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CBSE Class 12 Maths Board Paper 2026 (65/4/1) with Solutions

PREVIOUS YEAR PAPER · CLASS XII · MATHEMATICS (041) · BOARD EXAM 2026 · Q.P. CODE 65/4/1

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 65/4/1). 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.

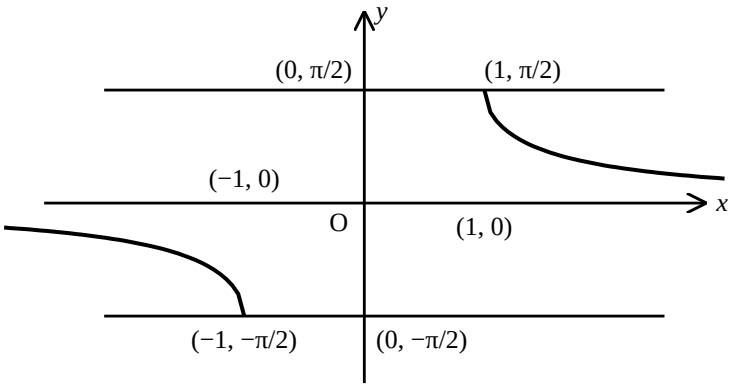
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Chapters: Full syllabus · **Topics:** Relations and Functions · Inverse Trigonometric Functions · Matrices · Determinants · Continuity and Differentiability · Applications of Derivatives · Integrals · Applications of Integrals · Differential Equations · 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 following graph represents : 1



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

(C) $y = \tan^{-1} x$ (D) $y = \text{cosec}^{-1} x$

2. If $A = [a_{ij}]$ is a 2×2 matrix whose elements are given by $a_{ij} = \frac{|i - 3j|}{2}$, then A' is : 1

(A) $\begin{pmatrix} 1 & \frac{5}{2} \\ \frac{1}{2} & 2 \end{pmatrix}$ (B) $\begin{pmatrix} 1 & \frac{1}{2} \\ \frac{5}{2} & 2 \end{pmatrix}$

(C) $\begin{pmatrix} 2 & \frac{5}{2} \\ \frac{1}{2} & 1 \end{pmatrix}$ (D) $\begin{pmatrix} 2 & \frac{1}{2} \\ \frac{5}{2} & 1 \end{pmatrix}$

3. The principal value of $\sec^{-1}(\sqrt{2}) + 2\,\text{cosec}^{-1}(-\sqrt{2})$ is : 1

(A) $-\frac{\pi}{2}$ (B) $-\frac{\pi}{4}$

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

4. If points (2, 3), (0, 4) and (p, 2) are collinear, then the value of p is : 1

(A) $\frac{4}{7}$ (B) $-\frac{3}{7}$

(C) 4 (D) − 4

5. Differential of e^{e^x} with respect to x is : 1

(A) $\log x$ (B) e^{e^x}

(C) $e^x e^{e^x}$ (D) $(e^x)^2$

6. The surface area of a sphere when its volume changes at the same rate as its radius is : 1

(A) 4π sq. units (B) 1 sq. unit

(C) 4 sq. units (D) π sq. units

7. 1

If $f(x) = \begin{cases} \frac{\sin x}{x} + \cos x, & x \neq 0 \\ k, & x = 0 \end{cases}$ is continuous at $x = 0$, then the value of k is :

(A) 0 (B) -2

(C) -1 (D) 2

8. The greatest integer function, $f(x) = [x]$, $0 < x < 3$ is ***not*** differentiable at how many points ? 1

(A) At only one point (B) At only two points

(C) At no point (D) At three points

9. $\int \frac{dx}{\sqrt{25 - 16x^2}}$ is equal to : 1

(A) $\frac{1}{5} \sin^{-1} 4x + C$ (B) $\frac{1}{25} \sin^{-1} 16x + C$

(C) $\frac{1}{4} \sin^{-1} \frac{4x}{5} + C$ (D) $\frac{1}{16} \sin^{-1} \frac{4x}{5} + C$

10. If $\int_0^1 \frac{dx}{e^x + e^{-x}} = \tan^{-1} e + k$, then the value of k is : 1

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

(C) 0 (D) $-\frac{\pi}{4}$

11. The area of the region bounded by the curve $y = x$ and x-axis, between $x = 0$ and $x = 2$ is : 1

(A) 2 sq. units (B) $\frac{1}{2}$ sq. unit

(C) 1 sq. unit (D) 4 sq. units

12. Product of the order and degree of differential equation $1 + (\frac{dy}{dx})^3 = \lambda (\frac{d^3y}{dx^3})^2$ is : 1

(A) 5 (B) 6

(C) 2 (D) 3

13. Which of the following is ***not*** a Linear Differential Equation ? 1

(A) $(1 + x^2) dy + 2xy\, dx = \cot x\, dx$ (B) $y + \frac{d}{dx}(xy) = x (\sin x + \log x)$

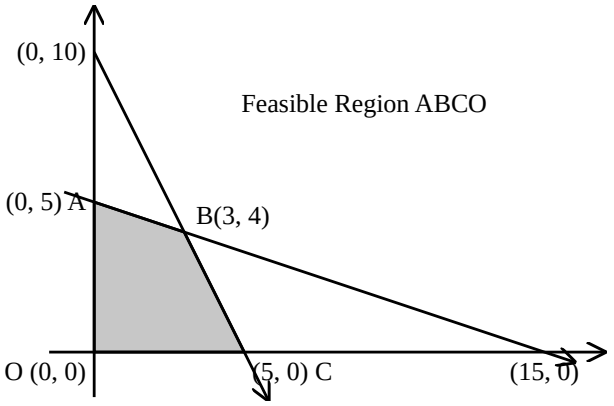
(C) $x (1 + y^2) dx - y (1 + x^2) dy = 0$ (D) $y\, dx - (x + 3y^2) dy = 0$

14. The region represented by the system of inequations $3x + y \geq 3$, $2x - y \geq -5$, $x, y \geq 0$ is : 1

(A) unbounded in 1st quadrant (B) bounded in 1st quadrant

(C) unbounded in 2nd quadrant (D) bounded in 2nd quadrant

15. In the graph, the feasible region representing the Linear Programming Problem for maximising objective function Z = p*x* + qy, p, q > 0 is shaded. If all points on segment AB give max (Z), then which of the following is true ? 1



(A) p = 2q (B) p = 3q

(C) q = 3p (D) q = 2p

16. If $(3\hat{i} - 2\hat{j} + 5\hat{k}) \times (4\hat{i} + p\hat{j} + q\hat{k}) = \boldsymbol{0}$, then the values of p and q are : 1

(A) $p = -\frac{2}{3}, q = \frac{5}{3}$ (B) $p = -\frac{8}{3}, q = \frac{20}{3}$

(C) $p = \frac{20}{3}, q = -\frac{8}{3}$ (D) p = 0, q = 0

17. Three points A(0, 1, 1), B(2, 0, −1) and C(1, 0, 3) form Δ ABC. The ar (Δ ABC) is : 1

(A) $\frac{\sqrt{53}}{2}$ sq. units (B) $\sqrt{53}$ sq. units

(C) $\frac{\sqrt{11}}{2}$ sq. units (D) $\sqrt{11}$ sq. units

18. A box contains 4 red, 5 blue and 1 green marble. A child randomly takes out a marble from the box, notes down the colour and puts it back in the box. If the activity is repeated 3 times, what is the probability that at least one marble is red ? 1

(A) $\frac{27}{125}$ (B) $\frac{8}{125}$

(C) $\frac{2}{125}$ (D) $\frac{98}{125}$

19. **Assertion (A) :** If A and B are two square matrices such that AB and BA are defined, then it is not necessary that AB = BA. 1

Reason (R) : Product of two diagonal matrices of same order is commutative.

(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 function f : N $\to$ N given by f(x) = $x^3 + 2$, $\forall\, x \in$ N is one-one but not onto. 1

Reason (R) : Since $\forall$ y $\in$ N (Codomain), there does not exist $x = (y - 2)^{1/3}$ in N (Domain) such that f(x) = $x^3 + 2$ = 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.

SECTION B

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

21. Evaluate : $\tan^{-1}(-\frac{1}{\sqrt{3}}) + \cot^{-1}(\frac{1}{\sqrt{3}}) + \tan^{-1}(\sin(-\frac{\pi}{2})) + \tan^{-1}(\tan\ \frac{2\pi}{3})$ 2

22. 2

(a) Show that the function f(x) = $\begin{cases} \dfrac{\cos x}{-x + \frac{\pi}{2}}, & x \neq \dfrac{\pi}{2} \\ 1, & x = \dfrac{\pi}{2} \end{cases}$ is continuous at $x = \frac{\pi}{2}$.

OR

(b) Find whether the function f(x) = $\begin{cases} x - 1, & x < 2 \\ 2x - 3, & x \geq 2 \end{cases}$ at x = 2 is differentiable or not.

23. Find the values of x for which f(x) = x^x, $x > 0$ is increasing. 2

24. If the position vectors of three points A, B and C are $3\hat{i} + \hat{j}$, $5\hat{i} + 6\hat{j} - 3\hat{k}$ and $4\hat{j}$ respectively, then show that they form an isosceles triangle. 2

25. (a) Let two rods placed on the ground be represented by vectors $4\hat{i} - \hat{j} + 3\hat{k}$ and $-2\hat{i} + \hat{j} - 2\hat{k}$. Find a vector representing a flag-post of height 5 m that has to be erected perpendicular to both the rods. 2

OR

(b) A unit vector $\boldsymbol{a}$ is such that it makes an angle $\frac{\pi}{4}$ with x-axis, $\frac{\pi}{3}$ with y-axis and an acute angle θ with z-axis. Find θ and the components of $\boldsymbol{a}$.

SECTION C

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

26. (a) Let A = R $-$ {3} and B = R $-$ {1}. A function f : A $\to$ B is defined by f(x) = $(\frac{x-2}{x-3})$. Find whether f is one-one and onto. 3

OR

(b) Let n be a fixed positive integer. A relation R is defined in set Z such that R = {(x, y) : (x $-$ y) is divisible by n, x, y $\in$ Z}. Determine if R is an equivalence relation.

27. If $A = \begin{pmatrix} 3 & 2 & 0 \\ 1 & 4 & 0 \\ 0 & 0 & 5 \end{pmatrix}$, then compute $A^2 - 7A + 10\,I$. 3

28. (a) If $xy = e^{x-y}$, then find $\frac{dy}{dx}$. 3

OR

(b) Differentiate $\tan^{-1}\left(\frac{\sqrt{1+x^2}-\sqrt{1-x^2}}{\sqrt{1+x^2}+\sqrt{1-x^2}}\right)$ with respect to $\cos^{-1} x^2$.

29. Solve the following Linear Programming Problem graphically : 3

Maximise $Z = 200x + 120y$

subject to the constraints

$x + y \le 300$

$3x + y \le 600$

$x - y \ge -100$

$x, y \ge 0$

30. (a) Find a point on the line $\frac{x-2}{3} = \frac{1-y}{2} = \frac{z-3}{2}$ at a distance of $\sqrt{2}$ units from the point (1, 2, 3). 3

OR

(b) Find the shortest distance between the lines $\boldsymbol{r} = (4 + \lambda)\hat{i} + (2\lambda - 1)\hat{j} - 3\lambda\hat{k}$ and $\boldsymbol{r} = (1 + 2\mu)\hat{i} + (2 - 5\mu)\hat{k} + (4\mu - 1)\hat{j}$.

31. In a school, the probability of holding a debate competition is $\frac{1}{3}$ and that of a quiz competition is $\frac{2}{3}$. 3

In the two participating teams, A has 4 girls and 6 boys and B has 7 girls and 3 boys. If a debate competition is held, the students are selected from team A and for the quiz competition they are selected from team B. If only two students are to be chosen from the teams, then find the probability that one will be a girl and the other a boy.

SECTION D

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

32. (a) Find : $\int \frac{x}{(x-1)(x^2+4)}\,dx$ 5

OR

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

33. Using integration, find the area of the region enclosed by the curve $y = |x - 6|$, the x-axis, and between $x = 4$ and $x = 8$. 5

34. (a) Solve the differential equation $y\,e^y\,dx = (y^3 + 2x\,e^y)\,dy$, when $y(0) = 1$. 5

OR

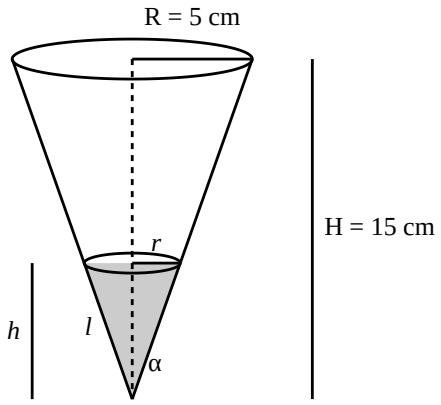
(b) Find the general solution of the differential equation $(x^3 - 3xy^2)\,dx = (y^3 - 3x^2y)\,dy$.

35. Find the equation of a line (in vector and cartesian form) that passes through the point of intersection of lines $\frac{x-1}{2} = \frac{y-2}{3} = \frac{z-3}{4}$ and $\frac{x-4}{5} = \frac{y-1}{2} = z$ and is parallel to the vector $3\hat{i} + 2\hat{j} - 8\hat{k}$. 5

SECTION E

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

36. At a birthday party, children are being served orange juice in conical cups, as shown in the figure.



Each cup is 15 cm deep and has a radius 5 cm. The juice is being poured into this cup at a rate of 0·1 cm^3/s. On the basis of the above information, answer the following questions :

(i) Establish a relation between the height h of the juice in the cup and radius r of the surface of the juice in the cup, if the semi-vertical angle of the cone is α. [1]

(ii) At what rate is the juice level in the cup rising when the juice is 6 cm deep ? [1]

(iii) (a) When the juice is 6 cm deep, then find at what rate is the upper surface area of juice increasing ? [2]

OR

(iii) (b) When the juice is 6 cm deep, then find the rate at which the wetted surface area of the cup is increasing. [2]

37. A carpenter needs to design a wooden box in the shape of a cuboid such that the sum of its length and breadth is 3 cm more than its height. Twice of its length, thrice of its breadth and its height add up to 10 cm. Its breadth added to 7 times its height is 1 cm less than 3 times its length. On the basis of the above information, answer the following questions :

(i) Write the equations representing the various dimensions and express them as the matrix equation AX = B. [1]

(ii) Find if A^{-1} exists. Justify your answer. [1]

(iii) (a) Find A^{-1}. [2]

OR

(iii) (b) Find $A^2 + 7$ I. [2]

38. An NGO organises a charity event in which they decide to distribute woollen caps to protect children from winter. The caps to be distributed are in three separate boxes, Box I has 30 red caps, Box II has 20 red and 10 green caps, and Box III has 30 green caps. The probability that a Box i is selected and a cap picked out is $\frac{i}{6}$, where i = 1, 2, 3. Based on the above information, answer the following questions : A person selects a cap.

(i) What is the probability that he selects a red cap ? [2]

(ii) If he selects a green cap, what is the probability that the cap has come from Box II ? [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)	(B)	(B)	(C)	(C)	(B)	(D)	(B)	(C)	(D)	(A)	(B)	(C)	(A)	(C)	(B)	(A)	(D)	(B)	(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). The graph exists only for $|x| \geq 1$, takes values in $[-\pi/2, \pi/2]$ except 0, equals $\pi/2$ at $x = 1$ and $-\pi/2$ at $x = -1$, and tends to 0 as $|x|$ grows: the principal branch of $\text{cosec}^{-1} x$.

Q2. Answer (B). $a_{11} = |1 - 3|/2 = 1$, $a_{12} = |1 - 6|/2 = 5/2$, $a_{21} = |2 - 3|/2 = 1/2$, $a_{22} = |2 - 6|/2 = 2$. $A = [[1, 5/2], [1/2, 2]]$, so $A' = [[1, 1/2], [5/2, 2]]$.

Q3. Answer (B). $\sec^{-1}\sqrt{2} = \pi/4$ and $\text{cosec}^{-1}(-\sqrt{2}) = -\pi/4$, so $\pi/4 + 2(-\pi/4) = -\pi/4$.

Q4. Answer (C). Area $= \frac{1}{2}|2(4 - 2) + 0(2 - 3) + p(3 - 4)| = \frac{1}{2}|4 - p| = 0$, so $p = 4$.

Q5. Answer (C). Chain rule: d/dx e^(e^x) = e^(e^x) × e^x.

Q6. Answer (B). $dV/dt = 4\pi r^2 \, dr/dt$. If $dV/dt = dr/dt$, then $4\pi r^2 = 1$: the surface area is 1 sq. unit.

Q7. Answer (D). $\lim (\sin x/x + \cos x) = 1 + 1 = 2$, so $k = 2$.

Q8. Answer (B). $[x]$ jumps (is discontinuous) at the integers 1 and 2 inside (0, 3), so it is not differentiable there: two points.

Q9. Answer (C). $\int dx/\sqrt{(25 - 16x^2)} = (1/4) \int d(4x)/\sqrt{(5^2 - (4x)^2)} = (1/4) \sin^{-1}(4x/5) + C$.

Q10. Answer (D). $\int_0^1 e^x \, dx/(e^{2x} + 1) = [\tan^{-1} e^x]_0^1 = \tan^{-1} e - \tan^{-1} 1 = \tan^{-1} e - \pi/4$, so $k = -\pi/4$.

Q11. Answer (A). $\int_0^2 x \, dx = 2$ (a triangle with base 2 and height 2).

Q12. Answer (B). Highest derivative d^3y/dx^3: order 3; it appears squared: degree 2. Product 6.

Q13. Answer (C). (A) and (B) are linear in y, (D) is linear in x ($dx/dy - x/y = 3y$). (C) gives $dy/dx = x(1 + y^2)/(y(1 + x^2))$, linear neither in y nor (dx/dy) in x: it is variables-separable but not linear.

Q14. Answer (A). With $x, y \geq 0$ the region is in the first quadrant: above $3x + y = 3$ and below $y = 2x + 5$. Points such as (k, 1) for every large k satisfy all of them, so it is unbounded.

Q15. Answer (C). Z is the same at A(0, 5) and B(3, 4): $5q = 3p + 4q$, so $q = 3p$. (Z is then parallel to AB, $x + 3y = 15$.)

Q16. Answer (B). The cross product is zero when the vectors are parallel: $4/3 = p/(-2) = q/5$, so $p = -8/3$ and $q = 20/3$.

Q17. Answer (A). $\overrightarrow{AB} = 2\hat{i} - \hat{j} - 2\hat{k}$, $\overrightarrow{AC} = \hat{i} - \hat{j} + 2\hat{k}$; $\overrightarrow{AB} \times \overrightarrow{AC} = -4\hat{i} - 6\hat{j} - \hat{k}$ with magnitude $\sqrt{53}$. Area $= \sqrt{53}/2$.

Q18. Answer (D). P(red) = 4/10 = 2/5 each draw (with replacement). P(no red in 3) $= (3/5)^3 = 27/125$, so P(at least one red) = 98/125.

Q19. Answer (B). Matrix multiplication is not commutative in general: A is true. Diagonal matrices of the same order do commute: R is true. But R (a special case where they commute) does not explain A. Answer (B).

Q20. Answer (C). $x^3 + 2$ is strictly increasing on N, so f is one-one; 1, 2, 4, … have no pre-image, so it is not onto: A is true. R says no y has a pre-image, which is false (y = 3 comes from x = 1); only some y lack one. Answer (C).

Q21. (2 marks) Answer: $-5\pi/12$.
$\tan^{-1}(-1/\sqrt{3}) = -\pi/6$; $\cot^{-1}(1/\sqrt{3}) = \pi/3$; $\tan^{-1}(\sin(-\pi/2)) = \tan^{-1}(-1) = -\pi/4$. [1]
$\tan^{-1}(\tan 2\pi/3) = \tan^{-1}(-\sqrt{3}) = -\pi/3$ (principal value). Sum $= -\pi/6 + \pi/3 - \pi/4 - \pi/3 = -5\pi/12$. [1]

Q22. (2 marks) Answer: (a) continuous; (b) not differentiable (LHD 1, RHD 2).
(a) Put $x = \pi/2 - h$: $\cos x/(\pi/2 - x) = \sin h/h \to 1$ as $h \to 0$. [1]
The limit equals $f(\pi/2) = 1$, so f is continuous at $x = \pi/2$. [1]
OR (b) $f(2) = 1$ and both one-sided limits are 1, so f is continuous at 2. LHD = $\lim (x - 1 - 1)/(x - 2) = 1$; RHD = $\lim (2x - 3 - 1)/(x - 2) = 2$. [1½]
LHD ≠ RHD: f is not differentiable at $x = 2$. [½]

Q23. (2 marks) Answer: $x \geq 1/e$.
$f'(x) = x^x(1 + \log x)$. [1]
$x^x > 0$, so $f'(x) \geq 0$ when $\log x \geq -1$, i.e. $x \geq 1/e$: f is increasing on $[1/e, \infty)$. [1]

Q24. (2 marks) Answer: AB = BC = √38.
$AB = 2\hat{i} + 5\hat{j} - 3\hat{k}$, $|AB| = \sqrt{38}$; $BC = -5\hat{i} - 2\hat{j} + 3\hat{k}$, $|BC| = \sqrt{38}$; $CA = 3\hat{i} - 3\hat{j}$, $|CA| = \sqrt{18}$. [1½]
AB = BC (and the points are not collinear), so ABC is isosceles. [½]

Q25. (2 marks) Answer: (a) $(5/3)(-\hat{i} + 2\hat{j} + 2\hat{k})$; (b) $\theta = \pi/3$, $a = \hat{i}/\sqrt{2} + \hat{j}/2 + \hat{k}/2$.
(a) $(4\hat{i} - \hat{j} + 3\hat{k}) \times (-2\hat{i} + \hat{j} - 2\hat{k}) = -\hat{i} + 2\hat{j} + 2\hat{k}$, of magnitude 3. [1]
Flag-post: $5 \times (-\hat{i} + 2\hat{j} + 2\hat{k})/3 = (5/3)(-\hat{i} + 2\hat{j} + 2\hat{k})$ (pointing upwards). [1]
OR (b) $\cos^2(\pi/4) + \cos^2(\pi/3) + \cos^2\theta = 1$: $1/2 + 1/4 + \cos^2\theta = 1$, $\cos\theta = 1/2$ (acute), $\theta = \pi/3$. [1]
$a = (1/\sqrt{2})\,\hat{i} + (1/2)\,\hat{j} + (1/2)\,\hat{k}$. [1]

Q26. (3 marks) Answer: (a) one-one and onto; (b) yes, an equivalence relation.
(a) One-one: $(a - 2)/(a - 3) = (b - 2)/(b - 3)$ gives $ab - 3a - 2b + 6 = ab - 2a - 3b + 6$, so $a = b$. [1]
Onto: for $y \in B$ $(y \neq 1)$, $x = (3y - 2)/(y - 1)$. [1]
$x \neq 3$ ($3y - 2 = 3y - 3$ is impossible) and $f(x) = y$, so every y has a pre-image: f is one-one and onto. [1]
OR (b) Reflexive: $x - x = 0$ is divisible by n. [1] Symmetric: if $n \mid (x - y)$, then $n \mid (y - x) = -(x - y)$. [1] Transitive: $x - y = kn$, $y - z = mn$ give $x - z = (k + m)n$. So R is an equivalence relation. [1]

Q27. (3 marks) Answer: O (the zero matrix).
$A^2 = [[11, 14, 0], [7, 18, 0], [0, 0, 25]]$. [1]
$7A = [[21, 14, 0], [7, 28, 0], [0, 0, 35]]$, $10I = [[10, 0, 0], [0, 10, 0], [0, 0, 10]]$. [1]
$A^2 - 7A + 10I = O$, the 3×3 zero matrix. [1]

Q28. (3 marks) Answer: (a) $y(x - 1)/(x(y + 1))$; (b) $-1/2$.
(a) Taking logs: $\log x + \log y = x - y$. [1]
$1/x + y'/y = 1 - y'$, so $y'(1/y + 1) = 1 - 1/x$. [1]
$dy/dx = y(x - 1)/(x(y + 1))$. [1]
OR (b) Put $x^2 = \cos\theta$ ($\theta = \cos^{-1} x^2$): $\sqrt{(1 + \cos\theta)} = \sqrt{2}\cos(\theta/2)$, $\sqrt{(1 - \cos\theta)} = \sqrt{2}\sin(\theta/2)$. [1]
The expression = $\tan^{-1}((\cos\theta/2 - \sin\theta/2)/(\cos\theta/2 + \sin\theta/2)) = \tan^{-1}\tan(\pi/4 - \theta/2) = \pi/4 - ½\cos^{-1} x^2$. [1]
Its derivative with respect to $\cos^{-1} x^2$ is $-1/2$. [1]

Q29. (3 marks) Answer: Max Z = 48,000 at (150, 150).
$x + y = 300$ and $3x + y = 600$ meet at (150, 150); $x + y = 300$ and $y = x + 100$ meet at (100, 200). Corners of the feasible region: (0, 0), (200, 0), (150, 150), (100, 200), (0, 100). [1½]
Z: 0, 40,000, 48,000, 44,000, 12,000. [1]
Maximum Z = 48,000 at $x = 150$, $y = 150$. [½]

Q30. (3 marks) Answer: (a) (2, 1, 3) or (4/17, 37/17, 31/17); (b) $6/\sqrt{5}$.
(a) A general point: $(3\lambda + 2, 1 - 2\lambda, 2\lambda + 3)$. [1]
Distance² from (1, 2, 3): $(3\lambda + 1)^2 + (2\lambda + 1)^2 + (2\lambda)^2 = 17\lambda^2 + 10\lambda + 2 = 2$, so $\lambda = 0$ or $\lambda = -10/17$. [1]
Points: (2, 1, 3) or (4/17, 37/17, 31/17). [1]
OR (b) $\vec{r} = (4\hat{i} - \hat{j}) + \lambda(\hat{i} + 2\hat{j} - 3\hat{k})$ and $\vec{r} = (\hat{i} - \hat{j} + 2\hat{k}) + \mu(2\hat{i} + 4\hat{j} - 5\hat{k})$. [1]
$\vec{b}_1 \times \vec{b}_2 = 2\hat{i} - \hat{j}$, $|\vec{b}_1 \times \vec{b}_2| = \sqrt{5}$; $\vec{a}_2 - \vec{a}_1 = -3\hat{i} + 2\hat{k}$. [1]
SD $= |(\vec{a}_2 - \vec{a}_1) \cdot (\vec{b}_1 \times \vec{b}_2)|/\sqrt{5} = 6/\sqrt{5} = 6\sqrt{5}/5$ units. [1]

Q31. (3 marks) Answer: 22/45.
From team A: P(one girl, one boy) $= (4 \times 6)/{}^{10}C_2 = 24/45$. From team B: $(7 \times 3)/45 = 21/45$. [1½]
Total probability: $(1/3)(24/45) + (2/3)(21/45) = 8/45 + 14/45 = 22/45$. [1½]

Q32. (5 marks) Answer: (a) $(1/5)\log|x - 1| - (1/10)\log(x^2 + 4) + (2/5)\tan^{-1}(x/2) + C$; (b) $(4 - \pi)/(4\sqrt{2})$.
(a) $x/((x - 1)(x^2 + 4)) = A/(x - 1) + (Bx + C)/(x^2 + 4)$, so $x = A(x^2 + 4) + (Bx + C)(x - 1)$. [1]
$x = 1$: $A = 1/5$; x^2 terms: $A + B = 0$, $B = -1/5$; constants: $4A - C = 0$, $C = 4/5$. [2]
$\int = (1/5)\log|x - 1| - (1/10)\log(x^2 + 4) + (2/5)\tan^{-1}(x/2) + C$. [2]
OR (b) Put $x = \tan\theta$, $dx = \sec^2\theta\, d\theta$; limits 0 to $\pi/4$: the integral becomes $\int_0^{\pi/4} \theta \sin\theta\, d\theta$. [2]
By parts: $[-\theta\cos\theta + \sin\theta]_0^{\pi/4}$ [1½]
$= -(\pi/4)(1/\sqrt{2}) + 1/\sqrt{2} = (4 - \pi)/(4\sqrt{2})$. [1½]

Q33. (5 marks) Answer: 4 sq units.
$y = 6 - x$ for $4 \le x \le 6$ and $y = x - 6$ for $6 \le x \le 8$ (two triangles meeting at (6, 0)). [1]
Area $= \int_4^6 (6 - x)\, dx + \int_6^8 (x - 6)\, dx$ [1] $= [6x - x^2/2]_4^6 + [x^2/2 - 6x]_6^8$ [1] $= 2 + 2$ [1] $= 4$ square units. [1]

Q34. (5 marks) Answer: (a) $x = y^2(e^{-1} - e^{-y})$; (b) $x^2 - y^2 = C(x^2 + y^2)^2$.
(a) $dx/dy - (2/y)x = y^2e^{-y}$: linear in x. [1]
IF $= e^{-2\log y} = 1/y^2$. [1]
$x/y^2 = \int e^{-y}\, dy = -e^{-y} + C$. [1½]
$x = 0$ when $y = 1$: $C = 1/e$. Solution: $x = y^2(e^{-1} - e^{-y})$. [1½]
OR (b) $dy/dx = (x^3 - 3xy^2)/(y^3 - 3x^2y)$ is homogeneous; put $y = vx$: $(1 - 3v^2)\, dx = (v^3 - 3v)(v\, dx + x\, dv)$, so $(1 - v^4)\, dx = x(v^3 - 3v)\, dv$. [1]
$dx/x = (v^3 - 3v)/((1 - v^2)(1 + v^2))\, dv = [-v/(1 - v^2) - 2v/(1 + v^2)]\, dv$ (partial fractions). [1½]
$\log|x| + \log C_1 = \tfrac{1}{2}\log|1 - v^2| - \log(1 + v^2)$, i.e. $x = C_2\sqrt{|1 - v^2|}/(1 + v^2)$. [1]
With $v = y/x$ and squaring: $x^2 = C(x^2 - y^2)x^2/(x^2 + y^2)^2$, so the general solution is $x^2 - y^2 = C(x^2 + y^2)^2$ (renaming the constant). [1½]

Q35. (5 marks) Answer: $\vec{r} = (-\hat{i} - \hat{j} - \hat{k}) + t(3\hat{i} + 2\hat{j} - 8\hat{k})$; $(x + 1)/3 = (y + 1)/2 = (z + 1)/(-8)$.
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 $\lambda = -1$, $\mu = -1$; y: $2 - 3 = -1 = 1 - 2$ ✓. [1½]
Point of intersection $(-1, -1, -1)$. [½]
Vector form: $\vec{r} = (-\hat{i} - \hat{j} - \hat{k}) + t(3\hat{i} + 2\hat{j} - 8\hat{k})$. [1]
Cartesian form: $(x + 1)/3 = (y + 1)/2 = (z + 1)/(-8)$. [1]

Q36. (4 marks) Answer: (i) $r = h\tan\alpha = h/3$; (ii) $1/(40\pi)$ cm/s; (iii)(a) 1/30 cm²/s; (iii)(b) $\sqrt{10}/30$ cm²/s.
(i) $r = h\tan\alpha$, and $\tan\alpha = 5/15 = 1/3$, so $r = h/3$. [1]
(ii) $V = (1/3)\pi r^2h = \pi h^3/27$; $dV/dt = (\pi h^2/9)\, dh/dt$. At $h = 6$: $0.1 = 4\pi\, dh/dt$, $dh/dt = 1/(40\pi)$ cm/s. [1]
(iii)(a) Upper surface $A = \pi r^2 = \pi h^2/9$; $dA/dt = (2\pi h/9)\, dh/dt$ [1] $= (12\pi/9) \times 1/(40\pi) = 1/30$ cm²/s. [1]
OR (iii)(b) Wetted (curved) surface $S = \pi rl$ with $l = \sqrt{(r^2 + h^2)} = h\sqrt{10}/3$: $S = \sqrt{10}\,\pi h^2/9$. [1] $dS/dt = (2\sqrt{10}\,\pi h/9)\, dh/dt = (12\sqrt{10}\,\pi/9)/(40\pi) = \sqrt{10}/30$ cm²/s. [1]

Q37. (4 marks) Answer: (ii) $|A| = 8$, A^{-1} exists; (iii)(a) $A^{-1} = (1/8)[[-20, 8, 4], [17, -4, -3], [-11, 4, 1]]$; (iii)(b) $[[7, 5, 7], [11, 17, -6], [-20, 7, 52]]$.

(i) $l + b - h = 3$, $2l + 3b + h = 10$, $3l - b - 7h = 1$. $A = [[1, 1, -1], [2, 3, 1], [3, -1, -7]]$, $X = [l, b, h]'$, $B = [3, 10, 1]'$. [1]

(ii) $|A| = 1(-21 + 1) - 1(-14 - 3) - 1(-2 - 9) = -20 + 17 + 11 = 8 \neq 0$, so A^{-1} exists. [1]

(iii)(a) adj $A = [[-20, 8, 4], [17, -4, -3], [-11, 4, 1]]$, so $A^{-1} = (1/8)[[-20, 8, 4], [17, -4, -3], [-11, 4, 1]]$. [2] (Then $X = A^{-1}B = [3, 1, 1]'$: $l = 3$ cm, $b = 1$ cm, $h = 1$ cm.)

OR (iii)(b) $A^2 = [[0, 5, 7], [11, 10, -6], [-20, 7, 45]]$. [1] $A^2 + 7I = [[7, 5, 7], [11, 17, -6], [-20, 7, 52]]$. [1]

Q38. (4 marks) Answer: (i) 7/18; (ii) 2/11.

(i) $P(E_1) = 1/6$, $P(E_2) = 2/6$, $P(E_3) = 3/6$. $P(\text{red}) = (1/6)(1) + (2/6)(2/3) + (3/6)(0)$ [1] $= 1/6 + 2/9 = 7/18$. [1]

(ii) $P(\text{green}) = (2/6)(1/3) + (3/6)(1) = 1/9 + 1/2 = 11/18$. [1] $P(\text{Box II} \mid \text{green}) = (1/9)/(11/18) = 2/11$. [1]

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