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CBSE Class 12 Maths Board Paper 2026 (65/5/1) with Solutions

PREVIOUS YEAR PAPER · CLASS XII · MATHEMATICS (041) · BOARD EXAM 2026 · Q.P. CODE 65/5/1

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 2 questions in Section E.
9. Use of calculator is not allowed.
10. This is the official 2026 board paper (Q.P. Code 65/5/1). 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 65/5/1, as published by CBSE at cbse.gov.in; figures redrawn. 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 matrix $A = \begin{pmatrix} -p & q \\ r & p \end{pmatrix}$ is such that $A^2 = I$, then : 1

(A) $1 + p^2 + qr = 0$ (B) $1 - p^2 - qr = 0$

(C) $1 - p^2 + qr = 0$ (D) $1 + p^2 - qr = 0$

2. If A is a square matrix such that $A^2 = A$, then $(A - I)^3 - A$ is equal to : 1

(A) I (B) − I

(C) A (D) A^2

3. For the inverse trigonometric functions, which of the following Principal Value Branch is ***not*** correctly defined ? 1

(A) $\tan^{-1} : R \to (-\frac{\pi}{2}, \frac{\pi}{2})$ (B) $\sec^{-1} : R - (-1, 1) \to [0, \pi] - \{\frac{\pi}{2}\}$

(C) $\cot^{-1} : R \to (0, \pi)$ (D) $\text{cosec}^{-1} : R - (-1, 1) \to [-\frac{\pi}{2}, \frac{\pi}{2}]$

4. Let $A = \begin{pmatrix} 0 & -3 & 4 \\ 1 & 0 & 2 \end{pmatrix}$ and $B = \begin{pmatrix} -3 & 0 & 1 \\ 2 & 4 & 0 \end{pmatrix}$. If A + B + C = O, then matrix C is : 1

(A) $\begin{pmatrix} -3 & -3 & 5 \\ 3 & 4 & 2 \end{pmatrix}$ (B) $\begin{pmatrix} 3 & 3 & 5 \\ -3 & -4 & -2 \end{pmatrix}$

(C) $\begin{pmatrix} 3 & 3 & -5 \\ -3 & -4 & -2 \end{pmatrix}$ (D) $\begin{pmatrix} -3 & -3 & -5 \\ 3 & 4 & 2 \end{pmatrix}$

5. If A is a non-singular matrix, then which of the following is ***not*** true ? 1

(A) adj A is singular (B) $(\text{adj } A)^{-1} = (\text{adj } A^{-1})$

(C) $|A| \neq 0$ (D) A^{-1} exists

6. If $f(x) = \begin{cases} \frac{x^2 - 4x - 5}{x + 1}, & x \neq -1 \\ k, & x = -1 \end{cases}$ is continuous at $x = -1$, then the value of k is : 1

(A) Any real value (B) 6

(C) −1 (D) − 6

7. If the area of Δ ABC with vertices A(3, 1), B(− 2, 1) and C(0, k) is 5 sq. units, then values of k are : 1

(A) 3, 1 (B) −1, 3

(C) −1, 2 (D) 0, 2

8. Derivative of $\cos^{-1}\left(\frac{\sin x + \cos x}{\sqrt{2}}\right)$, $-\frac{\pi}{4} < x < \frac{\pi}{4}$ with respect to x is : 1

(A) -1 (B) 1

(C) $\frac{\pi}{4}$ (D) $-\frac{\pi}{4}$

9. Absolute minimum value of $f(x) = (x - 2)^2 + 5$ in the interval $[-3, 2]$ is : 1

(A) -3 (B) 2

(C) 5 (D) 30

10. $\int \frac{1}{\sqrt{1 + \cos 2x}}\, dx$ is equal to : 1

(A) $\log \cos x + C$ (B) $\frac{1}{\sqrt{2}} \log |\sec x + \tan x| + C$

(C) $\frac{1}{\sqrt{2}} \log |\sec x - \tan x| + C$ (D) $\log \sin 2x + C$

11. The value of $\int_{-5}^{-1} \frac{1}{x}\, dx$ is equal to : 1

(A) $-\log 5$ (B) x^6

(C) $\log (-5)$ (D) x^{-6}

12. An ant is observed crawling on a sheet of paper along a straight line given by equation $y = 2x - 4$. Area of the surface covered by the ant bounded by y-axis, x-axis and $x = 1$ is : 1

(A) 1 sq. unit (B) 3 sq. units

(C) 2 sq. units (D) 4 sq. units

13. The order and degree of the differential equation $1 + \left(\frac{d^3y}{dx^3}\right)^3 = \lambda \frac{d^2y}{dx^2}$ is : 1

(A) Order = 3, Degree = 3 (B) Order = 2, Degree = 2

(C) Order = 3, Degree = 1 (D) Order = 2, Degree = 1

14. The general solution for the differential equation $\frac{dy}{dx} = e^{3x-y}$ is : 1

(A) $3e^y = e^{3x} + C$ (B) $\log (3x - y) = C$

(C) $e^{3x-y} = C$ (D) $-e^y + 3e^{3x} = C$

15. The corner points of the feasible region determined by the system of linear constraints are (0, 0), (0, 40), (20, 40) (60, 20) and (60, 0). If the objective function of an LPP is $Z = 4x + 3y$, then the maximum value is : 1

(A) 200 (B) 300

(C) 240 (D) 120

16. If position vector $\boldsymbol{p}$ of a point (24, n) is such that $|\boldsymbol{p}| = 25$, then the value of n is : 1

(A) ± 49 (B) ± 5

(C) ± 1 (D) ± 7

17. If vectors $\boldsymbol{a} = 3\hat{i} + 2\hat{j} + \lambda\hat{k}$ and $\boldsymbol{b} = 2\hat{i} - 4\hat{j} + 5\hat{k}$, represent the two strips of the Red Cross sign placed outside a doctor's clinic, then the value of λ is : 1

(A) 1 (B) $\frac{5}{2}$

(C) $\frac{2}{5}$ (D) 0

18. If $3P(A) = P(B) = \frac{3}{5}$ and $P(A|B) = \frac{2}{3}$, then $P(A \cup B)$ is : 1

(A) $\frac{3}{5}$ (B) $\frac{1}{5}$

(C) $\frac{2}{15}$ (D) $\frac{2}{5}$

19. **Assertion (A) :** A relation R on the set {1, 2, 3} defined as R = {(1, 1), (1, 2), (2, 1), (2, 2), (3, 3)} is an equivalence relation. 1

Reason (R) : A relation that is reflexive, symmetric and transitive is an equivalence relation.

(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) :** Consider a Linear Programming Problem with minimise $Z = x + 2y$ subject to constraints $2x + y \geq 3$, $x + 2y \geq 6$, $x, y \geq 0$ which gives minimum Z at infinitely many points. The corner points of feasible region are (0, 3) and (6, 0). 1

Reason (R) : If two corner points produce the same minimum value of the objective function, then every point on the line segment joining the points will give the same minimum value.

(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. Evaluate $\sin[\tan^{-1}\tan(\frac{3\pi}{4})]$. 2

22. (a) Differentiate x^x with respect to $x \log x$. 2

OR

(b) If $y = P\cos ux + Q\sin ux$, show that $\frac{d^2y}{dx^2} + u^2y = 0$.

23. Determine the values of x for which $f(x) = \frac{x-3}{x+1}$, $x \neq -1$ is an increasing function. 2

24. (a) Three honey bees were found flying along the vectors $\boldsymbol{a} = 2\hat{i} - 3\hat{j} + \hat{k}$, $\boldsymbol{b} = 4\hat{j} - 2\hat{k}$ and $\boldsymbol{c} = 3\hat{i} + 2\hat{k}$ respectively. Find the value of λ such that the path for $\boldsymbol{a} + \lambda\boldsymbol{b}$ is perpendicular to $\boldsymbol{c}$. 2

OR

(b) If A, B and C be three non-collinear points such that $\boldsymbol{AB} = \hat{i} + 2\hat{j} - \hat{k}$ and $\boldsymbol{AC} = 2\hat{i} - 3\hat{j}$, then find the area of Δ ABC.

25. Find the angle between the following pair of lines : $\frac{x-2}{3} = \frac{y+5}{2} = \frac{1-z}{-6}$ and $\frac{x-7}{1} = \frac{y}{2} = \frac{6-z}{-2}$ 2

SECTION C

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

26. A spherical balloon loses its volume due to escape of air from it in such a way that decrease of volume at any instant is proportional to its surface area. Show that the radius is decreasing at a constant rate. 3

27. (a) Find : $\int \frac{x - \sin x}{1 - \cos x}\, dx$ 3

OR

(b) Evaluate : $\int_0^2 \frac{1}{\sqrt{x^2 + 2x + 3}}\, dx$

28. Solve the differential equation $(x + 2y^3)\, dy = y\, dx$. 3

29. Solve the following Linear Programming Problem graphically : 3

Maximize $Z = \frac{2x}{5} + \frac{3y}{10}$

subject to constraints

$2x + y \leq 1000$

$x + y \leq 800$

$x, y \geq 0$.

30. (a) Let three toys A, B and C be placed in the same straight line. If the position vectors of A, B and C are $55\hat{i} - 2\hat{j}$, $5\hat{i} + 8\hat{j}$ and $a\hat{i} - 52\hat{j}$ respectively, find the value of 'a'. 3

OR

(b) If $\boldsymbol{a}$, $\boldsymbol{b}$ and $\boldsymbol{c}$ are unit vectors, then prove that $|\boldsymbol{a} - \boldsymbol{b}|^2 + |\boldsymbol{b} - \boldsymbol{c}|^2 + |\boldsymbol{c} - \boldsymbol{a}|^2 \leq 9$.

31. (a) A die is rolled. Consider events : A = {1, 2, 5}, B = {3, 5}, C = {2, 3, 4, 5} and hence find : 3

(i) P(A|C) and P(C|A)

(ii) $P(A \cap B|C)$ and $P(A \cup B|C)$

OR

(b) A box contains 6 cards numbered 1 to 6. A student is asked to pick up two cards, one by one after replacement and note down the numbers on the cards. Let A be the event of getting sum of the numbers on two cards as 10, and B, the event of a number other than 4 on the first card selected. Find P(A and B) and find whether the events A and B are independent events or not.

SECTION D

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

32. A man goes to buy fruits from the market. The shopkeeper informs him that 4 apples, 3 oranges and 2 bananas cost ₹ 60; 2 apples, 4 oranges and 6 bananas cost ₹ 90; whereas 6 apples, 2 oranges and 3 bananas cost ₹ 70. Using matrix method, find the cost of one fruit of each kind. 5

33. (a) If $y\sqrt{x^2+1} = \log(\sqrt{x^2+1} - x)$, show that $(x^2+1)\frac{dy}{dx} + xy + 1 = 0$. 5

OR

(b) Find the differential of $x^{\cot x} + \frac{2x^2-3}{2x^2-x+2}$ with respect to x.

34. Sketch the curve $\{(x, y) : 100x^2 + 25y^2 = 2500\}$ and find the area of the region enclosed by it, using integration. 5

35. (a) Find the foot of the perpendicular from the point (0, 2, 3) on the line $\frac{-x-3}{-5} = \frac{1-y}{-2} = \frac{3z+12}{9}$ and hence find the length of the perpendicular. 5

OR

(b) Find the value of p if the shortest distance between the lines $\boldsymbol{r} = (\hat{i} + 2\hat{j} + \hat{k}) + \lambda(\hat{i} - \hat{j} + \hat{k})$ and $\boldsymbol{r} = (p\hat{i} - \hat{j} - \hat{k}) + \mu(2\hat{i} + \hat{j} + 2\hat{k})$ is $\frac{3}{\sqrt{2}}$ units.

SECTION E

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

36. A school wants the students of class XII to do a project on 'Sustainability' keeping the world environment in mind. They select the student participants on the basis of an essay writing competition. 7 students out of 80 are selected for the project and are categorized into two sets such that : Girl students belong to Set A = $\{G_1, G_2, G_3, G_4\}$, Boy students belong to Set B = $\{B_1, B_2, B_3\}$. Based on the above information, answer the following questions :

(i) How many relations are possible from Set A → Set B ? [1]

(ii) Let R be a relation from A → B such that R = $\{(G_1, B_1), (G_2, B_2), (G_3, B_2), (G_4, B_3), (G_1, B_2)\}$. Is R an injective function ? Justify your answer. [1]

(iii) (a) Let the relation R from A → A be such that R = {(*x*, y), *x*, y ∈ A, *x* and y are students from the same colony in the city}. Verify if R is an equivalence relation. [2]

OR

(iii) (b) Verify if any function f : B → A is bijective. Give reason to support your answer. [2]

37. There are three types of vaccines A_1, A_2, A_3, available in the market to protect the population of the country from spread of certain infection. According to a survey conducted, it was found that 25% of the population was given Vaccine A_1, 35% of the population was given Vaccine A_2 and 40% of the population was given Vaccine A_3. The survey also stated that the probabilities that Vaccines A_1, A_2 and A_3 would protect against the infection were 60%, 55% and 50% respectively. Based on the above information, answer the following questions : Find the probability that :

(i) The person taking vaccine A_2 will get infected. [1]

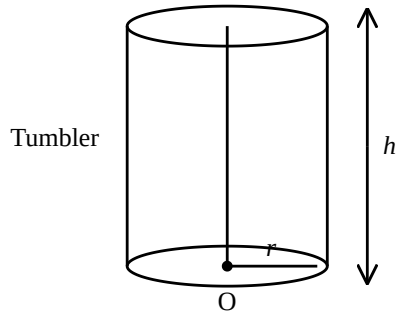
(ii) If a person is chosen randomly, he/she will be protected from the infection. [1]

(iii) (a) The person was given Vaccine A_1, given that the randomly chosen person is infected. [2]

OR

(iii) (b) The person was given Vaccine A_3, given that the randomly chosen person is not infected. [2]

38. A company produces cylindrical tumblers, open from the top. Since they want uniformity in the product, they fix the surface area of the tumblers produced.



Based on the above information, answer the following questions : If for a tumbler, V is its volume, h the height and r the radius of the circular base, then :

(i) Differentiate its volume with respect to radius of the base, where the surface area is constant. [2]

(ii) If the company wants to maximize the volume of each tumbler, then establish a relation between its height and the radius of the base. [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
(B)	(B)	(D)	(C)	(A)	(D)	(B)	(A)	(C)	(B)	(A)	(B)	(A)	(A)	(B)	(D)	(C)	(D)	(A)	(A)

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 (B). $A^2 = [[p^2 + qr, -pq + pq], [-pr + pr, qr + p^2]] = (p^2 + qr)\, I$. $A^2 = I$ gives $p^2 + qr = 1$, i.e. $1 - p^2 - qr = 0$.

Q2. Answer (B). $(A - I)^3 = A^3 - 3A^2 + 3A - I = A - 3A + 3A - I = A - I$ (as $A^2 = A^3 = A$). So $(A - I)^3 - A = -I$.

Q3. Answer (D). $\text{cosec}^{-1} x$ is never 0, so its principal branch is $[-\pi/2, \pi/2] - \{0\}$, not the whole closed interval.

Q4. Answer (C). $A + B = [[-3, -3, 5], [3, 4, 2]]$, so $C = -(A + B) = [[3, 3, -5], [-3, -4, -2]]$.

Q5. Answer (A). $|\text{adj } A| = |A|^{n-1} \neq 0$ when $|A| \neq 0$, so adj A is non-singular; statement (A) is false. The others hold for a non-singular A.

Q6. Answer (D). $(x^2 - 4x - 5)/(x + 1) = (x - 5)(x + 1)/(x + 1) = x - 5$ for $x \neq -1$, with limit -6. So $k = -6$.

Q7. Answer (B). Area $= \tfrac{1}{2}|3(1 - k) - 2(k - 1) + 0| = \tfrac{1}{2}|5 - 5k| = 5$, so $|1 - k| = 2$: $k = -1$ or 3.

Q8. Answer (A). $(\sin x + \cos x)/\sqrt{2} = \cos(x - \pi/4) = \cos(\pi/4 - x)$, and $\pi/4 - x \in (0, \pi/2)$ here. So the function is $\pi/4 - x$, with derivative -1.

Q9. Answer (C). f is decreasing on $[-3, 2]$ ($f' = 2(x - 2) \leq 0$); $f(2) = 5$ is the least value ($f(-3) = 30$ the greatest).

Q10. Answer (B). $1 + \cos 2x = 2\cos^2 x$, so the integrand is $(1/\sqrt{2}) \sec x$ (taking $\cos x > 0$): $(1/\sqrt{2}) \log|\sec x + \tan x| + C$.

Q11. Answer (A). $[\log|x|]_{-5}^{-1} = \log 1 - \log 5 = -\log 5$.

Q12. Answer (B). For $0 \leq x \leq 1$ the line is below the x-axis: area $= \int_0^1 (4 - 2x)\, dx = 4 - 1 = 3$ sq. units.

Q13. Answer (A). The highest derivative is d^3y/dx^3 (order 3), raised to the power 3 (degree 3).

Q14. Answer (A). $e^y\, dy = e^{3x}\, dx$ gives $e^y = e^{3x}/3 + C'$, i.e. $3e^y = e^{3x} + C$.

Q15. Answer (B). Z at the corners: 0, 120, 200, 300, 240. Maximum 300 at (60, 20).

Q16. Answer (D). $24^2 + n^2 = 625$, $n^2 = 49$, $n = \pm 7$.

Q17. Answer (C). The strips of a Red Cross are perpendicular: $6 - 8 + 5\lambda = 0$, $\lambda = 2/5$.

Q18. Answer (D). $P(B) = 3/5$, $P(A) = 1/5$, $P(A \cap B) = P(A|B)\, P(B) = 2/5$. $P(A \cup B) = 1/5 + 3/5 - 2/5 = 2/5$. (Note: these data are not consistent, since $P(A \cap B) = 2/5$ exceeds $P(A) = 1/5$; the formula gives 2/5, option (D), the answer intended.)

Q19. Answer (A). R contains (1, 1), (2, 2), (3, 3) (reflexive), with (1, 2) also (2, 1) (symmetric), and every chain closes (transitive), so it is an equivalence relation, by exactly the definition stated in R. Answer (A).

Q20. Answer (A). The feasible region is $x + 2y \geq 6$ (which already forces $2x + y \geq 3$ for $x, y \geq 0$), with corners (0, 3) and (6, 0). $Z = x + 2y \geq 6$ everywhere in it and $Z = 6$ at both corners, so the minimum 6 is attained at every point of the segment joining them. R is the reason. Answer (A).

Q21. (2 marks) Answer: $-1/\sqrt{2}$.
$\tan(3\pi/4) = -1$, and the principal value $\tan^{-1}(-1) = -\pi/4$. [1]
$\sin(-\pi/4) = -1/\sqrt{2}$. [1]

Q22. (2 marks) Answer: (a) x^x; (b) shown.
(a) $d(x^x)/dx = x^x(1 + \log x)$; $d(x \log x)/dx = 1 + \log x$. [1]
Required derivative $= x^x(1 + \log x)/(1 + \log x) = x^x$. [1]
OR (b) $dy/dx = -Pu \sin ux + Qu \cos ux$. [1]
$d^2y/dx^2 = -Pu^2 \cos ux - Qu^2 \sin ux = -u^2y$, so $d^2y/dx^2 + u^2y = 0$. [1]

Q23. (2 marks) Answer: all $x \neq -1$.
$f'(x) = ((x + 1) - (x - 3))/(x + 1)^2 = 4/(x + 1)^2$. [1]
$f'(x) > 0$ for every $x \neq -1$, so f is increasing on $(-\infty, -1)$ and on $(-1, \infty)$, i.e. for all $x \neq -1$. [1]

Q24. (2 marks) Answer: (a) $\lambda = 2$; (b) $\sqrt{62}/2$.
(a) $\vec{a} + \lambda\vec{b} = 2\hat{i} + (4\lambda - 3)\hat{j} + (1 - 2\lambda)\hat{k}$. [1]
$(\vec{a} + \lambda\vec{b}) \cdot \vec{c} = 6 + 2(1 - 2\lambda) = 8 - 4\lambda = 0$, so $\lambda = 2$. [1]
OR (b) $\vec{AB} \times \vec{AC} = (\hat{i} + 2\hat{j} - \hat{k}) \times (2\hat{i} - 3\hat{j}) = -3\hat{i} - 2\hat{j} - 7\hat{k}$. [1]
Area $= \frac{1}{2}\sqrt{(9 + 4 + 49)} = \sqrt{62}/2$ sq units. [1]

Q25. (2 marks) Answer: $\cos^{-1}(19/21)$.
In standard form the direction ratios are 3, 2, 6 and 1, 2, 2 (since $(1 - z)/(-6) = (z - 1)/6$ and $(6 - z)/(-2) = (z - 6)/2$). [1]
$\cos\theta = (3 + 4 + 12)/(7 \times 3) = 19/21$, so $\theta = \cos^{-1}(19/21)$. [1]

Q26. (3 marks) Answer: $dr/dt = -k$ (constant).
$V = (4/3)\pi r^3$, $S = 4\pi r^2$. Given $dV/dt = -kS = -4k\pi r^2$ ($k > 0$). [1]
$dV/dt = 4\pi r^2 \, dr/dt$. [1]
So $4\pi r^2 \, dr/dt = -4k\pi r^2$, i.e. $dr/dt = -k$: the radius decreases at a constant rate. [1]

Q27. (3 marks) Answer: (a) $-x \cot(x/2) + C$; (b) $\log((3 + \sqrt{11})/(1 + \sqrt{3}))$.
(a) $1 - \cos x = 2\sin^2(x/2)$ and $\sin x = 2\sin(x/2)\cos(x/2)$: the integrand is $(x/2)\,\mathrm{cosec}^2(x/2) - \cot(x/2)$. [1]
By parts, $\int (x/2)\,\mathrm{cosec}^2(x/2)\,dx = -x\cot(x/2) + \int \cot(x/2)\,dx$. [1]
The two $\cot(x/2)$ integrals cancel: answer $-x\cot(x/2) + C$. [1]
OR (b) $x^2 + 2x + 3 = (x + 1)^2 + (\sqrt{2})^2$. [1]
$\int = [\log|x + 1 + \sqrt{(x^2 + 2x + 3)}|]_0^2$ [1] $= \log(3 + \sqrt{11}) - \log(1 + \sqrt{3}) = \log((3 + \sqrt{11})/(1 + \sqrt{3}))$. [1]

Q28. (3 marks) Answer: $x = y^3 + Cy$.
$dx/dy = (x + 2y^3)/y$, i.e. $dx/dy - x/y = 2y^2$: linear in x. [1]
IF = e^(−∫ dy/y) = 1/y. [1]
$x/y = \int 2y\,dy = y^2 + C$, so $x = y^3 + Cy$. [1]

Q29. (3 marks) Answer: Max Z = 260 at (200, 600).
$2x + y = 1000$ and $x + y = 800$ meet at (200, 600). Corners of the feasible region: (0, 0), (500, 0), (200, 600), (0, 800). [1½]
Z: 0, 200, 260, 240. [1]
Maximum Z = 260 at $x = 200$, $y = 600$. [½]

Q30. (3 marks) Answer: (a) $a = 305$; (b) proved.
(a) $\vec{AB} = -50\hat{i} + 10\hat{j}$, $\vec{AC} = (a - 55)\hat{i} - 50\hat{j}$. [1]
Collinear: $\vec{AC} = \lambda\vec{AB}$, so $\lambda = -50/10 = -5$ and $a - 55 = -5 \times (-50) = 250$. [1]
$a = 305$. [1]
OR (b) The left side $= 2(|a|^2 + |b|^2 + |c|^2) - 2(a \cdot b + b \cdot c + c \cdot a) = 6 - 2(a \cdot b + b \cdot c + c \cdot a)$. [1]
$|a + b + c|^2 = 3 + 2(a \cdot b + b \cdot c + c \cdot a) \geq 0$, so $a \cdot b + b \cdot c + c \cdot a \geq -3/2$. [1]
Hence the left side $\leq 6 + 3 = 9$. [1]

Q31. (3 marks) Answer: (a) 1/2, 2/3; 1/4, 3/4; (b) 1/18, not independent.

(a) (i) $A \cap C = \{2, 5\}$: $P(A|C) = 2/4 = 1/2$; $P(C|A) = 2/3$. [1½]

(ii) $A \cap B \cap C = \{5\}$: $P(A \cap B|C) = 1/4$. $(A \cup B) \cap C = \{2, 3, 5\}$: $P(A \cup B|C) = 3/4$. [1½]

OR (b) $A = \{(4, 6), (5, 5), (6, 4)\}$, $P(A) = 3/36 = 1/12$; $P(B) = 5/6$. [1]

A and $B = \{(5, 5), (6, 4)\}$: $P(A \cap B) = 2/36 = 1/18$. [1]

$P(A)P(B) = 5/72 \neq 1/18$, so A and B are not independent. [1]

Q32. (5 marks) Answer: apple ₹ 5, orange ₹ 8, banana ₹ 8.

Let x, y, z be the costs of an apple, an orange and a banana: $4x + 3y + 2z = 60$, $2x + 4y + 6z = 90$, $6x + 2y + 3z = 70$; $AX = B$. [1]

$|A| = 4(12 - 12) - 3(6 - 36) + 2(4 - 24) = 0 + 90 - 40 = 50 \neq 0$. [1]

adj $A = [[0, -5, 10], [30, 0, -20], [-20, 10, 10]]$. [1½]

$X = (1/50)$ adj $A \cdot B = (1/50)[0 - 450 + 700, 1800 + 0 - 1400, -1200 + 900 + 700]' = [5, 8, 8]'$. [1]

Apple ₹ 5, orange ₹ 8, banana ₹ 8. [½]

Q33. (5 marks) Answer: (a) shown; (b) $x^{\cot x}(\cot x/x - \text{cosec}^2 x \log x) + (-2x^2 + 20x - 3)/(2x^2 - x + 2)^2$.

(a) Differentiating: $y'\sqrt{(x^2 + 1)} + xy/\sqrt{(x^2 + 1)} = (x/\sqrt{(x^2 + 1)} - 1)/(\sqrt{(x^2 + 1)} - x)$. [2]

The right side $= -(\sqrt{(x^2 + 1)} - x)/(\sqrt{(x^2 + 1)}(\sqrt{(x^2 + 1)} - x)) = -1/\sqrt{(x^2 + 1)}$. [1½]

Multiplying by $\sqrt{(x^2 + 1)}$: $(x^2 + 1)y' + xy = -1$, i.e. $(x^2 + 1)\,dy/dx + xy + 1 = 0$. [1½]

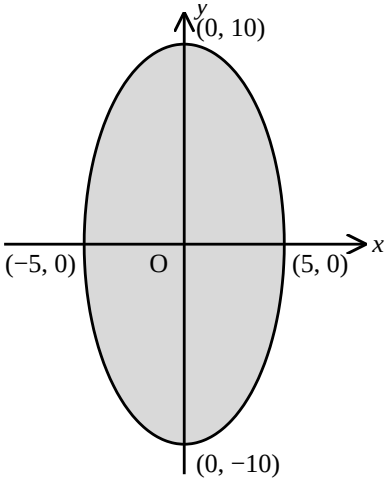
OR (b) $u = x^{\cot x}$: $\log u = \cot x \log x$, $u' = x^{\cot x}(\cot x/x - \text{cosec}^2 x \log x)$. [2½]

$v = (2x^2 - 3)/(2x^2 - x + 2)$: $v' = [4x(2x^2 - x + 2) - (2x^2 - 3)(4x - 1)]/(2x^2 - x + 2)^2 = (-2x^2 + 20x - 3)/(2x^2 - x + 2)^2$. [2]

Answer: $x^{\cot x}(\cot x/x - \text{cosec}^2 x \log x) + (-2x^2 + 20x - 3)/(2x^2 - x + 2)^2$. [½]

Q34. (5 marks) Answer: 50π sq units.

$x^2/25 + y^2/100 = 1$: an ellipse with centre O, semi-axes 5 along x and 10 along y.



[1½]

By symmetry, area $= 4\int_0^5 y\,dx = 4\int_0^5 2\sqrt{(25 - x^2)}\,dx$. [1]

$= 8[(x/2)\sqrt{(25 - x^2)} + (25/2)\sin^{-1}(x/5)]_0^5$ [1½] $= 8 \times (25/2)(\pi/2) = 50\pi$ sq units. [1]

Q35. (5 marks) Answer: (a) foot (2, 3, −1), length $\sqrt{21}$; (b) $p = 2$ or -4.

(a) Standard form: $(x + 3)/5 = (y - 1)/2 = (z + 4)/3$. General point $M(5\lambda - 3, 2\lambda + 1, 3\lambda - 4)$. [1½]

$PM = (5\lambda - 3, 2\lambda - 1, 3\lambda - 7)$ is perpendicular to (5, 2, 3): $25\lambda - 15 + 4\lambda - 2 + 9\lambda - 21 = 38\lambda - 38 = 0$, $\lambda = 1$. [1½]

Foot M(2, 3, −1). [1]

Length $PM = \sqrt{(4 + 1 + 16)} = \sqrt{21}$ units. [1]

OR (b) $b_1 \times b_2 = (\hat{i} - \hat{j} + \hat{k}) \times (2\hat{i} + \hat{j} + 2\hat{k}) = -3\hat{i} + 3\hat{k}$, $|b_1 \times b_2| = 3\sqrt{2}$. [1½]

$a_2 - a_1 = (p - 1)\hat{i} - 3\hat{j} - 2\hat{k}$; $(a_2 - a_1) \cdot (b_1 \times b_2) = -3(p - 1) - 6 = -3p - 3$. [1½]

$SD = |3p + 3|/(3\sqrt{2}) = |p + 1|/\sqrt{2} = 3/\sqrt{2}$, so $p + 1 = \pm 3$: $p = 2$ or $p = -4$. [2]

Q36. (4 marks) Answer: (i) 4096; (ii) not a function (G_1 has two images); (iii)(a) equivalence relation; (iii)(b) no.
(i) $A \times B$ has $4 \times 3 = 12$ elements, so there are $2^{12} = 4096$ relations. [1]
(ii) No. G_1 is related to both B_1 and B_2, so R is not even a function (and G_2, G_3 share B_2 as well). [1]
(iii)(a) Reflexive: every student is from the same colony as himself or herself. Symmetric: if x is from y's colony, y is from x's. [1] Transitive: x, y same colony and y, z same colony give x, z same colony. So R is an equivalence relation. [1]
OR (iii)(b) B has 3 elements and A has 4, so a function $f : B \to A$ can take at most 3 values and cannot be onto. [1] Hence no function from B to A is bijective. [1]

Q37. (4 marks) Answer: (i) 0.45; (ii) 0.5425; (iii)(a) 40/183; (iii)(b) 80/217.
(i) $1 - 0.55 = 0.45$. [1]
(ii) $P(\text{protected}) = 0.25 \times 0.60 + 0.35 \times 0.55 + 0.40 \times 0.50 = 0.15 + 0.1925 + 0.20 = 0.5425$ (= 217/400). [1]
(iii)(a) $P(\text{infected}) = 1 - 0.5425 = 0.4575$. [1] $P(A_1|\text{infected}) = 0.25 \times 0.40/0.4575 = 0.1/0.4575 = 40/183$. [1]
OR (iii)(b) $P(A_3|\text{not infected}) = 0.40 \times 0.50/0.5425$ [1] $= 0.2/0.5425 = 80/217$. [1]

Q38. (4 marks) Answer: (i) $dV/dr = (S - 3\pi r^2)/2$; (ii) $h = r$.
(i) Surface area (open top) $S = \pi r^2 + 2\pi rh$ is constant, so $h = (S - \pi r^2)/(2\pi r)$. [1] $V = \pi r^2 h = (Sr - \pi r^3)/2$, and $dV/dr = (S - 3\pi r^2)/2$. [1]
(ii) $dV/dr = 0$ gives $S = 3\pi r^2$, i.e. $\pi r^2 + 2\pi rh = 3\pi r^2$, so $h = r$. [1] $d^2V/dr^2 = -3\pi r < 0$, so the volume is maximum when the height equals the radius of the base. [1]

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