Marking Scheme
Strictly Confidential
(For Internal and Restricted use only)
Senior Secondary School Examination, 2025
APPLIED MATHEMATICS (241) PAPER CODE – 465

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 News Paper/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.**
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 (√) wherever answer is correct. For wrong answer CROSS ‘X” be marked. Evaluators will not put right (✓) 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	**In Q1-Q20, if a candidate attempts the question more than once (without canceling the previous attempt), marks shall be awarded for the first attempt only and the other answer scored out with a note “Extra Question”.**
10	**In Q21-Q38, 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”.**
11	No marks to be deducted for the cumulative effect of an error. It should be penalized only once.

12	A full scale of marks ____80______ (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.
13	● 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.
14	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.
15	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.
16	Any un assessed 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.
17	The Examiners should acquaint themselves with the guidelines given in the "**Guidelines for spot Evaluation**" before starting the actual evaluation.
18	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.
19	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)

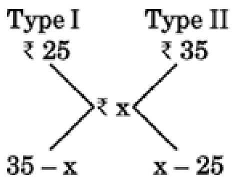
Section A

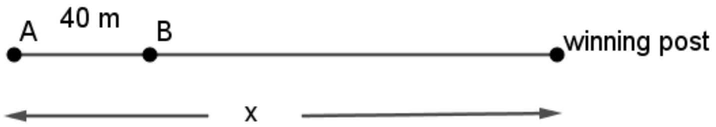
Q. No.	EXPECTED OUTCOMES/VALUE POINTS	Marks
	SECTION A Questions no. 1 to 18 are multiple choice questions (MCQs) and questions number 19 and 20 are Assertion-Reason based questions of **1 mark each.**	
1.	$-41 \bmod 9$ is (A) 5 (B) 4 (C) 3 (D) 0	
Sol.	(B) 4	**1**
2.	If $a > b$ and $c < 0$, then which of the following is true ? (A) $a + c < b + c$ (B) $a - c < b - c$ (C) $a c > b c$ (D) $a - c > b + c$	
Sol.	(D) $a - c > b + c$	**1**
3.	If A and B are symmetric matrices of the same order, then $(AB' - BA')$ is a (A) symmetric matrix (B) null matrix (C) diagonal matrix (D) skew symmetric matrix	
Sol.	(D) skew symmetric matrix	**1**
4.	The inverse of matrix $A = \begin{bmatrix} 4 & -1 \\ 2 & 1 \end{bmatrix}$ is (A) $\frac{1}{6}\begin{bmatrix} -4 & 2 \\ -1 & -1 \end{bmatrix}$ (B) $\begin{bmatrix} 1/3 & 1/6 \\ 2/3 & -1/6 \end{bmatrix}$ (C) $\begin{bmatrix} 1/6 & 1/6 \\ -1/3 & 2/3 \end{bmatrix}$ (D) $\begin{bmatrix} -2/3 & 1/6 \\ -1/3 & -1/6 \end{bmatrix}$	
Sol.	(C) $\begin{bmatrix} 1/6 & 1/6 \\ -1/3 & 2/3 \end{bmatrix}$	**1**
5.	If $\begin{vmatrix} 2x & 5 \\ 4 & x \end{vmatrix} = \begin{vmatrix} 3 & 5 \\ 4 & 6 \end{vmatrix}$, then the value of x is (A) $3/2$ (B) 6 (C) 3 (D) ± 3	
Sol.	(D) ± 3	**1**

6.	The slope of the normal to the curve $y = \frac{x-3}{x-4}$ at $x = 6$ is (A) 4 (B) $-\frac{1}{4}$ (C) -4 (D) $\frac{1}{4}$	
Sol.	(A) 4	**1**
7.	The rate of change of population P(t) with respect to time (t), where α, β are the constant birth and death rates, respectively, is (A) $\frac{dP}{dt} = (\alpha + \beta)P$ (B) $\frac{dP}{dt} = (\alpha - \beta)P$ (C) $\frac{dP}{dt} = \frac{\alpha + \beta}{P}$ (D) $\frac{dP}{dt} = \frac{\alpha - \beta}{P}$	
Sol.	(B) $\frac{dP}{dt} = (\alpha - \beta)P$	**1**
8.	A pair of dice is thrown two times. If X represents the number of doublets obtained, then the expectation of X is (A) $\frac{1}{6}$ (B) 1 (C) $\frac{1}{3}$ (D) $\frac{11}{36}$	
Sol.	(C) $\frac{1}{3}$	**1**
9.	The mean of t-distribution is (A) 0 (B) 1 (C) 2 (D) not defined	
Sol.	(A) 0	**1**
10.	The variations which occur due to change in climate, festivals or weather conditions are known as (A) secular variations (B) cyclic variations (C) seasonal variations (D) irregular variations	
Sol.	(C) seasonal variations	**1**
11.	In a LPP, the maximum value of $z = 3x + 4y$ subject to the constraints $x + y \leq 40$, $x + 2y \leq 60$, $x, y \geq 0$ is (A) 120 (B) 140 (C) 150 (D) 130	
Sol.	(B) 140	**1**

12.	The present value of a sequence of payments of ₹ 100 made at the end of every year and continuing forever, if the money is worth 5% compounded annually, is (A) ₹ 2,000 (B) ₹ 20,000 (C) ₹ 5,000 (D) ₹ 12,000	
Sol.	(A) ₹ 2,000	**1**
13.	The demand function of a monopolist is given by p = $30 + 5x - 3x^2$, where x is the number of units demanded and p is the price per unit. The marginal revenue when 2 units are sold, is (A) ₹ 28 (B) ₹ 23 (C) ₹ 1 (D) ₹ 14	
Sol.	(D) ₹ 14	**1**
14.	If the cost function and revenue function of x items are respectively given as $C(x) = 100 + 0.015\,x^2$, $R(x) = 3x$, then the value of x for maximum profit is (A) 50 (B) 100 (C) 150 (D) 200	
Sol.	(B) 100	**1**
15.	If a random variable X has the probability distribution $P(X = x) = \begin{cases} k, & \text{if } x = 0 \\ 2k, & \text{if } x = 1 \text{ or } 2 \\ 0, & \text{otherwise,} \end{cases}$ then the value of k is (A) $\frac{1}{3}$ (B) $\frac{1}{5}$ (C) $\frac{1}{6}$ (D) $\frac{1}{4}$	
Sol.	(B) $\frac{1}{5}$	**1**
16.	The test statistic t for testing the significance of differences between the means of two independent samples is given by (A) $t = \frac{\bar{x} - \bar{y}}{\sqrt{s}}$ (B) $t = \frac{\bar{x} - \bar{y}}{s\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$ (C) $t = \frac{\bar{x} - \bar{y}}{\frac{s}{\sqrt{n-1}}}$ (D) $t = \frac{\bar{x} + \bar{y}}{s\sqrt{\frac{1}{n_1} - \frac{1}{n_2}}}$	
Sol.	(B) $t = \frac{\bar{x} - \bar{y}}{s\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$	**1**

17.	The effective rate of interest equivalent to a nominal rate of 4% compounded semi-annually, is (A) 4.12% (B) 4.04% (C) 4.08% (D) 4.14%	
Sol.	(B) 4.04 %	**1**
18.	The CAGR of an investment, whose starting value is ₹ 5,000 and it grows to ₹ 25,000 in 4 years, is : [Given $(5)^{0.25} = 1.4953$] (A) 49.53% (B) 14.95% (C) 495.3% (D) 1.49%	
Sol.	(A) 49.53 %	**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)** : The area of the region bounded by the line $y - 1 = x$, the x-axis and the ordinates $x = -1$ and $x = 1$ is 2 square units. **Reason (R)** : The area of the region bounded by the curve $y = f(x)$, the x-axis and the ordinates $x = a$ and $x = b$ is given by $\int_a^b f(x)\,dx$.	
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)** : The differential equation representing the family of curves $y = mx$, m being an arbitrary constant, is $x\frac{dy}{dx} - y = 0$. **Reason (R)** : For a family of curves, the differential equation is obtained by differentiating the equation of family of curves with respect to x and then eliminating the arbitrary constant, if any.	
Sol.	**(A)** Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).	**1**

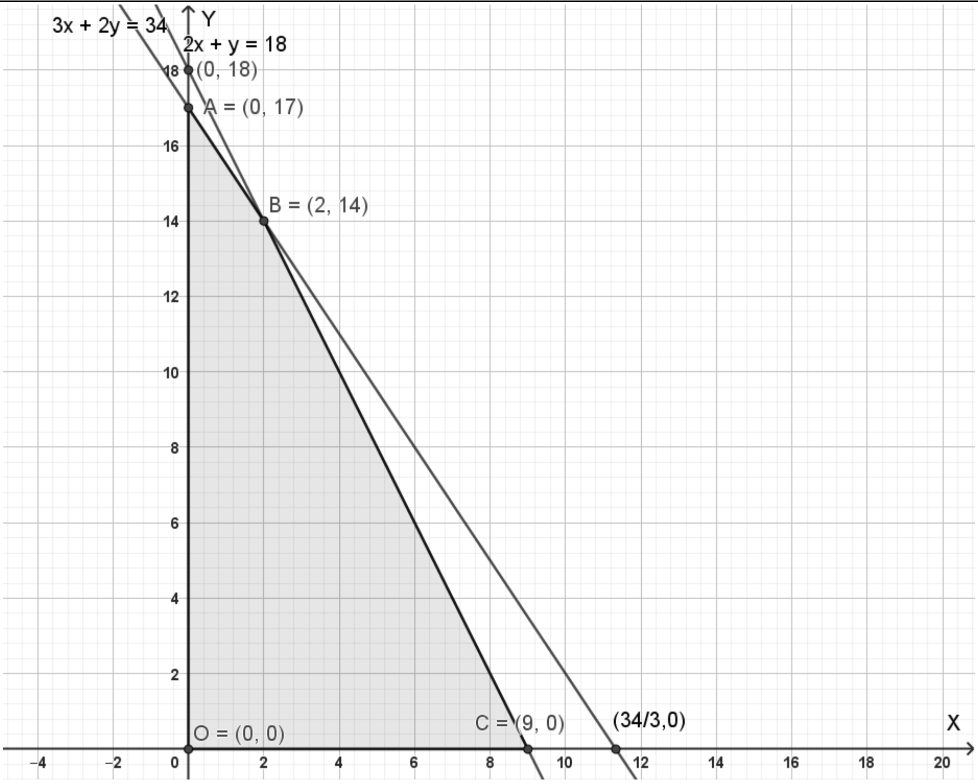
	SECTION B This section comprises very short answer (VSA) type questions of 2 marks each.	
21(a).	The cost of Type I sugar is ₹ 25 per kg and Type II sugar is ₹ 35 per kg. If both Type I sugar and Type II sugar are mixed in the ratio 3:2, find the price per kg of the mixture.	
Sol.	Let the price per kg of mixture be ₹ **x**  $\therefore \frac{35-x}{x-25}=\frac{3}{2}$ $\Longrightarrow 70-2x=3x-75$ Solving, we get $x=29$ ∴ Price per kg of the mixture is ₹ 29	**1** **1**
	OR	
21(b).	Pipe A can fill a tank in 1 hour and Pipe B can fill it in 1½ hours. If both the pipes are opened in the empty tank, how much time will they take to fill the tank ?	
Sol.	Let the required time taken be n minutes $\therefore \frac{1}{n}=\frac{1}{60}+\frac{1}{90}$ $\Longrightarrow \frac{1}{n}=\frac{3+2}{180}=\frac{5}{180}=\frac{1}{36}$ $\therefore n=36$ minutes or $\frac{3}{5}$ hours	**1** **1**
22.	A boat goes 3.5 km upstream and then returns. Total time taken is 1 hour and 12 minutes. If the speed of the current is 1 km/h, then find the speed of the boat in still water.	
Sol.	Let the speed of the boat be x km/h ∴ Speed of the boat upstream $=(x-1)$ km/h and speed of the boat downstream $=(x+1)$ km/h $\therefore \frac{3.5}{x-1}+\frac{3.5}{x+1}=1+\frac{12}{60}=\frac{6}{5}$ $\Longrightarrow 3.5\,(2x)5=6\,(x^2-1)$ $\Longrightarrow 6x^2-35x-6=0$ Solving, we get $x=6$ km/h (rejecting the -ve value)	½ ½ ½ ½

23.	A runs $\frac{3}{2}$ times as fast as B. If A gives B a start of 40 m, how far must the winning post from the starting point be, so that A and B reach at the same time ?	
Sol.	 Let the winning post be x metres away from the starting point. $\therefore \frac{x}{3/2} = \frac{x-40}{1}$ $\Rightarrow \frac{x}{2} = \frac{3}{2} \times 40 = 60 \Rightarrow x = 120$ metres	 **1** **1**
24.	Given $A = \begin{bmatrix} 2 & 0 & 1 \\ 3 & 4 & 5 \\ 0 & 2 & 3 \end{bmatrix}$ and $B = \begin{bmatrix} 1 & 1 & -5 \\ -5 & 1 & -5 \\ 1 & -2 & 4 \end{bmatrix}$, find BA.	
Sol.	$BA = \begin{bmatrix} 1 & 1 & -5 \\ -5 & 1 & -5 \\ 1 & -2 & 4 \end{bmatrix} \begin{bmatrix} 2 & 0 & 1 \\ 3 & 4 & 5 \\ 0 & 2 & 3 \end{bmatrix}$ Obtaining at least 4 correct entries $= \begin{bmatrix} 5 & -6 & -9 \\ -7 & -6 & -15 \\ -4 & 0 & 3 \end{bmatrix}$	 **1** **1**
25 (a).	If a fair coin is tossed 6 times, find the probability of getting atleast 4 heads.	
Sol.	Here, $n = 6, p = \frac{1}{2}, q = \frac{1}{2}$ P (at least 4 heads in 6 throws) $= P(X \geq 4)$ $= 6_{C_4} \left(\frac{1}{2}\right)^4 \left(\frac{1}{2}\right)^2 + 6_{C_5} \left(\frac{1}{2}\right)^5 \left(\frac{1}{2}\right)^1 + 6_{C_6} \left(\frac{1}{2}\right)^6 \left(\frac{1}{2}\right)^0$ $= 22 \left(\frac{1}{2}\right)^6 = \frac{22}{64}$ $or \frac{11}{32}$	½ **1** ½
	OR	
25 (b).	Given that mean of a normal variate X is 9 and standard deviation is 3, then find : (i) the z-score of the data point 15 (ii) the data point if its z-score is 4.	
Sol.	(i) $Z = \frac{X-\mu}{\sigma} = \frac{15-9}{3} = 2$ (ii) $4 = \frac{X-9}{3} \Rightarrow X = 21$	**1** **1**

<table>
<tr><td></td><td>SECTION C
This section comprises short answer (SA) type questions of 3 marks each.</td><td></td></tr>
<tr><td>26.</td><td>Find the units digit in 7^{295}.</td><td></td></tr>
<tr><td>Sol.</td><td>$7^2 = 49 \equiv -1(mod\ 10)$
$7^{295} = (7^2)^{147} \times 7$
Now, $(7^2)^{147} \equiv (-1)^{147}(mod\ 10) \equiv -1(mod\ 10)$
$\implies 7^{295} = (7^2)^{147} \times 7 \equiv -7(mod\ 10) \equiv 3(mod\ 10)$
∴ Units digit is 3.</td><td>1
1
½
½</td></tr>
<tr><td>27.</td><td>Two numbers are selected at random (without replacement) from first six positive integers. Let X denotes the smaller of the two numbers obtained. Calculate the mathematical expectation of X.</td><td></td></tr>
<tr><td>Sol.</td><td>Numbers on the dice are 1, 2, 3, 4, 5, 6
∴ X can take the values 1, 2, 3, 4, 5
<table>
<tr><td>X</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>P(X)</td><td>$\frac{5}{15}$</td><td>$\frac{4}{15}$</td><td>$\frac{3}{15}$</td><td>$\frac{2}{15}$</td><td>$\frac{1}{15}$</td></tr>
<tr><td>X P(X)</td><td>$\frac{5}{15}$</td><td>$\frac{8}{15}$</td><td>$\frac{9}{15}$</td><td>$\frac{8}{15}$</td><td>$\frac{5}{15}$</td></tr>
</table>
$E(X) = \sum X\ P(X) = \frac{35}{15} = \frac{7}{3}$</td><td>½
1
1
½</td></tr>
<tr><td>28 (a).</td><td>If the mean and variance of a binomial distribution are $\frac{4}{3}$ and $\frac{8}{9}$ respectively, then find $P(x = 1)$.</td><td></td></tr>
<tr><td>Sol.</td><td>Mean $= np = \frac{4}{3}$, variance $= npq = \frac{8}{9}$
$\implies q = \frac{8}{9} \times \frac{3}{4} = \frac{2}{3}$
$\therefore p = 1 - \frac{2}{3} = \frac{1}{3}$
$n \times \frac{1}{3} = \frac{4}{3} \implies n = 4$
$P(x = 1) = 4_{C_1} \left(\frac{1}{3}\right)^1 \left(\frac{2}{3}\right)^3 = 4 \times \frac{1}{3} \times \frac{8}{27}$
$= \frac{32}{81}$</td><td>½
½
½
½
½
½</td></tr>
<tr><td></td><td>OR</td><td></td></tr>
</table>

28 (b).	The mortality rate for a certain disease is 0.007. Using Poisson distribution, calculate the probability for 2 deaths in a group of 400 people. [Use $e^{-2.8} = 0.0608$]	
Sol.	Given, $p = 0.007, n = 400$ $\therefore\ \lambda = np = 400 \times 0.007 = 2.8$ Now, $P(X = 2) = \frac{(2.8)^2 e^{-2.8}}{2!}$ $= \frac{7.84}{2} \times 0.0608 = 0.2383$	½ **1** **1** ½
29 (a).	There are two types of fertilizers F_1 and F_2. F_1 consists of 10% nitrogen and 6% phosphoric acid. F_2 consists of 5% nitrogen and 10% phosphoric acid. After testing the soil conditions, a farmer finds that he needs atleast 14 kg of nitrogen and 14 kg of phosphoric acid for his crop. If F_1 costs ₹ 6 per kg and F_2 costs ₹ 5 per kg, how much of each type of fertilizer should be used so that the cost is minimum. Formulate a linear programming problem.	
Sol.	Let x kg of nitrogen and y kg of phosphoric acid is used for minimum cost. $\therefore$ the objective function is Minimize $Z = 6x + 5y$ Subject to the constraints $10\% \times x + 5\% \times y \geq 14$ or $2x + y \geq 280$ and $6\% \times x + 10\% \times y \geq 14$ or $3x + 5y \geq 700$ $x, y \geq 0$ **Note: *** Marks should be awarded for the formation of equations $2x + y = 280$ and $3x + 5y = 700$ instead of inequations in Hindi medium only.	 ½ **1** **1** ½
	OR	
29 (b).	Solve the following linear programming problem graphically : Maximise $z = 50x + 30y$ subject to $2x + y \leq 18$ $3x + 2y \leq 34$ $x, y \geq 0$.	

Sol.



1½ for correct graph

Corner Points	Value of Z
O (0,0)	0
A (0, 17)	510
B (2,14)	520
C (9, 0)	450

1 for correct table

∴ Maximum Z = 520 at B (2, 14) — ½

30. A machinist is making engine parts with axle diameter of 0.7 cm. A random sample of 10 parts shows mean diameter 0.742 cm with a standard deviation of 0.04 cm. On the basis of this sample, find if you would say that the work is inferior. (Given t_9 (0.05) = 2.262)

Sol.

$\bar{x} = 0.742,\ \mu = 0.7$

$n = 10, s = 0.04$ — ½

H_0: Null hypothesis : If there is no significant difference between $\bar{x}$ and μ

H_1: Alternate hypothesis : If there is a significant difference between $\bar{x}$ and μ

$t = \frac{\bar{x}-\mu}{\frac{s}{\sqrt{n-1}}} = \frac{0.742-0.7}{\frac{0.04}{\sqrt{9}}} = 3.15$ — **1½**

Df = 9 and $t_9(0.05) = 2.262$

Since $|t| = 3.15 > 2.262$ — ½

∴ Null hypothesis is rejected

	Hence the work is inferior **Note:*** $t = \frac{\bar{x}-\mu}{\frac{s}{\sqrt{n}}}$ should also be accepted.	½
31.	Calculate EMI under Flat-Rate System for a loan of ₹ 5,00,000 with 7.5% annual interest rate for 5 years.	
Sol.	$P = ₹\ 5,00,000$ Interest $= \frac{PRT}{100}$ $= \frac{500000 \times 7.5 \times 5}{100} = ₹\ 1,87,500$ $n = 5$ years $= 60$ months $\therefore$ EMI $= \frac{P+I}{n}$ $= \frac{500000+187500}{60}$ $= ₹\ 11,458.33$	 1 ½ 1 ½
	SECTION D This section comprises of Long Answer (LA) type questions of 5 marks each.	
32 (a).	If A = $\begin{bmatrix} 2 & -3 & 5 \\ 3 & 2 & -4 \\ 1 & 1 & -2 \end{bmatrix}$, find A^{-1} and hence solve the following system of linear equations : $2x - 3y + 5z = 11,\ 3x + 2y - 4z = -5,\ x + y - 2z = -3$	
Sol.	$\|A\| = 2(-4+4) + 3(-6+4) + 5(3-2) = -1 \neq 0$ $\therefore A^{-1}$ exists Now, $\begin{bmatrix} 2 & -3 & 5 \\ 3 & 2 & -4 \\ 1 & 1 & -2 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 11 \\ -5 \\ -3 \end{bmatrix}$ or $AX = B \Rightarrow X = A^{-1}B$ $\text{adj}(A) = \begin{bmatrix} 0 & -1 & 2 \\ 2 & -9 & 23 \\ 1 & -5 & 13 \end{bmatrix}$ $A^{-1} = \frac{1}{\|A\|}\text{adj}(A) = \frac{1}{-1}\begin{bmatrix} 0 & -1 & 2 \\ 2 & -9 & 23 \\ 1 & -5 & 13 \end{bmatrix} = -\begin{bmatrix} 0 & 1 & -2 \\ 2 & 9 & -23 \\ -1 & 5 & -13 \end{bmatrix}$ $\therefore \begin{bmatrix} x \\ y \\ z \end{bmatrix} = -\begin{bmatrix} 0 & 1 & -2 \\ 2 & 9 & -23 \\ -1 & 5 & -13 \end{bmatrix} \begin{bmatrix} 11 \\ -5 \\ -3 \end{bmatrix} = \begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix}$ So, $x = 1, y = 2, z = 3$	½ 1 1½ ½ 1 ½

	OR	
32 (b).	Using properties of determinants, prove that $$\Delta = \begin{vmatrix} (b+c)^2 & a^2 & a^2 \\ b^2 & (c+a)^2 & b^2 \\ c^2 & c^2 & (a+b)^2 \end{vmatrix} = 2\ abc\ (a+b+c)^3$$	
Sol.	LHS = $\Delta = \begin{vmatrix} (b+c)^2 & a^2 & a^2 \\ b^2 & (c+a)^2 & b^2 \\ c^2 & c^2 & (a+b)^2 \end{vmatrix}$ Applying, $C_1 \to C_1 - C_3$ $C_2 \to C_2 - C_3$ $\Delta = \begin{vmatrix} (b+c)^2 - a^2 & 0 & a^2 \\ 0 & (c+a)^2 - b^2 & b^2 \\ c^2 - (a+b)^2 & c^2 - (a+b)^2 & (a+b)^2 \end{vmatrix}$ $= (a+b+c)^2 \begin{vmatrix} b+c-a & 0 & a^2 \\ 0 & c+a-b & b^2 \\ c-a-b & c-a-b & (a+b)^2 \end{vmatrix}$ Applying, $R_1 \to R_3 - R_1 - R_2$ $= 2(a+b+c)^2 \begin{vmatrix} b+c-a & 0 & a^2 \\ 0 & c+a-b & b^2 \\ -b & -a & ab \end{vmatrix}$ Expanding, we get $\Delta = 2abc(a+b+c)^3$	 **1+1** **1** **2**
33.	If the supply function is $p = 4 - 5x + x^2$, then find the producer's surplus when price is 18.	
Sol.	$p = 4 - 5x + x^2$ $p_0 = 18$, we have $18 = 4 - 5x + x^2$ or $x^2 - 5x - 14 = 0$ $\Longrightarrow (x-7)(x+2) = 0$ $\therefore x = 7, x = -2$ is rejected $p_0 x_0 = 18 \times 7 = 126$ PS = $p_0 x_0 - \int_0^7 (x^2 - 5x + 4)\ dx$ $= 126 - \left[\frac{x^3}{3} - \frac{5x^2}{2} + 4x\right]_0^7$ $= 126 - \frac{119}{6}$ $= \frac{637}{6}$ or 106.17 approx.	 **1½** **½** **1** **1** **1**

34(a). Compute the seasonal indices by 4-year moving averages from the given data of production of paper (in thousand tons) :

Year :	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Index number :	2450	1470	2150	1800	1210	1950	2300	2500	2480	2680

Sol.

Year	Index Number	4 yearly moving total	4 yearly moving Average	Centered Total	Centered moving average
2001	2450				
2002	1470				
		7870	1967.5		
2003	2150			3625	1812.5
		6630	1657.5		
2004	1800			3435	1717.5
		7110	1777.5		
2005	1210			3592.5	1796.25
		7260	1815		
2006	1950			3805	1902.5
		7960	1990		
2007	2300			4297.5	2148.75
		9230	2307.5		
2008	2500			4797.5	2398.75
		9960	2490		
2009	2480				
2010	2680				

4 yearly moving total – 1 mark

4 yearly moving average – 1½ marks

centered total - 1 mark

centered moving average - 1½ marks

OR

34(b). Fit a straight-line trend by method of least squares for the following data :

Year :	2011	2012	2013	2014	2015	2016
Production (in tons) :	210	225	275	220	240	235

Sol.

Year (x_i)	Index Number (Y)	$X = \frac{x_i - A}{0.5} = \frac{x_i - 2013.5}{0.5}$	X^2	XY	$Y_t = a + bx$
2011	210	-5	25	-1050	$234.17 + (-5)1.64 = 225.97$
2012	225	-3	9	-675	229.25
2013	275	-1	1	-275	232.53
2014	220	1	1	220	235.81
2015	240	3	9	720	239.09
2016	235	5	25	1175	242.37
$n = 6$	1405	$\sum X = 0$	$\sum X^2 = 70$	$\sum XY = 115$	

2½ for the correct table

$a = \frac{\sum Y}{n} = \frac{1405}{6} = 234.17$ (approx.) **1**

$b = \frac{\sum XY}{\sum X^2} = \frac{115}{70} = 1.64$ (approx.) **1**

Required line is $Y = a + bx = 234.17 + 1.64\,x$ **½**

35. A machine costs ₹ 1,00,000 and its effective life is estimated to be 12 years. A sinking fund is created for replacing the machine by a new model at the end of its life time when its scrap realizes a sum of ₹ 5,000 only. Find what amount should be set aside at the end of each year, out of the profits for the sinking fund if it accumulates at 5% effective.

[Use $(1.05)^{12} = 1.7958$]

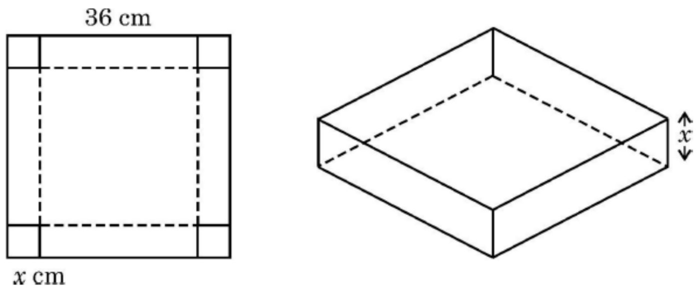
Sol. Amount needed after 12 years = ₹ 1,00,000 − ₹ 5,000 = ₹ 95,000 **1**

The payments into sinking fund consist of 12 annual payments at the rate of 5% per year.

$A = R\left[\frac{(1+i)^n - 1}{i}\right]$

$95000 = R\left[\frac{(1.05)^{12} - 1}{0.05}\right]$ **2**

$\Rightarrow R = \frac{95000 \times 0.05}{0.7958} =$ ₹ 5968.84 (or $\frac{4750}{0.8} =$ ₹ 5937.50 using approximations) **2**

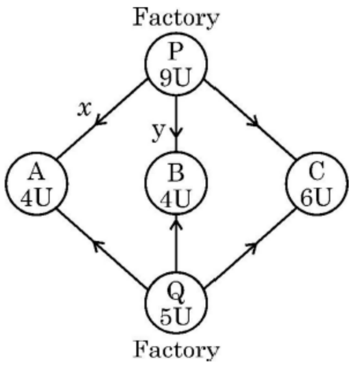
	SECTION E This section comprises of 3 case-study based questions of 4 marks each.	
36.	A man has an expensive square-shaped piece of golden board of side 36 cm. He wants to turn it into a box without top by cutting a square from each corner and folding the flaps. Let x cm be the side of square, which is cut from each corner.  Based on the above information, answer the following questions : (i) Find the expression for the volume (V) of open box in terms of x. (ii) Find $\frac{dV}{dx}$. (iii) Find the value of x for which the volume (V) is maximum. **OR** (iii) Find the maximum volume of the open box.	
Sol.	(i) $V = x\,(36-2x)^2$	**1**
	(ii) $\frac{dV}{dx} = (36-2x)^2 + 2x(36-2x)(-2)$ $= (36-2x)(36-2x-4x)$ $= (36-2x)(36-6x)$ $= 12\,(18-x)(6-x)$	**1**
	(iii) $\frac{dV}{dx} = 0 \implies x = 18$ or $x = 6$	**1**
	Rejecting $x = 18$, we have $x = 6$ and $\frac{d^2V}{dx^2} = 12(18-x)(-1) + 12\,(-1)(6-x)$ $\implies \frac{d^2V}{dx^2} < 0$ at $x = 6$	½
	∴ volume is maximum for $x = 6$	½
	OR (iii) $\frac{dV}{dx} = 0 \implies x = 18$ or $x = 6$	**1**
	Rejecting $x = 18$, we have $x = 6$ and $\frac{d^2V}{dx^2} = 12(18-x)(-1) + 12\,(-1)(6-x)$ $\implies \frac{d^2V}{dx^2} < 0$ at $x = 6$ ∴ Max V $= 6\,(36-12)^2 = 6\,(24)^2 = 3456\ cm^3$	**1**

37. There are two factories located one at P and the other at Q. From these locations, a certain commodity is to be delivered to each of the three depots situated at A, B and C. The weekly requirements of the depots are respectively 4, 4 and 6 units of the commodity while the production capacity of the factories at P and Q are 9 and 5 units respectively. The cost of transportation per unit is given as :

From / To	Cost (in ₹)		
	A	B	C
P	160	100	150
Q	100	120	100

Based on the above information, answer the following questions :

Let x units and y units of the commodity be transported from factory P to the depots at A and B respectively, then



(i) Find (in terms of x and y) how many units of commodity be transported from factory P to depot C.

(ii) Find how many units of commodity be transported from factory Q to A, B and C respectively.

(iii) Using (i) and (ii), find the total transportation cost z.

OR

(iii) Using (i) and (ii), find the constraint inequalities for minimum cost z.

Sol.

(i) P to C $= 9 - (x + y)$ **1**

(ii) Q to A $= (4 - x)$

Q to B $= (4 - y)$ } **½**

Q to C $= 6 - [9 - x - y] = (x + y - 3)$ **½**

(iii) $Z = 160\,x + 100\,y + 150\,(9 - x - y) + 100\,(4 - x) + 120(4 - y) + 100(x + y - 3)$ **1**

$= 10x - 70y + 1930$ **1**

OR

	(iii) $x + y \leq 9$	½
	$x + y \geq 3$	½
	$x \leq 4, y \leq 4$ $x, y \geq 0$ }	1
38.	Ramesh borrowed a home loan amount of ₹ 7,00,000 from a bank at an interest of 12% per annum for 30 years, to be paid in monthly installments. Based on the above information, answer the following questions : (i) Write the formula for calculating EMI by reducing balance method. (ii) Write the values of P, i and n respectively. (iii) Find the EMI. [Use $(1.01)^{-360} = 0.02781668$] **OR** (iii) If the loan is to be returned in 20 years, find EMI. [Use $(1.01)^{-240} = 0.09180584$]	
Sol.	(i) $E = \frac{P\,i}{1-(1+i)^{-n}}$ or $\frac{P\,i\,(1+i)^n}{(1+i)^n - 1}$	1
	(ii) $P = ₹\, 7,00,0000, i = \frac{12}{1200} = 0.01, n = 12 \times 30 = 360$ months	1
	(iii) $E = ₹\, \frac{7,00,000 \times 0.01}{1-(1.01)^{-360}}$	1
	$= \frac{7000}{0.97218332} = ₹\, 7200.29$ (or $\frac{7000}{0.97} = ₹\, 7216.49$ using approximations)	1
	OR	
	(iii) $E = ₹\, \frac{7,00,000 \times 0.01}{1-(1.01)^{-240}}$	1
	$= \frac{7000}{0.90819416} = ₹\, 7707.60$ (or $\frac{7000}{0.91} = ₹\, 7692.31$ using approximations)	1