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

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4.	Match the following columns to complete the sentence and choose the correct option **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	1
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 (A) will decrease. (B) will remain the same (C) will increase (D) will no longer be valid	1
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? (A) $\frac{k-p}{m} < 3$ (B) $\frac{k-p}{m} \leq 4$ (C) $\frac{k-p}{m} < 2$ (D) $\frac{k-p}{m} \leq 3$	1
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 (A) $A^2 = I$ (B) $A' = -I$ (C) $\|A\| = 0$ (D) A is a scalar matrix	1
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 (A) $\frac{1}{3}$ (B) $\frac{1}{2}$ (C) $\frac{1}{4}$ (D) $\frac{1}{6}$	1
9.	The central limit theorem states that if the sample size_______ (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	1

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

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	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

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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. (5)

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

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:

$x_d(A) = 82 - 3\,p_A + p_B \qquad x_S(A) = -5 + 15\,p_A$

$x_d(B) = 92 + 2\,p_A - 4p_B \qquad x_S(B) = -6 + 32\,p_B$

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.

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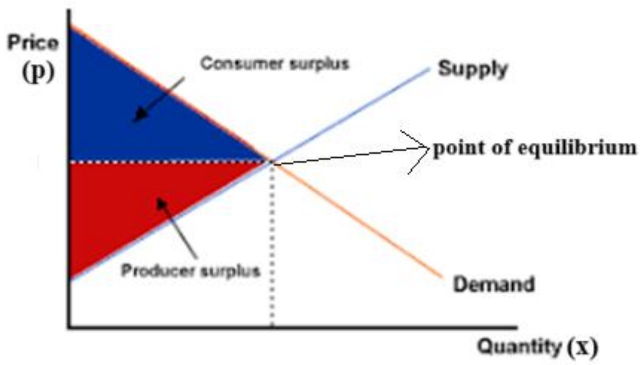
35.	Mr. Sharma plans to buy a car worth ₹10,00,000. He makes a down payment of 20% of the car price and takes a loan for the remaining amount. The loan is to be repaid in 5 years with an annual interest rate of 10%, compounded monthly. Calculate the monthly EMI using the reducing balance method and the 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

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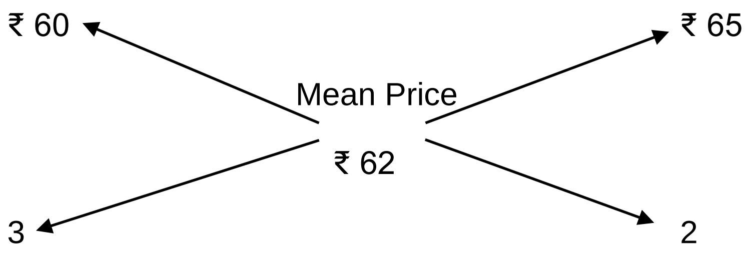
APPLIED MATHEMATICS – Code No.241
MARKING SCHEME
CLASS – XII (2025 - 26)

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)** $\frac{dy}{dx} = \frac{dy/dt}{dx/dt} = \frac{2a}{2at} = \frac{1}{t} \Rightarrow \frac{d^2y}{dx^2} = \frac{d}{dx}\left(\frac{1}{t}\right) = -\frac{1}{t^2}\frac{dt}{dx} = -\frac{1}{t^2}\left(\frac{1}{2at}\right) = -\frac{1}{2at^3}$ $At\ t = 2, \frac{d^2y}{dx^2} = -\frac{1}{2a(2)^3} = -\frac{1}{16a}$	**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 $\mathrm{B} = -\mathrm{A}^{-1}\mathrm{BA} \quad \Rightarrow \ AB = -BA$ $\therefore (\mathrm{A}+\mathrm{B})^2 = (\mathrm{A}+\mathrm{B})(\mathrm{A}+\mathrm{B})$ $= \mathrm{A}^2 + \mathrm{AB} + \mathrm{BA} + \mathrm{B}^2 = \mathrm{A}^2 - \mathrm{BA} + \mathrm{BA} + \mathrm{B}^2 = \mathrm{A}^2 + \mathrm{B}^2$	**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)** $P(X=k) = P(X=k+2)$ $\Longrightarrow \ 6_{C_k}\left(\frac{1}{2}\right)^{6-k}\left(\frac{1}{2}\right)^{k} = 6_{C_{k+2}}\left(\frac{1}{2}\right)^{6-k-2}\left(\frac{1}{2}\right)^{k+2}$ $\Longrightarrow \ 6_{C_k} = 6_{C_{k+2}} \Longrightarrow 2k+2 = 6 \ (\because k \neq k+2)$ $\Longrightarrow k = 2$	**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)** $adj\ (adj\ A) = adj\left[\mathrm{adj}\begin{pmatrix} a & b \\ c & d \end{pmatrix}\right] = adj\begin{pmatrix} d & -b \\ -c & a \end{pmatrix} = \begin{pmatrix} a & b \\ c & d \end{pmatrix} = A$ 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. ∴ 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 $0 \leq (1-p) \leq 1$ $np(1-p) \leq np \Longrightarrow$ Variance ≤ Mean ∴ 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, $100!\ mod\ 10 = 0 \quad \Rightarrow (2^{100} + 100!)mod\ 10 \equiv (6+0)mod10 = 6$ **OR**	**1** **1**
21 (B)	Obviously $\sqrt{6} + \sqrt{5} > \sqrt{3} + \sqrt{2} \quad \Rightarrow \frac{(\sqrt{6}+\sqrt{5})(\sqrt{6}-\sqrt{5})}{(\sqrt{6}-\sqrt{5})} > \frac{(\sqrt{3}+\sqrt{2})(\sqrt{3}-\sqrt{2})}{(\sqrt{3}-\sqrt{2})}$ $\Rightarrow \frac{6-5}{(\sqrt{6}-\sqrt{5})} > \frac{3-2}{(\sqrt{3}-\sqrt{2})} \quad \Rightarrow \frac{1}{(\sqrt{6}-\sqrt{5})} > \frac{1}{(\sqrt{3}-\sqrt{2})}$ $\Rightarrow \sqrt{6} - \sqrt{5} < \sqrt{3} - \sqrt{2} \quad \Rightarrow \sqrt{5} + \sqrt{3} > \sqrt{6} + \sqrt{2}$	½ **1** ½
22.	$P(X=1) + P(X=2) + P(X=3) + P(X=4) = 1$ $\Longrightarrow 1 \times a + 2 \times a + 3 \times a + b = 1$ $\Longrightarrow 6\,a + b = 1 \ldots$ (i) $E(X) = 1 \times a + 2 \times 2a + 3 \times 3a + 4 \times b = 2.8$ $\Longrightarrow 14\,a + 4\,b = 2.8 \ldots$ (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(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.	$D = \frac{C-S}{n}$ $\Rightarrow 2500 = \frac{25000-12500}{n}$ $\Rightarrow n = \frac{12500}{2500} = 5$ 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, $\frac{dy}{dx} = 0 \Rightarrow 6x^2 - 6x = 0 \Rightarrow 6x(x-1) = 0$ $\Rightarrow x = 0 \text{ or } 1$ 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 = $\frac{7 \times 56000}{400}$ = ₹ 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% × 50,000) = ₹ 65,000 A = Amount required in sinking fund = ₹ (65,0000 − 6,000) = ₹ 59,000 $R\left[\frac{(1+i)^{n}-1}{i}\right] = A$ $R\left[\frac{(1.06)^{8}-1}{0.06}\right] = 59000$ $R\left[\frac{1.6-1}{0.06}\right] = 59000$ $\Longrightarrow R = \frac{59000 \times 0.06}{0.6}$ = ₹ 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 The objective is to **maximize the profit**, which is given by: $$Z = 30\,x + 40\,y$$ subject to the following constraints: $$4\,x + 6\,y \le 500$$ $$x \le 80$$ $$y \le 60$$ $$x \ge 0, y \ge 0$$	½ 1 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

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

From the table we have

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

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

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

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, $|A| = 2(3-6) - 4(9-2) + 1(9-1)$

$= -6 - 28 + 8 = -26 \neq 0,$ **½**

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

$\implies P = -81x + 18x^2 - x^3 + c$ **1**

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

$\implies P = -81x + 18x^2 - x^3$ and at $x = 9, P = -729 + 2(729) - 729 = 0$ **½**

∴ Total profit at profit maximizing output is 0. **1**

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)	(table below)	**3 marks for correct table**

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	-	-

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

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

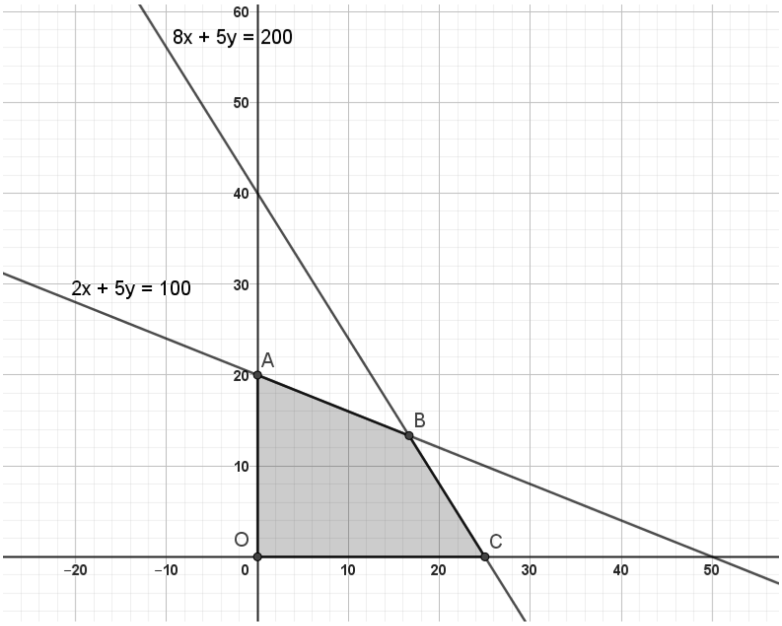
50 % of students scored below 75 marks. ½

(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

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

	(iii) (A) For $X = 67, Z = \frac{67-75}{8} = -1$ For $X = 83, Z = \frac{83-75}{8} = 1$ $P(67 < X < 83) = P(-1 < Z < 1)$ $= P(Z < 1) - P(Z < -1)$ $= 0.8413 - 0.1587 = 0.6826$ ∴ Required number of students $= 0.6826 \times 500 = 341.3 \approx 341$ **OR** (B) Top 10% corresponds to the 90th percentile. $\Longrightarrow Z = \frac{X-\mu}{\sigma} = 1.28$ $\Longrightarrow \frac{X-75}{8} = 1.28$ $\Longrightarrow X = 85.24 \approx 85$ ∴ 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 $a = 30, b = -\frac{1}{40}$ ∴ $p_d = 30 - \frac{1}{40}x$ (ii) For equilibrium, $p_d = p_s$ $\Longrightarrow 30 - \frac{1}{40}x = -15 + \frac{x}{20}$ ∴ $x = 600$ Equilibrium price $= 30 - \frac{1}{40} \times 600 =$ ₹ 15 (iii) (A) Consumer surplus $= \int_0^{600}\left(30 - \frac{1}{40}x\right)dx - 600 \times 15$ $= \left[30\,x - \frac{1}{80}x^2\right]_0^{600} - 9000$ $= 13500 - 90000 = 4500$ ∴ Consumer surplus = ₹ 4500 **OR** (B) Producer surplus $= 600 \times 15 - \int_0^{600}\left(-15 + \frac{x}{20}\right)dx$ $= 9000 - \left[-15\,x + \frac{1}{40}x^2\right]_0^{600}$ $= 9000 - (-9000 + 9000) = 9000$ ∴ 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: $\frac{x}{25} + \frac{y}{40} \leq 1$ i.e., $8x + 5y \leq 200$ $2x + 5y \leq 100$ $x \geq 0, y \geq 0$	½ ½ 1

	(ii)	
		**1½**

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

Thus, the maximum distance the man can travel within one hour is **30 km.** ½