

Second Semester MBA Degree Examination, June/July 2025  
**Operation Research**

Time: 3 hrs.

Max. Marks: 100

- Notes: 1. Answer any **FOUR** full questions from Q.No. 1 to Q.No. 7  
 2. Question No. 8 is compulsory.  
 3. M: Marks, L: Bloom's level, C: Course outcomes.

			M	L	C																																				
Q.1	a.	Give a brief historical development of Operations Research.	3	L1	CO1																																				
	b.	A firm is engaged in producing two products A and B. Each unit of product A requires 2 kg of raw material and 4 hours of processing time while each unit of product B requires 3 kg of raw material and 3 hours of processing time. The firm has an availability of 100 kg of raw material and 200 hours of processing time. The profit on one unit of product A and B are Rs.80 and Rs.60 respectively. Formulate the problem as an LPP.	7	L3	CO2																																				
	c.	Solve the following LPP using graphical method, $Z_{max} = 6x_1 + 8x_2$ , subject to $x_1 + x_2 \leq 450$ , $2x_1 + x_2 \leq 600$ and $x_1, x_2 \geq 0$ .	10	L3	CO2																																				
Q.2	a.	State the basic assumptions underlying sequencing problems.	3	L1	CO3																																				
	b.	Define the term Operations Research. Mention different phases of operations research.	7	L1	CO1																																				
	c.	Consider the processing time estimates (in minutes) of 5 jobs each of which should go through on two machines $M_1$ and $M_2$ in the order $M_1, M_2$ . <table border="1" style="margin-left: 20px;"> <thead> <tr> <th>Job</th> <th><math>J_1</math></th> <th><math>J_2</math></th> <th><math>J_3</math></th> <th><math>J_4</math></th> <th><math>J_5</math></th> </tr> </thead> <tbody> <tr> <td><math>M_1</math></td> <td>5</td> <td>1</td> <td>9</td> <td>3</td> <td>10</td> </tr> <tr> <td><math>M_2</math></td> <td>2</td> <td>6</td> <td>7</td> <td>8</td> <td>4</td> </tr> </tbody> </table> <p>Obtain an optimal sequence of the jobs on the machines; find the total elapsed time and idle time of each machine.</p>	Job	$J_1$	$J_2$	$J_3$	$J_4$	$J_5$	$M_1$	5	1	9	3	10	$M_2$	2	6	7	8	4	10	L3	CO3																		
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Q.3	a.	What is meant by an unbalanced transportation problem?	3	L2	CO1																																				
	b.	Find an initial basic feasible solution to the following Transportation Problem using North West Corner Rule. <table border="1" style="margin-left: 20px;"> <thead> <tr> <th colspan="2" rowspan="2"></th> <th colspan="3">Destination</th> <th rowspan="2"></th> </tr> <tr> <th><math>D_1</math></th> <th><math>D_2</math></th> <th><math>D_3</math></th> </tr> </thead> <tbody> <tr> <th rowspan="4">Origin</th> <th><math>O_1</math></th> <td>2</td> <td>7</td> <td>4</td> <td>5</td> </tr> <tr> <th><math>O_2</math></th> <td>3</td> <td>3</td> <td>1</td> <td>8</td> </tr> <tr> <th><math>O_3</math></th> <td>5</td> <td>4</td> <td>7</td> <td>7</td> </tr> <tr> <th><math>O_4</math></th> <td>1</td> <td>6</td> <td>2</td> <td>14</td> </tr> <tr> <td></td> <td></td> <td>8</td> <td>8</td> <td>18</td> <td></td> </tr> </tbody> </table>			Destination				$D_1$	$D_2$	$D_3$	Origin	$O_1$	2	7	4	5	$O_2$	3	3	1	8	$O_3$	5	4	7	7	$O_4$	1	6	2	14			8	8	18		7	L3	CO2
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	c.	Solve the following assignment problem. Assign the tasks (1, 2 and 3) to the persons (A, B and C) so as to minimize the total cost of assignment. <table border="1" style="margin-left: 20px;"> <thead> <tr> <th></th> <th>A</th> <th>B</th> <th>C</th> </tr> </thead> <tbody> <tr> <th>1</th> <td>12</td> <td>11</td> <td>8</td> </tr> <tr> <th>2</th> <td>8</td> <td>9</td> <td>11</td> </tr> <tr> <th>3</th> <td>11</td> <td>14</td> <td>12</td> </tr> </tbody> </table>		A	B	C	1	12	11	8	2	8	9	11	3	11	14	12	10	L3	CO2																				
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Q.4	a.	Write a note on degeneracy of transportation problem.	3	L2	CO2																												
	b.	Solve the following game using the concept of dominance. <table border="1" style="margin-left: 20px;"> <thead> <tr> <th colspan="2" rowspan="2"></th> <th colspan="3">B</th> </tr> <tr> <th>I</th> <th>II</th> <th>III</th> </tr> </thead> <tbody> <tr> <th rowspan="3">A</th> <th>I</th> <td>1</td> <td>7</td> <td>2</td> </tr> <tr> <th>II</th> <td>6</td> <td>2</td> <td>7</td> </tr> <tr> <th>III</th> <td>5</td> <td>2</td> <td>6</td> </tr> </tbody> </table>			B			I	II	III	A	I	1	7	2	II	6	2	7	III	5	2	6	7	L2	CO3							
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	c.	Solve the following $2 \times 3$ game using graphical method. <table border="1" style="margin-left: 20px;"> <thead> <tr> <th colspan="2" rowspan="2"></th> <th colspan="3">B</th> </tr> <tr> <th>I</th> <th>II</th> <th>III</th> </tr> </thead> <tbody> <tr> <th rowspan="2">A</th> <th>I</th> <td>1</td> <td>3</td> <td>11</td> </tr> <tr> <th>II</th> <td>8</td> <td>5</td> <td>2</td> </tr> </tbody> </table>			B			I	II	III	A	I	1	3	11	II	8	5	2	10	L2	CO3											
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Q.5	a.	Write a short note on Decision Theory.	3	L2	CO2																												
	b.	Obtain an initial basic feasible solution to the following transportation problem using Vogel's Approximation Method. <table border="1" style="margin-left: 20px;"> <thead> <tr> <th rowspan="2"></th> <th colspan="3">D<sub>1</sub> D<sub>2</sub> D<sub>3</sub></th> <th rowspan="2"></th> </tr> <tr> <th>D<sub>1</sub></th> <th>D<sub>2</sub></th> <th>D<sub>3</sub></th> </tr> </thead> <tbody> <tr> <th><math>O_1</math></th> <td>2</td> <td>2</td> <td>3</td> <td>10</td> </tr> <tr> <th><math>O_2</math></th> <td>4</td> <td>1</td> <td>2</td> <td>15</td> </tr> <tr> <th><math>O_3</math></th> <td>1</td> <td>3</td> <td>1</td> <td>40</td> </tr> <tr> <td></td> <td>20</td> <td>15</td> <td>30</td> <td></td> </tr> </tbody> </table>		D <sub>1</sub> D <sub>2</sub> D <sub>3</sub>				D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	$O_1$	2	2	3	10	$O_2$	4	1	2	15	$O_3$	1	3	1	40		20	15	30		7	L3	CO2
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	c.	Define the following terms with reference to game Theory: i) Pay off matrix      ii) Pure Strategy      iii) Mixed Strategy iv) Value of Game      v) Fair Game	10	L2	CO3																												
Q.6	a.	Define the term sequencing and state its importance.	3	L1	CO1																												
	b.	Explain the Max. Min and Min. Max principles with an example for each.	7	L2	CO3																												
	c.	Three different operations have to be performed on the machines $M_1, M_2$ and $M_3$ in the order $M_1M_2M_3$ . Obtain the optimal sequence if the processing time estimates of four jobs on the three machines are as follows. <table border="1" style="margin-left: 20px;"> <thead> <tr> <th>Job</th> <th><math>J_1</math></th> <th><math>J_2</math></th> <th><math>J_3</math></th> <th><math>J_4</math></th> </tr> </thead> <tbody> <tr> <td><math>M_1</math></td> <td>3</td> <td>12</td> <td>5</td> <td>2</td> </tr> <tr> <td><math>M_2</math></td> <td>8</td> <td>6</td> <td>4</td> <td>6</td> </tr> <tr> <td><math>M_3</math></td> <td>13</td> <td>14</td> <td>9</td> <td>12</td> </tr> </tbody> </table>	Job	$J_1$	$J_2$	$J_3$	$J_4$	$M_1$	3	12	5	2	$M_2$	8	6	4	6	$M_3$	13	14	9	12	10	L3	CO3								
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Q.7	a.	Describe the phases of project management.	3	L4	CO4																												
	b.	Differentiate between PERT and CPM.	7	L2	CO4																												
	c.	A small project consists of the following jobs whose time estimates in days are given in the table. <table border="1" style="margin-left: 20px;"> <thead> <tr> <th>Job</th> <th>1-2</th> <th>1-3</th> <th>2-3</th> <th>2-5</th> <th>3-4</th> <th>3-6</th> <th>4-5</th> <th>4-6</th> <th>5-6</th> <th>6-7</th> </tr> </thead> <tbody> <tr> <th>Time</th> <td>15</td> <td>15</td> <td>3</td> <td>5</td> <td>8</td> <td>12</td> <td>1</td> <td>14</td> <td>3</td> <td>14</td> </tr> </tbody> </table> i) Draw an arrow diagram representing the project. ii) Find the critical path and total project duration.	Job	1-2	1-3	2-3	2-5	3-4	3-6	4-5	4-6	5-6	6-7	Time	15	15	3	5	8	12	1	14	3	14	10	L4	CO4						
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**Compulsory Questions**

<b>Q.8</b>	<p>Larsen and Toubro construction company has a demand of 3, 3, 4 and 5 million cubic feet of fill at sites I, II, III and IV in Karnataka. It can transfer the fill from three places A, B and C where there is supply of 2, 6 and 7 million cubic feet of fill respectively. The cost of transportation per million cubic feet of fill in lakhs of rupees is given in the following table. Determine the optimum transportation schedule which minimizes the total cost to the company. What is the optimal transportation cost of the schedule made?</p>	<b>20</b>	<b>L3</b>	<b>CO2</b>																												
<table border="1" style="margin: auto;"> <thead> <tr> <th colspan="2"></th> <th colspan="4">To</th> </tr> <tr> <th colspan="2"></th> <th>I</th> <th>II</th> <th>III</th> <th>IV</th> </tr> </thead> <tbody> <tr> <th rowspan="3">From</th> <th>A</th> <td>15</td> <td>10</td> <td>17</td> <td>18</td> </tr> <tr> <th>B</th> <td>16</td> <td>13</td> <td>12</td> <td>13</td> </tr> <tr> <th>C</th> <td>12</td> <td>17</td> <td>20</td> <td>11</td> </tr> </tbody> </table>							To						I	II	III	IV	From	A	15	10	17	18	B	16	13	12	13	C	12	17	20	11
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**SECOND SEMESTER MBA DEGREE EXAMINATION, JUNE/ JULY 2025**

**OPERATION RESEARCH - MBA204**

<b>Q.NO</b>		<b>PARTICULARS</b>	<b>MARKS</b>
1	A	Historical Development of OR OR began during World War II when British and later U.S. military teams of scientists, mathematicians, and engineers were assembled to solve complex military problems — such as optimizing radar use and resource allocation. These efforts used scientific methods to improve operational effectiveness. The term “operational research” was first used around this time.	3 M
	B	MAX. $Z = 80X_1 + 60X_2$  SUBJECT TO CONSTRAINTS $2X_1 + 3X_2 < 100$ $4X_1 + 3X_2 < 200$  NON-NEGATIVITY FUNCTION $X_1, X_2 > 0$	7M
	C	AS PER GRAPHICAL METHOD $Z = 1200$ $X_1 = 300$ $X_2 = 450$	10M
2	A	ASSUMPTIONS UNDERSLYING SEQUENCING PROBLEMS <ul style="list-style-type: none"> <li>➤ Processing times are known and fixed — The time required for each job on each machine is exactly known and does not change with sequence.</li> <li>➤ Processing times are independent of job order — A job’s time on a machine doesn’t depend on where it appears in the sequence.</li> <li>➤ Only one job per machine at a time — A machine cannot process more than one job simultaneously.</li> <li>➤ No preemption — Once a job starts on a machine, it must finish there before another job can begin.</li> <li>➤ Negligible transfer time — Time to move a job from one machine to another is assumed negligible.</li> <li>➤ All jobs are ready — All jobs and machines are known, available, and ready to start at the beginning of the scheduling period.</li> </ul>	3 M
	B	PHASES IN OPERATION RESEACH Problem Formulation / Judgment Phase <ul style="list-style-type: none"> <li>✓ Identify and clearly define the problem, objectives, constraints and what needs to be measured.</li> <li>✓ Set suitable performance measures.</li> </ul> Data Collection & Research Phase	7M

		<ul style="list-style-type: none"> <li>✓ Gather relevant data and information about the problem.</li> <li>✓ Formulate hypotheses and build models (mathematical representations).</li> <li>✓ Test models using the data and analyses results.</li> </ul> <p>Model Construction</p> <ul style="list-style-type: none"> <li>✓ Translate the real-world situation into a mathematical or logical model that can be analyzed.</li> </ul> <p>Solution of the Model</p> <ul style="list-style-type: none"> <li>✓ Use suitable techniques (optimization, simulation, etc.) to derive the best solution from the model.</li> </ul> <p>Testing / Validation</p> <ul style="list-style-type: none"> <li>✓ Check if the model and its solution work correctly in practice; refine or update if necessary.</li> </ul> <p>Implementation / Action Phase</p> <ul style="list-style-type: none"> <li>✓ Apply the chosen solution in the real system.</li> <li>✓ Monitor and control the results to ensure the problem is solved effectively.</li> </ul>						
	C	<p>JOB SEQUENCING</p> <table border="1" style="width: 100%; text-align: center;"> <tr> <td style="width: 20%;">3</td> <td style="width: 20%;">4</td> <td style="width: 20%;">1</td> <td style="width: 20%;">2</td> <td style="width: 20%;">5</td> </tr> </table> <p>TOTAL ELAPSED TIME = 32  IDLE TIME FOR MACHINES  MACHINE 1 = 14  MACHINE 2 = 8</p>	3	4	1	2	5	10M
3	4	1	2	5				
3	A	<p>UNBALANCED TRANSPORTATION PROBLEM</p> <p>An unbalanced transportation problem occurs when the total supply from all sources (origins) is not equal to the total demand at all destinations.</p>	3 M					
	B	<p>INITIAL BASIC FEASIBLE SOLUTION</p> <p>D1 – O1 = 10  D2 – O1 = 9  D3 – O2 = 15  D3 – O4 = 12  TOTAL COST = 46</p>	7M					
	C	<p>ASSIGNING THE TASK TO THE PROBLEMS BASED ON OPTIONAL SOLUTION</p> <p>A – 2 = 08  B – 1 = 11  C – 3 = 12</p> <p>TOTAL OPTIMAL COST (MINIMUM COST) = 31</p>	10M					
4	A	<p>DEGENERACY OF TRANSPORTATION PROBLEM</p> <p>A transportation problem is said to be degenerate when a basic feasible solution (BFS) has fewer than <math>m + n - 1</math>, <math>m+n-1</math> allocated</p>	3 M					

		<p>(occupied) cells, where <math>m</math> is the number of origins and <math>n</math> is the number of destinations.</p> <p>Degeneracy can cause problems when testing for optimality (e.g., with the MODI or stepping-stone method) because it prevents computing all necessary dual variables.</p> <p>Degeneracy means not enough basic allocations to proceed with the usual solution process, and it must be fixed before continuing.</p>	
	B	<p>VALUE OF GAME = <math>3/5</math>  <math>P(A) = \{3/5, 2/5, 0\}</math>  <math>P(B) = \{0, 1/2, 1/2\}</math></p> <p>Value of a game is the expected payoff (gain or loss) that a player can guarantee for themselves when both players follow their optimal strategies in a competitive game — usually a two-person zero-sum game. It represents the average outcome per play if the game is repeated many times under optimal play.</p>	7M
	C	<p>GRAPHICAL METHOD</p> <p>VALUE OF GAME = <math>2/7</math>  <math>P(A) = \{3/5, 2/5\}</math>  <math>P(B) = \{0, 1/5, 4/5\}</math></p> <p>Value of a game is the expected payoff (gain or loss) that a player can guarantee for themselves when both players follow their optimal strategies in a competitive game — usually a two-person zero-sum game. It represents the average outcome per play if the game is repeated many times under optimal play.</p>	10M
5	A	<p>DECISION THEORY</p> <p>Decision Theory in Operations Research is a scientific approach to making the best possible choice among a set of alternative actions when outcomes are uncertain or risky. It provides a framework and analytical methods to help decision-makers select the most suitable course of action based on quantitative evaluation of alternatives and their possible consequences.</p>	3 M
	B	<p>VAM (Vogel's Approximation Method) is a heuristic technique used to find a good initial basic feasible solution for a transportation problem in Operations Research. It usually produces a starting solution that is closer to the optimal (minimum cost) than simpler methods like the North-West Corner or Least Cost methods.</p> <p>VAM works by computing penalty costs for each row and column — which measure the cost you'd incur by not choosing the cheapest route — and then allocating supplies where the largest potential cost saving (highest penalty) exists.</p> <p>INITIAL BASIC FEASIBLE SOLUTION – VAM  TOTAL COST = RS. 145</p>	7M

C	<p><b>GAME THEORY TERMS</b></p> <p><b>A.. PAY OFF MATRIX</b>  A payoff matrix is a tabular representation of the possible outcomes (payoffs) for players in a strategic situation (game), showing what each player receives for every combination of strategies chosen by the players.</p> <p>Rows represent the strategies of Player A (or the decision maker).</p> <p>Columns represent the strategies of Player B (or the opponent).</p> <p>Each cell entry gives the payoff(s) — the gain or loss — to the player(s) when a particular pair of strategies is chosen.</p> <p>In a two-person zero-sum game, the payoffs are usually shown for one player (since one’s gain is the other’s loss), or as a pair for both players.</p> <p><b>B.. PURE STRATEGY</b>  A pure strategy is a specific, fixed course of action that a player commits to in a game, choosing one particular move every time without using randomness or probabilities. It is a deterministic decision rule — the player always selects the same action in a given situation.</p> <p><b>C.. MIXED STRATEGY</b>  A mixed strategy is a type of strategy in game theory where a player randomizes among two or more pure strategies by assigning a probability to each instead of choosing one fixed action every time. This means the player does not always pick the same move but chooses their actions according to a probability distribution over all available options.</p> <p><b>D.. VALUE OF GAME</b>  Value of a game is the expected payoff (gain or loss) that a player can guarantee for themselves when both players use their best (optimal) strategies in a strategic game, especially in a two-person zero-sum game. It gives the average outcome per play of the game if it is played repeatedly under optimal play.</p> <p><b>E.. FAIR GAME</b>  In game theory, a game is called a fair game when the value of the game is zero, meaning neither player has an advantage when both use their optimal strategies. In such a game, the expected gain for</p>	10M
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		each player over the long run is zero — what one player wins is exactly what the other loses.	
6	A	<p><b>DEFINE THE TERM SEQUENCING AND ITS IMPORTANCE</b></p> <p>Sequencing is the process of determining the order in which jobs or tasks should be performed on one or more machines or workstations so that resources are used effectively and objectives (like minimizing total time) are achieved. It involves assigning priorities to waiting jobs to decide which one should be processed first.</p> <p><b>Importance of Sequencing</b></p> <p>Sequencing is important because:</p> <p><b>Improves Efficiency:</b> It helps ensure jobs flow smoothly through machines, reducing idle time and delays.</p> <p><b>Minimizes Total Time:</b> Proper sequencing can reduce the total time taken to complete all jobs</p> <p><b>Optimizes Resource Use:</b> It makes better use of machines and labor by prioritizing tasks effectively.</p> <p><b>Reduces Setup and Idle Times:</b> By ordering similar or compatible jobs together, setup time and downtime can be decreased.</p> <p><b>Improves Productivity and Delivery:</b> Good sequencing leads to higher production rates and better on-time delivery performance.</p>	3 M
	B	<p><b>EXPLAIN MAX. MIN AND MIN MAX PRINCIPLES WITH AN EXAMPLE FOR EACH</b></p> <p>The maximin principle means a player (usually the maximizing player) looks at the minimum payoff for each strategy (worst outcome if the opponent counters perfectly) and then chooses the strategy whose minimum payoff is highest. In other words: maximize the minimum gain.</p> <p>The minimax principle is used by the minimizing player — he looks at the maximum loss for each strategy and then chooses the strategy that gives the minimum of these maximum losses. In other words: minimize the maximum loss.</p>	7M
	C	<p><b>JOB SEQUENCE</b></p> <p><math>J_4 = J_2 = J_1 = J_3</math></p> <p><b>TOTAL ELAPSED TIME = 48</b></p> <p><b>IDLE TIME FOR MACHINES</b></p> <p><b>MACHINE 1 = 12</b></p> <p><b>MACHINE 2 = 8</b></p> <p><b>MACHINE 3 = 6</b></p>	10M

7	A	<p><b>PHASES OF PROJECT MANAGEMENT</b></p> <p><b>Initiation Phase</b></p> <ul style="list-style-type: none"> <li>• This is where a project idea is examined for feasibility and value.</li> <li>• The project purpose, goals, scope, stakeholders, and initial requirements are defined.</li> <li>• It often results in a project charter authorising the project to proceed.</li> </ul> <p><b>Planning Phase</b></p> <ul style="list-style-type: none"> <li>• A detailed plan is created outlining tasks, schedules, resources, budgets, risks, and quality criteria.</li> <li>• This roadmap guides team members throughout the project.</li> </ul> <p><b>Execution Phase</b></p> <ul style="list-style-type: none"> <li>• The project plan is put into action.</li> <li>• Teams carry out their tasks, resources are allocated, and deliverables begin to take shape.</li> </ul> <p><b>Monitoring &amp; Controlling Phase</b></p> <ul style="list-style-type: none"> <li>• Project progress is tracked and compared to the original plan.</li> <li>• Adjustments are made as needed to keep scope, time, cost, and quality on track.</li> <li>• This phase often happens alongside execution.</li> </ul> <p><b>Closure Phase</b></p> <ul style="list-style-type: none"> <li>• The project is completed and formally closed.</li> <li>• Deliverables are handed over, contracts are finalised, documentation is completed, and lessons learned are recorded.</li> </ul>	3 M
	B	<p><b>DIFFERENT BETWEEN PERT &amp; CPM</b></p> <ul style="list-style-type: none"> <li>□ <b>PERT</b> is used when you don't know exactly how long tasks will take — it uses <i>three time estimates</i> to give a more realistic picture.</li> <li>□ <b>CPM</b> is used when task durations are known and fixed, and it also helps manage <i>costs</i> along with scheduling.</li> </ul> <p><b>Example (Quick)</b></p> <p><b>PERT:</b> Planning a new research project where task durations are uncertain and experience is limited — you estimate times with best, worst, and most likely values.</p> <p><b>CPM:</b> Building a bridge — tasks like pouring concrete, welding, painting have known expected durations, and you want to optimize time and cost.</p>	7M

		<p><b>PERT (Program Evaluation and Review Technique)</b>      <b>CPM (Critical Path Method)</b></p> <p><b>Purpose</b>      Used for planning and controlling <b>uncertain activities</b> where time is not known.      Used for managing <b>well-defined activities</b> where time is known.</p> <p><b>Time Estimates</b>      Uses <b>three time estimates</b>: optimistic, most likely &amp; pessimistic.      Uses a <b>single fixed time estimate</b> for each activity.</p> <p><b>Model Type</b>      <b>Probabilistic model</b> — accounts for uncertainty.      <b>Deterministic model</b> — time values are certain.</p> <p><b>Focus</b>      Focuses mainly on <b>time</b> and scheduling under uncertainty.      Focuses on <b>time-cost trade-off</b> (cost optimization as well).</p> <p><b>Orientation</b>      <b>Event-oriented</b> — based on events/milestones.      <b>Activity-oriented</b> — based on activities/tasks.</p> <p><b>Application</b>      Best for <b>research and development</b> or projects with uncertain durations.      Best for <b>construction &amp; new manufacturing projects</b> where durations are predictable.</p> <p><b>Crashing</b>      Not typically used because times are uncertain.      <b>Crashing can be done</b> — schedule is shortened by spending extra cost.</p> <p><b>Complexity</b>      Handles uncertainty; useful when time estimates vary widely.      Simpler when tasks and their durations are well known.</p>	
	C	<p>CRITICAL PATH</p> <p>1 - 2 - 3 - 4 - 6 - 7</p> <p>TOTAL DURATION = 32</p> <p><b>Critical Path</b> is the <b>longest sequence of dependent activities</b> in a project network that determines the <b>minimum time required</b> to complete the entire project. It connects the <b>start event to the final event</b> and any delay in the activities on this path will directly delay the overall project completion.</p>	10M
8		TRANSPORTATION COST	20M

In the **transportation problem** (a special type of Linear Programming in Operations Research), **transportation cost** refers to the **cost of shipping one unit of a commodity from a specific source (origin) to a specific destination**. The goal of the transportation model is to **determine how much to transport on each route so that the total cost of transportation is minimized**, while satisfying supply and demand constraints.

**VAM (Vogel's Approximation Method)** is a popular technique used in solving the **transportation problem** to find a **good initial basic feasible solution** that often leads to a **lower total transportation cost** compared with simpler methods like the North-West Corner Rule.

Instead of simply picking the lowest cost cells first, **VAM considers "penalty costs"** which reflect the **potential extra cost if the best route is *not* chosen**. By allocating where the penalty is highest, VAM tends to reduce the **total transportation cost** early in the solution process.

TRANSPORTATION COST = 245