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CBSE Class 12 Maths Board Paper 2026 (65/1/1) with Solutions

PREVIOUS YEAR PAPER · CLASS XII · MATHEMATICS (041) · BOARD EXAM 2026 · Q.P. CODE 65/1/1

TIME ALLOWED	MAXIMUM MARKS	QUESTIONS	NAME / ROLL NO.
3 hours	80	38 (A 20 · B 5 · C 6 · D 4 · E 3)	

GENERAL INSTRUCTIONS

Read the following instructions very carefully and strictly follow them:

1. This Question paper contains 38 questions. All questions are compulsory.
2. Question paper is divided into FIVE Sections – Section A, B, C, D and E.
3. In Section A – Question Number 1 to 18 are Multiple Choice Questions (MCQs) and Question Number 19 & 20 are Assertion-Reason based questions of 1 mark each.
4. In Section B – Question Number 21 to 25 are Very Short Answer (VSA) type questions, carrying 2 marks each.
5. In Section C – Question Number 26 to 31 are Short Answer (SA) type questions, carrying 3 marks each.
6. In Section D – Question Number 32 to 35 are Long Answer (LA) type questions, carrying 5 marks each.
7. In Section E – Question Number 36 to 38 are case study based questions, carrying 4 marks each.
8. There is no overall choice. However, an internal choice has been provided in few questions in all the Sections except Section – A.
9. Use of calculator is NOT allowed.
10. This is the official 2026 board paper (Q.P. Code 65/1/1). The step marks shown in the solutions are our marking scheme in the CBSE style; CBSE's own marking scheme may award steps differently.
11. The answer key and the marking scheme are at the end of this booklet. Attempt the paper in 3 hours before you look at them.

Questions: CBSE board examination 2026, Q.P. Code 65/1/1, as published by CBSE at cbse.gov.in; figures redrawn, case-study photographs left out. Answers, step marks and worked solutions © Master Testing Agency. Free for personal practice; not for resale. Master Testing Agency is an independent test-prep publisher, not affiliated with, endorsed by or connected to the Central Board of Secondary Education (CBSE) or any other exam-conducting body.

Chapters: Full syllabus · **Topics:** Relations and Functions · Inverse Trigonometric Functions · Matrices · Determinants · Continuity and Differentiability · Applications of Derivatives · Integrals · Applications of Integrals · Differential Equations · Vectors · Three Dimensional Geometry · Linear Programming · Probability

SECTION A

This section comprises 20 questions of 1 mark each: 18 multiple choice questions (MCQs) and 2 assertion-reason based questions.

1. If $2\cos^{-1}x = y$, then 1

(A) $0 \le y \le \pi$ (B) $-\pi \le y \le \pi$

(C) $0 \le y \le 2\pi$ (D) $-\pi \le y \le 0$

2. Which of the following cannot be the order of a row-matrix ? 1

(A) 2×1 (B) 1×2

(C) 1×1 (D) $1 \times n$

3. Which of the following properties is/are true for two matrices of suitable orders ? 1

(i) $(A + B)' = A' + B'$ (ii) $(A - B)' = B' - A'$

(iii) $(AB)' = A'B'$ (iv) $(kAB)' = kB'A'$ (k is a scalar)

(A) (i) only (B) (i), (ii) and (iii)

(C) (i) and (ii) (D) (i) and (iv)

4. If $\Delta_1 = \begin{vmatrix} 1 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 3 \end{vmatrix}$ and $\Delta_2 = \begin{vmatrix} 0 & 2 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 6 \end{vmatrix}$, then 1

(A) $\Delta_1 = 2\Delta_2$ (B) $\Delta_2 = -2\Delta_1$

(C) $\Delta_1 = \Delta_2$ (D) $\Delta_2 = -\Delta_1$

5. One of the values of x for which $\begin{vmatrix} \cos x & \sin x \\ -\cos x & \sin x \end{vmatrix} = 1$ is 1

(A) 0 (B) $\frac{\pi}{4}$

(C) $\frac{\pi}{3}$ (D) $\frac{\pi}{2}$

6. If A and B are skew symmetric matrices of same order, then which of the following matrices is also skew symmetric ? 1

(A) AB (B) AB + BA

(C) $(A + B)^2$ (D) A − B

7. The least value of $f(x) = x^3 - 12x$, $x \in [0, 3]$ is 1

(A) −16 (B) −9

(C) 0 (D) 16

8. If $\int \frac{3ax}{b^2 + c^2x^2}\,dx = A \log|b^2 + c^2x^2| + K$, then the value of A is 1

(A) 3a (B) $\frac{3a}{2b^2}$

(C) $\frac{3a}{b^2c^2}$ (D) $\frac{3a}{2c^2}$

9. The value of $\int_{-1}^{1} \frac{x^3}{x^2 + 2|x| + 1}\, dx$ is 1

(A) 0 (B) log 2

(C) 2 log 2 (D) $\frac{1}{2}$ log 2

10. The area bounded by the curve $y = x|x|$, x-axis and the ordinates $x = -1$ and $x = 1$ is given by 1

(A) 0 (B) $\frac{1}{3}$

(C) $\frac{2}{3}$ (D) $\frac{4}{3}$

11. The integrating factor of differential equation $R\frac{dx}{dy} + Px = Q$ where P, Q, R are functions of y is 1

(A) $e^{\int (P/Q)\, dy}$ (B) $e^{\int P\, dy}$

(C) $e^{\int (P/R)\, dy}$ (D) $e^{\int (P/R)\, dx}$

12. The order and degree of the differential equation $\frac{d}{dx}(e^y) = 0$ respectively are 1

(A) 0, 1 (B) 1, 1

(C) 2, 1 (D) 1, not defined

13. The value of p for which vectors $\hat{i} + 2\hat{j} + 3\hat{k}$ and $2\hat{i} - p\hat{j} + \hat{k}$ are perpendicular to each other is 1

(A) 0 (B) 1

(C) $\frac{5}{2}$ (D) $-\frac{5}{2}$

14. The value of m for which the points with position vectors $-\hat{i} - \hat{j} + 2\hat{k}$, $2\hat{i} + m\hat{j} + 5\hat{k}$ and $3\hat{i} + 11\hat{j} + 6\hat{k}$ are collinear, is 1

(A) 8 (B) −8

(C) 2 (D) $\frac{5}{2}$

15. If $|\boldsymbol{a}| = 8$, $|\boldsymbol{b}| = 3$ and $|\boldsymbol{a} \times \boldsymbol{b}| = 12$, then the value of $|\boldsymbol{a} \cdot \boldsymbol{b}|$ 1

(A) $6\sqrt{3}$ (B) $8\sqrt{3}$

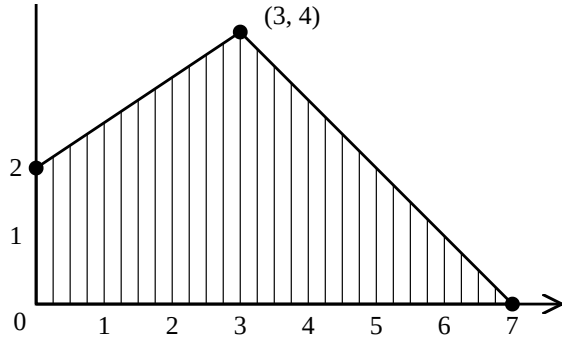
(C) $12\sqrt{3}$ (D) $3\sqrt{12}$

16. The length of perpendicular drawn from point (2, 5, 7) on line $\frac{x}{1} = \frac{y}{0} = \frac{z}{0}$ is 1

(A) 2 (B) 5

(C) $\sqrt{74}$ (D) $\sqrt{78}$

17. The feasible region of a linear programming problem with objective function Z = 5x + 7y is shown below : 1



The maximum value of Z − minimum value of Z is

(A) 8 (B) 29

(C) 35 (D) 43

18. The degree of an objective function of a linear programming problem is 1

(A) 0 (B) 1

(C) 2 (D) Any natural number

19. **Assertion (A) :** In an experiment of throwing an unbiased die, the probability of getting a prime number given that number appearing on the die being odd is $\frac{2}{3}$. 1

Reason (R) : For any two events A and B, $P(A|B) = \frac{P(A \cup B)}{P(B)}$

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

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

(C) Assertion (A) is true and Reason (R) is false.

(D) Assertion (A) is false and Reason (R) is true.

20. **Assertion (A) :** Lines given by x = py + q, z = ry + s and x = p′y + q′, z = r′y + s′ are perpendicular to each other when pp′ + rr′ = 1. 1

Reason (R) : Two lines $\boldsymbol{r} = \boldsymbol{a}_1 + \lambda\boldsymbol{b}_1$ and $\boldsymbol{r} = \boldsymbol{a}_2 + \mu\boldsymbol{b}_2$ are perpendicular to each other if $\boldsymbol{b}_1 \cdot \boldsymbol{b}_2 = 0$.

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

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

(C) Assertion (A) is true and Reason (R) is false.

(D) Assertion (A) is false and Reason (R) is true.

SECTION B

This section comprises 5 very short answer (VSA) type questions of 2 marks each.

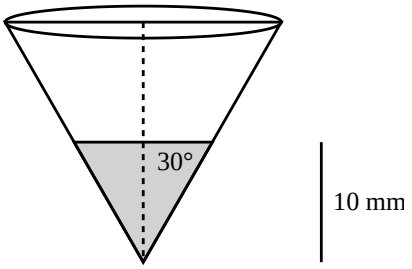
21. 2

(a) Check whether function f(x) defined as f(x) = $\begin{cases} \frac{|x-3|}{2(x-3)}, & x < 3 \\ \frac{x-6}{6}, & x \geq 3 \end{cases}$ is continuous at $x = 3$ or not ?

OR

(b) If $\sqrt{3}(x^2 + y^2) = 4xy$, then find $\frac{dy}{dx}$ at $(\frac{1}{2}, \frac{\sqrt{3}}{2})$.

22. A room freshner bottle in the shape of an inverted cone sprays the perfume at regular intervals such that volume of the perfume in the bottle decreases at the steady rate of 1 mm^3/min. Find the rate at which level of perfume is dropping at an instant when level of perfume in the bottle is 10 mm, if the semi-vertical angle of conical bottle is $\frac{\pi}{6}$. 2



23. Find the vector of magnitude 14 in the direction of **QP**, where P and Q are the points (1, 3, 2) and (−1, 0, 8) respectively. 2

24. Vectors $\boldsymbol{a} = 3\hat{i} - 2\hat{j} + 2\hat{k}$ and $\boldsymbol{b} = \hat{i} + 2\hat{k}$ represent the two adjacent sides of a parallelogram. Find the vectors representing its diagonals and hence find their lengths. 2

25. (a) Simplify : $\tan^{-1}(\frac{\cos 2x - \sin 2x}{\cos 2x + \sin 2x})$, $0 < x < \frac{\pi}{4}$. 2

OR

(b) Evaluate : $\tan(\sin^{-1} 1 - \cos^{-1}(-\frac{1}{2}))$

SECTION C

This section comprises 6 short answer (SA) type questions of 3 marks each.

26. Evaluate : $\int_0^1 x \tan^{-1} x \, dx$. 3

27. (a) Find $\int \sqrt{\frac{x+2}{x-2}} \, dx$ 3

OR

(b) Find : $\int \frac{x^2}{(x^2+9)(x^2+16)} \, dx$

28. If $I_1 = \int_{-\pi/4}^{\pi/4} \frac{dx}{1 + \cos 2x}$ and $I_2 = \int_{-1/2}^{1/2} |x|\, dx$, then show that $I_1 - 4I_2 = 0$. 3

29. (a) Find the general solution of the following differential equation : $x^2 \frac{dy}{dx} = x^2 + xy + y^2$ 3

OR

(b) Find the particular solution of the differential equation $xy \frac{dy}{dx} = (x + 2)(y + 2)$, given that $y(1) = -1$.

30. Solve the following linear programming problem graphically : 3
Minimize $Z = 13x - 15y$
Subject to constraints $x + y \leq 7$, $2x - 3y + 6 \geq 0$, $x \geq 0$, $y \geq 0$

31. (a) Out of two bags, bag I contains 3 red and 4 white balls and bag II contains 8 red and 6 white balls. A die is thrown. If it shows a number less than 3 then a ball is drawn at random from bag I, otherwise a ball is drawn at random from bag II. Find the probability that the ball drawn from one of the bags is a red ball. 3

OR

(b) The probability of simultaneous occurrence of atleast one of the two events X and Y is a. If the probability that exactly one of the events X, Y occurs is b, prove that $P(X') + P(Y') = 2 - 2a + b$.

SECTION D

This section comprises 4 long answer (LA) type questions of 5 marks each.

32. (a) A relation R is defined on Z, the set of integers, as $R = \{(x, y) : |x - y|$ is divisible by a prime number 'p', $x, y \in Z\}$ check whether R is an equivalence relation or not. 5

OR

(b) A function $f : R - \{\frac{3}{5}\} \to R - \{\frac{3}{5}\}$ is defined as $f(x) = \frac{3x + 2}{5x - 3}$. Show that f is one-one and onto.

33. (a) If $A = \begin{pmatrix} 0 & 2 & 1 \\ -2 & -1 & -2 \\ 1 & -1 & 0 \end{pmatrix}$, find A^{-1} and use it to solve the following system of equations : $-2y + z = 7$, $2x - y - z = 8$, $x - 2y = 10$ 5

OR

(b) If $\begin{pmatrix} 3 & -1 & \sin 3x \\ -7 & 4 & \cos 2x \\ -11 & 7 & 2 \end{pmatrix}$ is a singular matrix, then find all values of x where $x \in [0, \frac{\pi}{2}]$.

34. If $x = \cos t$, $y = \cos mt$, prove that $(1 - x^2) \frac{d^2y}{dx^2} - x \frac{dy}{dx} + m^2 y = 0$. 5

35. Check whether the lines given by $\frac{x-1}{2} = \frac{y-2}{3} = \frac{z-3}{4}$ and $\frac{x-4}{5} = \frac{y-1}{2} = z$ are parallel or not. If parallel, find the distance between them, otherwise find their point of intersection, if the lines are intersecting. 5

SECTION E

This section comprises 3 case study based questions of 4 marks each.

36. An online delivery company in a city has 5000 subscribers and collects annual subscription fees of ₹ 300 per subscriber for unlimited free deliveries. The company wishes to increase the annual subscription fee. It is predicted that, for every increase of ₹ 1, ten subscribers will discontinue. Assume that the company increased the annual fee by ₹ x.

Based on the given information, answer the following questions :

(i) How many subscribers will discontinue after an increase of ₹ x in annual fee ? [1]

(ii) If R(x) denotes the total revenue collected after the increase of ₹ x in subscription fee, express R(x) as a function of x. [1]

(iii) (a) Find the value of x for which R(x) is maximum. [2]

OR

(iii) (b) Find the sub-intervals of (0, 5000) in which R(x) is increasing and decreasing. [2]

37. In an online jackpot, there is one first prize of ₹ 3,00,000, two second prizes of ₹ 2,00,000 each and three third prizes of ₹ 50,000 each. A total of 1,00,000 jackpot tickets each costing ₹ 100 were sold there by raising a fund of ₹ 1,00,00,000. Rohan bought one ticket.

Based on given information, answer the following questions :

(i) What are the possible amounts, the person can win ? [1]

(ii) (a) What is the probability that the person wins atleast ₹ 2,00,000 ? [2]

OR

(ii) (b) What is the probability that the person does not win any amount ? [2]

(iii) In another jackpot, Rohan also bought a ticket having a prize money of ₹ 5,00,000. The chances of winning the jackpot are 1 in 1,00,000. Find the probability that on exactly one of tickets he wins the jackpot. [1]

38. Roundabouts are often made on busy roads to ease the traffic and avoid red lights. One such round-about is made such that equation representing its boundary is given by $C_1 : x^2 + y^2 = 64$. There is a circular pond with a fountain in the middle of the roundabout whose equation is given by $C_2 : x^2 + y^2 = 4$.

Based on the given information, answer the following questions :

(i) Represent the given equations C_1 and C_2 with the help of a diagram. [1]

(ii) Express y as a function of x, (y = f(x)), for both C_1 an C_2. [1]

(iii) (a) Using integration find the area of region covered by the roundabout. [2]

OR

(iii) (b) Using integration, find the area of region covered by circular pond. [2]

END OF THE QUESTION PAPER

ANSWER KEY — SECTION A

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
(C)	(A)	(D)	(B)	(B)	(D)	(A)	(D)	(A)	(C)	(C)	(B)	(C)	(A)	(C)	(C)	(D)	(B)	(C)	(D)

MARKING SCHEME AND WORKED SOLUTIONS

Marks for each step are shown in brackets, as in the CBSE marking scheme. Any correct alternative method earns full marks.

Q1. Answer (C). The principal value branch of $\cos^{-1}$ is $[0, \pi]$, so $0 \le \cos^{-1}x \le \pi$ and $0 \le 2\cos^{-1}x \le 2\pi$.

Q2. Answer (A). A row matrix has exactly one row: order $1 \times n$. A 2×1 matrix has two rows (it is a column matrix).

Q3. Answer (D). $(A + B)' = A' + B'$: true. $(A - B)' = A' - B'$, not $B' - A'$: false. $(AB)' = B'A'$, not $A'B'$: false. $(kAB)' = k(AB)' = kB'A'$: true. So (i) and (iv).

Q4. Answer (B). $\Delta_1 = 1 \times 2 \times 3 = 6$ (diagonal). $\Delta_2 = 0(0 - 0) - 2(6 - 0) + 0 = -12 = -2\Delta_1$.

Q5. Answer (B). The determinant $= \cos x \sin x - (-\cos x)\sin x = 2 \sin x \cos x = \sin 2x$. $\sin 2x = 1$ gives $2x = \pi/2$, $x = \pi/4$.

Q6. Answer (D). $A' = -A$ and $B' = -B$. $(A - B)' = A' - B' = -A + B = -(A - B)$: skew symmetric. $(AB + BA)' = B'A' + A'B' = BA + AB$ is symmetric, and $(A + B)^2$ is symmetric too.

Q7. Answer (A). $f'(x) = 3x^2 - 12 = 0$ at $x = 2$ in $[0, 3]$. $f(0) = 0$, $f(2) = 8 - 24 = -16$, $f(3) = 27 - 36 = -9$. Least value -16.

Q8. Answer (D). $\frac{d}{dx}(b^2 + c^2x^2) = 2c^2x$, so $\int \frac{3ax}{(b^2 + c^2x^2)}\,dx = (3a/2c^2)\int \frac{2c^2x}{(b^2 + c^2x^2)}\,dx = (3a/2c^2)\log|b^2 + c^2x^2| + K$. $A = 3a/(2c^2)$.

Q9. Answer (A). The integrand is odd (x^3 is odd and $x^2 + 2|x| + 1$ is even), and the limits are symmetric, so the integral is 0.

Q10. Answer (C). $y = x^2$ for $x \ge 0$ and $-x^2$ for $x < 0$. Area $= \int_{-1}^{0} x^2\,dx + \int_0^1 x^2\,dx = 1/3 + 1/3 = 2/3$. (The signed integral is 0, but area is never negative.)

Q11. Answer (C). Divide by R: $dx/dy + (P/R)x = Q/R$, linear in x with P/R a function of y. IF $= e^{\wedge}(\int (P/R)\,dy)$.

Q12. Answer (B). $\frac{d}{dx}(e^y) = e^y \frac{dy}{dx} = 0$. The highest derivative is dy/dx (order 1), and it appears to the power 1 (degree 1).

Q13. Answer (C). Perpendicular: dot product 0. $1 \times 2 + 2 \times (-p) + 3 \times 1 = 5 - 2p = 0$, $p = 5/2$.

Q14. Answer (A). $AB = 3\hat{i} + (m + 1)\hat{j} + 3\hat{k}$ and $AC = 4\hat{i} + 12\hat{j} + 4\hat{k}$. Collinear: $AB = \lambda\, AC$ with $\lambda = 3/4$, so $m + 1 = 12 \times 3/4 = 9$ and $m = 8$.

Q15. Answer (C). $|a \times b| = |a||b| \sin\theta$: $12 = 24 \sin\theta$, $\sin\theta = 1/2$, $|\cos\theta| = \sqrt{3}/2$. $|a \cdot b| = 24 \times \sqrt{3}/2 = 12\sqrt{3}$. (Check: $|a \times b|^2 + (a \cdot b)^2 = 144 + 432 = 576 = (|a||b|)^2$.)

Q16. Answer (C). The line is the x-axis. The foot of the perpendicular from (2, 5, 7) is (2, 0, 0), and the distance is $\sqrt{(5^2 + 7^2)} = \sqrt{74}$.

Q17. Answer (D). Corner points (0, 0), (7, 0), (3, 4), (0, 2): Z = 0, 35, 43, 14. Maximum 43, minimum 0, difference 43.

Q18. Answer (B). The objective function of an LPP is linear, $Z = ax + by$: degree 1.

Q19. Answer (C). Odd: {1, 3, 5}; prime and odd: {3, 5}. $P = 2/3$: A is true. The correct formula is $P(A|B) = P(A \cap B)/P(B)$, not $P(A \cup B)/P(B)$: R is false. Answer (C).

Q20. Answer (D). The first line is $(x - q)/p = y/1 = (z - s)/r$, direction $p\,\hat{i} + \hat{j} + r\,\hat{k}$; the second has direction $p'\,\hat{i} + \hat{j} + r'\,\hat{k}$. Perpendicular: $pp' + 1 + rr' = 0$, i.e. $pp' + rr' = -1$, not 1: A is false. R is the true condition. Answer (D).

Q21. (2 marks) Answer: (a) continuous at x = 3; (b) √3.
(a) For x < 3, |x − 3| = −(x − 3), so f(x) = −1/2 and LHL = −1/2. RHL = lim (x − 6)/6 = −3/6 = −1/2, and f(3) = −1/2. [1½]
LHL = RHL = f(3), so f is continuous at x = 3. [½]
OR (b) Differentiating: √3(2x + 2y y′) = 4y + 4x y′, so y′ = (2y − √3x)/(√3y − 2x). [1]
At (1/2, √3/2): y′ = (√3 − √3/2)/(3/2 − 1) = (√3/2)/(1/2) = √3. [1]

Q22. (2 marks) Answer: 3/(100π) mm/min (≈ 0.0095 mm/min).
With level h, the radius of the perfume surface is r = h tan(π/6) = h/√3, so V = (1/3)πr²h = πh³/9. [1]
dV/dt = (πh²/3) dh/dt. With dV/dt = −1 and h = 10: −1 = (100π/3) dh/dt, dh/dt = −3/(100π). The level drops at 3/(100π) mm/min. [1]

Q23. (2 marks) Answer: 4î + 6ĵ − 12k̂.
QP = (1 + 1)î + (3 − 0)ĵ + (2 − 8)k̂ = 2î + 3ĵ − 6k̂, |**QP**| = √(4 + 9 + 36) = 7. [1]
Required vector = 14 × (2î + 3ĵ − 6k̂)/7 = 4î + 6ĵ − 12k̂. [1]

Q24. (2 marks) Answer: 4î − 2ĵ + 4k̂, length 6; 2î − 2ĵ, length 2√2.
Diagonals: a + b = 4î − 2ĵ + 4k̂ and a − b = 2î − 2ĵ (or its negative). [1]
|a + b| = √(16 + 4 + 16) = 6; |a − b| = √(4 + 4) = 2√2. [1]

Q25. (2 marks) Answer: (a) π/4 − 2x; (b) −1/√3.
(a) Divide numerator and denominator by cos 2x: (1 − tan 2x)/(1 + tan 2x) = tan(π/4 − 2x). [1]
For 0 < x < π/4, −π/4 < π/4 − 2x < π/4, inside (−π/2, π/2), so the expression = π/4 − 2x. [1]
OR (b) $\sin^{-1} 1 = \pi/2$ and $\cos^{-1}(-1/2) = \pi - \pi/3 = 2\pi/3$. [1]
$\tan(\pi/2 - 2\pi/3) = \tan(-\pi/6) = -1/\sqrt{3}$. [1]

Q26. (3 marks) Answer: π/4 − 1/2.
By parts: $\int_0^1 x \tan^{-1}x\, dx = [(x^2/2)\tan^{-1}x]_0^1 - \int_0^1 (x^2/2)\cdot 1/(1+x^2)\, dx$. [1]
$= \pi/8 - \tfrac{1}{2}\int_0^1 (1 - 1/(1+x^2))\, dx = \pi/8 - \tfrac{1}{2}[x - \tan^{-1}x]_0^1$ [1]
$= \pi/8 - \tfrac{1}{2}(1 - \pi/4) = \pi/4 - 1/2$. [1]

Q27. (3 marks) Answer: (a) $\sqrt{(x^2-4)} + 2\log|x + \sqrt{(x^2-4)}| + C$; (b) $-(3/7)\tan^{-1}(x/3) + (4/7)\tan^{-1}(x/4) + C$.
(a) $\sqrt{((x+2)/(x-2))} = (x+2)/\sqrt{(x^2-4)}$ (for x > 2). [1]
$\int x/\sqrt{(x^2-4)}\, dx + 2\int dx/\sqrt{(x^2-4)}$ [½]
$= \sqrt{(x^2-4)} + 2\log|x + \sqrt{(x^2-4)}| + C$. [1½]
OR (b) Put $x^2 = t$: $t/((t+9)(t+16)) = A/(t+9) + B/(t+16)$ gives A = −9/7, B = 16/7. [1½]
$\int = -(9/7)\int dx/(x^2+9) + (16/7)\int dx/(x^2+16) = -(3/7)\tan^{-1}(x/3) + (4/7)\tan^{-1}(x/4) + C$. [1½]

Q28. (3 marks) Answer: $I_1 = 1$, $I_2 = 1/4$.
$1 + \cos 2x = 2\cos^2 x$, so $I_1 = \tfrac{1}{2}\int \sec^2 x\, dx = \tfrac{1}{2}[\tan x]$ from −π/4 to π/4 = ½ (1 + 1) = 1. [1½]
$I_2 = 2\int_0^{(1/2)} x\, dx = 2 \times 1/8 = 1/4$. [1]
$I_1 - 4I_2 = 1 - 1 = 0$. [½]

Q29. (3 marks) Answer: (a) $\tan^{-1}(y/x) = \log|x| + C$; (b) $y - 2\log|y+2| = x + 2\log|x| - 2$.
(a) $dy/dx = 1 + y/x + (y/x)^2$: homogeneous. Put y = vx: $v + x\, dv/dx = 1 + v + v^2$. [1]
$dv/(1+v^2) = dx/x$. [1]
$\tan^{-1} v = \log|x| + C$, i.e. $\tan^{-1}(y/x) = \log|x| + C$. [1]
OR (b) Separating: $y/(y+2)\, dy = (x+2)/x\, dx$, i.e. $(1 - 2/(y+2))\, dy = (1 + 2/x)\, dx$. [1]
$y - 2\log|y+2| = x + 2\log|x| + C$. [1]
y(1) = −1: −1 − 0 = 1 + 0 + C, C = −2. Solution: $y - 2\log|y+2| = x + 2\log|x| - 2$. [1]

Q30. (3 marks) Answer: minimum −30 at (0, 2).
Draw $x + y = 7$ (through (7, 0), (0, 7)) and $2x - 3y + 6 = 0$ (through (−3, 0), (0, 2)); the feasible region is bounded, with corners (0, 0), (7, 0), (3, 4) and (0, 2). [1½]
Z at the corners: 0, 91, 39 − 60 = −21, −30. [1]
Minimum Z = −30 at (0, 2). [½]

Q31. (3 marks) Answer: (a) 11/21; (b) proved.
(a) P(bag I) = 2/6 = 1/3, P(bag II) = 2/3. [1]
P(red) = (1/3)(3/7) + (2/3)(8/14) = 1/7 + 8/21 [1]
= 11/21. [1]
OR (b) $P(X \cup Y) = P(X) + P(Y) - P(X \cap Y) = a$, and P(exactly one) $= P(X) + P(Y) - 2P(X \cap Y) = b$. [1]
Subtracting: $P(X \cap Y) = a - b$, so $P(X) + P(Y) = a + (a - b) = 2a - b$. [1]
$P(X') + P(Y') = 2 - (P(X) + P(Y)) = 2 - 2a + b$. [1]

Q32. (5 marks) Answer: (a) R is an equivalence relation; (b) proved.
(a) Reflexive: $|x - x| = 0 = 0 \times p$, divisible by p, so $(x, x) \in R$. [1½]
Symmetric: if p divides $|x - y|$, then p divides $|y - x| = |x - y|$. [1½]
Transitive: if $x - y = mp$ and $y - z = np$, then $x - z = (m + n)p$, so p divides $|x - z|$. [1½]
Hence R is an equivalence relation. [½]
OR (b) One-one: f(a) = f(b) gives $(3a + 2)(5b - 3) = (3b + 2)(5a - 3)$, i.e. $-9a + 10b = -9b + 10a$, so $19a = 19b$ and $a = b$. [2]
Onto: for $y \neq 3/5$, solve $y = (3x + 2)/(5x - 3)$: $x = (3y + 2)/(5y - 3)$. [1½]
This x is real, and $x \neq 3/5$ ($x = 3/5$ would give $15y + 10 = 15y - 9$, impossible); and f(x) = y. So f is onto. [1½]

Q33. (5 marks) Answer: (a) x = 0, y = −5, z = −3; (b) x = 0, π/6.
(a) $|A| = 0(0 - 2) - 2(0 + 2) + 1(2 + 1) = -1 \neq 0$. [1]
adj A = [[−2, −1, −3], [−2, −1, −2], [3, 2, 4]], so $A^{-1} = -\text{adj } A$ = [[2, 1, 3], [2, 1, 2], [−3, −2, −4]]. [2]
The system is $A'X = B$ with B = [7, 8, 10]′, so $X = (A')^{-1}B = (A^{-1})'B$: x = 2(7) + 2(8) − 3(10) = 0, y = 1(7) + 1(8) − 2(10) = −5, z = 3(7) + 2(8) − 4(10) = −3. [1½]
x = 0, y = −5, z = −3. [½]
OR (b) Expanding along the third column: $\sin 3x(-49 + 44) - \cos 2x(21 - 11) + 2(12 - 7) = -5 \sin 3x - 10 \cos 2x + 10$. [2]
Singular: $\sin 3x = 2(1 - \cos 2x) = 4 \sin^2 x$, i.e. $3 \sin x - 4 \sin^3 x = 4 \sin^2 x$. [1]
$\sin x(4 \sin^2 x + 4 \sin x - 3) = 0$: $\sin x = 0$ or $(2 \sin x - 1)(2 \sin x + 3) = 0$, so $\sin x = 0$ or 1/2. [1]
In $[0, \pi/2]$: $x = 0$ or $x = \pi/6$. [1]

Q34. (5 marks) Answer: proved.
$dx/dt = -\sin t$, $dy/dt = -m \sin mt$, so $dy/dx = m \sin mt / \sin t$. [1]
$\sin t \cdot dy/dx = m \sin mt$; squaring, $(1 - \cos^2 t)(dy/dx)^2 = m^2(1 - \cos^2 mt)$, i.e. $(1 - x^2)(dy/dx)^2 = m^2(1 - y^2)$. [1½]
Differentiating w.r.t. x: $(1 - x^2) \cdot 2 (dy/dx)(d^2y/dx^2) - 2x (dy/dx)^2 = -2m^2 y (dy/dx)$. [1½]
Dividing by 2 dy/dx: $(1 - x^2) d^2y/dx^2 - x \, dy/dx + m^2 y = 0$. [1]

Q35. (5 marks) Answer: not parallel; they intersect at (−1, −1, −1).
Directions $2\hat{i} + 3\hat{j} + 4\hat{k}$ and $5\hat{i} + 2\hat{j} + \hat{k}$ are not proportional, so the lines are not parallel. [1]
General points: $(2\lambda + 1, 3\lambda + 2, 4\lambda + 3)$ and $(5\mu + 4, 2\mu + 1, \mu)$. [1]
Equating x and z: $2\lambda + 1 = 5\mu + 4$ and $4\lambda + 3 = \mu$ give $\lambda = -1$, $\mu = -1$. [1½]
Check y: $3(-1) + 2 = -1$ and $2(-1) + 1 = -1$: equal, so the lines intersect. [1]
Point of intersection (−1, −1, −1). [½]

Q36. (4 marks) Answer: (i) 10x; (ii) R(x) = (300 + x)(5000 − 10x); (iii)(a) x = 100; (iii)(b) increasing (0, 100), decreasing (100, 5000).

(i) 10x subscribers. [1]

(ii) R(x) = (300 + x)(5000 − 10x). [1]

(iii)(a) R′(x) = (5000 − 10x) − 10(300 + x) = 2000 − 20x = 0 at x = 100. [1]

R″(x) = −20 < 0, so R is maximum at x = 100 (fee ₹ 400, revenue ₹ 16,00,000). [1]

OR (iii)(b) R′(x) = 2000 − 20x is positive for x < 100 and negative for x > 100. [1]

R is increasing in (0, 100) and decreasing in (100, 5000). [1]

Q37. (4 marks) Answer: (i) ₹ 3,00,000, ₹ 2,00,000, ₹ 50,000, ₹ 0; (ii)(a) 3/1,00,000; (ii)(b) 99,994/1,00,000; (iii) $2 \times 99{,}999/10^{10}$.

(i) ₹ 3,00,000, ₹ 2,00,000, ₹ 50,000 or ₹ 0 (nothing). [1]

(ii)(a) Prizes of at least ₹ 2,00,000: 1 + 2 = 3 tickets out of 1,00,000. [1]

P = 3/1,00,000 = 0.00003. [1]

OR (ii)(b) Prize-winning tickets: 1 + 2 + 3 = 6. [1]

P(no prize) = 1 − 6/1,00,000 = 99,994/1,00,000 = 0.99994. [1]

(iii) Taking ‘winning the jackpot’ as the top prize on each ticket, with chance 1/1,00,000 each, independently: P(exactly one) $= 2 \times (1/10^5)(1 - 1/10^5) = 2 \times 99{,}999/10^{10} \approx 0.00002$. [1]

Q38. (4 marks) Answer: (i) concentric circles, radii 8 and 2; (ii) $y = \pm\sqrt{(64 - x^2)}$, $y = \pm\sqrt{(4 - x^2)}$; (iii)(a) 64π sq units; (iii)(b) 4π sq units.

(i) Two concentric circles with centre at the origin: C_1 of radius 8 and C_2 of radius 2. [1]

(ii) C_1: $y = \pm\sqrt{(64 - x^2)}$, $-8 \le x \le 8$; C_2: $y = \pm\sqrt{(4 - x^2)}$, $-2 \le x \le 2$. [1]

(iii)(a) Area $= 4\int_0^8 \sqrt{(64 - x^2)}\,dx = 4\,[\,(x/2)\sqrt{(64 - x^2)} + 32\sin^{-1}(x/8)\,]_0^8$ [1]

$= 4 \times 32 \times \pi/2 = 64\pi$ square units. (If the pond is left out, the ring has area $64\pi - 4\pi = 60\pi$.) [1]

OR (iii)(b) Area $= 4\int_0^2 \sqrt{(4 - x^2)}\,dx = 4\,[\,(x/2)\sqrt{(4 - x^2)} + 2\sin^{-1}(x/2)\,]_0^2$ [1]

$= 4 \times 2 \times \pi/2 = 4\pi$ square units. [1]

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