

Marking Scheme
Strictly Confidential
(For Internal and Restricted use only)
Senior Secondary Supplementary School Examination, 2026 (XII)
APPLIED MATHEMATICS (241) QUESTION PAPER CODE – 465/7

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 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 IPC.”
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. 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 two competency-based questions, please try to understand given answer and even if reply is not from 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 in the nature of 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 ($\sqrt{}$) wherever answer is correct. For wrong answer CROSS ‘X’ be marked. Evaluators will not put right ($\checkmark$) while evaluating which gives an impression that answer is correct and no marks are awarded. This is 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 of 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 ____ 80 ____ 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 has to 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 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 of marks to the title page, or totaling error detected by the candidate shall damage the prestige of all the personnel engaged in the evaluation work as also of the Board. Hence, in order 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 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
APPLIED MATHEMATICS (Subject Code–241)
(PAPER CODE: 465/7)

Section A

Q. No.	EXPECTED OUTCOMES/VALUE POINTS	Step	Marks
	SECTION A This section comprises of 20 Multiple Choice Questions (MCQs) of 1 mark each.		
1.	If $0 < x < 1$, then which of the following values is the greatest ? (A) x (B) x^2 (C) $\frac{1}{x}$ (D) $\frac{1}{x^2}$		
Sol.	(D) $\frac{1}{x^2}$	I	1
2.	In a 300 m race, player A beats player B by 22.5 m or 6 seconds. B's time to complete the race is : (A) 80 seconds (B) 82 seconds (C) 76 seconds (D) 90 seconds		
Sol.	(A) 80 seconds	I	1
3.	If $A = [a_{ij}]_{2 \times 2}$, where $a_{ij} = \begin{cases} 1, & \text{if } i \neq j \\ 0, & \text{if } i = j \end{cases}$, then A^2 is equal to : (A) I (B) A (C) O (D) none of these		
Sol.	(A) I	I	1
4.	$\begin{vmatrix} 49 & 1 & 6 \\ 39 & 7 & 4 \\ 26 & 2 & 3 \end{vmatrix}$ is equal to : (A) 7 (B) 10 (C) -2 (D) 0		
Sol.	(D) 0	I	1

5.	If $y = \log x$ and $z = \frac{1}{x}$, then $\frac{dy}{dz}$ is equal to : (A) $\frac{1}{x}$ (B) $-\frac{1}{x}$ (C) $-x$ (D) $-\frac{1}{x^3}$		
Sol.	(C) $-x$	I	1
6.	For the curve $\sqrt{x} + \sqrt{y} = 1$, $\frac{dy}{dx}$ at $\left(\frac{1}{4}, \frac{1}{4}\right)$ is : (A) -1 (B) 1 (C) 2 (D) $\frac{1}{2}$		
Sol.	(A) -1	I	1
7.	$\int \frac{x-1}{x(x-\log x)} dx$ equals : (A) $x - \log x + C$ (B) $\log x - \log x + C$ (C) $x + \log x + C$ (D) $\log x - \log x - x + C$		
Sol.	(B) $\log x - \log x + C$	I	1
8.	$\int_0^1 xe^x dx$ equals : (A) e (B) 1 (C) -1 (D) $-e$		
Sol.	(B) 1	I	1

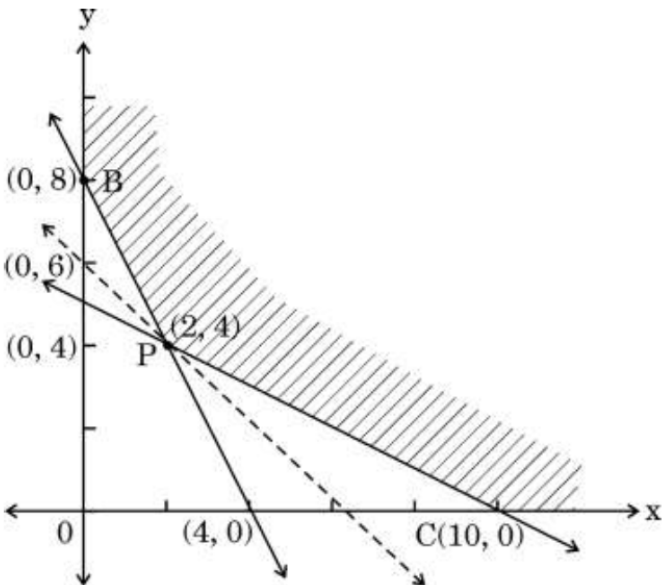
9.	The sum of the <i>order</i> and the <i>degree</i> of the differential equation : $\left(\frac{dy}{dx}\right)^5 + 3xy \left(\frac{d^3y}{dx^3}\right)^2 + y \left(\frac{d^2y}{dx^2}\right)^4 = 0$ is : (A) 7 (B) 6 (C) 5 (D) 4												
Sol.	(C) 5	I	1										
10.	Solution of the differential equation $x dy + y dx = 0$ is : (A) $x = Cy$ (B) $xy = C$ (C) $x^2y = C$ (D) $xy^2 = C$												
Sol.	(B) $xy = C$	I	1										
11.	If the probability distribution of a discrete random variable X is given as : <table border="1"><tr><td>X</td><td>1</td><td>2</td><td>3</td><td>4</td></tr><tr><td>P(X)</td><td>$\frac{1}{10}$</td><td>$\frac{1}{5}$</td><td>$\frac{3}{10}$</td><td>$\frac{2}{5}$</td></tr></table> then, $E(X^2)$ is equal to : (A) 3 (B) 5 (C) 7 (D) 10	X	1	2	3	4	P(X)	$\frac{1}{10}$	$\frac{1}{5}$	$\frac{3}{10}$	$\frac{2}{5}$		
X	1	2	3	4									
P(X)	$\frac{1}{10}$	$\frac{1}{5}$	$\frac{3}{10}$	$\frac{2}{5}$									
Sol.	(D) 10	I	1										
12.	For a binomial variate X, if $n = 4$ and $P(X = 0) = \frac{16}{81}$, then $P(X = 4)$ is : (A) $\frac{1}{3}$ (B) $\frac{1}{27}$ (C) $\frac{1}{81}$ (D) $\frac{1}{16}$												
Sol.	(C) $\frac{1}{81}$	I	1										

13.	If the variance of a Poisson distribution is 2, then $P(X = 2)$ is : (A) $\frac{2}{e^2}$ (B) $2e^2$ (C) $\frac{4}{e^2}$ (D) $4e^2$		
Sol.	(A) $\frac{2}{e^2}$	I	1
14.	If Z is a standard normal variate, then $P(0 < Z < 1.7)$ is equal to : (A) $F(0) - F(1.7)$ (B) $F(1.7) - F(0)$ (C) $1 - F(1.7)$ (D) $F(1.7) - 1$		
Sol.	(B) $F(1.7) - F(0)$	I	1
15.	In a binomial distribution, the probability of getting a success is $\frac{1}{4}$ and the standard deviation is 3. Then, its mean is : (A) 6 (B) 8 (C) 12 (D) 48		
Sol.	(C) 12	I	1
16.	The present value of a perpetuity of ₹ 750 payable at the beginning of each year, if money is worth 5% p.a. is : (A) ₹ 15,000 (B) ₹ 15,750 (C) ₹ 14,250 (D) None of these		
Sol.	(B) ₹ 15,750	I	1
17.	An investment of ₹ 10,000 becomes ₹ 60,000 in 4 years. The compound annual growth rate (CAGR) is given by : (A) $\frac{\sqrt[4]{6} - 1}{100}$ (B) $\frac{\sqrt[4]{6} + 1}{100}$ (C) $(\sqrt[4]{6} - 1) \times 100$ (D) $(\sqrt[4]{6} + 1) \times 100$		
Sol.	(C) $(\sqrt[4]{6} - 1) \times 100$	I	1

18.	Time series analysis helps to : (A) understand the behaviour of a variable in the past (B) predict the future behaviour of a variable (C) plan future operations (D) all of the above		
Sol.	(D) all of the above	I	1
	<i>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.</i> (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.	<i>Assertion (A) :</i> In a binomial distribution, if mean = 4 and variance = 3, then the number of trials is 16. <i>Reason (R) :</i> In a binomial distribution with parameters n and p, mean = np and variance = $\sqrt{npq}$.		
Sol.	(C) Assertion (A) is true, but Reason (R) is false.	I	1
20.	<i>Assertion (A) :</i> Meena takes a loan of ₹ 3,00,000 at an interest of 10% compounded annually for 3 years. Under flat rate method, she is paying EMI of ₹ 10,833.33. <i>Reason (R) :</i> In flat rate method, the principal amount remains the same throughout the tenure and interest is charged on it at a constant rate throughout the loan tenure.		
Sol.	(A) Both Assertion (A) and Reason (R) are true, and Reason (R) is the correct explanation of the Assertion (A).	I	1
	SECTION B This section comprises 5 very Short Answer (VSA) type questions of 2 marks each.		
21 (a).	In a 10 km race, A, B and C, each running at uniform speed get the gold, silver and bronze medals respectively. If A beats B by 1 km and B beats C by 1 km, then find by how many metres does A beat C.		
Sol.	A beats B by 1 km in a 10 km race		

	$\Rightarrow$ Speed of A : Speed of B = 10 : 9 Similarly, Speed of B : Speed of C = 10 : 9 or 90: 81 Thus, Speed of A : Speed of B : Speed of C = 100 : 90 : 81 $\Rightarrow$ When A runs 100 m, C runs only 81 m $\Rightarrow$ When A runs 10000 m, C runs only 8100 m Thus, A beats C by 1900 m	I	1																																
		II	1																																
	OR																																		
21 (b).	Find : $(486 + 729) \bmod 12$																																		
Sol.	$(486 + 729) \bmod 12 \equiv 1215 \bmod 12$ $\equiv 3 \bmod 12$ $= 3$	I	1																																
		II	1																																
22.	Calculate the trend values for the following data by the 3-yearly moving average method : <table><tr><td>Year</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td></tr><tr><td>Production (in tonnes)</td><td>2</td><td>4</td><td>5</td><td>7</td><td>8</td><td>10</td><td>13</td></tr></table>	Year	1	2	3	4	5	6	7	Production (in tonnes)	2	4	5	7	8	10	13																		
Year	1	2	3	4	5	6	7																												
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Sol.	<table><tr><td>Year</td><td>Production</td><td>3 – year total</td><td>3 – yearly moving average</td></tr><tr><td>1</td><td>2</td><td>-</td><td></td></tr><tr><td>2</td><td>4</td><td>11</td><td>$\frac{11}{3} = 3.67$</td></tr><tr><td>3</td><td>5</td><td>16</td><td>$\frac{16}{3} = 5.33$</td></tr><tr><td>4</td><td>7</td><td>20</td><td>$\frac{20}{3} = 6.67$</td></tr><tr><td>5</td><td>8</td><td>25</td><td>$\frac{25}{3} = 8.33$</td></tr><tr><td>6</td><td>10</td><td>31</td><td>$\frac{31}{3} = 10.33$</td></tr><tr><td>7</td><td>13</td><td>-</td><td></td></tr></table>	Year	Production	3 – year total	3 – yearly moving average	1	2	-		2	4	11	$\frac{11}{3} = 3.67$	3	5	16	$\frac{16}{3} = 5.33$	4	7	20	$\frac{20}{3} = 6.67$	5	8	25	$\frac{25}{3} = 8.33$	6	10	31	$\frac{31}{3} = 10.33$	7	13	-		I	2 for correct table
Year	Production	3 – year total	3 – yearly moving average																																
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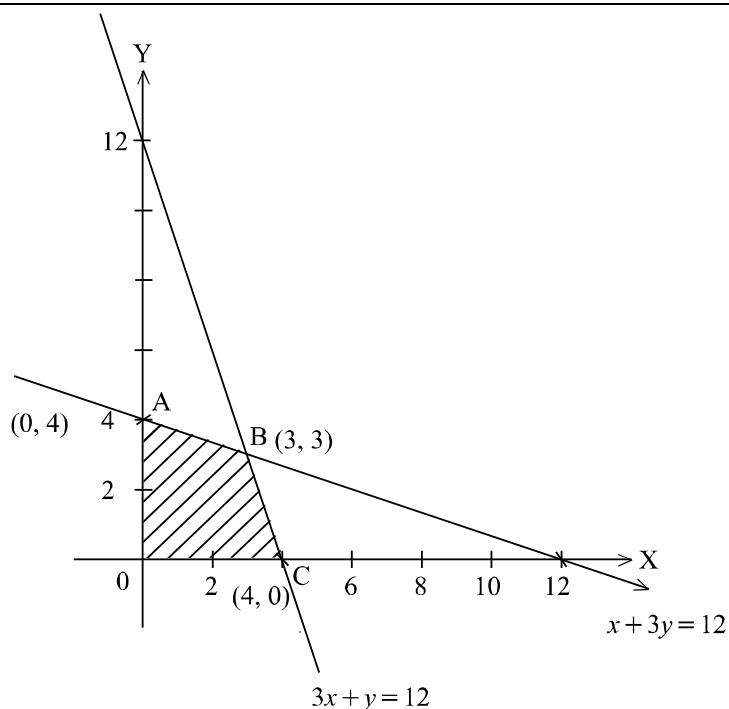
23 (a).	Rahul takes a personal loan of ₹ 2,00,000 at the rate of 12% p.a. for a period of 3 years. Calculate his EMI by using the flat rate method.		
Sol.	Given $P = 2,00,000$, $i = \frac{12}{12 \times 100} = 0.01$ and $n = 36$ So, $EMI = \frac{P + Pni}{n} = \frac{200000 + 200000 \times 36 \times 0.01}{36}$ $= \frac{200000 + 72000}{36}$ $= ₹ 7,555.56$	I II III IV	$\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$
	OR		
23 (b).	Rahul takes a personal loan of ₹ 2,00,000 at the rate of 12% p.a. for a period of 3 years. Calculate his EMI by using the reducing balance method. [Given : $(1.01)^{36} = 1.429$]		
Sol.	$i = \frac{12}{12 \times 100} = 0.01$ $EMI = \frac{P \times i \times (1 + i)^n}{(1 + i)^n - 1} = \frac{2,00,000 \times 0.01 \times (1.01)^{36}}{(1.01)^{36} - 1}$ $= \frac{200000 \times 0.01 \times 1.429}{1.429 - 1}$ $= \frac{2858}{0.429} \approx ₹ 6,662$	I II III IV	$\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$
24.	The annual depreciation of a car is ₹ 30,000. If the scrap value of the car after 15 years is ₹ 50,000, find the original cost of the car, using the linear method.		
Sol.	Annual depreciation = $\frac{\text{Original Cost} - \text{Scrap Value}}{n}$ $\Rightarrow 30000 = \frac{\text{Cost} - 50000}{15}$ $\Rightarrow \text{Original Cost} = 450000 + 50000 = 500000$ Original cost = ₹ 5,00,000	I II	1 1

25.	The feasible region for an LPP is shown shaded in the following figure. At which point does Min. $z = 50x + 70y$ occur ? Also, find the minimum value of z. 		
Sol.	$z_B = 560$ $z_P = 380$ $z_C = 500$	} I II III	1 $\frac{1}{2}$ $\frac{1}{2}$
	SECTION C This section comprises 6 short answer (SA) type questions of 3 marks each.		
26 (a).	How many litres of water must be added to 1125 litres of a 45% solution of acid so that the resulting mixture will contain more than 25%, but less than 30% acid content ?		
Sol.	Let x litres of water is to be added. Then $25\% \text{ of } (x + 1125) < 45\% \text{ of } 1125 < 30\% \text{ of } (x + 1125)$ $\Rightarrow \frac{25(x+1125)}{100} < 1125 \times \frac{45}{100} < \frac{30(x+1125)}{100}$ $\Rightarrow 5625 + 5x < 10125 < 6750 + 6x$ $\Rightarrow x < 900 \text{ and } x > 562.5$ Thus, $562.5 < x < 900$ So, quantity of water to be added should be more than 562.5 litres but less than 900 litres.	I II III	$1\frac{1}{2}$ $\frac{1}{2}$ 1

	OR		
26 (b).	Prove that the inequality $\sqrt{5} + \sqrt{3} > \sqrt{6} + \sqrt{2}$ holds true.		
Sol.	$(\sqrt{5} + \sqrt{3})^2 = 8 + 2\sqrt{15}$ $(\sqrt{6} + \sqrt{2})^2 = 8 + 2\sqrt{12}$ Since $15 > 12 \Rightarrow \sqrt{15} > \sqrt{12}$ $8 + 2\sqrt{15} > 8 + 2\sqrt{12}$ $\therefore \sqrt{5} + \sqrt{3} > \sqrt{6} + \sqrt{2}$	I III	1 1
27 (a).	For matrices $A = \begin{bmatrix} 2 & 3 \\ 1 & -4 \end{bmatrix}$ and $B = \begin{bmatrix} 1 & -2 \\ -1 & 3 \end{bmatrix}$, verify that $(AB)^{-1} = B^{-1}A^{-1}$.		
Sol.	$AB = \begin{bmatrix} 2 & 3 \\ 1 & -4 \end{bmatrix} \begin{bmatrix} 1 & -2 \\ -1 & 3 \end{bmatrix} = \begin{bmatrix} -1 & 5 \\ 5 & -14 \end{bmatrix}$ $ AB = -11$ $\text{LHS} = (AB)^{-1} = \frac{1}{-11} \begin{bmatrix} -14 & -5 \\ -5 & -1 \end{bmatrix} = \frac{1}{11} \begin{bmatrix} 14 & 5 \\ 5 & 1 \end{bmatrix}$ $ A = -11, B = 1$ $A^{-1} = \frac{1}{-11} \begin{bmatrix} -4 & -3 \\ -1 & 2 \end{bmatrix} = \frac{1}{11} \begin{bmatrix} 4 & 3 \\ 1 & -2 \end{bmatrix}$ $B^{-1} = \begin{bmatrix} 3 & 2 \\ 1 & 1 \end{bmatrix}$ $\text{RHS} = B^{-1}A^{-1} = \frac{1}{11} \begin{bmatrix} 3 & 2 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} 4 & 3 \\ 1 & -2 \end{bmatrix} = \frac{1}{11} \begin{bmatrix} 14 & 5 \\ 5 & 1 \end{bmatrix}$ $\text{LHS} = \text{RHS}$	I VI	$\frac{1}{2}$ $\frac{1}{2}$
	OR		
27 (b).	Using the matrix method, solve the system of equations : $5x - 7y = 2, 7x - 5y = 3$		
Sol.	The matrix equation is $AX = B$ where $A = \begin{bmatrix} 5 & -7 \\ 7 & -5 \end{bmatrix}, X = \begin{bmatrix} x \\ y \end{bmatrix}, B = \begin{bmatrix} 2 \\ 3 \end{bmatrix}$ $X = A^{-1}B$		

	$ A = 24 \neq 0$ $X = A^{-1}B = \frac{1}{24} \begin{bmatrix} -5 & 7 \\ -7 & 5 \end{bmatrix} \begin{bmatrix} 2 \\ 3 \end{bmatrix} = \frac{1}{24} \begin{bmatrix} 11 \\ 1 \end{bmatrix} = \begin{bmatrix} \frac{11}{24} \\ \frac{1}{24} \end{bmatrix}$ $x = \frac{11}{24}, y = \frac{1}{24}$	I II III	$\frac{1}{2}$ 1+1 $\frac{1}{2}$																																													
28.	Fit a straight line trend by the method of least squares and find the trend value for the year 2018. <table><tr><td>Year</td><td>2011</td><td>2012</td><td>2013</td><td>2014</td><td>2015</td><td>2016</td><td>2017</td></tr><tr><td>Production (in lakh tonnes)</td><td>30</td><td>35</td><td>36</td><td>32</td><td>37</td><td>40</td><td>36</td></tr></table>	Year	2011	2012	2013	2014	2015	2016	2017	Production (in lakh tonnes)	30	35	36	32	37	40	36																															
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Sol.	<table><tr><th>Year (t)</th><th>Production (y)</th><th>$x = t - 2014$</th><th>x^2</th><th>xy</th></tr><tr><td>2011</td><td>30</td><td>-3</td><td>9</td><td>-90</td></tr><tr><td>2012</td><td>35</td><td>-2</td><td>4</td><td>-70</td></tr><tr><td>2013</td><td>36</td><td>-1</td><td>1</td><td>-36</td></tr><tr><td>2014</td><td>32</td><td>0</td><td>0</td><td>0</td></tr><tr><td>2015</td><td>37</td><td>1</td><td>1</td><td>37</td></tr><tr><td>2016</td><td>40</td><td>2</td><td>4</td><td>80</td></tr><tr><td>2017</td><td>36</td><td>3</td><td>9</td><td>108</td></tr><tr><td>$n = 7$</td><td>$\sum y = 246$</td><td>$\sum x = 0$</td><td>$\sum x^2 = 28$</td><td>$\sum xy = 29$</td></tr></table> $a = \frac{\sum xy}{\sum x^2} = \frac{29}{28} = 1.04$ $b = \frac{\sum y}{n} = \frac{246}{7} = 35.14$ Trend line is $y = 35.14 + 1.04 x$ Trend value for the year 2018 = $35.14 + 4.16 = 39.3$ lakh tonnes	Year (t)	Production (y)	$x = t - 2014$	x^2	xy	2011	30	-3	9	-90	2012	35	-2	4	-70	2013	36	-1	1	-36	2014	32	0	0	0	2015	37	1	1	37	2016	40	2	4	80	2017	36	3	9	108	$n = 7$	$\sum y = 246$	$\sum x = 0$	$\sum x^2 = 28$	$\sum xy = 29$	I II III IV V	1 $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$
Year (t)	Production (y)	$x = t - 2014$	x^2	xy																																												
2011	30	-3	9	-90																																												
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$n = 7$	$\sum y = 246$	$\sum x = 0$	$\sum x^2 = 28$	$\sum xy = 29$																																												
29.	Mrs. Anita is considering a ₹ 1,000 par value bond bearing a coupon rate of 11% that matures after 5 years, and the bond will be redeemed at par. She wants a minimum rate of return of 15%. The bond is currently available at ₹ 870. Should she buy the bond ? [Given : $(1.15)^{-5} = 0.497$]																																															

	<table><tr><th>Corner Points</th><th>Value of Z</th></tr><tr><td>A(4,18)</td><td>260</td></tr><tr><td>B(6,12)</td><td>240 </td></tr><tr><td>C(15,0)</td><td>300</td></tr><tr><td>D(40,0)</td><td>800</td></tr></table> Minimum Value	Corner Points	Value of Z	A(4,18)	260	B(6,12)	240 	C(15,0)	300	D(40,0)	800	II	1
Corner Points	Value of Z												
A(4,18)	260												
B(6,12)	240 												
C(15,0)	300												
D(40,0)	800												
	Hence Z is minimum at B(6, 12) and minimum Z is 240												
31.	A manufacturer produces nuts and bolts for industrial machinery. It takes 1 hour of work on machine A and 3 hours on machine B to produce a packet of nuts, while it takes 3 hours on machine A and 1 hour on machine B to produce a packet of bolts. He earns a profit of ₹ 5 per packet of nuts and ₹ 2 per packet of bolts. How many packets of each should he produce per day so as to maximize his profit, if he operates his machines for at most 12 hours a day ? Formulate this problem as an LPP and solve graphically.												
Sol.	Let number of packets of nuts and bolts be x and y Maximize $z = 5x + 2y$ Subject to $x + 3y \leq 12$ $3x + y \leq 12$ $x \geq 0, y \geq 0$ 	I	1										



Corner Points	Value of Z
A(0,4)	8
B(3,3)	21
C(4,0)	20

Maximum Value

$\therefore$ Maximum profit is ₹21 by producing 3 packets of nuts and 3 packets of bolts.

SECTION D

This section comprises 4 Long Answer (LA) type questions of 5 marks each.

32 (a).

Find the adjoint of the matrix A given by,

$$A = \begin{bmatrix} 1 & 4 & 5 \\ 3 & 2 & 6 \\ 0 & 1 & 0 \end{bmatrix} \text{ and verify that}$$

$$A (\text{adj } A) = |A| I = (\text{adj } A) A.$$

Sol.

$$|A| = 9 \neq 0$$

II

1

III

1

I

1

	$\text{adj } A = \begin{bmatrix} -6 & 5 & 14 \\ 0 & 0 & 9 \\ 3 & -1 & -10 \end{bmatrix} \quad (\text{for every 4 cofactors give 1 mark})$	II	2
	$\text{Now, } A(\text{adj } A) = \begin{bmatrix} 1 & 4 & 5 \\ 3 & 2 & 6 \\ 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} -6 & 5 & 14 \\ 0 & 0 & 9 \\ 3 & -1 & -10 \end{bmatrix} = \begin{bmatrix} 9 & 0 & 0 \\ 0 & 9 & 0 \\ 0 & 0 & 9 \end{bmatrix} = A I$	III	1
	$\text{Also, } (\text{adj } A)A = \begin{bmatrix} -6 & 5 & 14 \\ 0 & 0 & 9 \\ 3 & -1 & -10 \end{bmatrix} \begin{bmatrix} 1 & 4 & 5 \\ 3 & 2 & 6 \\ 0 & 1 & 0 \end{bmatrix} = \begin{bmatrix} 9 & 0 & 0 \\ 0 & 9 & 0 \\ 0 & 0 & 9 \end{bmatrix} = A I$	IV	1
	OR		
32 (b).	Show that the matrix $A = \begin{bmatrix} 1 & 2 & 2 \\ 2 & 1 & 2 \\ 2 & 2 & 1 \end{bmatrix}$ satisfies the equation $A^2 - 4A - 5I_3 = O$ and hence find A^{-1}.		
Sol.	$A^2 = \begin{bmatrix} 1 & 2 & 2 \\ 2 & 1 & 2 \\ 2 & 2 & 1 \end{bmatrix} \begin{bmatrix} 1 & 2 & 2 \\ 2 & 1 & 2 \\ 2 & 2 & 1 \end{bmatrix} = \begin{bmatrix} 9 & 8 & 8 \\ 8 & 9 & 8 \\ 8 & 8 & 9 \end{bmatrix}$ So, $A^2 - 4A - 5I_3 = \begin{bmatrix} 9 & 8 & 8 \\ 8 & 9 & 8 \\ 8 & 8 & 9 \end{bmatrix} - 4 \begin{bmatrix} 1 & 2 & 2 \\ 2 & 1 & 2 \\ 2 & 2 & 1 \end{bmatrix} - 5 \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ $= \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} = O$ $A^2 - 4A - 5I_3 = O \Rightarrow A - 4I = 5A^{-1}$ $\Rightarrow 5A^{-1} = \begin{bmatrix} 1 & 2 & 2 \\ 2 & 1 & 2 \\ 2 & 2 & 1 \end{bmatrix} - 4 \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} -3 & 2 & 2 \\ 2 & -3 & 2 \\ 2 & 2 & -3 \end{bmatrix}$ Hence, $A^{-1} = \frac{1}{5} \begin{bmatrix} -3 & 2 & 2 \\ 2 & -3 & 2 \\ 2 & 2 & -3 \end{bmatrix}$	I II III IV V	1 1 1 1 1

33.	Students of a class were given a mathematical aptitude test. Their marks were found to be normally distributed with mean 60 and standard deviation 5. What percent of students scored : (i) more than 60 marks ? (ii) less than 56 marks ? (iii) below 45 and 65 marks ? $\left[\begin{array}{lcl} P(0 \leq z < 0.8) & = & 0.2881 \\ \text{Given : } P(0 < z < 1) & = & 0.3413 \\ P(0 < z < 3) & = & 0.4986 \end{array} \right]$		
Sol.	Let $Z = \frac{X-60}{5}$ (i) Here, $X=60$ $Z = 0$ Thus, $P(X > 60) = P(Z > 0) = 0.5$ Thus, 50% of the students scored more than 60 marks. (ii) Here, $X = 56$ $Z = \frac{56-60}{5} = -0.8$ $P(X < 56) = P(Z < -0.8) = P(Z > 0.8)$ $= 0.5 - P(0 < Z < 0.8)$ $= 0.5 - 0.2881$ $= 0.2119$ Thus, 21.19% of the students scored less than 56 marks. (iii) There is a discrepancy in the Hindi and English version, so both answers are provided and should be marked correct First Solution For $X = 45$, $Z = \frac{45-60}{5} = -3$ and for $X = 65$, $Z = \frac{65-60}{5} = 1$ So, $P(45 < X < 65) = P(-3 < Z < 1)$ $= P(-3 < Z < 0) + P(0 < Z < 1)$ $= P(0 < Z < 3) + P(0 < Z < 1)$ $= 0.4986 + 0.3413$ $= 0.8399$ Thus 83.99% of the students scored between 45 and 65 marks. Second Solution	I II III IV V VI VII VIII	1 $\frac{1}{2}$ 1 $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$

	For $X = 45$, $Z = \frac{45-60}{5} = -3$ So, $P(X < 45) = P(Z < -3)$ $= 0.5 - P(-3 < Z < 0)$ $= 0.5 - P(0 < Z < 3)$ $= 0.5 - 0.4986$ $= 0.0014$ Thus, 14 % of the students scored below 45 marks. For $X = 65$, $Z = \frac{65-60}{5} = 1$ So, $P(X < 65) = P(Z < 1)$ $= 0.5 + P(0 < Z < 1)$ $= 0.5 + 0.3413$ $= 0.8413$ Thus, 84.13 % of the students scored below 45 marks.		
34.	(i) Define a hypothesis. Differentiate between Null and Alternative hypothesis. (ii) Consider the following hypothesis : $H_0 : \mu = 35$ $H_a : \mu \neq 35$ A sample of 81 items is taken whose mean is 37.5 and the population standard deviation is 5. Test the hypothesis at 1% level of significance. (Use : $z_\alpha = -2.33$)		
Sol.	(i) A hypothesis is simply a quantitative statement about the population. Null Hypothesis (H_0) suggests that there is no significant difference between the sample statistic and the corresponding population parameter value. Alternative Hypothesis (H_1) is a hypothesis which contradicts the null hypothesis. (ii) Here, the test statistic Z is given by	I II	1 1

	$Z = \frac{\bar{x} - \mu_0}{\sigma/\sqrt{n}}$ $\Rightarrow Z = \frac{37.5 - 35}{5/\sqrt{81}} = 4.5$ Clearly, $4.5 > -2.33$ i.e., $Z > Z_\alpha$ Thus, we reject the Null Hypothesis.	III	2
		IV	$\frac{1}{2}$
		V	$\frac{1}{2}$
35 (a).	A loan of ₹ 2,00,000 at the interest of 6% p.a. compounded monthly is to be amortized by equal payment at the end of each month for 5 years. Find : (i) The amount of each monthly installment. (ii) The principal outstanding at the beginning of the 40th month. (iii) Interest paid in the 40th installment. (iv) Principal amount in the 40th installment, and (v) Total interest paid. [Given : $(1.005)^{60} = 1.3489$; $(1.005)^{21} = 1.1104$]		
Sol.	$P = 2,00,000, i = \frac{6}{12 \times 100} = 0.005, n = 60$ months (i) $EMI = \frac{200000 \times 0.005 \times (1.005)^{60}}{(1.005)^{60} - 1}$ $= \frac{200000 \times 0.005 \times 1.3489}{0.3489}$ $= ₹ 3,866.15$ (ii) Principal outstanding at the beginning of 40th month $= \frac{EMI[(1+i)^{60-40+1} - 1]}{i(1+i)^{60-40+1}}$ $= \frac{3866.15[(1.005)^{21} - 1]}{0.005(1.005)^{21}}$ $= \frac{3866.15[1.1104 - 1]}{0.005 \times 1.1104}$ $= \frac{3866.15 \times 0.1104}{0.005 \times 1.1104}$ $= ₹ 76,877.53$ (iii) Interest paid in 40th instalment $= \frac{EMI[(1+i)^{60-40+1} - 1]}{(1+i)^{60-40+1}}$ $= \frac{3866.15 \times 0.1104}{1.1104}$ $= ₹ 386.38$	I	$\frac{1}{2}$
		II	$\frac{1}{2}$
		III	$\frac{1}{2}$
		IV	$\frac{1}{2}$
		V	$\frac{1}{2}$
		VI	$\frac{1}{2}$

	(iv) Principal paid in 40th instalment $= \text{EMI} - \text{Interest}$ $= ₹ (3866.15 - 386.38) = ₹ 3,479.80$ (v) Total interest $= n \times \text{EMI} - P$ $= 60 \times 3866.15 - 2,00,000$ $= ₹ 31,969$	VII	1
		VIII	1
	OR		
35 (b).	A firm anticipates a capital expenditure of ₹ 50,000 for new equipment in 5 years. How much should be set aside quarterly in a sinking fund earning 12% p.a. compounded quarterly, to provided for the expenditure ? (Given : $(1.03)^{20} = 1.803$)		
Sol.	Future Value (S): ₹ 50,000 Time Period: 5 years $\Rightarrow n = 5 \times 4 = 20$ quarters Interest Rate per Quarter (i): $i = \frac{12}{100 \times 4} = 0.03$ The future value S of an ordinary annuity is given by: $S = R \left[\frac{(1+i)^n - 1}{i} \right]$ $50,000 = R \left[\frac{(1+0.03)^{20} - 1}{0.03} \right]$ $50,000 = R \left[\frac{(1.03)^{20} - 1}{0.03} \right]$ $50,000 = R \left[\frac{0.803}{0.03} \right]$ $R = \frac{50,000 \times 0.03}{0.803} = \frac{1,500}{0.803} \approx 1,867.995 \approx 1,868$ Thus, ₹ 1,868 (rounded to the nearest rupee) must be set aside quarterly for the sinking fund.	I II III II	$\frac{1}{2}$ $\frac{1}{2}$ 2 2

	SECTION E This section comprises 3 case-study based questions of 4 marks each.		
36.	According to an educational board survey, it was observed that class XII students apply at least one to four weeks before the colleges' application deadlines and the probability of a student to get admission in the college $P(X = x)$ is given as follows : $P(X = x) = \begin{cases} \frac{kx}{6}, & \text{when } x = 0, 1 \text{ or } 2 \\ \frac{(1 - k)x}{6}, & \text{when } x = 3 \\ \frac{kx}{2}, & \text{when } x = 4 \\ 0, & \text{when } x > 4 \end{cases}$ where k is a real number. Based on the above information, answer the following questions. Show steps to support your answer. (i) Find the value of k. 1 (ii) What is the probability that a student named Neha will get admission in the college, given that she applied at least 2 weeks before the application deadline ? 1 (iii) (a) Calculate the mathematical expectation of the number of weeks taken by a student to apply before the college's application deadline. 2 OR (iii) (b) To promote early admissions, the college is offering scholarships to the students for applying before the deadline as follows : 2 ₹ 50,000 for applying 4 weeks early ₹ 20,000 for applying 3 weeks early ₹ 12,000 for applying 2 weeks early ₹ 9,600 for applying 1 week early What is the expected scholarship offered by the college ?		
Sol.	(i) Since the sum of all probabilities is 1 $\frac{k}{6} + \frac{2k}{6} + \frac{3(1-k)}{6} + \frac{4k}{2} = 1$ Solving, we get $k = \frac{1}{4}$	I	1

(ii) Let X be defined as the number of weeks the student applied before the application

$$P(X \geq 2) = P(X = 2) + P(X = 3) + P(X = 4)$$

Substituting $k = \frac{1}{4}$, we get

$$P(X \geq 2) = \frac{23}{24}$$

(iii) (a)

X	1	2	3	4
P(X)	$\frac{1}{24}$	$\frac{1}{12}$	$\frac{3}{8}$	$\frac{1}{2}$
XP(X)	$\frac{1}{24}$	$\frac{1}{6}$	$\frac{9}{8}$	2

$$E(X) = \sum X P(X)$$

$$= \frac{1}{24} + \frac{1}{6} + \frac{9}{8} + 2 = \frac{10}{3}$$

OR

(iii) (b) Let random variable X denote the amount of fees as per the application

Week applied ahead	1	2	3	4
X	9600	12000	20000	50000
P(X)	$\frac{1}{24}$	$\frac{1}{12}$	$\frac{3}{8}$	$\frac{1}{2}$
XP(X)	400	1000	7500	25000

I

1

I

1

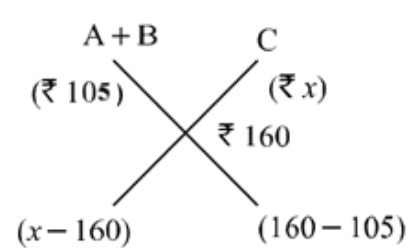
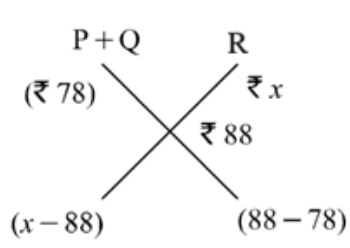
II

1

I

1

	$E(X) = \sum X P(X)$ $= 400 + 1000 + 7500 + 25000$ $= 33,900$	II	1
37.	Pulses are a good source of protein, vitamins and minerals. Rice is a source of carbohydrate which is the main fuel source for a human body. A grocer has two varieties A and B of pulses costing ₹ 75 per kg and ₹ 125 per kg respectively. Also, he has two varieties P and Q of rice costing ₹ 74 per kg and ₹ 84 per kg respectively. Based on the above information, answer the following questions : (i) If the pulses A and B are mixed in the ratio 2 : 3, then find the cost (per kg) of the resulting mixture. 1 (ii) In what ratio must the grocer mix the rice P and Q so that he gets a resulting mixture costing ₹ 78 per kg ? 1 (iii) (a) If another variety C of pulses is mixed with pulses A and B such that A : B : C = 2 : 3 : 6 and the cost of the resulting mixture is ₹ 160 per kg, then find the price per kg of C. 2 OR (iii) (b) If another variety R of rice is mixed with rice P and Q such that P : Q : R = 3 : 2 : 8 and the cost of the resulting mixture is ₹ 88 per kg, then find the price per kg of R. 2		
Sol.	(i) $\begin{array}{ccc} A & & B \\ (\text{₹ } 75) & & (\text{₹ } 125) \\ & \swarrow \quad \searrow & \\ & \text{₹ } x & \\ & \swarrow \quad \searrow & \\ (125 - x) & & (x - 75) \end{array}$ So, $\frac{125-x}{x-75} = \frac{2}{3}$ $\Rightarrow x = 105$ (ii) $\begin{array}{ccc} P & & Q \\ (\text{₹ } 74) & & (\text{₹ } 84) \\ & \swarrow \quad \searrow & \\ & \text{₹ } 18 & \\ & \swarrow \quad \searrow & \\ \text{₹ } 6 & & \text{₹ } 4 \end{array}$	I	1

	$\frac{6}{4} = \frac{3}{2}$ So, the ratio is 3: 2	I	1
	(iii) (a)  $\frac{x-160}{160-105} = \frac{5}{6} \Rightarrow \frac{x-160}{55} = \frac{5}{6}$ $\Rightarrow x = 206$ OR	I II	1 1
	(iii) (b)  $\frac{x-88}{88-78} = \frac{5}{8}$ $\Rightarrow x = 94.25$ Price of R is ₹ 94.25	I II	1 1

