Marking Scheme **Strictly Confidential** **(For Internal and Restricted use only)** **Senior Secondary Certificate Examination, 2026** **MATHEMATICS (041) (PAPER CODE 65/5/1)**

General Instructions: -

1.	You are aware that evaluation is the most important process in the actual and correct assessment of the candidates. A small mistake in evaluation may lead to serious problems which may affect the future of the candidates, education system and teaching profession. To avoid mistakes, it is requested that before starting evaluation, you must read and understand the spot evaluation guidelines carefully.
2.	**"Evaluation policy is a confidential policy as it is related to the confidentiality of the examinations conducted, Evaluation done and several other aspects. Its leakage to the public in any manner could lead to derailment of the examination system and affect the life and future of millions of candidates. Sharing this policy/document to anyone, publishing in any magazine and printing in Newspaper/Website, etc. may invite action under various rules of the Board and BNS."**
3.	Evaluation is to be done as per instructions provided in the Marking Scheme. It should not be done according to one's own interpretation or any other consideration. The Marking Scheme should be strictly adhered to and religiously followed. **However, while evaluating, Answers which are based on latest information or knowledge and/or are innovative, they may be assessed for their correctness otherwise and due marks be awarded to them. In class-XII, while evaluating the competency-based questions, please try to understand the given Answer and even if reply is not from a marking scheme but correct competency is enumerated by the candidate, due marks should be awarded.**
4.	The Marking Scheme carries only suggested value points for the Answers. These are Guidelines only and do not constitute the complete Answer. The students can have their own expression and if the expression is correct, the due marks should be awarded accordingly.
5.	The Head-Examiner must go through the first five Answer books evaluated by each evaluator on the first day, to ensure that evaluation has been carried out as per the instructions given in the Marking Scheme. If there is any variation, the same should be zero after deliberation and discussion. The remaining Answer books meant for evaluation shall be given only after ensuring that there is no significant variation in the marking of individual evaluators.
6.	Evaluators will mark (√) wherever Answer is correct. For wrong Answer CROSS 'X' be marked. Evaluators will not put right (✓) while evaluating which gives the impression that the Answer is correct, and no marks are awarded. **This is the most common mistake which evaluators are committing.**
7.	If a question has parts, please award marks on the right-hand side for each part. Marks awarded for different parts of the question should then be totaled up and written in the left- hand margin and encircled. This may be followed strictly.
8.	If a question does not have any parts, marks must be awarded in the left-hand margin and encircled. This may also be followed strictly.
9.	If a student has attempted an extra question, Answer to the question deserving more marks should be retained and the other Answer scored out with a note **"Extra Question"**.
10.	No marks to be deducted for the cumulative effect of an error. It should be penalized only once.
11.	A full scale of marks_ (example 0 to 80/70/60/50/40/30 marks as given in Question Paper) has to be used. Please do not hesitate to award full marks if the Answer deserves it.

12.	Every examiner must necessarily do evaluation work for full working hours, i.e., 8 hours every day and evaluate 20 Answer books per day in main subjects and 25 Answer books per day in other subjects (Details are given in Spot Guidelines). This is in view of the reduced syllabus and number of questions in question paper.
13.	Ensure that you do not make the following common types of errors committed by the Examiner in the past: - ● Leaving Answer or part thereof unassessed in an Answer book. ● Giving more marks for an Answer than assigned to it. ● Wrong totaling of marks awarded on an Answer. ● Wrong transfer of marks from the inside pages of the Answer book to the title page. ● Wrong question wise totaling on the title page. ● Wrong totaling of marks of the two columns on the title page. ● Wrong grand total. ● Marks in words and figures not tallying/not same. ● Wrong transfer of marks from the Answer book to online award list. ● Answers marked as correct, but marks not awarded. (Ensure that the right tick mark is correctly and clearly indicated. It should merely be a line. Same is with the X for incorrect Answer.) ● Half or a part of the Answer marked correct and the rest as wrong, but no marks awarded.
14.	While evaluating the Answer books if the Answer is found to be totally incorrect, it should be marked as cross (X) and awarded zero (0) Marks.
15.	Any unassessed portion, non-carrying over marks to the title page, or total error detected by the candidate shall damage the prestige of all the personnel engaged in the evaluation work as also of the Board. Hence, to uphold the prestige of all concerned, it is again reiterated that the instructions be followed meticulously and judiciously.
16.	The Examiners should acquaint themselves with the guidelines given in the "**Guidelines for Spot Evaluation**" before starting the actual evaluation.
17.	Every Examiner shall also ensure that all the Answers are evaluated, marks carried over to the title page, correctly totaled and written in figures and words.
18.	The candidates are entitled to obtain a photocopy of the Answer Book on request on payment of the prescribed processing fee. All Examiners/Additional Head Examiners/Head Examiners are once again reminded that they must ensure that evaluation is carried out strictly as per value points for each Answer as given in the Marking Scheme.

MARKING SCHEME
MATHEMATICS (Subject Code–041)
(PAPER CODE: 65/5/1)

Q. No.	EXPECTED OUTCOMES/VALUE POINTS	Steps	Marks
	SECTION A Q. Number 1 to 20 are multiple choice questions of 1 mark each.		
1.	If matrix A = $\begin{bmatrix} -p & q \\ r & p \end{bmatrix}$ is such that $A^2 = I$, then : (A) $1 + p^2 + qr = 0$ (B) $1 - p^2 - qr = 0$ (C) $1 - p^2 + qr = 0$ (D) $1 + p^2 - qr = 0$		
Sol.	(B) $1 - p^2 - qr = 0$		1
2.	If A is a square matrix such that $A^2 = A$, then $(A - I)^3 - A$ is equal to : (A) I (B) $-I$ (C) A (D) A^2		
Sol.	(B) $-I$		1
3.	For the inverse trigonometric functions, which of the following Principal Value Branch is ***not*** correctly defined ? (A) $\tan^{-1} : R \to \left(-\frac{\pi}{2}, \frac{\pi}{2}\right)$ (B) $\sec^{-1} : R - (-1, 1) \to [0, \pi] - \left\{\frac{\pi}{2}\right\}$ (C) $\cot^{-1} : R \to (0, \pi)$ (D) $\operatorname{cosec}^{-1} : R - (-1, 1) \to \left[-\frac{\pi}{2}, \frac{\pi}{2}\right]$		
Sol.	(D) $\operatorname{cosec}^{-1} : R - (-1, 1) \to \left[-\frac{\pi}{2}, \frac{\pi}{2}\right]$		1
4.	Let A = $\begin{bmatrix} 0 & -3 & 4 \\ 1 & 0 & 2 \end{bmatrix}$ and B = $\begin{bmatrix} -3 & 0 & 1 \\ 2 & 4 & 0 \end{bmatrix}$. If A + B + C = O, then matrix C is : (A) $\begin{bmatrix} -3 & -3 & 5 \\ 3 & 4 & 2 \end{bmatrix}$ (B) $\begin{bmatrix} 3 & 3 & 5 \\ -3 & -4 & -2 \end{bmatrix}$ (C) $\begin{bmatrix} 3 & 3 & -5 \\ -3 & -4 & -2 \end{bmatrix}$ (D) $\begin{bmatrix} -3 & -3 & -5 \\ 3 & 4 & 2 \end{bmatrix}$		

Sol.	(C) $\begin{bmatrix} 3 & 3 & -5 \\ -3 & -4 & -2 \end{bmatrix}$		1
5.	If A is a non-singular matrix, then which of the following is ***not*** true ? (A) adj A is singular (B) $(\text{adj } A)^{-1} = (\text{adj } A^{-1})$ (C) $\lvert A \rvert \neq 0$ (D) A^{-1} exists		
Sol.	(A) adj A is singular		1
6.	If $f(x) = \begin{cases} \dfrac{x^2 - 4x - 5}{x+1}, & x \neq -1 \\ k, & x = -1 \end{cases}$ is continuous at $x = -1$, then the value of k is : (A) Any real value (B) 6 (C) -1 (D) -6		
Sol.	(D) -6		1
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 : (A) 3, 1 (B) −1, 3 (C) −1, 2 (D) 0, 2		
Sol.	(B) −1, 3		1
8.	Derivative of $\cos^{-1}\left(\dfrac{\sin x + \cos x}{\sqrt{2}}\right)$, $-\dfrac{\pi}{4} < x < \dfrac{\pi}{4}$ with respect to x is : (A) -1 (B) 1 (C) $\dfrac{\pi}{4}$ (D) $-\dfrac{\pi}{4}$		
Sol.	(A) -1		1
9.	Absolute minimum value of $f(x) = (x-2)^2 + 5$ in the interval $[-3, 2]$ is : (A) -3 (B) 2 (C) 5 (D) 30		
Sol.	(C) 5		1

10.	$\int \frac{1}{\sqrt{1+\cos 2x}} dx$ is equal to : (A) $\log \cos x + C$ (B) $\frac{1}{\sqrt{2}} \log \lvert \sec x + \tan x \rvert + C$ (C) $\frac{1}{\sqrt{2}} \log \lvert \sec x - \tan x \rvert + C$ (D) $\log \sin 2x + C$		
Sol.	(B) $\frac{1}{\sqrt{2}} \log \lvert \sec x + \tan x \rvert + C$		1
11.	The value of $\int_{-5}^{-1} \frac{1}{x} dx$ is equal to : (A) $-\log 5$ (B) x^6 (C) $\log(-5)$ (D) x^{-6}		
Sol.	(A) $-\log 5$		1
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 : (A) 1 sq. unit (B) 3 sq. units (C) 2 sq. units (D) 4 sq. units		
Sol.	(B) 3 sq. units		1
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 : (A) Order = 3, Degree = 3 (B) Order = 2, Degree = 2 (C) Order = 3, Degree = 1 (D) Order = 2, Degree = 1		
Sol.	(A) Order = 3, Degree = 3		1
14.	The general solution for the differential equation $\frac{dy}{dx} = e^{3x-y}$ is : (A) $3e^y = e^{3x} + C$ (B) $\log(3x - y) = C$ (C) $e^{3x-y} = C$ (D) $-e^y + 3e^{3x} = C$		
Sol.	(A) $3e^y = e^{3x} + C$		1

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 : (A) 200 (B) 300 (C) 240 (D) 120		
Sol.	(B) 300		1
16.	If position vector $\vec{p}$ of a point (24, n) is such that $\lvert \vec{p} \rvert = 25$, then the value of n is : (A) ± 49 (B) ± 5 (C) ± 1 (D) ± 7		
Sol.	(D) ± 7		1
17.	If vectors $\vec{a} = 3\hat{i} + 2\hat{j} + \lambda\hat{k}$ and $\vec{b} = 2\hat{i} - 4\hat{j} + 5\hat{k}$, represent the two strips of the Red Cross sign placed outside a doctor's clinic, then the value of λ is : (A) 1 (B) $\frac{5}{2}$ (C) $\frac{2}{5}$ (D) 0		
Sol.	(C) $\frac{2}{5}$		1
18.	If $3P(A) = P(B) = \frac{3}{5}$ and $P(A\mid B) = \frac{2}{3}$, then $P(A \cup B)$ is : (A) $\frac{3}{5}$ (B) $\frac{1}{5}$ (C) $\frac{2}{15}$ (D) $\frac{2}{5}$		
Sol.	(D) $\frac{2}{5}$		1

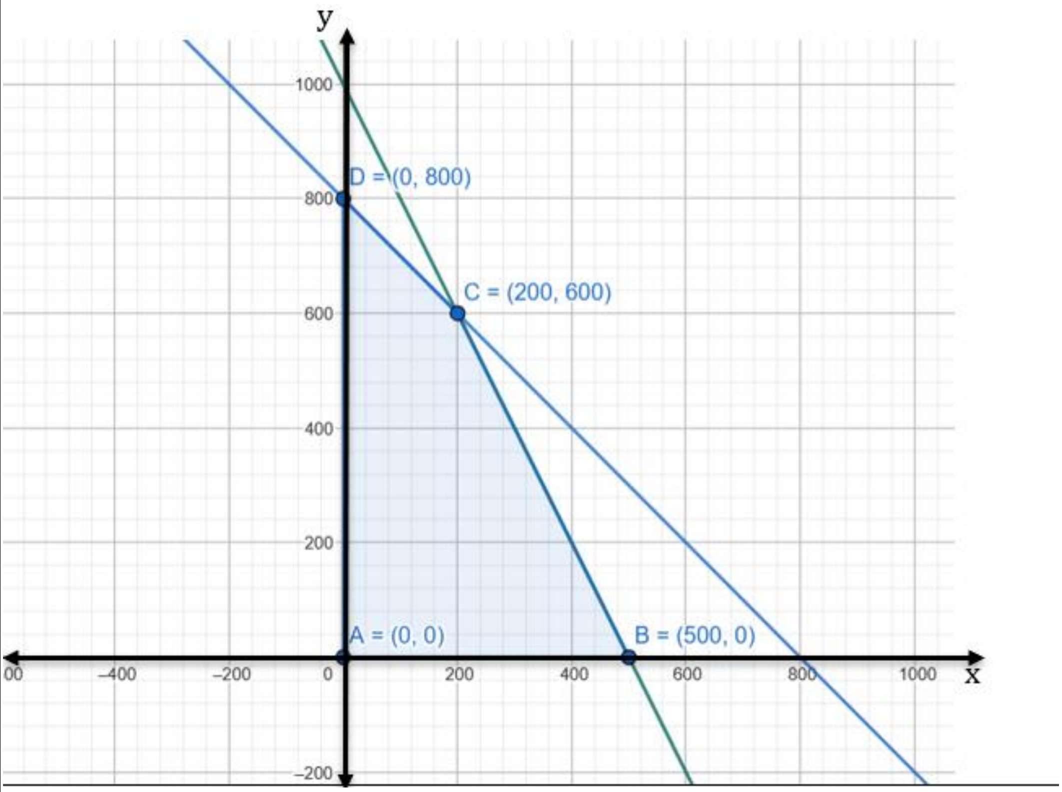
	*Questions number **19** and **20** are Assertion and Reason based questions. Two statements are given, one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (A), (B), (C) and (D) as given below.* (A) Both Assertion (A) and Reason (R) are true and Reason (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, but Reason (R) is false. (D) Assertion (A) is false, but Reason (R) is true.		
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. *Reason (R) :* A relation that is reflexive, symmetric and transitive is an equivalence relation.		
Sol.	(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).		1
20.	*Assertion (A) :* Consider a Linear Programming Problem with minimise Z = x + 2y subject to constraints 2x + y ≥ 3, x + 2y ≥ 6, x, y ≥ 0 which gives minimum Z at infinitely many points. The corner points of feasible region are (0, 3) and (6, 0). *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.		
Sol.	(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).		1
	SECTION B Q. Numbers 21 to 25 are very short answer questions of 2 marks each.		
21.	Evaluate $\sin\left[\tan^{-1}\tan\left(\frac{3\pi}{4}\right)\right]$.		
Sol.	Given expression = $\sin[\tan^{-1}(-1)]$ or $\sin[\tan^{-1}\tan(\pi - \frac{\pi}{4})]$ $= \sin\left(-\frac{\pi}{4}\right)$ $= -\frac{1}{\sqrt{2}}$	I II III	1 ½ ½

22.	(a) Differentiate x^x with respect to $x \log x$. **OR** (b) If $y = P \cos ux + Q \sin ux$, show that $\frac{d^2y}{dx^2} + u^2y = 0$.		
Sol.	(a) Let $u = x^x$ and $v = x \log x$	I	½
	$\frac{du}{dx} = x^x(1 + \log x)$	II	½
	$\frac{dv}{dx} = 1 + \log x$	III	½
	$\therefore \frac{du}{dv} = x^x$	IV	½
	OR		
	(b) $\frac{dy}{dx} = -P u \sin ux + Q u \cos ux$	I	½
	$\frac{d^2y}{dx^2} = -P u^2 \cos ux - Q u^2 \sin ux$	II	½
	$\frac{d^2y}{dx^2} = -u^2(P \cos ux + Q \sin ux)$	III	½
	$\therefore \frac{d^2y}{dx^2} + u^2y = 0$	IV	½
23.	Determine the values of x for which $f(x) = \frac{x-3}{x+1}$, $x \neq -1$ is an increasing function.		
Sol.	$f'(x) = \frac{(x+1).1-(x-3).1}{(x+1)^2}$	I	1
	$= \frac{4}{(x+1)^2} > 0$	II	½
	$\therefore$ f(x) is an increasing function for all $x \in R - \{-1\}$	III	½

24.	(a) Three honey bees were found flying along the vectors $\vec{a} = 2\hat{i} - 3\hat{j} + \hat{k}$, $\vec{b} = 4\hat{j} - 2\hat{k}$ and $\vec{c} = 3\hat{i} + 2\hat{k}$ respectively. Find the value of λ such that the path for $\vec{a} + \lambda\vec{b}$ is perpendicular to $\vec{c}$. **OR** (b) If A, B and C be three non-collinear points such that $\overrightarrow{AB} = \hat{i} + 2\hat{j} - \hat{k}$ and $\overrightarrow{AC} = 2\hat{i} - 3\hat{j}$, then find the area of Δ ABC.		

Sol.	As $\vec{a} + \lambda\vec{b}$ is perpendicular to $\vec{c}$ $\therefore (\vec{a} + \lambda\vec{b}) . \vec{c} = 0$	I	½
	i.e. $\vec{a}.\vec{c} + \lambda\vec{b}.\vec{c} = 0$		
	which gives $8 + \lambda(-4) = 0$	II	1
	$\lambda = 2$	III	½
	OR		
	Area of $\Delta ABC = \frac{1}{2}\lvert \overrightarrow{AB} \times \overrightarrow{AC} \rvert$		
	$= \frac{1}{2}\lvert -3\hat{i} - 2\hat{j} - 7\hat{k} \rvert$	I	1
	$= \frac{\sqrt{62}}{2}$	II	1
25.	Find the angle between the following pair of lines : $\frac{x-2}{3} = \frac{y+5}{2} = \frac{1-z}{-6}$ and $\frac{x-7}{1} = \frac{y}{2} = \frac{6-z}{-2}$		
Sol.	Drs of given lines are <3, 2, 6> and <1, 2, 2 >	I	½
	Let θ be angle between given lines		
	$\therefore \cos\theta = \frac{3\times1+2\times2+6\times2}{7\times3}$	II	1
	Thus, $\theta = \cos^{-1}\left(\frac{19}{21}\right)$	III	½
	SECTION C Q. Numbers 26 to 31 are short answer 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.		
Sol.	Let r be the radius, V= $\frac{4}{3}\pi r^3$ be the volume $\frac{\mathrm{dV}}{\mathrm{dt}} = -k(4\pi r^2)$ where $k > 0$ $4\pi r^2 \frac{\mathrm{dr}}{\mathrm{dt}} = -4k\pi r^2$ $\therefore \frac{\mathrm{dr}}{\mathrm{dt}} = -k$ which is a constant Thus, radius is decreasing at a constant rate	I II III	1 1 1
27.	(a) Find : $$\int \frac{x - \sin x}{1 - \cos x}\,dx$$ **OR** (b) Evaluate : $$\int_0^2 \frac{1}{\sqrt{x^2 + 2x + 3}}\,dx$$		
Sol.	(a) Let $I = \int \frac{x - \sin x}{1 - \cos x}\,dx$ $= \int \frac{x}{1-\cos x}\,dx - \int \frac{\sin x}{1-\cos x}\,dx$ $= \int \frac{x}{2\sin^2\frac{x}{2}}\,dx - \int \frac{2\sin\frac{x}{2}\cos\frac{x}{2}}{2\sin^2\frac{x}{2}}\,dx$ $= -\frac{x}{2}.2\cot\frac{x}{2} - \frac{1}{2}\int -2\cot\frac{x}{2}\,dx - \int \cot\frac{x}{2}\,dx$ $= -x\cot\frac{x}{2} + C$ **OR** (b) $I = \int_0^2 \frac{1}{\sqrt{x^2+2x+3}}\,dx$ $= \int_0^2 \frac{1}{\sqrt{(x+1)^2+2}}\,dx$ $= \left[\log\left(x + 1 + \sqrt{x^2 + 2x + 3}\,\right)\right]_0^2$ $= \log\left(3 + \sqrt{11}\right) - \log\left(1 + \sqrt{3}\right)$ or $\log\left(\frac{3+\sqrt{11}}{1+\sqrt{3}}\right)$	I II III IV I II III	½ 1 1 ½ 1 1 1
28.	Solve the differential equation $(x + 2y^3)\,dy = y\,dx$.		
Sol.	Given differential equation can be written as		

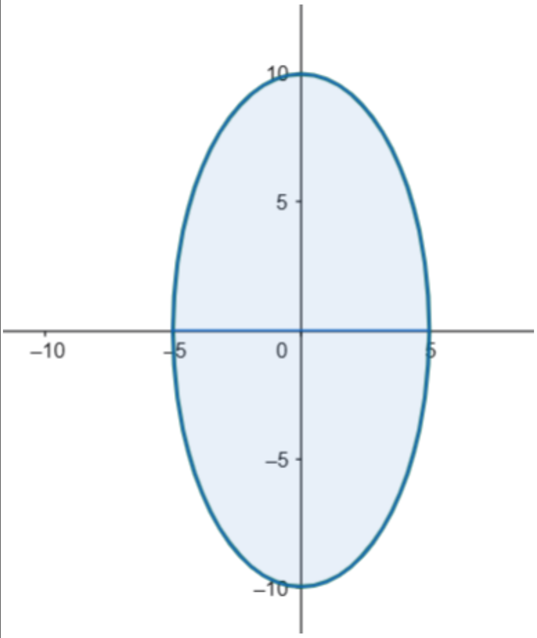
<table>
<tr><td></td><td>$\frac{dx}{dy} - \frac{x}{y} = 2y^2$
Integrating factor = $e^{\int -\frac{1}{y} dy} = e^{-\log y} = \frac{1}{y}$
Solution is $x.\frac{1}{y} = \int 2y\,dy + C$
i.e., $x\,.\frac{1}{y} = y^2 + C$ or $x = y^3 + Cy$</td><td>I
II
III
IV</td><td>½
1
1
½</td></tr>
<tr><td>29.</td><td>Solve the following Linear Programming Problem graphically :
Maximize $Z = \frac{2x}{5} + \frac{3y}{10}$
subject to constraints
$2x + y \le 1000$
$x + y \le 800$
$x, y \ge 0.$</td><td></td><td></td></tr>
<tr><td>Sol</td><td>

Corner Points | Value of Z
(0, 0) | 0
(500, 0) | 200
(200, 600) | 260
(0, 800) | 240
$Z_{max} = 260$ at $x = 200, y = 600$</td><td>I
II
III</td><td>Correct Lines and Shading 1½
1
½</td></tr>
</table>

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'. **OR** (b) If $\vec{a}$, $\vec{b}$ and $\vec{c}$ are unit vectors, then prove that $|\vec{a} - \vec{b}|^2 + |\vec{b} - \vec{c}|^2 + |\vec{c} - \vec{a}|^2 \leq 9.$		
Sol.	(a) $\overrightarrow{AB} = -50\hat{\imath} + 10\hat{\jmath}$ and $\overrightarrow{BC} = (a-5)\hat{\imath} - 60\hat{\jmath}$ As $\overrightarrow{AB}$ and $\overrightarrow{BC}$ are collinear vectors $\therefore \frac{-50}{a-5} = \frac{10}{-60}$ a = 305 **OR** (b) $\lvert\vec{a}\rvert = \lvert\vec{b}\rvert = \lvert\vec{c}\rvert = 1$ Now, consider $\lvert\vec{a} - \vec{b}\rvert^2 + \lvert\vec{b} - \vec{c}\rvert^2 + \lvert\vec{c} - \vec{a}\rvert^2$ $= 2\lvert\vec{a}\rvert^2 + 2\lvert\vec{b}\rvert^2 + 2\lvert\vec{c}\rvert^2 - 2\vec{a}.\vec{b} - 2\vec{b}.\vec{c} - 2\vec{c}.\vec{a}$ $= 3\lvert\vec{a}\rvert^2 + 3\lvert\vec{b}\rvert^2 + 3\lvert\vec{c}\rvert^2 - (\lvert\vec{a}\rvert^2 + \lvert\vec{b}\rvert^2 + \lvert\vec{c}\rvert^2 + 2\vec{a}.\vec{b} + 2\vec{b}.\vec{c} + 2\vec{c}.\vec{a})$ $= 9 - \lvert\vec{a} + \vec{b} + \vec{c}\rvert^2 \leq 9$ $\lvert\vec{a} - \vec{b}\rvert^2 + \lvert\vec{b} - \vec{c}\rvert^2 + \lvert\vec{c} - \vec{a}\rvert^2 \leq 9$	I II III I II III IV	1 1 1 ½ 1½ ½ ½
31.	(a) A die is rolled. Consider events : A = {1, 2, 5}, B = {3, 5}, C = {2, 3, 4, 5} and hence find : (i) P(A | C) and P(C | A) (ii) $P(A \cap B \mid C)$ and $P(A \cup B \mid C)$ **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.		
Sol.	(a) (i) $P(A\|C) = \frac{n(A\cap C)}{n(C)} = \frac{2}{4}$ or $\frac{1}{2}$	I	1

	and $P(C\|A) = \frac{n(C\cap A)}{n(A)} = \frac{2}{3}$ (ii) $P(A \cap B\|C) = \frac{n(A\cap B\cap C)}{n(C)} = \frac{1}{4}$ and $P(A \cup B\|C) = \frac{n[(A\cup B)\cap C]}{n(C)} = \frac{3}{4}$	II III IV	½ 1 ½
	OR (b) $A = \{(4, 6), (6, 4), (5, 5)\}$ or $n(A) = 3$ $n(B) = 30$ $n(A \cap B) = 2$ $P(A \cap B) = \frac{2}{36}$ $P(A) = \frac{3}{36} = \frac{1}{12}$ $P(B) = \frac{30}{36} = \frac{5}{6}$ $P(A).P(B) = \frac{5}{72} \neq P(A \cap B)$ Hence A and B are not independent	I II III IV V VI	½ ½ ½ ½ ½ ½
	SECTION D Q. Numbers 32 to 35 are long answer 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.		
Sol.	Let cost of one apple, one orange, one banana be ₹ x, ₹ y and ₹ z respectively According to the question, $\left.\begin{array}{l} 4x + 3y + 2z = 60 \\ 2x + 4y + 6z = 90 \\ 6x + 2y + 3z = 70 \end{array}\right\}$	I	1
	Let $A = \begin{bmatrix} 4 & 3 & 2 \\ 2 & 4 & 6 \\ 6 & 2 & 3 \end{bmatrix}$, $X = \begin{bmatrix} x \\ y \\ z \end{bmatrix}$, $B = \begin{bmatrix} 60 \\ 90 \\ 70 \end{bmatrix}$ $\|A\| = 50 \neq 0 \Rightarrow A^{-1}$ exists System becomes AX = B. So, $X = A^{-1}B$	II	1
	$adjA = \begin{bmatrix} 0 & -5 & 10 \\ 30 & 0 & -20 \\ -20 & 10 & 10 \end{bmatrix}$	III	1½
	$A^{-1} = \frac{1}{50}\begin{bmatrix} 0 & -5 & 10 \\ 30 & 0 & -20 \\ -20 & 10 & 10 \end{bmatrix}$	IV	½
	$X = \frac{1}{50}\begin{bmatrix} 0 & -5 & 10 \\ 30 & 0 & -20 \\ -20 & 10 & 10 \end{bmatrix}\begin{bmatrix} 60 \\ 90 \\ 70 \end{bmatrix}$ $X = \begin{bmatrix} 5 \\ 8 \\ 8 \end{bmatrix}$	V	1

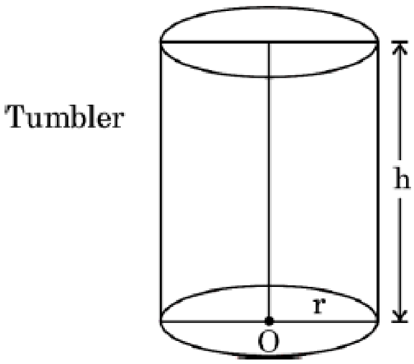
	∴ cost of one apple, one orange, one banana is ₹ 5, ₹ 8 and ₹ 8 respectively		
33.	(a) If $y\sqrt{x^2+1} = \log\left(\sqrt{x^2+1} - x\right)$, show that $(x^2+1)\dfrac{dy}{dx} + xy + 1 = 0.$ **OR** (b) Find the differential of $x^{\cot x} + \dfrac{2x^2-3}{2x^2-x+2}$ with respect to x.		
Sol.	(a) Differentiating both sides with respect to x, we get		
	$\sqrt{x^2+1}\,\frac{dy}{dx} + y.\frac{x}{\sqrt{x^2+1}} = \frac{1}{\sqrt{x^2+1}}.\frac{x}{\sqrt{x^2+1}} - 1$	I	2 + 2
	$(x^2+1)\frac{dy}{dx} + y.x = \frac{x}{\sqrt{x^2+1}} - \sqrt{x^2+1}$	II	1
	Note: In case student, considers $\sqrt{x^2+1} - x$ as part of log and writes following solution		
	Differentiating both sides with respect to x, we get		
	$\sqrt{x^2+1}\,\frac{dy}{dx} + y.\frac{x}{\sqrt{x^2+1}} = \frac{1}{\sqrt{x^2+1}-x}.\left(\frac{x}{\sqrt{x^2+1}} - 1\right)$	I	2
	$\sqrt{x^2+1}\,\frac{dy}{dx} + y.\frac{x}{\sqrt{x^2+1}} = \frac{1}{\sqrt{x^2+1}-x}.\left(\frac{x-\sqrt{x^2+1}}{\sqrt{x^2+1}}\right)$	II	1
	$\sqrt{x^2+1}\,\frac{dy}{dx} + y.\frac{x}{\sqrt{x^2+1}} = \frac{-1}{\sqrt{x^2+1}}$	III	1
	gives $(x^2+1)\frac{dy}{dx} + y.x = -1$ or $(x^2+1)\frac{dy}{dx} + x.y + 1 = 0$	IV	1
	OR		
	(b) Let $u = x^{\cot x}$ and $v = \frac{2x^2-3}{2x^2-x+2}$	I	½
	$\log u = \cot x.\log x$	II	½
	$\frac{1}{u}\frac{du}{dx} = \frac{\cot x}{x} + \log x(-\mathrm{cosec}^2 x)$	III	1
	$\frac{du}{dx} = x^{\cot x}\left(\frac{\cot x}{x} - \mathrm{cosec}^2 x.\log x\right)$	IV	½
	$\frac{dv}{dx} = \frac{(2x^2-x+2)(4x)-(2x^2-3)(4x-1)}{(2x^2-x+2)^2}$	V	1
	$= \frac{-2x^2+20x-3}{(2x^2-x+2)^2}$	VI	1
	Required derivative $= x^{\cot x}\left(\frac{\cot x}{x} - \mathrm{cosec}^2 x.\log x\right) + \frac{-2x^2+20x-3}{(2x^2-x+2)^2}$	VII	½

34.	Sketch the curve $\{(x, y) : 100x^2 + 25y^2 = 2500\}$ and find the area of the region enclosed by it, using integration.		
Sol.	 	I	1½
	Required area $= 4\int_0^5 \frac{10}{5}\sqrt{25-x^2}\,dx$	II	1½
	$= 8\left[\frac{x}{2}\sqrt{25-x^2}+\frac{25}{2}\sin^{-1}\frac{x}{5}\right]_0^5$	III	1
	$= 50\pi$	IV	1
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. **OR** (b) Find the value of p if the shortest distance between the lines $\vec{r} = (\hat{i} + 2\hat{j} + \hat{k}) + \lambda(\hat{i} - \hat{j} + \hat{k})$ and $\vec{r} = (p\hat{i} - \hat{j} - \hat{k}) + \mu(2\hat{i} + \hat{j} + 2\hat{k})$ is $\frac{3}{\sqrt{2}}$ units.		

Sol.	(a) Given line is $\frac{x+3}{5}=\frac{y-1}{2}=\frac{z+4}{3}=\lambda$ Any general point on line l is $(5\lambda-3, 2\lambda+1, 3\lambda-4)$ Drs of given line are <5, 2, 3> Drs of perpendicular line $are < 5\lambda-3, 2\lambda-1, 3\lambda-7 >$ As lines are perpendicular $\therefore 5(5\lambda-3)+2(2\lambda-1)+3(3\lambda-7)=0$ gives, $\lambda=1$ $\therefore$ coordinates of foot of perpendicular are $(2,3,-1)$ length of perpendicular $=\sqrt{21}$	I II III IV V VI	1 ½ ½ 1 1 1
	OR (b) Let $\vec{a}_1=\hat{i}+2\hat{j}+\hat{k}$, $\vec{a}_2=p\hat{i}-\hat{j}-\hat{k}$, and $\vec{b}_1=\hat{i}-\hat{j}+\hat{k}$, $\vec{b}_2=2\hat{i}+\hat{j}+2\hat{k}$ Here $(\vec{a}_2-\vec{a}_1)=(p-1)\hat{i}-3\hat{j}-2\hat{k}$ $\vec{b}_1\times\vec{b}_2=-3\hat{i}+3\hat{k}$ S.D. $=\left\lvert\frac{(\vec{a}_2-\vec{a}_1).(\vec{b}_1\times\vec{b}_2)}{\lvert\vec{b}_1\times\vec{b}_2\rvert}\right\rvert$ $\frac{-3p-3}{3\sqrt{2}}=\pm\frac{3}{\sqrt{2}}$ gives $p=-4, 2$	 I II III IV	 1 1½ 1½ 1
	SECTION E This section (Q. 36 to 38) has 3 case study based questions of 4 marks each.		
36.	**Case Study – 1** 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 $\rightarrow$ 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 $\rightarrow$ A be such that R = {(x, y), x, y $\in$ 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 $\rightarrow$ A is bijective. Give reason to support your answer. *2*		
Sol.	(i) Number of relations from A to B is 2^{12} or 4096	I	1
	(ii) No R is not injective	I	½
	It is not a function as G_1 has two images B_1 and B_2	II	½
	(iii) (a) R is reflexive as $(x, x) \in R \ \forall \in A$ because x and x are students from same colony	I	½
	Let $(x, y) \in R$ so x and y are students from same colony Hence y and x are students from same colony Thus, $(y, x) \in R$ $\therefore$ R is symmetric	II	½
	Let $(x, y) \in R$ and $(y, z) \in R$ so x and y are students from same colony, y and z are students from same colony Thus, x and z are students from same colony $\therefore (x, z) \in R$ Thus, R is transitive	III	½
	As R is reflexive, symmetric and transitive, hence R is an equivalence relation	IV	½
	OR		
	(iii) (b) Any function f from B to A will not be bijective	I	1
	As f from B to A cannot be surjective because n(B) < n(A) or A and B are finite sets and $n(A) \neq n(B)$	II	1

37.	**Case Study – 2** 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*		
Sol.	(i) P (Person taking vaccine A_2 will be infected) = 45% or 0.45	I	1
	(ii) P (Person is protected from infection) $= \frac{25}{100}\cdot\frac{60}{100} + \frac{35}{100}\cdot\frac{55}{100} + \frac{40}{100}\cdot\frac{50}{100}$	I	½
	$= \frac{5425}{10000}$ or 0.5425	II	½
	(iii) (a) P (A_1/person is infected) $= \dfrac{\frac{25}{100}\cdot\frac{40}{100}}{\frac{25}{100}\cdot\frac{40}{100}+\frac{35}{100}\cdot\frac{45}{100}+\frac{40}{100}\cdot\frac{50}{100}}$	I	1½
	$= \frac{1000}{4575}$ or $\frac{40}{183}$	II	½
	OR		
	(iii) (b) P(A_3/person is not infected) $= \dfrac{\frac{40}{100}\cdot\frac{50}{100}}{\frac{25}{100}\cdot\frac{60}{100}+\frac{35}{100}\cdot\frac{55}{100}+\frac{40}{100}\cdot\frac{50}{100}}$	I	1½
	$= \frac{2000}{5425}$ or $\frac{80}{217}$	II	½

38.	**Case Study – 3** 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*		
Sol.	(i) Surface area $S = 2\pi rh + \pi r^2$	I	½
	$V = \pi r^2 h = \frac{\pi r^2 (S - \pi r^2)}{2\pi r} = \frac{(Sr - \pi r^3)}{2}$	II	1
	$\frac{dV}{dr} = \frac{(S - 3\pi r^2)}{2}$	III	½
	(ii) $\frac{dV}{dr} = 0$ gives $S = 3\pi r^2$	I	1
	$\frac{d^2V}{dr^2} = -3\pi r < 0$ V is maximum when $S = 3\pi r^2$	II	½
	Thus, $h = \frac{3\pi r^2 - \pi r^2}{2\pi r} = r$	III	½