**Roll No:** | | | | | | | | | | | |

# PRESIDENCY UNIVERSITY

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Bengaluru

## Mid Term Examinations - October 2026

**Date:** 05/10/2026 **Time:** 11:45 AM - 01:15 PM

**Course Code:** MAT4002 **Course Name:** Introduction to Operations Research

**Semester:** Third Semester **Max. Marks:** 50 **Weightage:** 50%

| CO - Levels | CO1 | CO2 |
|---|---|---|
| Marks | 92 | 88 |

ANSWER KEY

### PART A: Answer Following Questions. 10 M

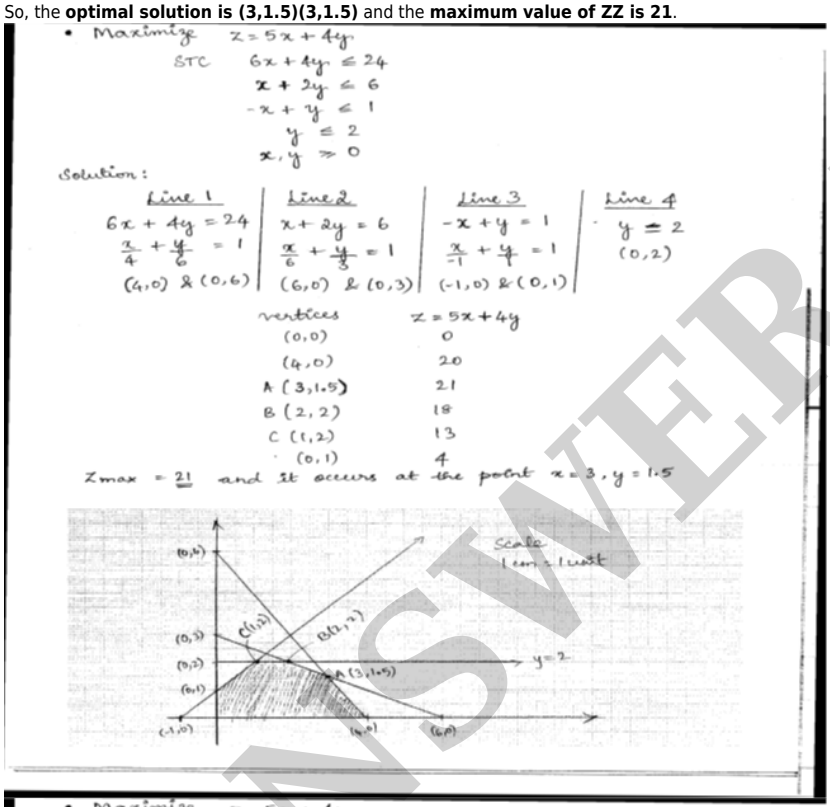
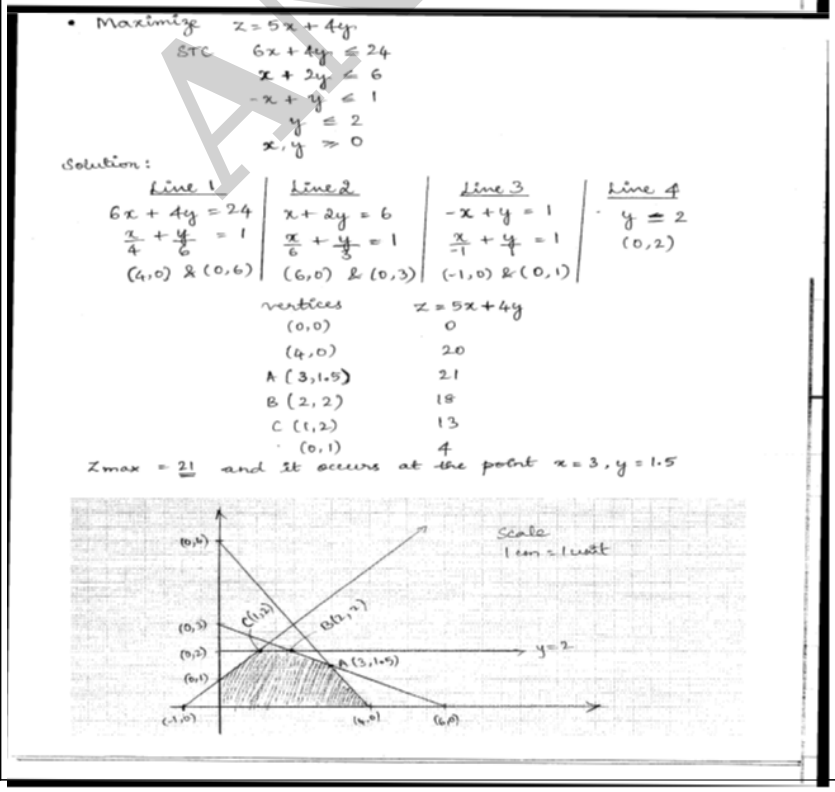
| Q.N. | Questions | M | CO | BT |
|---|---|---|---|---|
| 1 | Definition | 2 | CO1 | BT1 |
| 2 | Objective | 2 | CO2 | BT2 |
| 3 | N-W Coorner Rule Method<br>Least COst Method<br>VAM | 2 | CO2 | BT1 |
| 4 | Three Steps | 2 | CO1 | BT2 |
| 5 | Applications | 2 | CO1 | BT2 |

### PART B : Answer Any 1 Following Questions. 10 M

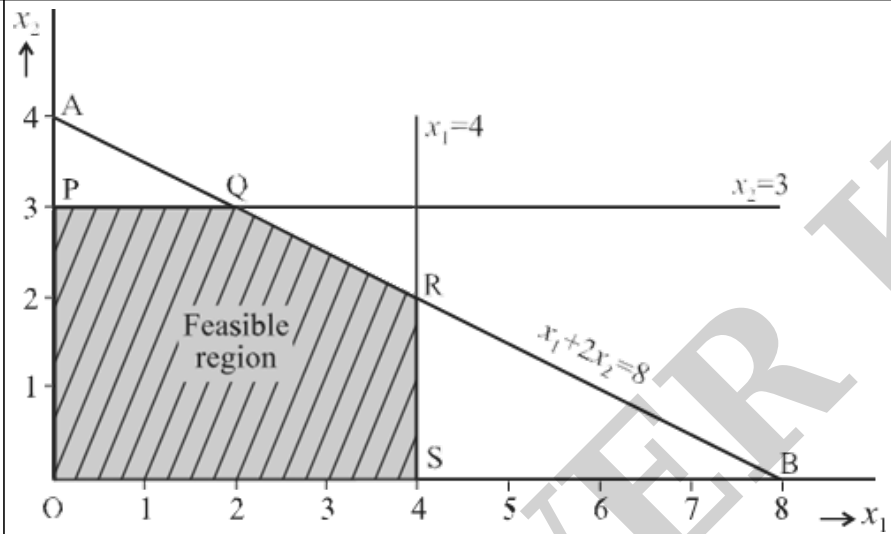
| Q.N. | Questions | M | CO | BT |
|---|---|---|---|---|
| 6 | Phases and LPP fot the given Problem<br>Let the number of units to be manufactured be $x1$, $x2$ and $x3$ respectively for product $P$, $Q$ and $R$.<br>Then decision variables are related to the profit related information.<br>Hence, Maximise Profit = $10x1 + 15x2 + 20x3$.<br>The given constraints are that of production capacity, manhours availability for production and daily demands. These can be converted into linear relations as follows:<br>$0.5x1 + 1.5x2 + 2.0x3 \leq 300$<br>$x1 \leq 50$<br>$x2 \leq 30$ Resources Constraints<br>$x3 \leq 45$<br>$x1 \geq 25$<br>$x2 \geq 20$ Demand Constraints<br>$x3 \geq 35$<br>and $x1$, $x2$ and $x3$ are to be non-negative integer values, the products being produced in whole numbers. | 10 | CO1 | BT3 |



PTO (Please Turn Over)

| | | | | |
|---|---|---|---|---|
| 7 | Steps<br><br>We need to solve the LPP:<br>Maximize Z=5x+4y\text{Maximize } Z=5x+4y<br>Subject to:<br>6x+4y≤246x+4y\leq24 x+2y≤6x+2y\leq6 −x+y≤1-x+y\leq1 y≤2y\leq2 x,y≥0x,y\geq0<br>**1. Convert the constraints into boundary equations**<br>6x+4y=24⇒3x+2y=126x+4y=24 \quad\Rightarrow\quad 3x+2y=12 x+2y=6x+2y=6<br>−x+y=1⇒y=x+1-x+y=1 \quad\Rightarrow\quad y=x+1 y=2y=2<br>**2. Find the feasible-region corner points**<br>The feasible corner points are:<br>(0,0),(1,2),(2,2),(3,1.5),(4,0)(0,0),\quad (1,2),\quad (2,2),\quad (3,1.5),\quad (4,0)<br><br>**3. Evaluate Z=5x+4yZ=5x+4y**<br>**Corner point (x,y)(x,y) Z=5x+4yZ=5x+4y**<br>(0,0)(0,0) 00<br>(1,2)(1,2) 5+8=135+8=13<br>(2,2)(2,2) 10+8=1810+8=18<br>(3,1.5)(3,1.5) 15+6=2115+6=21<br>(4,0)(4,0) 2020<br>**4. Optimal solution**<br>The **maximum value is**<br>Zmax=21\boxed{Z_{\max}=21}<br>at<br>x=3,y=1.5\boxed{x=3,\quad y=1.5}<br>So, the **optimal solution is (3,1.5)(3,1.5)** and the **maximum value of ZZ is 21**.<br><br>• Maximize $Z = 5x + 4y$<br>S.T.C $6x + 4y \leq 24$<br>$x + 2y \leq 6$<br>$-x + y \leq 1$<br>$y \leq 2$<br>$x, y \geq 0$<br>Solution:<br>Line 1: $6x + 4y = 24$, $\frac{x}{4} + \frac{y}{6} = 1$, (4,0) & (0,6)<br>Line 2: $x + 2y = 6$, $\frac{x}{6} + \frac{y}{3} = 1$, (6,0) & (0,3)<br>Line 3: $-x + y = 1$, $\frac{x}{-1} + \frac{y}{1} = 1$, (-1,0) & (0,1)<br>Line 4: $y = 2$, (0,2)<br>vertices $Z = 5x + 4y$<br>(0,0) 0<br>(4,0) 20<br>A (3,1.5) 21<br>B (2,2) 18<br>C (1,2) 13<br>(0,1) 4<br>$Z_{max} = 21$ and it occurs at the point $x = 3, y = 1.5$<br><br>Scale<br>1 cm = 1 unit<br>(0,4) (0,3) (0,2) (0,1) (-1,0) (4,0) (6,0)<br>C(1,2) B(2,2) A(3,1.5) y=2<br><br>• Maximize $Z = 5x + 4y$<br>S.T.C $6x + 4y \leq 24$<br>$x + 2y \leq 6$<br>$-x + y \leq 1$<br>$y \leq 2$<br>$x, y \geq 0$<br>Solution:<br>Line 1: $6x + 4y = 24$, $\frac{x}{4} + \frac{y}{6} = 1$, (4,0) & (0,6)<br>Line 2: $x + 2y = 6$, $\frac{x}{6} + \frac{y}{3} = 1$, (6,0) & (0,3)<br>Line 3: $-x + y = 1$, $\frac{x}{-1} + \frac{y}{1} = 1$, (-1,0) & (0,1)<br>Line 4: $y = 2$, (0,2)<br>vertices $Z = 5x + 4y$<br>(0,0) 0<br>(4,0) 20<br>A (3,1.5) 21<br>B (2,2) 18<br>C (1,2) 13<br>(0,1) 4<br>$Z_{max} = 21$ and it occurs at the point $x = 3, y = 1.5$<br><br>Scale<br>1 cm = 1 unit<br>(0,4) (0,3) (0,2) (0,1) (-1,0) (4,0) (6,0)<br>C(1,2) B(2,2) A(3,1.5) y=2 | 10 | CO1 | BT3 |

ANSWER KEY

| PART C: Answer Any 1 Following Questions. 10 M | | | | |
|---|---|---|---|---|
| **Q.N.** | **Questions** | **M** | **CO** | **BT** |
| 8 | • Maximise $Z$ = $40x1 + 35x2$ Profit<br>• Subject to, $2x1 + 3x2$ <= 60<br>• Material constraint $4x1 + 3x2$ <= 96 is<br>• Labour constraint<br>Values of $Z$ corresponding to all corner points are:<br><br>*Point* — $x1$ — $x2$ — $Z$<br>O — 0 — 0 — 0<br>P — 0 — 20 — 700<br>Q — 18 — 8 — 1,000 (max.)<br>R — 24 — 0 — 960<br>• Since value of $Z$ is maximum at $Q$, optimal solution is to produce 18 units of product A and 8 units of product B every week so as to get the profit of ₹ 1,000. By this combination, the material as well as labour resources are fully utilised. | 10 | CO1 | BT3 |
| 9 | <br><br>*Point* — $x1$ — $x2$ — $Z$<br>O — 0 — 0 — 0<br>P — 0 — 3 — 15<br>Q — 2 — 3 — 19 (max.)<br>R — 4 — 2 — 18<br>S — 4 — 0 — 8<br>• Maximum $Z$ can be established at point $Q$ and the value of $Z$(max.) = 19<br>• Thus the product mix for maximum $Z$ (say profit) will be 2 units of $x1$ and 3 units of $x2$. | 10 | CO1 | BT3 |

| PART D: Answer Any 1 Following Questions. 10 M | | | | |
|---|---|---|---|---|
| **Q.N.** | **Questions** | **M** | **CO** | **BT** |

ANSWER KEY

Total availability = Total requirement = 78 This is a balanced transportation problem Feasible solution exists
Assign $x_{11}$ = min [20, 40] = 20 in the cell (1, 1). Availability at A is exhausted. Score out the first row.

**I II III IV V**

| | | | | |
|---|---|---|---|---|
| 20<br>3 | 4 | 6 | 8 | 9 |
| 2 | 10 | 1 | 5 | 8 |
| 7 | 11 | 20 | 40 | 3 |
| 2 | 1 | 9 | 14 | 16 |

**A 20**

**B**

**30**

**C**

**15**

**D**

**13**

**40 20 6 8 18 6**

**Next allocate $x_{21}$ = min [30, 20] = 20 in the cell (2, 1).**

10

**Hence a basic solution to the T.P. is**
**$x_{11}$ = 20, $x_{22}$ = 6, $x_{23}$ = 4, $x_{33}$ = 4, $x_{34}$ = 11, $x_{44}$ = 7, $x_{45}$ = 6,**
**Number of allocation is 8, which is equal to m + n – 1 = 4 + 5 – 1 = 8**
**Hence the solution the solution the solution is a non-degenerate basic feasible solution.**
**Total transportation cost according to this allocation = 20(3) + 20(2) + 6(10) + 4(20) + 11940+7(14) + 6(16) = Rs. 878.**

1. Find an initial basic feasible solution to the following T.P. by North West corner method.

| | | A | B | C | D | Availability |
|---|---|---|---|---|---|---|
| | I | 1 | 5 | 3 | 3 | 34 |
| Origin | II | 3 | 3 | 1 | 2 | 15 |
| | III | 2 | 2 | 2 | 3 | 12 |
| | IV | 2 | 7 | 7 | 4 | 19 |
| Requirement | | 21 | 25 | 17 | 17 | |

**Solution**
**Total availability = Total requirement = 80 Balanced TP**

**According to this allocation the total transportation cost.**
**= 21(1) + (13) (5) + (12) (3) (1) + 4(12) (2) + (2*12) + (17*4)=21+68+36+96+2+17=231 Rs**

10 | CO2 | BT3

ANSWER KEY

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | | | | | | | | | | 10 | CO2 | BT3 |

| Warehouse / Factory | D | | E | F | G | Capacity | Diff1 | Diff2 | Diff3 | Diff4 |
|---|---|---|---|---|---|---|---|---|---|---|
| A | 42 | | 48 | 38 | **37 160** | 160 | 1 | 1 | 1 | - |
| B | **40** | **80** | 49 | **52 1051 60** | | 150 | 9 | 11* | 1 | 1 |
| C | 39 | | **38 90 40 100** 43 | | | 190 | 1 | 1 | 3 | 3 |
| Requirement | 80 | | 90 | 110 | 220 | 500 | | | | |
| Diff1 | 1 | | 10* | 2 | 6 | | | | | |
| Diff2 | 1 | | - | 2 | 6 | | | | | |
| Diff3 | - | | - | 2 | 6* | | | | | |
| Diff4 | - | | - | 12* | 8 | | | | | |

Thus, the total transportation cost
=40 × 80 + 38 × 90 + 52 × 10 + 40 × 100 + 37 × 160 + 51 × 60
= 3200 + 3420 + 520 + 4000 + 5920 + 306 = 20120

**PART E: Answer Any 1 Following Questions. 10 M**

| Q.N. | Questions | M | CO | BT |
|---|---|---|---|---|
| 12 | Using these values, we fill all the vacant (unoccupied) cells of the table using $\square_{ij} = \square_i + \square_j$ for each unoccupied cell and put dots in the already filled cells so that these cells are not considered again. | 10 | CO2 | BT3 |

| | $\square_1 = 19$ | $\square_2 = 2$ | $\square_3 = 12$ | $\square_4 = 12$ |
|---|---|---|---|---|
| $\square_1 = 0$ | · | 2 | -8 | · |
| $\square_2 = 28$ | 47 | · | · | 40 |
| $\square_3 = 8$ | 27 | · | 20 | · |

Now, subtracting these values from the corresponding values of the original cost matrix, we have the net evaluations, i.e., $\Delta_{ij} = \square_{ij} - (\square_i + \square_j)$

| | | | |
|---|---|---|---|
| · | 28 | 38 | · |
| 23 | · | · | 20 |
| 13 | · | 40 | · |

Since none of the net evaluation is negative, this solution is optimal. Thus, the total minimum transportation cost is Rs799 and the maximum saving = (1000-799) = 201.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 13 | Here the total capacity of sources (factories) is 160 + 150 + 190 = 500. It is greater than the total requirement of all the destinations (warehouses) which is 80 + 90 + 110 + 160 = 440.<br>Therefore, we added dummy destination in the transportation table with zero transportation cost and take 60 as its requirement. Thus, the problem becomes balanced that is the total capacity and total requirement are equal the balanced., the problem is as follows: | 10 | CO2 | BT3 |

| From / To | D | E | F | G | H | Capacity |
|---|---|---|---|---|---|---|
| A | 42 | 48 | 38 | 37 | 0 | 160 |
| B | 40 | 49 | 52 | 51 | 0 | 150 |
| C | 39 | 38 | 40 | 43 | 0 | 190 |
| Requirement | 80 | 90 | 110 | 160 | 60 | 500 |

We can solve this problem using VAM to determine the basic feasible solution and then use MODI method to find the optimal solution. We have solved this problem in VAM Method.

The optimum allocation is:
160to (A, F), 80 to (B, D), 10 to (B, E), 60 to (B, G), 80 to (C, E) and 110 to (C, F).

ANSWER KEY