

Mathematics (Standard) 2025, Set 30/6/1

Q.P. Code 30/6/1 · Series F6EGH · 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 · REAL NUMBERS · 1 MARK

$\sqrt{0.4}$ is a/an

- (A) natural number (B) integer
(C) rational number (D) irrational number

SOLUTION

$$\sqrt{0.4} = \sqrt{\frac{4}{10}} = \frac{2}{\sqrt{10}}.$$

10 is not a perfect square, so $\sqrt{10}$ is irrational, and a non-zero rational number divided by an irrational number is irrational.

Answer: (D) irrational number

Common mistake: Thinking 0.4 is rational so its root must be. A square root of a rational number is rational only when it is a perfect square ratio, like $\sqrt{0.25} = 0.5$.

Q2 · REAL NUMBERS · 1 MARK

Which of the following cannot be the unit digit of 8^n , where n is a natural number?

- (A) 4 (B) 2
(C) 0 (D) 6

SOLUTION

The unit digits of $8^1, 8^2, 8^3, 8^4, \dots$ are 8, 4, 2, 6 and then repeat.

So the unit digit can be 8, 4, 2 or 6, but never 0. ($8^n = 2^{3n}$ has no factor 5, so it is never divisible by 10.)

Answer: (C) 0

Q3 · QUADRATIC EQUATIONS · 1 MARK

Which of the following quadratic equations has real and equal roots?

- (A) $(x+1)^2 = 2x+1$ (B) $x^2 + x = 0$
(C) $x^2 - 4 = 0$ (D) $x^2 + x + 1 = 0$

SOLUTION

Check the discriminant $D = b^2 - 4ac$ of each.

(A) $x^2 + 2x + 1 = 2x + 1$ gives $x^2 = 0$: $D = 0$, equal roots 0, 0. ✓

(B) $D = 1 > 0$ (roots 0, -1). (C) $D = 16 > 0$ (roots ± 2). (D) $D = 1 - 4 = -3 < 0$ (no real roots).

Answer: (A) $(x + 1)^2 = 2x + 1$

Common mistake: Reading (A) as already in standard form. Expand it first.

Q4 · POLYNOMIALS · 1 MARK

If the zeroes of the polynomial $ax^2 + bx + \frac{2a}{b}$ are reciprocal of each other, then the value of b is

(A) 2

(B) $\frac{1}{2}$

(C) -2

(D) $-\frac{1}{2}$

SOLUTION

Zeroes that are reciprocals of each other have product 1.

$$\text{Product of zeroes} = \frac{c}{a} = \frac{2a/b}{a} = \frac{2}{b}.$$

$$\frac{2}{b} = 1, \text{ so } b = 2.$$

Answer: (A) 2

Q5 · COORDINATE GEOMETRY · 1 MARK

The distance of the point $A(-3, -4)$ from x -axis is

(A) 3

(B) 4

(C) 5

(D) 7

SOLUTION

The distance of a point from the x -axis is the absolute value of its y -coordinate.

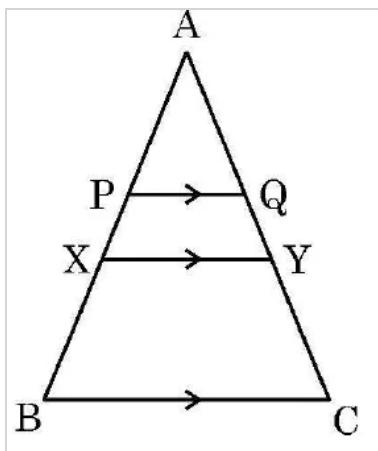
$$|-4| = 4.$$

Answer: (B) 4

Common mistake: Answering 5 (the distance from the origin). The question is about the x -axis only.

Q6 · TRIANGLES · 1 MARK

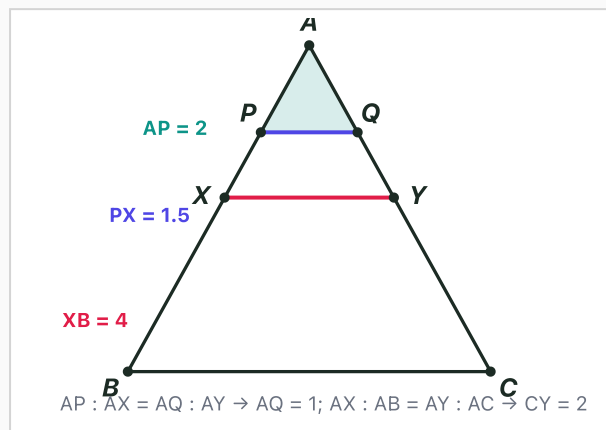
In the adjoining figure, $PQ \parallel XY \parallel BC$, $AP = 2$ cm, $PX = 1.5$ cm and $BX = 4$ cm. If $QY = 0.75$ cm, then $AQ + CY =$



- (A) 6 cm
(C) 3 cm

- (B) 4.5 cm
(D) 5.25 cm

SOLUTION



$PQ \parallel XY$ in $\triangle AXY$: $\frac{AP}{PX} = \frac{AQ}{QY}$, so $\frac{2}{1.5} = \frac{AQ}{0.75}$ and $AQ = 1$ cm.

$AY = AQ + QY = 1.75$ cm and $AX = AP + PX = 3.5$ cm.

$XY \parallel BC$ in $\triangle ABC$: $\frac{AX}{XB} = \frac{AY}{YC}$, so $\frac{3.5}{4} = \frac{1.75}{CY}$ and $CY = 2$ cm.

$AQ + CY = 1 + 2 = 3$ cm.

Answer: (C) 3 cm

Common mistake: Using $\frac{AP}{PB}$ directly. P and Q are parallel to XY , so compare with AX , not AB .

Q7 · TRIANGLES · 1 MARK

Given $\triangle ABC \sim \triangle PQR$, $\angle A = 30^\circ$ and $\angle Q = 90^\circ$. The value of $(\angle R + \angle B)$ is

- (A) 90°
(C) 150°

- (B) 120°
(D) 180°

SOLUTION

$\triangle ABC \sim \triangle PQR$ means $A \leftrightarrow P, B \leftrightarrow Q, C \leftrightarrow R$. So $\angle P = 30^\circ, \angle B = \angle Q = 90^\circ$.

In $\triangle PQR$: $\angle R = 180^\circ - 30^\circ - 90^\circ = 60^\circ$.

$$\angle R + \angle B = 60^\circ + 90^\circ = 150^\circ.$$

Answer: (C) 150°

Common mistake: Taking $\angle A = 30^\circ$ to be in $\triangle PQR$ without matching the letters. The order $ABC \leftrightarrow PQR$ decides which angles are equal.

Q8 · PROBABILITY · 1 MARK

Two coins are tossed simultaneously. The probability of getting atleast one head is

- (A) $\frac{1}{4}$ (B) $\frac{1}{2}$
 (C) $\frac{3}{4}$ (D) 1

SOLUTION

Outcomes: HH, HT, TH, TT — 4 in all.

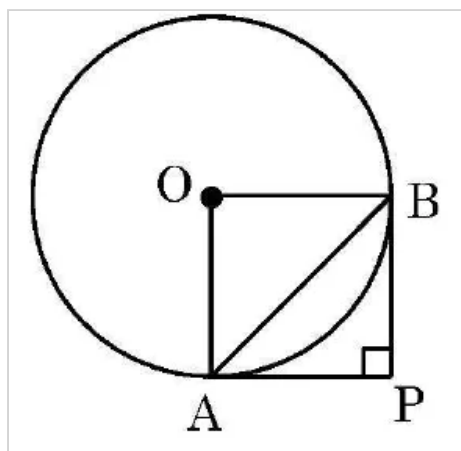
At least one head: HH, HT, TH — 3 outcomes (only TT has none).

$$P = \frac{3}{4}.$$

Answer: (C) $\frac{3}{4}$

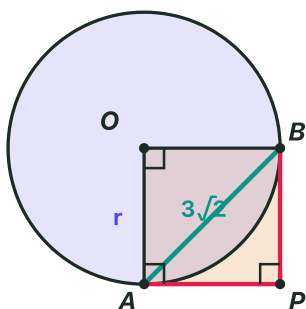
Q9 · CIRCLES · 1 MARK

In the adjoining figure, PA and PB are tangents to a circle with centre O such that $\angle P = 90^\circ$. If $AB = 3\sqrt{2}$ cm, then the diameter of the circle is



- (A) $3\sqrt{2}$ cm (B) $6\sqrt{2}$ cm
 (C) 3 cm (D) 6 cm

SOLUTION



OAPB is a square: $AB = r\sqrt{2} = 3\sqrt{2}$, $r = 3$

$OA \perp PA$ and $OB \perp PB$, and $\angle P = 90^\circ$. So $OAPB$ has four right angles, and $OA = OB = r$ gives a square of side r .

AB is a diagonal of this square: $AB = r\sqrt{2} = 3\sqrt{2}$, so $r = 3$ cm.

Diameter $= 2r = 6$ cm.

Answer: (D) 6 cm

Common mistake: Calling AB the diameter. AB is a chord, the diagonal of the square $OAPB$.

Q10 · CIRCLES · 1 MARK

For a circle with centre O and radius 5 cm, which of the following statements is true?

P : Distance between every pair of parallel tangents is 5 cm.

Q : Distance between every pair of parallel tangents is 10 cm.

R : Distance between every pair of parallel tangents must be between 5 cm and 10 cm.

S : There does not exist a point outside the circle from where length of tangent is 5 cm.

(A) P

(B) Q

(C) R

(D) S

SOLUTION

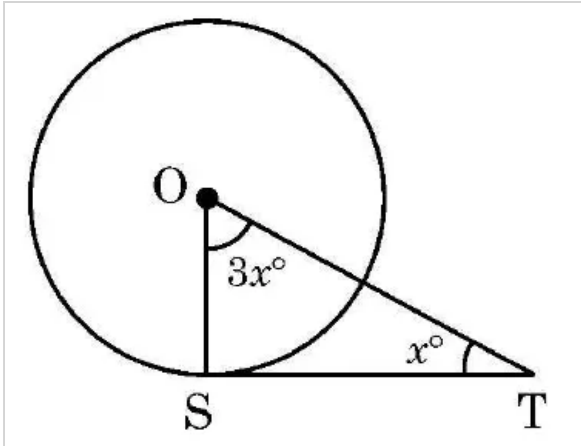
A pair of parallel tangents touch the circle at the two ends of a diameter, so the distance between them is the diameter, $2 \times 5 = 10$ cm, for every pair. So Q is true (and P, R are false).

S is false: from a point $5\sqrt{2}$ cm from the centre, the tangent length is $\sqrt{(5\sqrt{2})^2 - 5^2} = 5$ cm.

Answer: (B) Q

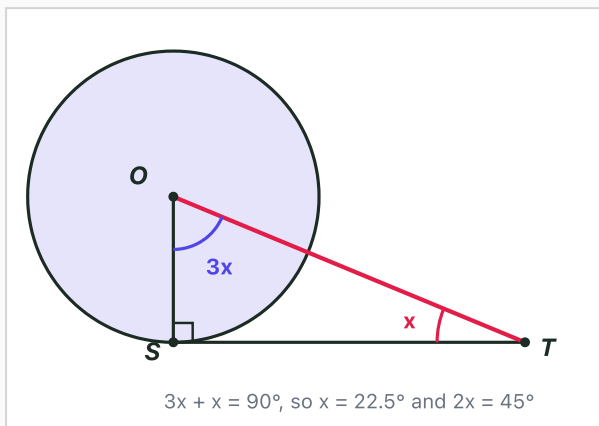
Q11 · CIRCLES · 1 MARK

In the adjoining figure, TS is a tangent to a circle with centre O . The value of $2x^\circ$ is



- (A) 22.5 (B) 45
(C) 67.5 (D) 90

SOLUTION



TS is a tangent, so $OS \perp TS$ and $\angle OST = 90^\circ$.

In $\triangle OST$: $3x + x + 90^\circ = 180^\circ$, so $4x = 90^\circ$ and $x = 22.5^\circ$.

$2x = 45^\circ$.

Answer: (B) 45

Common mistake: Stopping at $x = 22.5$. The question asks for $2x$.

Q12 · TRIGONOMETRY · 1 MARK

If $x \left(\frac{2 \tan 30^\circ}{1 + \tan^2 30^\circ} \right) = y \left(\frac{2 \tan 30^\circ}{1 - \tan^2 30^\circ} \right)$, then $x : y =$

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

SOLUTION

$$\tan 30^\circ = \frac{1}{\sqrt{3}}, \text{ so } \tan^2 30^\circ = \frac{1}{3}.$$

$$\frac{2 \tan 30^\circ}{1 + \tan^2 30^\circ} = \frac{2/\sqrt{3}}{4/3} = \frac{\sqrt{3}}{2} \text{ (this is } \sin 60^\circ \text{)}.$$

$$\frac{2 \tan 30^\circ}{1 - \tan^2 30^\circ} = \frac{2/\sqrt{3}}{2/3} = \sqrt{3} \text{ (this is } \tan 60^\circ \text{)}.$$

So $x \cdot \frac{\sqrt{3}}{2} = y\sqrt{3}$, giving $x = 2y$ and $x : y = 2 : 1$.

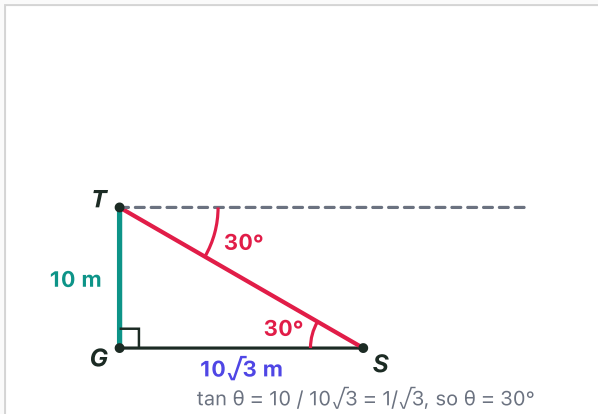
Answer: (C) 2 : 1

Q13 · APPLICATIONS OF TRIGONOMETRY · 1 MARK

A peacock sitting on the top of a tree of height 10 m observes a snake moving on the ground. If the snake is $10\sqrt{3}$ m away from the base of the tree, then angle of depression of the snake from the eye of the peacock is

- (A) 30° (B) 45°
(C) 60° (D) 90°

SOLUTION



In the right triangle formed by the tree, the ground and the line of sight: $\tan \theta = \frac{\text{height}}{\text{distance}} = \frac{10}{10\sqrt{3}} = \frac{1}{\sqrt{3}}$.

So $\theta = 30^\circ$ at the snake. The angle of depression at the peacock equals this angle of elevation (alternate angles), 30° .

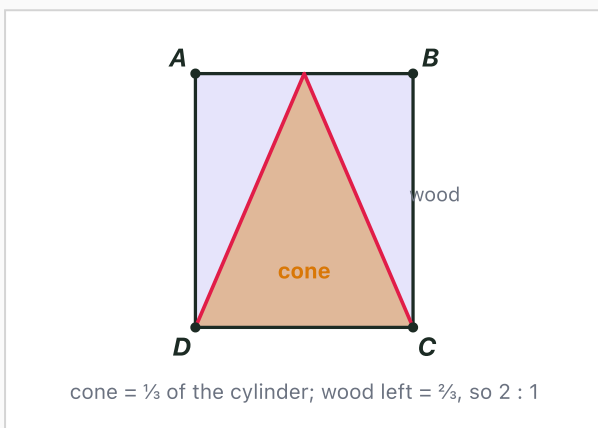
Answer: (A) 30°

Q14 · SURFACE AREAS AND VOLUMES · 1 MARK

If a cone of greatest possible volume is hollowed out from a solid wooden cylinder, then the ratio of the volume of remaining wood to the volume of cone hollowed out is

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

SOLUTION



The greatest cone has the same base radius r and the same height h as the cylinder.

Cone = $\frac{1}{3}\pi r^2 h$ and cylinder = $\pi r^2 h$, so the remaining wood = $\pi r^2 h - \frac{1}{3}\pi r^2 h = \frac{2}{3}\pi r^2 h$.

Remaining wood : cone = $\frac{2}{3} : \frac{1}{3} = 2 : 1$.

Answer: (C) 2 : 1

Q15 · STATISTICS · 1 MARK

If the mode of some observations is 10 and sum of mean and median is 25, then the mean and median respectively are

(A) 12 and 13

(B) 13 and 12

(C) 10 and 15

(D) 15 and 10

SOLUTION

Mode = 3 Median – 2 Mean, and Mean + Median = 25, so Mean = 25 – Median.

$10 = 3 \text{ Median} - 2(25 - \text{Median}) = 5 \text{ Median} - 50$, so Median = 12.

Mean = $25 - 12 = 13$. So the mean is 13 and the median is 12.

Answer: (B) 13 and 12

Common mistake: Reading the options as (median, mean). The question asks for the mean first.

Q16 · STATISTICS · 1 MARK

If the maximum number of students has obtained 52 marks out of 80, then

(A) 52 is the mean of the data.

(B) 52 is the median of the data.

(C) 52 is the mode of the data.

(D) 52 is the range of the data.

SOLUTION

The mode is the value that occurs most often, that is the value obtained by the maximum number of students.

So 52 is the mode of the data.

Answer: (C) 52 is the mode of the data.

Q17 · LINEAR EQUATIONS · 1 MARK

The system of equations $2x + 1 = 0$ and $3y - 5 = 0$ has

(A) unique solution

(B) two solutions

(C) no solution

(D) infinite number of solutions

SOLUTION

$2x + 1 = 0$ gives $x = -\frac{1}{2}$ and $3y - 5 = 0$ gives $y = \frac{5}{3}$.

These are a vertical and a horizontal line, which always cross at exactly one point, $\left(-\frac{1}{2}, \frac{5}{3}\right)$. A unique solution.

Answer: (A) unique solution

Q18 · TRIGONOMETRY · 1 MARK

In a right triangle ABC , right-angled at A , if $\sin B = \frac{1}{4}$, then the value of $\sec B$ is

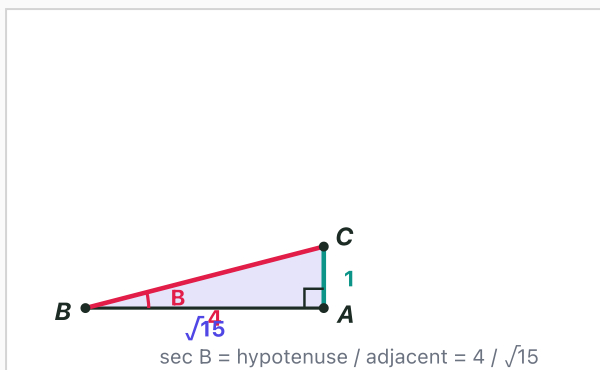
(A) 4

(B) $\frac{\sqrt{15}}{4}$

(C) $\sqrt{15}$

(D) $\frac{4}{\sqrt{15}}$

SOLUTION



$$\sin B = \frac{AC}{BC} = \frac{1}{4}. \text{ Take } AC = 1 \text{ and } BC = 4.$$

$$AB = \sqrt{BC^2 - AC^2} = \sqrt{16 - 1} = \sqrt{15}.$$

$$\cos B = \frac{AB}{BC} = \frac{\sqrt{15}}{4}, \text{ so } \sec B = \frac{1}{\cos B} = \frac{4}{\sqrt{15}}.$$

Answer: (D) $\frac{4}{\sqrt{15}}$

Common mistake: Giving $\cos B = \frac{\sqrt{15}}{4}$ (option B). Secant is the reciprocal of cosine.

Q19 · REAL NUMBERS · 1 MARK

Assertion (A): For any two prime numbers p and q , their HCF is 1 and LCM is $p + q$.

Reason (R): For any two natural numbers, $\text{HCF} \times \text{LCM} = \text{product of numbers}$.

(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 two different primes the HCF is 1, but the LCM is $p \times q$, not $p + q$ (for $p = 2$, $q = 3$ the LCM is 6, not 5). The assertion is false.

(R) $\text{HCF} \times \text{LCM} = \text{product of the two numbers}$ is a true standard result.

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

Q20 · PROBABILITY · 1 MARK

In an experiment of throwing a die,

Assertion (A): Event E_1 : getting a number less than 3 and Event E_2 : getting a number greater than 3 are complementary events.

Reason (R): If two events E and F are complementary events, then $P(E) + P(F) = 1$.

- (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) $E_1 = \{1, 2\}$ and $E_2 = \{4, 5, 6\}$. Together they miss the outcome 3, so E_2 is not "not E_1 ". They are not complementary. The assertion is false.

(R) Complementary events satisfy $P(E) + P(F) = 1$. True.

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

Section B: Very short answer

5 questions, 2 marks each.

Q21 · LINEAR EQUATIONS · 2 MARKS

(a) Solve the following pair of equations algebraically: $101x + 102y = 304$ and $102x + 101y = 305$.

OR

(b) In a pair of supplementary angles, the greater angle exceeds the smaller by 50° . Express the given situation as a system of linear equations in two variables and hence obtain the measure of each angle.

SOLUTION

(a) Add the equations: $203x + 203y = 609$, so $x + y = 3$ (i)

Subtract the first from the second: $x - y = 1$, that is $-x + y = -1$ (ii)

From (i) and (ii): $x = 2$ and $y = 1$. (Check: $101 \times 2 + 102 = 304$ ✓.)

(b) Let the smaller angle be x and the greater angle y . Supplementary: $x + y = 180$. The greater exceeds the smaller by 50 : $y = x + 50$.

Put in: $x + x + 50 = 180$, so $x = 65^\circ$ and $y = 115^\circ$.

Answer: (a) $x = 2, y = 1$ (b) $x + y = 180, y - x = 50$; angles 65° and 115°

Q22 · TRIGONOMETRY · 2 MARKS

(a) If $a \sec \theta + b \tan \theta = m$ and $b \sec \theta + a \tan \theta = n$, prove that $a^2 + n^2 = b^2 + m^2$.

OR

(b) Use the identity $\sin^2 A + \cos^2 A = 1$ to prove that $\tan^2 A + 1 = \sec^2 A$. Hence, find the value of $\tan A$, when $\sec A = \frac{5}{3}$, where A is an acute angle.

SOLUTION

(a) $m^2 = a^2 \sec^2 \theta + b^2 \tan^2 \theta + 2ab \sec \theta \tan \theta$ and $n^2 = b^2 \sec^2 \theta + a^2 \tan^2 \theta + 2ab \sec \theta \tan \theta$.

Subtract: $m^2 - n^2 = a^2(\sec^2 \theta - \tan^2 \theta) + b^2(\tan^2 \theta - \sec^2 \theta) = a^2 - b^2$ (as $\sec^2 \theta - \tan^2 \theta = 1$).

So $m^2 - n^2 = a^2 - b^2$, that is $a^2 + n^2 = b^2 + m^2$.

(b) Divide $\sin^2 A + \cos^2 A = 1$ by $\cos^2 A$: $\tan^2 A + 1 = \sec^2 A$.

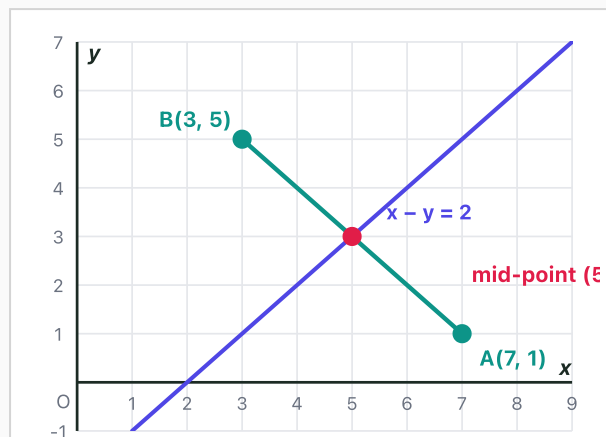
With $\sec A = \frac{5}{3}$: $\tan^2 A = \frac{25}{9} - 1 = \frac{16}{9}$, so $\tan A = \frac{4}{3}$ (positive, as A is acute).

Answer: (a) proved (b) $\tan A = \frac{4}{3}$

Q23 · COORDINATE GEOMETRY · 2 MARKS

Prove that abscissa of a point P which is equidistant from points with coordinates $A(7, 1)$ and $B(3, 5)$ is 2 more than its ordinate.

SOLUTION



The perpendicular bisector of AB: $x - y = 2$, so the abscissa is 2 more than the ordinate.

Let $P = (x, y)$ with $PA = PB$, so $PA^2 = PB^2$.

$$(x - 7)^2 + (y - 1)^2 = (x - 3)^2 + (y - 5)^2.$$

$$x^2 - 14x + 49 + y^2 - 2y + 1 = x^2 - 6x + 9 + y^2 - 10y + 25, \text{ so } -8x + 8y = -16.$$

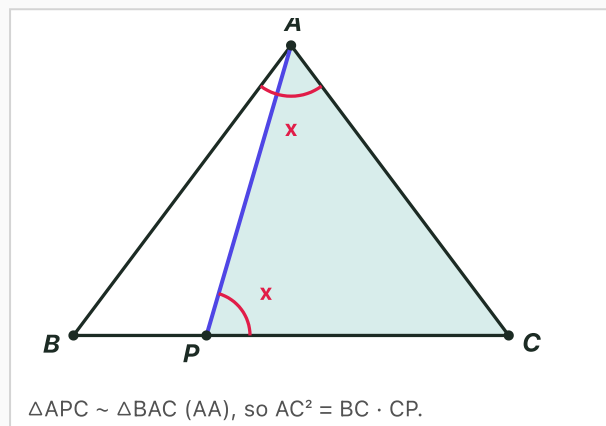
$x - y = 2$, that is $x = y + 2$: the abscissa is 2 more than the ordinate.

Answer: $x = y + 2$

Q24 · TRIANGLES · 2 MARKS

P is a point on the side BC of $\triangle ABC$ such that $\angle APC = \angle BAC$. Prove that $AC^2 = BC \cdot CP$.

SOLUTION



$\triangle APC \sim \triangle BAC$ (AA), so $AC^2 = BC \cdot CP$.

In $\triangle APC$ and $\triangle BAC$: $\angle APC = \angle BAC$ (given) and $\angle C$ is common.

So $\triangle APC \sim \triangle BAC$ by AA similarity.

Corresponding sides are proportional: $\frac{AC}{BC} = \frac{CP}{AC}$, so $AC^2 = BC \cdot CP$.

Answer: $AC^2 = BC \cdot CP$

Common mistake: Writing $\frac{AC}{CP} = \frac{BC}{AC}$ with the wrong pairing. Match the vertices in order: $A \leftrightarrow B, P \leftrightarrow A, C \leftrightarrow C$.

Q25 · PROBABILITY · 2 MARKS

The number of red balls in a bag is three more than the number of black balls. If the probability of drawing a red ball at random from the given bag is $\frac{12}{23}$, find the total number of balls in the given bag.

SOLUTION

Let the black balls be x . Red balls = $x + 3$ and the total = $2x + 3$.

$$\frac{x + 3}{2x + 3} = \frac{12}{23}, \text{ so } 23x + 69 = 24x + 36 \text{ and } x = 33.$$

$$\text{Total} = 2 \times 33 + 3 = 69. \text{ (Check: red} = 36 \text{ and } \frac{36}{69} = \frac{12}{23} \checkmark.)$$

Answer: 69 balls

Section C: Short answer

6 questions, 3 marks each.

Q26 · REAL NUMBERS · 3 MARKS

(a) Prove that $\sqrt{5}$ is an irrational number.

OR

(b) Let p, q and r be three distinct prime numbers. Check whether $p \cdot q \cdot r + q$ is a composite number or not. Further, give an example for 3 distinct primes p, q, r such that (i) $p \cdot q \cdot r + 1$ is a composite number. (ii) $p \cdot q \cdot r + 1$ is a prime number.

SOLUTION

(a) Suppose $\sqrt{5} = \frac{p}{q}$, with p, q co-prime and $q \neq 0$. Then $5q^2 = p^2$, so 5 divides p^2 and so 5 divides p . Write $p = 5a$.

Then $25a^2 = 5q^2$, so $q^2 = 5a^2$, so 5 divides q^2 and hence q . Now 5 divides both p and q , contradicting that they are co-prime. So $\sqrt{5}$ is irrational.

(b) $pqr + q = q(pr + 1)$. It has the factor q and the factor $(pr + 1) > 1$, so it has more than two factors: it is a composite number.

(i) Take $p = 3, q = 5, r = 7$: $pqr + 1 = 105 + 1 = 106 = 2 \times 53$, composite.

(ii) Take $p = 2, q = 3, r = 5$: $pqr + 1 = 30 + 1 = 31$, which is prime.

Answer: (a) proved (b) composite; (i) 106 (ii) 31

Common mistake: In (b), assuming $pqr + 1$ is always prime or always composite. It can be either, so an example is needed for each.

Q27 · POLYNOMIALS · 3 MARKS

Find the zeroes of the polynomial $p(x) = 3x^2 - 4x - 4$. Hence, write a polynomial whose each of the zeroes is 2 more than zeroes of $p(x)$.

SOLUTION

$$3x^2 - 4x - 4 = 3x^2 - 6x + 2x - 4 = 3x(x - 2) + 2(x - 2) = (3x + 2)(x - 2).$$

The zeroes are $x = -\frac{2}{3}$ and $x = 2$.

The new zeroes are each 2 more: $-\frac{2}{3} + 2 = \frac{4}{3}$ and $2 + 2 = 4$.

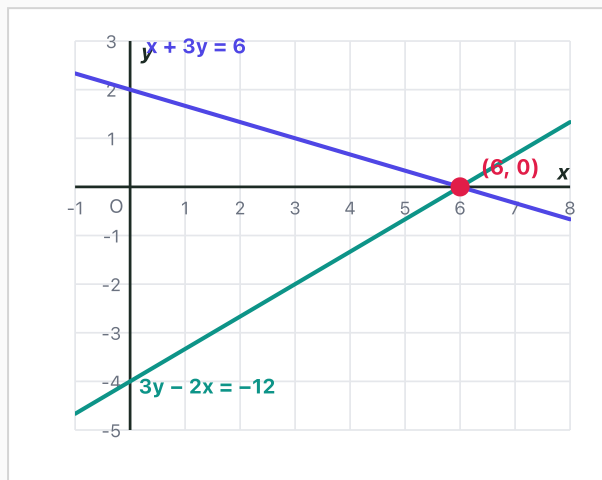
$$\text{Sum} = \frac{4}{3} + 4 = \frac{16}{3} \text{ and product} = \frac{4}{3} \times 4 = \frac{16}{3}.$$

Polynomial: $x^2 - \frac{16}{3}x + \frac{16}{3}$, or multiplying by 3: $3x^2 - 16x + 16$.

Answer: Zeroes $-\frac{2}{3}$ and 2; new polynomial $3x^2 - 16x + 16$

Q28 · LINEAR EQUATIONS · 3 MARKS

Check whether the following pair of equations is consistent or not. If consistent, solve graphically: $x + 3y = 6$ and $3y - 2x = -12$.

SOLUTION

Write as $x + 3y - 6 = 0$ and $-2x + 3y + 12 = 0$. $\frac{a_1}{a_2} = \frac{1}{-2}$ and $\frac{b_1}{b_2} = \frac{3}{3} = 1$.

$\frac{a_1}{a_2} \neq \frac{b_1}{b_2}$, so the lines intersect at one point: the pair is consistent.

First line: $(0, 2), (3, 1), (6, 0)$. Second line: $3y = 2x - 12$, points $(0, -4), (3, -2), (6, 0)$.

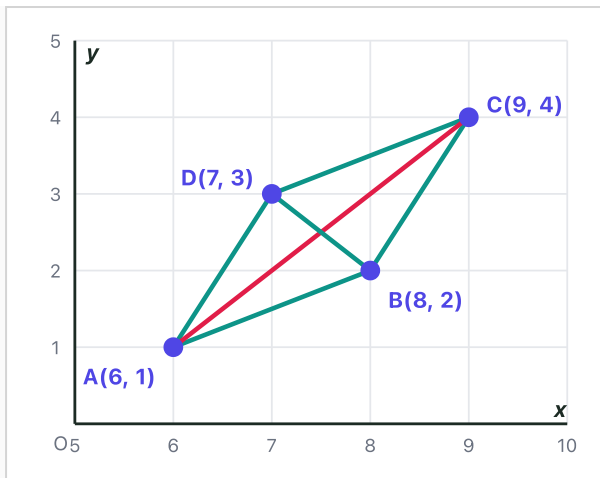
The two lines cross at $(6, 0)$. So $x = 6, y = 0$.

Answer: Consistent; $x = 6, y = 0$

Q29 · COORDINATE GEOMETRY · 3 MARKS

If the points $A(6, 1), B(p, 2), C(9, 4)$ and $D(7, q)$ are the vertices of a parallelogram $ABCD$, then find the values of p and q . Hence, check whether $ABCD$ is a rectangle or not.

SOLUTION



The diagonals of a parallelogram bisect each other, so the mid-point of AC equals the mid-point of BD .

$$\text{Mid-point of } AC = \left(\frac{6+9}{2}, \frac{1+4}{2} \right) = \left(\frac{15}{2}, \frac{5}{2} \right). \text{ Mid-point of } BD = \left(\frac{p+7}{2}, \frac{2+q}{2} \right).$$

$$\frac{p+7}{2} = \frac{15}{2} \text{ gives } p = 8, \text{ and } \frac{2+q}{2} = \frac{5}{2} \text{ gives } q = 3.$$

$$\text{Now } B = (8, 2) \text{ and } D = (7, 3). AC = \sqrt{3^2 + 3^2} = 3\sqrt{2} \text{ and } BD = \sqrt{(-1)^2 + 1^2} = \sqrt{2}.$$

The diagonals of a rectangle are equal. Here $AC \neq BD$, so $ABCD$ is not a rectangle.

Answer: $p = 8, q = 3$; $ABCD$ is not a rectangle

Q30 · TRIGONOMETRY · 3 MARKS

(a) Prove that: $\frac{\cos \theta - 2 \cos^3 \theta}{\sin \theta - 2 \sin^3 \theta} + \cot \theta = 0$.

OR

(b) Given that $\sin \theta + \cos \theta = x$, prove that $\sin^4 \theta + \cos^4 \theta = \frac{2 - (x^2 - 1)^2}{2}$.

SOLUTION

(a) Factorise: $\frac{\cos \theta(1 - 2 \cos^2 \theta)}{\sin \theta(1 - 2 \sin^2 \theta)}$. Write $1 = \sin^2 \theta + \cos^2 \theta$ in each bracket.

$$1 - 2 \cos^2 \theta = \sin^2 \theta - \cos^2 \theta \text{ and } 1 - 2 \sin^2 \theta = \cos^2 \theta - \sin^2 \theta. \text{ So the fraction is } \cot \theta \times \frac{\sin^2 \theta - \cos^2 \theta}{\cos^2 \theta - \sin^2 \theta} = -\cot \theta.$$

$$\text{LHS} = -\cot \theta + \cot \theta = 0 = \text{RHS}.$$

(b) Square $\sin \theta + \cos \theta = x$: $1 + 2 \sin \theta \cos \theta = x^2$, so $2 \sin \theta \cos \theta = x^2 - 1$.

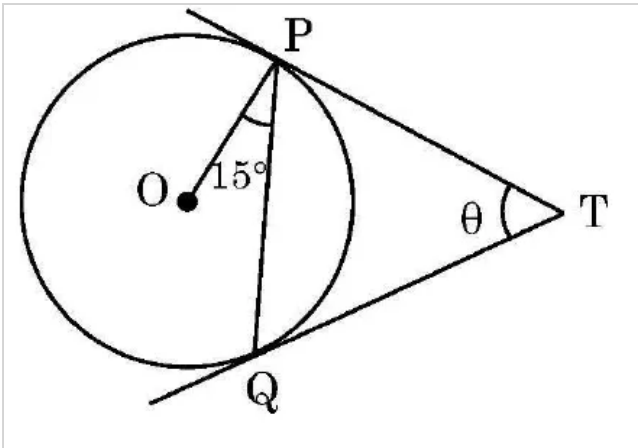
$$\text{RHS} = \frac{2 - (2 \sin \theta \cos \theta)^2}{2} = \frac{2 - 4 \sin^2 \theta \cos^2 \theta}{2} = 1 - 2 \sin^2 \theta \cos^2 \theta.$$

$$1 = (\sin^2 \theta + \cos^2 \theta)^2 = \sin^4 \theta + \cos^4 \theta + 2 \sin^2 \theta \cos^2 \theta, \text{ so } \text{RHS} = \sin^4 \theta + \cos^4 \theta = \text{LHS}.$$

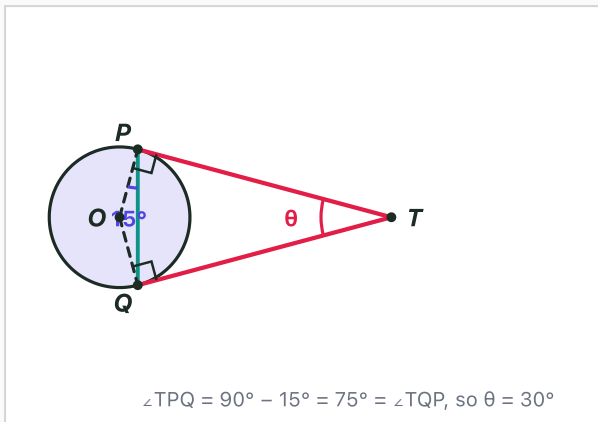
Answer: Both proved

Q31 · CIRCLES · 3 MARKS

In the adjoining figure, TP and TQ are tangents drawn to a circle with centre O . If $\angle OPQ = 15^\circ$ and $\angle PTQ = \theta$, then find the value of $\sin 2\theta$.



SOLUTION



$OP \perp TP$, so $\angle OPT = 90^\circ$. Then $\angle TPQ = \angle OPT - \angle OPQ = 90^\circ - 15^\circ = 75^\circ$.

Tangents from T are equal: $TP = TQ$, so $\angle TQP = \angle TPQ = 75^\circ$.

In $\triangle TPQ$: $\theta = 180^\circ - 75^\circ - 75^\circ = 30^\circ$.

$$\sin 2\theta = \sin 60^\circ = \frac{\sqrt{3}}{2}.$$

Answer: $\sin 2\theta = \frac{\sqrt{3}}{2}$

Common mistake: Answering $\sin 30^\circ$. The question asks for $\sin 2\theta$, with $\theta = 30^\circ$.

Section D: Long answer

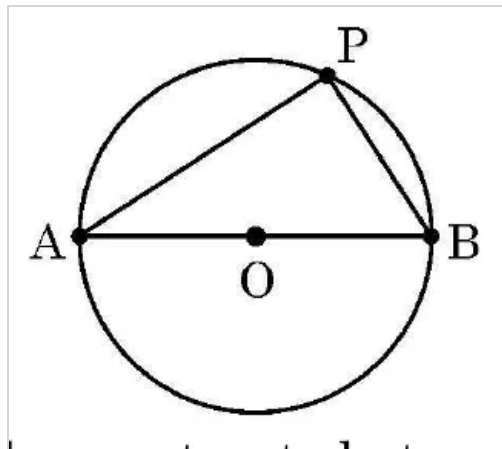
4 questions, 5 marks each.

Q32 · QUADRATIC EQUATIONS · 5 MARKS

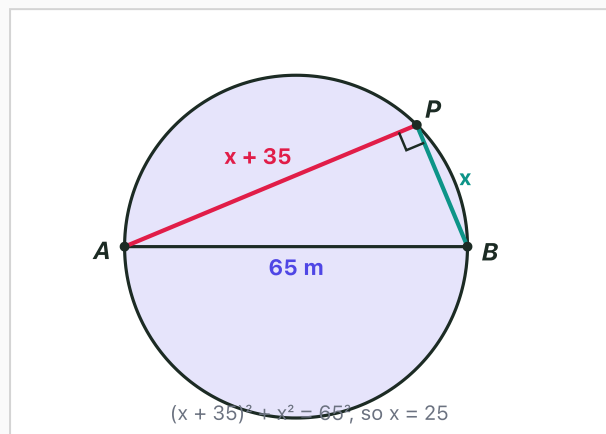
(a) There is a circular park of diameter 65 m as shown in the following figure, where AB is a diameter. An entry gate is to be constructed at a point P on the boundary of the park such that distance of P from A is 35 m more than the distance of P from B . Find distance of point P from A and B respectively.

OR

(b) Find the smallest value of p for which the quadratic equation $x^2 - 2(p+1)x + p^2 = 0$ has real roots. Hence, find the roots of the equation so obtained.



SOLUTION



(a) Let $PB = x$ m. Then $PA = (x + 35)$ m.

AB is a diameter, so $\angle APB = 90^\circ$ (angle in a semicircle). By Pythagoras: $(x + 35)^2 + x^2 = 65^2$.

$2x^2 + 70x + 1225 = 4225$, so $x^2 + 35x - 1500 = 0$. Factorise: $(x + 60)(x - 25) = 0$.

A distance is positive, so $x = 25$. $PB = 25$ m and $PA = 25 + 35 = 60$ m.

(b) Real roots need $D \geq 0$: $[-2(p+1)]^2 - 4 \times 1 \times p^2 \geq 0$, so $4(p^2 + 2p + 1) - 4p^2 \geq 0$ and $8p + 4 \geq 0$.

$p \geq -\frac{1}{2}$, so the smallest value is $p = -\frac{1}{2}$.

Put $p = -\frac{1}{2}$: $x^2 - 2\left(-\frac{1}{2}\right)x + \frac{1}{4} = 0$, that is $x^2 - x + \frac{1}{4} = 0$ or $4x^2 - 4x + 1 = 0$. So $(2x - 1)^2 = 0$ and $x = \frac{1}{2}, \frac{1}{2}$.

Answer: (a) $PA = 60$ m, $PB = 25$ m (b) $p = -\frac{1}{2}$; roots $\frac{1}{2}, \frac{1}{2}$

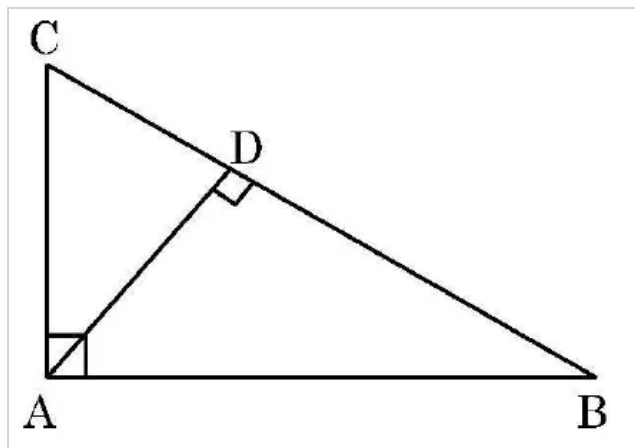
Common mistake: In (b), writing " $D > 0$ ". Real roots include the equal case, so $D \geq 0$, which gives the smallest p .

Q33 · TRIANGLES · 5 MARKS

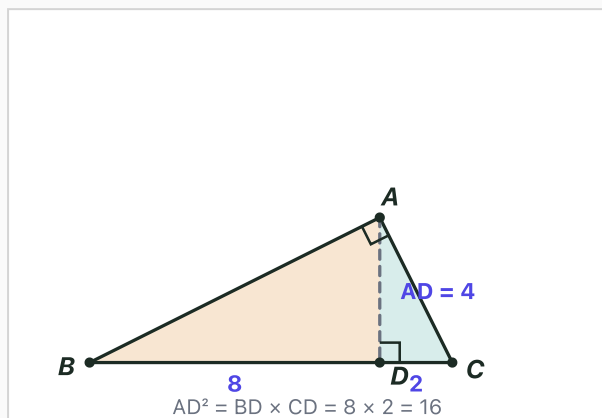
(a) If a line drawn parallel to one side of triangle intersecting the other two sides in distinct points divides the two sides in the same ratio, then it is parallel to third side. State and prove the converse of the above statement.

OR

(b) In the adjoining figure, $\triangle CAB$ is a right triangle, right angled at A and $AD \perp BC$. Prove that $\triangle ADB \sim \triangle CDA$. Further, if $BC = 10$ cm and $CD = 2$ cm, find the length of AD .



SOLUTION



(a) As printed, the English statement is already the converse of the Basic Proportionality Theorem (BPT), so "its converse" would be the BPT itself. CBSE's marking scheme notes that the English statement is not correct and gives full marks for a correct attempt: it expects the statement and proof of the BPT. Both are given here.

BPT: if a line is drawn parallel to one side of a triangle to meet the other two sides in distinct points, it divides those sides in the same ratio.

Proof: in $\triangle ABC$ let $DE \parallel BC$ with D on AB and E on AC . Join BE and CD . Triangles BDE and CDE are on the same base DE and between the same parallels, so $\text{ar}(BDE) = \text{ar}(CDE)$.

$\frac{\text{ar}(ADE)}{\text{ar}(BDE)} = \frac{AD}{DB}$ (same height from E) and $\frac{\text{ar}(ADE)}{\text{ar}(CDE)} = \frac{AE}{EC}$ (same height from D). The right sides have equal denominators in area, so $\frac{AD}{DB} = \frac{AE}{EC}$.

The statement as worded in the question, "if a line divides two sides in the same ratio, then it is parallel to the third side" (the converse), is proved by contradiction: if DE were not parallel to BC , draw $DE' \parallel BC$. Then $\frac{AE'}{E'C} = \frac{AD}{DB} = \frac{AE}{EC}$, which forces $E' = E$, so $DE \parallel BC$.

(b) In $\triangle ADB$ and $\triangle CDA$: $\angle ADB = \angle CDA = 90^\circ$. Also $\angle DAB = 90^\circ - \angle B$, and in $\triangle CAB$ (right angled at A) $\angle C = 90^\circ - \angle B$, so $\angle DAB = \angle C$.

So $\triangle ADB \sim \triangle CDA$ (AA). Then $\frac{AD}{CD} = \frac{BD}{AD}$, so $AD^2 = BD \times CD$.

$BD = BC - CD = 10 - 2 = 8$ cm. $AD^2 = 8 \times 2 = 16$, so $AD = 4$ cm.

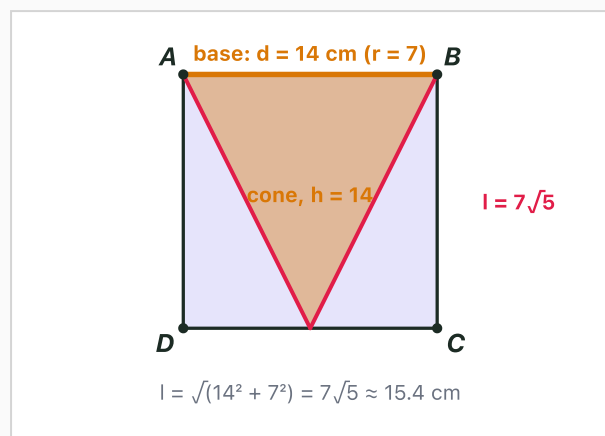
Answer: (a) BPT and its converse proved (b) $\triangle ADB \sim \triangle CDA$; $AD = 4$ cm

Common mistake: In (b), using $BD = 10$. $BD = BC - CD = 8$ cm.

Q34 · SURFACE AREAS AND VOLUMES · 5 MARKS

From one face of a solid cube of side 14 cm, the largest possible cone is carved out. Find the volume and surface area of the remaining solid. (Use $\pi = \frac{22}{7}$, $\sqrt{5} = 2.2$)

SOLUTION



The largest cone on a face of side 14 cm has base diameter 14 cm, so $r = 7$ cm, and height $h = 14$ cm (the side of the cube).

Slant height $l = \sqrt{h^2 + r^2} = \sqrt{14^2 + 7^2} = \sqrt{245} = 7\sqrt{5} = 7 \times 2.2 = 15.4$ cm.

Volume of the remaining solid = cube - cone = $14^3 - \frac{1}{3} \times \frac{22}{7} \times 7^2 \times 14 = 2744 - \frac{2156}{3} = \frac{8232 - 2156}{3} = \frac{6076}{3} \approx 2025.33$ cm³.

Surface area = cube - base circle + curved surface of the cone = $6 \times 14^2 - \frac{22}{7} \times 7 \times 7 + \frac{22}{7} \times 7 \times 15.4$.
 $= 1176 - 154 + 338.8 = 1360.8$ cm².

Answer: Volume = $\frac{6076}{3} \approx 2025.33$ cm³; surface area = 1360.8 cm²

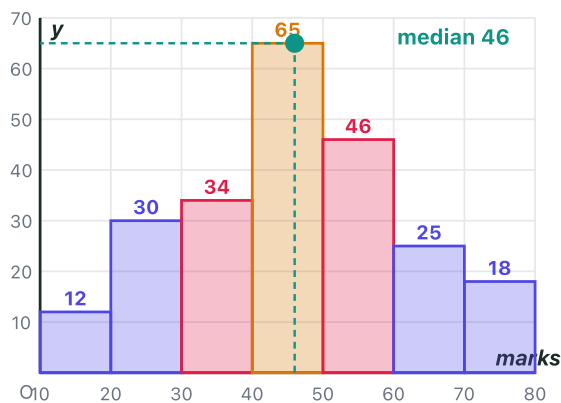
Common mistake: Adding the circle area instead of subtracting it: the circular face of the cube is taken away and replaced by the cone's curved surface.

Q35 · STATISTICS · 5 MARKS

Following distribution shows the marks of 230 students in a particular subject. If the median marks are 46, then find the values of x and y.

Marks	10 – 20	20 – 30	30 – 40	40 – 50	50 – 60	60 – 70	70 – 80
Number of Students	12	30	x	65	y	25	18

SOLUTION



Median class 40 – 50; the red bars are the unknown frequencies $x = 34$ and $y = 46$.

Total = 230: $12 + 30 + x + 65 + y + 25 + 18 = 230$, so $150 + x + y = 230$ and $x + y = 80$ (i)

Cumulative frequencies: 12, 42, $42 + x$, $107 + x$, $107 + x + y$, ... The median is 46, which lies in the class 40 – 50. So the median class is 40 – 50, with $l = 40$, $f = 65$, $cf = 42 + x$, $h = 10$, and $\frac{N}{2} = 115$.

$$\text{Median} = l + \frac{\frac{N}{2} - cf}{f} \times h: 46 = 40 + \frac{115 - (42 + x)}{65} \times 10.$$

$$6 = \frac{(73 - x) \times 10}{65}, \text{ so } 73 - x = \frac{6 \times 65}{10} = 39 \text{ and } x = 34.$$

From (i): $y = 80 - 34 = 46$.

Answer: $x = 34$ and $y = 46$

Common mistake: Using $cf = 42$ without the x . The class before 40 – 50 is 30 – 40, whose frequency is x , so $cf = 42 + x$.

Section E: Case studies

3 case studies, 4 marks each.

Q36 · AREAS RELATED TO CIRCLES · 4 MARKS

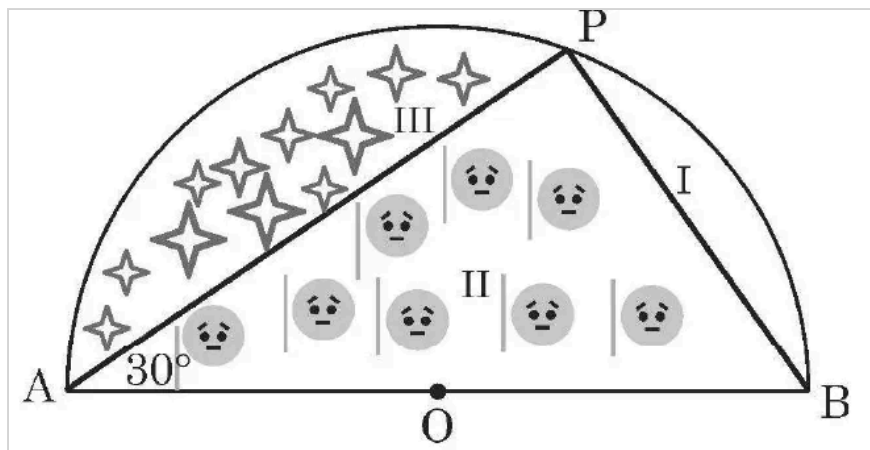
Case study 1. Anurag purchased a farmhouse which is in the form of a semicircle of diameter 70 m. He divides it into three parts by taking a point P on the semicircle in such a way that $\angle PAB = 30^\circ$ as shown in the following figure, where O is the centre of semicircle. In part I, he planted saplings of Mango tree, in part II, he grew tomatoes and in part III, he grew oranges.

Based on given information, answer the following questions.

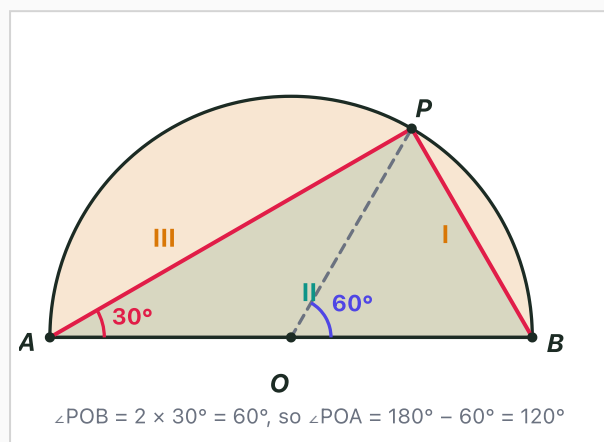
- (i) What is the measure of $\angle POA$? [1]
- (ii) Find the length of wire needed to fence entire piece of land. [1]
- (iii) (a) Find the area of region in which saplings of Mango tree are planted. [2]

OR

- (iii) (b) Find the length of wire needed to fence the region III. [2]



SOLUTION



(i) The angle at the centre is twice the angle at the circumference on the same arc: $\angle POB = 2 \times \angle PAB = 60^\circ$. So $\angle POA = 180^\circ - 60^\circ = 120^\circ$.

(ii) Radius $r = 35$ m. Fence the whole land: semicircular arc plus the diameter $= \pi r + 2r = \frac{22}{7} \times 35 + 70 = 110 + 70 = 180$ m.

(iii)(a) Region I is the segment cut off by the chord PB . $\angle POB = 60^\circ$ and $OP = OB$, so $\triangle OPB$ is equilateral.

$$\text{Segment} = \text{sector} - \text{triangle} = \frac{60}{360} \times \frac{22}{7} \times 35^2 - \frac{\sqrt{3}}{4} \times 35^2.$$

$$= \frac{1925}{3} - \frac{1225\sqrt{3}}{4} \text{ m}^2 \approx 111.89 \text{ m}^2.$$

(iii)(b) Region III is bounded by the arc AP (central angle 120°) and the chord AP . $\triangle ABP$ is right angled at P (angle in a semicircle), so $AP = AB \cos 30^\circ = 70 \times \frac{\sqrt{3}}{2} = 35\sqrt{3}$ m.

$$\text{Arc } AP = \frac{120}{360} \times 2 \times \frac{22}{7} \times 35 = \frac{220}{3} \text{ m. Wire} = \frac{220}{3} + 35\sqrt{3} \text{ m} \approx 133.8 \text{ m.}$$

Answer: (i) 120° (ii) 180 m (iii)(a) $\frac{1925}{3} - \frac{1225\sqrt{3}}{4} \approx 111.89 \text{ m}^2$ (iii)(b) $\frac{220}{3} + 35\sqrt{3} \approx 133.8 \text{ m}$

Common mistake: In (i), answering 60° , which is $\angle POB$. The question asks for $\angle POA = 120^\circ$.

Q37 · ARITHMETIC PROGRESSIONS · 4 MARKS

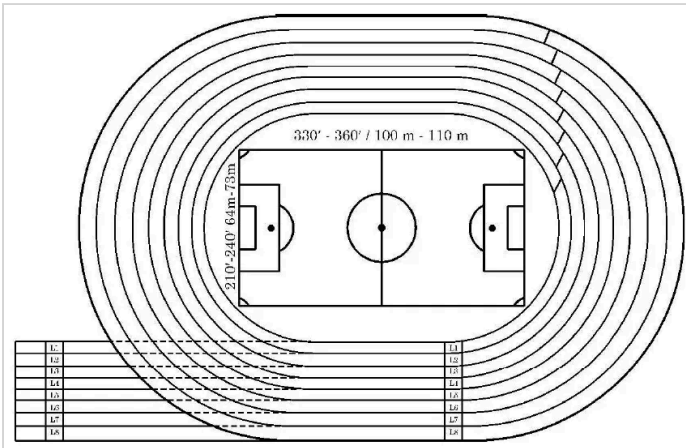
Case study 2. In order to organise Annual Sports Day, a school prepared an eight lane running track with an integrated football field inside the track area as shown below. The length of innermost lane of the track is 400 m and each subsequent lane is 7.6 m longer than the preceding lane.

Based on given information, answer the following questions, using concept of Arithmetic Progression.

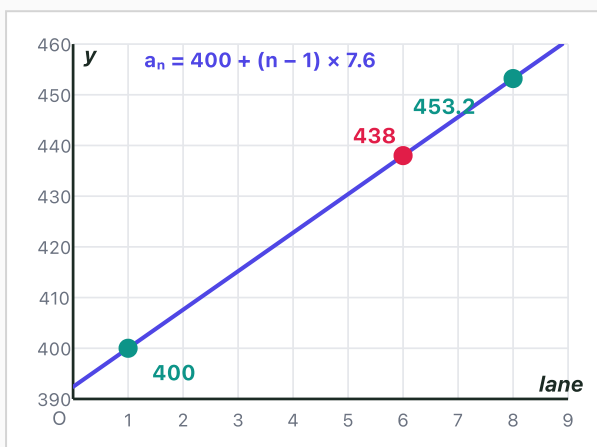
- (i) What is the length of the 6th lane? [1]
(ii) How long is the 8th lane than that of 4th lane? [1]
(iii) (a) While practicing for a race, a student took one round each in first six lanes. Find the total distance covered by the student. [2]

OR

- (iii) (b) A student took one round each in lane 4 to lane 8. Find the total distance covered by the student. [2]



SOLUTION



The lane lengths form an AP: 400, 407.6, 415.2, ... with $a = 400$ and $d = 7.6$.

(i) $a_6 = a + 5d = 400 + 5 \times 7.6 = 400 + 38 = 438 \text{ m.}$

(ii) $a_8 - a_4 = (8 - 4)d = 4 \times 7.6 = 30.4 \text{ m longer.}$

(iii)(a) $S_6 = \frac{6}{2}[2 \times 400 + 5 \times 7.6] = 3 \times 838 = 2514 \text{ m.}$

$$(iii)(b) \text{ Lanes 4 to 8} = S_8 - S_3 = \frac{8}{2}[800 + 7 \times 7.6] - \frac{3}{2}[800 + 2 \times 7.6] = 4 \times 853.2 - 1.5 \times 815.2 = 3412.8 - 1222.8 = 2190 \text{ m.}$$

Answer: (i) 438 m (ii) 30.4 m (iii)(a) 2514 m (iii)(b) 2190 m

Common mistake: In (iii)(b), computing $S_8 - S_4$. That leaves out lane 4. Lanes 4 to 8 are $S_8 - S_3$.

Q38 · APPLICATIONS OF TRIGONOMETRY · 4 MARKS

Case study 3. The Statue of Unity situated in Gujarat is the world's largest Statue which stands over a 58 m high base. As part of the project, a student constructed an inclinometer and wishes to find the height of Statue of Unity using it. He noted following observations from two places:

Situation – I: The angle of elevation of the top of Statue from Place A which is $80\sqrt{3}$ m away from the base of the Statue is found to be 60° .

Situation – II: The angle of elevation of the top of Statue from a Place B which is 40 m above the ground is found to be 30° and entire height of the Statue including the base is found to be 240 m.

Based on given information, answer the following questions:

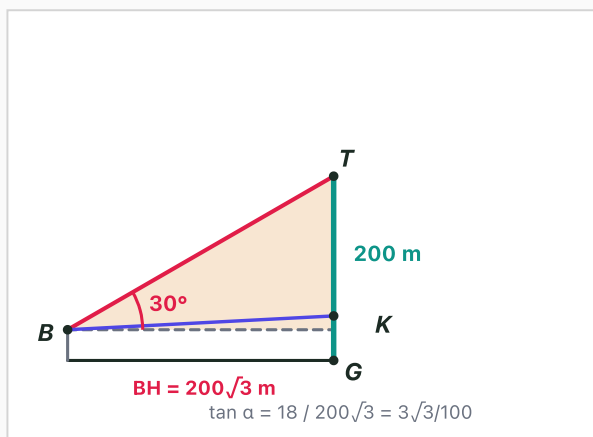
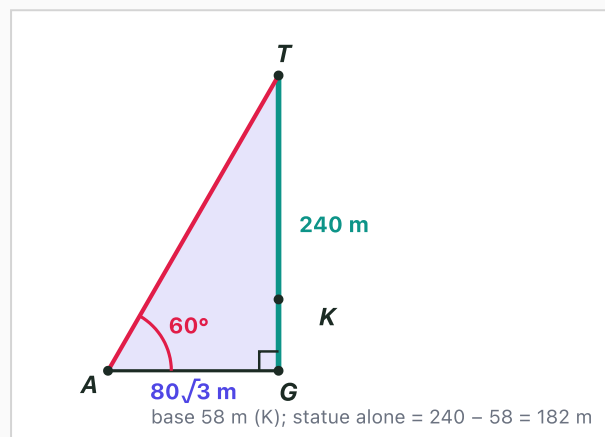
- Represent the Situation – I with the help of a diagram. [1]
- Represent the Situation – II with the help of a diagram. [1]
- (a) Calculate the height of Statue excluding the base and also find the height including the base with the help of Situation – I. [2]

OR

- (b) Find the horizontal distance of point B (Situation – II) from the Statue and the value of $\tan \alpha$, where α is the angle of elevation of top of base of the Statue from point B. [2]



SOLUTION



(i), (ii) The two situations are drawn above: in each a right triangle is formed by the observer, the foot of the statue and the top of the statue.

(iii)(a) Situation I: $\tan 60^\circ = \frac{\text{height}}{80\sqrt{3}}$, so the height of the top above the ground $= 80\sqrt{3} \times \sqrt{3} = 240$ m. This is the height including the base.

The base is 58 m high, so the height of the statue excluding the base $= 240 - 58 = 182$ m.

(iii)(b) Situation II: B is 40 m above the ground, so the top of the statue is $240 - 40 = 200$ m above B . $\tan 30^\circ = \frac{200}{d} = \frac{1}{\sqrt{3}}$, so the horizontal distance $d = 200\sqrt{3}$ m.

The top of the base is 58 m high, which is $58 - 40 = 18$ m above B . $\tan \alpha = \frac{18}{200\sqrt{3}} = \frac{9}{100\sqrt{3}} = \frac{3\sqrt{3}}{100}$.

Answer: (iii)(a) 182 m excluding the base, 240 m including it (iii)(b) $200\sqrt{3}$ m and $\tan \alpha = \frac{3\sqrt{3}}{100}$

Common mistake: In (iii)(b), using 240 or 58 directly. The observer is 40 m up, so measure the heights from B : 200 m and 18 m.

Stuck on a step? CogniGuru's AI tutor explains any doubt one minute at a time, in English or Hindi.

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