

Mathematics (Standard) 2025, Set 30/5/1

Q.P. Code 30/5/1 · Series EH5GF · 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

$(\sqrt{3} + 2)^2 + (\sqrt{3} - 2)^2$ is a/an

- (A) positive rational number
(B) negative rational number
(C) positive irrational number
(D) negative irrational number

SOLUTION

$$(\sqrt{3} + 2)^2 = 3 + 4\sqrt{3} + 4 = 7 + 4\sqrt{3} \text{ and } (\sqrt{3} - 2)^2 = 3 - 4\sqrt{3} + 4 = 7 - 4\sqrt{3}.$$

Adding, the $4\sqrt{3}$ terms cancel: $7 + 7 = 14$, a positive rational number.

Answer: (A) positive rational number

Q2 · REAL NUMBERS · 1 MARK

Let $x = a^2b^3c^n$ and $y = a^3b^m c^2$, where a, b, c are prime numbers. If LCM of x and y is $a^3b^4c^3$, then the value of $m + n$ is

- (A) 10
(B) 7
(C) 6
(D) 5

SOLUTION

LCM takes the greater power of each prime.

For b : $\max(3, m) = 4$, so $m = 4$. For c : $\max(n, 2) = 3$, so $n = 3$. (For a : $\max(2, 3) = 3$ ✓.)

$$m + n = 4 + 3 = 7.$$

Answer: (B) 7

Q3 · REAL NUMBERS · 1 MARK

For any prime number p , if p divides a^2 , where a is any real number then p also divides

- (A) a
(B) $a^{1/2}$
(C) $a^{3/2}$
(D) $a^{1/8}$

SOLUTION

This is the key fact used in proofs of irrationality: if a prime p divides a^2 , then p divides a .

(Because the prime factorisation of a^2 has the same primes as that of a .)

Answer: (A) a

Q4 · QUADRATIC EQUATIONS · 1 MARK

Which of the following equations is a quadratic equation?

(A) $x^2 + 1 = (x - 1)^2$

(B) $(x + \sqrt{x})^2 = 2x\sqrt{x}$

(C) $x^3 + 3x^2 = (x + 1)^3$

(D) $(x + 1)(x - 1) = (x + 1)^2$

SOLUTION

(A) $x^2 + 1 = x^2 - 2x + 1$ gives $2x = 0$: linear.

(B) $x^2 + 2x\sqrt{x} + x = 2x\sqrt{x}$ gives $x^2 + x = 0$: quadratic. ✓

(C) $x^3 + 3x^2 = x^3 + 3x^2 + 3x + 1$ gives $3x + 1 = 0$: linear.

(D) $x^2 - 1 = x^2 + 2x + 1$ gives $2x + 2 = 0$: linear.

Answer: (B) $(x + \sqrt{x})^2 = 2x\sqrt{x}$

Common mistake: Judging by the highest power you can see. Expand both sides first: the higher powers may cancel.

Q5 · QUADRATIC EQUATIONS · 1 MARK

If $x^2 + bx + b = 0$ has two real and distinct roots, then the value of b can be

(A) 0

(B) 4

(C) 3

(D) -3

SOLUTION

Real and distinct roots need $D > 0$: $b^2 - 4b > 0$, that is $b(b - 4) > 0$.

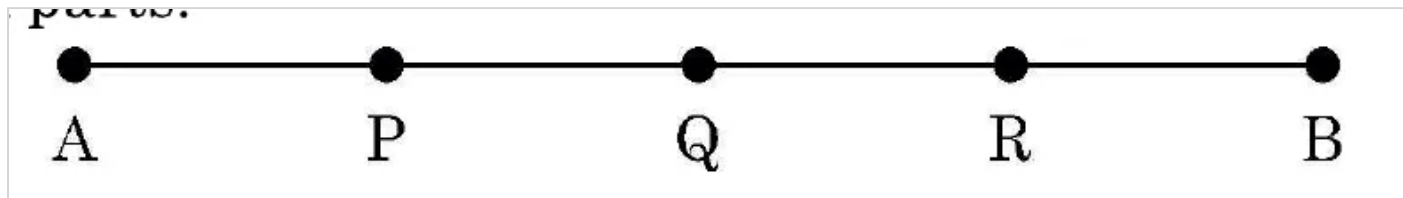
This holds when $b < 0$ or $b > 4$. Among the options only -3 is in that range.

(Check the others: $b = 0$ and $b = 4$ give $D = 0$; $b = 3$ gives $D = 9 - 12 < 0$.)

Answer: (D) -3

Q6 · COORDINATE GEOMETRY · 1 MARK

In the figure given below, points P, Q, R divides the line segment AB in four equal parts. The point Q divides PB in the ratio



(A) 1 : 3

(B) 2 : 3

(C) 1 : 2

(D) 1 : 1

SOLUTION

Let each equal part be 1 unit. Then $AP = PQ = QR = RB = 1$.

$PQ = 1$ and $QB = QR + RB = 2$. So Q divides PB in the ratio $PQ : QB = 1 : 2$.

Answer: (C) 1 : 2

Q7 · PROBABILITY · 1 MARK

A bag contains red balls and black balls in the ratio 3 : 7. A ball is drawn at random. The probability that ball so drawn is black in colour, is

(A) $\frac{3}{7}$

(B) 0.3

(C) 0.7

(D) $\frac{1}{7}$

SOLUTION

Red : black = 3 : 7, so out of every $3 + 7 = 10$ balls, 7 are black.

$$P(\text{black}) = \frac{7}{10} = 0.7.$$

Answer: (C) 0.7

Common mistake: Using $\frac{3}{7}$, the ratio itself. A probability is a part over the whole: $\frac{7}{10}$.

Q8 · TRIANGLES · 1 MARK

Which of the following statements is false?

(A) Two right triangles are always similar.

(B) Two squares are always similar.

(C) Two equilateral triangles are always similar.

(D) Two circles are always similar.

SOLUTION

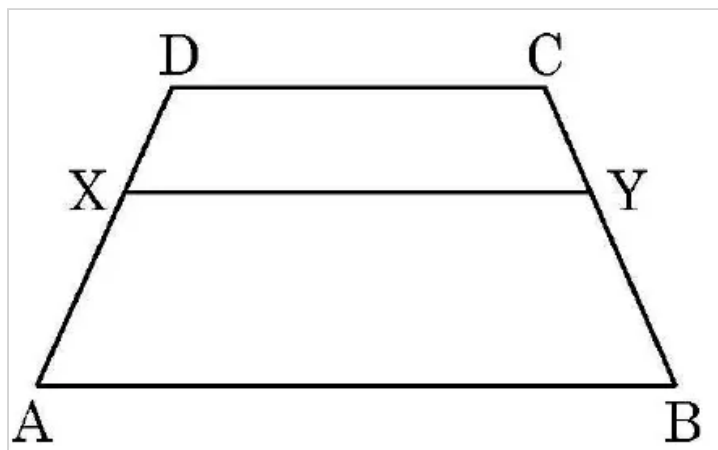
Two right triangles have one equal angle (90°) but the other angles can differ (for example 30° - 60° and 45° - 45°), so they need not be similar. (A) is false.

Two squares have all angles 90° and sides in the same ratio; two equilateral triangles have all angles 60° ; any two circles have the same shape. So (B), (C) and (D) are true.

Answer: (A) Two right triangles are always similar.

Q9 · TRIANGLES · 1 MARK

In the adjoining figure, $ABCD$ is a trapezium in which $XY \parallel AB \parallel CD$. If $AX = \frac{2}{3}AD$, then $CY : YB =$



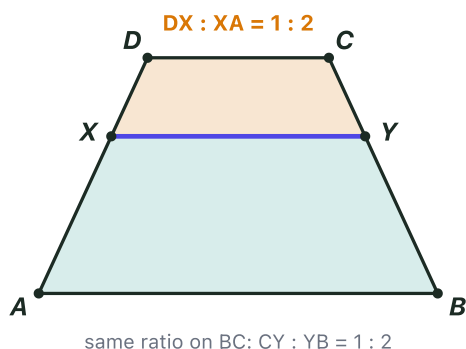
(A) 2 : 3

(B) 3 : 2

(C) 1 : 3

(D) 1 : 2

SOLUTION



$AX = \frac{2}{3}AD$, so $XD = AD - AX = \frac{1}{3}AD$. Hence $DX : XA = 1 : 2$.

Three parallel lines cut the two transversals AD and BC in the same ratio: $\frac{DX}{XA} = \frac{CY}{YB}$.

So $CY : YB = 1 : 2$.

Answer: (D) 1 : 2

Common mistake: Answering 2 : 3 or 3 : 2 straight from the fraction. $\frac{2}{3}$ is $AX : AD$, not $AX : XD$.

Q10 · CIRCLES · 1 MARK

Which of the following statements is false?

- (A) Infinite number of tangents can be drawn to a circle. (B) Infinite number of tangents can be drawn to a circle from a point outside the circle.
- (C) Infinite number of secants can be drawn to a circle from a point outside the circle. (D) Angle between tangent and diameter at point of contact is 90° .

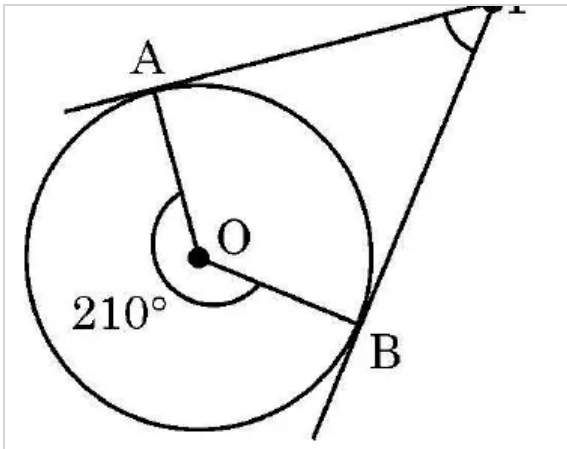
SOLUTION

- (A) Every point of the circle has one tangent, so there are infinitely many. True.
- (B) From a point outside a circle exactly 2 tangents can be drawn, not infinitely many. False.
- (C) Infinitely many secants pass through an outside point (rotate the line). True. (D) The tangent is perpendicular to the radius, hence to the diameter through the point of contact. True.

Answer: (B) Infinite number of tangents can be drawn to a circle from a point outside the circle.

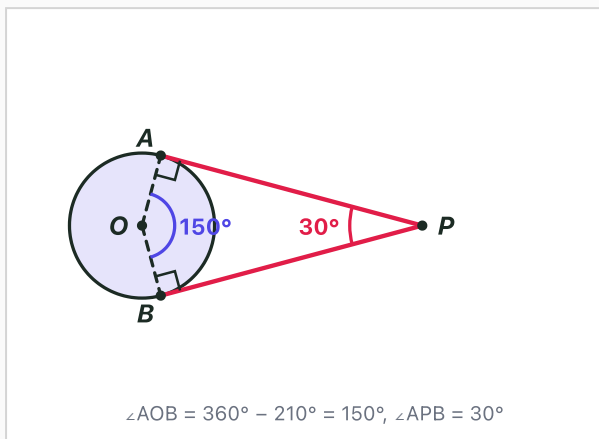
Q11 · CIRCLES · 1 MARK

In the adjoining figure, PA and PB are tangents to a circle with centre O. The measure of angle APB is



- (A) 210° (B) 150°
(C) 105° (D) 30°

SOLUTION



The marked 210° is the reflex angle at O . The angle on the other side is $\angle AOB = 360^\circ - 210^\circ = 150^\circ$.

$OA \perp PA$ and $OB \perp PB$, so in quadrilateral $OAPB$: $\angle APB = 360^\circ - 90^\circ - 90^\circ - 150^\circ = 30^\circ$.

Answer: (D) 30°

Common mistake: Using 210° directly. The angle between the radii that goes with the tangents is the smaller one, 150° .

Q12 · TRIGONOMETRY · 1 MARK

$\frac{1 - \tan^2 30^\circ}{1 + \tan^2 30^\circ}$ is equal to

- (A) $\sin 60^\circ$ (B) $\cos 60^\circ$
(C) $\tan 60^\circ$ (D) $\sec 60^\circ$

SOLUTION

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

$$\frac{1 - \frac{1}{3}}{1 + \frac{1}{3}} = \frac{2/3}{4/3} = \frac{1}{2}.$$

$$\cos 60^\circ = \frac{1}{2}. \text{ (This is the identity } \cos 2A = \frac{1 - \tan^2 A}{1 + \tan^2 A} \text{ with } A = 30^\circ.)$$

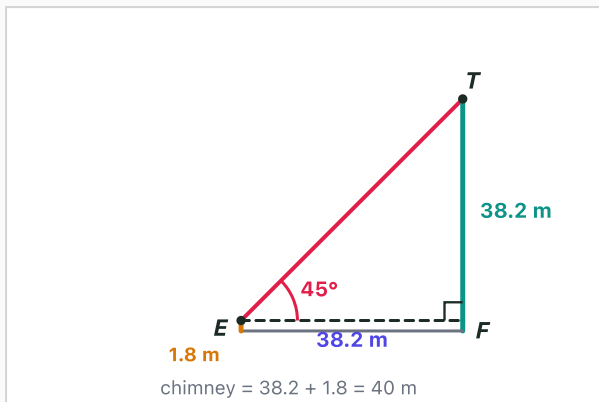
Answer: (B) $\cos 60^\circ$

Q13 · APPLICATIONS OF TRIGONOMETRY · 1 MARK

An observer 1.8 m tall stands away from a chimney at a distance of 38.2 m along the ground. The angle of elevation of top of chimney from the eyes of observer is 45° . The height of the chimney above the ground is

- (A) 38.2 m (B) 36.4 m
(C) 40 m (D) $(38.2)\sqrt{2}$ m

SOLUTION



Draw a horizontal line from the observer's eyes to the chimney. The part of the chimney above this line is h .

$$\tan 45^\circ = \frac{h}{38.2} = 1, \text{ so } h = 38.2 \text{ m.}$$

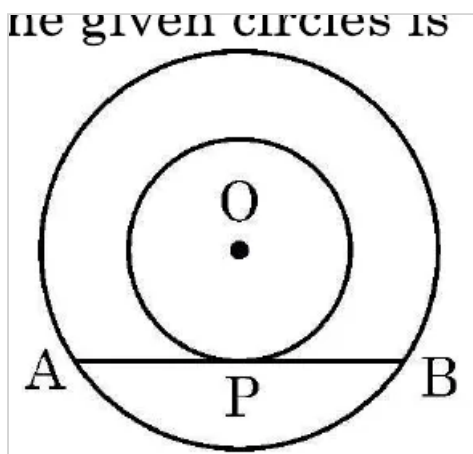
The eyes are 1.8 m above the ground, so the chimney's height = $38.2 + 1.8 = 40$ m.

Answer: (C) 40 m

Common mistake: Forgetting to add the observer's height of 1.8 m. The 38.2 m is only the part above eye level.

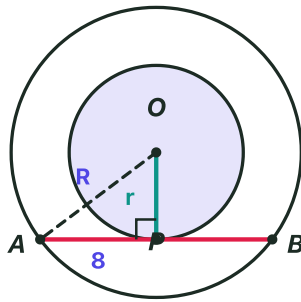
Q14 · CIRCLES · 1 MARK

In the adjoining figure, the sum of radii of two concentric circles is 16 cm. The length of chord AB which touches the inner circle at P is 16 cm. The difference of the radii of the given circles is



- (A) 8 cm (B) 4 cm
(C) 2 cm (D) 3 cm

SOLUTION



$$R^2 - r^2 = 8^2 = 64, (R + r) = 16, \text{ so } R - r = 4$$

Let the radii be R (large) and r (small). $R + r = 16$.

$OP \perp AB$ and P is the mid-point of the chord, so $AP = 8$ cm. In right triangle OPA : $R^2 = r^2 + 8^2$, so $R^2 - r^2 = 64$.

$(R + r)(R - r) = 64$ gives $16(R - r) = 64$, so $R - r = 4$ cm.

(So $R = 10$ and $r = 6$.)

Answer: (B) 4 cm

Q15 · SURFACE AREAS AND VOLUMES · 1 MARK

A cone of height 12 cm and slant height 13 cm is surmounted on a hemisphere having radius equal to that of cone. The entire height of the solid is

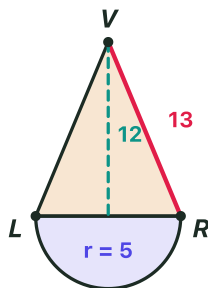
(A) 17 cm

(B) 18 cm

(C) 22 cm

(D) 23 cm

SOLUTION



$$r = \sqrt{13^2 - 12^2} = 5, \text{ height} = 12 + 5 = 17 \text{ cm}$$

Radius of the cone = $\sqrt{l^2 - h^2} = \sqrt{13^2 - 12^2} = \sqrt{25} = 5$ cm.

The hemisphere has the same radius, 5 cm, so it adds a height of 5 cm.

Entire height = $12 + 5 = 17$ cm.

Answer: (A) 17 cm

Q16 · STATISTICS · 1 MARK

If x median $+ y$ mean $= z$ mode is the empirical relationship between mean, median and mode, then the value of $x + y + z$ is

- (A) 6 (B) 3
(C) 2 (D) 1

SOLUTION

The empirical relationship is $\text{Mode} = 3 \text{ Median} - 2 \text{ Mean}$.

Rewrite: $3 \text{ Median} + (-2) \text{ Mean} = 1 \cdot \text{Mode}$. So $x = 3, y = -2, z = 1$.

$$x + y + z = 3 - 2 + 1 = 2.$$

Answer: (C) 2

Q17 · STATISTICS · 1 MARK

Following data shows the marks obtained by 100 students in a class test:

The median will be the average of which two observations?

Marks obtained	20	29	28	33	42	38	43	25
Number of students	6	28	24	15	2	4	1	20

- (A) 29 and 33 (B) 25 and 28
(C) 28 and 29 (D) 33 and 38

SOLUTION

The number of observations is $n = 100$ (even), so the median is the average of the $\frac{n}{2} = 50$ th and 51st observations, after arranging in order.

Arrange the marks in increasing order with cumulative frequency: 20 (6), 25 (26), 28 (50), 29 (78), 33 (93), 38 (97), 42 (99), 43 (100).

The 50th observation is 28 (cumulative frequency reaches 50 at 28) and the 51st is 29.

Answer: (C) 28 and 29

Common mistake: Taking the 50th and 51st entries of the table as printed. The marks must be sorted first.

Q18 · PROBABILITY · 1 MARK

The probability of getting a composite number greater than 3 on throwing a die is

- (A) $\frac{1}{6}$ (B) $\frac{1}{3}$
(C) $\frac{1}{2}$ (D) $\frac{2}{3}$

SOLUTION

Numbers on a die: 1, 2, 3, 4, 5, 6. Greater than 3: 4, 5, 6.

Of these, composite numbers are 4 and 6 (5 is prime). That is 2 favourable outcomes.

$$P = \frac{2}{6} = \frac{1}{3}.$$

Answer: (B) $\frac{1}{3}$

Q19 · TRIGONOMETRY · 1 MARK

Assertion (A): For an acute angle θ , $\sin \theta = \frac{3}{5} \Rightarrow \cos \theta = -\frac{4}{5}$.

Reason (R): For any value of θ , $(0^\circ \leq \theta \leq 90^\circ)$ $\sin^2 \theta + \cos^2 \theta = 1$.

(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) $\cos^2 \theta = 1 - \frac{9}{25} = \frac{16}{25}$, so $\cos \theta = \pm \frac{4}{5}$. For an acute angle cosine is positive, so $\cos \theta = +\frac{4}{5}$. The assertion (with the minus sign) is false.

(R) $\sin^2 \theta + \cos^2 \theta = 1$ is true for every angle. True.

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

Q20 · ARITHMETIC PROGRESSIONS · 1 MARK

Assertion (A): For an A.P., 3, 6, 9, ..., 198, 10th term from the end is 168.

Reason (R): If ' a ' and ' l ' are the first term and last term of an A.P. with common difference ' d ', then n^{th} term from the end of the given A.P. is $l - (n - 1)d$.

(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

(R) Going backward from the last term, each step subtracts d , so the n^{th} term from the end is $l - (n - 1)d$. True.

(A) Here $l = 198$ and $d = 3$. The 10th term from the end is $198 - 9 \times 3 = 198 - 27 = 171$, not 168. So the assertion is false.

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

Common mistake: Using $198 - 10 \times 3 = 168$. The first term from the end is l itself, so the 10th uses $(n - 1) = 9$ steps.

Section B: Very short answer

5 questions, 2 marks each.

Q21 · LINEAR EQUATIONS · 2 MARKS

(a) The cost of 2 kg apples and 1 kg of grapes on a day was found to be ₹ 320. The cost of 4 kg apples and 2 kg grapes was found to be ₹ 600. If cost of 1 kg of apples and 1 kg of grapes is ₹ x and ₹ y respectively, represent the given situation algebraically as a system of equations and check whether the system so obtained is consistent or not.

OR

(b) Solve for x and y : $\sqrt{2}x + \sqrt{3}y = 5$ and $\sqrt{3}x - \sqrt{8}y = -\sqrt{6}$.

SOLUTION

(a) The equations are $2x + y = 320$ and $4x + 2y = 600$.

$$\frac{a_1}{a_2} = \frac{2}{4} = \frac{1}{2}, \frac{b_1}{b_2} = \frac{1}{2} \text{ and } \frac{c_1}{c_2} = \frac{320}{600} = \frac{8}{15}.$$

Since $\frac{a_1}{a_2} = \frac{b_1}{b_2} \neq \frac{c_1}{c_2}$, the lines are parallel and the system has no solution: it is not consistent. (The second says $2x + y = 300$, which contradicts $2x + y = 320$.)

(b) Multiply the first equation by $\sqrt{3}$ and the second by $\sqrt{2}$: $\sqrt{6}x + 3y = 5\sqrt{3}$ and $\sqrt{6}x - 4y = -2\sqrt{3}$.

Subtract: $7y = 7\sqrt{3}$, so $y = \sqrt{3}$. Then $\sqrt{2}x + 3 = 5$, so $x = \frac{2}{\sqrt{2}} = \sqrt{2}$.

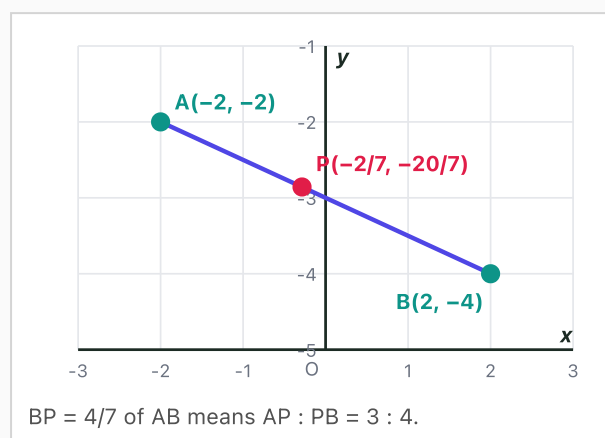
Check in the second: $\sqrt{3} \cdot \sqrt{2} - \sqrt{8} \cdot \sqrt{3} = \sqrt{6} - 2\sqrt{6} = -\sqrt{6} \checkmark$.

Answer: (a) $2x + y = 320$, $4x + 2y = 600$; not consistent (b) $x = \sqrt{2}$, $y = \sqrt{3}$

Q22 • COORDINATE GEOMETRY • 2 MARKS

The coordinates of the end points of the line segment AB are $A(-2, -2)$ and $B(2, -4)$. P is the point on AB such that $BP = \frac{4}{7}AB$. Find the coordinates of point P .

SOLUTION



$BP = \frac{4}{7}AB$, so $AP = AB - BP = \frac{3}{7}AB$. Hence $AP : PB = 3 : 4$.

Section formula with $m : n = 3 : 4$: $x = \frac{3 \times 2 + 4 \times (-2)}{3 + 4} = \frac{-2}{7}$.

$y = \frac{3 \times (-4) + 4 \times (-2)}{7} = \frac{-20}{7}$.

Answer: $P\left(-\frac{2}{7}, -\frac{20}{7}\right)$

Common mistake: Using the ratio 4 : 3. $BP = \frac{4}{7}AB$ is measured from B , so $AP : PB = 3 : 4$.

Q23 • TRIGONOMETRY • 2 MARKS

(a) It is given that $\sin(A - B) = \sin A \cos B - \cos A \sin B$. Use it to find the value of $\sin 15^\circ$.

OR

(b) If $\sin A = y$, then express $\cos A$ and $\tan A$ in terms of y .

SOLUTION

(a) $15^\circ = 45^\circ - 30^\circ$, so $\sin 15^\circ = \sin 45^\circ \cos 30^\circ - \cos 45^\circ \sin 30^\circ$.

$= \frac{1}{\sqrt{2}} \times \frac{\sqrt{3}}{2} - \frac{1}{\sqrt{2}} \times \frac{1}{2} = \frac{\sqrt{3} - 1}{2\sqrt{2}} = \frac{\sqrt{6} - \sqrt{2}}{4}$.

(b) $\cos A = \sqrt{1 - \sin^2 A} = \sqrt{1 - y^2}$ (for an acute angle).

$$\tan A = \frac{\sin A}{\cos A} = \frac{y}{\sqrt{1-y^2}}.$$

Answer: (a) $\frac{\sqrt{6}-\sqrt{2}}{4}$ **(b)** $\cos A = \sqrt{1-y^2}$, $\tan A = \frac{y}{\sqrt{1-y^2}}$

Q24 · TRIANGLES · 2 MARKS

AD and PS are medians of triangles ABC and PQR respectively such that $\triangle ABD \sim \triangle PQS$. Prove that $\triangle ABC \sim \triangle PQR$.

SOLUTION

$\triangle ABD \sim \triangle PQS$, so $\frac{AB}{PQ} = \frac{BD}{QS}$ and $\angle B = \angle Q$.

AD and PS are medians, so $BD = \frac{BC}{2}$ and $QS = \frac{QR}{2}$. Then $\frac{BD}{QS} = \frac{BC}{QR}$, so $\frac{AB}{PQ} = \frac{BC}{QR}$.

In $\triangle ABC$ and $\triangle PQR$: $\frac{AB}{PQ} = \frac{BC}{QR}$ and the included angles $\angle B = \angle Q$. So $\triangle ABC \sim \triangle PQR$ by SAS.

Answer: Proved

Common mistake: Forgetting to say that a median joins a vertex to the mid-point, which is why $BD = BC/2$.

Q25 · PROBABILITY · 2 MARKS

While shuffling a pack of 52 cards, one card was accidentally dropped. Find the probability that the dropped card

(i) is not a face card.

(ii) is a black king.

SOLUTION

A pack has 52 cards, with 12 face cards (jack, queen and king of each of 4 suits). So there are $52 - 12 = 40$ cards that are not face cards.

(i) $P(\text{not a face card}) = \frac{40}{52} = \frac{10}{13}$.

(ii) There are 2 black kings (spades and clubs): $P = \frac{2}{52} = \frac{1}{26}$.

Answer: (i) $\frac{10}{13}$ **(ii)** $\frac{1}{26}$

Common mistake: Counting only 4 face cards (the kings). Jack, queen and king are face cards: 12 in all.

Section C: Short answer

6 questions, 3 marks each.

Q26 · REAL NUMBERS · 3 MARKS

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

OR

(b) State true or false for each of the following statements and justify in each case: (i) $2 \times 3 \times 5 \times 7 + 7$ is a composite number. (ii) $2 \times 3 \times 5 \times 7 + 1$ is a composite number.

SOLUTION

(a) Suppose $\sqrt{3} = \frac{p}{q}$ with p, q co-prime integers and $q \neq 0$. Squaring: $3q^2 = p^2$.

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

Now 3 is a common factor of p and q , contradicting that they are co-prime. So $\sqrt{3}$ is irrational.

(b)(i) True. $2 \times 3 \times 5 \times 7 + 7 = 7(2 \times 3 \times 5 + 1) = 7 \times 31$, which has more than two factors (it is divisible by 7 and 31).

(b)(ii) False. $2 \times 3 \times 5 \times 7 + 1 = 210 + 1 = 211$, which is a prime number (it has only two factors, 1 and 211).

Answer: (a) proved (b)(i) True (b)(ii) False

Common mistake: In (b), saying "true" because the number looks big. Actually factorise (i) and test (ii) for factors.

Q27 · POLYNOMIALS · 3 MARKS

Obtain the zeroes of the polynomial $7x^2 + 18x - 9$. Hence, write a polynomial each of whose zeroes is twice the zeroes of given polynomial.

SOLUTION

$$7x^2 + 18x - 9 = 7x^2 + 21x - 3x - 9 = 7x(x + 3) - 3(x + 3) = (7x - 3)(x + 3).$$

The zeroes are $x = \frac{3}{7}$ and $x = -3$.

The new zeroes are twice these: $\frac{6}{7}$ and -6 .

$$\text{Sum} = \frac{6}{7} + (-6) = -\frac{36}{7} \text{ and product} = \frac{6}{7} \times (-6) = -\frac{36}{7}.$$

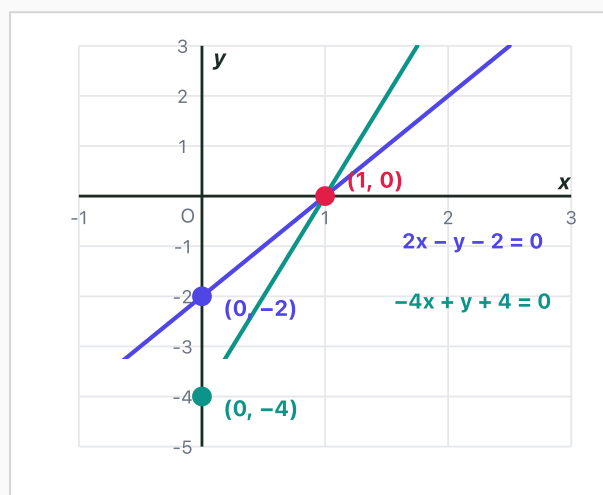
Polynomial: $x^2 + \frac{36}{7}x - \frac{36}{7}$, or multiplying by 7: $7x^2 + 36x - 36$.

Answer: Zeroes -3 and $\frac{3}{7}$; new polynomial $7x^2 + 36x - 36$

Q28 · LINEAR EQUATIONS · 3 MARKS

Solve the following system of equations graphically: $2x - y - 2 = 0$ and $-4x + y + 4 = 0$. Also, find the absolute difference between the ordinates of the points where given lines cut y -axis.

SOLUTION



First line: $y = 2x - 2$. Points: $(0, -2)$, $(1, 0)$, $(2, 2)$.

Second line: $y = 4x - 4$. Points: $(0, -4)$, $(1, 0)$, $(2, 4)$.

Plot both. They cross at $(1, 0)$, so the solution is $x = 1, y = 0$.

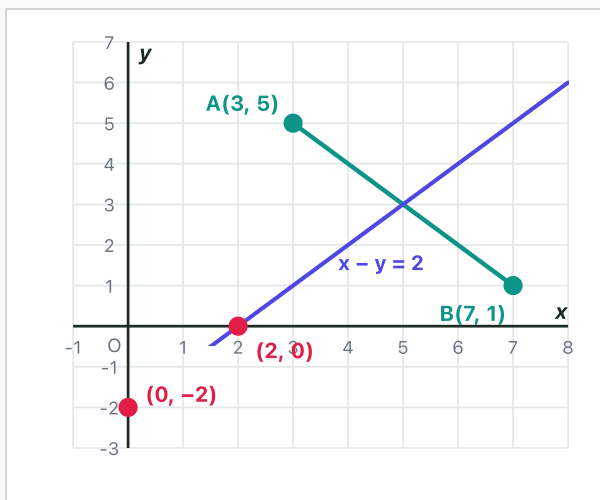
The lines cut the y -axis at $(0, -2)$ and $(0, -4)$. The absolute difference of the ordinates is $|-2 - (-4)| = 2$.

Answer: $x = 1, y = 0$; absolute difference = 2

Q29 · COORDINATE GEOMETRY · 3 MARKS

Find a relation between x and y such that $P(x, y)$ is equidistant from the points $A(3, 5)$ and $B(7, 1)$. Hence, write the coordinates of the points on x -axis and y -axis which are equidistant from points A and B .

SOLUTION



$$PA = PB \text{ gives } PA^2 = PB^2: (x - 3)^2 + (y - 5)^2 = (x - 7)^2 + (y - 1)^2.$$

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

On the x -axis $y = 0$: $x = 2$, so the point is $(2, 0)$.

On the y -axis $x = 0$: $-y = 2$, so $y = -2$ and the point is $(0, -2)$.

Answer: $x - y = 2$; $(2, 0)$ on the x -axis and $(0, -2)$ on the y -axis

Q30 · TRIGONOMETRY · 3 MARKS

(a) Prove the following trigonometric identity:
$$\frac{1 + \operatorname{cosec} A}{\operatorname{cosec} A} = \frac{\cos^2 A}{1 - \sin A}$$

OR

(b) Let $2A + B$ and $A + 2B$ be acute angles such that $\sin(2A + B) = \frac{\sqrt{3}}{2}$ and $\tan(A + 2B) = 1$. Find the value of $\cot(4A - 7B)$.

SOLUTION

$$(a) \text{ LHS} = \frac{1 + \frac{1}{\sin A}}{\frac{1}{\sin A}} = \frac{\sin A + 1}{1} = \sin A + 1.$$

$$\text{Multiply and divide by } (1 - \sin A): \frac{(1 + \sin A)(1 - \sin A)}{1 - \sin A} = \frac{1 - \sin^2 A}{1 - \sin A} = \frac{\cos^2 A}{1 - \sin A} = \text{RHS.}$$

$$(b) \sin(2A + B) = \frac{\sqrt{3}}{2} \text{ with an acute angle gives } 2A + B = 60^\circ. \dots (i)$$

$$\tan(A + 2B) = 1 \text{ gives } A + 2B = 45^\circ. \dots (ii)$$

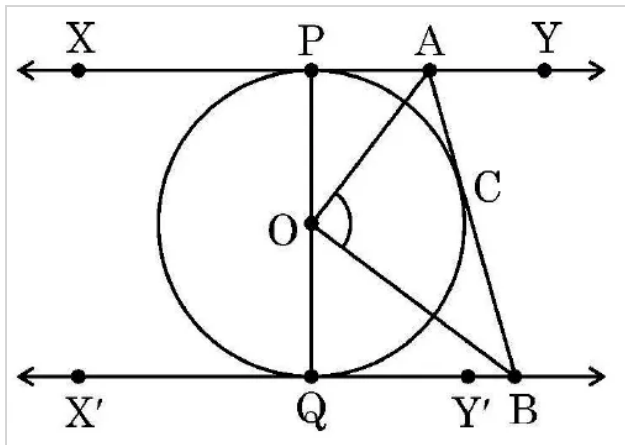
Add: $3A + 3B = 105^\circ$, so $A + B = 35^\circ$. Subtract (ii) from (i): $A - B = 15^\circ$. Hence $A = 25^\circ$ and $B = 10^\circ$.

$$4A - 7B = 100^\circ - 70^\circ = 30^\circ, \text{ so } \cot 30^\circ = \sqrt{3}.$$

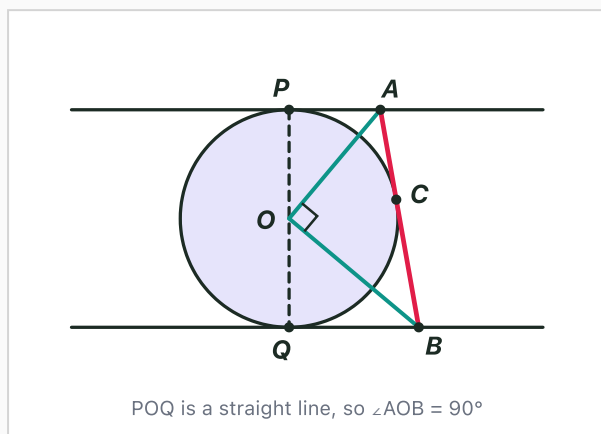
Answer: (a) proved (b) $\sqrt{3}$

Q31 · CIRCLES · 3 MARKS

In the adjoining figure, XY and $X'Y'$ are parallel tangents to a circle with centre O . Another tangent AB touches the circle at C intersecting XY at A and $X'Y'$ at B . Prove that AB subtends right angle at the centre of the circle; or $\angle AOB = 90^\circ$.



SOLUTION



Join OC . PA and CA are tangents from A , with $OP = OC$ (radii) and OA common. So $\triangle POA \cong \triangle COA$ (SSS), giving $\angle POA = \angle COA$.

In the same way, $\triangle QOB \cong \triangle COB$, so $\angle QOB = \angle COB$.

PQ is a diameter (the tangents are parallel, so P, O, Q lie on one straight line). So $\angle POA + \angle COA + \angle COB + \angle QOB = 180^\circ$.

This is $2\angle COA + 2\angle COB = 180^\circ$, so $\angle COA + \angle COB = 90^\circ$.

$\angle AOB = \angle COA + \angle COB = 90^\circ$.

Answer: $\angle AOB = 90^\circ$

Section D: Long answer

4 questions, 5 marks each.

Q32 · QUADRATIC EQUATIONS · 5 MARKS

(a) A 2-digit number is seven times the sum of its digits and two (2) more than 5 times the product of its digits. Find the number.

OR

(b) Find the value(s) of p for which the quadratic equation given as $(p + 4)x^2 - (p + 1)x + 1 = 0$ has real and equal roots. Also, find the roots of the equation(s) so obtained.

SOLUTION

(a) Let the ones digit be x and the tens digit be y . The number is $10y + x$.

Seven times the sum of the digits: $10y + x = 7(x + y)$, so $3y = 6x$ and $y = 2x$ (i)

Two more than 5 times the product: $10y + x = 5xy + 2$ (ii)

Put (i) in (ii): $20x + x = 10x^2 + 2$, so $10x^2 - 21x + 2 = 0$ and $(x - 2)(10x - 1) = 0$. The digit x must be a whole number, so $x = 2$ and $y = 4$.

The number is 42. (Check: $7 \times 6 = 42 \checkmark$ and $5 \times 8 + 2 = 42 \checkmark$.)

(b) Real and equal roots need $D = 0$: $[-(p + 1)]^2 - 4(p + 4)(1) = 0$, so $p^2 + 2p + 1 - 4p - 16 = 0$ and $p^2 - 2p - 15 = 0$.

$(p - 5)(p + 3) = 0$, so $p = 5$ or $p = -3$.

For $p = 5$: $9x^2 - 6x + 1 = 0$, so $(3x - 1)^2 = 0$ and $x = \frac{1}{3}, \frac{1}{3}$.

For $p = -3$: $x^2 + 2x + 1 = 0$, so $(x + 1)^2 = 0$ and $x = -1, -1$.

Answer: (a) 42 (b) $p = 5$: roots $\frac{1}{3}, \frac{1}{3}$; $p = -3$: roots $-1, -1$

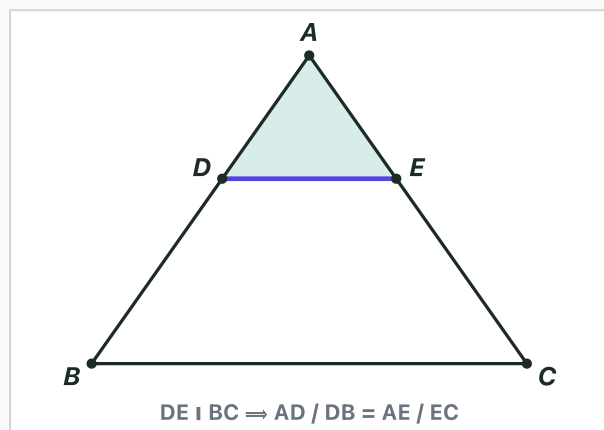
Common mistake: In (b), writing only $p = 5$. Both values of p make the roots equal, so give both with their roots.

Q33 · TRIANGLES · 5 MARKS

If a line is drawn parallel to one side of a triangle intersecting the other two sides in distinct points then it divides the two sides in the same ratio. Prove it.

Also, state the converse of the above statement.

SOLUTION



Given: $\triangle ABC$ with $DE \parallel BC$, where D is on AB and E is on AC . To prove: $\frac{AD}{DB} = \frac{AE}{EC}$.

Construction: join BE and CD . Draw $EF \perp AB$ and $DG \perp AC$.

$\text{ar}(\triangle ADE) = \frac{1}{2} \times AD \times EF$ and $\text{ar}(\triangle BDE) = \frac{1}{2} \times DB \times EF$. So $\frac{\text{ar}(\triangle ADE)}{\text{ar}(\triangle BDE)} = \frac{AD}{DB}$ (i)

Likewise $\frac{\text{ar}(ADE)}{\text{ar}(CDE)} = \frac{\frac{1}{2} \times AE \times DG}{\frac{1}{2} \times EC \times DG} = \frac{AE}{EC}$ (ii)

$\triangle BDE$ and $\triangle CDE$ are on the same base DE and between the same parallels DE and BC , so $\text{ar}(BDE) = \text{ar}(CDE)$ (iii)

From (i), (ii) and (iii): $\frac{AD}{DB} = \frac{AE}{EC}$. Hence proved.

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

Answer: Basic Proportionality Theorem proved, and its converse stated

Common mistake: Skipping the construction (join BE and CD, draw the perpendiculars). It carries marks in the CBSE scheme.

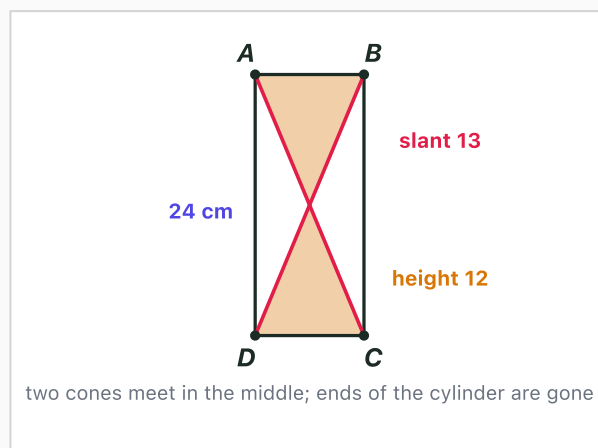
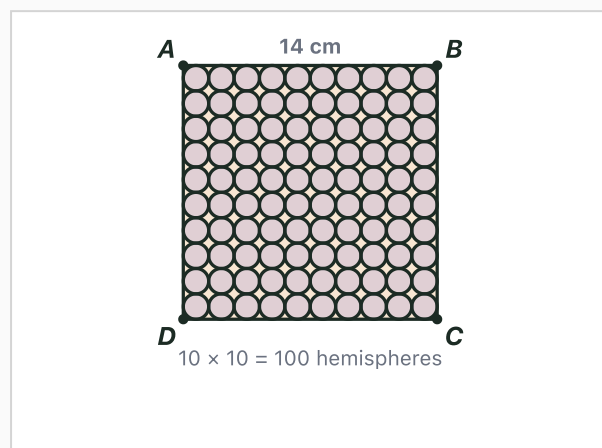
Q34 · SURFACE AREAS AND VOLUMES · 5 MARKS

(a) From one of the faces of a solid wooden cube of side 14 cm, maximum number of hemispheres of diameter 1.4 cm are scooped out. Find the total number of hemispheres that can be scooped out. Also, find the total surface area of the remaining solid.

OR

(b) From a solid cylinder of height 24 cm and radius 5 cm, two cones of height 12 cm and radius 5 cm are hollowed out. Find the volume and surface area of the remaining solid.

SOLUTION



(a) Along an edge of 14 cm, hemispheres of diameter 1.4 cm fit $\frac{14}{1.4} = 10$ times. On the square face: $10 \times 10 = 100$ hemispheres. Radius $r = 0.7$ cm.

Scooping out each hemisphere removes a circle πr^2 of the face and adds a curved surface $2\pi r^2$. Net gain per hemisphere = πr^2 .

$$\text{TSA} = 6 \times 14^2 + 100 \times \pi r^2 = 1176 + 100 \times \frac{22}{7} \times 0.7 \times 0.7 = 1176 + 154 = 1330 \text{ cm}^2.$$

$$\text{(b) Volume of the cylinder} = \pi r^2 h = \frac{22}{7} \times 5 \times 5 \times 24 = \frac{13200}{7} \text{ cm}^3.$$

$$\text{Volume of two cones} = 2 \times \frac{1}{3} \pi r^2 h = 2 \times \frac{1}{3} \times \frac{22}{7} \times 5 \times 5 \times 12 = \frac{4400}{7} \text{ cm}^3.$$

$$\text{Volume of the remaining solid} = \frac{13200}{7} - \frac{4400}{7} = \frac{8800}{7} \approx 1257.14 \text{ cm}^3.$$

$$\text{Slant height of each cone } l = \sqrt{12^2 + 5^2} = 13 \text{ cm.}$$

$$\text{Surface area} = \text{CSA of cylinder} + \text{CSA of two cones (the flat ends of the cylinder are completely hollowed away)} = 2\pi r h + 2\pi r l = 2 \times \frac{22}{7} \times 5 \times 24 + 2 \times \frac{22}{7} \times 5 \times 13 = \frac{5280 + 2860}{7} = \frac{8140}{7} \approx 1162.86 \text{ cm}^2.$$

Answer: (a) 100 hemispheres; TSA = 1330 cm² (b) volume $\frac{8800}{7} \approx 1257.14 \text{ cm}^3$; surface area $\frac{8140}{7} \approx 1162.86 \text{ cm}^2$

Common mistake: In (a), adding the hemisphere surface but forgetting to subtract the circular opening removed from the face.

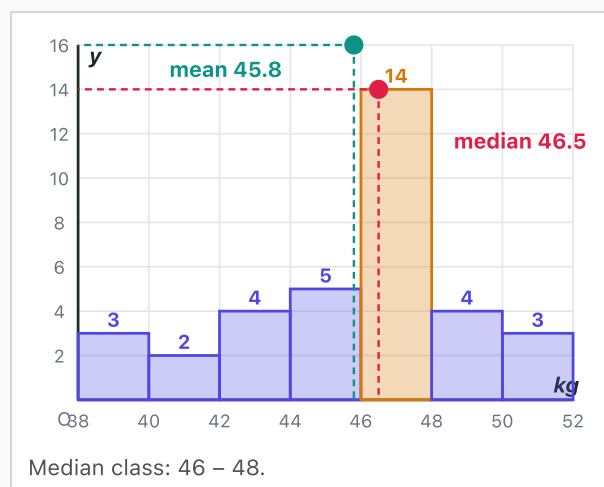
Q35 · STATISTICS · 5 MARKS

Medical check-up was carried out for 35 students of a class and their weights were recorded as follows:

Find the difference between the mean weight and the median weight.

Weight (in kg)	38–40	40–42	42–44	44–46	46–48	48–50	50–52
Number of Students	3	2	4	5	14	4	3

SOLUTION



Class marks x_i : 39, 41, 43, 45, 47, 49, 51. Take $a = 45$ and $h = 2$, so $u_i = \frac{x_i - 45}{2} = -3, -2, -1, 0, 1, 2, 3$.

$f_i u_i$: -9, -4, -4, 0, 14, 8, 9. Sum $\sum f_i u_i = 14$, with $\sum f_i = 35$.

Mean = $a + \frac{\sum f_i u_i}{\sum f_i} \times h = 45 + \frac{14}{35} \times 2 = 45 + 0.8 = 45.8 \text{ kg}$.

Cumulative frequencies: 3, 5, 9, 14, 28, 32, 35. $\frac{N}{2} = 17.5$, so the median class is 46 – 48 with $l = 46$, $cf = 14$, $f = 14$, $h = 2$.

Median = $46 + \frac{17.5 - 14}{14} \times 2 = 46 + 0.5 = 46.5 \text{ kg}$.

Difference = $46.5 - 45.8 = 0.7 \text{ kg}$.

Answer: Difference = 0.7 kg (mean 45.8 kg, median 46.5 kg)

Section E: Case studies

3 case studies, 4 marks each.

Q36 · AREAS RELATED TO CIRCLES · 4 MARKS

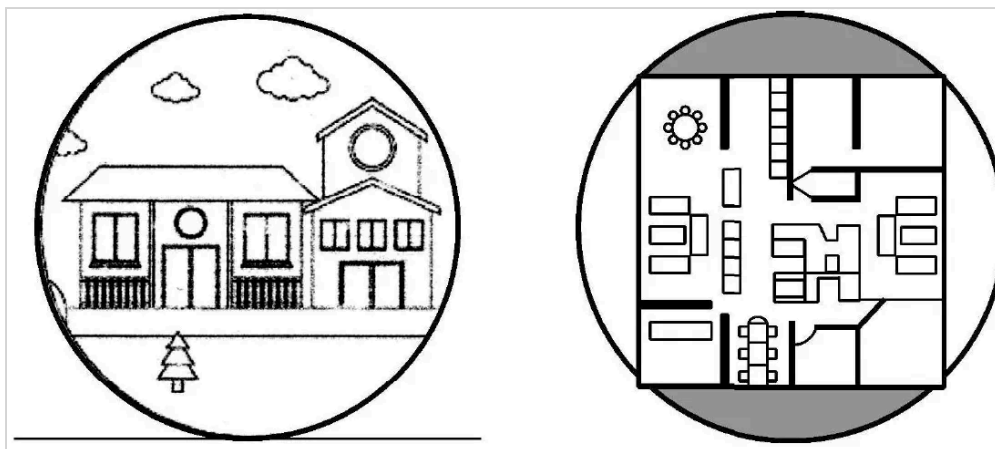
Case study 1. A farmer has a circular piece of land. He wishes to construct his house in the form of largest possible square within the land as shown below. The radius of circular piece of land is 35 m.

Based on given information, answer the following questions:

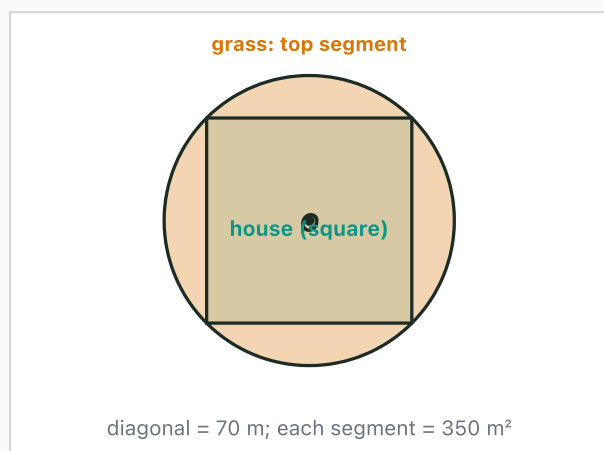
- (i) Find the length of wire needed to fence the entire land. [1]
- (ii) Find the length of each side of the square land on which house will be constructed. [1]
- (iii) (a) The farmer wishes to grow grass on the shaded region around the house. Find the cost of growing the grass at the rate of ₹ 50 per square metre. [2]

OR

- (iii) (b) Find the ratio of area of land on which house is built to remaining area of circular piece of land. [2]



SOLUTION



(i) Length of wire to fence the whole land = circumference = $2\pi r = 2 \times \frac{22}{7} \times 35 = 220$ m.

(ii) The largest square in a circle has its diagonal equal to the diameter: 70 m. Side = $\frac{70}{\sqrt{2}} = 35\sqrt{2}$ m (≈ 49.5 m).

(iii)(a) The shaded region is the top and bottom segments. Each segment = sector of 90° – triangle = $\frac{90}{360} \times \frac{22}{7} \times 35 \times 35 - \frac{1}{2} \times 35 \times 35 = 962.5 - 612.5 = 350$ m².

Two segments = 700 m². Cost = $700 \times 50 = ₹35,000$.

(iii)(b) Area of the house (square) = $(35\sqrt{2})^2 = 2450$ m². Area of the circle = $\frac{22}{7} \times 35 \times 35 = 3850$ m². Remaining area = $3850 - 2450 = 1400$ m².

Ratio = $\frac{2450}{1400} = \frac{7}{4}$, that is 7 : 4.

Answer: (i) 220 m (ii) $35\sqrt{2}$ m (iii)(a) ₹ 35,000 (iii)(b) 7 : 4

Common mistake: In (iii)(a), taking circle — square (1400 m^2). Only the top and bottom segments are shaded, which is half of that, 700 m^2 .

Q37 · ARITHMETIC PROGRESSIONS · 4 MARKS

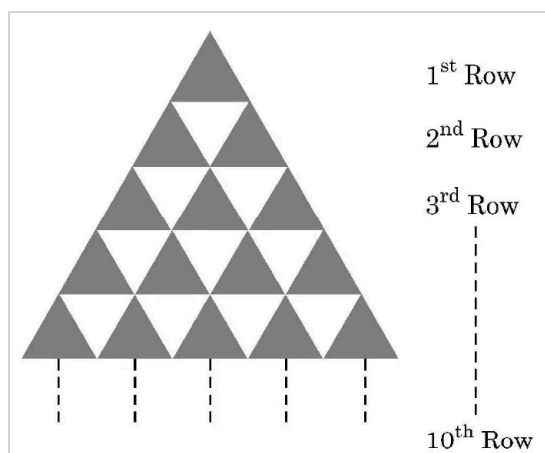
Case study 2. In an equilateral triangle of side 10 cm, equilateral triangles of side 1 cm are formed as shown in the figure below, such that there is one triangle in the first row, three triangles in the second row, five triangles in the third row and so on.

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

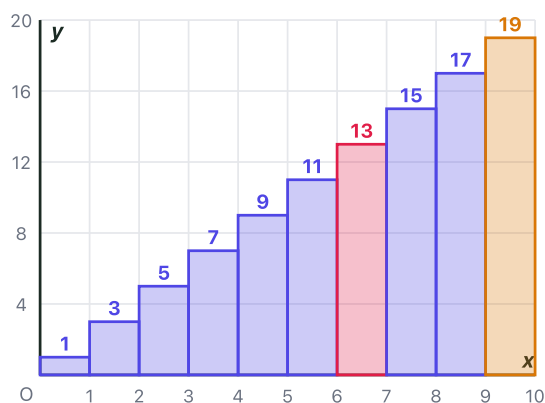
- (i) How many triangles will be there in bottom most row? [1]
- (ii) How many triangles will be there in fourth row from the bottom? [1]
- (iii) (a) Find the total number of triangles of side 1 cm each till 8th row. [2]

OR

- (iii) (b) How many more number of triangles are there from 5th row to 10th row than in first 4 rows? Show working. [2]



SOLUTION



Each row has 2 more triangles than the one above: an AP with $a = 1$ and $d = 2$.

The numbers of triangles in the rows are 1, 3, 5, ..., an AP with $a = 1$ and $d = 2$. The side is 10 cm, so there are 10 rows.

- (i) Bottom most row is the 10th: $a_{10} = 1 + 9 \times 2 = 19$ triangles.
- (ii) The fourth row from the bottom is the 7th row: $a_7 = 1 + 6 \times 2 = 13$ triangles. (Or start at the bottom: $19 + 3 \times (-2) = 13$.)
- (iii)(a) $S_8 = \frac{8}{2}[2 \times 1 + 7 \times 2] = 4 \times 16 = 64$ triangles.

$$(iii)(b) \text{ Triangles in rows 5 to 10} = S_{10} - S_4 = \frac{10}{2}[2 + 9 \times 2] - \frac{4}{2}[2 + 3 \times 2] = 100 - 16 = 84.$$

First 4 rows: $S_4 = 16$. So rows 5 to 10 have $84 - 16 = 68$ more triangles.

Answer: (i) 19 (ii) 13 (iii)(a) 64 (iii)(b) 68 more

Common mistake: In (iii)(b), stopping at 84. The question asks how many MORE there are than in the first 4 rows: $84 - 16 = 68$.

Q38 · APPLICATIONS OF TRIGONOMETRY · 4 MARKS

Case study 3. Passenger boarding stairs, sometimes referred to as boarding ramps, stair cars or aircraft steps, provide a mobile means to travel between the aircraft doors and the ground. Larger aircraft have door sills 5 to 20 feet (1 foot = 30 cm) high. Stairs facilitate safe boarding and de-boarding. An aircraft has a door sill at a height of 15 feet above the ground. A stair car is placed at a horizontal distance of 15 feet from the plane.

Based on given information, answer the questions given in part (i) and (ii).

(i) Find the angle at which stairs are inclined to reach the door sill 15 feet high above the ground. [1]

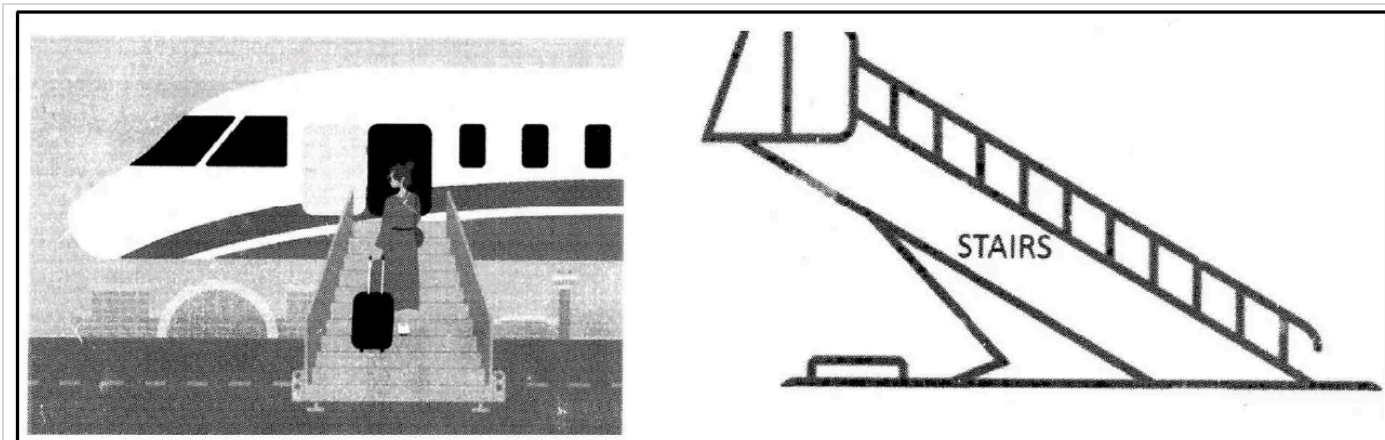
(ii) Find the length of stairs used to reach the door sill. [1]

Further, answer any one of the following questions:

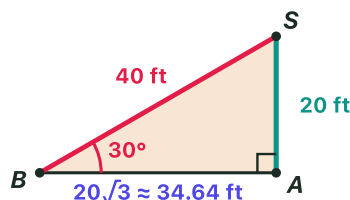
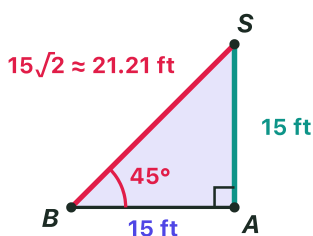
(iii) (a) If the 20 feet long stairs is inclined at an angle of 60° to reach the door sill, then find the height of the door sill above the ground. (use $\sqrt{3} = 1.732$) [2]

OR

(iii) (b) What should be the shortest possible length of stairs to reach the door sill of the plane 20 feet above the ground, if the angle of elevation cannot exceed 30° ? Also, find the horizontal distance of base of stair car from the plane. [2]



SOLUTION



(i) The stairs, the ground and the plane make a right triangle with height 15 ft and base 15 ft. $\tan \theta = \frac{15}{15} = 1$, so $\theta = 45^\circ$.

(ii) $\sin 45^\circ = \frac{15}{l}$, so $l = 15\sqrt{2}$ ft ≈ 21.21 ft.

(iii)(a) $\sin 60^\circ = \frac{h}{20}$, so $h = 20 \times \frac{\sqrt{3}}{2} = 10\sqrt{3} = 10 \times 1.732 = 17.32$ ft.

(iii)(b) The shortest stairs correspond to the steepest allowed angle, 30° . $\sin 30^\circ = \frac{20}{l} = \frac{1}{2}$, so $l = 40$ ft.

The horizontal distance: $\tan 30^\circ = \frac{20}{x} = \frac{1}{\sqrt{3}}$, so $x = 20\sqrt{3} \approx 34.64$ ft.

Answer: (i) 45° (ii) $15\sqrt{2} \approx 21.21$ ft (iii)(a) 17.32 ft (iii)(b) 40 ft and $20\sqrt{3} \approx 34.64$ ft

Common mistake: In (iii)(b), picking the largest angle. A smaller angle needs longer stairs, so the shortest stairs use the largest allowed angle, 30° .

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