SUBJECT: APPLIED MATHEMATICS (241)
SAMPLE QUESTION PAPER
CLASS- XII (2026-27)

Maximum Marks: 80 **Time Allowed: 3 Hours**

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 no. 19 and 20 are Assertion-Reason based questions of 1 mark each.
4. In Section B, Question number 21 to 25 are Very Short Answer (VSA)-type questions, carrying 2 marks each.
5. In Section C, Question number. 26 to 31 are Short Answer (SA)-type questions, carrying 3 marks each.
6. In Section D, Question number 32 to 35 are Long Answer (LA)-type questions, carrying 5 marks each.
7. In Section E, Question number 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, 2 questions in Section C, 2 questions in Section D and one sub-part each in 2 questions of Section E.
9. Draw neat and clean figures wherever required. Take π = $\frac{22}{7}$ wherever required, if not stated
10. Use of calculators is not allowed.

SECTION – A (20 x 1 = 20)

This section comprises of 18 multiple choice questions and two assertion and reason type questions of 1 mark each.

Q. NO.	Question	Marks
1.	Given two integers a, b such that $a < b$ and c be any non-zero integer then which of the following always holds true: (A) $a - c > b - c$ (B) $ac < bc$ (C) $ac > bc$ (D) $a + c < b + c$	**1**
2.	Vessel A contains milk and water in the ratio **4 : 5**. Vessel B contains milk and water in the ratio **5 : 1**. In what ratio should quantities be taken from both vessels to form a mixture in which milk and water are in the ratio **5 : 4**? (A) 5 : 2 (B) 5 : 3 (C) 4 : 1 (D) 1 : 4	**1**
3.	Number of symmetric matrices of order 3×3 with each entry 1 or -1 is (A) 512 (B) 64 (C) 8 (D) 4	**1**
4.	In a car race, car A beats car B by 45 km, car B beats car C by 50 km, and car A beats car C by 90 km then the length of the race course is (A) 400 km (B) 450 km (C) 500 km (D) 550 km	**1**

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5.	If $x = \log t$ and $y = t^2$, then value of $\frac{d^2y}{dx^2}$ at $t = \frac{1}{\sqrt{2}}$ is (A) 4 (B) 2 (C) $2\sqrt{2}$ (D) 1	**1**
6.	Which of the following statements about the future value (FV) of a perpetuity is true? (A) The future value can be calculated by compounding the present value to a specific future date. (B) The future value is equal to twice the present value multiplied by number of payments. (C) The future value is always equal to the total cash flows received up to the future date. (D) The future value of perpetuity is undefined**.**	**1**
7.	The order of the differential equation whose general solution is given by $y = (\mathrm{a} + \mathrm{b})\log(x + \mathrm{c}) - \mathrm{d}e^{x+\mathrm{k}}$ where $\mathrm{a}, \mathrm{b}, \mathrm{c}, \mathrm{d}$ and k are arbitrary constants, is (A) 4 (B) 5 (C) 3 (D) 2	**1**
8.	The Marginal Revenue (MR) of a company is given by the function $MR(x) = 20e^{0.5x}$ where x is the number of units sold. The additional revenue generated when sales increase from 2 units to 4 units is: (A) $20\,e^2$ (B) $20(e^2 - e^1)$ (C) $40\,e^2$ (D) $40(e^2 - e^1)$	**1**
9.	In the context of standard reducing-balance EMI, over the loan period, which of the following is correct? (A) Principal and Interest components both remain constant. (B) Principal component decreases, and Interest component increases. (C) Principal component increases, and Interest component decreases. (D) Principal component remains constant, and Interest component decreases.	**1**
10.	If you are willing to pay ₹ 40,000 today for an investment that promises to pay ₹ 3,200 at the end of every year indefinitely, then the implied rate of return is (A) 6 % (B) 8 % (C) 10 % (D) 12.5 %	**1**
11.	A foreign research lab observes that the number of microscopic defects on a solar-panel surface follows a Poisson distribution with mean 2 defects per $100\ cm^2$. If a scientist inspects an area of $250\ cm^2$, what is the probability that exactly 1 defect is found? (A) $6e^{-5}$ (B) $5e^{-5}$ (C) $4e^{-5}$ (D) $3e^{-2}$	**1**
12.	Which of the following statement(s) is/are true: I: The mean of a population is denoted by $\bar{x}$. II: The population mean is a statistic. (A) I only (B) II only (C) Both I and II (D) Neither I nor II	**1**

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13.	Two random variables X and Y have the same mean $\mu = 50$. If $Var(X) = 100$ and $Var(Y) = 25$, which statement is TRUE? (A) X is more consistent than Y (B) Y is more consistent than X (C) Both have equal consistency (D) Cannot be determined with the given data	**1**
14.	A trend line is considered the best fit when the sum of squares of residuals is (A) Maximum (B) Minimum (C) Positive (D) Negative	**1**
15.	A sample of 100 cereal boxes has mean = 505g and SD = 15g. The 99% confidence interval for the true mean μ is (501.125, 508.875) grams. Which of the following is the correct interpretation of this interval? (A) 99% of repeated samples will have means in the interval (501.125,508.875) grams. (B) The probability that the mean weight, μ, is between 501.125 and 508.875 grams is 0.99. (C) We are 99% confident that the calculated interval of (501.125, 508.875) grams contains the true mean weight μ. (D) Approximately 99% of all boxes have a weight between 501.125 and 508.875 grams.	**1**
16.	Let X be a random variable following the binomial distribution $B(6, p)$. If $2\,\mathrm{P}(\mathrm{X} = 4) = 3\,\mathrm{P}(\mathrm{X} = 3)$, then the value of p is: (A) $\frac{1}{3}$ (B) $\frac{1}{2}$ (C) $\frac{2}{3}$ (D) $\frac{3}{4}$	**1**
17.	Suppose a random variable X follows the binomial distribution with parameters n and p, where $0 < p < 1$. If $\frac{P(X=r)}{P(X=n-r)}$ is independent of n and r, then p equals (A) $\frac{1}{2}$ (B) $\frac{1}{3}$ (C) $\frac{1}{5}$ (D) $\frac{1}{7}$	**1**
18.	A firm manufacturing two types of lubricants whose non-negative production quantities, represented by decision variables x and y satisfy the following constraints: $$x \geq 2, \quad y \leq 3, \quad x + y = 5$$ Then the feasible region of the above LPP is: (A) A triangle (B) A quadrilateral (C) A line segment (D) unbounded	**1**

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	Assertion-Reason Based Questions **Directions: Question numbers 19 and 20 are Assertion and Reason based questions carrying 1 mark each. Two statements are given, one labelled Assertion (A) and the other labelled Reason (R).** **Select the correct answer from the options (A), (B), (C) and (D) as given below:** (A) Both Assertion (A) and Reason (R) are true and (R) is the correct explanation of Assertion (A). (B) Both Assertion (A) and Reason (R) are true but (R) is not the correct explanation of 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):** Let A be a non-singular square matrix of order 3. If $\|A\| = 4$, then the value of $\|2.adj\ (A)\|$ is 128. **Reason (R):** For a matrix A, $\|adj(A)\| = \|A\|^{n-1}$ and $\|k\ A\| = k\ \|A\|$	**1**
20.	**Assertion (A):** If two probability distributions have the same mean, they must have the same variance. **Reason (R):** Variance measures the spread of data around the mean and is calculated as $Var(X) = E(X^2) - [E(X)]^2$	**1**
	SECTION – B (5 x 2 = 10) **This section comprises of 5 very short answer (VSA) type questions of 2 marks each.**	
21(A).	If x is an odd integer, show that $x^2 \equiv 1(mod 8)$	**2**
	OR	
21(B).	If $3^{333} \equiv x\ mod 11$, find x.	
22.	An asset was purchased for ₹120,000 with an expected salvage value of ₹10,000 and 10-year useful life. What is the asset's book value at the end of sixth year?	**2**
23.	A man rows 12 km downstream and 12 km upstream, taking 4 hours in total. If the speed of the stream is 4 km/h, find the speed of the man in still water.	**2**
24(A).	The number of customer complaints received by an e-commerce company follows a Poisson distribution. It is observed that the probability of receiving exactly 2 complaints in a day is equal to the probability of receiving exactly 3 complaints in a day. Find the mean and the variance of the distribution.	**2**
	OR	
24(B).	A metro station observes that trains arrive at a particular platform at an average rate of 20 trains per hour during peak hours. (i) What is the expected number of trains arriving in a 6-minute interval? (ii) Find the probability that exactly 2 trains arrive in a 6-minute interval. [Use $e^{-2} = 0.1353$]	

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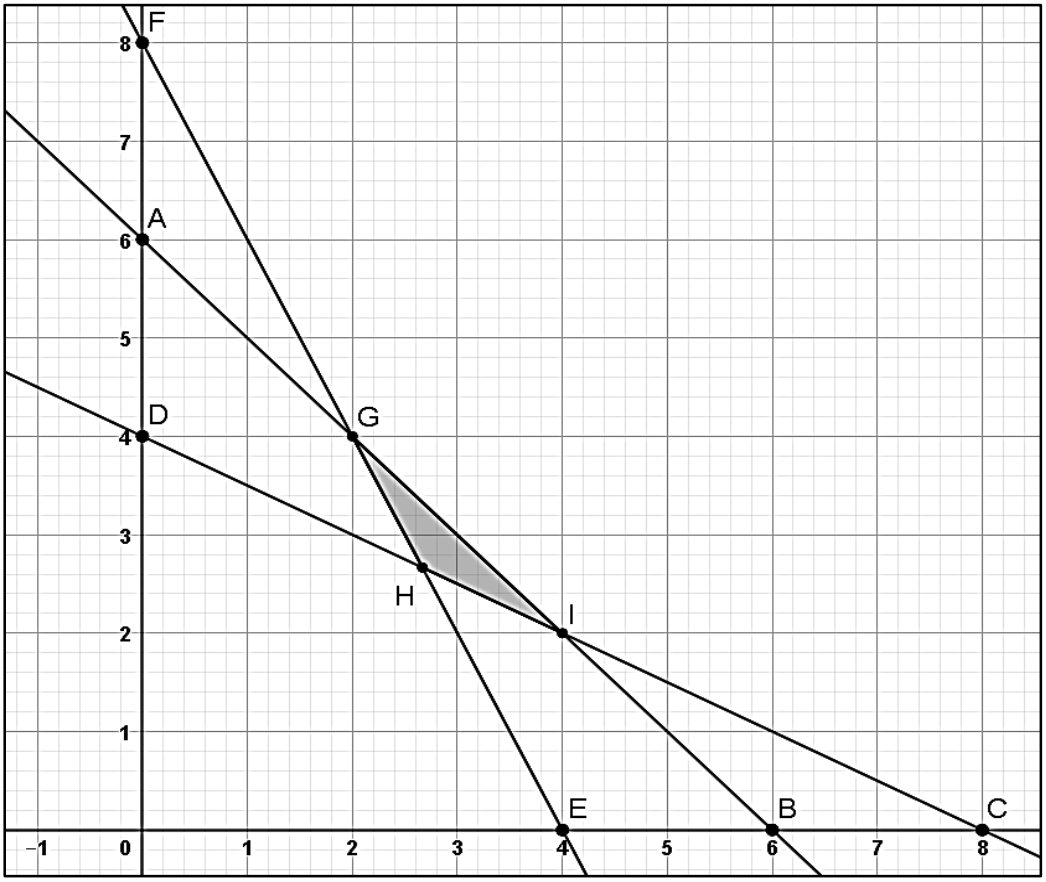
25.	The feasible region for an LPP is shown as in the graph below:  Frame all the constraints of the LPP represented by the above graph.	**2**

SECTION – C (6 x 3 = 18)

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

26(A).	The price of a stock S (in dollars) t days after its IPO is modeled by $S(t) = \frac{4t^2+1}{t}$, $t > 0$. Show that the stock price decreased for the first half of the opening day and then started increasing thereon.	**3**
	OR	
26(B).	Consider a simple market where quantity demanded is $Q_d = 15 - 2P$ and quantity supplied is $Q_S = 3P - 5$. The rate of change of price i.e., $\frac{dP}{dt}$ is half of the excess demand i.e. $(Q_d - Q_S)$. (i) Show that $\frac{dP}{dt} = \frac{1}{2}(20 - 5P)$. (ii) If $P = 2$ when $t = 0$, then show that $P = 2(2 - e^{-2.5t})$	
27.	A ₹1000 bond with a 4% coupon rate is 5 years until maturity and pays quarterly interest. If the annual market yield to maturity is 6%, what is the purchase price of the bond? [Given: $1.015^{-20} = 0.742$]	**3**
28(A).	The overall increase in a company's market share was 33.1%. Management reports the growth rate as a CAGR of 8.5%. Assuming the CAGR is accurate, how many years did it take for the market share to grow this much? [Use $\log(1.331) = 0.124$ and $\log(1.085) = 0.035$]	**3**

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	OR	
28(B).	A company needs to accumulate ₹ 45,000,000 in n years to replace a fleet of vehicles. They decide to make annual deposits of ₹ 5,00,000 at the end of each year into a sinking fund. If the interest rate is 15% compounded annually, then in how many years will it take to reach the target? [Use $\log(14.5) = 1.161$ and $\log(1.15) = 0.061$]	
29.	For the matrix $A = \begin{bmatrix} 1 & 2 \\ 2 & 1 \end{bmatrix}$, show that $A^3 - 7A - 6I = O$, where I is an identity matrix of order 2 and O is a zero matrix of order 2×2. Hence find A^{-1}.	**3**
30.	In an examination, 2000 students appeared and the mean of the normal distribution of marks is 30 with standard deviation as 6.25. Find how many students are expected to score: (i) between 20 and 40 marks? (ii) less than 25 marks? [Use $P(0 \leq Z < 1.6) = 0.4452$ and $P(0 \leq Z \leq 0.8) = 0.2881$]	**3**
31.	A nutritionist claims that the average daily calorie intake of Indian teenagers is 2200 calories. To verify this claim, a random sample of 25 teenagers was selected, and their daily calorie intake was recorded. The sample mean was found to be 2080 calories with a sample standard deviation of 280 calories. Test at the 5% level of significance whether the nutritionist's claim is valid. Assume that the calorie intake follows a normal distribution. [Use $t_{24}(0.025) = 2.064$]	**3**
	SECTION – D (4 x 5= 20) **This section comprises of 4 long answer (LA) type questions of 5 marks each.**	
32.	Under monopoly, the quantity sold and market price are determined by demand function $p = 274 - x^2$. If the marginal cost for a profit maximising monopolist is equal to $4 + 3x$, find the consumer's surplus.	**5**
33(A).	A textile factory manufactures three types of fabrics: Cotton (C), Silk (S), and Wool (W). These fabrics must pass through three processing units: Weaving (U_1), Dyeing (U_2), and Packaging (U_3). The per hour processing speeds of the units are as follows: • Unit U_1 (Weaving): 20 units of Cotton, 40 units of Silk, 20 units of Wool. • Unit U_2 (Dyeing): 25 units of Cotton, 50 units of Silk, 50 units of Wool. • Unit U_3 (Packaging): 20 units of Cotton, 20 units of Silk, 40 units of Wool. The total available processing time for the units are 20 hours for Weaving (U_1), 12 hours for Dyeing (U_2), and 19 hours for Packaging (U_3). Using Cramer's Rule, find the number of units of Cotton, Silk, and Wool that can be produced if the available time is fully utilized.	**5**
	OR	

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<table>
<tr><td>33(B).</td><td>"Cyber-Safe" has upgraded their encryption protocol. They now use a more complex Encoding Matrix (E) to encrypt the 3-letter keyword that unlocks their central server. The encryption follows the formula: $\mathrm{C} = \mathrm{E} \,.\, \mathrm{P}$, where P is the column matrix of the letter positions $(\mathrm{A} = 1, \mathrm{B} = 2, \mathrm{C} = 3, \ldots, \mathrm{Z} = 26)$.
You are an interceptor who has received an encrypted message matrix C and you have managed to crack the Encoding Matrix E.
The Encoding matrix E is given as $\mathrm{E} = \begin{bmatrix} 2 & 1 & 1 \\ 1 & 0 & 1 \\ 0 & 2 & 1 \end{bmatrix}$
The intercepted encrypted matrix C is given as $\mathrm{C} = \begin{bmatrix} 52 \\ 36 \\ 35 \end{bmatrix}$
Using matrix algebra, determine the original numerical matrix P. Also decode the numbers into letters to reveal the 3-letter secret code word.</td><td></td></tr>
<tr><td>34.</td><td>A farmer can buy local goats at ₹400 each and hybrid goats at ₹600 each. A local goat produces milk worth ₹190 per week, while a hybrid goat produces milk worth ₹250 per week. The weekly maintenance cost of each goat is ₹60. The farmer has at most ₹12,000 to spend on buying goats and can maintain not more than 22 goats.

Formulate the Linear Programming Problem and find how many local goats and hybrid goats the farmer should buy to maximize the weekly profit? Also, find the maximum profit.</td><td>5</td></tr>
<tr><td>35(A).</td><td>The following data represents the production of wheat in India (in Million Tonnes) over a period of 9 years. Due to climatic variations, the production fluctuates annually:

<table><tr><th>Year</th><th>Production (in Million Tonnes)</th></tr><tr><td>2015</td><td>86</td></tr><tr><td>2016</td><td>92</td></tr><tr><td>2017</td><td>98</td></tr><tr><td>2018</td><td>100</td></tr><tr><td>2019</td><td>103</td></tr><tr><td>2020</td><td>108</td></tr><tr><td>2021</td><td>109</td></tr><tr><td>2022</td><td>107</td></tr><tr><td>2023</td><td>110</td></tr></table>
Calculate the trend values using the 4-Year Centred Moving Average method for the given data.</td><td>5</td></tr>
<tr><td></td><td>OR</td><td></td></tr>
</table>

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35(B). The "Digital India" initiative has led to a massive surge in digital payment transactions across the country. The following data represents the volume of digital transactions (UPI, NEFT, IMPS, debit card etc.) in India (in Crores) for 6 consecutive years. The growth has been significant due to the push for a digital economy.

Year	2018	2019	2020	2021	2022	2023
Volume (in crores)	2071	3134	4572	5554	8839	13462

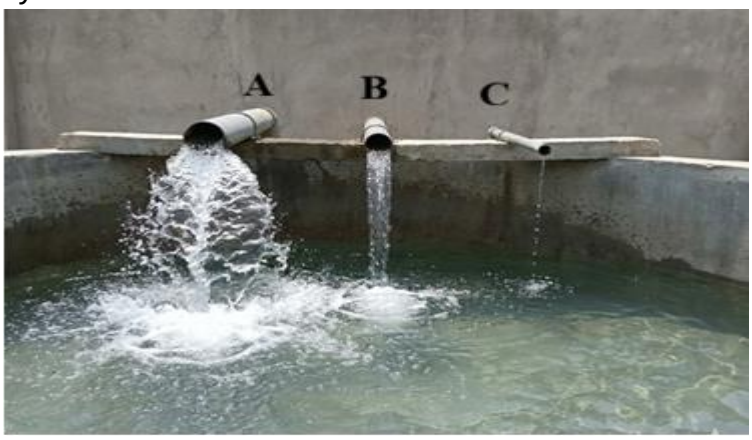
(i) Fit a straight-line trend to the above data using the method of Least Squares.

(ii) Estimate the likely volume of transactions for the year 2025, assuming the current trend continues.

SECTION – E (3 x 4 = 12)

This section comprises of 3 case-study/passage-based questions of 4 marks each with sub parts. The first two case study questions have three sub parts (i), (ii), (iii) of marks 1, 1, 2 respectively. The third case study question has two sub parts of 2 marks each

36. Three pipes A, B and C can fill a tank in 12 hours, 15 hours and 20 hours respectively. Pipe A is kept open continuously. Pipes B and C in that order are open alternately for one hour each.



Based upon the above information, answer the following questions:

(i) Find the part of the tank filled in one hour when pipes A and C are open together. **1**

(ii) Find the part of the tank filled in one hour when pipes A and B are open together. **1**

(iii) (A) Find the part of tank filled by the three pipes in the first 6 hours. **2**

OR

(iii) (B) Find the part of the unfilled tank at the end of 7 hours.

37. The cost of building an office block, x floors high, consists of three components:

- ₹ 80 crores for the land
- ₹ 2 crores per floor
- Extra structural costs ₹ $(0.08\,x)$ crores for each floor, where x is the total number of floors.

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	Based on the above information, answer the following questions: (i) Find the total cost of building the office block x floors high. (ii) Find the average cost per floor in terms of x. (iii) (A) Find, how many floors the office block should have if the average cost per floor is to be minimized? **OR** (iii) (B) Find, for how many floors the average cost keeps decreasing? [Use $\sqrt{10} = 3.2$]	**1** **1** **2**
38.	A couple wishes to purchase a house for ₹15,00,000 with a down payment of ₹4,00,000. If they amortize the balance at an interest rate of 9% per annum compounded monthly for 10 years. (i) Find the monthly installment using the flat rate method. (ii) Find the monthly installment using the reducing balance method. [Use $(1.0075)^{120} = 2.451$ and $\frac{2.451}{1.451} = 1.69$]	 **2** **2**

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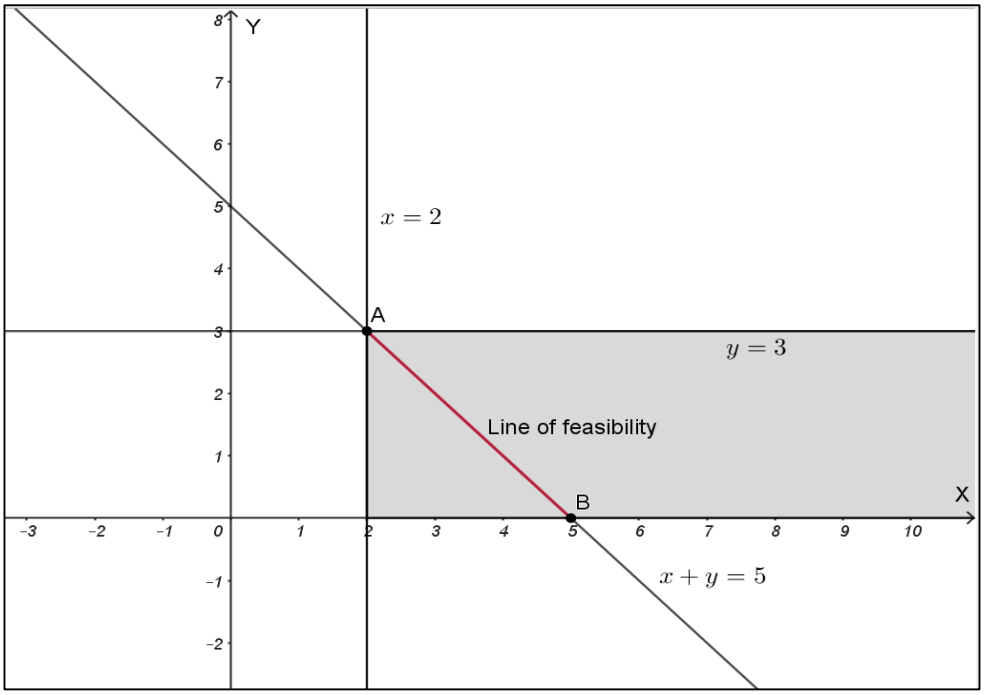
APPLIED MATHEMATICS (CODE-241)
MARKING SCHEME
CLASS- XII (2026-27)

SECTION – A (Solutions of MCQs of 1 Mark each)

Q. No.	ANS	HINTS/SOLUTIONS	Marks
1.	**(D)**	$\boldsymbol{a + c < b + c}$ Adding the same number to both sides of an inequality preserves the inequality, regardless of whether the added number is positive or negative.	**1**
2.	**(A)**	**5: 2** • Vessel A (Milk fraction): $\frac{4}{4+5} = \frac{4}{9}$ • Vessel B (Milk fraction): $\frac{5}{5+1} = \frac{5}{6}$ • Target Mixture (Milk fraction): $\frac{5}{5+4} = \frac{5}{9}$ Required ratio $= \frac{\frac{5}{6} - \frac{5}{9}}{\frac{5}{9} - \frac{4}{9}} = \frac{5}{18} : \frac{1}{9} = 5 : 2$	**1**
3.	**(B)**	**64** A 3×3 symmetric matrix will be of the form $\begin{bmatrix} a & b & c \\ b & d & e \\ c & e & f \end{bmatrix}$ There are 6 unique entries in this matrix: a, b, c, d, e, f. Each of these entries can be either 1 or -1. ∴ Number of symmetric matrices will be $2^6 = 64$	**1**
4.	**(B)**	**450 km** Let d km be the length of the racecourse. Let S_A , S_B and S_C be the constant speeds of cars A, B and C respectively. $S_A : S_B = d : d - 45$, $S_B : S_C = d : d - 50$ and $S_A : S_C = d : d - 90$ Now, $\frac{S_A}{S_C} = \frac{S_A}{S_B} \times \frac{S_B}{S_C}$ $\Rightarrow \frac{d}{d-90} = \frac{d}{d-45} \times \frac{d}{d-50}$ $\Rightarrow (d-45)(d-50) = d(d-90) \quad \Rightarrow d^2 - 95d + 2250 = d^2 - 90d$ $\Rightarrow 5\,d = 2250 \quad \Rightarrow d = 450\ km$	**1**
5.	**(B)**	**2** $\frac{dy}{dx} = \frac{dy/dt}{dx/dt} = \frac{2t}{1/t} = 2t^2 \Rightarrow \frac{d^2y}{dx^2} = \frac{d}{dt}\left(\frac{dy}{dx}\right) \times \frac{dt}{dx} = 4t \times t = 4t^2$ $\Rightarrow \left.\frac{d^2y}{dx^2}\right]_{t=\frac{1}{\sqrt{2}}} = 2$	**1**

6.	**(D)**	**The future value of perpetuity is undefined.**	**1**
7.	**(C)**	**3** Here $y = (a + b)\log(x + c) - de^{x+k}$ can be written as $y = A\log(x + c) - de^{x}.\ e^{k}$ $\Rightarrow\ y = A\log(x + c) - Be^{x}$, where $a\ +\ b\ =\ A$ and $d.e^{k}\ =\ B$. Clearly the given differential equation has three arbitrary constants, so its order is 3	**1**
8.	**(D)**	$\boldsymbol{40(e^2 - e^1)}$ Increase in revenue $= \int_2^4 20e^{0.5x}dx\ = \frac{20\ e^{0.5x}}{0.5}\Big]_2^4 = 40\ (e^2 - e^1)$	**1**
9.	**(C)**	**Principal component increases and interest component decreases.**	**1**
10.	**(B)**	**8 %** $P = \frac{R}{i} \quad \Longrightarrow 40000 = \frac{3200}{i} \qquad \Longrightarrow i = 0.08$ $\Longrightarrow\ r = 0.08 = 8\ \%$	**1**
11.	**(B)**	$\boldsymbol{5e^{-5}}$ Mean rate per $100\ cm^2\ =\ 2$ For $250\ cm^2$, mean $\lambda = \frac{2}{100} \times 250 = 5$ $P(X = 1) = e^{-5} \times \frac{5^1}{1!} = 5e^{-5}$	**1**
12.	**(D)**	**Neither I nor II**	**1**
13.	**(B)**	**Y is more consistent than X** Variance measures spread/dispersion around mean. Lower Variance → More Consistent (as the values closer to mean) Higher Variance → Less Consistent (values more spread out) Since Y has lower variance, its values are more tightly clustered around the mean. So, Y is more consistent than X.	**1**
14.	**(B)**	**Minimum**	**1**
15.	**(C)**	**We are 99% confident that the calculated interval of (501.125, 508.875) grams contains the true mean weight μ.**	**1**
16.	**(C)**	$\boldsymbol{\frac{2}{3}}$ $2 \times 6_{C_4} \times p^4 \times q^2 = 3 \times 6_{C_3} \times p^3 \times q^3$ $\Longrightarrow 30\ p^4q^2 = 60\ p^3q^3$ $\Longrightarrow p = 2q$ $\Longrightarrow p = 2(1 - p)$ $\therefore p = \frac{2}{3}$	**1**

17.	**(A)**	$\frac{1}{2}$ $\frac{P(X=r)}{P(X=n-r)} = \frac{n_{C_r} p^r q^{n-r}}{n_{C_{n-r}} p^{n-r} q^r} = \left(\frac{p}{q}\right)^{2r-n}$ which will be independent of n and r only when $\frac{p}{q} = 1$ i.e., $p = q = \frac{1}{2}$	**1**
18.	**(C)**	**A line segment**  The feasible region is the line segment $x + y = 5$.	**1**
19.	**(C)**	**Assertion (A) is true but Reason (R) is false.** $\|2.adj\ (A)\| = 2^3 \|adj(A)\| = 8 \times 4^2 = 128$. So, Assertion is true, whereas Reason is false as $\|k\ A\| = k^n\ \|A\|$	**1**
20.	**(D)**	**Assertion (A) is false but Reason (R) is true.** Two distributions can have same mean but different variance. So, Assertion is false whereas Reason is true.	**1**

Section –B

[This section comprises of solution of very short answer type questions (VSA) of 2 marks each]

21(A).	As x is an odd integer so $x = 2n + 1$, where $n \in Z$ Now to show $x^2 \equiv 1(mod 8)$ Consider, $(2n+1)^2 = 4n^2 + 4n + 1 = 4n(n+1) + 1 = 4(2m) + 1$ $\because$ product of two consecutive integers is always even $\Rightarrow x^2 = (2n+1)^2 = 8m + 1 \equiv 1(mod 8) \Rightarrow x^2 \equiv 1(mod 8)$ $\because 8m + 1$ leaves remainder 1 when divided by 8.	**1** **1**
	OR	

21(B).	Given $(3)^{333} \equiv x\,(mod 11)$, to find x. We have, $3^5 \equiv 243\,(mod 11) \equiv 1\,(mod\ 11)$ $\Rightarrow 3^5 \equiv 1(mod 11) \quad \Rightarrow (3^5)^{66} \equiv 1^{66} mod 11 \equiv 1\, mod 11$ $\Rightarrow 3^{330} \equiv 1(mod 11) \quad \Rightarrow 3^{330} \times 3^3 \equiv 27(mod 11) \quad \Rightarrow 3^{333} \equiv 27(mod 11)$ $\Rightarrow 3^{333} \equiv 5(mod 11) \quad \therefore x = 5$	½ 1 ½
22.	Under linear depreciation, $D = \frac{C-S}{n}$ $\Longrightarrow D = \frac{120000-10000}{10}$ $\Longrightarrow D = \frac{110000}{10} = 11000$ The annual depreciation is ₹ 11000. By the end of 6 years the book value $= (C - 6D) = 120000 - 6(11000)$ $= ₹\,54000$	½ ½ 1
23.	Distance covered upstream and downstream is 12 km each side. Let speed of man in still water be x km/h and speed of the stream is 4 km/h Then speed downstream $= (x + 4)$ km/h and speed upstream $= (x - 4)$ km/h According to question, $\frac{12}{x+4} + \frac{12}{x-4} = 4$ $\Longrightarrow \frac{1}{x+4} + \frac{1}{x-4} = \frac{1}{3} \quad \Longrightarrow \frac{x-4+x+4}{(x+4)(x-4)} = \frac{1}{3}$ $\Longrightarrow 6x = x^2 - 16 \quad \Longrightarrow \quad x^2 - 6x - 16 = 0$ $\Longrightarrow (x - 8)(x + 2) = 0$ $\Longrightarrow x = 8$ or $x = -2$ but $x \neq -2 \quad \therefore x = 8$ km/h. Hence speed of man in still water is 8 km/h.	½ ½ ½ ½
24(A).	Given $P(X = 2) = P(X = 3)$ $\Longrightarrow e^{-m}\frac{m^2}{2!} = e^{-m}\frac{m^3}{3!}$ $\Longrightarrow 3m^2 = m^3$ $\therefore m = 3$ So, mean = variance $= m = 3$	½ 1 ½
	OR	
24 (B).	(i) Rate per 6 minutes $= 20 \times \frac{6}{60} = 2$ trains $\therefore m = 2$ (ii) Probability of exactly 2 trains $= (X = 2) = e^{-2}\frac{2^2}{2!}$ $= 2 \times 0.1353 = 0.2706$	½ ½ 1

25.	Equation of AB is $\frac{x}{6}+\frac{y}{6}=1$ i.e, $x+y=6$	½
	Equation of CD is $\frac{x}{8}+\frac{y}{4}=1$ i.e, $x+2y=8$	½
	Equation of EF is $\frac{x}{4}+\frac{y}{8}=1$ i.e, $2x+y=8$	½
	Constraints are: $x+y\leq 6, x+2y\geq 8, 2x+y\geq 8$	½

Section –C

[This section comprises of solution of short answer type questions (SA) of 3 marks each]

26(A)	Given $S(t)=\frac{4t^2+1}{t}, t>0$ For finding intervals for increasing or decreasing let's find $S'(t)$. $S(t)=\frac{4t^2+1}{t}=4t+\frac{1}{t}$ $\Rightarrow S'(t)=4-\frac{1}{t^2}=\frac{4t^2-1}{t^2}=\frac{(2t-1)(2t+1)}{t^2}$	**1**
	Now for decreasing: $S'(t)\leq 0 \Rightarrow (2t-1)(2t+1)\leq 0 \Rightarrow -\frac{1}{2}\leq t\leq \frac{1}{2}$ As $t>0$ $\therefore$ for $0<t\leq\frac{1}{2}$, $S(t)$ is decreasing.	**1**
	⇒ for first half of the opening day, the price of the IPO decreased. **Now for increasing**: $S'(t)\geq 0 \Rightarrow (2t-1)(2t+1)\geq 0$ $\Rightarrow t\leq -\frac{1}{2}$ *and* $t\geq\frac{1}{2}$ As $t>0$ $\therefore$ for $t\geq\frac{1}{2}$, $S(t)$ is increasing.	**1**
	⇒ After the first half of the opening day, the price of the IPO kept increasing. Hence, the stock price decreased for the first half of the opening day and then started increasing thereon.	
	OR	
26(B).	(i) $\frac{dP}{dt}=\frac{1}{2}(Q_d-Q_S)=\frac{1}{2}[(15-2P)-(3P-5)]=\frac{1}{2}(20-5P)$ $\Rightarrow \frac{dP}{dt}=\frac{1}{2}(20-5P)$	**1**
	(ii) Solving the differential equation by separating the variables $\frac{dP}{20-5P}=\frac{1}{2}dt \Rightarrow \int\frac{1}{20-5P}dP=\frac{1}{2}\int dt+C$	½
	$\Rightarrow \frac{\log\lvert 20-5P\rvert}{-5}=\frac{1}{2}t+C$ $\Rightarrow 2\log\lvert 20-5P\rvert=-5t-10C$ (1)	½

	Now when $t = 0, P = 2$ $\Rightarrow 2\log\|20 - 10\| = -10\,C \quad \Rightarrow -\frac{1}{5}\log 10 = C$ Using this in (1), we get $2\log\|20 - 5P\| = -5t + 2\log 10$ $\Rightarrow 2\log\left(\frac{20-5P}{10}\right) = -5t \quad \Rightarrow \log\left(\frac{20-5P}{10}\right) = -2.5t \quad \Rightarrow \frac{20-5P}{10} = e^{-2.5t}$ $\Rightarrow 20 - 5P = 10e^{-2.5t} \quad \Rightarrow 20 - 10e^{-2.5t} = 5P$ $\Rightarrow P = 4 - 2e^{-2.5t} \quad \Rightarrow P = 2(2 - e^{-2.5t})$	½ ½
27.	Converting the parameters to their quarterly values. Periods of interest (n) = 4 x 5 = 20, yield rate r = 6% so i = 6/400 = 0.015 Face value (F) = ₹1000 Annual coupon payment = 1000 x 4% = ₹40 Quarterly coupon payment = 40/4 = ₹10 Now redemption price = face value Purchase price of bond (P) = $C\left[\frac{1-(1+i)^{-n}}{i}\right] + R(1+i)^{-n} = 10\left[\frac{1-(1+0.015)^{-20}}{0.015}\right] + 1000(1+0.015)^{-20}$ $= 10\left[\frac{1-0.742}{0.015}\right] + 1000 \times 0.742$ $= 172 + 742 = ₹914$	½ ½ 1 1
28(A).	Let PV of the share is ₹ 100 then final value = 100 + 0.331 × 100 = ₹133.10 CAGR $= \left[\left(\frac{FV}{PV}\right)^{\frac{1}{n}} - 1\right] \times 100$ $\Rightarrow 8.5 = \left[\left(\frac{133.10}{100}\right)^{\frac{1}{n}} - 1\right] \times 100 \Rightarrow 8.5 = \left[(1.331)^{\frac{1}{n}} - 1\right] \times 100$ $\Rightarrow 1.085 = (1.331)^{\frac{1}{n}}$ $\Rightarrow \log(1.085) = \frac{1}{n}\log(1.331) \quad \Rightarrow n = \frac{\log(1.331)}{\log(1.085)}$ $\Rightarrow n = \frac{0.124}{0.035} = 3.5$ years (approx.) ∴ Required number of years = 3.5 years (approx.)	½ ½ 1 1
	OR	

28(B).	Capital requirement after n years = ₹ 45,000,000 Annual payment into the sinking fund = ₹ 5,00,000 $r = 15\% \implies i = 0.15$ Now sinking fund $S = P \times \frac{(1+i)^n - 1}{i}$ $\implies 45000000 = 500000 \times \frac{(1+0.15)^n - 1}{0.15}$ $\implies 90 \times 0.15 = [(1.15)^n - 1] \implies 13.50 = (1.15)^n - 1 \implies (1.15)^n = 14.5$ Applying log on both sides we get $n\log(1.15) = \log(14.5)$ $\implies n = \frac{\log(14.5)}{\log(1.15)} = \frac{1.161}{0.061} = 19.03$ years (approx.) So, the required number of years $= 19.03$ years (approx.)	½ ½ 1 1
29.	$\mathrm{A} = \begin{bmatrix} 1 & 2 \\ 2 & 1 \end{bmatrix}$ $\mathrm{A}^2 = \begin{bmatrix} 5 & 4 \\ 4 & 5 \end{bmatrix}$ $\mathrm{A}^3 = \begin{bmatrix} 13 & 14 \\ 14 & 13 \end{bmatrix}$ $\implies \mathrm{A}^3 - 7\mathrm{A} - 6\,\mathrm{I} = \begin{bmatrix} 13 & 14 \\ 14 & 13 \end{bmatrix} - \begin{bmatrix} 7 & 14 \\ 14 & 7 \end{bmatrix} - \begin{bmatrix} 6 & 0 \\ 0 & 6 \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} = \mathrm{O}$ Now, $\mathrm{A}^{-1} = \frac{1}{6}(\mathrm{A}^2 - 7\mathrm{I}) = \frac{1}{6}\left(\begin{bmatrix} 5 & 4 \\ 4 & 5 \end{bmatrix} - \begin{bmatrix} 7 & 0 \\ 0 & 7 \end{bmatrix}\right) = \frac{1}{6}\begin{bmatrix} -2 & 4 \\ 4 & -2 \end{bmatrix} = \begin{bmatrix} -1/3 & 2/3 \\ 2/3 & -1/3 \end{bmatrix}$	½ ½ 1 1
30.	Mean $(\mu) = 30$, standard deviation $(\sigma) = 6.25$ (i) For $X = 20, Z = \frac{20-30}{6.25} = -1.6$ For $X = 40, Z = \frac{40-30}{6.25} = 1.6$ $P(20 < X < 40) = P(-1.6 < Z < 1.6) = 2\,P(0 \le Z < 1.6)$ $= 2 \times 0.4452 = 0.8904$ $\therefore$ Number of students $= 2000 \times 0.8904 = 1780.8 \approx 1781$ students (ii) For $X = 25, Z = \frac{25-30}{6.25} = -0.8$ $P(X < 25) = P(Z < -0.8) = 0.5 - P(0 \le Z \le 0.8)$ $= 0.5 - 0.2881 = 0.2119$ $\therefore$ Number of students $= 2000 \times 0.2119 = 423.8 \approx 424$ students	1 ½ 1 ½
31.	$\bar{x} = 2080,\ \mu = 2200$ $n = 25, s = 280$ H_0: Null hypothesis : There is no significant difference between $\bar{x}$ and μ H_1: Alternate hypothesis : There is a significant difference between $\bar{x}$ and μ	½ ½

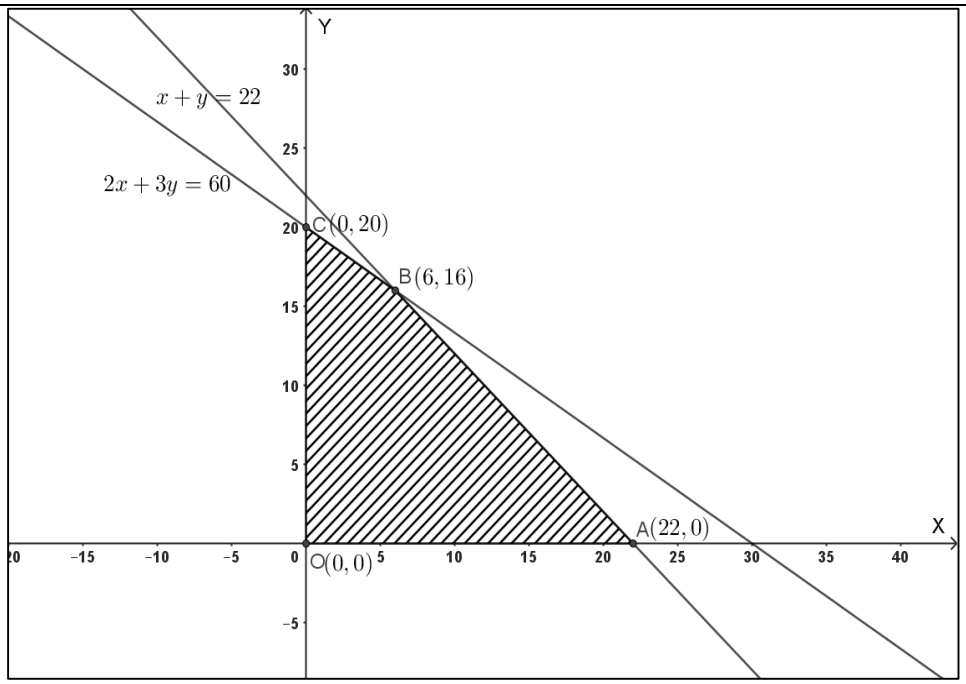
	$t = \frac{\bar{x}-\mu}{\frac{s}{\sqrt{n}}} = \frac{2080-2200}{\frac{280}{\sqrt{25}}} = -2.143$	**1**
	df $= 24$ and $t_{24}(0.025) = 2.064$	
	Since $\lvert t \rvert = 2.143 > 2.064$	**½**
	∴ Null hypothesis is rejected. So, nutritionist's claim is not valid.	**½**

Section –D

[This section comprises of solution of long answer type questions (LA) of 5 marks each]

32.	First, we use the demand function to calculate the revenue function	
	$p = 274 - x^2$	
	$R(x) = xp = x(274 - x^2) = 274x - x^3$ (1)	
	Marginal Revenue $(MR) = R'(x) = 274 - 3x^2$ (2)	**½**
	Marginal Cost $(MC) = 4 + 3x$ (given)	
	Let P be the profit	
	To calculate value of x for which P is maximum	
	Now,	
	$\frac{dP}{dx} = R'(x) - C'(x) = MR - MC = 274 - 3x^2 - 4 - 3x$ using (1) and (2)	
	$= 270 - 3x - 3x^2$	**1**
	For maximum profit, $\frac{dP}{dx} = 0$	
	$\Longrightarrow 3(90 - x - x^2) = 0 \Longrightarrow x = 9, -10$	
	but $x \neq -10$ so $x = 9$	**1**
	$\because \frac{d^2P}{dx^2} = 0 - 3 - 6x < 0$ at $x = 9$ ∴ P is maximum at $x = 9$	
	When $x_0 = 9$ then $p_0 = 274 - 9^2 = 193$	**½**
	To find consumer surplus	
	C.S. $= \int_0^{x_0} p\,dx - x_0p_0$	
	$= \int_0^9 [274 - x^2]dx - 9 \times 193$	**1**
	$= \left(274x - \frac{x^3}{3}\right)_0^9 - 1737 = 2223 - 1737 = ₹\,486$	**1**
33(A).	Let x, y and z respectively be the number of units of Cotton, Silk, and Wool that can be produced.	
	For unit U_1, $\frac{x}{20} + \frac{y}{40} + \frac{z}{20} = 20$ i.e, $2x + y + 2z = 800$ For unit U_2, $\frac{x}{25} + \frac{y}{50} + \frac{z}{50} = 12$ i.e, $2x + y + z = 600$ For unit U_3, $\frac{x}{20} + \frac{y}{20} + \frac{z}{40} = 19$ i.e, $2x + 2y + z = 760$	**1½**

	Now, $D = \begin{vmatrix} 2 & 1 & 2 \\ 2 & 1 & 1 \\ 2 & 2 & 1 \end{vmatrix} = 2(1-2) - 1(2-2) + 2(4-2) = 2 \neq 0$	½
	$D_x = \begin{vmatrix} 800 & 1 & 2 \\ 600 & 1 & 1 \\ 760 & 2 & 1 \end{vmatrix} = 800(1-2) - 1(600-760) + 2(1200-760) = 240$	½
	$D_y = \begin{vmatrix} 2 & 800 & 2 \\ 2 & 600 & 1 \\ 2 & 760 & 1 \end{vmatrix} = 2(600-760) - 800(2-2) + 2(1520-1200) = 320$	½
	$D_z = \begin{vmatrix} 2 & 1 & 800 \\ 2 & 1 & 600 \\ 2 & 2 & 760 \end{vmatrix} = 2(760-1200) - 1(1520-1200) + 800(4-2) = 400$	½
	$\therefore x = \frac{D_x}{D} = 120, y = \frac{D_y}{D} = 160$ and $z = \frac{D_z}{D} = 200$	1/2
	Hence, the firm can produce 120 units of Cotton, 160 units of Silk, and 200 units of Wool with the available time fully used.	**1**
	OR	
33(B).	$\mathrm{P} = \mathrm{E}^{-1}.\mathrm{C}$, where $\mathrm{E} = \begin{bmatrix} 2 & 1 & 1 \\ 1 & 0 & 1 \\ 0 & 2 & 1 \end{bmatrix}, \mathrm{C} = \begin{bmatrix} 52 \\ 36 \\ 35 \end{bmatrix}$ and let $\mathrm{P} = \begin{bmatrix} \mathrm{x} \\ \mathrm{y} \\ \mathrm{z} \end{bmatrix}$	½
	$\lvert\mathrm{E}\rvert = 2(0-2) - 1(1-0) + 1(2-0) = -3 \neq 0 \ \therefore \mathrm{E}^{-1}$ exists	½
	$\mathrm{E}^{-1} = \frac{1}{\lvert\mathrm{E}\rvert}\begin{bmatrix} -2 & 1 & 1 \\ -1 & 2 & -1 \\ 2 & -4 & -1 \end{bmatrix} = \frac{1}{-3}\begin{bmatrix} -2 & 1 & 1 \\ -1 & 2 & -1 \\ 2 & -4 & -1 \end{bmatrix}$	**1**
	$\Longrightarrow \mathrm{P} = \begin{bmatrix} \mathrm{x} \\ \mathrm{y} \\ \mathrm{z} \end{bmatrix} = \frac{1}{-3}\begin{bmatrix} -2 & 1 & 1 \\ -1 & 2 & -1 \\ 2 & -4 & -1 \end{bmatrix}\begin{bmatrix} 52 \\ 36 \\ 35 \end{bmatrix} = \frac{1}{-3}\begin{bmatrix} -33 \\ -15 \\ -75 \end{bmatrix}$	**1**
	$\Longrightarrow \mathrm{x} = 11, \mathrm{y} = 5, \mathrm{z} = 25$	**1½**
	Now, $11 \rightarrow \mathrm{K}, 5 \rightarrow \mathrm{E}, 25 \rightarrow \mathrm{Y}$	
	So, the secret code word is 'KEY'	½
34.	Let the number of local and hybrid goats be x and y respectively.	
	Profit on a local goat $= ₹\,(190-60) = ₹\,130$ Profit on a hybrid goat $= ₹\,(250-60) = ₹\,190$	½
	So, the LPP is	
	Maximize $Z = 130x + 190y$ subject to $400x + 600y \leq 12000$ or $2x + 3y \leq 60$ $x + y \leq 22$ $x \geq 0, y \geq 0$	**1½**



2 for correct graph

Corner Points	Value of Z
O (0,0)	0
A (22,0)	2860
B (0,20)	3800
C (6, 16)	3820 → Maximum value

1 for correct table

Hence the maximum weekly profit of ₹ 3,820 is obtained when the farmer buys 6 local goats and 16 hybrid goats.

35(A).

Year	Production	4 yearly moving total	4 yearly moving Average	Centered Total	Centered moving average
2015	86				
2016	92				
		376	94		
2017	98			192.25	96.125
		393	98.25		
2018	100			200.5	100.25
		409	102.25		
2019	103			207.25	103.625

4 yearly moving total → 1 mark

4 yearly moving average → 1½ marks

		420	105		
2020	108			211.75	105.875
		427	106.75		
2021	109			215.25	107.625
		434	108.5		
2022	107				
2023	110				

centered total → 1 mark

centered moving average → 1½ marks

OR

35(B). (i)

Year (x_i)	Volume in crores (Y)	$X = \frac{x_i - A}{0.5} = \frac{x_i - 2020.5}{0.5}$	X^2	XY
2018	2071	-5	25	-10355
2019	3134	-3	9	-9402
2020	4572	-1	1	-4572
2021	5554	1	1	5554
2022	8839	3	9	26517
2023	13462	5	25	67310
$n = 6$	$\sum Y = 37632$	$\sum X = 0$	$\sum X^2 = 70$	$\sum XY = 75052$

2½ for correct table

$a = \frac{\sum Y}{n} = \frac{37632}{6} = 6272$ **½**

$b = \frac{\sum XY}{\sum X^2} = \frac{75052}{70} = 1072.17$ (approx.) **½**

Required line is $Y = a + bX = 6272 + 1072.17\,X$ **½**

(ii) Estimate trend Value for 2025 $= 6272 + 1072.17 \times 9 = 15921.53$ crores **1**

Section –E

[This section comprises solution of 3 case- study/passage-based questions of 4 marks]

36.

(i) Part of tank filled by pipe A and C in 1 hour = $\frac{1}{12} + \frac{1}{20} = \frac{2}{15}$ **1**

(ii) Part of tank filled by pipe A and B in 1 hour = $\frac{1}{12} + \frac{1}{15} = \frac{3}{20}$ **1**

(iii) (A) Tap A always remains open and tap B and C are open alternatively for 1 hour

So, Part of tank filled in 2 hours = $\frac{1}{12} + \frac{1}{15} + \frac{1}{12} + \frac{1}{20}$

$= \frac{2}{12} + \frac{1}{15} + \frac{1}{20} = \frac{17}{60}$ **1**

Now, part of tank filled after three full cycles (6 hours)

$= 3 \times \frac{17}{60} = \frac{17}{20}$ **1**

OR

(iii) (B) Part of tank filled in 2 hours = $\frac{1}{12} + \frac{1}{15} + \frac{1}{12} + \frac{1}{20}$

$= \frac{2}{12} + \frac{1}{15} + \frac{1}{20} = \frac{17}{60}$ **½**

Now, part of tank filled after three full cycles (6 hours) = $3 \times \frac{17}{60} = \frac{17}{20}$ **½**

Part of tank left to be filled = $1 - \frac{17}{20} = \frac{3}{20}$

In the 7th hour, tank filled by pipes A and B = $\frac{1}{12} + \frac{1}{15} = \frac{3}{20}$ **½**

which is same as the part of unfilled tank, so the tank will be filled completely at the end of 7th hour. **½**

So, the part of unfilled tank at the end of 7 hours is 0.

37.

(i) Total cost: $TC(x) = 80 + 2x + (0.08x)x$

$= 80 + 2x + 0.08x^2$ **1**

(ii) Average Cost: $AC(x) = \frac{\text{Total cost}}{x} = \frac{80}{x} + 2 + 0.08x$ **1**

(iii) (A) To minimize average cost, we differentiate $AC(x)$

$AC(x) = \frac{80}{x} + 2 + 0.08x$

$AC'(x) = \frac{-80}{x^2} + 0 + 0.08 = \frac{0.08x^2 - 80}{x^2}$ **½**

For minima $AC'(x) = 0$ and $AC''(x) > 0$

Now $AC'(x) = 0$

$\Rightarrow \frac{0.08x^2 - 80}{x^2} = 0 \Rightarrow x^2 - 1000 = 0 \Rightarrow x = \pm 10\sqrt{10}$ **½**

Since $x \neq -10\sqrt{10}$ $\therefore x = 10\sqrt{10}$ $\Rightarrow x = 10(3.2) = 32$ **½**

$AC''(x) = \frac{160}{x^3} > 0$, for all $x > 0$ **½**

So, for minimum average cost per floor 32 floors should be built.

OR

	(iii) (B) For finding interval for strictly decreasing value of average cost we differentiate $AC(x)$ $AC(x) = \frac{80}{x} + 2 + 0.08\,x$ $AC'(x) = \frac{-80}{x^2} + 0 + 0.08 = \frac{0.08\,x^2 - 80}{x^2}$ For decreasing $AC'(x) \leq 0$ $\Rightarrow \frac{0.08\,x^2 - 80}{x^2} \leq 0 \Rightarrow x^2 - 1000 \leq 0$ as $x^2 > 0$ for all x. $\Rightarrow (x - 10\sqrt{10})(x + 10\sqrt{10}) \leq 0 \Rightarrow -10\sqrt{10} \leq x \leq 10\sqrt{10}$ Since $x > 0$ as number of floors can't be negative. $\therefore 0 < x \leq 10\sqrt{10} \Rightarrow 0 < x \leq 32$ So, for integral values of floors, the average cost decreases till the building of 32 floors.	½ ½ ½ ½
38.	Loan amount $= P = ₹\,(15{,}00{,}000 - 4{,}00{,}000) = ₹\,11{,}00{,}000$ $i = \frac{9}{12\times100} = 0.0075$, $n = 10 \times 12 = 120$ (i) under flat rate EMI = $P\left(i + \frac{1}{n}\right)$ = $1100000\left(0.0075 + \frac{1}{120}\right)$ $= 1100000(0.0075 + 0.0083) = 1100000 \times 0.0158 = ₹\,17{,}380$ (ii) EMI $= \frac{P\times i\times(1+i)^n}{(1+i)^n - 1}$ $= \frac{1100000\times0.0075\times(1+0.0075)^{120}}{(1+0.0075)^{120}-1}$ $= \frac{1100000\times0.0075\times2.451}{2.451-1} = 1100000 \times 0.0075 \times 1.69 = ₹\,13{,}942.50$	½ ½ 1 1 1

APPLIED MATHEMATICS – Code No.241
SAMPLE QUESTION PAPER
CLASS – XII (2025 - 26)

Maximum Marks: 80 **Time: 3 hours**

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 no. 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, 2 questions in Section C, 2 questions in Section D and one sub-part each in 2 questions of Section E.
9. Use of calculators is not allowed.

SECTION – A

This section comprises of 18 multiple choice questions and two assertion and reason type questions of 1 mark each.

Q.No.	Question	Marks
1.	In what ratio must a grocer mix two varieties of tea worth ₹ 60 per kg and ₹ 65 per kg so that by selling the mixture at ₹ 68.20 per kg the gain is 10%? (A) 3 : 2 (B) 2 : 3 (C) 2 : 5 (D) 3 : 5	1
2.	In a 100m race, A can give B a start of 10 m and can give C a start of 28 m. In the same race, B can give C a start of (A) 10 m (B) 20 m (C) 18 m (D) 8 m	1
3.	If $x = a\,t^2$ and $y = 2at$, then at $t = 2$ the value of $\frac{d^2y}{dx^2}$ is (A) $-\frac{1}{16a}$ (B) $-\frac{1}{16}$ (C) $\frac{1}{8a}$ (D) $-\frac{1}{4}$	1

4. Match the following columns to complete the sentence and choose the correct option — 1

Trend Component	**Pattern of variation**	**Time period of variation**
I. Secular trend	a. is a regular periodic variability	i. over a period more than a year
II. cyclical trend	b. has smooth, regular variations	ii. within a period of one year
III. seasonal trend	c. has oscillatory variation	iii. over a long-term period

(A) I – a – ii; II – b – iii; III – c – i (B) I – b – iii; II – c – i; III – a – ii
(C) I – b – ii; II – c – i; III – a – iii (D) I – b – ii; II – a – iii; III – c – i

5. For the annual payment R to remain the same in case the interest rate decreases from 6% to 4%, the present value of a perpetuity — 1

(A) will decrease.
(B) will remain the same
(C) will increase
(D) will no longer be valid

6. If $13 \leq k \leq 21,\ 9 \leq p \leq 19,\ 2 < m < 6$ and k, p, m are integers, then which of the following inequality is always valid? — 1

(A) $\frac{k-p}{m} < 3$ (B) $\frac{k-p}{m} \leq 4$ (C) $\frac{k-p}{m} < 2$ (D) $\frac{k-p}{m} \leq 3$

7. Let A = $\begin{bmatrix} 0 & 0 & -1 \\ 0 & -1 & 0 \\ -1 & 0 & 0 \end{bmatrix}$. The only correct statement about the matrix A is — 1

(A) $A^2 = I$ (B) $A' = -I$ (C) $|A| = 0$ (D) A is a scalar matrix

8. If $\int \frac{x+2}{2x^2+6x+5} dx = P \int \frac{4x+6}{2x^2+6x+5} dx + \frac{1}{2} \int \frac{dx}{2x^2+6x+5}$ then the value of P is — 1

(A) $\frac{1}{3}$ (B) $\frac{1}{2}$ (C) $\frac{1}{4}$ (D) $\frac{1}{6}$

9. The central limit theorem states that if the sample size_____ — 1

(A) increases then sampling distribution must approach normal distribution
(B) decreases then the sample distribution must approach normal distribution
(C) increases then the sampling distribution much approach an exponential distribution
(D) decreases then the sampling distribution much approach an exponential distribution

10.	Two groups of students from different schools are tested for their average mathematics scores. Group 1 has 12 students, and Group 2 has 10 students. What is the degree of freedom for this independent two-sample t-test? (A) 20 (B) 21 (C) 19 (D) 22	1
11.	If $P = \begin{bmatrix} 1 & \alpha & 3 \\ 1 & 3 & 3 \\ 2 & 4 & 4 \end{bmatrix}$ is adjoint of a 3 x 3 matrix A and $\lvert A \rvert = 4$, then α is equal to (A) 4 (B) 8 (C) 11 (D) 256	1
12.	The order of the differential equation $\frac{d}{dx}\left[\left(\frac{dy}{dx}\right)^3\right] = 0$ is (A) 2 (B) 1 (C) 5 (D) 3	1
13.	At what rate of interest will the present value of a perpetuity of ₹ 500 payable at the end of each quarter be ₹ 40000? (A) 1.25 % p.a (B) 2.5 % p.a. (C) 5 % p.a. (D) 6 % p.a	1
14.	If A and B are two square matrices such that $B = -A^{-1}BA$, then $(A + B)^2$ is equal to (A) 0 (B) $A^2 + B^2$ (C) $A^2 + B^2 + 2AB$ (D) $A^2 + B^2 - 2AB$	1
15.	In solving the LPP: Minimize $Z = 6x + 10y$ subject to constraints $x \geq 6,\ y \geq 2,\ 2x + y \geq 10,\ x \geq 0,\ y \geq 0$ the redundant constraints are (A) $x \geq 6, y \geq 2$ (B) $y \geq 2$ (C) $x \geq 6$ (D) $2x + y \geq 10, x \geq 0, y \geq 0$	1
16.	A fair coin is tossed 6 times. Let X be the number of heads obtained. If $P(X = k) = P(X = k + 2)$, then the value of k is (A) 4 (B) 3 (C) 2 (D) 1	1
17.	A and B are square matrices of order 3. The determinants of A and B are 5 and 4 respectively, then the determinant of the matrix $4A^2\ B$ is (A) 64 (B) 400 (C) 1600 (D) 6400	1
18.	Using flat rate method, the EMI to repay a loan of ₹ 20000 in $2\frac{1}{2}$ years at an interest rate of 8 % p.a. is (A) ₹ 700 (B) ₹ 800 (C) ₹ 90 (D) ₹ 100	1

	Questions number 19 and 20 are Assertion and Reason based questions carrying 1 mark each. Two statements are given, one labelled Assertion (A) and the other labelled Reason (R). **Select the correct answer from the options (A), (B), (C) and (D) as given below:** (A) Both Assertion (A) and Reason (R) are true and (R) is the correct explanation of Assertion (A). (B) Both Assertion (A) and Reason (R) are true but (R) is not the correct explanation of 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):** Let A be a 2 x 2 matrix, then $adj\ (adj\ A) = A$ **Reason (R):** $\|adj\ A\| = \|A\|$	1
20.	**Assertion (A):** If a random variable X follows a binomial distribution with parameters n and p, then the mean of X is always less than its variance. **Reason (R):** Probability of an event lies between 0 and 1 (0 and 1 included).	1
	SECTION – B **This section comprises of 5 very short answer (VSA) type questions of 2 marks each**.	
21(A).	Find the last digit of $(2^{100} + 100!)$ **OR**	2
21(B).	Without finding the values of the square roots, prove that the inequality $\sqrt{5}+\sqrt{3} > \sqrt{6}+\sqrt{2}$ holds true.	
22.	A random variable X has the following probability distribution: $P(X=x) = \begin{cases} a\,x, & \text{if } x = 1,2,3 \\ b, & \text{if } x = 4 \end{cases}$ where a and b are constants. If it is given that the mean of the distribution is 2.8, then find the values of a and b.	2
23.	The population of a town increases from 75,000 to 1,25,000 over a period of time. If the compound annual growth rate is 5%, calculate the number of complete years it will take for the population to grow from 75,000 to 1,25,000. [Use $\log(1.67) = 0.223$ and $\log(1.05) = 0.021$]	2
24(A).	A small town experiences an average of 2 power outages per month. Assuming the number of power outages follows a Poisson distribution, find the probability that in a given month, there will be exactly 3 power outages, given that there will be at least one power outage (Use $e^{-2} = 0.14$). **OR**	2

24(B).	A certain type of electronic component fails at a rate of 2 failures per 1000 hours of operation. Assuming the failures follow a Poisson distribution, find the probability that in a 5000-hour operation, there will be more than 1 failure. (Use $e^{-10} = 4.54 \times 10^{-5}$)	
25.	The value $V(t)$ of a machine at time t, in years, follows a linear depreciation model, where the initial value of the machine is ₹ 25,000 and it depreciates by ₹ 2,500 each year. At what time will the value of the machine be half of its initial value? Find the value of the machine after 6 years.	2
	SECTION – C **This section comprises of 6 short answer (SA) type questions of 3 marks each**.	
26.	A boat running upstream takes 8 hours 48 minutes to cover a certain distance, while it takes 4 hours to cover the same distance running downstream. What is the ratio between the speed of the boat and speed of the water current?	3
27(A).	A curve given by $y = px^3 + qx^2$, where p and q are constants, has one of its critical points at $(1, -1)$. Find the values of p and q. Also find the other critical point. **OR**	3
27(B).	The total revenue function for a commodity is $R = 15x + \frac{x^2}{3} - \frac{x^4}{36}$. Show that the point at which average revenue is maximum, the average revenue and marginal revenue has the same value.	
28(A).	A bond having a face or maturity value of ₹ 56,000, redeemable at par in 6 years carries a coupon rate of 7% p.a., to be paid quarterly. Find the purchase price of the bond if effective yield rate is to be 9% p.a., compounded quarterly. [Use $(1.0225)^{-24} = 0.58$] **OR**	3
28(B).	A company purchases a machine for ₹ 50,000. The machine is expected to be used for 8 years, and its scrap value at the end of this period is estimated to be ₹ 6,000. A sinking fund is set up for replacing the machine with a new one after 8 years, which is expected to cost 30% more than the current machine. The sinking fund earns 6% interest per annum, compounded annually. Calculate the yearly payment required to be put in the sinking fund. [Use $(1.06)^8 = 1.6$]	
29.	Pipes A, B and C can fill a tank in 30, 60 and 120 minutes respectively. Pipes B and C are kept open for 10 minutes, and then Pipe B is shut while Pipe A is opened. Pipe C is closed 10 minutes before the tank overflows. How long does it take to fill the tank?	3

30.	Hole punching machine is set to punch a hole 1.84 cm in diameter in a strip of sheet metal in a manufacturing process. The strip of metal is then creased and sent on to the next phase of production, where a metal rod is slipped through the hole. It's important that the hole be punched to the specified diameter of 1.84 cm. To test punching accuracy, technicians randomly sampled 16 punched holes and measured the diameters. The sample data (in centimetres) has a mean of 1.85 and variance 0.0064. Set up null and alternate hypothesis to test if the machine is working properly (whether the holes are being punched an average of 1.84 centimetres), at an alpha level of 0.05. Assume the punched holes are normally distributed in the population. Given: [$t(0.05,15) = 2.131$]	3
31.	A company produces two types of products, A and B. The company is limited by a constraint on the number of labour hours available, which is 500 hours. Product A requires 4 hours of labour per unit, while Product B requires 6 hours of labour per unit. Additionally, the company is restricted by a maximum of 80 units of product A and 60 units of product B that can be produced per day. The profit per unit of product A is ₹ 30, and the profit per unit of product B is ₹ 40. Formulate the Linear Programming Problem (LPP) to maximize the profit.	3
	SECTION – D **This section comprises of 4 long answer (LA) type questions of 5 marks each**.	
32(A).	The purchase officer of a pharmaceutical company informs the production manager that during the month, following supply of three chemicals i.e., Aspirin (A), Caffeine (C) and Decongestant (D) used in the production of three types of pain-killing tablet will be 16 kg, 10 kg and 16 kg respectively. According to the specification, each strip of 10 tablets of Paingo requires 2 gm of A, 3 gm of C and 1 gm of D. The requirements for other tablets are: X-prene | 4 gm of A | 1 gm of C | 3 gm of D Relaxo | 1 gm of A | 2 gm of C | 3 gm of D Taking suitable variables form the system of linear equations and use matrix method to find the number of strips of each type so that the raw materials are consumed entirely. **OR**	5
32(B).	Given the following equations for two related markets A and B, find the equilibrium conditions for each market and the price for each by Cramer's rule: $x_d(A) = 82 - 3\,p_A + p_B$ $\quad x_S(A) = -5 + 15\,p_A$ $x_d(B) = 92 + 2\,p_A - 4p_B$ $\quad x_S(B) = -6 + 32\,p_B$ where x_d and x_S denotes the quantity demanded and quantity supplied respectively and p_A and p_B represents the price for each in the two markets.	

33. A company has approximated the marginal cost and marginal revenue functions for one of its products by $MC = 81 - 16x + x^2$ and $MR = 20x - 2x^2$ respectively. Determine the profit maximizing output and the total profit at the optimum output, assuming fixed cost as zero. 5

34(A). The annual rice production (in million tonnes) in a particular state over the past five years is as follows: 5

Year	2017	2018	2019	2020	2021
Rice Production (million tonnes)	9.5	10.0	10.5	11.2	12.0

Find the best fitted trend line by the method of least squares and tabulate the trend values that represents the rice production. Also predict the production for the year 2025.

OR

34(B). The following data shows the number of vehicles passing through a busy traffic intersection on a specific road in National Capital of India during the months of March to December in 2023:

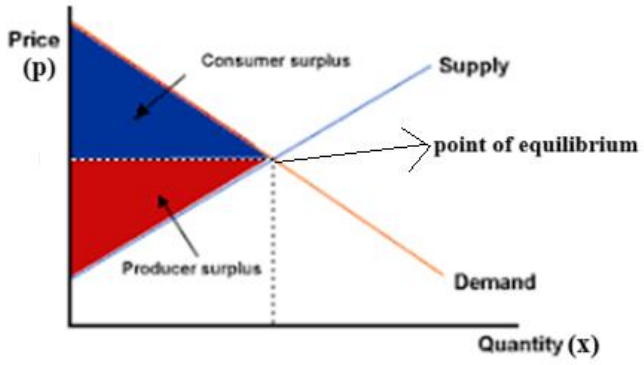
Month	**Number of vehicles (in thousands)**
March	30
April	35
May	38
June	36
July	40
August	42
September	39
October	45
November	48
December	47

Calculate the 3-month moving average for the given data and determine the trend. Plot the graph to represent the trend values.

35.	Mr. Sharma plans to buy a car worth ₹10,00,000. He makes a down payment of 20% of the car price and takes a loan for the remaining amount. The loan is to be repaid in 5 years with an annual interest rate of 10%, compounded monthly. Calculate the monthly EMI using the reducing balance method and the total interest paid over the loan period. [Use $(1.0083)^{60} = 1.64$]	5

SECTION – E

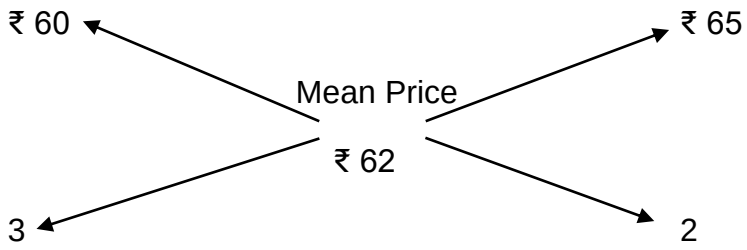
This section comprises of 3 case-study/passage-based questions of 4 marks each with sub parts. The first two case study questions have three sub parts (i), (ii), (iii) of marks 1, 1, 2 respectively. The third case study question has two sub parts of 2 marks each

36.	The Mathematics scores of a group of 500 students follow a normal distribution with a mean of 75 and a standard deviation of 8. Based on this data, answer the following questions: (i) What percentage of students scored below 75 marks? (ii) Find the number of students who scored more than 82 marks. (iii) (A) Calculate the number of students scoring between 67 and 83 marks. **OR** (iii) (B) The top 10% of students are awarded a scholarship. The Z-score for the 90th percentile is 1.28. Determine the minimum score required to qualify for the scholarship. Use $P(Z < 0.875) = 0.8092, P(Z < 1) = 0.8413, P(Z < -1) = 0.1587$	1 1 2
37.	**Analysing the Grain Market for Wheat**  In the grain market for wheat, the relationship between price and quantity demanded can be modelled using a linear demand function. Suppose the following information is available from market data: • At a price of ₹ 20 per kilogram, the quantity demanded is 400 tons. • At a price of ₹ 25 per kilogram, the quantity demanded decreases to 200 tons.	

	Based on the above information, answer the following questions: (i) Formulate the linear demand function based on the given data. (ii) Suppose the supply function is given by $p_s = -15 + \frac{x}{20}$, determine the equilibrium price and quantity. (iii) (A) Using integration, calculate the consumer surplus at the equilibrium price. **OR** (B) Using integration, calculate the producer surplus at the equilibrium price.	1 1 2
38.	If a young man rides his motorcycle at 25 km/hr, he had to spend ₹ 2 per km on petrol. If he rides at a faster speed of 40 km/hr, the petrol cost increases to ₹ 5 per km. He has ₹ 100 to spend on petrol and wishes to find the maximum distance he can travel within one hour. Based on the given information, answer the following questions: (i) Formulate the objective function and the constraints of the above Linear programming problem. (ii) Find the maximum distance the man can travel within one hour.	2 2

***Please note that the assessment scheme of the Academic Session 2024-25 will continue in the current session i.e. 2025-26**

APPLIED MATHEMATICS – Code No.241
MARKING SCHEME
CLASS – XII (2025 - 26)

SECTION – A (Solutions of MCQs of 1 Mark each)		
Q. No.	**HINTS/SOLUTIONS**	**Marks**
1.	**Answer: (A)** S. P of 1 kg of the mixture $= ₹\ 68.20$, Gain $= 10\%$ C. P of 1 kg of the mixture $= ₹\ \left(\frac{100}{110} \times 68.20\right) = ₹\ 62$ By the rule of alligation, we have Cost of 1 kg tea of 1st kind Cost of 1 kg tea of 2nd kind  ∴ Required ratio $= 3:2$	**1**
2.	**Answer: (B)** Ratio of distances covered by three of them can be expressed as A : B: C :: 100 : 90 : 72 When B covers 90m, C covers 72m When B covers 100m, C covers $\frac{72}{90} \times 100 = 80$ m. ∴ B can give C a start of $(100 - 80)$ m = 20 m	**1**
3.	**Answer: (A)** $\frac{dy}{dx} = \frac{dy/dt}{dx/dt} = \frac{2a}{2at} = \frac{1}{t} \quad \Rightarrow \frac{d^2y}{dx^2} = \frac{d}{dx}\left(\frac{1}{t}\right) = -\frac{1}{t^2}\frac{dt}{dx} = -\frac{1}{t^2}\left(\frac{1}{2at}\right) = -\frac{1}{2at^3}$ $At\ t\ =\ 2, \frac{d^2y}{dx^2} = -\frac{1}{2a(2)^3} = -\frac{1}{16a}$	**1**
4.	**Answer: (B)** I – b – iii; II – c – i; III – a – ii	**1**
5.	**Answer: (C)** The present value of the perpetuity will increase as interest rate and present value of perpetuity are in inverse variation.	**1**

6.	**Answer: (B)** $\frac{k-p}{m}$ will be largest when k is largest, p is smallest and m is smallest So $\frac{k-p}{m} \leq \frac{21-9}{3} = \frac{12}{3} = 4$	**1**
7.	**Answer: (A)** $A^2 = I$	**1**
8.	**Answer: (C)** $x + 2 = \frac{1}{4}(4x + 6) + \frac{1}{2}$ so, $P = \frac{1}{4}$	**1**
9.	**Answer: (A)** increases then sampling distribution must approach normal distribution	**1**
10.	**Answer: (A)** Degree of freedom $= 12 + 10 - 2 = 20$	**1**
11.	**Answer: (C)** $\|P\| = 1(12 - 12) - \alpha(4 - 6) + 3(4 - 6) = 2(\alpha - 3)$ Given $P = adj\ A \Rightarrow \|P\| = \|adj\ A\| = \|A\|^2$ $\Rightarrow 2(\alpha - 3) = 4^2 = 16 \Rightarrow 2\alpha = 16 + 6 = 22$ $\Rightarrow \alpha = 11$	**1**
12.	**Answer: (A)** $\frac{d}{dx}\left[\left(\frac{dy}{dx}\right)^3\right] = 0 \Rightarrow 3\left(\frac{dy}{dx}\right)^2 \frac{d^2y}{dx^2} = 0$ Order of the differential equation $= 2$	**1**
13.	**Answer: (C)** $P = \frac{R}{i}$ $\Longrightarrow 40000 = \frac{500}{i}$ $\Longrightarrow i = 0.0125$ $\Longrightarrow \frac{r}{4} = 0.0125$ $\therefore r = 0.0125 \times 4 = 0.05 = 5\ \%$ p.a.	**1**

14.	**Answer: (B)** Given $\mathrm{B} = -\mathrm{A}^{-1}\mathrm{BA} \Rightarrow AB = -BA$ $\therefore (\mathrm{A}+\mathrm{B})^2 = (\mathrm{A}+\mathrm{B})(\mathrm{A}+\mathrm{B})$ $= \mathrm{A}^2 + \mathrm{AB} + \mathrm{BA} + \mathrm{B}^2 = \mathrm{A}^2 - \mathrm{BA} + \mathrm{BA} + \mathrm{B}^2 = \mathrm{A}^2 + \mathrm{B}^2$	**1**
15.	**Answer: (D)** Redundant constraints are the constraints that can be removed without changing or affecting the feasible region of a problem $2x + y \geq 10, x \geq 0, y \geq 0$ are the constraints that can be removed.	**1**
16.	**Answer: (C)** $P(X = k) = P(X = k+2)$ $\Rightarrow {}^6C_k \left(\frac{1}{2}\right)^{6-k} \left(\frac{1}{2}\right)^k = {}^6C_{k+2} \left(\frac{1}{2}\right)^{6-k-2} \left(\frac{1}{2}\right)^{k+2}$ $\Rightarrow {}^6C_k = {}^6C_{k+2} \Rightarrow 2k+2 = 6 \ (\because k \neq k+2)$ $\Rightarrow k = 2$	**1**
17.	**Answer: (D)** $\lvert 4A^2B \rvert = 4^3 \lvert A \rvert^2 \lvert B \rvert = 4^3 \times 5^2 \times 4 = 6400$	**1**
18.	**Answer: (B)** $n = 2\frac{1}{2}$ years $= 30$ months $I = ₹\,20000 \times \frac{8}{100} \times \frac{5}{2} = ₹\,4000$ EMI $= \frac{P+I}{n}$ $= ₹\left(\frac{20000+4000}{30}\right) = ₹\,800$	**1**
19.	**Answer: (B)** $adj\,(adj\,A) = adj\left[\text{adj}\begin{pmatrix} a & b \\ c & d \end{pmatrix}\right] = adj\begin{pmatrix} d & -b \\ -c & a \end{pmatrix} = \begin{pmatrix} a & b \\ c & d \end{pmatrix} = A$ So, assertion is true. $\lvert adj\,A \rvert = da - b(-c) = ad - bc = \lvert A \rvert$ Reason statement is true However, Reason statement is not the correct explanation of Assertion. $\therefore$ Both Assertion (A) and Reason (R) are true and (R) is not the correct explanation of Assertion (A).	**1**
20.	**Answer: (D)** Since $0 \leq p \leq 1$, we have $0 \leq (1-p) \leq 1$ $np(1-p) \leq np \Rightarrow$ Variance $\leq$ Mean $\therefore$ Assertion (A) is false and Reason (R) is true.	**1**

Section –B

[This section comprises of solution of very short answer type questions (VSA) of 2 marks each]

21 (A)	Last digit can be obtained by division with 10. required answer = $(2^{100} + 100!\,)mod\ 10$ $2^5 mod 10 = 32 mod 10 \equiv 2 mod 10 \Rightarrow 2^5 \equiv 2 \text{mod} 10 \Rightarrow (2^5)^5 \equiv 2^5 \text{mod} 10 \equiv 2 \text{ mod} 10$ $\Rightarrow (2^{25})^4 \equiv 2^4 \text{mod} 10 \equiv 16 \text{ mod} 10 \equiv 6 \text{ mod} 10 = 6$ Also 100! = 100 x 99! which is divisible by 10 So, $100!\ mod\ 10 = 0 \Rightarrow (2^{100} + 100!\,)mod\ 10 \equiv (6+0) mod 10 = 6$ **OR**	**1** **1**
21 (B)	Obviously $\sqrt{6} + \sqrt{5} > \sqrt{3} + \sqrt{2} \Rightarrow \frac{(\sqrt{6}+\sqrt{5})(\sqrt{6}-\sqrt{5})}{(\sqrt{6}-\sqrt{5})} > \frac{(\sqrt{3}+\sqrt{2})(\sqrt{3}-\sqrt{2})}{(\sqrt{3}-\sqrt{2})}$ $\Rightarrow \frac{6-5}{(\sqrt{6}-\sqrt{5})} > \frac{3-2}{(\sqrt{3}-\sqrt{2})} \Rightarrow \frac{1}{(\sqrt{6}-\sqrt{5})} > \frac{1}{(\sqrt{3}-\sqrt{2})}$ $\Rightarrow \sqrt{6} - \sqrt{5} < \sqrt{3} - \sqrt{2} \Rightarrow \sqrt{5} + \sqrt{3} > \sqrt{6} + \sqrt{2}$	½ **1** ½
22.	$P(X=1) + P(X=2) + P(X=3) + P(X=4) = 1$ $\Longrightarrow 1 \times a + 2 \times a + 3 \times a + b = 1$ $\Longrightarrow 6\,a + b = 1$ … (i) $E(X) = 1 \times a + 2 \times 2a + 3 \times 3a + 4 \times b = 2.8$ $\Longrightarrow 14\,a + 4\,b = 2.8$ … (ii) Solving (i) and (ii), we get $a = 0.12$ and $b = 0.28$	½ ½ ½+½
23.	CAGR $= \left[\left(\frac{EV}{SV}\right)^{\frac{1}{n}} - 1\right] \times 100$ $\Longrightarrow 5 = \left[\left(\frac{125000}{75000}\right)^{\frac{1}{n}} - 1\right] \times 100$ $\Longrightarrow 1.05 = \left(\frac{5}{3}\right)^{\frac{1}{n}}$ $\Longrightarrow \log(1.05) = \frac{1}{n}\log(1.67)$ $\Longrightarrow n = \frac{0.223}{0.021} = 10.6 \approx 11$ ∴ required number of years = 11 years	**1** ½ ½
24 (A)	Here, $\lambda = 2$ Required probability $= P(X = 3/X \geq 1) = \frac{P(X=3 \cap X \geq 1)}{P(X \geq 1)} = \frac{P(X=3)}{P(X \geq 1)}$ $P(X=3) = \frac{2^3 e^{-2}}{3!} = 0.19$ $P(X \geq 1) = 1 - P(X=0) = 1 - \frac{2^0 e^{-2}}{0!} = 1 - 0.14 = 0.86$ $\therefore P(X = 3/X \geq 1) = \frac{0.19}{0.86} = 0.22$ **OR**	½ ½ ½ ½

24 (B)	$\lambda = \frac{2}{1000} \times 5000 = 10$ $P(\text{more than 1 failure}) = P(X > 1) = 1 - [P(X = 0) + P(X = 1)]$ $= 1 - \left[\frac{10^0 e^{-10}}{0!} + \frac{10^1 e^{-10}}{1!}\right]$ $= 1 - e^{-10}(1 + 10)$ $= 1 - 4.54 \times 10^{-5} \times 11$ $= 1 - 0.0004994 = 0.9995$ approx.	½ ½ ½ ½
25.	$D = \frac{C-S}{n}$ $\Longrightarrow 2500 = \frac{25000-12500}{n}$ $\Longrightarrow n = \frac{12500}{2500} = 5$ So, after 5 years the value of the machine will be half of its initial value. Value of machine after 6 years $= 25000 - 2500 \times 6 = ₹\,10{,}000$	**1** ½ ½
Section –C **[This section comprises of solution short answer type questions (SA) of 3 marks each]**		
26.	Let speed upstream be x km/hr and speed downstream be y km/hr Since distance upstream and downstream is same $\therefore 8\frac{4}{5}\, x = 4y \;\Rightarrow \frac{44}{5}\, x = 4y \;\Rightarrow \frac{y}{x} = \frac{11}{5}$ (i) Now, speed of boat : speed of stream $= \frac{x+y}{2} : \frac{y-x}{2}$ (i) $\Rightarrow \frac{y+x}{y-x} = \frac{11+5}{11-5} \Rightarrow \frac{\frac{y+x}{2}}{\frac{y-x}{2}} = \frac{8}{3}$ $\therefore$ speed of boat : speed of stream $= 8:3$	**1** **1** **1**
27 (A)	Given $y = px^3 + qx^2 \Rightarrow \frac{dy}{dx} = 3px^2 + 2qx$ (i) Since $x = 1$ is a critical point $\therefore 3p(1)^2 + 2q(1) = 0 \Rightarrow 3p + 2q = 0$ (ii) Also, curve passes through (1, −1) so $-1 = p + q$ (iii) Solving (ii) and (iii) we get, $p = 2$ and $q = -3$ Using this in (i) we get $\frac{dy}{dx} = 6x^2 - 6x$ Now for other critical point, $\frac{dy}{dx} = 0 \Rightarrow 6x^2 - 6x = 0 \Rightarrow 6x(x-1) = 0$ $\Rightarrow x = 0\ or\ 1$ Thus, the other critical point is $(0,0)$ **OR**	**1** ½ **1** ½
27 (B)	$AR(x) = \frac{R(x)}{x} = 15 + \frac{x}{3} - \frac{x^3}{36}$, Now $\frac{d}{dx} AR(x) = 0 \Rightarrow 0 + \frac{1}{3} - \frac{3x^2}{36} = 0$ $\Rightarrow x^2 = 4 \Rightarrow x = 2$ (as x is non negative) $\Rightarrow x = 2$ is the critical point of $AR(x)$. Now $\frac{d^2[AR(x)]}{dx^2} = 0 - \frac{6(2)}{36} < 0$ hence $AR(x)$ is maximum at $x = 2$ $AR(2) = 15 + \frac{2}{3} - \frac{8}{36} = 15 + \frac{4}{9}$ Now, $MR(x) = 15 + \frac{2x}{3} - \frac{4x^3}{36} \Rightarrow MR(2) = 15 + \frac{4}{3} - \frac{8}{9} = 15 + \frac{4}{9}$ $\therefore AR(2) = MR(2)$	½ ½ ½ ½ ½ ½

28 (A)	C = Face value or maturity value = ₹ 56,000, n = number of periodic interest payments = $4 \times 6 = 24$ Yield rate $(i) = \frac{9}{400} = 0.0225$ R = Coupon Payment = $\frac{7\times56000}{400}$ = ₹ 980 Purchase price of the bond $(V) = R\left[\frac{1-(1+i)^{-n}}{i}\right] + C\,(1+i)^{-n}$ $= 980\left[\frac{1-(1+0.0225)^{-24}}{0.0225}\right] + 56000(1+0.0225)^{-24}$ $= 980\left[\frac{1-0.58}{0.0225}\right] + 56000 \times 0.58$ $= ₹\,(18293.33 + 32480) = ₹\,50773.33$ **OR**	½ ½ **1** ½ ½
28 (B)	Cost of new machine = ₹ $(50{,}000 + 30\% \times 50{,}000)$ = ₹ 65,000 A = Amount required in sinking fund = ₹ $(65{,}0000 - 6{,}000)$ = ₹ 59,000 $R\left[\frac{(1+i)^n-1}{i}\right] = A$ $R\left[\frac{(1.06)^8-1}{0.06}\right] = 59000$ $R\left[\frac{1.6-1}{0.06}\right] = 59000$ $\Longrightarrow R = \frac{59000\times0.06}{0.6}$ = ₹ 5900 So, the required amount to be retained = ₹ 5900	½ ½ **1** **1**
29.	Let **t** minutes be the total time taken to fill the tank So according to the question, pipe A is open for (t – 10) minutes, pipe C is open for (t – 10) minutes, pipe B is open for 10 minutes. Using work done per minute, we get $\frac{t-10}{30} + \frac{10}{60} + \frac{t-10}{120} = 1 \;\Rightarrow\; \frac{5t-30}{120} = 1$ $\Rightarrow\; 5t = 150 \Rightarrow t = 30$ minutes. ∴ It will take 30 minutes to fill the tank.	 **1** **1+½** **½**
30.	H_0: $\mu = 1.84$ cm (machine is working properly) H_1: $\mu \neq 1.84$ cm (machine is not working properly) For sample: $\bar{x} = 1.85$ cm and $s = \sqrt{0.0064} = 0.08$ cm At $\alpha = 0.05$ and df = 15 $t = \frac{\bar{x}-\mu}{\frac{s}{\sqrt{n}}} = \frac{1.85-1.84}{\frac{0.08}{\sqrt{16}}} = \frac{0.01}{0.08} \times 4 = 0.5$ $\lvert t_{cal}\rvert = 0.5 < t_{critical} = 2.131$ at $\alpha = 0.05$ and df = 15 ∴ null hypothesis is accepted, there is no significant difference between the sample mean and the population mean, hence machine is working properly.	½ ½ **1** ½ ½

31. Let x be the number of units of Product A produced per day and y be the number of units of Product B produced per day — **½**

The objective is to **maximize the profit**, which is given by:

$$Z = 30\,x + 40\,y$$

subject to the following constraints: — **1**

$$4\,x + 6\,y \leq 500$$
$$x \leq 80$$
$$y \leq 60$$
$$x \geq 0, y \geq 0$$

— **1½**

Section –D

[This section comprises of solution of long answer type questions (LA) of 5 marks each]

32 (A) Let the production manager produces x number of strips (of 10 tablets) of Paingo, y number of strips (of 10 tables) X -prene and z number of strips (of 10 tablets) Relaxo. — **½**

We have the following information from the question

From the table we have

$2x + 4y + z = 16000$ (1)

$3x + y + 2z = 10000$ (2)

$x + 3y + 3z = 16000$ (3)

	Paingo	X-prene	Relaxo	Availability
A	$2x$	$4y$	z	16000
C	$3x$	y	$2z$	10000
D	x	$3y$	$3z$	16000

The matrices representation of above system of equations is

$$\begin{bmatrix} 2 & 4 & 1 \\ 3 & 1 & 2 \\ 1 & 3 & 3 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 16000 \\ 10000 \\ 16000 \end{bmatrix}$$ — **1**

or $AX = B$

Since, $|A| = 2(3-6) - 4(9-2) + 1(9-1)$ — **½**

$= -6 - 28 + 8 = -26 \neq 0,$

Thus A^{-1} exists, so that the unique solution of $AX = B$ is $X = A^{-1}B$.

Here, $\text{adj}\,A = \begin{bmatrix} -3 & -9 & 7 \\ -7 & 5 & -1 \\ 8 & -2 & -10 \end{bmatrix}$ — **1**

$A^{-1} = \frac{1}{|A|}(adj\ A) = \frac{1}{-26}\begin{bmatrix} -3 & -9 & 7 \\ -7 & 5 & -1 \\ 8 & -2 & -10 \end{bmatrix}$ — **½**

Now, $X = A^{-1}B = \frac{1}{-26}\begin{bmatrix} -3 & -9 & 7 \\ -7 & 5 & -1 \\ 8 & -2 & -10 \end{bmatrix}\begin{bmatrix} 16000 \\ 10000 \\ 16000 \end{bmatrix} = \begin{bmatrix} 1000 \\ 3000 \\ 2000 \end{bmatrix}$

Hence, number of strips of Paingo, X -prene and Relaxo are 1000, 3000 and 2000 respectively — **1½**

OR

32 (B)

Under equilibrium condition,

For market A

$82 - 3p_A + p_B = -5 + 15p_A \implies 18p_A - p_B = 87$ **1½**

For market B

$92 + 2p_A - 4p_B = -6 + 32p_B \implies 2p_A - 36p_B = -98$ **1**

Now,

$|D| = -646$, $|D_A| = -3230$, $|D_B| = -1938$ **1 ½**

$p_A = \frac{|D_A|}{|D|} = \frac{-3230}{-646} = 5$ **½**

$p_B = \frac{|D_B|}{|D|} = \frac{-1938}{-646} = 3$ **½**

33.

Profit = Revenue – Cost $\implies \frac{dP}{dx} = \frac{dR}{dx} - \frac{dC}{dx}$ **1**

$\implies \frac{dP}{dx}$ = MR – MC $\implies \frac{dP}{dx} = -81 + 36x - 3x^2$ **1**

For maximum profit $\frac{dP}{dx} = 0 \implies -81 + 36x - 3x^2 = 0 \implies x = 3 \text{ or } 9$ **½**

Now $\frac{d^2P}{dx^2} = 36 - 6x = 36 - 54 < 0$, at $x = 9$, so P is maximum at $x = 9$.

Since $\frac{dP}{dx} = -81 + 36x - 3x^2 \implies P = \int(-81 + 36x - 3x^2)dx + c$ **1**

$\implies P = -81x + 18x^2 - x^3 + c$

When $x = 0, P = 0 \implies c = 0$ **½**

$\implies P = -81x + 18x^2 - x^3$ and at $x = 9, P = -729 + 2(729) - 729 = 0$ **1**

∴ Total profit at profit maximizing output is 0.

34 (A)

Take 2019 as the middle year, i.e., $A = 2019$

Year (x_i)	**Rice Production (million tonnes) (Y)**	$X = x_i - A$	X^2	XY	**Trend Values** $Y = a + bX$
2017	9.5	−2	4	−19.0	9.40
2018	10.0	−1	1	−10.0	10.02
2019	10.5	0	0	0.0	10.64
2020	11.2	1	1	11.2	11.26
2021	12.0	2	4	24.0	11.88
Total	53.2	0	10	6.2	

3 marks for correct table

$a = \frac{\sum Y}{n} = \frac{53.2}{5} = 10.64$ **½**

$b = \frac{\sum XY}{\sum X^2} = \frac{6.2}{10} = 0.62$ **½**

∴The trend equation is $y = 10.64 + 0.62\,x$ **½**

For the year 2025; $y = 10.64 + 0.62(6) = 14.36$ million tonnes **½**

OR

34 (B)

Month	Number of vehicles (Thousands)	3-Month Moving Total	3-Month Moving Average
March	30	-	-
April	35	103	34.33
May	38	109	36.33
June	36	114	38.00
July	40	118	39.33
August	42	121	40.33
September	39	126	42.00
October	45	132	44.00
November	48	140	46.67
December	47	-	-

3 marks for correct table

Correct graph

2

35. Loan amount $= P = ₹\,(10{,}00{,}000 - 2{,}00{,}000) = ₹\,8{,}00{,}000$ **½**

$i = \frac{10}{12\times100} = 0.0083$ **½**

$n = 5 \times 12 = 60$ **½**

EMI $= \frac{P\times i\times(1+i)^n}{(1+i)^n-1}$

$= \frac{800000\times0.0083\times(1+0.0083)^{60}}{(1+0.0083)^{60}-1}$ **1**

$= \frac{800000\times0.0083\times1.64}{1.64-1} = ₹\,17{,}015$ **1½**

Total interest paid $= n \times EMI - P$

$= ₹\,(17{,}015 \times 60 - 8{,}00{,}000)$

$= ₹\,(10{,}20{,}900 - 8{,}00{,}000) = ₹\,2{,}20{,}900$ **1**

Section –E

[This section comprises solution of 3 case- study/passage-based questions of 4 marks each. Solutions of the first two case study questions have three sub parts (i),(ii),(iii) of 1,1 and 2 marks respectively. Solution of the third case study question has two sub parts of 2 marks each.]

36. Here, $\mu = 75, \sigma = 8, n = 500$

(i) For $X = 75, Z = \frac{X-\mu}{\sigma} = \frac{75-75}{8} = 0$ **½**

$P(X < 75) = P(Z < 0) = 0.5$

50 % of students scored below 75 marks. **½**

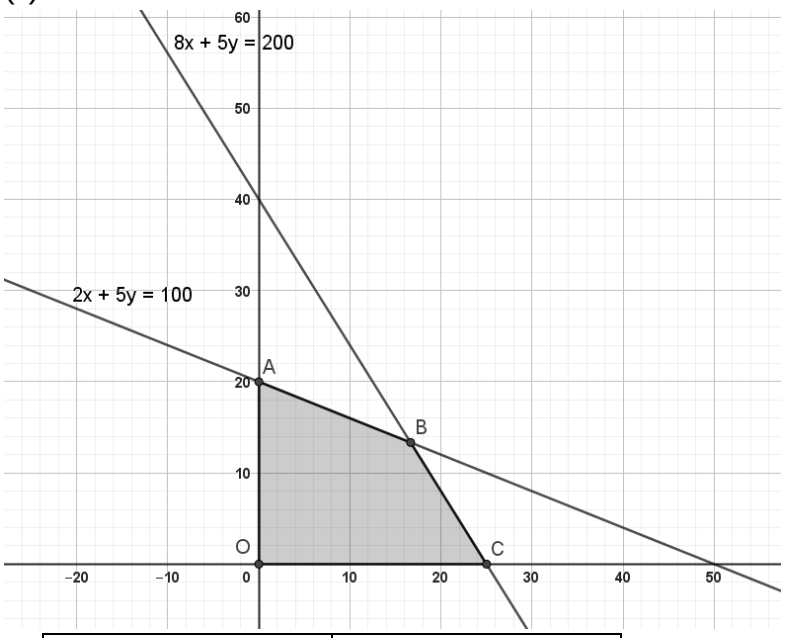
(ii) For $X = 82, Z = \frac{82-75}{8} = 0.875$ **½**

$P((X > 82) = P(Z > 0.875) = 1 - P(Z < 0.875) = 1 - 0.8092 = 0.1908$ **½**

$\therefore$ Required number of students $= 0.1908 \times 500 = 95.4 \approx 95$

	(iii) (A) For $X = 67, Z = \frac{67-75}{8} = -1$ For $X = 83, Z = \frac{83-75}{8} = 1$ $P(67 < X < 83) = P(-1 < Z < 1)$ $= P(Z < 1) - P(Z < -1)$ $= 0.8413 - 0.1587 = 0.6826$ $\therefore$ Required number of students $= 0.6826 \times 500 = 341.3 \approx 341$ **OR** (B) Top 10% corresponds to the 90th percentile. $\Longrightarrow Z = \frac{X-\mu}{\sigma} = 1.28$ $\Longrightarrow \frac{X-75}{8} = 1.28$ $\Longrightarrow X = 85.24 \approx 85$ $\therefore$ The minimum score required to qualify for the scholarship is 85 marks.	½ 1 ½ 1 1
37.	(i) $p_d = a + bx$ $\Longrightarrow 20 = a + 400\,b$ … (i) and $25 = a + 200\,b$ … (ii) Solving (i) and (ii), we get $a = 30, b = -\frac{1}{40}$ $\therefore\ p_d = 30 - \frac{1}{40}x$ (ii) For equilibrium, $p_d = p_s$ $\Longrightarrow 30 - \frac{1}{40}x = -15 + \frac{x}{20}$ $\therefore x = 600$ Equilibrium price $= 30 - \frac{1}{40} \times 600 = ₹\,15$ (iii) (A) Consumer surplus $= \int_0^{600} \left(30 - \frac{1}{40}x\right) dx - 600 \times 15$ $= \left[30\,x - \frac{1}{80}x^2\right]_0^{600} - 9000$ $= 13500 - 90000 = 4500$ $\therefore$ Consumer surplus $= ₹\,4500$ **OR** (B) Producer surplus $= 600 \times 15 - \int_0^{600} \left(-15 + \frac{x}{20}\right) dx$ $= 9000 - \left[-15\,x + \frac{1}{40}x^2\right]_0^{600}$ $= 9000 - (-9000 + 9000) = 9000$ $\therefore$ Producer surplus $= ₹\,9000$	½ ½ ½ ½ 1 1 1 1
38.	(i) Let the distance the man travels at 25 km/hr be denoted by x and the distance he travels at 40 km/hr be denoted by y Linear programming problem is Objective function is to Maximize $Z = x + y$ Subject to the constraints: $\frac{x}{25} + \frac{y}{40} \le 1$ i.e., $8x + 5y \le 200$ $2x + 5y \le 100$ $x \ge 0, y \ge 0$	½ ½ 1

(ii)



Corner Points	Value of Z
$O(0,0)$	0
$A(0,20)$	20
$B\left(\frac{50}{3},\frac{40}{3}\right)$	30
$C(25,0)$	25

1½

Thus, the maximum distance the man can travel within one hour is **30 km.**

½

SAMPLE QUESTION PAPER (2024 - 25)

CLASS- XII

SUBJECT: Applied Mathematics (241)

Time: 3 Hours. **Maximum Marks: 80**

General Instructions:

Read the following instructions very carefully and strictly follow them:

(i) This Question paper contains **38** questions. **All** questions are **compulsory.**

(ii) This Question paper is divided into **five** Sections - **A, B, C, D** and **E.**

(iii) In **Section A**, Questions no. **1** to **18** are **multiple choice questions (MCQs)** and Questions no. **19** and **20** are **Assertion-Reason based** questions of **1 mark each**.

(iv) In **Section B,** Questions no. **21** to **25** are **Very Short Answer (VSA)-type** questions, carrying **2 marks each**.

(v) In **Section C,** Questions no. **26** to **31** are **Short Answer (SA)-type** questions, carrying **3 marks each**.

(vi) In **Section D,** Questions no. **32** to **35** are **Long Answer (LA)-type** questions, carrying **5 marks each**.

(vii) In **Section E,** Questions no. **36** to **38** are **case study-based questions** carrying **4 marks each.**

(viii) There is no overall choice. However, an internal choice has been provided in 2 questions in Section B, 2 questions in Section C, 2 questions in Section D and one sub-part each in 2 questions of Section E.

(ix) Use of calculators is **not** allowed.

SECTION-A $[1\times 20 = 20]$

(*This section comprises of multiple-choice questions (MCQs) of 1 mark each*)

Select the correct option (Question 1 - Question 18):

Q.1. The area (in sq units) bounded by the curve $y = \sqrt{x}$, the $x-$axis, $x = 1$ and $x = 4$ is

(A) $\frac{11}{3}$ (B) $\frac{1}{4}$ (C) $\frac{14}{3}$ (D) $\frac{13}{3}$

Q.2. Sampling which provides for a known non-zero equal chance of selection is

(A) Systematic sampling (B) Convenience sampling

(C) Quota sampling (D) Purposive sampling

Q.3. Let the cost function for a manufacturer is given by $C(x) = \frac{x^3}{3} - x^2 + 2x$ (In rupees)

Which of the following statement is correct based on the above information?

(A) The marginal cost decreases from 0 to 1 and then increases onwards.

(B) The marginal cost increases from 0 to 1 and then decreases onwards.

(C) Marginal cost decreases as production level increases from zero.

(D) Marginal cost increases as production level increases from zero.

Q.4. The absolute minimum value of the function $f(x) = 4x - \frac{1}{2}x^2$ in the interval $\left[-2, \frac{9}{2}\right]$ is:

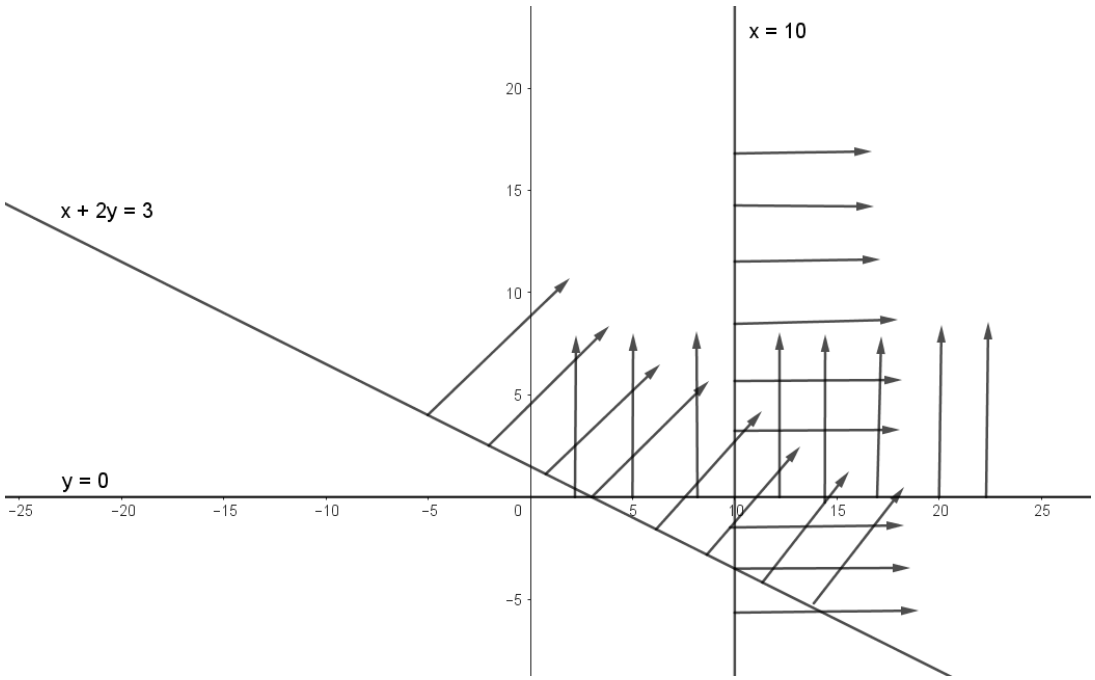
(A) -8 (B) -9 (C) -10 (D) -16

Q.5. For the purpose of $t-$ test of significance, a random sample of size $(n)_{2025}$ is drawn from a normal population, then the degree of freedom (υ) is

(A) 2025^{2025} (B) 2024^{2025} (C) 2025 (D) 2024

Q.6. The constraints of a linear programming problem along with their graphs is shown below:

$x + 2y \geq 3,\ x \geq 10,\ y \geq 0$



Which of the following inequality may be removed so that the feasible region remains the same in above graph?

(A) $x + 2y \geq 3$

(B) $x \geq 10$

(C) $y \geq 0$

(D) $x \geq 0$

Q.7. A player rolls one fair die. If the die shows an odd number, the player wins the value that appears on the die, else loses half the value that appears on it. The expected gain of the player is

(A) $-\frac{1}{2}$ (B) 0 (C) $\frac{1}{2}$ (D) 1

Q.8. The original cost of a machine is ₹ **1200000** and the scarp value of the machine after a useful life of **3 years is** ₹ **300000**, then the book value of the machine at the end **2 years** is

(A) ₹ **100000** (B) ₹ **250000** (C) ₹ **600000** (D) ₹ **800000**

Q.9. A fish jumps out of the water surface and follows the parabolic path $y = 6x - x^2 - 8;\ 2 \le x \le 4$. The fish reaches the highest height in its path at $(3,1)$. The slope of the path of the fish at $(3,1)$ is

(A) **0** (B) **1** (C) **2** (D) **3**

Q.10. In a large consignment of electric bulbs 5% of a batch of batteries are defective. A random sample of **80** is taken for inspection with replacement. Then the Variance of the number of defectives in the sample, is

(A) $\frac{18}{5}$ (B) $\frac{19}{5}$ (C) **4.555** (D) **8**

Q.11. If it is currently $6{:}\,00$ pm in 12 hours clock then what will be the time after 375 hours?

(A) 6 am (B) 6 pm (C) 9 am (D) 9 pm

Q.12. The values of $\frac{1}{x}$ for the given values of $x \in (-1,3) - \{0\}$ is

(A) $\left(-1,\frac{1}{3}\right) \cup (3,\infty)$ (B) $(-\infty,-1) \cup \left(\frac{1}{3},\infty\right)$ (C) $\left(-\frac{1}{3},1\right)$ (D) $\left(-\frac{1}{3},-1\right)$

Q.13. The component of a time series attached to long term variations is termed as

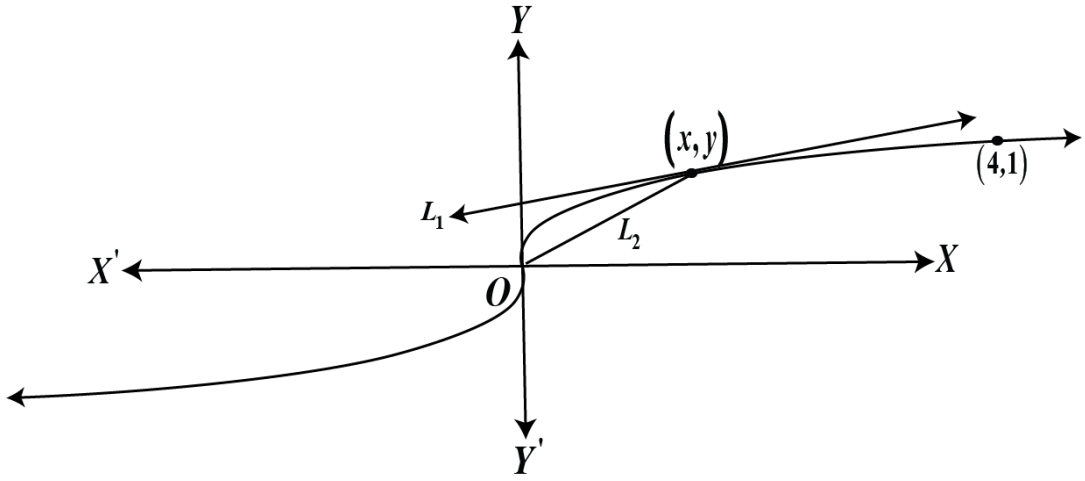
(A) Seasonal variations (B) Irregular variations

(C) Secular trend variations (D) Cyclic variations

Q.14. The present value of a sequence of payments of **₹ 800** made at the end of every **6 month** and continuing forever. If money is worth **4%** per annum compounded semi-annually, then the present value of the sequence is:

(A) ₹ 20000 (B) ₹ 40000 (C) ₹ 60000 (D) ₹ 80000

Q.15. Shown below is a curve.



L_1 is the tangent to any point (x, y) on the curve.

L_2 is the line that connects the point (x, y) to the origin.

The slope of L_1 is one third of the slope of L_2.

Then the differential equation, using the given conditions is:

(A) $\frac{dy}{dx} = \frac{y}{3x}$ (B) $\frac{dy}{dx} = \frac{y}{x}$ (C) $\frac{dy}{dx} = \frac{x}{3y}$ (D) $\frac{dy}{dx} = \frac{3y}{x}$

Q.16. For a 3×3 matrix if $\text{adj A} = 2\text{A}^{-1}$, find $|3\text{AA}^{\text{T}}|$

(A) 108 (B) 12 (C) 54 (D) 8

Q.17. For two matrices $P = \begin{bmatrix} 3 & 4 \\ -1 & 2 \\ 0 & 1 \end{bmatrix}$ & $Q^T = \begin{bmatrix} -1 & 2 & 1 \\ 1 & 2 & 3 \end{bmatrix}$; $\left(\text{where } Q^T \text{ is the transpose of the matrix } Q\right)$

, $P - Q$ is:

(A) $\begin{bmatrix} 2 & 3 \\ -3 & 0 \\ 0 & -3 \end{bmatrix}$ (B) $\begin{bmatrix} 4 & 3 \\ -3 & 0 \\ -1 & -2 \end{bmatrix}$ (C) $\begin{bmatrix} 4 & 3 \\ 0 & -3 \\ -1 & -2 \end{bmatrix}$ (D) $\begin{bmatrix} 2 & 3 \\ 0 & -3 \\ 0 & -3 \end{bmatrix}$

Q.18. The order and degree of a differential equation $\frac{d^2y}{dx^2} + \left(\frac{dy}{dx}\right)^4 + x^{\frac{1}{5}} = 0$; respectively, are

(A) 2 and 4 (B) 2 and 1
(C) 2 and 3 (D) 3 and 3

ASSERTION-REASON BASED QUESTIONS

(Questions number 19 and 20 are Assertion and Reason based questions carrying 1 mark each. 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.)

$[1 \times 2 = 2]$

(A) Both (A) and (R) are true and (R) is the correct explanation of (A).

(B) Both (A) and (R) are true but (R) is not the correct explanation of (A).

(C) (A) is true but (R) is false.

(D) (A) is false but (R) is true.

Q.19. Assertion (A): The effective rate of interest equivalent to a nominal rate of 6% when compounded continuously is equal to $e^{0.06} - 1 = 6.18\%$.

Reason (R): The relation between effective rate $\left(r_{eff}\right)$ of interest and nominal rate (r) of interest: $r_{eff} = e^{r} - 1;$ where $'e'$ - Euler's number (approximate value is 2.71828), when compounded continuously.

Q.20. Assertion(A): $A = [a_{ij}] = \begin{cases} m; i = j \\ 0; i \neq j \end{cases}$

where m is a scalar, is an identity matrix if $m = 1$

Reason (R): Every identity matrix is not a scalar matrix

SECTION B $[2 \times 5 = 10]$

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

Q.21. (a) In what ratio water must be added in milk costing ₹ 60 per litre, so that the resulting mixture would be of worth ₹ 50 per litre?

OR

Q.21. (b) A pump can fill a tank with water in 2 hours. Because of leakage, it took $\frac{7}{3}$ hrs to fill the tank. How much time will it take for the leakage to drain all the water in the full tank?

Q.22. In a 200 m race, A can give a start of 18 m to B and a start of 31 m to C. In a race of 350 m, how much start can B give to C?

Q.23. A boat takes thrice as long to go upstream to a point as to return downstream to the starting point. If the speed of the stream is $5km/h$, find the speed of the boat in still water.

Q.24. (a) The incidence of occupational disease in an industry is such that the workers have a **20%** chance of suffering from it. What is the probability that out of six workers **4 or more** will catch the disease?

OR

Q.24. (b) The lifetime of an item produced by a machine has a normal distribution with **mean 12 months** and **standard deviation** of 2 months. Find the probability of an item produced by this machine will last

(i) less than **7** months

(ii) between **7** and **14** months.

(Given $P\left(Z < \frac{5}{2}\right) = 0.9938$ and $P(Z < 1) = 0.8413$)

Q.25. If $A = \begin{bmatrix} \alpha & 0 \\ 1 & 1 \end{bmatrix}$ and $B = \begin{bmatrix} 1 & 0 \\ 5 & 1 \end{bmatrix}$, then find the value of α (if exists) for which $A^2 = B$.

SECTION C

$[3 \times 6 = 18]$

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

Q.26. Find the remainder when 5^{61} is divided by 7.

Q.27. (a) Two batches of the same product are tested for their mean life. Assuming that, the lives of the product follow a normal distribution with an unknown variance; test the hypothesis that the mean life is the same for both the branches, given the following information:

Batch	**Sample Size**	**Mean life** (in hours)	**Standard Deviation** (in hours)
Batch I	10	750	12
Batch II	8	820	14

$\left[\textbf{Given } \sqrt{4.4444} = 2.1081 \textbf{ and } t_{16}(0.05) = 2.120\right]$

OR

Q.27. (b) The manufacturer of electrical items makes bulbs and claims that these bulbs have a mean life of 25 months. The life in months of a random sample of 6 such bulbs are given to be 24, 26, 30, 20, 20 and 18. Test the validity of the manufacturer's claim at 1% level of significance. [Given $t_5(0.01) = 4.032$]

Q.28. A traffic engineer records the number of bicycle riders that use a particular cycle track. He records that an average of 3.2 bicycle riders use the cycle track every hour. Given that the number of bicycles that use the cycle track follow a Poisson distribution, what is the probability that 2 or less bicycle riders will use the cycle track within an hour? Also find the mean expectation and variance for the random variable. (Given $e^{-3.2} = 0.041$)

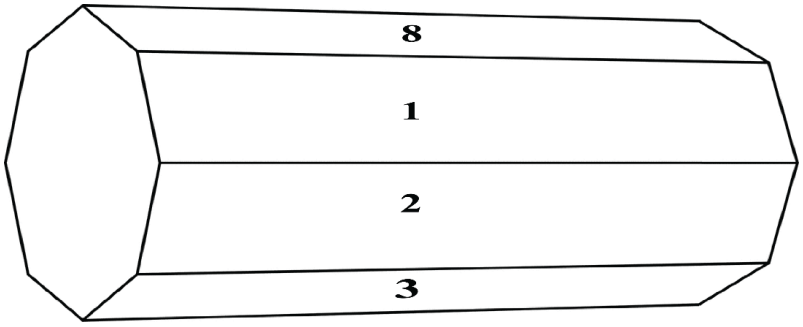
Q.29. Mr Rohit invested ₹ **5000** in a fund at the beginning of year **2021** and by the end of year **2021** his investment was worth ₹ **9000**. Next year market crashed and he lost ₹ **3000** and ending up with ₹ **6000** at the end of year **2022**. Next year i.e. **2023** he gained ₹ **4500** and ending up with ₹ **10500** at the end of the year. Find **CAGR** (Compounded Annual Growth Rate) of his investment. (Use $(2.1)^{1/3} = 1.2805$)

Q.30. A small firm manufactures necklaces and bracelets. The total number of necklaces and bracelets that it can handle per day is at most **25**. It takes one hour to make a bracelet and half

an hour to make a necklace. The maximum number of hours available per day is **14**. If the profit on a necklace is **₹ 100** and that on a bracelet is **₹ 300**, formulate an **L.P.P**. for finding how many of each should be produced daily to maximize the profit? It is being given that at least one of each must be produced.

(Note: No need to find the feasible region and optimal solution)

Q.31.(a) An octagonal prism is a three-dimensional polyhedron bounded by two octagonal bases and eight rectangular side faces. It has 24 edges and 16 vertices.



The prism is rolled along the rectangular faces and number on the bottom face (touching the ground) is noted. Let X denotes the number obtained on the bottom face and the following table gives the probability distribution of X .

X :	1	2	3	4	5	6	7	8
$P(X)$:	p	$2p$	$2p$	p	$2p$	p^2	$2p^2$	$7p^2 + p$

On the above context, answer the following questions.

(i) Find the value of p .

(ii) Find the mean, $E(X)$.

OR

Q.31.(b) If the probability of success in a single trial is 0.01 , how many minimum number of Bernoulli trials must be performed in order that the probability of at least one success is $\frac{1}{2}$ or more?

$\left(\text{Use } \log_{10} 2 = 0.3010 \text{ and } \log_{10} 99 = 1.9956\right)$

SECTION D $[5 \times 4 = 20]$

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

Q.32. (a) Fit a straight-line trend by using the method of least squares for the following data and calculate the trend values.

Year	Production (in tonnes)
1962	2
1963	4
1964	3
1965	4
1966	4
1967	2
1968	4
1969	9
1970	7
1971	10
1972	8

OR

Q.32. (b) The quarterly profits of a small-scale industry (₹ in thousands) are as follows.

Year	Quarter 1	Quarter 2	Quarter 3	Quarter 4
2020	39	47	20	56
2021	68	59	66	72
2022	88	60	60	67

Calculate **4-quarterly** moving averages.

Q.33. (a) An owl was sitting at $(0,k);\ k>0$. Then it starts flying along the path whose equation is given by $y=ax^2+bx+c,$ where $a\in\mathbb{R}-\{0\}$, $b,c\in\mathbb{R}$. It passes through the points $(1,2),(2,1)$ and $(4,5)$. Using **Cramer's Rule**, find the values of a, b, c and hence k

OR

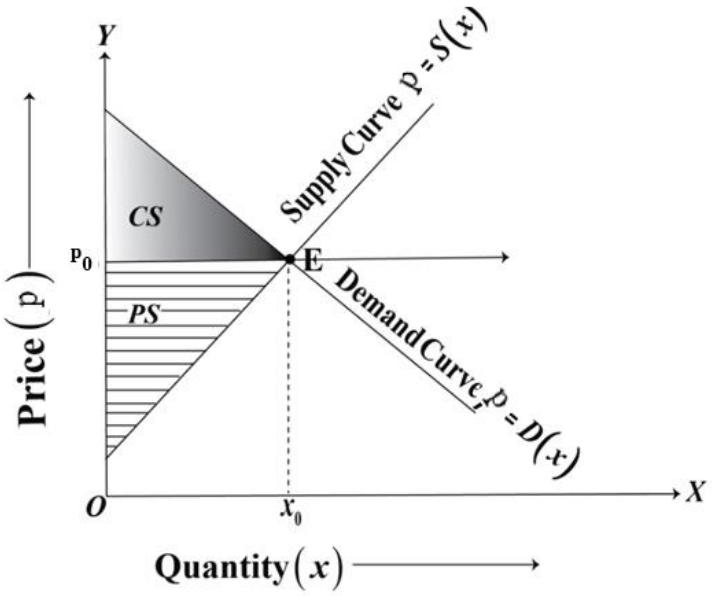
Q.33. (b) A toy rocket is fired, from a platform, vertically into the air, its height above the ground after t seconds is given by $s(t)=at^2+bt+c,$ where $a,b,c\in\mathbb{R};\ a\neq 0$ and $s(t)$ is measured in

metres. After **10** second, the rocket is **16 m** above the ground; after **20** seconds, **22 m**; after **30** seconds, **25 m**.

(i) Write down a system of three linear equations in terms of a, b and c.

(ii) Hence find the values of a, b and c, using matrix method.

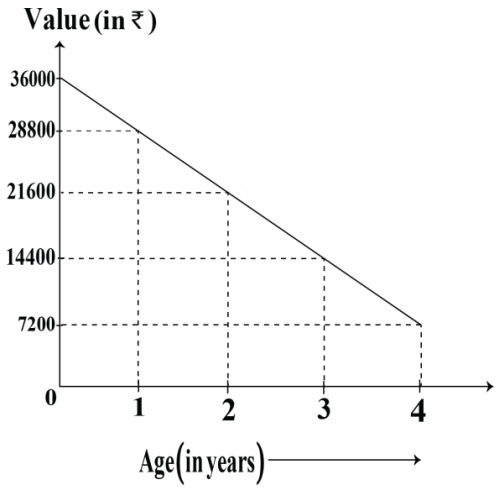
Q.34. Supply and demand curves of a tyre manufacturer company is given below:



The above graph showing the demand and supply curves of a tyre manufacturer company which are linear. 'ABC' tyre manufacturer sold **25** units every month when the price of a tyre was ₹ **20000** per units and 'ABC' tyre manufacturer sold **125** units every month when the price dropped to ₹ **15000** per unit. When the price was ₹ **25000** per unit, **180** tyres were available per month for sale and when the price was only ₹ **15000** per unit, **80** tyres remained. Find the demand function. Also find the consumer surplus if the supply function is given to be $S(x) = 100x + 7000$

Q.35. In **4** years, a mobile costing **₹ 36,000** will have a salvage value of ₹ **7200**.

The following graph shows the depreciation of a mobile's value over 4 years.



A new mobile at that time (i.e., after **4 years**) is expected to cost for ₹ **55,200**. In order to provide funds for the difference between the replacement cost and the salvage cost, a sinking

fund is set up into which equal payments are placed at the end of each year. If the fund earns interest at the rate 7% compounded annually, how much should each payment be? Also find the amount of Annual Depreciation of the mobile's value over **4** years and find the rate of depreciation (under straight line method). Use $(1.07)^4 = 1.3107$.

SECTION- E $[4 \times 3 = 12]$

(*This section comprises of 3 case-study/passage-based questions of 4 marks each with sub parts. The first two case study questions have three sub parts (i), (ii), (iii) of marks 1, 1, 2 respectively. The third case study question has two sub parts of 2 marks each)*

Case Study-1

Q.36. A student Shivam is running on a playground along the curve given by $y = x^2 + 7$. Another student Manita standing at point $(3, 7)$ on playground wants to hit Shivam by paper ball when Shivam is nearest to Manita.

Based on above information, answer the following questions:

(i) Let at any instant while running along the curve $y = x^2 + 7$, Shivam's position be (x, y). Find the expression for the distance (D) between Shivam and Manita in terms of 'x'. [1]

(ii) Find the critical point(s) of the distance function. [1]

(iii) (a) What is the distance between Shivam and Manita when they are at least distance from each other. [2]

OR

(iii) (b) Find the position of Shivam, when he is closest to Manita. [2]

Case Study-2

Q.37. EQUATED MONTHLY INSTALMENTS (EMI): -

Each instalment can be considered as consisting of two parts:

(i) Interest on the outstanding loan (ii) Repayment of part of the loan.

Methods of calculation of EMI or Instalment: -

EMI or Installment can be calculated by two methods:

1. Flat Rate Method
2. Reducing-balance method or Amortization of Loan

Rajesh purchased a house from a company for ₹ 2500000 and made a down payment of ₹ 500000 He repays the balance in 25 **years** by monthly instalments at the rate of 9% per annum compounded monthly. $\left(\text{Given}\left(1.0075\right)^{-300} = 0.1062\right)$

Based on the above information, answer the following questions:

(i) Find the number of payments and find the rate of interest per month. [1]

(ii) (a) What are the monthly payments of instalments using ***reducing balance method***? [2]

OR

(ii) (b) What are the monthly payments of instalments using ***flat rate method***? [2]

(iii) What is the total interest payment made in the process applied to calculate **EMI** in the above part $\left(37(ii)\right)$? [1]

Case Study- 3

Q.38. A company has two factories located at **P** and **Q** and has three depots situated at **A, B** and **C**. The weekly requirement of the depots at **A, B** and **C** is respectively **5, 5** and **4** units, while the production capacity of the factories **P** and. **Q** are respectively **8** and **6** units. The cost (in ₹) of transportation per unit is given below.

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

Based on the above information, answer the following questions:

(i) Formulate the objective function and the constraints of the above Linear programming problem. [2]

(ii) How many units should be transported from each factory to each depot in order that the transportation cost is minimum? [2]

****

MARKING SCHEME

CLASS XII

APPLIED MATHEMATICS (CODE-241)

SECTION: A (Solution of MCQs of 1 Mark each)

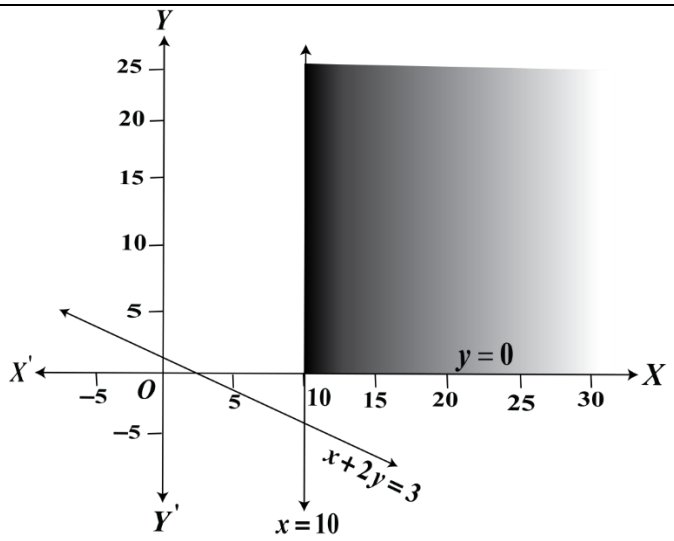
Q no.	ANS	HINTS/SOLUTION
1.	(C)	The required area is given by $\left\|\int_1^4 \left(\sqrt{x}\right)dx\right\| = \left\|\left[\frac{x^{\frac{3}{2}}}{\frac{3}{2}}\right]_1^4\right\| = \left\|\frac{2}{3}\left(8-1\right)\right\| = \frac{14}{3}\,\text{sq units.}$
2.	(A)	Systematic Sampling as it is a type of probability sampling while others are types of non-probability sampling. (When selection of objects from the population is random, then objects of the population have an equal probability i.e., has a known non-zero equal chance of selection. In other words, in probability sampling, sample units are selected at random.)
3.	(A)	The cost function for a manufacturer is given by $C(x)=\frac{x^3}{3}-x^2+2x$ (in rupees). The marginal cost function is given by $MC(x)=\frac{dC}{dx}=x^2-2x+2$ $MC'(x)=2x-2$ So, the marginal cost decreases from 0 to 1 and then increases onwards
4.	(C)	$f(x)=4x-\frac{1}{2}x^2$ **Being a polynomial function** $f(x)$ **is differentiable** $\forall x \in \left(-2,\frac{9}{2}\right)$ $f'(x)=4-x$ **.** $f'(x)=4-x=0 \Rightarrow x=4$ **.** **For the function** $f(x)=4x-\frac{1}{2}x^2$ **in the interval** $\left[-2,\frac{9}{2}\right]$**, the end points are** $x=-2$ **&** $x=\frac{9}{2}$ ∴The absolute minimum value of the function $f(x)=4x-\frac{1}{2}x^2$ in the interval $\left[-2,\frac{9}{2}\right]$ is $\text{Min}\left\{f(-2), f(4), f\left(\frac{9}{2}\right)\right\}=\text{Min}\left\{-10,8,\frac{63}{8}\right\}=-10.$

5. **(D)**

Here $n = 2025$

$\therefore$ Degree of freedom $= 2025 - 1 = 2024.$

6. **(A)**



From the graph, it is clear that $x + 2y \geq 3$ may be removed so that the feasible region remains the same.

7. **(C)**

Number on the die	x_i	p_i	$p_i x_i$
1	1	$\frac{1}{6}$	$\frac{1}{6}$
2	-1	$\frac{1}{6}$	$-\frac{1}{6}$
3	3	$\frac{1}{6}$	$\frac{3}{6}$
4	-2	$\frac{1}{6}$	$-\frac{2}{6}$
5	5	$\frac{1}{6}$	$\frac{5}{6}$
6	-3	$\frac{1}{6}$	$-\frac{3}{6}$

Expected gain $= E(X) = \sum p_i x_i = \frac{3}{6} = \frac{1}{2}$

8. **(C)**

Annual depreciation $= \dfrac{1200000 - 300000}{3} = ₹\ 300000$

$\therefore$ Book value of the asset at the end of **2 years** $= ₹\ (1200000 - 2 \times 300000) = ₹\ 600000.$

9. **(A)**

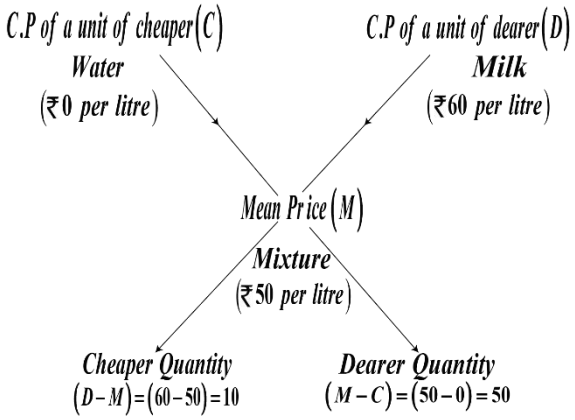
The equation of the parabolic path $y = 6x - x^2 - 8;\ 2 \leq x \leq 4$

		$\frac{dy}{dx} = 6 - 2x$ $\Rightarrow \frac{dy}{dx}_{x=3} = 6 - 2 \times 3 = 0.$
10.	**(B)**	This is a binomial distribution with $n = 80, p = 5\% = \frac{1}{20}$. If X is the binomial random variable for the number of defectives then X is $B\left(80, \frac{1}{20}\right)$. So, $\sigma^2 = npq = 80 \times \frac{1}{20} \times \frac{19}{20} = \frac{19}{5}$.
11.	**(C)**	$375\,\text{hours} = (24 \times 15 + 15)\,\text{hours}$ $\therefore 375 \pmod{24} = 15$ Therefore, it will be **9 am** after $375\,\text{hours}$.
12.	**(B)**	$x \in (-1,3) - \{0\} \Rightarrow x \in (-1,0) \cup (0,3)$ When $x \in (-1,0)$ then $\frac{1}{x} \in (-\infty,-1).....(i)$ When $x \in (0,3)$ then $\frac{1}{x} \in \left(\frac{1}{3},\infty\right).....(ii)$ From (i) & (ii) , we have $\frac{1}{x} \in (-\infty,-1) \cup \left(\frac{1}{3},\infty\right)$.
13.	**(C)**	Secular trend variations are considered as long-term variation, attributable to factor such as population change, technological progress and large –scale shifts in consumer tastes.
14.	**(B)**	$R = ₹\ 800.$ $i = \frac{4}{200} = 0.02$ $P = \frac{R}{i} = \frac{800}{0.02} = ₹\ 40000.$
15.	**(A)**	The slope of L_1 at any arbitrary point (x, y) is $\frac{dy}{dx}$. The slope of L_2 that connects the point (x, y) to the origin is $\frac{y-0}{x-0} = \frac{y}{x}$ Now, $\frac{dy}{dx} = \frac{1}{3} \times \frac{y}{x}$ $\therefore \frac{dy}{dx} = \frac{y}{3x}$.

16.	**(A)**	$\text{adj A} = 2\text{A}^{-1} \implies \text{A}^{-1} = \frac{1}{2}(\text{adj A})$ $\therefore \lvert\text{A}\rvert = 2$ Now, $\lvert 3\text{AA}^{\text{T}}\rvert = 3^3 \times \lvert\text{A}\rvert^2 = 108$
17.	**(B)**	We have, $\boldsymbol{P} = \begin{bmatrix} 3 & 4 \\ -1 & 2 \\ 0 & 1 \end{bmatrix}$ & $\boldsymbol{Q}^T = \begin{bmatrix} -1 & 2 & 1 \\ 1 & 2 & 3 \end{bmatrix} \Rightarrow \boldsymbol{Q} = \begin{bmatrix} -1 & 1 \\ 2 & 2 \\ 1 & 3 \end{bmatrix}$ So, $\boldsymbol{P} - \boldsymbol{Q} = \begin{bmatrix} 3 & 4 \\ -1 & 2 \\ 0 & 1 \end{bmatrix} - \begin{bmatrix} -1 & 1 \\ 2 & 2 \\ 1 & 3 \end{bmatrix} = \begin{bmatrix} 4 & 3 \\ -3 & 0 \\ -1 & -2 \end{bmatrix}$.
18.	**(B)**	order is **2** and degree is **1**.
19.	**(A)**	**Both (A) and (R) are true and (R) is the correct explanation of (A).**
20.	**(C)**	**(A) is true but (R) is false.**

Section –B

[This section comprises of solution of very short answer type questions (VSA) of 2 marks each]

21(a).	 **C.P** of 1 litre of water = ₹ **0** **C.P** of 1 litre of milk = ₹ **60** Mean Price = ₹ **50** Therefore, ratio of water and milk = $\frac{60-50}{50-0} = \frac{10}{50} = \frac{1}{5}$ or $1:5$	**1** **1**
	OR	
21(b).	Time taken to drain full tank $= x$ hours i.e., the time rate of drain the tank $= \frac{1}{x}$ units per hour	

	Time taken to fill the full tank is 2 hours i.e., the time rate of filling the tank $=\frac{1}{2}$ units per hour Again, with the leakage, the pipe takes $2\frac{1}{3}=\frac{7}{3}$ hours to fill the full tank. The rate of filling the tank along with the leakage will be $=\frac{3}{7}$ units per hour. Now, according to question, $\left(\frac{1}{2}\right)-\left(\frac{1}{x}\right)=\left(\frac{3}{7}\right)$ Solving, we get $x=14$ Hence, 14 hours are required to drain the full tank.	½ 1 ½
22.	In a $200m$ race, when A covers $200m$ then B covers $(200-18)=182m$ and C covers $(200-31)=169m$ $\Rightarrow A : C = 200 : 169$ $\frac{B}{C}=\frac{A}{C}\times\frac{B}{A}=\frac{200}{169}\times\frac{182}{200}=\frac{182}{169}$ When B covers $182m$ then C covers $169m$ When B covers $350m$ then C covers $\frac{169}{182}\times 350=325m$ Therefore, B can give a start of $(350-325)=25m$ to C.	½ ½ ½ ½
23.	Let the total distance be d km and the speed of boat in still water be x km/h Speed of stream = 5 km/h Speed upstream $=(x-5)$ km/h Speed downstream $=(x+5)$ km/h According to question, $\frac{d}{x-5}=3\times\frac{d}{x+5}$ Solving, we get $x=10$ Hence, the speed of boat in still water is 10 km/h	½ ½ ½ ½
24(a).	Let X be the random variable denoting the number of workers who catch the disease.	

	Given, $p=\frac{20}{100}=\frac{1}{5}\Rightarrow q=\frac{4}{5}$ and $n=6$ Now, $P(X=x)={}^{6}C_{x}\left(\frac{1}{5}\right)^{x}\left(\frac{4}{5}\right)^{6-x}$, $x=0,1,....,6$ So, the required probability that out of six workers **4** or more will catch the disease is $P(X\geq 4)=P(X=4)+P(X=5)+P(X=6)$ $={}^{6}C_{4}\left(\frac{1}{5}\right)^{4}\left(\frac{4}{5}\right)^{2}+{}^{6}C_{5}\left(\frac{1}{5}\right)^{5}\left(\frac{4}{5}\right)^{1}+{}^{6}C_{6}\left(\frac{1}{5}\right)^{6}\left(\frac{4}{5}\right)^{0}$ $=\frac{265}{5^{6}}$ **or** 0.017 .	½ **1** ½
	OR	
24(b).	We have, mean $\mu=12$ and standard deviation $\sigma=2$, i.e., $X\sim N(\mu,\sigma^{2})$ (i) Let X denote the count of the months for which this machine lasts. The probability of an item produced by this machine will last less than 7 months is $P(X<7)$ **For** $X=7$, $Z=\frac{7-12}{2}=-\frac{5}{2}$ Now, $P(X<7)=P\left(Z<-\frac{5}{2}\right)=P\left(Z>\frac{5}{2}\right)$ $=1-P\left(Z<\frac{5}{2}\right)=1-0.9938=0.0062$ (ii) The probability of an item produced by this machine will last more than 7 months and less than 14 months is $P(7<X<14)$ **For** $X=7$, $Z=\frac{7-12}{2}=-\frac{5}{2}$ **and for** $X=14$, $Z=\frac{14-12}{2}=1$ $P(7<X<14)=P\left(-\frac{5}{2}<Z<1\right)$ $=P(Z<1)-P\left(Z<-\frac{5}{2}\right)$ $=0.8413-0.0062=0.8351$	½ ½ ½ ½
25.	Given, $A^{2}=B$	

	$\Rightarrow \begin{bmatrix} \alpha & 0 \\ 1 & 1 \end{bmatrix}\begin{bmatrix} \alpha & 0 \\ 1 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 5 & 1 \end{bmatrix}$ $\Rightarrow \begin{bmatrix} \alpha^2 & 0 \\ \alpha+1 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 5 & 1 \end{bmatrix}$	**1**
	$\Rightarrow \alpha^2 = 1$ **and** $\alpha + 1 = 5$.	½
	Hence, no real value of α exists.	½
	Section –C **[This section comprises of solution short answer type questions (SA) of 3 marks each]**	
26.	$5 \equiv 5(\text{mod } 7)$ $\Rightarrow 5^2 \equiv 25(\text{mod } 7)$ $\Rightarrow 5^2 \equiv 4(\text{mod } 7)$	**1**
	$\Rightarrow 5^4 \equiv 4^2(\text{mod } 7)$ $\Rightarrow 5^4 \equiv 2(\text{mod } 7)$ $\Rightarrow 5^{20} \equiv 32(\text{mod } 7)$ $\Rightarrow 5^{20} \equiv 4(\text{mod } 7)$	**1**
	$\Rightarrow 5^{60} \equiv 1(\text{mod } 7)$ $\Rightarrow 5^{61} \equiv 5(\text{mod } 7)$ Hence, the remainder when 5^{61} is divided by 7 is 5	**1**
27(a).	Given, $n_1 = 10,\ n_2 = 8,\ \overline{x_1} = 750,\ \overline{x_2} = 820,\ s_1 = 12\ \&\ s_2 = 14$ Consider, Null hypothesis $\mathbf{H_0}$: Mean life is same for both the batches i.e., $(\mu_1 = \mu_2)$. Alternate hypothesis $\mathbf{H_\alpha}$: Two batches have different mean lives i.e., $(\mu_1 \neq \mu_2)$. Test Statistics, $\mathbf{t} = \frac{\overline{x_1} - \overline{x_2}}{\mathbf{S}} \times \sqrt{\frac{n_1 n_2}{n_1 + n_2}}$, Where $S = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}}$ $\Rightarrow \quad \mathbf{S} = \sqrt{\frac{9 \times 144 + 7 \times 196}{10 + 8 - 2}}$	**1**

	$= \sqrt{\frac{2668}{16}} = 12.91$ $\therefore\ t = \frac{750-820}{12.91} \times \sqrt{\frac{10\times 8}{10+8}}$ $= \frac{-70}{12.91} \times 2.1081$ $= -11.430$ Since, calculated value $\lvert t\rvert = 11.430 >$ tabulated value $t_{16}(0.05) = 2.120$ So, rejected the null hypothesis at **5%** level of significance. Hence, the mean life for both the batches is not the same.	½ **1** ½
	OR	
27(b).	Here, population mean $(\mu) = 25$ Sample mean $(\bar{x}) = \frac{\sum x_i}{n} = \frac{138}{6} = 23$ Sample size $(n) = 6$ Consider, Null hypothesis $\mathbf{H_0}$: There is no significant difference between the sample mean and the population mean i.e., $(\mu_1 = \mu_2)$. Alternate hypothesis $\mathbf{H_\alpha}$: There is no significant difference between the sample mean and the population mean i.e., $(\mu_1 \neq \mu_2)$. Values of $(x_i - \bar{x})^2$ are $1, 9, 49, 9, 9$ and 25 $\therefore s = \sqrt{\frac{102}{5}} = 4.52$ Now, $t = \frac{\bar{x}-\mu}{\frac{s}{\sqrt{n}}} = \frac{23-25}{\frac{4.52}{\sqrt{6}}}$ $= -1.09$ $\Longrightarrow\ \lvert t\rvert = 1.09$ Since, calculated value $\lvert t\rvert = 10.763 <$ tabulated value $t_5(0.01) = 4.132$ So, the null hypothesis is accepted. Hence, the manufacturer's claim is valid at 1% level of significance.	½ **1** **1** ½
28.	Given, mean $= \lambda = 3.2$ Let X be the number of bicycle riders which use the cycle track.	½

	Required probability $= P(X \leq 2) = P(X = 0) + P(X = 1) + P(X = 2)$ $= \frac{e^{-3.2}(3.2)^0}{0!} + \frac{e^{-3.2}(3.2)^1}{1!} + \frac{e^{-3.2}(3.2)^2}{2!}$ $= e^{-3.2}(1 + 3.2 + 5.12)$ $= 0.041 \times 9.32 = 0.618$ Also, mean expectation = variance of $X = \lambda = 3.2$	1½ ½ ½
29.	Here, Initial investment value $(IV) = ₹\,5000$ Final investment value $(FV) = ₹\,10500$ No of period $(n) = 3$ (starting from 2021 to 2023) $\Rightarrow r = \left(\frac{FV}{IV}\right)^{\frac{1}{n}} - 1 = \left(\frac{10500}{5000}\right)^{\frac{1}{3}} - 1$ $= 1.2805 - 1 = 0.2805$ $CAGR = 28.05\%$	½ ½ 1 ½ ½
30.	Let the number of necklaces manufactured be x, and the number of bracelets manufactured be y. According to question, $x + y \leq 25$ and $\frac{x}{2} + y \leq 14$ The profit on one necklace is **₹ 100** and the profit on one bracelet is **₹ 300**. Let the profit (the objective function) be Z, which has to be maximized. Therefore, required LPP is Maximize $Z = 100x + 300y$ Subject to the constraints $x + y \leq 25$ $\frac{x}{2} + y \leq 14$ $x, y \geq 0$	1 ½ 1 ½
31(a).	(i) **We have,** $\sum_{i=1}^{8} P(X = i) = 1$	

	$\Rightarrow p+2p+2p+p+2p+p^2+2p^2+7p^2+p=1$	½
	$\Rightarrow 10p^2+9p-1=0$	
	$\Rightarrow (10p-1)(p+1)=0$ $\Rightarrow p\neq -1$ $\therefore p=\frac{1}{10}$	1
	(ii) **Mean,** $E(X)=\sum_{i=1}^{8} i\,P(X=i)$	½
	$=1\times p+2\times p+3\times 2p+4\times p+5\times 2p+6\times p^2+7\times 2p^2+8\times(7p^2+p)$	½
	$=33p+76p^2$	
	$=\frac{33}{10}+\frac{76}{100}=\frac{203}{50}$	½
	OR	
31(b).	We have, $p=0.01=\frac{1}{100}\Rightarrow q=\frac{99}{100}$	½
	Let number of Bernoulli trials be n.	
	Now, the binomial distribution formula is for any random variable (X) is given by	
	$P(X=x)={}^{n}C_{x}\left(\frac{1}{100}\right)^{x}\left(\frac{99}{100}\right)^{n-x}$	
	So, the probability of at least one success is	
	$P(X\geq 1)=1-P(X=0)=1-{}^{n}C_{0}\left(\frac{1}{100}\right)^{0}\left(\frac{99}{100}\right)^{n}=1-\left(\frac{99}{100}\right)^{n}$	1
	According to condition, $P(X\geq 1)\geq 0.5\Rightarrow 1-\left(\frac{99}{100}\right)^{n}\geq 0.5\Rightarrow\left(\frac{99}{100}\right)^{n}\leq 0.5$	½
	$\Rightarrow n\log_{10}\frac{99}{100}\leq\log_{10}0.5\Rightarrow n\geq\frac{\log_{10}0.5}{\log_{10}0.99};\quad(\text{as }\log_{10}0.99<0)$	½
	$\left[\text{Using }\log_{10}2=0.3010\text{ and }\log_{10}99=1.9956\right]\Rightarrow n\geq 68.409\Rightarrow n=69\ [\because n\in\mathbb{N}]$.	½

Section –D

[This section comprises of solution of long answer type questions (LA) of 5 marks each]

32(a). Here, number of observations $n = 11(\textit{odd number})$

Year (t)	Production (y)	$x = t_i - 1967$	x^2	xy
1962	2	-5	25	-10
1963	4	-4	16	-16
1964	3	-3	9	-9
1965	4	-2	4	-8
1966	4	-1	1	-4
1967	2	0	0	0
1968	4	1	1	4
1969	9	2	4	18
1970	7	3	9	21
1971	10	4	16	40
1972	8	5	25	40
Total	$\sum y = 57$	$\sum x = 0$	$\sum x^2 = 110$	$\sum xy = 76$

2 marks for correct table

Year **1967** is taken as year of origin.

The normal equations are $\sum y = na + b\sum x$ and $\sum xy = a\sum x + b\sum x^2$

Since, $\sum x = 0$ i.e., deviation from actual mean is zero,

we have $a = \frac{\sum y}{n} = \frac{57}{11} = 5.18$, $b = \frac{\sum xy}{\sum x^2} = \frac{76}{110} = 0.69$

Therefore, the required equation of the trend line $y = 5.18 + 0.69x$ **1**

The trend values are

$1.73, 2.42, 3.11, 3.8, 4.49, 5.18, 5.87, 6.56, 7.25, 7.94, 8.63$ **2**

OR

32(b).

Yearly/ Quarterly		Small scale industry	4-quarterly moving total	4-quarterly moving average	4-year centered moving average
	I	**39**			

2020	II	**47**	162	40.5		**1½ marks each for 3rd and 4th column** **2 marks for last column**
	III	**20**	191	47.75	**44.125**	
	IV	**56**	203	50.75	**49.25**	
2021	I	**68**	249	62.25	**56.5**	
	II	**59**	265	66.25	**64.25**	
	III	**66**	285	71.25	**68.75**	
	IV	**72**	286	71.5	**71.375**	
2022	I	**88**	280	70.00	**70.75**	
	II	**60**	275	68.75	**69.375**	
	III	**60**				
	IV	**67**				

33(a).

$y = ax^2 + bx + c$

Owl passes through the points $(1,2), (2,1)$ and $(4,5)$. So, it must satisfy the given equation

Therefore,

$2 = a + b + c$

$1 = 4a + 2b + c$

$5 = 16a + 4b + c$ } **1**

Now, $D = \begin{vmatrix} 1 & 1 & 1 \\ 4 & 2 & 1 \\ 16 & 4 & 1 \end{vmatrix} = 1(2-4) - 1(4-16) + 1(16-32) = -6 \neq 0$ **½**

$D_a = \begin{vmatrix} 2 & 1 & 1 \\ 1 & 2 & 1 \\ 5 & 4 & 1 \end{vmatrix} = 2(2-4) - 1(1-5) + 1(4-10) = -6$ **½**

$D_b = \begin{vmatrix} 1 & 2 & 1 \\ 4 & 1 & 1 \\ 16 & 5 & 1 \end{vmatrix} = 1(1-5) - 2(4-16) + 1(20-16) = 24$ **½**

	and $D_c = \begin{vmatrix} 1 & 1 & 2 \\ 4 & 2 & 1 \\ 16 & 4 & 5 \end{vmatrix} = 1(10-4) - 1(20-16) + 2(16-32) = -30$	½
	$\therefore a = \frac{D_a}{D} = \frac{-6}{-6} = 1$; ,b $= \frac{D_b}{D} = \frac{24}{-6} = -4$, ,c $= \frac{D_c}{D} = \frac{-30}{-6} = 5$	1½
	Therefore, equation of the curve is $y = x^2 - 4x + 5$	
	When owl is sitting at $(0,k)$ then $x = 0 \Rightarrow k = 5$	½
	OR	
33(b).	(i) $s(t) = at^2 + bt + c$; $t \geq 0$	
	Clearly, $(10,16),(20,22),(30,25)$ **lie on the curve of** $s(t)$.	
	Then, $100a + 10b + c = 16$ $400a + 20b + c = 22$ $900a + 30b + c = 25$	1
	(ii) **Let,** $A = \begin{pmatrix} 100 & 10 & 1 \\ 400 & 20 & 1 \\ 900 & 30 & 1 \end{pmatrix}$; $X = \begin{pmatrix} a \\ b \\ c \end{pmatrix}$; $B = \begin{pmatrix} 16 \\ 22 \\ 25 \end{pmatrix}$	½
	Then, the system becomes, $AX = B$ $\lvert A \rvert = 100(-10) - 400(-20) + 900(-10)$ $= -1000 + 8000 - 9000$ $= -2000 \neq 0$	½
	Now, $adjA = \begin{pmatrix} -10 & 500 & -6000 \\ 20 & -800 & 6000 \\ -10 & 300 & -2000 \end{pmatrix}^T = \begin{pmatrix} -10 & 20 & -10 \\ 500 & -800 & 300 \\ -6000 & 6000 & -2000 \end{pmatrix}$	1
	Therefore, $A^{-1} = \frac{1}{\lvert A \rvert}(adjA) = \frac{1}{-2000}\begin{pmatrix} -10 & 20 & -10 \\ 500 & -800 & 300 \\ -6000 & 6000 & -2000 \end{pmatrix}$	½

	Then, $X = A^{-1}B = \frac{1}{-2000}\begin{pmatrix} -10 & 20 & -10 \\ 500 & -800 & 300 \\ -6000 & 6000 & -2000 \end{pmatrix}\begin{pmatrix} 16 \\ 22 \\ 25 \end{pmatrix}$ $= \frac{1}{-2000}\begin{pmatrix} 30 \\ -2100 \\ -14000 \end{pmatrix}$ $= \begin{pmatrix} -\frac{3}{200} \\ \frac{21}{20} \\ 7 \end{pmatrix}$ **Therefore,** $a = -\frac{3}{200}, b = \frac{21}{20}, c = 7.$	**1½**
34.	Let us consider demand function be $p = D(x) = ax + b.....(i)$ When $x = 25$ then $p = 20000$ From equation (i), we have $20000 = 25a + b.....(ii)$ And when $x = 125$ then $p = 15000$ From equation (i), we have $15000 = 125a + b.....(ii)$ On solving equations (i) and (ii), we get $a = -50$ and $b = 21250$ Therefore, demand function, $p = D(x) = -50x + 21250$ For equilibrium point $D(x_0) = S(x_0)$ $\Rightarrow -50x_0 + 21250 = 100x_0 + 7000$ $\Rightarrow -150x_0 = -14250$ $\Rightarrow x_0 = 95$ On putting value of x_0 in demand function and supply function, we get $p_0 = 16500$	½ ½ **1** ½ ½ ½

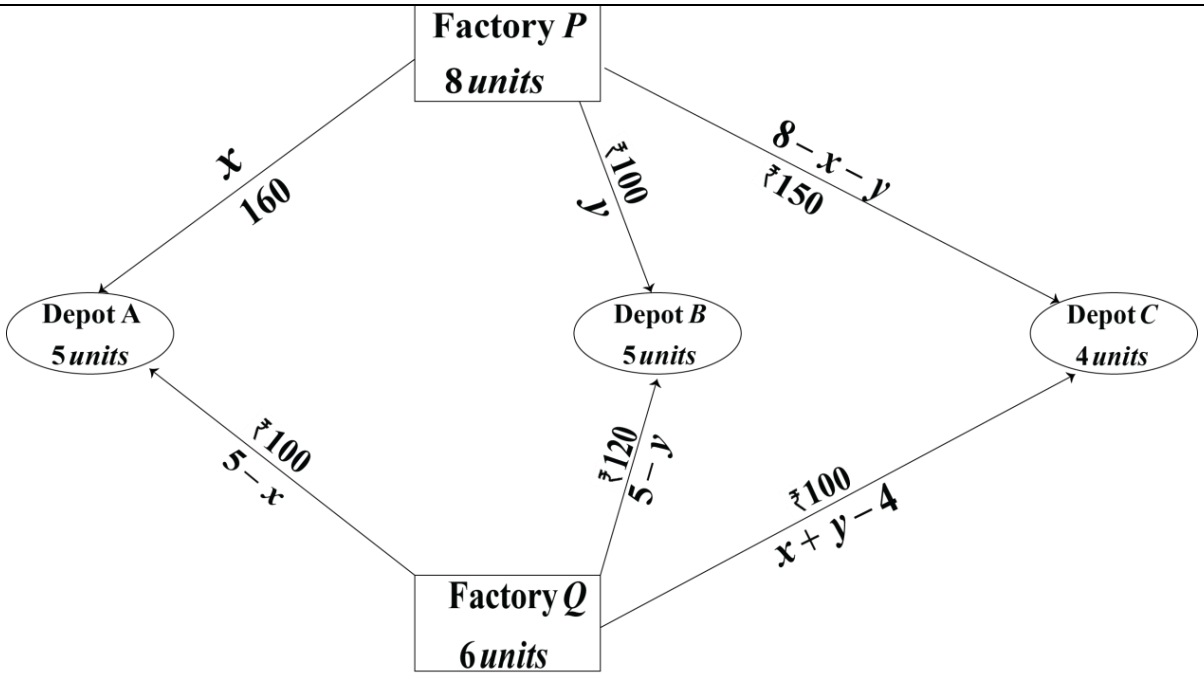
	$\therefore$ Consumer surplus (CS) $= \int_0^{x_0} D(x)dx - p_0 x_0$ $= \int_0^{95} (-50x + 21250)dx - 16500 \times 95$ $= \left(-50\frac{x^2}{2} + 2150x\right)_0^{95} - 1567500$ $= 1793125 - 1567500$ $= ₹\ 225625$	**1** **½**
35.	Amount needed after **4** years = Replacement Cost - Salvage Cost = ₹ (**55,200** – 72**00)** = **₹ 48,000** The payments into sinking fund consisting of 10 annual payments at the rate **7%** per year is given by $A = RS_{\overline{n}|i} = R\left[\frac{(1+i)^n - 1}{i}\right]$ $\Rightarrow 48000 = R\left[\frac{(1+0.07)^4 - 1}{0.07}\right] = R\left[\frac{(1.07)^4 - 1}{0.07}\right]$ $\Rightarrow R = \frac{48000}{4.4385} = ₹10814.5$ **Amount of Annual Depreciation** $= \frac{36000-7200}{4} = \frac{28800}{4} = ₹7200$ **and rate of Depreciation** $= \frac{7200}{36000-7200} \times 100 = 25\%$	**1** **2** **1** **1**

Section –E

[This section comprises solution of 3 case- study/passage-based questions of 4 marks each with two sub parts. Solution of the first two case study questions have three sub parts (i),(ii),(iii) of marks 1,1,2 respectively. Solution of the third case study question has two sub parts of 2 marks each.]

36.	(i) For all values of $x, y = x^2 + 7$ $\therefore$ Shivam's position at any point of x will be $\left(x,\ x^2+7\right)$ The measure of the distance between Shivam and Manita, i.e., D $D = \sqrt{(x-3)^2 + \left(x^2+7-7\right)^2} = \sqrt{(x-3)^2 + x^4}$ (ii) We have, $D = \sqrt{(x-3)^2 + x^4}$ $\text{Let } \Delta = D^2 = (x-3)^2 + x^4$ Now, $\frac{d}{dx}(\Delta) = 2(x-3) + 4x^3 = 4x^3 + 2x - 6$ $\frac{d}{dx}(\Delta) = 0 \Rightarrow x = 1$ (iii) (a): $\Delta''(x) = 8x^2 + 2$ Clearly, $\Delta''(x) = 8x^2 + 2 > 0$ at $x = 1$ $\therefore$ Value of x for which D will be minimum is 1. For $x = 1, y = 8.$ Therefore, required distance = $D = \sqrt{(1-3)^2 + (1)^4} = \sqrt{4+1} = \sqrt{5}$ **OR** (iii) (b): $\Delta''(x) = 8x^2 + 2$ Clearly, $\Delta''(x) = 8x^2 + 2 > 0$ at $x = 1$ $\therefore$ Value of x for which D will be minimum is 1. For $x = 1, y = 8.$ Thus, the required position for Shivam is $(1, 8)$ when he is closest to Manita.	½ + ½ ½ ½ 1 1 1 1
37.	(i) Here, time = 25 **years** $\therefore$ Total number of payments = $25 \times 12 = 300$ $R = 9\%$ per annum. Rate of interest per month = $\frac{9}{1200} = 0.0075$ (ii) (a) Cost of house = ₹ 2500000 Down Payment = ₹ 500000	½ ½

	$\therefore$ Principal amount $= ₹\left(2500000 - 500000\right)$ $= ₹\,2000000$	½
	EMI (using ***reducing balance method***) $= \dfrac{P \times i}{1-\left(1+i\right)^{-n}}$ $= \dfrac{2000000 \times 0.0075}{1-\left(1+0.0075\right)^{-300}}$ $= \dfrac{15000}{1-\left(1.0075\right)^{-300}}$ $= \dfrac{15000}{1-\left(0.1062\right)}$ $= \dfrac{15000}{0.8938} = 16782.27$ Hence, monthly payment is ₹ 16782.27	1 ½
	OR	
	(ii) (b) Cost of house $= ₹\,2500000$ Down Payment $= ₹\,500000$ $\therefore$ Principal amount $= ₹\left(2500000 - 500000\right)$ $= ₹\,2000000$	½
	EMI (using ***flat rate method***) $= P\left(i + \dfrac{1}{n}\right)$ $= 2000000\left(0.0075 + \dfrac{1}{300}\right) = 2000000\left(0.0108333\right)$ $= ₹\,21666.66$	1 ½
	(iii) **EMI** (using ***reducing balance method***) = ₹ 16782.27 $\therefore$ **Total interest** $= n \times \text{EMI} - P$ $= 300 \times 16782.27 - 2000000$ $= 3034681$ Hence, total interest is ₹ 3034681 When **EMI** is calculated by (using ***flat rate method***), then **Total interest** $= n \times EMI - \text{P} = 300 \times 21666.6 - 2000000$ $= ₹\,4499980$	½ ½ ½ ½
38.	(i) Let the factory P supply x units per week to depot **A** and y units to depot **B** so that it supplies $8 - x - y$ units to depot **C**. Obviously $0 \le x \le 5, 0 \le y \le 5, 0 \le 8 - x - y \le 4.$ The given data can be represented diagrammatically as:	



Thus, total transportation cost (in ₹)

$= 160x + 100y + 150(8 - x - y) + 100(5 - x) + 120(5 - y) + 100(x + y - 4) = 10(x - 7y + 190).$

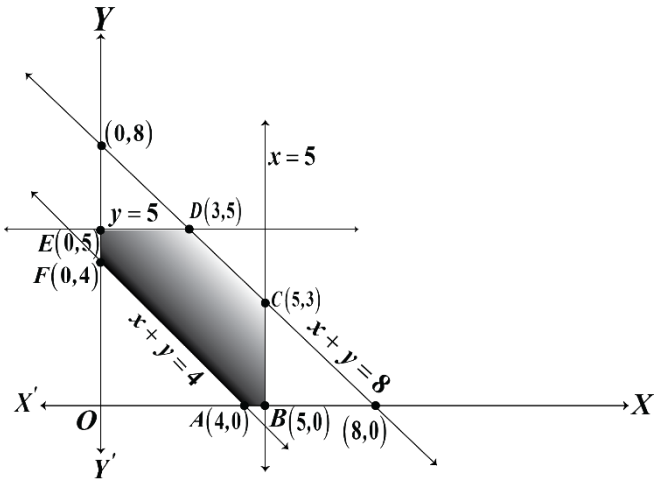
Hence the given problem can be formulated as an L.P.P as: **1**

Minimize $Z = 10(x - 7y + 190)$

subject to the constraints

$x + y \geq 4,$
$x + y \leq 8,$
$x \leq 5,$
$y \leq 5$
$x \geq 0, y \geq 0$ **1**

(ii) The feasible region corresponding to these in equations is shown shaded in the figure given below.



1

Corner Points	Value of $Z = 10(x - 7y + 190)$
A (4,0)	1940
B (5,0)	1950
C (5,3)	1740
D (3,5)	1580
E (0,5)	**1550 $\rightarrow$ Minimum**
F (0,3)	1690

1

We observe that Z is minimum at point $E(0, 5)$ and minimum value is ₹ 1550.

Hence $x = 0, y = 5$. Thus for minimum transportation cost, factory P should supply $0, 5, 3$ units to depots **A, B, C** respectively and factory **Q** should supply $5, 0, 1$ units respectively to depots **A, B, C**.