CBSE Class 12 Maths Board Paper 2026 (65/2/1) with Solutions

PREVIOUS YEAR PAPER · CLASS XII · MATHEMATICS (041) · BOARD EXAM 2026 · Q.P. CODE 65/2/1

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 65/2/1). 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 65/2/1, 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. A relation R on set A = {1, 2, 3} defined as R = {(1, 1), (2, 2), (1, 2)} is 1

(A) Reflexive only
(B) Reflexive and Transitive
(C) Symmetric and Transitive
(D) Transitive only

2. If A and B are square matrices of same order, then which of the following statements is/are always true ? 1

(i) $(A + B)(A - B) = A^2 - B^2$
(ii) $AB = BA$
(iii) $(A + B)^2 = A^2 + AB + BA + B^2$
(iv) $AB = 0 \Rightarrow A = 0$ or $B = 0$

(A) Only (i) and (iii)
(B) Only (ii) and (iii)
(C) Only (iii)
(D) Only (iii) and (iv)

3. If $A = \begin{pmatrix} 1 & a & b \\ -1 & 2 & c \\ 0 & 5 & 3 \end{pmatrix}$ is a symmetric matrix, then the value of 3a + b + c is 1

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

4. If $A = \begin{pmatrix} \cos x & -\sin x \\ \sin x & \cos x \end{pmatrix}$ and $A + A' = I$, then the value of $x \in [0, \frac{\pi}{2}]$ is 1

(A) 0
(B) $\frac{\pi}{4}$
(C) $\frac{\pi}{3}$
(D) $\frac{\pi}{2}$

5. For a square matrix A, $(3A)^{-1}$ = 1

(A) $3A^{-1}$
(B) $9A^{-1}$
(C) $\frac{1}{3}A^{-1}$
(D) $\frac{1}{9}A^{-1}$

6. If $\begin{vmatrix} -1 & -2 & 5 \\ -2 & a & -1 \\ 0 & 4 & 2a \end{vmatrix} = -86$, then the sum of all possible values of a is 1

(A) 4
(B) 5
(C) −4
(D) 9

7. If $e^{-x} + e^{-y} = 2$, then $\frac{dy}{dx}$ is 1

(A) e^{x-y}
(B) e^{y-x}
(C) $-e^{x-y}$
(D) $-e^{y-x}$

8. For $f(x) = x + \frac{1}{x}$ $(x \neq 0)$ 1

(A) local maximum value is 2 (B) local minimum value is −2

(C) local maximum value is −2 (D) local minimum value < local maximum value

9. If $\int_0^{2a} \frac{1}{1+4x^2}\,dx = \frac{\pi}{6}$, then the value of a is 1

(A) $\frac{\sqrt{3}}{4}$ (B) $\frac{\sqrt{3}}{2}$

(C) $\sqrt{3}$ (D) $2\sqrt{3}$

10. Which of the following expressions will give the area of region bounded by the curve $y = x^2$ and line $y = 16$? 1

(A) $\int_0^4 x^2\,dx$ (B) $2\int_0^4 x^2\,dx$

(C) $\int_0^{16} \sqrt{y}\,dy$ (D) $2\int_0^{16} \sqrt{y}\,dy$

11. The general solution of the differential equation $\frac{dy}{dx} = \frac{\sqrt{y}}{\sqrt{x}}$ is 1

(A) $\log \sqrt{y} = \log \sqrt{x} + C$ (B) $\sqrt{y} + \sqrt{x} = C$

(C) $\sqrt{y} - \sqrt{x} = C$ (D) $\log \sqrt{y} + \log \sqrt{x} = C$

12. The integrating factor of the differential equation $2x\frac{dy}{dx} - y = 3$ is 1

(A) $\sqrt{x}$ (B) $\frac{1}{\sqrt{x}}$

(C) e^x (D) e^{-x}

13. If $|\boldsymbol{a}| = 5$ and $-2 \le \lambda \le 1$, then the sum of greatest and the smallest value of $|\lambda \boldsymbol{a}|$ is 1

(A) −5 (B) 5

(C) 10 (D) 15

14. Vector of magnitude 3 making equal angles with x and y axes and perpendicular to z axis is 1

(A) $\hat{i} + 2\sqrt{2}\,\hat{j}$ (B) $3\hat{k}$

(C) $\frac{3\sqrt{2}}{2}\hat{i} + \frac{3\sqrt{2}}{2}\hat{j}$ (D) $\sqrt{3}\,\hat{i} + \sqrt{3}\,\hat{j} + \sqrt{3}\,\hat{k}$

15. Direction cosines of the line given by equations : $\frac{2x-1}{4} = \frac{1-y}{3} = \frac{-z}{6}$ are 1

(A) 2, −3, −6 (B) $\frac{2}{7}, \frac{-3}{7}, \frac{-6}{7}$

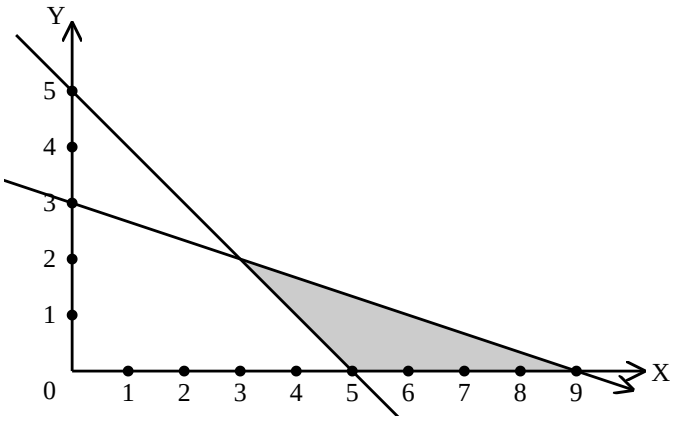
(C) $\frac{2}{7}, \frac{-3}{7}, \frac{6}{7}$ (D) $\frac{4}{\sqrt{61}}, \frac{-3}{\sqrt{61}}, \frac{-6}{\sqrt{61}}$

16. In a linear programming problem, the linear function which has to be maximized or minimized is called 1

(A) a feasible function (B) an objective function

(C) an optimal function (D) a constraint

17. For the feasible region shown below, the non-trivial constraints of the linear programming problem are 1



(A) $x + y \leq 5, x + 3y \leq 9$ (B) $x + y \leq 5, x + 3y \geq 9$

(C) $x + y \geq 5, x + 3y \leq 9$ (D) $x + y \geq 5, 3x + y \leq 9$

18. For two events A and B such that $P(A) \neq 0$ and $P(B) \neq 1$, $P(A'/B') =$ 1

(A) $1 - P(A/B)$ (B) $1 - P(A'/B)$

(C) $\frac{1 - P(A \cap B)}{P(B')}$ (D) $\frac{1 - P(A \cup B)}{P(B')}$

19. For two vectors $\boldsymbol{a}$ and $\boldsymbol{b}$ 1

Assertion (A) : $|\boldsymbol{a} \times \boldsymbol{b}|^2 + (\boldsymbol{a} \cdot \boldsymbol{b})^2 = |\boldsymbol{a}|^2 |\boldsymbol{b}|^2$

Reason (R) : $|\boldsymbol{a} \times \boldsymbol{b}| = (\boldsymbol{a} \cdot \boldsymbol{b}) \tan\theta, (\theta \neq \frac{\pi}{2})$

(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) :** A line can have direction cosines < 1, 1, 1 > 1

Reason (R) : $\cos\theta = 1$ is possible for $\theta = 0$.

(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. (a) Check whether f : R − {3} → R defined as $f(x) = \frac{x-2}{x-3}$ is onto or not. 2

OR

(b) Check whether f : Z × Z → Z × Z (where Z is the set of integers) defined as f(*x*, y) = (2y, 3*x*) is injective or not.

22. If $x = a\sin^3 t$, $y = b\cos^3 t$, then find $\frac{dy}{dx}$ at $t = \frac{\pi}{4}$. 2

23. (a) Find the absolute maximum value of $f(x) = \cos x + \sin^2 x$, $x \in [0, \pi]$ 2

OR

(b) If the volume of a solid hemisphere increases at a uniform rate, prove that its surface area varies inversely as its radius.

24. If $\overline{AB} = \hat{j} + \hat{k}$ and $\overline{AC} = 3\hat{i} - \hat{j} + 4\hat{k}$ represent the two vectors along the sides AB and AC of ΔABC, prove that the median $\overline{AD} = \frac{\overline{AB} + \overline{AC}}{2}$, where D is midpoint of BC. Hence, find the length of median AD. 2

25. Find the co-ordinates of the point on the line $\boldsymbol{r} = -\hat{j} + 3\hat{k} + \lambda(2\hat{i} - 2\hat{j} + \hat{k})$ such that the sum of co-ordinates is 3. 2

SECTION C

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

26. Find : $\int \frac{x+2}{\sqrt{9x - x^2}}\,dx$ 3

27. (a) Evaluate : $\int_{\frac{\pi}{12}}^{\frac{5\pi}{12}} \frac{dx}{1 + \sqrt{\cot x}}$ 3

OR

(b) Evaluate : $\int_{\frac{-\pi}{6}}^{\frac{\pi}{2}} (\sin|x| + \cos|x|)\,dx$

28. If $\frac{d}{dx}(F(x)) = \frac{1}{e^x + 1}$, then find F(*x*) given that $F(0) = \log\frac{1}{2}$. 3

29. (a) Solve the following differential equation : $x\frac{dy}{dx} = y - x\sin^2\left(\frac{y}{x}\right)$, given that $y(1) = \frac{\pi}{6}$ 3

OR

(b) Find the general solution of the differential equation : $y\log y\frac{dx}{dy} + x = \frac{2}{y}$.

30. Solve the following linear programming problem graphically : 3

Maximize Z = 10500x + 9000y

Subject to constraints

x + y ≤ 50

2x + y ≤ 80

x, y ≥ 0

31. (a) The probability of hitting the target by a trained sniper is three times the probability of not hitting the target on a stormy day due to high wind speed. The sniper fired two shots on the target on a stormy day when wind speed was very high. Find the probability that 3

(i) target is hit

(ii) atleast one shot misses the target.

OR

(b) Mother, Father and Son line up at random for a family picture. Let events E : Son on one end and F : Father in the middle. Find P(E/F).

SECTION D

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

32. (a) If P = $\begin{pmatrix} 1 & -1 & 0 \\ 2 & 3 & 4 \\ 0 & 1 & 2 \end{pmatrix}$ and Q = $\begin{pmatrix} 2 & 2 & -4 \\ -4 & 2 & -4 \\ 2 & -1 & 5 \end{pmatrix}$, find (QP) and hence solve the following system of equations using matrices : x − y = 3, 2x + 3y + 4z = 17, y + 2z = 7 5

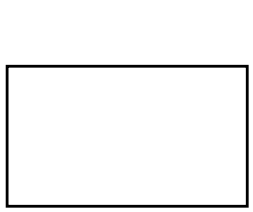
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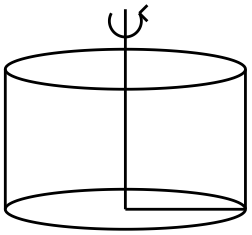
(b) Obtain the value of $\Delta = \begin{vmatrix} 1+x & 1 & 1 \\ 1 & 1+y & 1 \\ 1 & 1 & 1+z \end{vmatrix}$ in terms of x, y and z. Further, if $\Delta = 0$ and x, y, z are non-zero real numbers, prove that $x^{-1} + y^{-1} + z^{-1} = -1$.

33. (a) Find the sub intervals in which f(x) = $\cot^{-1}(\sin x + \cos x)$, $x \in (0, \pi)$ is increasing and decreasing. 5

OR

(b) A rectangle of perimeter 36 cm is revolved around one of its sides to sweep out a cylinder of maximum volume.





Find the dimensions of the rectangle.

34. Find the domain of $g(x) = \cos^{-1}(x^2 - 1)$. Hence, find the value of x for which $g(x) = \frac{\pi}{3}$. 5

Also, write the range of $\cos^{-1} x$ other than its principal branch.

35. A line passing through the points A(1, 2, 3) and B(5, 8, 11) intersects the line $\boldsymbol{r} = 4\hat{i} + \hat{j} + \lambda(5\hat{i} + 2\hat{j} + \hat{k})$. 5
Find the co-ordinates of the point of intersection. Hence, write the equation of a line passing through the point of intersection and perpendicular to both the lines.

SECTION E

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

36. Smoking increases the risk of lung problems. A study revealed that 170 in 1000 males who smoke develop lung complications, while 120 out of 1000 females who smoke develop lung related problems. In a colony, 50 people were found to be smokers of which 30 are males. A person is selected at random from these 50 people and tested for lung related problems. Based on the given information, answer the following questions :

(i) What is the probability that selected person is a female ? [1]

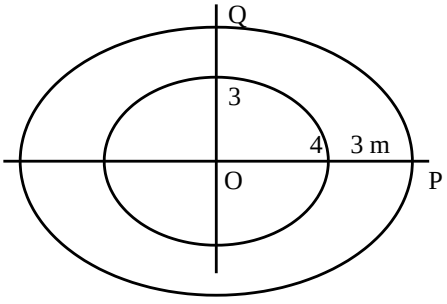
(ii) If a male person is selected, what is the probability that he will not be suffering from lung problems ? [1]

(iii) (a) A person selected at random is detected with lung complications. Find the probability that selected person is a female. [2]

OR

(iii) (b) A person selected at random is not having lung problems, find the probability that the person is a male. [2]

37. A racing track is build around an elliptical ground whose equation is given by $9x^2 + 16y^2 = 144$. The width of the track is 3 m as shown below :



Based on given information, answer the following questions :

(i) Express y as a function of x from the given equation of ellipse. [1]

(ii) Integrate the function obtained in (i) with respect to x. [1]

(iii) (a) Find the area of the region enclosed within the elliptical ground excluding the track using integration. [2]

OR

(iii) (b) Write the co-ordinates of the points P and Q where the outer edge of the track cuts x axis and y axis in first quadrant and find the area of the triangle formed by points P, O, Q using integration. [2]

38. Sports car racing is a form of motorsport which uses sports car prototypes. The competition is held on special tracks designed in various shapes. The equation of one such track is given as follows :

$$f(x) = \begin{cases} x^4 - 4x^2 + 4, & 0 \le x < 3 \\ x^2 + 40, & x \ge 3 \end{cases}$$

Based on given information, answer the following questions :

(i) Find $f'(x)$ for $0 < x < 3$. [1]

(ii) Find $f'(4)$ [1]

(iii) (a) Test for continuity of $f(x)$ at $x = 3$. [2]

OR

(iii) (b) Test for differentiability of $f(x)$ at $x = 3$. [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
(D)	(C)	(A)	(C)	(C)	(C)	(D)	(C)	(A)	(D)	(C)	(B)	(C)	(C)	(C)	(B)	(C)	(D)	(B)	(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 (D). $(3, 3) \notin R$, so R is not reflexive; $(1, 2) \in R$ but $(2, 1) \notin R$, so not symmetric. Every pair (a, b), (b, c) in R gives (a, c) in R (e.g. (1, 1), (1, 2) → (1, 2); (1, 2), (2, 2) → (1, 2)), so R is transitive only.

Q2. Answer (C). Matrix multiplication is not commutative, so (i) and (ii) fail in general; $(A + B)^2 = A^2 + AB + BA + B^2$ always holds; AB = 0 is possible with $A \neq 0$, $B \neq 0$. Only (iii).

Q3. Answer (A). Symmetric: $a_{12} = a_{21}$ gives $a = -1$, $a_{13} = a_{31}$ gives $b = 0$, $a_{23} = a_{32}$ gives $c = 5$. $3a + b + c = -3 + 0 + 5 = 2$.

Q4. Answer (C). $A + A' = [[2 \cos x, 0], [0, 2 \cos x]] = I$ gives $2 \cos x = 1$, $\cos x = 1/2$, $x = \pi/3$.

Q5. Answer (C). $(3A)((1/3)A^{-1}) = AA^{-1} = I$, so $(3A)^{-1} = (1/3)A^{-1}$ (for invertible A).

Q6. Answer (C). Expanding along the first column: $-1(2a^2 + 4) + 2(-4a - 20) = -2a^2 - 8a - 44 = -86$, so $a^2 + 4a - 21 = 0$, $(a + 7)(a - 3) = 0$. $a = -7$ or 3; sum -4.

Q7. Answer (D). $-e^{-x} - e^{-y}\, dy/dx = 0$, so $dy/dx = -e^{-x}/e^{-y} = -e^{\wedge}(y - x)$.

Q8. Answer (C). $f'(x) = 1 - 1/x^2 = 0$ at $x = \pm 1$; $f''(x) = 2/x^3$. At $x = -1$, $f'' < 0$: local maximum $f(-1) = -2$. At $x = 1$: local minimum $f(1) = 2$ (greater than the local maximum).

Q9. Answer (A). $\int dx/(1 + 4x^2) = (1/2) \tan^{-1} 2x$. So $(1/2) \tan^{-1} 4a = \pi/6$, $\tan^{-1} 4a = \pi/3$, $4a = \sqrt{3}$, $a = \sqrt{3}/4$.

Q10. Answer (D). The region lies between $x = -\sqrt{y}$ and $x = \sqrt{y}$ for $0 \le y \le 16$, symmetric about the y-axis: area $= 2 \int_0^{16} \sqrt{y}\, dy$ (= 256/3).

Q11. Answer (C). Separating: $dy/\sqrt{y} = dx/\sqrt{x}$, so $2\sqrt{y} = 2\sqrt{x} + C'$, i.e. $\sqrt{y} - \sqrt{x} = C$.

Q12. Answer (B). $dy/dx - y/(2x) = 3/(2x)$. IF $= e^{\wedge}(\int -1/(2x)\, dx) = e^{\wedge}(-\tfrac{1}{2} \log x) = 1/\sqrt{x}$.

Q13. Answer (C). $|\lambda a| = |\lambda| \times 5$ and $|\lambda|$ ranges over [0, 2]: smallest 0 ($\lambda = 0$), greatest 10 ($\lambda = -2$). Sum 10.

Q14. Answer (C). Perpendicular to the z-axis: no $\hat{k}$ part; equal angles with x and y: equal $\hat{i}$ and $\hat{j}$ parts, $a\,\hat{i} + a\,\hat{j}$. Magnitude 3: $a\sqrt{2} = 3$, $a = 3\sqrt{2}/2$.

Q15. Answer (C). In standard form: $(x - \tfrac{1}{2})/2 = (y - 1)/(-3) = z/6$ (dividing the first by 2 and changing the signs of the other two). Direction ratios 2, −3, 6 with $\sqrt{(4 + 9 + 36)} = 7$: direction cosines 2/7, −3/7, 6/7.

Q16. Answer (B). The linear function $Z = ax + by$ to be optimised is the objective function.

Q17. Answer (C). The lines are $x + y = 5$ (through (5, 0), (0, 5)) and $x + 3y = 9$ (through (9, 0), (0, 3)). The shaded triangle (3, 2), (5, 0), (9, 0) lies on the far side of $x + y = 5$ from the origin ($x + y \ge 5$) and on the origin side of $x + 3y = 9$ ($x + 3y \le 9$).

Q18. Answer (D). $P(A'|B') = P(A' \cap B')/P(B') = P((A \cup B)')/P(B') = (1 - P(A \cup B))/P(B')$.

Q19. Answer (B). A: $|a \times b|^2 + (a \cdot b)^2 = |a|^2|b|^2(\sin^2\theta + \cos^2\theta) = |a|^2|b|^2$, true. R: $(a \cdot b) \tan\theta = |a||b| \cos\theta \cdot \sin\theta/\cos\theta = |a||b| \sin\theta = |a \times b|$ for every $\theta \neq \pi/2$ (for obtuse θ both $\cos\theta$ and $\tan\theta$ are negative), so R is true. But A follows from $\sin^2\theta + \cos^2\theta = 1$, not from R. Answer (B).

Q20. Answer (D). Direction cosines satisfy $l^2 + m^2 + n^2 = 1$, but $1 + 1 + 1 = 3$: A is false. $\cos 0 = 1$ is true. Answer (D).

Q21. (2 marks) Answer: (a) not onto (1 has no pre-image); (b) injective.
(a) Let $y = (x - 2)/(x - 3)$; then $xy - 3y = x - 2$, so $x = (3y - 2)/(y - 1)$. [1]
For $y = 1$ there is no x (indeed $(x - 2)/(x - 3) = 1$ gives $-2 = -3$, impossible), so $1 \in R$ has no pre-image: f is not onto. [1]
OR (b) Let $f(x_1, y_1) = f(x_2, y_2)$: $(2y_1, 3x_1) = (2y_2, 3x_2)$. [1] Then $y_1 = y_2$ and $x_1 = x_2$, so $(x_1, y_1) = (x_2, y_2)$: f is injective. [1]

Q22. (2 marks) Answer: $-b/a$.
$dx/dt = 3a \sin^2 t \cos t$, $dy/dt = -3b \cos^2 t \sin t$. [1]
$dy/dx = -(b/a) \cot t$; at $t = \pi/4$, $dy/dx = -b/a$. [1]

Q23. (2 marks) Answer: (a) 5/4; (b) $dS/dt = 3k/r$.
(a) $f'(x) = -\sin x + 2 \sin x \cos x = \sin x (2 \cos x - 1) = 0$ at $x = 0, \pi/3, \pi$. [1]
$f(0) = 1$, $f(\pi/3) = 1/2 + 3/4 = 5/4$, $f(\pi) = -1$. Absolute maximum 5/4 (at $x = \pi/3$). [1]
OR (b) $V = (2/3)\pi r^3$, so $dV/dt = 2\pi r^2 \, dr/dt = k$ (constant), $dr/dt = k/(2\pi r^2)$. [1]
Total surface area of a solid hemisphere $S = 2\pi r^2 + \pi r^2 = 3\pi r^2$, so $dS/dt = 6\pi r \, dr/dt = 6\pi r \cdot k/(2\pi r^2) = 3k/r$: the rate of change of the surface area varies inversely as the radius. [1]

Q24. (2 marks) Answer: $\sqrt{34}/2$.
Taking A as origin, B and C have position vectors AB and AC, and D, the mid-point of BC, has position vector $(AB + AC)/2$; so $AD = (AB + AC)/2$. [1]
$AD = (3\hat{i} + 0\hat{j} + 5\hat{k})/2$, $|AD| = \sqrt{(9 + 25)}/2 = \sqrt{34}/2$. [1]

Q25. (2 marks) Answer: (2, −3, 4).
A general point is $(2\lambda, -1 - 2\lambda, 3 + \lambda)$. [1]
Sum $= 2 + \lambda = 3$, so $\lambda = 1$ and the point is (2, −3, 4). [1]

Q26. (3 marks) Answer: $-\sqrt{(9x - x^2)} + (13/2) \sin^{-1}((2x - 9)/9) + C$.
Write $x + 2 = -\frac{1}{2}(9 - 2x) + 13/2$. [1]
$\int -\frac{1}{2}(9 - 2x)/\sqrt{(9x - x^2)} \, dx = -\sqrt{(9x - x^2)}$. [1]
$(13/2) \int dx/\sqrt{((9/2)^2 - (x - 9/2)^2)} = (13/2) \sin^{-1}((2x - 9)/9)$. Answer: $-\sqrt{(9x - x^2)} + (13/2) \sin^{-1}((2x - 9)/9) + C$. [1]

Q27. (3 marks) Answer: (a) $\pi/6$; (b) $(7 - \sqrt{3})/2$.
(a) $I = \int \sqrt{\sin x}/(\sqrt{\sin x} + \sqrt{\cos x}) \, dx$. Using $\int_a^b f(x) \, dx = \int_a^b f(a + b - x) \, dx$ with $a + b = \pi/2$: $I = \int \sqrt{\cos x}/(\sqrt{\cos x} + \sqrt{\sin x}) \, dx$. [1½]
Adding: $2I = \int 1 \, dx = 5\pi/12 - \pi/12 = \pi/3$, so $I = \pi/6$. [1½]
OR (b) For $x < 0$, $|x| = -x$: $\int_{-\pi/6}^{0} (-\sin x + \cos x) \, dx = [\cos x + \sin x]_{-\pi/6}^{0} = 1 - (\sqrt{3}/2 - 1/2) = 3/2 - \sqrt{3}/2$. [1½]
$\int_0^{\pi/2} (\sin x + \cos x) \, dx = [-\cos x + \sin x]_0^{\pi/2} = 2$. Total $= (7 - \sqrt{3})/2$. [1½]

Q28. (3 marks) Answer: $F(x) = x - \log(e^x + 1)$.
$F(x) = \int dx/(e^x + 1) = \int e^{-x}/(1 + e^{-x}) \, dx = -\log(1 + e^{-x}) + C$. [2]
$F(0) = -\log 2 + C = \log \frac{1}{2} = -\log 2$, so $C = 0$ and $F(x) = -\log(1 + e^{-x}) = x - \log(e^x + 1)$. [1]

Q29. (3 marks) Answer: (a) $\cot(y/x) = \log|x| + \sqrt{3}$; (b) $x \log y = -2/y + C$.
(a) Homogeneous: put $y = vx$, $dy/dx = v + x \, dv/dx$: $v + x \, dv/dx = v - \sin^2 v$, so $\operatorname{cosec}^2 v \, dv = -dx/x$. [1]
$-\cot v = -\log|x| + C$, i.e. $\cot(y/x) = \log|x| + C$. [1]
$y(1) = \pi/6$: $\cot(\pi/6) = \sqrt{3} = C$. Solution: $\cot(y/x) = \log|x| + \sqrt{3}$. [1]
OR (b) $dx/dy + x/(y \log y) = 2/(y^2 \log y)$: linear in x. IF $= e^{\int dy/(y \log y)} = \log y$. [1]
$x \log y = \int (2/y^2) \, dy = -2/y + C$. [1]
General solution: $x \log y = -2/y + C$. [1]

Q30. (3 marks) Answer: Max Z = 4,95,000 at (30, 20).
The lines $x + y = 50$ and $2x + y = 80$ meet at (30, 20). The feasible region is the quadrilateral with corners (0, 0), (40, 0), (30, 20), (0, 50). [1½]
Z at the corners: 0, 4,20,000, 4,95,000, 4,50,000. [1]
Maximum Z = 4,95,000 at x = 30, y = 20. [½]

Q31. (3 marks) Answer: (a) (i) 15/16, (ii) 7/16; (b) 1.
(a) $p = 3(1 - p)$, so $p = 3/4$ (hit) and $q = 1/4$ (miss) for each shot, independently. [1]
(i) Target is hit (at least one hit) $= 1 - (1/4)^2 = 15/16$. [1]
(ii) At least one miss $= 1 - (3/4)^2 = 7/16$. [1]
OR (b) There are $3! = 6$ equally likely line-ups. F = {MFS, SFM}, $P(F) = 2/6$. [1]
In both line-ups of F the son is at an end, so $E \cap F = F$. [1]
$P(E|F) = P(E \cap F)/P(F) = 1$. [1]

Q32. (5 marks) Answer: (a) QP = 6I; x = 2, y = −1, z = 4; (b) $\Delta = xyz + xy + yz + zx$.
(a) QP = [[6, 0, 0], [0, 6, 0], [0, 0, 6]] = 6I. [2]
So $P^{-1} = (1/6)Q$. The system is PX = B with $B = [3, 17, 7]'$. [1]
$X = P^{-1}B = (1/6)[[2, 2, -4], [-4, 2, -4], [2, -1, 5]][3, 17, 7]' = (1/6)[12, -6, 24]' = [2, -1, 4]'$. [1½]
x = 2, y = −1, z = 4. [½]
OR (b) $C_1 \to C_1 - C_3$, $C_2 \to C_2 - C_3$ gives $\Delta = |x\ 0\ 1;\ 0\ y\ 1;\ -z\ -z\ 1 + z|$. [2]
Expanding: $\Delta = x(y(1 + z) + z) + 1(yz) = xyz + xy + yz + zx$. [1½]
If $\Delta = 0$ with x, y, z ≠ 0, dividing by xyz: $1 + 1/z + 1/x + 1/y = 0$, so $x^{-1} + y^{-1} + z^{-1} = -1$. [1½]

Q33. (5 marks) Answer: (a) decreasing $(0, \pi/4)$, increasing $(\pi/4, \pi)$; (b) 12 cm × 6 cm.
(a) $f'(x) = -(\cos x - \sin x)/(1 + (\sin x + \cos x)^2)$. [2]
The denominator is positive. $f'(x) < 0$ when $\cos x > \sin x$, i.e. $x \in (0, \pi/4)$; $f'(x) > 0$ when $\sin x > \cos x$, i.e. $x \in (\pi/4, \pi)$. [2]
f is decreasing in $(0, \pi/4)$ and increasing in $(\pi/4, \pi)$. [1]
OR (b) Let the sides be x (radius) and y (the side it revolves about, the height): $2(x + y) = 36$, $y = 18 - x$. [1]
$V = \pi x^2 y = \pi(18x^2 - x^3)$; $dV/dx = \pi(36x - 3x^2) = 0$ gives x = 12. [2]
$d^2V/dx^2 = \pi(36 - 6x) = -36\pi < 0$ at x = 12: maximum. [1]
Dimensions: 12 cm × 6 cm (revolved about the 6 cm side); maximum volume 864π cm³. [1]

Q34. (5 marks) Answer: domain $[-\sqrt{2}, \sqrt{2}]$; $x = \pm\sqrt{6}/2$; e.g. $[\pi, 2\pi]$.
$-1 \le x^2 - 1 \le 1$, i.e. $0 \le x^2 \le 2$: domain $[-\sqrt{2}, \sqrt{2}]$. [2]
$g(x) = \pi/3$: $x^2 - 1 = \cos(\pi/3) = 1/2$, $x^2 = 3/2$, $x = \pm\sqrt{(3/2)} = \pm\sqrt{6}/2$ (both in the domain). [2]
Other branches of $\cos^{-1}$: e.g. $[\pi, 2\pi]$ or $[-\pi, 0]$. [1]

Q35. (5 marks) Answer: (−1, −1, −1); $(x + 1)/(-5) = (y + 1)/18 = (z + 1)/(-11)$.
Line AB: direction $4\hat{i} + 6\hat{j} + 8\hat{k} \parallel 2\hat{i} + 3\hat{j} + 4\hat{k}$; general point $(1 + 2\mu, 2 + 3\mu, 3 + 4\mu)$. Other line: $(4 + 5\lambda, 1 + 2\lambda, \lambda)$. [1]
Equating: $3 + 4\mu = \lambda$ and $2 + 3\mu = 1 + 2\lambda$ give $\mu = -1$, $\lambda = -1$; check x: $1 - 2 = -1 = 4 - 5$. ✓ [1½]
Point of intersection (−1, −1, −1). [½]
Perpendicular direction: $(2\hat{i} + 3\hat{j} + 4\hat{k}) \times (5\hat{i} + 2\hat{j} + \hat{k}) = -5\hat{i} + 18\hat{j} - 11\hat{k}$. [1]
Line: $\vec{r} = (-\hat{i} - \hat{j} - \hat{k}) + t(-5\hat{i} + 18\hat{j} - 11\hat{k})$, i.e. $(x + 1)/(-5) = (y + 1)/18 = (z + 1)/(-11)$. [1]

Q36. (4 marks) Answer: (i) 2/5; (ii) 83/100; (iii)(a) 8/25; (iii)(b) 249/425.
(i) 20/50 = 2/5. [1]
(ii) 1 − 170/1000 = 83/100. [1]
(iii)(a) $P(L) = (3/5)(17/100) + (2/5)(12/100) = 51/500 + 24/500 = 3/20$. [1] $P(F|L) = (24/500)/(3/20) = 8/25$. [1]
OR (iii)(b) $P(L') = 1 - 3/20 = 17/20$. [1] $P(M|L') = (3/5)(83/100)/(17/20) = (249/500)/(17/20) = 249/425$. [1]

Q37. (4 marks) Answer: (i) $y = (3/4)\sqrt{(16 - x^2)}$; (iii)(a) 12π m²; (iii)(b) P(7, 0), Q(0, 6), 21 m².
(i) $x^2/16 + y^2/9 = 1$, so $y = (3/4)\sqrt{(16 - x^2)}$ (taking the upper half). [1]
(ii) $\int (3/4)\sqrt{(16 - x^2)}\,dx = (3/4)[(x/2)\sqrt{(16 - x^2)} + 8\sin^{-1}(x/4)] + C$. [1]
(iii)(a) Area $= 4\int_0^4 (3/4)\sqrt{(16 - x^2)}\,dx = 3[(x/2)\sqrt{(16 - x^2)} + 8\sin^{-1}(x/4)]_0^4$ [1] $= 3 \times 8 \times \pi/2 = 12\pi$ m². [1]
OR (iii)(b) The outer edge is 3 m beyond the ground: P(7, 0) and Q(0, 6). [1] Line PQ: $y = 6 - 6x/7$. Area $= \int_0^7 (6 - 6x/7)\,dx = [6x - 3x^2/7]_0^7 = 42 - 21 = 21$ m². [1]

Q38. (4 marks) Answer: (i) $4x^3 - 8x$; (ii) 8; (iii)(a) continuous; (iii)(b) not differentiable.

(i) $f'(x) = 4x^3 - 8x$. [1]

(ii) For $x > 3$, $f'(x) = 2x$, so $f'(4) = 8$. [1]

(iii)(a) LHL = $81 - 36 + 4 = 49$; RHL = $9 + 40 = 49$; $f(3) = 49$. [1] All equal, so f is continuous at $x = 3$. [1]

OR (iii)(b) LHD = $\lim (4x^3 - 8x)$ as $x \to 3^-$ = $108 - 24 = 84$; RHD = $2 \times 3 = 6$. [1] LHD $\neq$ RHD, so f is not differentiable at $x = 3$. [1]

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