frac{OA}{OC} = \frac{OD}{OB}$ pairs A with C and D with B .

Q25 · CIRCLES · 2 MARKS

At point A on the diameter AB of a circle of radius 10 cm, tangent XAY is drawn to the circle. Find the length of the chord CD parallel to XY at a distance of 16 cm from A .



SOLUTION



XY is a tangent at A , so $AB \perp XY$. The chord $CD \parallel XY$, so $CD \perp AB$ too, and AB bisects CD at P .

$AP = 16$ cm and $OA = 10$ cm, so $OP = AP - OA = 16 - 10 = 6$ cm (the chord is on the far side of the centre).

In right triangle OPC : $CP^2 = OC^2 - OP^2 = 10^2 - 6^2 = 64$, so $CP = 8$ cm.

$CD = 2 \times CP = 16$ cm.

Answer: $CD = 16$ cm

Common mistake: Using $OP = 16$. The distance 16 cm is measured from A , not from the centre.

Section C: Short answer

6 questions, 3 marks each.

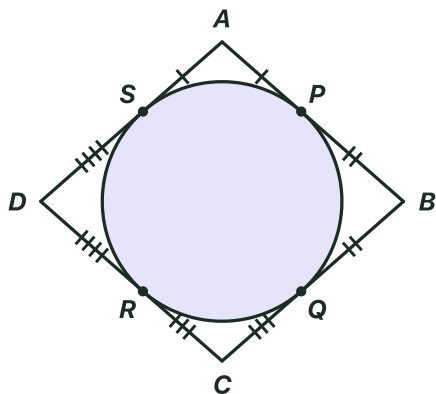
Q26 · CIRCLES · 3 MARKS

(a) Prove that the parallelogram circumscribing a circle is a rhombus.

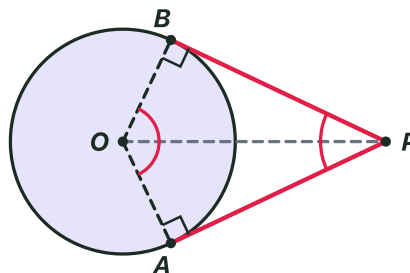
OR

(b) Prove that the angle between the two tangents drawn from an external point to a circle is supplementary to the angle subtended by the line-segment joining the points of contact at the centre.

SOLUTION



Tangents from a point are equal (same tick marks).
Adding them gives $AB + CD = AD + BC$.



$$\angle AOB + \angle APB = 360^\circ - 90^\circ - 90^\circ = 180^\circ$$

(a) Let parallelogram $ABCD$ circumscribe a circle touching AB, BC, CD, DA at P, Q, R, S .

Tangents from an outside point are equal: $AP = AS, BP = BQ, CR = CQ, DR = DS$.

Add all four: $(AP + BP) + (CR + DR) = (AS + DS) + (BQ + CQ)$, that is $AB + CD = AD + BC$.

In a parallelogram $AB = CD$ and $AD = BC$, so $2AB = 2BC$ and $AB = BC$.

So all four sides are equal: $AB = BC = CD = DA$. A parallelogram with all sides equal is a rhombus.

(b) Let PA and PB be tangents from P to a circle with centre O . Join OA and OB .

A radius is perpendicular to the tangent at the point of contact, so $\angle OAP = \angle OBP = 90^\circ$.

In quadrilateral $OAPB$ the angles add up to 360° : $\angle APB + \angle AOB + 90^\circ + 90^\circ = 360^\circ$, so $\angle APB + \angle AOB = 180^\circ$.

Answer: Both proved

Common mistake: Writing the equal tangent lengths without stating the reason (tangents from an external point are equal).

Q27 · TRIGONOMETRY · 3 MARKS

(a) Prove that: $\left(1 + \frac{1}{\tan^2 \theta}\right) \left(1 + \frac{1}{\cot^2 \theta}\right) = \frac{1}{\sin^2 \theta - \sin^4 \theta}$

OR

(b) Prove that: $\sqrt{\frac{\operatorname{cosec} \theta - 1}{\operatorname{cosec} \theta + 1}} + \sqrt{\frac{\operatorname{cosec} \theta + 1}{\operatorname{cosec} \theta - 1}} = 2 \sec \theta$

SOLUTION

(a) $\frac{1}{\tan^2 \theta} = \cot^2 \theta$ and $\frac{1}{\cot^2 \theta} = \tan^2 \theta$, so LHS = $(1 + \cot^2 \theta)(1 + \tan^2 \theta)$.

$$= \operatorname{cosec}^2 \theta \cdot \sec^2 \theta = \frac{1}{\sin^2 \theta} \cdot \frac{1}{\cos^2 \theta} = \frac{1}{\sin^2 \theta (1 - \sin^2 \theta)}$$

$$= \frac{1}{\sin^2 \theta - \sin^4 \theta} = \text{RHS.}$$

(b) Put $c = \operatorname{cosec} \theta$. Over a common root: $\frac{(c-1) + (c+1)}{\sqrt{(c+1)(c-1)}} = \frac{2c}{\sqrt{c^2-1}}$.

$$c^2 - 1 = \operatorname{cosec}^2 \theta - 1 = \cot^2 \theta, \text{ so this is } \frac{2 \operatorname{cosec} \theta}{\cot \theta} = 2 \times \frac{1}{\sin \theta} \times \frac{\sin \theta}{\cos \theta} = \frac{2}{\cos \theta} = 2 \sec \theta.$$

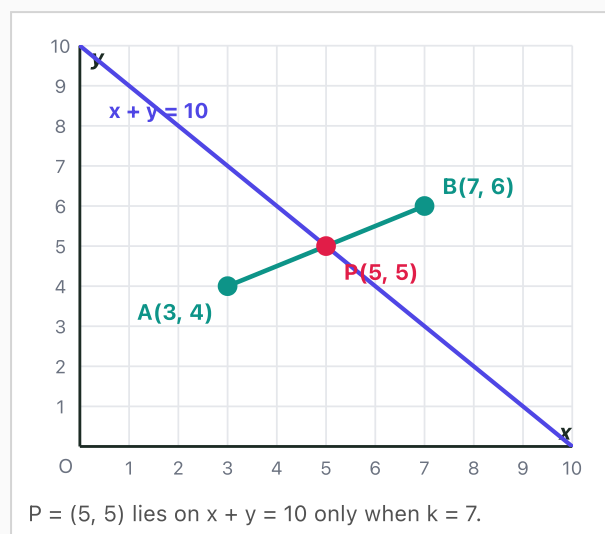
Answer: Both identities proved

Common mistake: In (a), forgetting $1 - \sin^2 \theta = \cos^2 \theta$ when turning $\sec^2 \theta$ into the form on the right.

Q28 · COORDINATE GEOMETRY · 3 MARKS

If the mid-point of the line segment joining the points $A(3, 4)$ and $B(k, 6)$ is $P(x, y)$ and $x + y - 10 = 0$, then find the value of k .

SOLUTION



Mid-point $P = \left(\frac{3+k}{2}, \frac{4+6}{2} \right) = \left(\frac{3+k}{2}, 5 \right)$, so $x = \frac{3+k}{2}$ and $y = 5$.

Put in $x + y - 10 = 0$: $\frac{3+k}{2} + 5 - 10 = 0$.

$\frac{3+k}{2} = 5$, so $3+k = 10$ and $k = 7$.

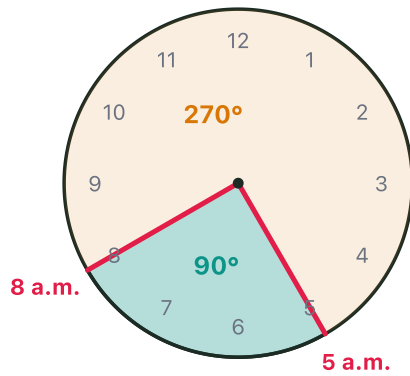
Answer: $k = 7$

Common mistake: Forgetting to divide the sum of coordinates by 2 for the mid-point.

Q29 · AREAS RELATED TO CIRCLES · 3 MARKS

The length of the hour hand of a clock is 10 cm. Find the area of the minor sector swept by the hour hand of the clock between 5 a.m. to 8 a.m. Also, find the area of the major sector.

SOLUTION



In 3 hours the hour hand turns $3 \times 30^\circ = 90^\circ$.

The hour hand makes a full turn of 360° in 12 hours, so it turns $\frac{360^\circ}{12} = 30^\circ$ every hour.

From 5 a.m. to 8 a.m. is 3 hours, so the angle is $3 \times 30^\circ = 90^\circ$. Radius $r = 10$ cm. Use $\pi = \frac{22}{7}$.

$$\text{Minor sector} = \frac{90}{360} \times \pi r^2 = \frac{1}{4} \times \frac{22}{7} \times 100 = \frac{550}{7} \approx 78.57 \text{ cm}^2.$$

$$\text{Whole circle} = \pi r^2 = \frac{22}{7} \times 100 = \frac{2200}{7} \text{ cm}^2.$$

$$\text{Major sector} = \frac{2200}{7} - \frac{550}{7} = \frac{1650}{7} \approx 235.71 \text{ cm}^2.$$

Answer: Minor sector $\frac{550}{7} \approx 78.57 \text{ cm}^2$; major sector $\frac{1650}{7} \approx 235.71 \text{ cm}^2$

Common mistake: Using 60° per hour (that is the minute hand: 6° per minute). The hour hand turns only 30° per hour.

Q30 · REAL NUMBERS · 3 MARKS

Prove that $\sqrt{3}$ is an irrational number.

SOLUTION

Suppose $\sqrt{3}$ is rational. Then $\sqrt{3} = \frac{p}{q}$ with integers p, q ($q \neq 0$) having no common factor.

Squaring: $3q^2 = p^2$. So 3 divides p^2 , and since 3 is prime, 3 divides p . Write $p = 3a$.

Then $3q^2 = 9a^2$, so $q^2 = 3a^2$. So 3 divides q^2 , and hence 3 divides q .

Now 3 is a common factor of p and q , which contradicts "no common factor". So $\sqrt{3}$ is irrational.

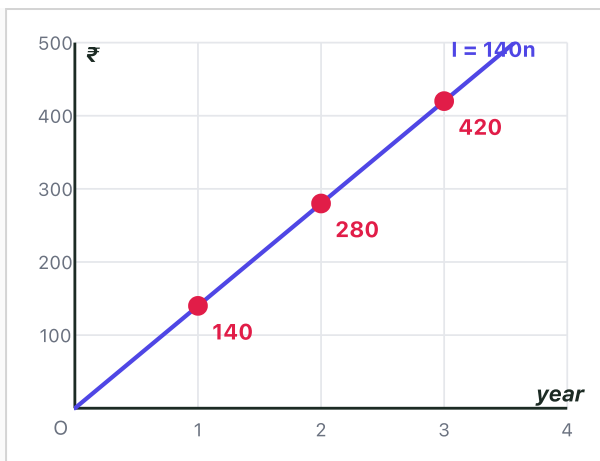
Answer: Proved by contradiction

Common mistake: Skipping the reason that "3 divides p squared" gives "3 divides p ": it works because 3 is prime.

Q31 · ARITHMETIC PROGRESSIONS · 3 MARKS

A sum of ₹ 2,000 is invested at 7% per annum simple interest. Calculate the interests at the end of 1st, 2nd and 3rd year. Do these interests form an AP? If so, find the interest at the end of the 27th year.

SOLUTION



Simple interest = $\frac{P \times R \times T}{100}$. Each year adds $\frac{2000 \times 7}{100} = ₹140$.

End of year 1: ₹140. End of year 2: $\frac{2000 \times 7 \times 2}{100} = ₹280$. End of year 3: ₹420.

The list 140, 280, 420, ... goes up by 140 each time (difference $280 - 140 = 140 = 420 - 280$), so yes, it is an AP with $a = 140$ and $d = 140$.

Interest at the end of the 27th year: $a_{27} = a + 26d = 140 + 26 \times 140 = 140 \times 27 = ₹3780$.

Answer: ₹140, ₹280, ₹420; yes, an AP; ₹3780 at the end of the 27th year

Common mistake: Using the $(n - 1)$ rule on the wrong number: here the n th term is simply $140 \times n$, and the 27th is 140×27 .

Section D: Long answer

4 questions, 5 marks each.

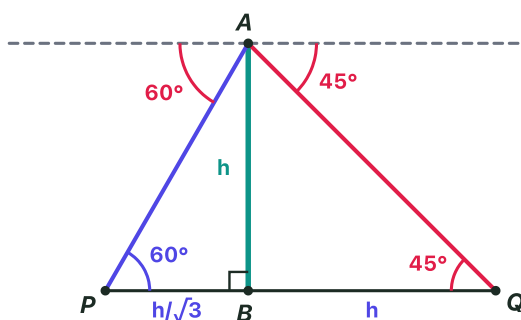
Q32 · APPLICATIONS OF TRIGONOMETRY · 5 MARKS

(a) Two ships are sailing in the sea on either side of a lighthouse. The angles of depression to the two ships as observed from the top of the lighthouse are 60° and 45° , respectively. If the distance between the ships is $100 \left(\frac{1 + \sqrt{3}}{\sqrt{3}} \right)$ m, then find the height of the lighthouse.

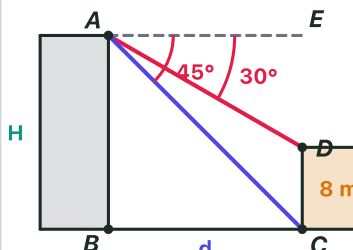
OR

(b) The angles of depression of the top and the bottom of an 8 m tall building from the top of another multistoried building are 30° and 45° , respectively. Find the height of the multistoried building and the distance between the two buildings.

SOLUTION



Alternate angles: the angle of depression from A equals the angle of elevation of A from the ship.



At 45° to the bottom, $d = H$. At 30° to the top, $(H - 8)/d = \tan 30^\circ$.

(a) Let the lighthouse be $AB = h$, with the ships at P (angle of depression 60°) and Q (angle of depression 45°) on either side of B .

The angle of depression from A equals the angle of elevation of A from the ship (alternate angles). In $\triangle ABP$:

$$\tan 60^\circ = \frac{h}{PB}, \text{ so } PB = \frac{h}{\sqrt{3}}.$$

$$\text{In } \triangle ABQ: \tan 45^\circ = \frac{h}{BQ} = 1, \text{ so } BQ = h.$$

$$PQ = PB + BQ = \frac{h}{\sqrt{3}} + h = h \left(\frac{1 + \sqrt{3}}{\sqrt{3}} \right).$$

$$\text{This equals } 100 \left(\frac{1 + \sqrt{3}}{\sqrt{3}} \right), \text{ so } h = 100 \text{ m.}$$

(b) Let the tall building have height H and the buildings be d apart. The bottom C of the small building is seen at 45° : $\tan 45^\circ = \frac{H}{d}$, so $d = H$.

$$\text{The top } D \text{ of the small building is } 8 \text{ m above } C, \text{ so it is } H - 8 \text{ below the observer's level. } \tan 30^\circ = \frac{H - 8}{d} = \frac{H - 8}{H} = \frac{1}{\sqrt{3}}.$$

$$\sqrt{3}(H - 8) = H, \text{ so } H(\sqrt{3} - 1) = 8\sqrt{3} \text{ and } H = \frac{8\sqrt{3}}{\sqrt{3} - 1} = \frac{8\sqrt{3}(\sqrt{3} + 1)}{2} = 4\sqrt{3}(\sqrt{3} + 1) = 12 + 4\sqrt{3} \text{ m.}$$

The distance between the buildings is $d = H = (12 + 4\sqrt{3}) \text{ m} \approx 18.93 \text{ m}$.

Answer: (a) 100 m (b) height $(12 + 4\sqrt{3}) \text{ m} \approx 18.93 \text{ m}$; distance $(12 + 4\sqrt{3}) \text{ m}$

Common mistake: In (b), using H for the height of the top of the small building. Its top is $H - 8$ below the observer, and that is the side used with $\tan 30^\circ$.

Q33 · QUADRATIC EQUATIONS · 5 MARKS

(a) The sum of the areas of two squares is 52 cm^2 and difference of their perimeters is 8 cm . Find the lengths of the sides of the two squares.

OR

(b) The time taken by a person to travel an upward distance of 150 km was $2\frac{1}{2}$ hours more than the time taken in the downward return journey. If he returned at a speed of 10 km/h more than the speed while going up, find the speeds in each direction.

SOLUTION

(a) Let the sides be $x \text{ cm}$ and $y \text{ cm}$ with $x > y$. Areas: $x^2 + y^2 = 52$ (i)

Perimeters differ by 8: $4x - 4y = 8$, so $x - y = 2$ and $x = y + 2$ (ii)

Put (ii) in (i): $(y + 2)^2 + y^2 = 52$, so $2y^2 + 4y + 4 = 52$ and $y^2 + 2y - 24 = 0$.

$(y + 6)(y - 4) = 0$. A side cannot be negative, so $y = 4$ and $x = 6$.

Check: $36 + 16 = 52 \checkmark$ and $4 \times 6 - 4 \times 4 = 8 \checkmark$.

(b) Let the speed going up be x km/h, so the speed coming down is $(x + 10)$ km/h.

Time up = $\frac{150}{x}$ and time down = $\frac{150}{x + 10}$. The time up was $2\frac{1}{2} = \frac{5}{2}$ hours more: $\frac{150}{x} - \frac{150}{x + 10} = \frac{5}{2}$.

Combine: $\frac{150 \times 10}{x(x + 10)} = \frac{5}{2}$, so $x(x + 10) = 600$ and $x^2 + 10x - 600 = 0$.

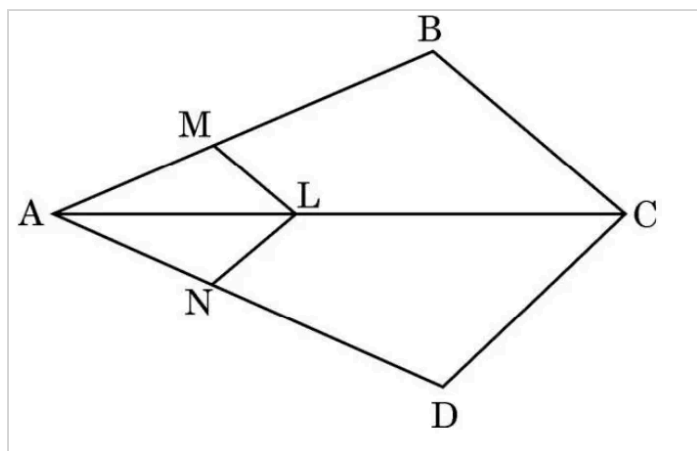
$(x + 30)(x - 20) = 0$. Speed cannot be negative, so $x = 20$. The speed going up is 20 km/h and coming down is 30 km/h.

Answer: (a) 6 cm and 4 cm (b) 20 km/h up and 30 km/h down

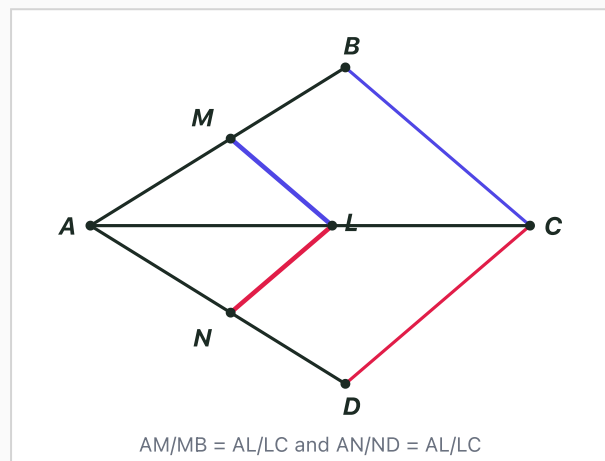
Common mistake: Leaving the negative root. Say clearly why a negative length or speed is rejected.

Q34 · TRIANGLES · 5 MARKS

Prove that a line drawn parallel to one side of a triangle to intersect the other two sides in distinct points divides the other two sides in the same ratio. Hence, in the figure given below, prove that $\frac{AM}{MB} = \frac{AN}{ND}$ where $LM \parallel CB$ and $LN \parallel CD$.



SOLUTION



Basic Proportionality Theorem: if $DE \parallel BC$ in $\triangle ABC$ with D on AB and E on AC , then $\frac{AD}{DB} = \frac{AE}{EC}$.

Proof: join BE and CD . Triangles BDE and DEC stand on the same base DE and lie between the same parallels DE and BC , so $\text{area}(\triangle BDE) = \text{area}(\triangle DEC)$.

Triangles ADE and BDE have the same height from E , so $\frac{\text{area}(ADE)}{\text{area}(BDE)} = \frac{AD}{DB}$. Triangles ADE and DEC have the same height from D , so $\frac{\text{area}(ADE)}{\text{area}(DEC)} = \frac{AE}{EC}$.

The areas of BDE and DEC are equal, so $\frac{AD}{DB} = \frac{AE}{EC}$. This proves the theorem.

Application. In $\triangle ABC$, $LM \parallel CB$ with M on AB and L on AC , so $\frac{AM}{MB} = \frac{AL}{LC}$... (i)

In $\triangle ADC$, $LN \parallel CD$ with N on AD and L on AC , so $\frac{AN}{ND} = \frac{AL}{LC}$... (ii)

The right sides of (i) and (ii) are the same, so $\frac{AM}{MB} = \frac{AN}{ND}$.

Answer: Theorem proved and $\frac{AM}{MB} = \frac{AN}{ND}$

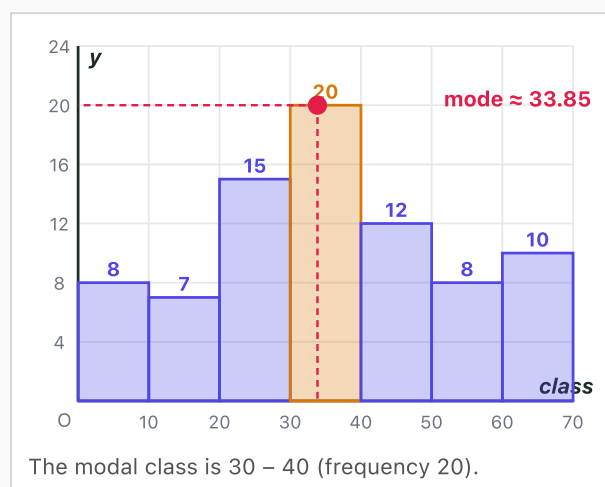
Common mistake: Using the theorem without first naming the triangle in which the line is parallel to a side.

Q35 · STATISTICS · 5 MARKS

Find the Mean and Mode of the following frequency distribution:

Class	Frequency
0 – 10	8
10 – 20	7
20 – 30	15
30 – 40	20
40 – 50	12
50 – 60	8
60 – 70	10

SOLUTION



Class marks x_i : 5, 15, 25, 35, 45, 55, 65. Frequencies f_i : 8, 7, 15, 20, 12, 8, 10, with $\sum f_i = 80$.

Products $f_i x_i$: 40, 105, 375, 700, 540, 440, 650. Their sum is $\sum f_i x_i = 2850$.

$$\text{Mean} = \frac{\sum f_i x_i}{\sum f_i} = \frac{2850}{80} = 35.625.$$

The highest frequency is 20, so the modal class is 30 – 40: $l = 30$, $f_1 = 20$, $f_0 = 15$, $f_2 = 12$, $h = 10$.

$$\text{Mode} = l + \frac{f_1 - f_0}{2f_1 - f_0 - f_2} \times h = 30 + \frac{20 - 15}{40 - 15 - 12} \times 10 = 30 + \frac{5}{13} \times 10 = 30 + \frac{50}{13} \approx 33.85.$$

Answer: Mean = 35.625 and Mode ≈ 33.85 (exactly $\frac{440}{13}$)

Common mistake: Using the wrong neighbours in the mode formula: f_0 is the frequency of the class BEFORE the modal class and f_2 of the class AFTER it.

Section E: Case studies

3 case studies, 4 marks each.

Q36 · LINEAR EQUATIONS · 4 MARKS

Case study 1. A school is organizing a grand cultural event to show the talent of its students. To accommodate the guests, the school plans to rent chairs and tables from a local supplier. It finds that rent for each chair is ₹50 and for each table is ₹200. The school spends ₹30,000 for renting the chairs and tables. Also, the total number of items (chairs and tables) rented are 300.

If the school rents 'x' chairs and 'y' tables, answer the following questions:

(i) Write down the pair of linear equations representing the given information. [1]

(ii) (a) Find the number of chairs and number of tables rented by the school. [2]

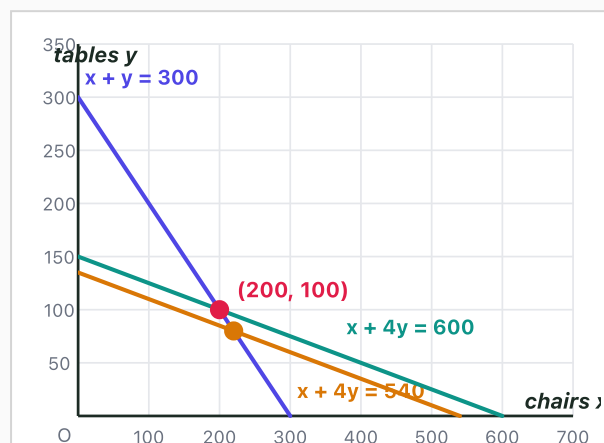
OR

(ii) (b) If the school wants to spend a maximum of ₹27,000 on 300 items (tables and chairs), then find the number of chairs and tables it can rent. [2]

(iii) What is maximum number of tables that can be rented in ₹30,000 if no chairs are rented? [1]

Figure: A photo of a hall set with rows of tables and chairs.

SOLUTION



Part (ii)(a): the first two lines meet at (200, 100). Part (ii)(b): the first and the amber line meet at (220, 80).

(i) Total items: $x + y = 300$. Total rent: $50x + 200y = 30000$, which simplifies (divide by 50) to $x + 4y = 600$.

(ii)(a) Subtract the first equation from the second: $(x + 4y) - (x + y) = 600 - 300$, so $3y = 300$ and $y = 100$. Then $x = 300 - 100 = 200$. The school rents 200 chairs and 100 tables.

(ii)(b) With a budget of ₹27000: $50x + 200y = 27000$, i.e. $x + 4y = 540$. With $x + y = 300$: $3y = 240$, so $y = 80$ and $x = 220$. It can rent 220 chairs and 80 tables.

(iii) With no chairs, all the money buys tables: $\frac{30000}{200} = 150$ tables.

Answer: (i) $x + y = 300$, $x + 4y = 600$ (ii)(a) 200 chairs, 100 tables (ii)(b) 220 chairs, 80 tables (iii) 150

Common mistake: Keeping $50x + 200y = 30000$ without simplifying. Dividing by 50 makes the subtraction method easy.

Q37 · PROBABILITY · 4 MARKS

Case study 2. Rahul is a lucky charm for his cricket team. He has a jar of cards with numbers from 10 to 74. Before each match, he draws a card from the jar. If the card bears an even number, the team wins. If the number is even and divisible by 5, they win by a big margin. If the number is an odd number less than 30, they win by a small margin. And if the number is a prime number between 50 and 74, they lose.

Answer the following questions if Rahul draws a card today:

- (i) What is the probability that Rahul draws a card with an even number? [1]
- (ii) What is the probability that Rahul draws a card with an odd number less than 30? [1]
- (iii) (a) What is the probability that Rahul draws a card with a prime number between 50 and 74? [2]

OR

- (iii) (b) What is the probability that Rahul draws a card with an even number divisible by 5? [2]

Figure: A photo of a hand dropping a folded paper card into a glass jar full of cards.

SOLUTION

Total number of cards = $74 - 10 + 1 = 65$ (the numbers 10, 11, ..., 74).

(i) Even numbers from 10 to 74: 10, 12, ..., 74. Count = $\frac{74 - 10}{2} + 1 = 33$. So $P(\text{even}) = \frac{33}{65}$.

(ii) Odd numbers less than 30 (from 10): 11, 13, 15, 17, 19, 21, 23, 25, 27, 29. That is 10 numbers. $P = \frac{10}{65} = \frac{2}{13}$.

(iii)(a) Primes between 50 and 74: 53, 59, 61, 67, 71, 73. That is 6 numbers. $P = \frac{6}{65}$.

(iii)(b) Even numbers divisible by 5 are the multiples of 10: 10, 20, 30, 40, 50, 60, 70. That is 7 numbers. $P = \frac{7}{65}$.

Answer: (i) $\frac{33}{65}$ (ii) $\frac{2}{13}$ (iii)(a) $\frac{6}{65}$ (iii)(b) $\frac{7}{65}$

Common mistake: Taking the total as 74 or 64. The cards run from 10 to 74, so there are 65 of them.

Q38 · SURFACE AREAS AND VOLUMES · 4 MARKS

Case study 3. A skilled carpenter decided to craft a special rolling pin for the local baker. He carefully joined three cylindrical pieces of wood – two small ones on the ends and one larger in the centre to create a perfect tool. The baker loved the rolling pin, as it rolled out the smoothest dough for breads and pastries.

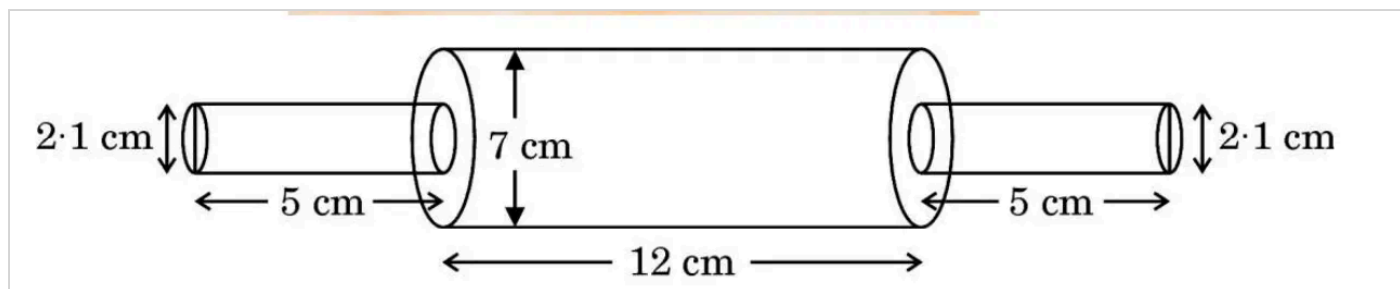
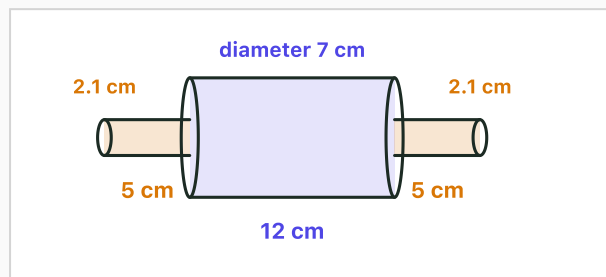
The length of the bigger cylindrical part is 12 cm and diameter is 7 cm and the length of each smaller cylindrical part is 5 cm and diameter is 2.1 cm.

Based on the above information, answer the following questions:

- (i) Find the volume of the bigger cylindrical part. [1]
- (ii) Find the curved surface area of the bigger cylindrical part. [1]
- (iii) (a) Find the ratio of the volume of the bigger cylindrical part to the total volume of the two smaller (identical) cylindrical parts. [2]

OR

- (iii) (b) Find the sum of the curved surface areas of the two identical smaller cylindrical parts. [2]

**SOLUTION**

Bigger cylinder: diameter 7 cm, so $r = 3.5$ cm, and length $h = 12$ cm. Use $\pi = \frac{22}{7}$.

(i) Volume = $\pi r^2 h = \frac{22}{7} \times 3.5 \times 3.5 \times 12 = 22 \times 0.5 \times 3.5 \times 12 = 462 \text{ cm}^3$.

(ii) Curved surface area = $2\pi r h = 2 \times \frac{22}{7} \times 3.5 \times 12 = 264 \text{ cm}^2$.

(iii)(a) Each smaller cylinder: diameter 2.1 cm, so $r = 1.05$ cm, and length 5 cm. Volume of one = $\frac{22}{7} \times 1.05 \times 1.05 \times 5 = 17.325 \text{ cm}^3$. Two of them: $2 \times 17.325 = 34.65 \text{ cm}^3$.

Ratio = $462 : 34.65 = \frac{462}{34.65} = \frac{40}{3}$, that is 40 : 3 (equivalently 3080 : 231).

(iii)(b) Curved surface area of one small cylinder = $2\pi r h = 2 \times \frac{22}{7} \times 1.05 \times 5 = 33 \text{ cm}^2$. For two: $2 \times 33 = 66 \text{ cm}^2$.

Answer: (i) 462 cm^3 (ii) 264 cm^2 (iii)(a) 40 : 3 (iii)(b) 66 cm^2

Common mistake: Using the diameter in place of the radius in $\pi r^2 h$. Halve the diameter first.

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