

**STELLA MARIS COLLEGE (AUTONOMOUS) CHENNAI – 86**  
**(For candidates admitted from the academic year 2023– 2024 and thereafter)**

**B.Sc. DEGREE EXAMINATION, APRIL 2026**  
**BRANCH I - MATHEMATICS**  
**SIXTH SEMESTER**

**COURSE : MAJOR ELECTIVE**  
**PAPER : OPERATIONS RESEARCH**  
**SUBJECT CODE : 23MT/ME/OR45**  
**TIME : 3 HOURS** **MAX. MARKS: 100**

<b>Q. No.</b>	<b>SECTION A (5 × 2 = 10)</b> <b>Answer ANY FIVE questions</b>	<b>CO</b>	<b>KL</b>
1.	Define slack and surplus variables in a linear programming problem.	1	1
2.	Mention the difference between transportation model and assignment model.	1	1
3.	State the assumptions made in sequencing.	1	1
4.	Define the terms payoff matrix, pure strategy in game theory.	1	1
5.	Explain the terms: (i) optimistic time (ii) pessimistic time	1	1
6.	Give the merits and demerits of AON diagram.	1	1
<b>Q. No.</b>	<b>SECTION B (10 × 1 = 10)</b> <b>Answer ALL questions</b>	<b>CO</b>	<b>KL</b>
7.	In the _____ form of the LPP, all the constraints are expressed as equations. a) canonical      b) standard      c) feasible      d) basic	2	2
8.	The optimal solution of a LPP in a graphical method lies at _____ of the feasible region. a) center      b) origin      c) corner point      d) None of the above	2	2
9.	If the primal problem has an unbounded solution, the dual problem has _____ solution. a) unbounded      b) unique optimal      c) no feasible      d) degenerate	2	2
10.	To balance an unbalanced transportation problem where demand exceeds supply, you must add a _____. a) dummy destination      b) dummy source      c) slack variable      d) surplus variable	2	2
11.	Which algorithm is commonly used to solve an assignment problem? a) Simplex Algorithm      b) Vogel's Approximation Method c) Hungarian Algorithm      d) North-West Corner Rule	2	2
12.	Which of the following is NOT an assumption in sequencing problems? a) Processing times are known b) Transfer time between machines is significant c) A machine can process only one job at a time d) A job must be completed before starting another	2	2
13.	When the maximum of column minima equals the minimum of row maxima, the game has _____. a) mixed strategy      b) saddle point      c) no solution      d) unstable solution	2	2



19.	<p>a) Six jobs A, B, C, D, E and F have arrived at one time to be processed on a single machine. Assuming that no new jobs arrive thereafter, determine</p> <ol style="list-style-type: none"> <li>Optimal sequence as per SPT rule</li> <li>Completion times of the jobs</li> <li>Mean flow time</li> <li>Average in-process inventory</li> </ol> <table border="1"> <thead> <tr> <th>Job</th> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>E</th> <th>F</th> </tr> </thead> <tbody> <tr> <td>Processing time (minutes)</td> <td>7</td> <td>6</td> <td>8</td> <td>4</td> <td>3</td> <td>5</td> </tr> </tbody> </table> <p>b) Find the range of <math>p</math> and <math>q</math> which will render the entry (2,2) a saddle point for the game.</p> <table border="1"> <thead> <tr> <th></th> <th>B1</th> <th>B2</th> <th>B3</th> </tr> </thead> <tbody> <tr> <th>A1</th> <td>2</td> <td>4</td> <td>5</td> </tr> <tr> <th>A2</th> <td>10</td> <td>7</td> <td><math>q</math></td> </tr> <tr> <th>A3</th> <td>4</td> <td><math>p</math></td> <td>6</td> </tr> </tbody> </table> <p style="text-align: right;"><b>(9+6)</b></p>	Job	A	B	C	D	E	F	Processing time (minutes)	7	6	8	4	3	5		B1	B2	B3	A1	2	4	5	A2	10	7	$q$	A3	4	$p$	6	3	3
Job	A	B	C	D	E	F																											
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A2	10	7	$q$																														
A3	4	$p$	6																														
20.	<p>The utility data for a network are given below. Draw the network diagram, determine the total, free, independent and interfering floats and identify the critical path.</p> <table border="1"> <tbody> <tr> <td>Activity:</td> <td>1 – 2</td> <td>1 – 3</td> <td>1 – 5</td> <td>2 – 3</td> <td>2 – 4</td> <td>3 – 4</td> <td>3 – 5</td> <td>3 – 6</td> <td>4 – 6</td> <td>5 – 6</td> </tr> <tr> <td>Duration:</td> <td>8</td> <td>7</td> <td>12</td> <td>4</td> <td>10</td> <td>3</td> <td>5</td> <td>10</td> <td>7</td> <td>4</td> </tr> </tbody> </table>	Activity:	1 – 2	1 – 3	1 – 5	2 – 3	2 – 4	3 – 4	3 – 5	3 – 6	4 – 6	5 – 6	Duration:	8	7	12	4	10	3	5	10	7	4	3	3								
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Duration:	8	7	12	4	10	3	5	10	7	4																							
<b>Q. No.</b>	<p><b>SECTION D (<math>2 \times 15 = 30</math>)</b></p> <p><b>Answer ANY TWO questions</b></p>	<b>CO</b>	<b>KL</b>																														
21.	<p>Solve the following LPP using simplex algorithm</p> $\text{Maximize } Z = 4x_1 + 10x_2$ <p>subject to</p> $2x_1 + x_2 \leq 100$ $2x_1 + 5x_2 \leq 200$ $2x_1 + 3x_2 \leq 180 \text{ and } x_1, x_2 \geq 0$	4	4																														

22.	<p>a) Solve the following travelling salesman problem.</p> <table border="1"> <tr> <td></td> <td>A</td> <td>B</td> <td>C</td> <td>D</td> </tr> <tr> <td>A</td> <td>0</td> <td>46</td> <td>16</td> <td>40</td> </tr> <tr> <td>B</td> <td>41</td> <td>0</td> <td>50</td> <td>40</td> </tr> <tr> <td>C</td> <td>82</td> <td>32</td> <td>0</td> <td>60</td> </tr> <tr> <td>D</td> <td>40</td> <td>40</td> <td>36</td> <td>0</td> </tr> </table> <p>b) A and B play a game in which each has three coins, a 5P, a 10P and a 20P. Each player selects a coin without the knowledge of the other's choice. If the sum of the coins is an odd amount, A wins B's coin; if the sum is even, B wins A's coin. Find the best strategy for each player and the value of the game. <span style="float: right;">(7+8)</span></p>		A	B	C	D	A	0	46	16	40	B	41	0	50	40	C	82	32	0	60	D	40	40	36	0	4	4																													
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D	40	40	36	0																																																					
23.	<p>a) Determine the initial solution using North West Corner rule.</p> <table border="1"> <tr> <td>Demand</td> <td>W1</td> <td>W2</td> <td>W3</td> <td>W4</td> <td>Supply</td> </tr> <tr> <td>F1</td> <td>42</td> <td>48</td> <td>38</td> <td>37</td> <td>160</td> </tr> <tr> <td>F2</td> <td>40</td> <td>49</td> <td>52</td> <td>51</td> <td>150</td> </tr> <tr> <td>F3</td> <td>39</td> <td>38</td> <td>40</td> <td>43</td> <td>190</td> </tr> <tr> <td>Demand</td> <td>80</td> <td>90</td> <td>110</td> <td>160</td> <td></td> </tr> </table> <p>b) There are seven jobs, each of which has to go through the machines A and B in the order AB. Processing times in hours are given as</p> <table style="margin-left: auto; margin-right: auto;"> <tr> <td>Job</td> <td>: 1</td> <td>2</td> <td>3</td> <td>4</td> <td>5</td> <td>6</td> <td>7</td> </tr> <tr> <td>Machine A</td> <td>: 3</td> <td>12</td> <td>15</td> <td>6</td> <td>10</td> <td>11</td> <td>9</td> </tr> <tr> <td>Machine B</td> <td>: 8</td> <td>10</td> <td>10</td> <td>6</td> <td>12</td> <td>1</td> <td>3</td> </tr> </table> <p>Find the minimum total elapsed time and the idle time of the machines. <span style="float: right;">(6+9)</span></p>	Demand	W1	W2	W3	W4	Supply	F1	42	48	38	37	160	F2	40	49	52	51	150	F3	39	38	40	43	190	Demand	80	90	110	160		Job	: 1	2	3	4	5	6	7	Machine A	: 3	12	15	6	10	11	9	Machine B	: 8	10	10	6	12	1	3	4	4
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24.	<p>a) Solve the following game by using the principle of dominance:</p> <p style="text-align: center;">Player B</p> <table border="1"> <tr> <td colspan="2" rowspan="2"></td> <td>I</td> <td>II</td> <td>III</td> </tr> <tr> <td>A</td> <td>1</td> <td>7</td> <td>2</td> </tr> <tr> <td rowspan="2">Player A</td> <td>B</td> <td>6</td> <td>2</td> <td>7</td> </tr> <tr> <td>C</td> <td>6</td> <td>1</td> <td>1</td> </tr> </table>			I	II	III	A	1	7	2	Player A	B	6	2	7	C	6	1	1	4	4																																				
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	C	6	1	1																																																					

	b) Draw the network diagram for the following list of activities and number the events according to Fulkerson's rule:																																
	Activity	A	B	C	D	E	F	G	H	I	J	K																					
	Predecessor	-	-	A	A	I, J, K	B, D	B, D	F	A	G, H	F																					
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<b>Q. No.</b>	<b>SECTION E (2 × 10 = 20)</b> <b>Answer ANY TWO questions</b>											<b>CO</b>	<b>KL</b>																				
25.	<p>An advertising company wishes to plan its advertising strategy in four different cities. The purpose of advertising is to reach as large a number of potential customers as possible. Following data has been obtained from market survey:</p> <table border="1"> <thead> <tr> <th></th> <th>Chennai</th> <th>Bangalore</th> <th>Calcutta</th> <th>Hyderabad</th> </tr> </thead> <tbody> <tr> <td>Cost of an advertising unit</td> <td>Rs 30,000</td> <td>Rs 20,000</td> <td>Rs15,000</td> <td>Rs10,000</td> </tr> <tr> <td>No. of potential customers reached per unit</td> <td>Rs2,00,000</td> <td>Rs6,00,000</td> <td>Rs1,50,000</td> <td>Rs1,00,000</td> </tr> <tr> <td>No. of female customers reached per unit</td> <td>Rs1,50,000</td> <td>Rs 4,00,000</td> <td>Rs 70,000</td> <td>Rs 50,000</td> </tr> </tbody> </table> <p>The company wants to spend no more than Rs.4,00,000 on advertising. Following are the further requirements that must be met:</p> <ol style="list-style-type: none"> <li>At least 1million exposures take place among female customers.</li> <li>Advertising in Calcutta and Hyderabad be limited to Rs.1,50,000.</li> <li>At least 3 advertising units be bought in Calcutta and 2 units in Hyderabad.</li> <li>The number advertising units in Chennai and Bangalore should each be between 5 and 10.</li> </ol> <p>Formulate an L.P. model for the problem.</p>												Chennai	Bangalore	Calcutta	Hyderabad	Cost of an advertising unit	Rs 30,000	Rs 20,000	Rs15,000	Rs10,000	No. of potential customers reached per unit	Rs2,00,000	Rs6,00,000	Rs1,50,000	Rs1,00,000	No. of female customers reached per unit	Rs1,50,000	Rs 4,00,000	Rs 70,000	Rs 50,000	5	5
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26.	<p>a) Construct the dual of the problem</p> <p style="text-align: center;">Minimize <math>Z = x_2 + 3x_3</math></p> <p>subject to <math>2x_1 + x_2 \leq 3</math>;</p> <p style="text-align: center;"><math>x_1 + 2x_2 + 6x_3 \geq 5</math></p> <p style="text-align: center;"><math>-x_1 + x_2 + 2x_3 = 2</math> and <math>x_1, x_2, x_3 \geq 0</math></p> <p>b) Give the mathematical formulation of Transportation Model. (5+5)</p>	5	5																																								
27.	<p>Solve the following game by graphical method.</p> <p style="text-align: center;"><b>B</b></p> <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td style="padding: 5px;"></td> <td style="padding: 5px;"></td> <td style="padding: 5px;"><math>y_1</math></td> <td style="padding: 5px;"><math>y_2</math></td> <td style="padding: 5px;"><math>y_3</math></td> <td style="padding: 5px;"><math>y_4</math></td> <td style="padding: 5px;"><math>y_5</math></td> </tr> <tr> <td style="padding: 5px;"><b>A</b></td> <td style="padding: 5px;"><math>x_1</math></td> <td style="padding: 5px;">2</td> <td style="padding: 5px;">-1</td> <td style="padding: 5px;">5</td> <td style="padding: 5px;">-2</td> <td style="padding: 5px;">6</td> </tr> <tr> <td style="padding: 5px;"></td> <td style="padding: 5px;"><math>x_2 = 1 - x_1</math></td> <td style="padding: 5px;">-2</td> <td style="padding: 5px;">4</td> <td style="padding: 5px;">-3</td> <td style="padding: 5px;">1</td> <td style="padding: 5px;">0</td> </tr> </table>			$y_1$	$y_2$	$y_3$	$y_4$	$y_5$	<b>A</b>	$x_1$	2	-1	5	-2	6		$x_2 = 1 - x_1$	-2	4	-3	1	0	5	5																			
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28.	<p>The following table shows the jobs of a network along with their time estimates.</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td style="padding: 5px;">Activity</td> <td style="padding: 5px;">1-2</td> <td style="padding: 5px;">1-6</td> <td style="padding: 5px;">2-3</td> <td style="padding: 5px;">2-4</td> <td style="padding: 5px;">3-5</td> <td style="padding: 5px;">4-5</td> <td style="padding: 5px;">6-7</td> <td style="padding: 5px;">5-8</td> <td style="padding: 5px;">7-8</td> </tr> <tr> <td style="padding: 5px;">Optimistic time estimate</td> <td style="padding: 5px;">1</td> <td style="padding: 5px;">2</td> <td style="padding: 5px;">2</td> <td style="padding: 5px;">2</td> <td style="padding: 5px;">7</td> <td style="padding: 5px;">5</td> <td style="padding: 5px;">5</td> <td style="padding: 5px;">3</td> <td style="padding: 5px;">8</td> </tr> <tr> <td style="padding: 5px;">Most likely time estimate</td> <td style="padding: 5px;">7</td> <td style="padding: 5px;">5</td> <td style="padding: 5px;">14</td> <td style="padding: 5px;">5</td> <td style="padding: 5px;">10</td> <td style="padding: 5px;">5</td> <td style="padding: 5px;">8</td> <td style="padding: 5px;">3</td> <td style="padding: 5px;">17</td> </tr> <tr> <td style="padding: 5px;">Pessimistic time estimate</td> <td style="padding: 5px;">13</td> <td style="padding: 5px;">14</td> <td style="padding: 5px;">26</td> <td style="padding: 5px;">8</td> <td style="padding: 5px;">19</td> <td style="padding: 5px;">17</td> <td style="padding: 5px;">29</td> <td style="padding: 5px;">9</td> <td style="padding: 5px;">32</td> </tr> </table> <p>Draw the project network and find the probability that the project is completed in 40 days.</p>	Activity	1-2	1-6	2-3	2-4	3-5	4-5	6-7	5-8	7-8	Optimistic time estimate	1	2	2	2	7	5	5	3	8	Most likely time estimate	7	5	14	5	10	5	8	3	17	Pessimistic time estimate	13	14	26	8	19	17	29	9	32	5	5
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