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CBSE Class 12 Maths Board Paper 2026 (65/3/1) with Solutions

PREVIOUS YEAR PAPER · CLASS XII · MATHEMATICS (041) · BOARD EXAM 2026 · Q.P. CODE 65/3/1

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. This question paper is divided into five Sections – A, B, C, D and E.
3. In Section A, Questions no. 1 to 18 are multiple choice questions (MCQs) and questions number 19 and 20 are Assertion-Reason based questions of 1 mark each.
4. In Section B, Questions no. 21 to 25 are very short answer (VSA) type questions, carrying 2 marks each.
5. In Section C, Questions no. 26 to 31 are short answer (SA) type questions, carrying 3 marks each.
6. In Section D, Questions no. 32 to 35 are long answer (LA) type questions carrying 5 marks each.
7. In Section E, Questions no. 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 2 questions in Section B, 3 questions in Section C, 2 questions in Section D and 3 questions in Section E.
9. Use of calculator is not allowed.
10. This is the official 2026 board paper (Q.P. Code 65/3/1). 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 65/3/1, 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. The domain of $f(x) = \cos^{-1}(2x - 5)$ is : 1

(A) $[-1, 1]$ (B) $[4, 6]$

(C) $[-7, -3]$ (D) $[2, 3]$

2. If $A^2 = 4A + 3I$ and $A^{-1} = xA + yI$, then the value of $(x + y)$ is : 1

(A) -1 (B) 1

(C) $\frac{5}{3}$ (D) 7

3. If A and B are skew-symmetric matrices of same order, then $AB' + BA'$ is a/an : 1

(A) symmetric matrix (B) skew-symmetric matrix

(C) null matrix (D) identity matrix

4. If $\begin{pmatrix} 4 \\ 1 \\ 3 \end{pmatrix} A = \begin{pmatrix} -4 & 8 & 4 \\ -1 & 2 & 1 \\ -3 & 6 & 3 \end{pmatrix}$, then order of A must be : 1

(A) 3×1 (B) 1×3

(C) 1×1 (D) 3×3

5. If a square matrix A is such that $A^2 = A$ and $(I - A)^3 = xA + I$, then value of x must be : 1

(A) 7 (B) 5

(C) -7 (D) -1

6. If $B(\text{adj } B) = \begin{pmatrix} \frac{1}{3} & 0 & 0 \\ 0 & \frac{1}{3} & 0 \\ 0 & 0 & \frac{1}{3} \end{pmatrix}$, then the value of $\det(B^{-1})$ = 1

(A) $\frac{1}{3}$ (B) $\frac{1}{9}$

(C) 3 (D) 9

7. The value of k for which the function $f(x) = \begin{cases} x^2 \sin\frac{1}{x}, & x \neq 0 \\ k(x+1), & x = 0 \end{cases}$ is a continuous function, is : 1

(A) $\frac{1}{4}$ (B) 2

(C) $\frac{1}{2}$ (D) 0

8. If $\sin^{-1} x = y$, then $\frac{dy}{dx}$ is : 1

(A) $\cos^{-1} x$ (B) cos y

(C) $\frac{1}{1 - x^2}$ (D) sec y

9. The rate of change of volume of a sphere with respect to its diameter, when its radius is 5 cm, is : 1

(A) 400π cm^3/cm (B) 100π cm^3/cm

(C) 50π cm^3/cm (D) 25π cm^3/cm

10. $\int \frac{dx}{2^x + 2^{-x}}$ is equal to : 1

(A) $\tan^{-1}(2^x) + C$ (B) $\tan^{-1}(2^{-x}) + C$

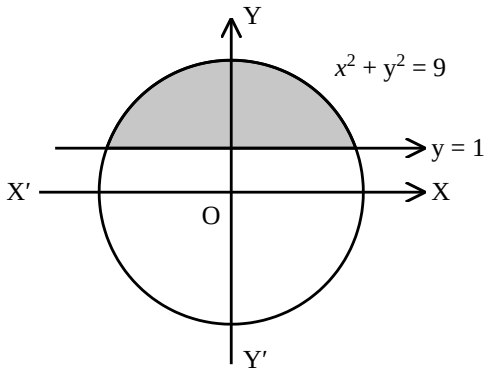
(C) $\frac{\tan^{-1}(2^x)}{\log 2} + C$ (D) $(\log 2)\tan^{-1}(2^x) + C$

11. $\int_{-1}^{1} (1 - |x|)\, dx$ is equal to : 1

(A) $2\int_0^1 (1 + x)\, dx$ (B) $2\int_{-1}^0 (1 + x)\, dx$

(C) 0 (D) $2\int_{-1}^0 (1 - x)\, dx$

12. The area of the shaded region of the circle given below is equal to : 1



(A) $\int_1^3 \sqrt{9 - y^2}\, dy$ (B) $2\int_1^3 \sqrt{9 - y^2}\, dy$

(C) $\int_0^3 \sqrt{9 - x^2}\, dx$ (D) $2\int_0^3 \sqrt{9 - x^2}\, dx$

13. $\frac{dy}{dx} = F(x, y)$ will be a homogeneous differential equation for which of the following functions ? 1

(i) $F(x, y) = 3x + 2y$ (ii) $F(x, y) = \sin \frac{y}{x} + \log y - \log x$

(iii) $F(x, y) = e^{y/x} + 1$ (iv) $F(x, y) = \sqrt{x^2 + y^2} - y$

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

(C) (ii), (iii) and (iv) (D) (ii) and (iii)

14. For any two vectors $\boldsymbol{a}$ and $\boldsymbol{b}$, which of the following statements is always true ? 1

(A) $\boldsymbol{a} \cdot \boldsymbol{b} \leq |\boldsymbol{a}|\,|\boldsymbol{b}|$

(B) $|\boldsymbol{a} + \boldsymbol{b}| \geq |\boldsymbol{a}| + |\boldsymbol{b}|$

(C) $|\boldsymbol{a} - \boldsymbol{b}| = |\boldsymbol{a}| - |\boldsymbol{b}|$

(D) $|\boldsymbol{a} \times \boldsymbol{b}| \geq |\boldsymbol{a}|\,|\boldsymbol{b}|$

15. If $(\boldsymbol{a} + \boldsymbol{b}) \cdot (\boldsymbol{a} - \boldsymbol{b}) = 198$ and $|\boldsymbol{a}| = 10|\boldsymbol{b}|$, then : 1

(A) $|\boldsymbol{a}| = \sqrt{2}$

(B) $|\boldsymbol{b}| = \sqrt{2}$

(C) $|\boldsymbol{b}| = 10\sqrt{2}$

(D) $|\boldsymbol{a}| = \dfrac{10}{\sqrt{2}}$

16. If l_1, m_1, n_1 and l_2, m_2, n_2 are direction cosines of lines L_1 and L_2 respectively and θ is the acute angle between them, then : 1

(A) $\cos\theta = l_1l_2 + m_1m_2 + n_1n_2$

(B) $\sin\theta = l_1l_2 + m_1m_2 + n_1n_2$

(C) $\tan\theta = \dfrac{l_1}{l_2} + \dfrac{m_1}{m_2} + \dfrac{n_1}{n_2}$

(D) $\cos\theta = |\, l_1l_2 + m_1m_2 + n_1n_2 \,|$

17. Direction ratios of lines l_1 and l_2 are <12, − 3, 9> and <4, q, − p> respectively. The values of p and q for which l_1 and l_2 are parallel are respectively : 1

(A) − 1, 3

(B) 3, 1

(C) − 3, − 1

(D) − 1, − 3

18. If E and F are two independent events such that $P(E) = \dfrac{3}{10}$, $P(E \cup F) = \dfrac{1}{2}$, then P(E|F) − P(F|E) is equal to : 1

(A) $\dfrac{2}{7}$

(B) $\dfrac{3}{35}$

(C) $\dfrac{1}{70}$

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

19. **Assertion (A) :** One of the particular solutions of the differential equation $\dfrac{dy}{dx} = e^{x+y}$ can be $e^x + e^{-y} = -2$. 1

Reason (R) : $e^x + e^{-y} = C$ is the general solution of the differential equation $\dfrac{dy}{dx} = e^{x+y}$.

(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) :** The vectors $\boldsymbol{a}$ and $(-2\boldsymbol{a})$, where $\boldsymbol{a} \neq \boldsymbol{0}$ are collinear vectors. 1

Reason (R) : $\boldsymbol{a} \cdot (-2\boldsymbol{a}) = 0$.

(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. If $x = t + \frac{1}{t}$ and $y = t - \frac{1}{t}$, find $\frac{dy}{dx}$ at $t = 2$. 2

22. Find the sub-interval(s) of $(0, \frac{\pi}{2})$ in which $f(x) = \tan x - 4x$ is increasing. 2

23. (a) Find the value of $\sin [\cot^{-1} \sqrt{2} (\cos (\tan^{-1} 1))]$. 2

OR

(b) A relation R on A = {1, 2, 3} is defined as R = {(1, 1) (3, 3), (1, 2)}. Is R a symmetric relation ? Justify. Write the smallest relation set R_1 such that R ∪ R_1 becomes an equivalence relation on the set {1, 2, 3}.

24. If for two unit vectors $\boldsymbol{a}$ and $\boldsymbol{b}$, $|\boldsymbol{a} + 2\boldsymbol{b}| = |2\boldsymbol{a} - \boldsymbol{b}|$, then find the angle between $\boldsymbol{a}$ and $\boldsymbol{b}$. 2

25. (a) If the lines $\frac{x-3}{1} = \frac{1-y}{1} = \frac{z+2}{p}$ and $\frac{2-x}{3} = \frac{y+1}{5} = \frac{z+56}{2p}$ are perpendicular to each other, then find the value(s) of p. 2

OR

(b) Find the vector equation of a line passing through the origin and perpendicular to both the lines $\boldsymbol{r} = 2\hat{i} - \hat{j} + 2\hat{k} + \lambda(3\hat{i} + 4\hat{j} + 2\hat{k})$ and $\boldsymbol{r} = \mu(\hat{i} - \hat{j} + \hat{k})$.

SECTION C

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

26. (a) Find : $\int \frac{dx}{x^{1/2} + x^{1/3}}$ 3

OR

(b) Find : $\int \tan^{-1} (\frac{1-x}{1+x})\, dx$

27. Evaluate : $\int_0^{\pi} \frac{\sin^{2026} x}{\sin^{2026} x + \cos^{2026} x}\, dx$ 3

28. (a) Find : $\int \frac{\cos x}{(2 + \sin x)(4 + \sin x)}\, dx$ 3

OR

(b) Find : $\int \frac{x + 3}{x^2 + 4x + 5}\, dx$

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

OR

(b) Find a particular solution of the differential equation $(x + 1) \frac{dy}{dx} = 2e^{-y} - 1$, given that $y = 0$ when $x = 0$.

30. If $(\sin x)^y = y^{\cos x}$, then find $\frac{dy}{dx}$. 3

31. A survey was conducted on the patients who have undergone knee replacement surgeries. It was found that, Robotic Knee replacement surgeries have 90% success rate. On a particular day, robotic surgery was performed on three patients, A, B and C, one after the other. Assuming that the success and failure of each surgery is independent of each other, find the probability that : 3

(i) exactly one surgery is successful,

(ii) at most two surgeries are successful.

SECTION D

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

32. Show that $f : R \to R$ defined as $f(x) = \frac{x}{\sqrt{1 + x^2}}$ is one-one but not onto. 5

33. Solve the following Linear Programming Problem graphically : 5

Maximise $Z = 600x + 400y$

subject to the constraints

$x + 2y \leq 12$

$4x + 5y \geq 20$

$2x + y \leq 12$

$x, y \geq 0$

34. (a) On the inauguration day of a new showroom, a lucky draw was organized and some vouchers of ₹ 1,000 and ₹ 500 were given to the lucky draw winners. A total of 60 vouchers were given on the day. The number of ₹ 1,000 vouchers added to 3 times the number of ₹ 500 vouchers, gives 100. Express the given information as a system of linear equations in two variables. Hence, find the number of vouchers of each type by matrix method. 5

OR

(b) Given that $P = \begin{pmatrix} 2 & -1 \\ 3 & 4 \end{pmatrix}$, $Q = \begin{pmatrix} 5 & 2 \\ 7 & 4 \end{pmatrix}$ and $R = \begin{pmatrix} 2 & 5 \\ 3 & 8 \end{pmatrix}$, find a matrix S such that $PQ - RS$ is a null matrix.

35. (a) Represent the equations of lines l_1 and l_2 in vector form and check whether they are intersecting or not. 5

$l_1 : \frac{x+3}{-3} = \frac{y-1}{1} = \frac{z-5}{5}$ $\quad l_2 : \frac{x+1}{-1} = \frac{2-y}{-2} = \frac{z-5}{5}$

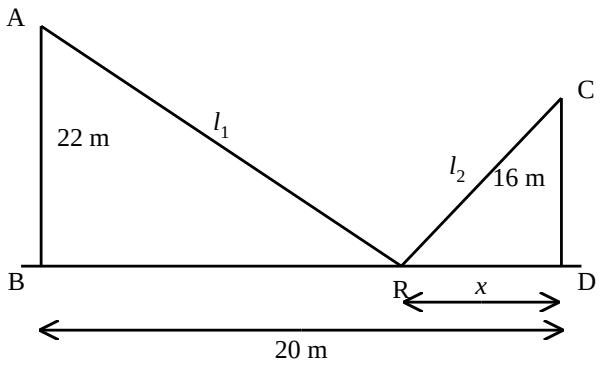
OR

(b) Opposite sides of a square are along the lines : $\boldsymbol{r} = \hat{i} + 2\hat{j} - 4\hat{k} + \lambda(2\hat{i} + 3\hat{j} + 6\hat{k})$ and $\boldsymbol{r} = 3\hat{i} + 3\hat{j} - 5\hat{k} + \mu(2\hat{i} + 3\hat{j} + 6\hat{k})$. Find the area of the square if direction ratios of other pair of opposite sides of the square are given by $<-3, 6, p>$. Also, find the value of p.

SECTION E

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

36. Two vertical light poles of height 22 m and 16 m stand on the opposite sides of a 20 m wide road as shown below in the figure.



Two ladders of length l_1 and l_2 are placed from a common point R on the road at a distance of x m from the smaller pole. Based on the above information, answer the following questions :

(i) Express $p(x) = l_1 + l_2$ in terms of x. [1]

(ii) Find $p'(x)$. [1]

(iii) (a) Find the value of x for which $l_1^2 + l_2^2$ is minimum. [2]

OR

(iii) (b) If the 22 m long pole is also replaced by a 16 m long pole, at what distance from either pole should the ladders be kept so that the sum of squares of lengths of ladders needed to reach the top of the pole is minimum ? [2]

37. A survey was conducted to find out the success rate of students who qualified the entrance examination by dropping a year after class XII. As per the data collected, 40% students appearing in the examination were dropouts and the remaining students were regular students of class XII. Of the dropouts, 5% qualify the examination while 10% of the regular students qualify the examination. Based on the above information, answer the following questions.

(i) Find the probability that a student selected at random is a regular student. [1]

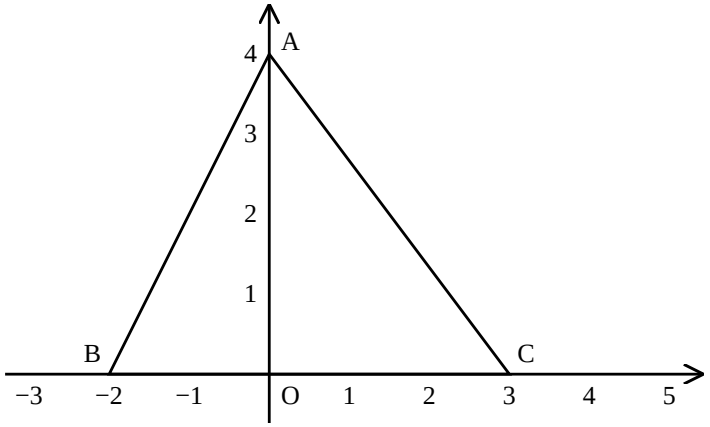
(ii) A student is selected at random from a group of dropout students. What is the probability that the student will not qualify the examination ? [1]

(iii) (a) A student selected at random qualified the examination. Find the probability that student is not a dropout. [2]

OR

(iii) (b) A student selected at random did not qualify the examination. Find the probability that the student was a regular student. [2]

38. There is a triangular park in the society. The park is divided into two sections as shown in the figure.



In the region OAC, children are allowed to play games like cricket, football, while in the region AOB, activities which involve running are not allowed. The vertices of the triangular park ABC are A(0, 4), B(− 2, 0) and C(3, 0). Based on the above information, answer the following questions :

(i) Write the equation of the boundary line AB of the park. [1]

(ii) Write the equation of the boundary line AC of the park. [1]

(iii) (a) Using integration, find the area of region OAC, in which children are allowed to play cricket, football. [2]

OR

(iii) (b) Using integration, find the area of region AOB. [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)	(A)	(A)	(B)	(D)	(C)	(D)	(D)	(C)	(C)	(B)	(B)	(D)	(A)	(B)	(D)	(C)	(C)	(D)	(C)

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). $-1 \le 2x - 5 \le 1$ gives $4 \le 2x \le 6$, i.e. $2 \le x \le 3$.

Q2. Answer (A). $A^2 - 4A = 3I$, so $A(A - 4I) = 3I$ and $A^{-1} = (1/3)A - (4/3)I$. $x + y = 1/3 - 4/3 = -1$.

Q3. Answer (A). $A' = -A$, $B' = -B$, so $AB' + BA' = -(AB + BA)$. Its transpose is $-(B'A' + A'B') = -(BA + AB)$, the same matrix: symmetric.

Q4. Answer (B). A 3×1 matrix times A gives a 3×3 matrix, so A has 1 row and 3 columns: 1×3 (here $A = [-1\ 2\ 1]$).

Q5. Answer (D). $(I - A)^3 = I - 3A + 3A^2 - A^3 = I - 3A + 3A - A = I - A$ (since $A^2 = A^3 = A$). So $x = -1$.

Q6. Answer (C). $B(\text{adj } B) = |B| I$, so $|B| = 1/3$ and $\det(B^{-1}) = 1/|B| = 3$.

Q7. Answer (D). $|x^2 \sin(1/x)| \le x^2 \to 0$, so the limit at 0 is 0. Continuity needs $f(0) = k(0 + 1) = k = 0$.

Q8. Answer (D). $x = \sin y$, $dx/dy = \cos y$, so $dy/dx = 1/\cos y = \sec y$ $(= 1/\sqrt{(1 - x^2)})$.

Q9. Answer (C). $V = \pi D^3/6$, $dV/dD = \pi D^2/2$. With $D = 10$ cm: 50π cm³/cm.

Q10. Answer (C). $\int 2^x\, dx/(4^x + 1)$. Put $t = 2^x$, $dt = 2^x \log 2\, dx$: $(1/\log 2) \int dt/(1 + t^2) = \tan^{-1}(2^x)/\log 2 + C$.

Q11. Answer (B). $1 - |x|$ is even, so the integral is $2\int_{-1}^{0} (1 - |x|)\, dx = 2\int_{-1}^{0} (1 + x)\, dx$ $(= 1)$.

Q12. Answer (B). The shaded part lies above $y = 1$, between $x = -\sqrt{(9 - y^2)}$ and $x = \sqrt{(9 - y^2)}$ for $1 \le y \le 3$: area $= 2 \int_1^3 \sqrt{(9 - y^2)}\, dy$.

Q13. Answer (D). $dy/dx = F(x, y)$ is homogeneous when F is homogeneous of degree 0. (ii) = sin(y/x) + log(y/x) and (iii) = e^(y/x) + 1 are; (i) and (iv) have degree 1.

Q14. Answer (A). $a \cdot b = |a||b| \cos\theta \le |a||b|$. The triangle inequality goes the other way in (B), (C) is false in general, and $|a \times b| = |a||b| \sin\theta \le |a||b|$.

Q15. Answer (B). $|a|^2 - |b|^2 = 198$ and $|a|^2 = 100|b|^2$, so $99|b|^2 = 198$, $|b|^2 = 2$, $|b| = \sqrt{2}$.

Q16. Answer (D). For the acute angle, $\cos\theta$ must be non-negative: $\cos\theta = |l_1 l_2 + m_1 m_2 + n_1 n_2|$.

Q17. Answer (C). Parallel: $12/4 = -3/q = 9/(-p) = 3$, so $q = -1$ and $p = -3$.

Q18. Answer (C). Independent: $P(E \cup F) = P(E) + P(F) - P(E)P(F)$: $1/2 = 3/10 + (7/10)P(F)$, $P(F) = 2/7$. $P(E|F) - P(F|E) = P(E) - P(F) = 3/10 - 2/7 = 1/70$.

Q19. Answer (D). $e^{-y}\, dy = e^x\, dx$ gives $-e^{-y} = e^x + K$, i.e. $e^x + e^{-y} = C$: R is true. But $e^x + e^{-y}$ is always positive, so it can never equal -2: A is false. Answer (D).

Q20. Answer (C). $-2a$ is a scalar multiple of a, so they are collinear: A is true. $a \cdot (-2a) = -2|a|^2 \ne 0$: R is false. Answer (C).

Q21. (2 marks) Answer: 5/3.
$dx/dt = 1 - 1/t^2$, $dy/dt = 1 + 1/t^2$, so $dy/dx = (t^2 + 1)/(t^2 - 1)$. [1]
At $t = 2$: $dy/dx = 5/3$. [1]

Q22. (2 marks) Answer: (π/3, π/2).
f′(x) = sec²x − 4 > 0 when sec²x > 4, i.e. cos x < 1/2 (cos x > 0 here). [1]
In (0, π/2) this holds for x ∈ (π/3, π/2): f is increasing in (π/3, π/2). [1]

Q23. (2 marks) Answer: (a) 1/√2; (b) not symmetric; R_1 = {(2, 2), (2, 1)}.
(a) tan⁻¹ 1 = π/4, cos(π/4) = 1/√2, so √2 × 1/√2 = 1. [1]
cot⁻¹ 1 = π/4 and sin(π/4) = 1/√2. [1]
OR (b) (1, 2) ∈ R but (2, 1) ∉ R, so R is not symmetric. [1]
R_1 = {(2, 2), (2, 1)}: R ∪ R_1 = {(1, 1), (2, 2), (3, 3), (1, 2), (2, 1)} is reflexive, symmetric and transitive. [1]

Q24. (2 marks) Answer: π/2.
Squaring: |a|² + 4a · b + 4|b|² = 4|a|² − 4a · b + |b|², i.e. 1 + 4a · b + 4 = 4 − 4a · b + 1. [1]
8a · b = 0, so a · b = 0 and the angle is π/2. [1]

Q25. (2 marks) Answer: (a) p = ±2; (b) r = λ(6î − ĵ − 7k̂).
(a) In standard form the direction ratios are 1, −1, p and −3, 5, 2p. [1]
Perpendicular: −3 − 5 + 2p² = 0, p² = 4, p = ±2. [1]
OR (b) Direction: (3î + 4ĵ + 2k̂) × (î − ĵ + k̂) = 6î − ĵ − 7k̂. [1]
Line: r = λ(6î − ĵ − 7k̂). [1]

Q26. (3 marks) Answer: (a) 2√x − 3x^(1/3) + 6x^(1/6) − 6 log(1 + x^(1/6)) + C; (b) πx/4 − x tan⁻¹x + ½ log(1 + x²) + C.
(a) Put x = t⁶, dx = 6t⁵ dt: ∫ 6t⁵ dt/(t³ + t²) = 6 ∫ t³/(t + 1) dt. [1]
= 6 ∫ (t² − t + 1 − 1/(t + 1)) dt = 2t³ − 3t² + 6t − 6 log|1 + t| + C. [1]
= 2√x − 3x^(1/3) + 6x^(1/6) − 6 log(1 + x^(1/6)) + C. [1]
OR (b) Put x = tan θ: tan⁻¹((1 − x)/(1 + x)) = π/4 − tan⁻¹ x (for x > −1). [1]
∫ (π/4 − tan⁻¹ x) dx = πx/4 − [x tan⁻¹ x − ½ log(1 + x²)] (by parts). [1]
= πx/4 − x tan⁻¹ x + ½ log(1 + x²) + C. [1]

Q27. (3 marks) Answer: π/2.
Let f(x) be the integrand. sin(π − x) = sin x and $\cos^{2^{o}26}(\pi - x) = \cos^{2^{o}26} x$ (even power), so f(π − x) = f(x) and I = 2 $\int_0^{\pi/2}$ f(x) dx. [1]
Let J = $\int_0^{\pi/2}$ f(x) dx. Using x → π/2 − x, J = $\int_0^{\pi/2} \cos^{2^{o}26} x/(\cos^{2^{o}26} x + \sin^{2^{o}26} x)$ dx; adding, 2J = π/2, J = π/4. [1½]
I = 2 × π/4 = π/2. [½]

Q28. (3 marks) Answer: (a) ½ log|(2 + sin x)/(4 + sin x)| + C; (b) ½ log(x² + 4x + 5) + tan⁻¹(x + 2) + C.
(a) Put t = sin x, dt = cos x dx: ∫ dt/((2 + t)(4 + t)). [1]
1/((2 + t)(4 + t)) = ½[1/(2 + t) − 1/(4 + t)]. [1]
= ½ log|(2 + sin x)/(4 + sin x)| + C. [1]
OR (b) x + 3 = ½(2x + 4) + 1. [1]
½ ∫ (2x + 4)/(x² + 4x + 5) dx = ½ log(x² + 4x + 5). [1]
∫ dx/((x + 2)² + 1) = tan⁻¹(x + 2). Answer: ½ log(x² + 4x + 5) + tan⁻¹(x + 2) + C. [1]

Q29. (3 marks) Answer: (a) −2x/y = log|x| + C; (b) y = log((2x + 1)/(x + 1)).
(a) dy/dx = (y² + 2xy)/(2x²) is homogeneous; put y = vx: v + x dv/dx = v²/2 + v. [1]
x dv/dx = v²/2, so 2 dv/v² = dx/x and −2/v = log|x| + C. [1]
General solution: −2x/y = log|x| + C (or 2x + y log|x| + Cy = 0). [1]
OR (b) dy/(2e⁻ʸ − 1) = dx/(x + 1), i.e. eʸ dy/(2 − eʸ) = dx/(x + 1). [1]
−log|2 − eʸ| = log|x + 1| + C; y = 0 at x = 0 gives C = 0. [1]
(2 − eʸ)(x + 1) = 1, so y = log((2x + 1)/(x + 1)) (x > −½). [1]

Q30. (3 marks) Answer: $dy/dx = y(y \cot x + \sin x \log y)/(\cos x - y \log \sin x)$.
Taking logs: $y \log \sin x = \cos x \log y$. [1]
Differentiating: $y' \log \sin x + y \cot x = -\sin x \log y + (\cos x/y)\, y'$. [1]
$dy/dx = (y \cot x + \sin x \log y)/(\cos x/y - \log \sin x) = y(y \cot x + \sin x \log y)/(\cos x - y \log \sin x)$. [1]

Q31. (3 marks) Answer: (i) 0.027; (ii) 0.271.
Each surgery: success $p = 0.9$, failure $q = 0.1$, independently. [1]
(i) Exactly one: $3 \times 0.9 \times 0.1 \times 0.1 = 0.027$. [1]
(ii) At most two = $1 - P(\text{all three}) = 1 - 0.9^3 = 1 - 0.729 = 0.271$. [1]

Q32. (5 marks) Answer: one-one; range $(-1, 1)$, so not onto.
One-one: let $f(x_1) = f(x_2)$. Then x_1 and x_2 have the same sign ($f(x)$ has the sign of x), and squaring, $x_1^2(1 + x_2^2) = x_2^2(1 + x_1^2)$, i.e. $x_1^2 = x_2^2$. With the same sign, $x_1 = x_2$. [2½]
Not onto: $|f(x)| = |x|/\sqrt{(1 + x^2)} < 1$ for every x, so e.g. 1 (or any y with $|y| \geq 1$) has no pre-image. Solving $y = x/\sqrt{(1 + x^2)}$ gives $x = y/\sqrt{(1 - y^2)}$, defined only for $-1 < y < 1$: the range is $(-1, 1) \neq \mathbb{R}$. [2½]

Q33. (5 marks) Answer: Max $Z = 4000$ at $(4, 4)$.
Lines: $x + 2y = 12$ through $(12, 0)$, $(0, 6)$; $4x + 5y = 20$ through $(5, 0)$, $(0, 4)$; $2x + y = 12$ through $(6, 0)$, $(0, 12)$. $x + 2y = 12$ and $2x + y = 12$ meet at $(4, 4)$. [2]
The feasible region (on the far side of $4x + 5y = 20$) has corners $(5, 0)$, $(6, 0)$, $(4, 4)$, $(0, 6)$, $(0, 4)$. [1]
Z: 3000, 3600, 4000, 2400, 1600. [1]
Maximum $Z = 4000$ at $x = 4$, $y = 4$. [1]

Q34. (5 marks) Answer: (a) 40 and 20; (b) $S = [[-191, -110], [77, 44]]$.
(a) Let x = number of ₹ 1,000 vouchers, y = number of ₹ 500 vouchers: $x + y = 60$, $x + 3y = 100$. [1]
$AX = B$ with $A = [[1, 1], [1, 3]]$, $B = [60, 100]'$; $|A| = 2 \neq 0$. [1]
$A^{-1} = ½[[3, -1], [-1, 1]]$. [1]
$X = A^{-1}B = ½[180 - 100, -60 + 100]' = [40, 20]'$. [1]
40 vouchers of ₹ 1,000 and 20 of ₹ 500. [1]
OR (b) $PQ = [[10 - 7, 4 - 4], [15 + 28, 6 + 16]] = [[3, 0], [43, 22]]$. [1½]
$PQ - RS = O$ gives $S = R^{-1}(PQ)$; $|R| = 16 - 15 = 1$, $R^{-1} = [[8, -5], [-3, 2]]$. [1½]
$S = [[8, -5], [-3, 2]][[3, 0], [43, 22]] = [[24 - 215, -110], [-9 + 86, 44]] = [[-191, -110], [77, 44]]$. [2]

Q35. (5 marks) Answer: (a) the lines intersect (at the origin); (b) area 293/49 sq units, $p = -2$.
(a) l_1: $\vec{r} = (-3\hat{i} + \hat{j} + 5\hat{k}) + \lambda(-3\hat{i} + \hat{j} + 5\hat{k})$. For l_2, $(2 - y)/(-2) = (y - 2)/2$, so l_2: $\vec{r} = (-\hat{i} + 2\hat{j} + 5\hat{k}) + \mu(-\hat{i} + 2\hat{j} + 5\hat{k})$. [1½]
$b_1 \times b_2 = (-3, 1, 5) \times (-1, 2, 5) = (-5, 10, -5)$; $a_2 - a_1 = (2, 1, 0)$. [1½]
$(a_2 - a_1) \cdot (b_1 \times b_2) = -10 + 10 + 0 = 0$, and the lines are not parallel, so they intersect. [1]
(Point: $\lambda = \mu = -1$ gives $(0, 0, 0)$ on both lines: they intersect at the origin.) [1]
OR (b) The side length is the distance between the parallel lines: $a_2 - a_1 = 2\hat{i} + \hat{j} - \hat{k}$, $b = 2\hat{i} + 3\hat{j} + 6\hat{k}$, $|b| = 7$. [1]
$b \times (a_2 - a_1) = -9\hat{i} + 14\hat{j} - 4\hat{k}$, magnitude $\sqrt{(81 + 196 + 16)} = \sqrt{293}$. [1½]
Side = $\sqrt{293}/7$; area = 293/49 square units. [1]
The other sides are perpendicular to these: $2(-3) + 3(6) + 6p = 0$, so $p = -2$. [1½]

Q36. (4 marks) Answer: (i) $\sqrt{((20 - x)^2 + 484)} + \sqrt{(x^2 + 256)}$; (iii)(a) $x = 10$ m; (iii)(b) 10 m from either pole.
(i) $l_2 = \sqrt{(x^2 + 16^2)}$, $l_1 = \sqrt{((20 - x)^2 + 22^2)}$: $p(x) = \sqrt{((20 - x)^2 + 484)} + \sqrt{(x^2 + 256)}$. [1]
(ii) $p'(x) = x/\sqrt{(x^2 + 256)} - (20 - x)/\sqrt{((20 - x)^2 + 484)}$. [1]
(iii)(a) $S(x) = l_1^2 + l_2^2 = (20 - x)^2 + 484 + x^2 + 256$; $S'(x) = -2(20 - x) + 2x = 0$ gives $x = 10$. [1] $S''(x) = 4 > 0$: minimum at $x = 10$ m. [1]
OR (iii)(b) $S(x) = (20 - x)^2 + 256 + x^2 + 256$; $S'(x) = 4x - 40 = 0$ at $x = 10$, $S'' = 4 > 0$. [1] The ladders should be kept 10 m from either pole (mid-way). [1]

Q37. (4 marks) Answer: (i) 3/5; (ii) 0.95; (iii)(a) 3/4; (iii)(b) 27/46.

(i) 0.6 (= 3/5). [1]

(ii) 1 − 0.05 = 0.95. [1]

(iii)(a) P(Q) = 0.4 × 0.05 + 0.6 × 0.10 = 0.02 + 0.06 = 0.08. [1] P(regular | Q) = 0.06/0.08 = 3/4. [1]

OR (iii)(b) P(not Q) = 1 − 0.08 = 0.92. [1] P(regular | not Q) = 0.6 × 0.9/0.92 = 0.54/0.92 = 27/46. [1]

Q38. (4 marks) Answer: (i) y = 2x + 4; (ii) 4x + 3y = 12; (iii)(a) 6 sq units; (iii)(b) 4 sq units.

(i) Through (−2, 0) and (0, 4): y = 2x + 4. [1]

(ii) Through (0, 4) and (3, 0): 4x + 3y = 12, i.e. y = 4 − 4x/3. [1]

(iii)(a) Area OAC = $\int_0^3 (4 - 4x/3)\,dx = [4x - 2x^2/3]_0^3$ [1] = 12 − 6 = 6 square units. [1]

OR (iii)(b) Area AOB = $\int_{-2}^{0} (2x + 4)\,dx = [x^2 + 4x]_{-2}^{0}$ [1] = 0 − (4 − 8) = 4 square units. [1]

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