NARASARAOPETA ENGINEERING COLLEGE

(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

COURSE FILE

Academic year	: 2022-23
Department	: ME
Course Name	: B.Tech
Student's Batch	: 2022-23
Regulation	: R20
Year and Semester	: III B.Tech I Semester
Name of the Subject	: Operations Research
Subject Code	: R20CC10E07
Faculty In charge	: K. John Baby

Signature of Faculty

Head of the Department

Professor & Head
Dept. of Mechanical Engineering
NARASARAOPETA ENGINEERING COLLEGE
NARASARAOPET - 522 601, Guntur (Dt), A.P.

NEC NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

COURSE FILE CONTENTS

NARASARAOPETA
NEC ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

INSTITUTE VISION AND MISSION

NARASARAOPETA
NEC ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

INSTITUTE VISION AND MISSION

VISION:

To emerge as a **Centre of excellence** in technical education with a blend of effective **student centric teaching learning** practices as well as **research** for the transformation of **lives and community**.

MISSION:

1. Provide the best class infrastructure to explore the field of engineering and research.
2. Build a passionate and a determined team of faculty with student centric teaching, imbibing experiential and innovative skills.
3. Imbibe lifelong learning skills, entrepreneurial skills and ethical values in students for addressing societal problems.

PRINCIPAL

NARASARAOPETA
NEC ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

DEPARTMENT VISION AND MISSION

NEC NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

DEPARTMENT VISION AND MISSION

VISION:

To strive for making competent **Mechanical Engineering Professionals** to cater the real time needs of Industry and **Research** Organizations of high repute with **Entrepreneurial Skills and Ethical Values.**

MISSION:

M1. To train the students with State of Art Infrastructure to make them industry ready professionals and to promote them for higher studies and research.

M2. To employ committed faculty for developing competent mechanical engineering graduates to deal with complex problems.

M3. To support the students in developing professionalism and make them socially committed mechanical engineers with morals and ethical values.

HOD-ME

NARASARAOPETA
NEC ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

AND

PROGRAM SPECIFIC OUTCOMES (PSOs)

NARASARAOPETA
NEC ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO 1: Excel in profession with sound knowledge in mathematics and applied sciences

PEO 2: Demonstrate leadership qualities and team spirit in achieving goals

PEO 3: Pursue higher studies to ace in research and develop as entrepreneurs.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1. The students will be able to apply knowledge of modern tools in manufacturing enabling to conquer the challenges of Modern Industry.

PSO2. The students will be able to design various thermal engineering systems by applying the principles of thermal sciences.

PSO3. The students will be able to design different mechanisms and machine components of transmission of power and automation in modern industry.

HOD-ME

NARASARAOPETA
NEC ENGINEERING COLLEGE
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DEPARTMENT OF MECHANICAL ENGINEERING

PROGRAM OUTCOMES
(POs)

NEC NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

PROGRAM OUTCOMES (POs):

Engineering Graduates will be able to:

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

HOD-ME

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BLOOM'S TAXONOMY LEVELS

REVISED Bloom's Taxonomy Action Verbs

Definitions	I. Remembering	II. Understanding	III. Applying	IV. Analyzing	V. Evaluating	VI. Creating
Bloom's Definition	Exhibit memory of previously learned material by recalling facts, terms, basic concepts, and answers.	Demonstrate understanding of facts and ideas by organizing, comparing, translating, interpreting, giving descriptions, and stating main ideas.	Solve problems to new situations by applying acquired knowledge, facts, techniques and rules in a different way.	Examine and break information into parts by identifying motives or causes. Make inferences and find evidence to support generalizations.	Present and defend opinions by making judgments about information, validity of ideas, or quality of work based on a set of criteria.	Compile information together in a different way by combining elements in a new pattern or proposing alternative solutions.
Verbs	• Choose • Define • Find • How • Label • List • Match • Name • Omit • Recall • Relate • Select • Show • Spell • Tell • What • When • Where • Which • Who • Why	• Classify • Compare • Contrast • Demonstrate • Explain • Extend • Illustrate • Infer • Interpret • Outline • Relate • Rephrase • Show • Summarize • Translate	• Apply • Build • Choose • Construct • Develop • Experiment with • Identify • Interview • Make use of • Model • Organize • Plan • Select • Solve • Utilize	• Analyze • Assume • Categorize • Classify • Compare • Conclusion • Contrast • Discover • Dissect • Distinguish • Divide • Examine • Function • Inference • Inspect • List • Motive • Relationships • Simplify • Survey • Take part in • Test for • Theme	• Agree • Appraise • Assess • Award • Choose • Compare • Conclude • Criteria • Criticize • Decide • Deduct • Defend • Determine • Disprove • Estimate • Evaluate • Explain • Importance • Influence • Interpret • Judge • Justify • Mark • Measure • Opinion • Perceive • Prioritize • Prove • Rate • Recommend • Rule on • Select • Support • Value	• Adapt • Build • Change • Choose • Combine • Compile • Compose • Construct • Create • Delete • Design • Develop • Discuss • Elaborate • Estimate • Formulate • Happen • Imagine • Improve • Invent • Make up • Maximize • Minimize • Modify • Original • Originate • Plan • Predict • Propose • Solution • Solve • Suppose • Test • Theory

derson, L. W., & Krathwohl, D. R. (2001). A taxonomy for learning, teaching, and assessing, Abridged Edition. Boston, MA: Allyn and Bacon.

NARASARAOPETA
NEC ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

COURSE OUTCOMES
(COs)

NEC NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

B.TECH – R20 REGULATION - COURSE OUTCOMES

III B. TECH I SEMESTER

Course Name: OPERATIONS RESEARCH (Open Elective –I)		Course Code: C314
CO	**After successful completion of this course, the students will be able to:**	
C314.1	**Illustrate** and **solve** linear programming problems.	
C314.2	**Solve** transportation and assignment problems.	
C314.3	**Select** a suitable sequencing and Solve waiting line theory problems.	
C314.4	**Solve** networking models and replacement problems.	
C314.5	**Analyze** game theory & Dynamic Programming.	

NARASARAOPETA
ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

COURSE INFORMATION SHEET

NEC	**Narasaraopeta Engineering College** **(Autonomous)** **Yallmanda(Post), Narasaraopet- 522601** **Department of Mechanical Engineering**

COURSE INFORMATION SHEET

PROGRAME: B.Tech Mechanical Engineering	
COURSE: **OPERATIONS RESEARCH**	Semester : **V** CREDITS: **3**
COURSE CODE: **R20CC31OE03** REGULATION: R20 **Autonomous**	COURSE TYPE (CORE /ELECTIVE / BREADTH/ S&H): **OPEN ELECTIVE**
COURSE AREA/DOMAIN: **Industrial Engineering**	PERIODS: 6Per Week.

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
R20CC1102	Mathematics – I	Matrix Algebra and Calculus	I-I

COURSE OUTCOMES:

SNO	Course Outcome Statement
CO1	Illustrate and solve linear programming problems **[K3]**
CO2	Solve transportation and assignment problems. **[K3]**
CO3	**Select** the suitable sequencing and solve waiting line theory problems **[K4].**
CO4	**Solve** network models and replacement problems**[K3]**
CO5	**Analyze** game theory & Dynamic programming **[K4]**

SYLLABUS:

UNIT	DETAILS
I	Development-definition, characteristics and phases, types of operation research models, applications. **LINEAR PROGRAMMING PROBLEM:** Formulation, graphical solution, simplex method, artificial variables techniques, two–phase method, big-M method, duality principle.
II	**TRANSPORTATION PROBLEM:** Formulation, types of initial basic feasible solution using different methods, optimal solution, unbalanced transportation problem, degeneracy. **ASSIGNMENT PROBLEM:** Formulation, optimal solution, variants of assignment problem, Travelling salesman problem.
III	**SEQUENCING:** Introduction, flow, shop sequencing, *n* jobs through two machines, *n* jobs through three machines, job shop sequencing, and two jobs through 'm' machines. **WAITING LINES:** Introduction – single channel – poison arrivals –exponential service times – with infinite population and finite population models– multichannel – poison arrivals – exponential service times with infinite population single channel poison arrivals.
IV	**REPLACEMENT**: Replacement Model, Replacement of items that deteriorate, Gradually, Fail suddenly, group Replacement policy analysis, Problems. **NETWORKING MODELS:** Earliest Completion time of a project and Critical path, Programme Evaluation Review Technique, Total Slack, Free Slack, Probability of achieving completion date, Cost Analysis, Crashing the network, Resource Scheduling-Advantages, Limitations, Cost Analysis, Distinction between PERT and CPM, LPP Formulation
V	**THEORY OF GAMES:** Introduction – mini. max (max. mini) – criterion and optimal strategy

	– solution of games with saddle points – rectangular games without saddle points – 2 x 2 games – dominance principle – m x 2 &2 x n games -graphical method. **DYNAMIC PROGRAMMING:** Introduction, Bellman's principle of optimality, Applications of dynamic programming.

TEXT BOOKS	
T	**BOOK TITLE/AUTHORS/PUBLISHER**
T1	Operations Research, S.D.Sharma, KedarNath Ram Nath Publishers
T2	Operations Research, A.M.Natarajan, P.Balasubramani and A. Tamilarasi, Pearson Education
REFERENCE BOOKS	
R	**BOOK TITLE/AUTHORS/PUBLISHER**
R1	Introduction to O.R, Hiller &Libermann, Tata McGraw Hill
R2	Operations Research, R.Pannerselvam, PHI Publications
R3	Operations Research, Wagner, PHI Publications

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS:

SNO	DESCRIPTION	Associated PO & PSO
1	Inventory	PO1,PO2 PO3 & PSO1

WEB SOURCE REFERENCES:

1	https://onlinecourses.nptel.ac.in/noc18_mg41/preview
2	https://nptel.ac.in/courses/112106134/1
3	https://nptel.ac.in/courses/112106134/3
4	https://nptel.ac.in/courses/112106134/4
5	https://nptel.ac.in/courses/112106134/5
6	https://nptel.ac.in/courses/112106134/8
7	https://nptel.ac.in/courses/112106134/14
8	https://nptel.ac.in/courses/112106134/16
9	https://nptel.ac.in/courses/112106134/21

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

√ Chalk & Talk	√ PPT	☐Active Learning
√Web Resources	☐ Students Seminars	☐Case Study
☐Blended Learning	☐ Quiz	☐Tutorials
☐Project based learning	☐NPTEL/MOOCS	☐ Simulation
☐Flipped Learning	☐Industrial Visit	☐Model Demonstration
☐Brain storming	☐Role Play	☐Virtual Labs

MAPPING CO'S WITH PO'S

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
C315.1	3	3	2	-	-	-	-	-	-	-	-	-	3	-	-
C315.2	3	3	2	-	-	-	-	-	-	-	-	-	3	-	-
C315.3	3	3	2	-	-	-	-	-	-	-	-	-	3	-	-
C315.4	3	3	2	-	-	-	-	-	-	-	-	-	3	-	-
C315.5	3	3	2	-	-	—		-	-	-	-	-	3	-	-
C315.6	3	3	2	-	-	-	-	-	-	-	-	-	3	-	-
Average	3.00	3.00	2.00	-	-	-	-	-	-	-	-	-	3.00	-	-

MAPPING COURSE WITH POs & PSOs

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
C311	3.00	3.00	2.00	-	-	-	-	-	-	-	-	-	3.00	-	-

<table>
<tr><th colspan="3">Course Outcome Assessment Methods</th><th colspan="2">Weightages</th><th rowspan="6">Final Course Outcome (100%)</th></tr>
<tr><td rowspan="4">Direct Assessment</td><td rowspan="3">Cumulative Internal Examinations (CIE)</td><td>Descriptive Test</td><td rowspan="3">30%</td><td rowspan="4">90%</td></tr>
<tr><td>Objective Test</td></tr>
<tr><td>Assignment Test</td></tr>
<tr><td colspan="2">Semester End Examinations (SEE)</td><td>70%</td></tr>
<tr><td>Indirect Assessment</td><td colspan="3">Course End Survey</td><td>10%</td></tr>
</table>

Rubrics for overall attainment of course outcomes:
If 50% of the students crossed 50% of the marks: Attainment Level 1
If 60% of the students crossed 50% of the marks: Attainment Level 2
If 70% of the students crossed 50% of the marks: Attainment Level 3

Note: Percentages mentioned in above rubrics can be slightly changed depending upon the complexity of your respected subject.

Ch. Sekhar

Course Instructor **Course Coordinator** **Module Coordinator** **Head of the Department**

ANNEXURE I:

(A) PROGRAM OUTCOMES(POs) Engineering Graduates will be able to:

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5.Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

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10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

(B) PROGRAM SPECIFIC OUTCOMES (PSOs) :

PSO1.The students will be able to understand the modern tools of machining which gives them good expertise on advanced manufacturing methods.

PSO2.The students will be able to design different heat transfer devices with emphasis on combustion and power production.

PSO3.The students are able to design different mechanisms and machine components suitable to automation industry.

Cognitive levels as per Revised Blooms Taxonomy:

Cognitive Domain	LEVEL	Key words
Remember	K1	Defines, describes, identifies, knows, labels, lists, matches, names, outlines, recalls, recognizes, reproduces, selects, states.
Understand	K2	Comprehends, converts, defends, distinguishes, estimates, explains, extends, generalizes, gives an example, infers, interprets, paraphrases, predicts, rewrites, summarizes, translates.
Apply	K3	Applies, changes, computes, constructs, demonstrates, discovers, manipulates, modifies, operates, predicts, prepares, produces, relates, selcts, shows, solves, uses.
Analyse	K4	Analyzes, breaks down, compares, contrasts, diagrams, deconstructs, differentiates, discriminates, distinguishes, identifies, illustrates, infers, outlines, relates, selects, separates.
Evaluate	K5	Appraises, compares, concludes, contrasts, criticizes, critiques, defends, describes, discriminates, evaluates, explains, interprets, justifies, relates, summarizes, supports
Create	K6	Categorizes, combines, compiles, composes, creates, devises, designs, explains, generates, modifies, organizes, plans, rearranges, reconstructs, relates, reorganizes, revises, rewrites, summarizes, tells, write

Unit wise Sample assessment questions

COURSE OUTCOMES: Students are able to

CO1 Illustrate and solve linear programming pr[oblems **K2& K3]**

CO2 Solve transportation and assignment problems. **[K2 &K3]**

CO3 Select the suitable sequencing and solve waiting line theory problems **[K2 & K3].**

CO4 Solve network models and replacement problems**[K3]**

CO5 Analyze game theory & Dynamic programming **[K2& K3]**

S NO	QUESTION	KNOWLEDGE LEVEL	CO
	UNIT I		
1	A) Explain various phases in solving an Operations Research problem. B) What are the applications of Operations Research? C) Explain the characteristics and the limitations of Operations Research.	Remembering (K1)	CO1
2	Use graphical method to solve the LPP. Maximize $Z= 6x_1+4x_2$ Subject to the constraints: $-2x_1+x_2 \leq 2$ $x_1-x_2 \leq 2$ $3x_1+2x_2 \leq 9$ and $x_1,x_2 \geq 0$	Understanding & Applying (K2, K3)	CO1
3	Solve the following LP problem graphically: Minimize $Z= -6x_1-4x_2$ Subject to the constraints: $2x_1+3x_2 \geq 30$ $3x_1+2x_2 \leq 24$ $x_1+x_2 \geq 3$ and $x_1,x_2 \geq 0$	Understanding & Applying (K2, K3)	CO1
4	Solve the following using graphical method Maximize $Z= 9x + 10y$ subject to $11x + 9y \leq 9900$ $7x + 12y \leq 8400$ $6x + 16y \leq 9600$ and $x \geq 0, y \geq 0$	Understanding & Applying (K2, K3)	CO1
	UNIT 2		
1	Solve the following transportation problem using penalty method. <table><tr><td>4</td><td>6</td><td>8</td><td>8</td><td>40</td></tr><tr><td>6</td><td>8</td><td>6</td><td>7</td><td>60</td></tr><tr><td>5</td><td>7</td><td>6</td><td>8</td><td>50</td></tr><tr><td>20</td><td>30</td><td>50</td><td>50</td><td></td></tr></table>	Applying (K3)	CO2

2	Solve the following transportation problem	Applying (K3)	CO2

	D1	D2	D3	D4	D5	Supply
A	4	1	2	6	9	100
B	6	4	3	5	7	120
C	5	2	6	4	8	120
Demand	40	50	70	90	90	

3	Determine the optimal solution for the following degenerate transportation problem;	Applying (K3)	CO2

SS	D1	D2	D3	D4	D5	Supply
O1	4	7	3	8	2	4
O2	1	4	7	3	8	7
O3	7	2	4	7	7	9
O4	4	8	2	4	7	2
Demand	8	3	7	2	2	

4	Solve the following unbalanced assignment problem.	Applying (K3)	CO2

Job/Machine	A	B	C	D	E
P	4	3	6	2	7
Q	10	12	11	14	16
R	4	3	2	1	5
S	8	7	6	9	6

UNIT 3

1	We have five jobs each of which must go through the machines A, B and in the order ABC. Determine the sequence that will minimize the total elapse time:	Applying (K3)	CO3

Job No	1	2	3	4	5
M/C A	5	7	6	9	5
M/C B	2	1	4	5	3
M/C C	3	7	5	6	7

Also determine the idle time of each machine.

2	A book binder company has one printing machine and one binding machine. There are manuscripts of a number of different books. Processing times for printing and binding are given in the following table:	Applying (K3)	CO3

	<table><tr><th rowspan="2">Book</th><th colspan="2">Time (in hours)</th></tr><tr><th>Printing</th><th>Binding</th></tr><tr><td>A</td><td>5</td><td>2</td></tr><tr><td>B</td><td>1</td><td>6</td></tr><tr><td>C</td><td>9</td><td>7</td></tr><tr><td>D</td><td>3</td><td>8</td></tr><tr><td>E</td><td>10</td><td>4</td></tr></table> Determine the sequence in which books should be processed on the machines so that the total time required is minimized.		
3	A petrol station has two pumps. The service time is with a mean of 5 minutes and cars arrive for service at the rate of 12 cars per hour. Find the probability that a customer has to wait for service. What portion of time do the pumps remain idle?	Applying (K3)	**CO3**
4	A barber shop has space to accommodate only 8 customers. Customers randomly arrive at an average rate 12 per hour and the barbers service time is with an average of 5 minutes per customer. Find P_0 and P_n.	Applying (K3)	**CO3**
	UNIT-4		
1	The probability of failure just before age 'n' is shown below. If individual replacement costs Rs12.50 and group replacement cost Rs 3 per item. Find the optimal replacement policy. <table><tr><td>n</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr><tr><td>P_n</td><td>0.1</td><td>0.2</td><td>0.25</td><td>0.3</td><td>0.15</td></tr></table>	Applying (K3)	**CO4** Applying (K3)
2	The following failure rates have been observed for a certain type of light bulb. The replacement of an individual bulb on failure cost Rs 1.25. The cost of group replacement is 80paise per bulb. Determine the better one among the individual and group replacement policies. <table><tr><td>End of the week</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>Probability failure to date</td><td>0.05</td><td>0.15</td><td>0.25</td><td>0.46</td><td>0.68</td><td>0.88</td><td>1.00</td></tr></table>	Applying (K3)	**CO4**
3	A project consists of different activities as mentioned in the below table. Draw the network diagram and find the minimum time of completion of the project. <table><tr><td>Activity</td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td><td>G</td><td>H</td><td>I</td></tr><tr><td>Preceding activity</td><td>-</td><td>-</td><td>-</td><td>A</td><td>A</td><td>B, D</td><td>C</td><td>B</td><td>F, G</td></tr><tr><td>Duration</td><td>23</td><td>8</td><td>20</td><td>16</td><td>24</td><td>18</td><td>19</td><td>4</td><td>10</td></tr></table>	Applying (K3)	**CO3**
4	A book binder has one printing press, one binding machine and the manuscripts of a number of different books. The time required	Applying	**CO3**

	performing printing and binding operations for each book are shown below. Determine the order in which books should be processed in order to minimize the total time required to turn out all the books. Also find the idle time for both the machines. Book: 1, 2, 3, 4, 5, 6 Processing time(hrs): 30, 120, 50, 20, 90, 110 Binding time(hrs): 80, 100, 90, 60, 30, 10	(K3)	
5	With the help of following data , i) Draw the network ii) Find project duration for the following project and iii) Identify the critical path.	Applying (K3)	CO3

Book	1	2	3	4	5	6
Processing time(hrs)	30	120	50	20	90	110
Binding time(hrs)	80	100	90	60	30	10

Activity	1-2	1-3	1-4	2-4	2-5	3-4	3-7	4-6	4-7	5-6	5-7
Time (months)	4	6	12	7	11	7	8	8	13	4	4

UNIT-5

1	Determine which of the following two person zero sum games are strictly determinable and fair. Give the optimum strategy for each player in the case of strictly determinable games. a. $\begin{matrix} -5 & 2 \\ -7 & -4 \end{matrix}$ b. $\begin{matrix} 1 & 1 \\ 4 & -3 \end{matrix}$	Applying (K3)	CO5
2	Solve the following pay-off matrix. Also determine optimal strategies and value of the game. $\begin{matrix} 4 & -4 \\ -4 & 4 \end{matrix}$	Applying (K3)	CO5
3	Solve the following 2X3 game graphically. $\begin{matrix} 1 & 3 & 11 \\ 8 & 5 & 2 \end{matrix}$	Applying (K3)	CO5
4	Explain how simulation technique can be used in solving queuing problems.	Applying (K3)	CO5
5	State the advantages and limitations of simulation	Applying (K3)	CO5

III B.Tech I Semester Regular Examinations

Sub Code: R20CC31OE03 **Subject Name: OPERATIONS RESEARCH**

(ME)

MODEL PAPER-I

Time: 3 hours | Max. Marks: 70

Note: Answer All **FIVE** Questions.
All Questions Carry Equal Marks (5 X 14 = 70M)

Q.No.		Questions	Marks	CO	KL
		Unit-I			
1	a	A company is manufacturing two different types of products, A and B. Each product has to be processes on two machines M1 and M2, Product A requires 2 hours on machine M1 and 1 hour on machine M2, product B requires 1 hour on machine M1 and2 hours on machine M2. The available capacity of machine M1 is 104 hours and that of machine M2 is 76 hours. Profit per unit for product A is Rs.6 and that for B is Rs.11.Calculate i) Formulate the problem ii) Find out the optimal solution by Simplex method.	[14M]	CO1	K3
		OR			
	b	Briefly explain the applications of Operation Research.	[7M]	CO1	K3
		State different types of models used in operation research. Explain any two in detail.	[7M]	CO1	K4
		Unit-II			
2	a	Find the Feasible solution to the Transportation schedule using North west corner cell method , least cost cell method and VAM method	[14M]	CO2	K4

Company	Retail R1	Retail R2	Retail R3	Supply
P1	10	7	8	45
P2	15	12	9	15
P3	7	8	12	40
Demand	25	55	20	

OR

Solve the assignment problem: [14M] CO2 K3

	1	2	3	4	5
A	6	5	8	11	16
B	1	13	16	1	10
C	16	11	8	8	8
D	9	14	12	10	16
E	10	13	11	8	16

Unit-III

		Questions	Marks	CO	KL
	a	A book binder company has one printing machine and one binding machine. There are manuscripts of a number of different books. Processing times for printing and binding are given in the following table:	[14M]	CO3	K3

JOBS	A	B	C	D	E
Printing	5	1	9	3	10
Binding	2	6	7	8	4

OR

3 b The Peachtree Airport in Atlanta serves light aircraft. It has a single runway and one air traffic controller to land planes. It takes an airplane 12 minutes to land and clear the run way. Planes arrive at the airport at the rate of 4 per hour. [14M] CO3 K3

1. Determine the average number of planes that will stack up waiting to land.
2. Find the average time a plane must wait in line before it can land.
3. Calculate the average time it takes a plane to clear the runway once it has notified the airport that it is in the vicinity and want to land.
4. The FAA has a rule that an air traffic controller can on the average land planes a maximum of 45 minutes out of every hour. There must be 15 minutes of idle time available to relieve the tension. Will this airport have to hire an extra air traffic controller?

Unit-III

4 a A firm is considering replacement of a machine, whose cost price is Rs. 12,200 and the scrap value is Rs. 200. The running (maintenance and operating) cost are found from experience are as follows: [14M] CO4 K3

Year	1	2	3	4	5	6	7	8
Running Cost	200	500	800	1200	1800	2500	3200	4000

When should the machine be replaced?

OR

b With the help of following data , i) Draw the network ii) Find project duration for the following project and iii) Identify the critical path. [14M] CO4 K3

Activity	1-2	1-3	1-4	2-4	2-5	3-4	3-7	4-6	4-7	5-6	5-7
Time (months)	4	6	12	7	11	7	8	8	13	4	4

Unit-IV

5 a Solve the following pay-off matrix. Also, determine optimal strategies and value of the game. [14M] CO5 K3

$$\begin{matrix} 5 & 1 \\ 3 & 4 \end{matrix}$$

OR

b Discuss the types of simulation models. [7M] CO5 K3

Explain briefly the advantages and the disadvantages of simulation. [7M] CO5 K4

NARASARAOPETA ENGINEERING COLLEGE

(AUTONOMOUS)

III B.Tech I Semester Regular Examinations

Sub Code: R20CC31OE03 **Subject Name: OPERATIONS RESEARCH (ME)**

MODEL PAPER -II

Time: 3 hours Max. Marks: 70

Note: Answer All **FIVE** Questions.
All Questions Carry Equal Marks (5 X 14 = 70M)

Q.No.		Questions	Marks	CO	KL
		Unit-I			
1	a	Solve the linear programming problem (LPP) by using Simplex method Maximize $Z=5x_1-4x2+3x3$ Subject to $2x_1+x_2-6x_3 \leq 20$ $6x_1+5x_2+10x_3 \leq 76$ $8x_1-3x_2+6x_3 \leq 50$ $x_1, x_2, x_3 \geq 0$	[14M]	CO1	K3
		OR			
	b	Use penalty (or Big-M) method to maximize $z = 3x_1- x_2$ Subject to the constraints $2x_1+ x_2 \geq 2$; $x_1+ 3x_2 \leq 3$; $x_2 \leq 4$ and $x_1, x_2 \geq 0$	[14M]	CO1	K3
		Unit-II			
2	a	Solve the following transportation problem using north west corner cell method: (table 1 below)	[7M]	CO2	K3
		Solve the transportation problem using VAM. (table 2 below)	[7M]	CO2	K3
		OR			
		Solve the following assignment problem shown in Table using Hungarian method. The matrix entries are processing time of each	[14M]	CO2	K3

Table 1:

	P	Q	R	S	Availability
A	22	46	16	40	8
B	42	15	50	18	8
C	82	32	48	60	6
D	40	40	36	83	3
Requirements	2	2	5	6	

Table 2:

	D	E	F	G	Available
A	34	13	17	14	250
B	16	8	14	10	690
C	21	14	13	4	400
Demand	200	225	475	250	

	a	man in hours. $$\begin{array}{c|ccccc} & I & II & III & IV & V \\ \hline 1 & 20 & 15 & 18 & 20 & 25 \\ 2 & 18 & 20 & 12 & 14 & 15 \\ 3 & 21 & 23 & 25 & 27 & 25 \\ 4 & 17 & 18 & 21 & 23 & 20 \\ 5 & 18 & 18 & 16 & 19 & 20 \end{array}$$			
		Unit-III			
3	a	Suppose that there are five jobs, each of which has to be processed on two machines A and B in the order AB. Processing times are given in the following table JOBS: 1, 2, 3, 4, 5 MACHINE A: 6, 2, 10, 4, 11 MACHINE B: 3, 7, 8, 9, 5 Determine a sequence in which these jobs should be processed so as to minimize the total processing time.	[14M]	CO3	K3
		OR			
	b	A harbor has a single dock to unload the containers from the incoming ships. The arrival rate of ships at the harbor follows Poisson distribution and the unloading time for the ships follow exponential distribution and hence, the service rate also follows Poisson distribution. The arrival rate and service rate are 8 ships per week and 14 ships per week, respectively. **Find the following** a) Utilization factor of the dock b) Average number of waiting ships in the queue c) Average number of waiting ships in the system d) Average waiting time per ship in the queue e) Average waiting time per ship in the system	[14M]	CO3	K3
		Unit-IV			
4	a	The data collected in running a machine, the cost of which is Rs. 60,000 are given below and Determine the optimum period for the replacement of the machine. Year: 1, 2, 3, 4, 5 Resale Value: 42000, 30000, 20400, 14400, 9650 Cost of Spares: 4000, 4270, 4880, 5700, 6800 Cost of Labour: 14000, 16000, 18000, 21000, 25000	[14M]	CO4	K4
		OR			
	b	A project consists of different activities as mentioned in the below table. Draw the network diagram and find the minimum time of completion of the project. Activity: A, B, C, D, E, F, G, H, I	[14M]	CO4	K3

		Preceding activity	-	-	-	A	A	B,D	C	B	F,G				
		Duration	23	8	20	16	24	18	19	4	10				
		Unit-V													
5	a	Solve the following pay-off matrix. Also determine optimal strategies and value of the game. **4 -4** **-4 4**											[14M]	CO5	K3
		OR													
	b	Explain the advantages, disadvantages and applications of simulation.											[7M]	CO5	K3
		Explain Monte-Carlo simulation.											[7M]	CO5	K3

NARASARAOPETA
NEC ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

ACADEMIC CALENDAR

NEC

NARASARAOPETA ENGINEERING COLLEGE

(AUTONOMOUS)

ACADEMIC CALENDAR

(B.Tech. 2020 Admitted Batch, Academic Year 2022-23)

2020 Batch 3rd Year 1st Semester			
Description	**From Date**	**To Date**	**Duration**
Commencement of Class Work	25-07-2022		7 Weeks
1st Spell of Instructions	25-07-2022	10-09-2022	
Assignment Test-I	15-08-2022	20-08-2022	
I Mid examinations	12-09-2022	17-09-2022	1 Week
2nd Spell of Instructions	19-09-2022	05-11-2022	7 Weeks
Assignment Test-II	10-10-2022	15-10-2022	
II Mid examinations	07-11-2022	12-11-2022	1 Week
Preparation & Practicals	14-11-2022	19-11-2022	1Week
Semester End Examinations	21-11-2022	03-12-2022	2 Weeks
2020 Batch 3rd Year 2nd Semester			
Commencement of Class Work	05-12-2022		7 Weeks
1st Spell of Instructions	05-12-2022	21-01-2023	
Assignment Test-I	26-12-2022	31-12-2022	
I Mid examinations	23-01-2023	28-01-2023	1 Week
2nd Spell of Instructions	30-01-2023	18-03-2023	7 Weeks
Assignment Test-II	20-02-2023	25-02-2023	
II Mid examinations	20-03-2023	25-03-2023	1 Week
Preparation & Practicals	27-03-2023	01-04-2023	1 Week
Semester End Examinations	03-04-2023	15-04-2023	2 Weeks
Commencement of 4th Year 1st Sem Class Work	05-06-2023		

PRINCIPAL

NEC NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

TIME TABLE

NARASARAOPETA ENGINEERING COLLEGE: NARASARAOPET (AUTONOMOUS)
DEPARTMENT OF MECHANICAL ENGINEERING
III B.TECH I SEM TIME TABLE
Section-A

ROOM NO: 1212

Wef: 12/06/2023

	1	2	BREAK	3	4		5	6	7
TIMINGS	9.10-10.00	10.00-10.50	10.50-11.00	11.00-11.50	11.50-12.40	12.40-1.30	1.30-2.20	2.20-3.10	3.10-4.00
MON	AI&ML			DME-I		L	AI&ML LAB		
TUE	HPE	HPE / ROB&3D PRINTING LAB				U	OR		AI&ML
WED	PEHV	AI&ML LAB				N	AI&ML	HPE	
THU	OR			MCMT		C	DME-I		PEHV
FRI	HPE			MCMT		H	HPE	OR	
SAT	DME-I			AI&ML			HPE / ROB&3D PRINTING LAB		

CODE	SUBJECT	FACULTY
AI&ML	Artificial Intelligence & Machine Learning	Dr.D.Jagadish
HPE	Heat Power Engineering	Mr.P.Srinivasa Rao
DME-I	Design of Machine Elements-I	Dr.B.Ravi Naik
OR	Operation Research	Mr.K.John Babu
MCMT	Metal Cutting & Machine Tools	Dr.D.Suneel
AI&ML LAB	Artificial Intelligence & Machine Learning Lab	Mr.T.Ashok Kumar/SK.N.Meeravali
HPE LAB	Heat Power Engineering	Mr.P.Srinivasa Rao/ P.Sravani
ROB&3D P LAB	Robotics & 3D-Printing Lab	Mr.CH.Sekhar/Dr.M.Venkanna Babu
PEHV	PE&HV	Dr.B.Anki Reddy

Signature of HOD

Signature of Principal

NARASARAOPETA ENGINEERING COLLEGE: NARASARAOPET (AUTONOMOUS)
DEPARTMENT OF MECHANICAL ENGINEERING
III B.TECH I SEM TIME TABLE
Section-B

ROOM NO: 1321

Wef: 25/07/2022

	1	2	BREAK	3	4		5	6	7	8
TIMINGS	9.10-10.00	10.00-10.50	10.50-11.00	11.00-11.50	11.50-12.40	12.40-1.30	1.30-2.20	2.20-3.10	3.10-4.00	
MON	AI&ML		B	DME-I		L	PEHV	OR		
TUE	HPE		R	OR		U	AI&ML	DME-I		Honors/ Minors
WED	PEHV	ROBOTICS& 3-D PRINTING LAB	E			N	HPE/AI&ML LAB			
THU	DME-I		A	MCMT		C	AI&ML	HPE		Honors/ Minors
FRI	HPE		K	MCMT		H	ROBOTICS& 3-D PRINTING LAB			
SAT	AI&ML	HPE/AI&ML LAB					OR		Honors/ Minors	

CODE	SUBJECT	FACULTY
MCMT	Metal Cutting & Machine Tools	Dr.M.Sreenivasa Kumar
HPE	Heat Power Engineering	Mrs. P. Sravani
DME-I	Design of Machine Elements -I	Mrs. D.Raghavendra
AI&ML	Artificial Intelligence & Machine Learning	Dr. B. Ravi Naik
OR	Operation Research	Mr. R.Chinnna Rao
PEHV	Professional Ethics & Human Values	Dr.Y.Siva Reddy
HPE Lab	Heat Power Engineering Lab	Mrs.P.Sravani/ Sk. Nagul Meeravali
ROB& 3D PRINTING LAB	ROBOTICS& 3-D PRINTING LAB	Mr. A.Pavan Kumar /Mr.SK.Bajan
AI&ML LAB	Artificial Intelligence & Machine Learning Lab	Dr.S.Jaya Krishna /Mr. M. Srinadh

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NARASARAOPETA ENGINEERING COLLEGE: NARASARAOPET (AUTONOMOUS)
DEPARTMENT OF MECHANICAL ENGINEERING
II B.TECH II SEM TIME TABLE
Section-B

ROOM NO: 1217

Wef: 30/03/2021

	1	2	BREAK	3	4		5	6	7
TIMINGS	9.10-10.00	10.00-10.50	10.50-11.00	11.00-11.50	11.50-12.40	12.40-1.30	1.30-2.20	2.20-3.10	3.10-4.00
MON	M&I	OR		KOM		L	MT/DASSAULT LAB		
TUE	KOM			M&I		U	ECS		LIB/SPORTS
WED	OR			ATD		N	MT		M&I
THU	MT	ATD/M&I LAB				C	KOM		Mentoring
FRI	ATD	MT/DASSAULT LAB				H	OR		MT
SAT	MT	ATD/M&I LAB					M&I	ATD	

CODE	SUBJECT	FACULTY
M&I	Metrology & Instrumentation	Mr.T.Narender
OR	Operations Research	Mr. Ch.Sekhar
KOM	Kinematics of Machinery	Dr.T.Praveen Kumar
ATD	Applied Thermodynamics	Dr.B.Ravi Naik
MT	Manufacturing Technology	Mr. TNV Mahesh Babu
ATD LAB	Applied Thermodynamics Lab	Dr.B.Ravi Naik /Mr.P.Kiran Kumar
M&I LAB	Metrology & Instrumentation Lab	Mr.T.Narender /Mr.R.Harsha Vardhan
MT LAB	Manufacturing Technology Lab	Mr.T.N.V.Mahesh/Dr.M.Rama Kotaiah
DASSAULT LAB	DASSAULT Lab	Mr.M.Venkanna Babu
ECS	English Communication Skills	Mrs.V.Aruna

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NARASARAOPETA ENGINEERING COLLEGE: NARASARAOPET (AUTONOMOUS)
DEPARTMENT OF MECHANICAL ENGINEERING
II B.TECH II SEM TIME TABLE
Section-A

ROOM NO: 1216 **Wef: 30/03/2021**

<table>
<tr><th></th><th>1</th><th>2</th><th>BREAK</th><th>3</th><th>4</th><th></th><th>5</th><th>6</th><th>7</th></tr>
<tr><td>TIMINGS</td><td>9.10-10.00</td><td>10.00-10.50</td><td>10.50-11.00</td><td>11.00-11.50</td><td>11.50-12.40</td><td>12.40-1.30</td><td>1.30-2.20</td><td>2.20-3.10</td><td>3.10-4.00</td></tr>
<tr><td>MON</td><td colspan="2">OR</td><td></td><td colspan="2">ATD</td><td rowspan="6">L
U
N
C
H</td><td>M&I</td><td colspan="2">KOM</td></tr>
<tr><td>TUE</td><td colspan="2">ECS</td><td></td><td colspan="2">MT</td><td colspan="3">ATD/M&I LAB</td></tr>
<tr><td>WED</td><td>OR</td><td>M&I</td><td></td><td colspan="2">MT</td><td colspan="2">KOM</td><td>ATD</td></tr>
<tr><td>THU</td><td>M&I</td><td colspan="4">MT/DASSAULT LAB</td><td colspan="2">OR</td><td>LIB/SPORTS</td></tr>
<tr><td>FRI</td><td>M&I</td><td colspan="4">ATD/M&I LAB</td><td colspan="2">ATD</td><td>Mentoring</td></tr>
<tr><td>SAT</td><td>M&I</td><td>KOM</td><td></td><td>KOM</td><td>MT</td><td colspan="3">MT/DASSAULT LAB</td></tr>
</table>

CODE	SUBJECT	FACULTY
M&I	Metrology & Instrumentation	Mr.B.Rambabu
OR	Operations Research	Mr.E.Saidulu
KOM	Kinematics of Machinery	Mr.M.Venkanna Babu
ATD	Applied Thermodynamics	Mr.Sk.Bajan
MT	Manufacturing Technology	Dr.D.Suneel
ATD LAB	Applied Thermodynamics Lab	Mr. Sk.Bajan /Mr.Dr.T.Praveen Kumar
M&I LAB	Metrology & Instrumentation Lab	Mr. B.Rambabu / Mr.R.Harsha Vardhan
MT LAB	Manufacturing Technology Lab	Dr.S.Jaya Krishna/B.Rajiv Kumar
DASSAULT LAB	DASSAULT Lab	Mr.M.Venkanna Babu
ECS	English Communication Skills	Mrs.V.Aruna

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NARASARAOPETA
ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

SYLLABUS COPY

III B.TECH I-SEMESTER Open Elective -I	L	T	P	INTERNAL MARKS	EXTERNAL MARKS	TOTAL MARKS	CREDITS
	3	0	0	30	70	100	3
Code: R20CC1OE07	OPERATIONS RESEARCH						

COURSE OBJECTIVES:

The course content enables students to:

- To learn the importance of Operations Research in the design, planning, scheduling, manufacturing and business applications
- To use the various techniques of Operations Research in solving such problems.

COURSE OUTCOMES:

After successful completion of this course, the students will be able to:

CO 1: Illustrate and solve linear programming problems.

CO 2: Solve transportation and assignment problems.

CO 3: Select a suitable sequencing and Solve waiting line theory problems.

CO 4: Solve networking models and replacement problems.

CO 5: Analyze game theory & Dynamic Programming.

UNIT-I INTRODUCTION:

Development-definition, characteristics and phases, types of operation research models, applications.

LINEAR PROGRAMMING PROBLEM: LPP Formulation, graphical method, simplex method, two–phase method, big-M method, duality principle.

UNIT-II TRANSPORTATION PROBLEM:

Formulation, types of initial basic feasible solution using different methods, optimal solution, unbalanced transportation problem, degeneracy.

ASSIGNMENT PROBLEM: Formulation, optimal solution, unbalanced assignment problem, travelling salesman problem.

UNIT-III SEQUENCING:

Introduction, flow, shop sequencing, n jobs through two machines, n jobs through three machines, job shop sequencing, and two jobs through 'm' machines.

WAITING LINES: Introduction – single channel – poison arrivals –exponential service times – with infinite population and finite population models– multichannel – poison arrivals – exponential service times with infinite population single channel poison arrivals.

UNIT–IV REPLACEMENT:

Replacement Model, Replacement of items that deteriorate, Gradually, Fail suddenly, group Replacement policy analysis, Problems.

NETWORKING MODELS: Earliest Completion time of a project and Critical path, Programme Evaluation Review Technique, Total Slack, Free Slack, Probability of achieving completion date, Cost Analysis, Resource Scheduling-Advantages, Limitations, Distinction between PERT and CPM.

UNIT-V THEORY OF GAMES:

Introduction – mini. max (max. mini) – criterion and optimal strategy – solution of games with saddle points – rectangular games without saddle points – 2 x 2 games – dominance principle – m x 2 &2 x n games -graphical method.

DYNAMIC PROGRAMMING: Introduction, Bellman's principle of optimality, applications of dynamic programming.

SIMULATION: Definition, types of simulation models, phases of simulation, applications of simulation, inventory and queuing problems, advantages and disadvantages.

TEXT BOOKS:

1. Operations Research, S.D.Sharma, KedarNath Ram Nath Publishers
2. Operations Research, A.M.Natarajan, P.Balasubramani and A. Tamilarasi, Pearson Education.

REFERENCE BOOKS:

1. Introduction to O.R, Hiller &Libermann, Tata McGraw Hill
2. Operations Research, R.Pannerselvam, PHI Publications
3. Operations Research, Wagner, PHI Publications

WEB LINKS:

- http://www.bbau.ac.in/dept/UIET/EME-601%20Operation%20Research.pdf
- https://www.cs.toronto.edu/~stacho/public/IEOR4004-notes1.pdf

III B.TECH II SEMESTER **Professional Elective-I**	L	T	P	INTERNAL MARKS	EXTERNAL MARKS	TOTAL MARKS	CREDITS
	2	1	-	40	60	100	3
Code: 19BME6PE07	**OPERATIONS RESEARCH**						

COURSE OBJECTIVES:

The course content enables students to:

- To learn the importance of Operations Research in the design, planning, scheduling, manufacturing and business applications
- To use the various techniques of Operations Research in solving such problems.

COURSE OUTCOMES:

After successful completion of this course, the students will be able to:

CO 1 **Illustrate and solve** linear programming problems.
CO 2 **Solve** transportation and assignment problems.
CO 3 **Select** a suitable sequencing and networking models.
CO 4 **Solve** waiting line theory problems.
CO 5 **Analyze** game theory & replacement problems.

UNIT-I

INTRODUCTION: Development-definition, characteristics and phases, types of operation research models, applications.

LINEAR PROGRAMMING PROBLEM: LPP Formulation, graphical method, simplex method, two–phase method, big-M method, duality principle.

UNIT-II

TRANSPORTATION PROBLEM: Formulation, types of initial basic feasible solution using different methods, optimal solution, unbalanced transportation problem, degeneracy.

ASSIGNMENT PROBLEM: Formulation, optimal solution, Unbalanced assignment problem, travelling salesman problem.

UNIT-III

SEQUENCING: Introduction, flow, shop sequencing, *n* jobs through two machines, *n* jobs through three machines, job shop sequencing, and two jobs through 'm' machines.

NETWORKING MODELS: Earliest Completion time of a project and Critical path, Programme Evaluation Review Technique, Total Slack, Free Slack, Probability of achieving completion date, Cost Analysis, Resource Scheduling-Advantages, Limitations, Distinction between PERT and CPM.

UNIT–IV

WAITING LINES: Introduction – single channel – poison arrivals –exponential service times – with infinite population and finite population models– multichannel – poison arrivals – exponential service times with infinite population single channel poison arrivals.

DYNAMIC PROGRAMMING: Introduction, Bellman's principle of optimality, applications of dynamic programming.

UNIT-V

THEORY OF GAMES: Introduction – mini. max (max. mini) – criterion and optimal strategy – solution of games with saddle points – rectangular games without saddle points – 2 x 2 games – dominance principle – m x 2 &2 x n games -graphical method.

REPLACEMENT: Replacement Model, Replacement of items that deteriorate, Gradually, Fail suddenly, group Replacement policy analysis, Problems.

TEXT BOOKS:

1. Operations Research, S.D.Sharma, KedarNath Ram Nath Publishers
2. Operations Research, A.M.Natarajan, P.Balasubramani and A. Tamilarasi, Pearson Education

REFERENCE BOOKS:
Introduction to O.R, Hiller &Libermann, Tata McGraw Hill

REFERENCE BOOKS:

1. Introduction to O.R, Hiller &Libermann, Tata McGraw Hill
2. Operations Research, R.Pannerselvam, PHI Publications
3. Operations Research, Wagner, PHI Publications

Web Links:

- **http://www.bbau.ac.in/dept/UIET/EME-601%20Operation%20Research.pdf**
- **https://www.cs.toronto.edu/~stacho/public/IEOR4004-notes1.pdf**

NARASARAOPETA
NEC ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

LESSON PLAN

NEC	**Narasaraopeta Engineering College** **(Autonomous)** **Yallmanda(Post), Narasaraopet- 522601**

DEPARTMENT OF MECHANICAL ENGINEERING
LESSON PLAN

Course Code	Course Title (Regulation)	Sem	Branch	Contact Periods/Week	Sections
R20CC31OE03	OPERATIONS RESEARCH	V	Mechanical Engineering	6	A & B

COURSE OUTCOMES: Students are able to

SNO	Course Outcome Statement
CO1	**Illustrate** and solve linear programming problems. [K3]
CO2	**Solve** transportation and assignment problems. [K3]
CO3	**Select** a suitable sequencing and Solve Waiting line theory problems. [K4]
CO4	**Solve** networking models and replacement problems. [K3]
CO5	**Analyze** game theory & Dynamic Programming. [K4]

Unit No	Outcome		Topics/Activity	Ref Text book	Total Periods	Delivery Method
			UNIT– I			
1	**CO1: Illustrate** and solve linear programming problems. [K3]	1.1	INTRODUCTION: Development-definition, characteristics and phases	T1, T2, R1	2	Chalk & Talk
		1.2	Types of operation research models, applications	T1, T2, R1	2	Chalk & Talk
		1.3	LINEAR PROGRAMMING PROBLEM: LPP Formulation,	T1, T2, R1	4	Chalk & Talk
		1.4	Graphical method, simplex method,	T1, R1	4	Chalk & Talk
		1.5	Two–phase method, big-M method, duality principle.	T1, T2, R1	4	Chalk & Talk
			UNIT-II			
2	**CO2: Solve** transportation and assignment problems. [K3]	2.1	**TRANSPORTATION PROBLEM:** Formulation,	T1, R1	2	Chalk & Talk
		2.2	Types of initial basic feasible solution using different methods	T1, R1	2	Chalk & Talk
		2.3	Optimal solution, unbalanced transportation problem, degeneracy.	T1, R1	2	Chalk & Talk
		2.4	**ASSIGNMENT PROBLEM:** Formulation, optimal solution	T1, T2, R2	2	Chalk & Talk
		2.5	Unbalanced assignment problem	T1, R1	2	Chalk & Talk
		2.6	Travelling salesman problem.	T1, R1	2	Chalk & Talk
			UNIT-III			

3	**CO3** **Select** a suitable sequencing and Solve waiting line theory problems. [K4]	3.1	**SEQUENCING:** Introduction, flow, shop sequencing	T1,R2	2	Chalk, Talk & PPT
		3.2	n jobs through two machines ,n jobs through three machines	T1,R2	2	Chalk & Talk
		3.3	Job shop sequencing, and two jobs through 'm' machines.	T1, R2	2	Chalk & Talk
			MID I EXAMINATION			
		3.4	**WAITING LINES:** Introduction – single channel – poison arrivals –exponential service times – with infinite population and finite population models	T1, R2	4	Chalk & Talk
		3.5	multichannel – poison arrivals – exponential service times with infinite population single channel poison arrivals	T1, R2	4	Chalk & Talk
			UNIT-IV			
4	**CO4** **Solve** networking models and replacement problems. [K3]	4.1	**REPLACEMENT:** Replacement Model, Replacement of items that deteriorate	T1, R2	2	Chalk & Talk
		4.2	Gradually, Fail suddenly, group Replacement policy analysis, Problems	T1, T2,R2	4	Chalk & Talk
		4.3	**NETWORKING MODELS:** Earliest Completion time of a project and Critical path, Programme Evaluation Review Technique,	T1, R2	2	Chalk & Talk
		4.4	Total Slack, Free Slack, Probability of achieving completion date, Cost Analysis, Resource	T1, R2	2	Chalk & Talk
		4.5	Scheduling-Advantages, Limitations, Distinction between PERT and CPM.	T1, R2	2	Chalk & Talk
			UNIT V			
5	**CO5** **Analyze** game theory and Dynamic Programming. [K4]	5.1	THEORY OF GAMES: Introduction – mini. max (max. mini) – criterion and optimal strategy – solution of games with saddle points	T1, R3	2	Chalk & Talk
		5.2	rectangular games without saddle points – 2 x 2 games –dominance principle	T1, R3	2	Chalk & Talk
		5.3	m x 2 &2 x n games -graphical method	T1, R3	2	Chalk & Talk
		5.4	**DYNAMIC PROGRAMMING:** Introduction, Bellman's principle of optimality	T1, R3	2	Chalk & Talk
		5.5	applications of dynamic programming	T1, R3	2	Chalk & Talk
			MID II EXAMINATION			
			END EXAMINATIONS			

ext Books:

'1 Operations Research, S.D.Sharma, KedarNath Ram Nath Publishers

T2 Operations Research, A.M.Natarajan, P.Balasubramani and A. Tamilarasi, Pearson Education

Reference Books:

R1 Introduction to O.R, Hiller &Libermann, Tata McGraw Hill

R2 Operations Research, R.Pannerselvam, PHI Publications

R3 Operations Research, Wagner, PHI Publications

Faculty **HOD** **Principal**

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DEPARTMENT OF MECHANICAL ENGINEERING

CO-POs & CO-PSOs MAPPING (COURSE ARTICULATION MATRIX)

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III B.Tech I SEM OPERATION RESEARCH

Course Code: C314	Course Name: OPERATIONS RESEARCH (Open Elective –I)														
COs	POs & PSOs														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
C314.1	3	3	2	-	-	-	-	-	-	-	-	-	2	-	1
C314.2	3	3	2	-	-	-	-	-	-	-	-	-	2	-	1
C314.3	3	3	2	-	-	-	-	-	-	-	-	-	2	-	1
C314.4	3	3	3	-	-	-	-	-	-	-	2	-	2	-	1
C314.5	3	3	3	-	-	-	-	-	-	-	-	-	2	-	1
C314	3.00	3.00	2.40	-	-	-	-	-	-	-	2.00	-	2.00	-	1.00

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WEB REFERENCES

NEC NARASARAOPETA ENGINEERING COLLEGE

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DEPARTMENT OF MECHANICAL ENGINEERING

OPERATIONS RESEARCH

WEB REFERENCES:

- http://www.bbau.ac.in/dept/UIET/EME-601%20Operation%20Research.pdf
- https://www.cs.toronto.edu/~stacho/public/IEOR4004-notes1.pdf

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DEPARTMENT OF MECHANICAL ENGINEERING

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DEPARTMENT OF MECHANICAL ENGINEERING		
III B.Tech I Sem		
SECTION-A		
S.No	HTNo	Name of the Student
1	20471A0301	ALAVALA ADITHYA VARA PRASAD
2	20471A0302	BATTULA RAJESH
3	20471A0303	BHIMAVARAPU HEMANTH KUMAR
4	20471A0304	BONAM JAYA PRAKASH
5	20471A0305	BOYAPATI PAVAN KUMAR
6	20471A0306	DADDANALA VEERANJIREDDY
7	20471A0307	DERANGILA PARDHU GANESH
8	20471A0308	DOPPALAPUDI S S NAGA RAVITEJA
9	20471A0309	EEDARA MOHON SAI
10	20471A0310	GANESH SAI PAVAN
11	20471A0311	GANGARAPU VENKATA REDDY
12	20471A0312	GERA KOTESWARA RAO
13	20471A0313	KARASALA PRASANTH
14	20471A0314	KARASANI PAVAN KUMAR REDDY
15	20471A0315	KATTA MAHESWAR
16	20471A0317	KESARI DHANUNJAYA REDDY
17	20471A0318	KOMARAGIRI SASIKUMAR
18	20471A0319	KOMERA SIVA NAGARAJU
19	20471A0320	KOTHA GOPI
20	20471A0321	KUNDURTHI NAVEEN
21	20471A0323	MADANU JOSEPH VINAY KUMAR
22	20471A0324	MADDUMALA RAMAKRISHNA
23	20471A0325	MAGANTI SASI PAVAN
24	20471A0326	MAKKENA SAMBASIVA RAO
25	20471A0327	MIRIYALA SASHANK
26	20471A0328	NALLA ABHIRAM CHOWDARY
27	20471A0329	NUTHAKKI RAKESH
28	20471A0330	ARAVAPALLI SAI SRINIVAS
29	20471A0331	PALETI JOHN HOSANNA
30	20471A0332	PERUMAALLA SRIKANTH
31	20471A0333	POLURI KRISHNA CHAITHANYA

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33	20471A0336	PATHAN MEERA VALI
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50	20471A0354	VEERAGANDHAM VENKATA MANIKANTA
51	20471A0356	ADAKA GOPIRAJU
52	20471A0357	ATCHYUTHA PAVAN KUMAR
53	20471A0358	BALLE RAMANJANEYULU
54	20471A0359	BANDARU SAI GANESH
55	20471A0360	BERAM NARENDRA REDDY
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57	20471A0362	CHENNAMSETTY GOPI
58	20471A0363	GANGULA SUNNY
59	20471A0364	GANJI HANUMA KOTI GANESH
60	20471A0365	GANNNAVARAPU JAYA SRIKANTH
61	20471A0366	GUTTIKONDA AYYAPPA REDDY
62	20471A0367	MADDINENI AJAY
63	20471A0368	MANNEPALLI VEERA NARASIMHA
64	20471A0369	MARAGANI NAGA THIRUMALA RAO
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69	20471A0374	SHAIK MOHAMMAD TAHEER
70	20471A0375	THOTA SRIVAMSI NADH
71	20471A0376	YAKKANTI SAI KIRAN REDDY
72	21475A0301	PALLAPOTHU SAIKIRAN YADAV
73	21475A0302	SYED SARDAR VALI
74	21475A0303	DERANGULA GOPI KRISHNA
75	21475A0304	VADDANI RAKESH
76	21475A0305	SHAIK ADIL
77	21475A0306	JANAPAREDDI PRASAD
78	21475A0307	REPALLE YASHWANTH
79	21475A0308	RAMAVATHU PAVAN KUMAR NAIK
80	21475A0309	NELAVALLI VIKAS
81	21475A0310	DUDDU JOSEPH
82	21475A0311	MUNIKOLA SANTHOSH KUMAR
83	21475A0312	MORAPAKULA CHARAN TEJA
84	21475A0313	GODA SANDEEP
85	21475A0314	MOGILI PRAKASH
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87	21475A0316	DAGGUPATI VENKATA PRADEEP
88	21475A0317	NAGASURENDRA CHARI UPPALAPATI
89	21475A0318	NALLURI NAVEEN
90	21475A0319	ORCHU VENKATA RAVINDRA
91	21475A0320	NELLURI YASWANTH
92	21475A0321	PENUMALA PAVAN KUMAR
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94	21475A0323	BOJANKI DEMUDU BABU
95	21475A0324	DATTI CHANDU
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97	21475A0326	VARIKUTI KARTHIK VENKATA RAM
98	21475A0327	GOLLA SUNDARA SAMRAJYA SUGNAN
99	21475A0328	CHATTA VENKATRAMAIAH
100	21475A0329	KSHATRIYA JITHENDRA SINGH
101	21475A0330	BOMMALI BALA SIVA YOGENDRA SAI NANDU

102	21475A0331	REVALLA SAI
103	21475A0332	BANDI SRINIVAS
104	21475A0333	GURRAM SIVA GANESH
105	21475A0334	EMANI LEELA SHANKAR
106	21475A0335	KUPPALA SRINU

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Branch : ME

S.NO.	H.T.NO.	STUDENT NAME
1	19471A0301	ARIKATLA RAGHU RAMI REDDY
2	19471A0302	BADDETI RAMBABU
3	19471A0303	BANDARU PRASANNA BABU
4	19471A0304	BOBBILI VISHNU VARDHAN REDDY
5	19471A0305	CHAVA ASHOK
6	19471A0306	CHIRUGURI KARUNAKAR
7	19471A0307	DURGAMPUDI MAHESH REDDY
8	19471A0308	GANGAVARAPU SRI CHANDRASEKHAR
9	19471A0309	GANNEPALLI RAVI
10	19471A0310	GANNEPALLII RAMESH
11	19471A0311	GONA VAMSI
12	19471A0312	GORANTLA ANIL
13	19471A0313	GUDE JAYANTH KUMAR
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16	19471A0317	JONNALAGADDA MADHU
17	19471A0318	KAKANI NAGENDRA BABU
18	19471A0319	KAMBAMPATI AJITHKUMAR
19	19471A0320	KIKKURU PRUDHVI YASHWANTH REDDY
20	19471A0321	KONDA JOHNY
21	19471A0322	LINGISETTY RAJASEKHAR
22	19471A0323	MAHANKALI RAKESH
23	19471A0324	MALLAVARAPU PRABHAKAR
24	19471A0325	MEDARAMETLA GANESH KUMAR
25	19471A0326	MELAM STEPHEN WILLIAMS
26	19471A0327	NARENDRA BABU SADHE
27	19471A0328	NOORBASHA ANWAR BASHA
28	19471A0329	ONTERU VEERANJANEYULU

Branch : ME

S.NO.	H.T.NO.	STUDENT NAME
29	19471A0330	PATHAN AMEER KHAN
30	19471A0331	PEERLA HUSSIAN
31	19471A0332	DUGGI VAMSIKRISHNA
32	19471A0333	PODILA GOPINADH
33	19471A0334	RAGI SASANK KUMAR
34	19471A0335	RAMAR SATISH KUMAR
35	19471A0336	SAVALAM MANI KUMAR
36	19471A0337	SHAIK JILANI
37	19471A0338	SHAIK MAHAMMAD BILAL
38	19471A0339	SHAIK MAHAMMAD RIYAZ
39	19471A0340	SHAIK SUBHANI
40	19471A0341	TALAKAYALA VINAY KUMAR
41	19471A0342	VADLAMUDI YASWANTH SAI
42	19471A0343	VEERLA KOTESWARA RAO
43	19471A0344	VEJARLA AVINASH
44	19471A0345	YEDLURI ABHILASH
45	20475A0301	PUTTA RAJESH
46	20475A0302	LINGIREDDY GOPI REDDY
47	20475A0303	YELURI RAKESH
48	20475A0304	VANGAVOLU NAGA SESHU
49	20475A0305	GUNJI VENKATA BHASKAR
50	20475A0306	THAPPETA RADHAKRISHNA
51	20475A0307	EDEBOINA ASHOK
52	20475A0308	MARRI AJAY KUMAR
53	20475A0309	MADEM JAYANTH KUMAR
54	20475A0310	RAJABATHULA KISHORE
55	20475A0311	SHAIK SAMEER
56	20475A0312	SHAIK THUPAKULA MASTAN VALI
57	20475A0313	PARIMI GANESH
58	20475A0314	MUVVA VAMSI

Branch : ME

S.NO.	H.T.NO.	STUDENT NAME
59	20475A0315	RYALI M T SURYA PRAKASH
60	20475A0316	SHAIK DASTAGIRI
61	20475A0317	MANDA RAJA SEKHAR
62	20475A0318	DANDE VENKATA GOPAL
63	20475A0319	KOTA LAKSHMI VARAPRASAD
64	20475A0320	BALACHANDAR M
65	20475A0321	KUKKAMALLA NIKHIL KUMAR
66	20475A0322	PENUMALA KALYAN
67	20475A0323	KOTHAMSETTI ASHOK
68	20475A0324	NUNNA BALA NAVEEN
69	20475A0325	KOTHAMASU ANANTA KOTI SRIKRISHNA
70	20475A0326	NAGISETTY RAKESH
71	20475A0327	RAVURI SIVANJANEYULU
72	20475A0328	ANKEM NAGENDRA BABU
73	20475A0330	PARASA NAVEEN
74	20475A0331	DUPATI ANIL
75	20475A0332	SHAIK NARAVADA ALTHAF HUSSAIN
76	20475A0333	RAVURI ANIL
77	20475A0334	TELUKUTLA SIVAREDDY
78	20475A0335	KOTARU SAIRAGHU VAMSI
79	20475A0336	MIDDELA BAJIVALI
80	20475A0337	VATTIGORLA YOGANJANEYULU
81	20475A0338	GANTASALA GOPI CHAND
82	20475A0339	KOILADA PRADEEP
83	20475A0340	DASARI HEMAGURUNADH
84	20475A0341	JILABOINA KARUNAKAR
85	20475A0342	MALLAVARAPU JESUDASU
86	20475A0343	VANGARA AYYAPPA
87	20475A0344	YADARI RAJESH
88	20475A0345	KASUKURTHI AKASH

Branch : ME

S.NO.	H.T.NO.	STUDENT NAME
89	20475A0346	KANAPARTHI VENKATA KRISHNA
90	20475A0347	SHAIK AMEER
91	20475A0348	MEKA SAI VINAY
92	20475A0349	AVVARU YUGANDHAR
93	20475A0350	CHINTALAPUDI SRIRAM
94	20475A0351	ILLA RATNAM RAJU
95	20475A0352	GUNTAKA HARIKRISHNA REDDY
96	20475A0353	GADIBOYINA NAGAIAH
97	20475A0354	KOPPOLU BHANU PRASAD
98	20475A0355	CHOPPARA LAKSHMI SUMANTH
99	20475A0356	INDURI PRATHAP REDDY
100	20475A0357	INAGANTI NAGULMEERAVALI
101	20475A0358	BATTU JAGADEESH
102	20475A0359	VEMULA HEMANTH KUMAR
103	20475A0360	KAKARLAMUDI NAVEEN
104	20475A0361	KUMMARA PARAMESWARA RAO
105	20475A0362	BOKKA PRASANNA KUMAR
106	20475A0363	GANJI HASHWANTH PRAVEEN REDDY
107	20475A0364	URJANA SHANMUKHARAO
108	20475A0365	DAMERA SANTHOSH
109	20475A0366	MUVVA NAGA LAKSHMAIAH

PRINCIPAL

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21 BATCH III-I PROMOTION LIST

S.No	HT No.	Student Name
1	21471A0301	ANGIREKULA VEERANJANEYULU
2	21471A0302	BATTULA YUVA RAJU
3	21471A0303	BOMMIREDDY VENU
4	21471A0304	JEEDIMALLA SRI LAKSHMI NILENDRA
5	21471A0305	KONATHAM VENKATA NARAYANA
6	21471A0306	KUNCHALA ANKA RAO
7	21471A0307	PATHAN RIYAZ
8	21471A0309	SASAPU SAI SANTOSH
9	21471A0310	SOUBHAGYAPU SAI RAM
10	21471A0311	MUNAGA RAMANJANEYULU
11	21471A0312	YELCHURI HEMALATHA MEGHANA
12	21471A0314	ALLAM TIRUMALA RAJU
13	22475A0301	LUKALAPU RAMBABU
14	22475A0302	THUNUGUNTLA NAGA THARUN
15	22475A0303	MAILAVARAPU PAVAN KALYAN
16	22475A0304	KOLLI GOWRI SANKARA RAO
17	22475A0305	VANTAKU GANAPATHI LAKSHMI NAIDU
18	22475A0306	SYED HUSSAIN
19	22475A0307	BEHERA SANJAY KUMAR
20	22475A0308	YASAM MANIKANTA
21	22475A0309	MALLADI GOPI PURNA
22	22475A0310	UNGATI LOKESH

23	22475A0311	RAMAVATH VASU DEVA NAIK
24	22475A0312	PASALA SYAM KUMAR
25	22475A0313	THURIMELLA VAMSI GANESH
26	22475A0314	KUKKAMALLA KARTHIK
27	22475A0315	VUTLA KISHORE
28	22475A0316	DHARMANA APPALA NAIDU
29	22475A0317	NIKKU SURESH
30	22475A0318	GORANTLA SIVA KOTESWARA RAO
31	22475A0319	POGUNOLLA KARUN KUMAR
32	22475A0321	BANDLAMUDI NAGA RAJU
33	22475A0322	BOJJA SYAM BABU
34	22475A0323	ATHULURI PURNA VENKATA RAMARAO
35	22475A0324	BATTULA LAKSHMI NARAYANA
36	22475A0325	GUDIKANDULA ANJANEYULU
37	22475A0326	AYINAMPUDI KISHORE BABU
38	22475A0327	KETHABOYINA MAHESH
39	22475A0328	SHAIK BABULAL
40	22475A0329	BANDARU VENU GOPAL
41	22475A0330	YADAVALLI LOKESH
42	22475A0331	CHOUDAM VENKATESH
43	22475A0332	CHATTI MURALI KRISHNA
44	22475A0333	DARAM PRUDHVI KRISHNA
45	22475A0334	SHAIK NAGUR BASHA
46	22475A0335	GOLLAPUDI SARATH KUMAR
47	22475A0336	ADAKA VINOD
48	22475A0337	JANNI ARUN
49	22475A0338	NOWPADA MEGHANADH
50	22475A0339	BALAGA YUGANDHAR
51	22475A0340	NEYYELA KUMAR BEHERA

52	22475A0341	KUNITI PAVAN KUMAR
53	22475A0342	BHUKYA DIWAKAR NAIK
54	22475A0343	VOONA NARENDRA
55	22475A0344	CHANDARLAPATI GANESH
56	22475A0345	BALAGA MOHAN
57	22475A0346	BOMMALI MAHESH
58	22475A0347	DUDDETI NAGA SAI
59	22475A0348	BASWA DILLESWARA RAO
60	22475A0349	KORRAPATI MOHAN KRISHNA
61	22475A0350	NAKKANABOINA NAGA SRIDHAR
62	22475A0351	GONDU GANESH PAVAN
63	22475A0352	LINGA SRINIVAS

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HAND WRITTEN/PRINTED LECTURE NOTES

OPERATION RESEARCH.

* old hens can be bought at Rs. 30 each and young ones at Rs. 50 each. The old hens lay 3 eggs per week and the young ones lay 6 eggs per week, each egg being worth 1.75 paise. A hen (young & old) cost Rs. 3 per week to feed. I have only Rs 100 spend for hens. How many of each kind should I buy to give a profit of more than Rs. 6 per week, assuming that I cannot house more than 20 hens

Sol: Let x_1 be the no. of old hens and

x_2 be the no. of young hens to be bought.

Now the old hens lay 3 eggs per week and young one lays 6 eggs per week. Hence total number of eggs one get is $z = 3x_1 + 6x_2$

Total revenue from the sale of eggs per week ;)

$$\max z = 1.75 [3x_1 + 6x_2] - (x_1 + x_2) 3$$

$$5.25x_1 + 10.5x_2 - 3x_1 - 3x_2$$

$$\boxed{z = 2.25x_1 + 7.5x_2}$$

subjected to $30x_1 + 50x_2 \leq 100$

$x_1 + x_2 \leq 20$

$2.25x_1 + 7.5x_2 \geq 6.$

$x_1, \geq 20.$

1) A company manufactures 2 types of products x, y both the products passes through 2 machines m1 & manufacturing of 1 unit of product x requires 3 hou of machine 1 & 6 hours of machines 2. manufacturing of 1 unit of product y require 4 hours of m1 & 2 hours of machine 2. Total machine hours availab per month m1 = 240, m2 = 180, if the profit of 1 unit of product x is 40 and 1 unit of product y is 60Rs. how many unit of product x & y are to be manufactured in order to maximize profit.

Sol:

Machines	products X	products Y	Available Time
Machine 1	3	4	240
Machine 2	6	2	180
profit	40 Rs	60 Rs.	

objective Function

Maximize $Z = 40x + 60y$

subject to

$3x + 4y \leq 240$

$6x + 2y \leq 180$

x_1 and $x_2 \geq 0$ Non-Negative constraints.

Development / Formulation of LP models :

* Decision variable
  objective function coefficient
  objective function
  Techological coefficient
  Resource availability
  Set of constraints
  Non-Negative constraints.

* A company manufacturing two types of products A_1 and A_2. Each product uses milling and Drilling machine. The process time per unit of A_1 on the milling is 10 hours and on the Drilling machine is 8 hours. The processing time per unit of A_2 on the milling is 15 hours and on the Drilling machine 10 hours. The maximum no. of hours available per week on the milling and Drilling machine are 80 hours and 60 hours respectively. Also the profit per unit of Selling A_1 and A_2 are Rs. 25 and Rs. 35, respectively. Formulate a LP model to determine the production volume of each of the products such that the total profit is maximized.

Sol:-

Machine	Machine hours / unit		Limit on machine hours
	product A_1	product A_2	
Milling machine	10	15	80
Drilling machine	8	10	60
profit/unit (Rs.)	25	35	

Let x_1 and x_2 be the production volumes of products A_1 and A_2 respectively.

Maximize $Z = 25x_1 + 35x_2$

subject to
$$10x_1 + 15x_2 \le 80$$
$$8x_1 + 10x_2 \le 60$$
$$x_1 \text{ and } x_2 \ge 0$$

) A nutrition scheme for babies is proposed by a committee of doctors. Babies can be given three types of food (I, II, III) which are available in standard sized packets weighting 100 grams. The cost packets of these foods are Rs 5, Rs. 4 and Rs 6 respectively. The vitamin availability in each type of food per packet and minimum vitamin requirement for each type of vitamin are summarized in the following table.

Vitamin	vitamin availability per packet Food Type I	II	III	Min daily required vitamin
1	1	2	1	6
2	5	3	2	20
Cost/packet	5	4	6	

Develop a LPP model to determine the optimal combination of food types with the minimum cost such that the minimum requirement of vitamin in each types is satisfied.

Sol: Minimize $Z = 5x_1 + 4x_2 + 6x_3$

subject to $x_1 + 2x_2 + x_3 \geq 6$

$5x_1 + 3x_2 + 2x_3 \geq 20$

x_1, x_2 and $x_3 \geq 0$

* A manufacturing company is engaged in producing three types of products A, B and C. The production department produces each day components sufficient to make 50 units of A, 25 units of B, 30 units of C. The management confronted with the problem of optimizing the daily production the products in the assembly department where only 100 man hours are available for assembling the products. The following additional information is available

Type of products	profit contribution per unit of product (Rs)	Assembly time per products (Rs)
A	12	0.8
B	20	1.7
C	45	2.5

The company has a daily order commitment for 20 units of products A and a total of 15 units of products B and C. Formulate this problem as LP model as to maximize total profit.

Sol:

	A	B	C	
No. of units	X_1	X_2	X_3	Total Available
Components	50	25	30	
Assembly Time	0.8	1.7	2.5	100
profit	12	20	45	
Minimum products	20	15		

Maximization $Z = 12x_1 + 20x_2 + 45x_3$

$x_1 \le 50, \; x_2 \le 25, \; x_3 \le 30$

$x_1 \ge 20, \quad x_2 + x_3 \ge 15$

$0.8x_1 + 1.7x_2 + 2.5x_3 \le 100$

x_1, x_2 and $x_3 \ge 0,$

) A firm makes two types of furniture - chairs and Tables. The contribution for each product is calculated by the accounting department is Rs 20 per chair and 30 per day. Both the products are processed on three machines M1, M2 and M3. The time required in hours by each product and total time available in hours per week on each machine are as follows.

Machine	chair	Table	Available Time
M1	3	3	36
M2	5	2	50
M3	2	6	60

Find the maximum contribution made by the three machines in the production of the furniture.

Sol Furnitures to be made : Chairs and Table
Machines Available : M1, M2 and M3

Let no. of chairs $= x_1$

no. of Tables $= x_2$

Max $Z = 20x_1 + 30x_2$

$3x_1 + 3x_2 \le 36$

$5x_1 + 2x_2 \le 50$

$2x_1 + 6x_2 \le 60$

x_1 and $x_2 \ge 0$

Linear programming problem (LPP) by Graphical method:

① Maximize $z = 12x_1 + 16x_2$

Subject to $10x_1 + 20x_2 \leq 120$

$8x_1 + 8x_2 \leq 80$

x_1 and $x_2 \geq 0$

Sol: $10x_1 + 20x_2 = 120$ —①

when $x_1 = 0 \Rightarrow 20x_2 = 120 \Rightarrow x_2 = 6$

when $x_2 = 0 \Rightarrow 10x_1 = 120 \Rightarrow x_1 = 12$

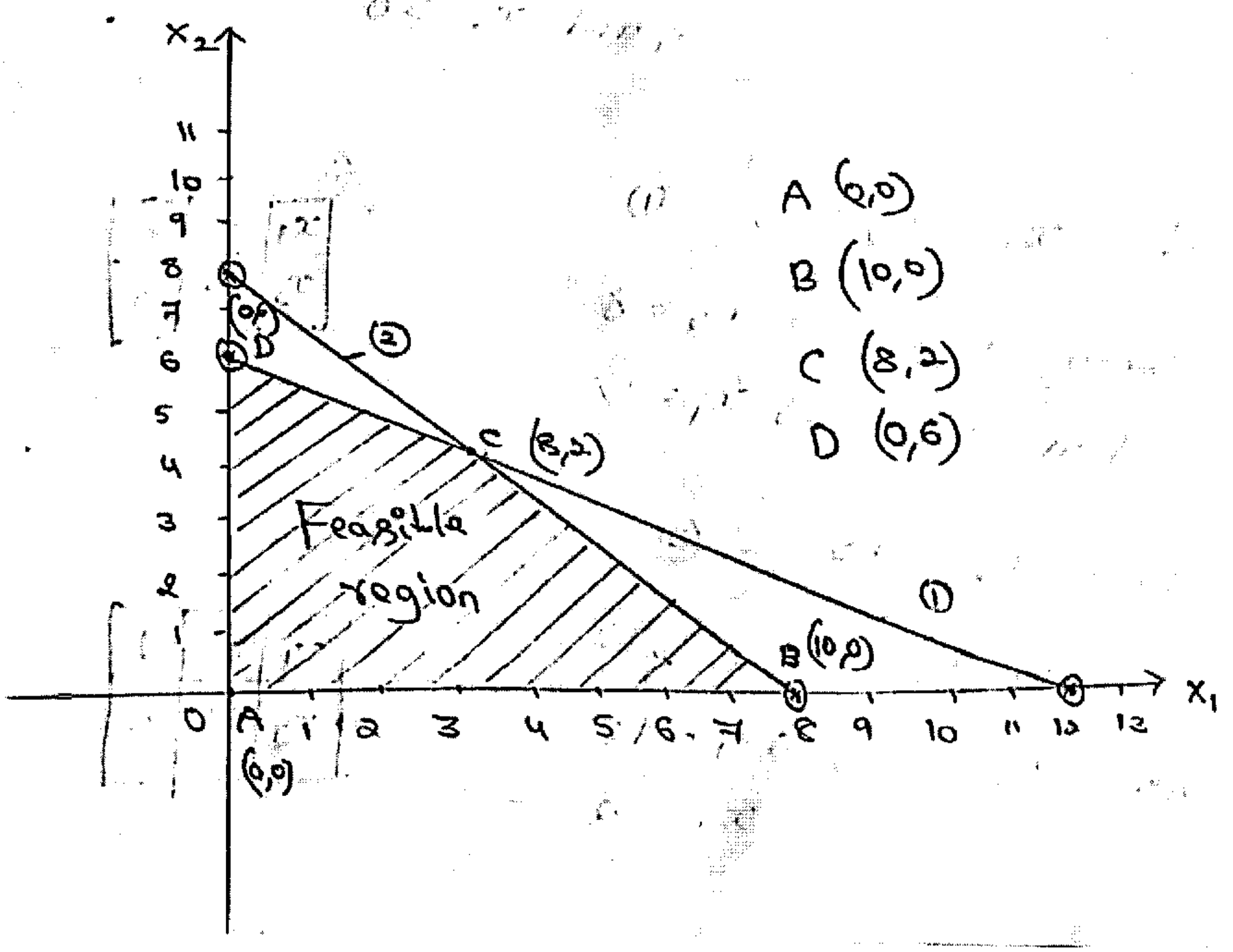
x_1	0	12
x_2	6	0

$8x_1 + 8x_2 = 80$ —②

when $x_1 = 0 \Rightarrow 8x_2 = 80 \Rightarrow x_2 = 10$

when $x_2 = 0 \Rightarrow 8x_1 = 80 \Rightarrow x_1 = 10$

x_1	0	10
x_2	10	0



A (0,0)

B (10,0)

C (8,2)

D (0,6)

Max $Z = 12x_1 + 16x_2$

$Z(A) = 12(0) + 16(0) = 0$

$Z(B) = 12(10) + 16(0) = 120$

$Z(C) = 12(8) + 16(2) = 96 + 32 = 128$

$Z(D) = 12(0) + 16(6) = 0 + 96 = 96$

$x_1 = 8, \; x_2 = (2) \;. \; Z \text{ (optimum)} = 128.$

) Solve the following LPP using graphical method

Minimize $Z = 4x_1 + 6x_2$

subject to

$x_1 + x_2 \geq 8$

$6x_1 + x_2 \geq 12$

x_1 and $x_2 \geq 0$

Sol: $x_1 + x_2 = 8$ —(1)

When $x_1 = 0 \Rightarrow x_2 = 8$

When $x_2 = 0 \Rightarrow x_1 = 8$

x_1	0	8
x_2	8	0

$6x_1 + x_2 = 12$ —(2)

hen $x_1 = 0 \Rightarrow x_2 = 12$

hen $x_2 = 0 \Rightarrow 6x_1 = 12$

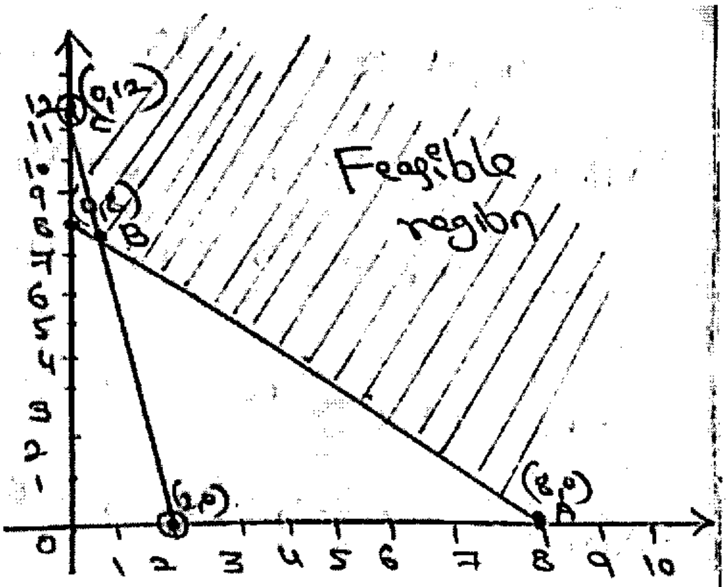
$x_1 = 2$

x_1	0	2
x_2	12	0

A (8, 0)

B (0.8, 7.2)

C (0, 12)



Minimize $Z = 4x_1 + 6x_2$

$Z(A) = 4(8) + 6(0) = 32$

$Z(B) = 4(0.8) + 6(7.2) = 3.2 + 43.2 = 46.4$

$Z(C) = 4(0) + 6(12) = 72$

optimum solution is point (A)

$x_1 = 8, \quad x_2 = 0, \quad Z\text{(optimum)} = 32$

(*) Solve the following LPP using graphical method

Maximize $Z = 100x_1 + 60x_2$

Subject to $5x_1 + 10x_2 \le 50$ (below)

$8x_1 + 2x_2 \ge 16$ (above)

$3x_1 - 2x_2 \ge 6$ (above)

x_1 and $x_2 \ge 0$

Sol: $5x_1 + 10x_2 = 50$ — (1)

When $x_1 = 0 \Rightarrow 10x_2 = 50 \Rightarrow x_2 = 5$

When $x_2 = 0 \Rightarrow 5x_1 = 50 \Rightarrow x_1 = 10$

x_1	0	10
x_2	5	0

$8x_1 + 2x_2 = 16$ —— (2)

When $x_1 = 0 \Rightarrow 2x_2 = 16 \Rightarrow x_2 = 8$

When $x_2 = 0 \Rightarrow 8x_1 = 16 \Rightarrow x_1 = 2$

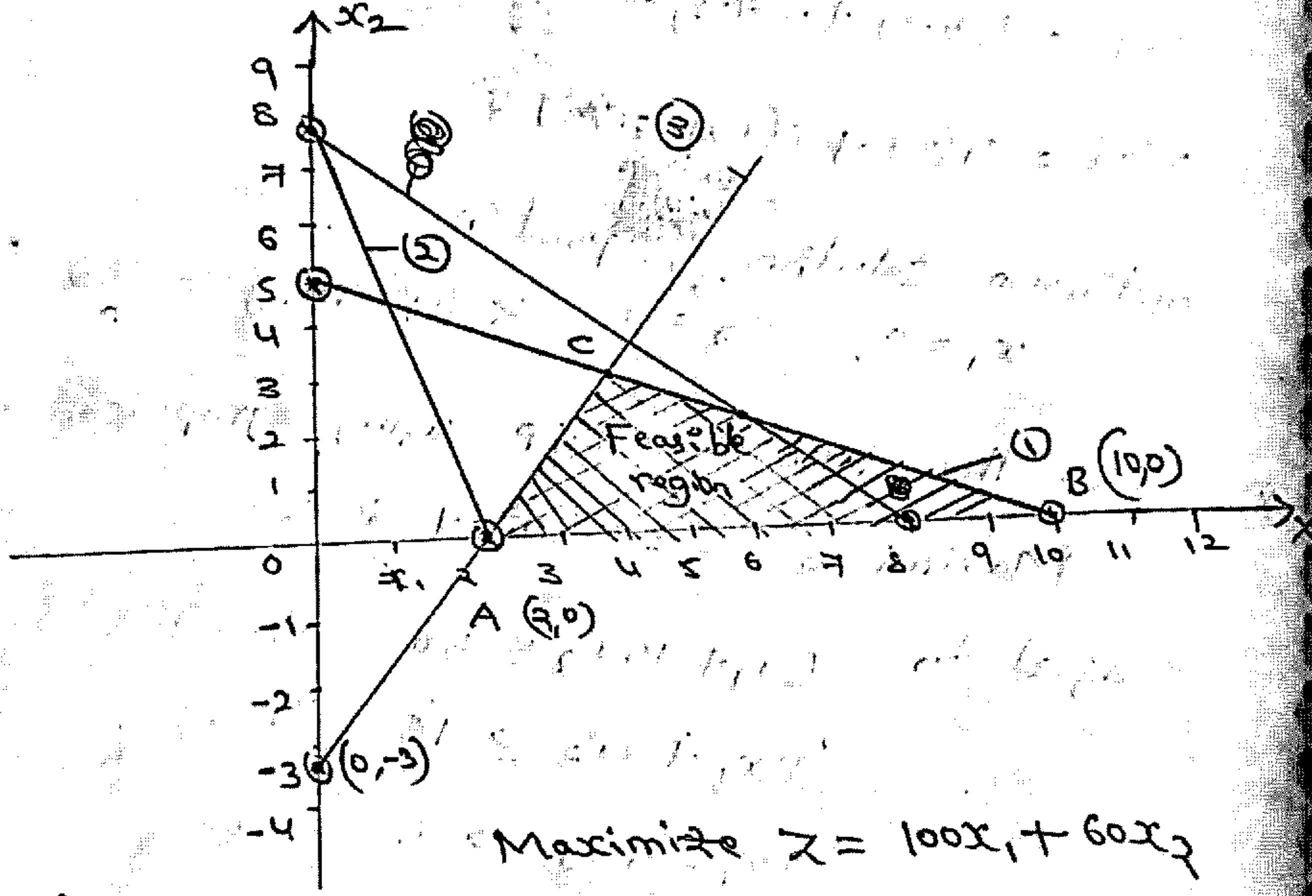
x_1	0	2
x_2	8	0

$3x_1 - 2x_2 = 6$ —— (3)

When $x_1 = 0 \Rightarrow -2x_2 = 6 \Rightarrow x_2 = -3$

When $x_2 = 0 \Rightarrow 3x_1 = 6 \Rightarrow x_1 = 2$

x_1	0	2
x_2	-3	0



Maximize $Z = 100x_1 + 60x_2$

A $(2,0)$ $\quad Z(A) = 100(2) + 60(0) = 200$

B $(10,0)$ $\quad Z(B) = 100(10) + 60(0) = 1000$

C $(4,3)$ $\quad Z(C) = 100(4) + 60(3) = 400 + 180 = 580$

point (B) is optimum value

$\therefore \quad x_1 = 10, \quad x_2 = 0 \quad Z(\text{optimum}) = 1000.$

Simplex method

1) Solve the following LPP using the Simplex method

Maximize $Z = 12x_1 + 16x_2$

subject to $10x_1 + 20x_2 \leq 120$

$8x_1 + 8x_2 \leq 80$

x_1 and $x_2 \geq 0$

Sol: Max $Z = 12x_1 + 16x_2 + 0s_1 + 0s_2$

subject to $10x_1 + 20x_2 + s_1 = 120$ —(1)

$8x_1 + 8x_2 + s_2 = 80$ —(2)

x_1, x_2, s_1 and $s_2 \geq 0$

Initial Simplex Table

CB	c_j / Basic variable	12 (x_1)	16 (x_2)	0 (s_1)	0 (s_2)	Solution	Ratio
0	s_1	10	20	1	0	120	$\frac{120}{20} = 6$
0	s_2	8	8	0	1	80	$\frac{80}{8} = 10$
	z_j	0	0	0	0	0	
	$c_j - z_j$	12	16	0	0		

$$z_j = \sum_{i=1}^{2} (C_{B_i})(a_{ij})$$

∴ Optimality conditions

For Maximization problem :

all $C_j - Z_j \leq 0$

for Minimization problem

all $C_j - Z_j \geq 0$

Note :- we need to proceed for optimality select the maximum value in the $(C_j - Z_j)$.

$$\text{New value} = \text{old value} - \frac{\text{corresponding Key column value} \times \text{corresponding Key row value}}{\text{Key element}}$$

$$\therefore\ 8 - \frac{8 \times 10}{20} = 8 - \frac{80}{20} = 8 - 4 = 4$$

$$8 - \frac{8 \times 20}{20} = 8 - 8 = 0$$

$$0 - \frac{8 \times 1}{20} = \frac{0 - 8}{20} = \frac{-8}{20} = \frac{-2}{5}$$

$$1 - \frac{8 \times 0}{20} = 1 - \frac{0}{20} = 1$$

$$80 - \frac{8 \times \cancel{120}^{6}}{\cancel{20}} = 80 - 48 = 32$$

Iteration - 1

CB_i	C_j	12	16	0	0	Solution	Ratio
	B.V	X_1	X_2	S_1	S_2		
16	X_2	$1/2$	1	$1/20$	0	6	$\frac{6}{1/2} = 12$
0	S_2	4	0	$-2/5$	1	32	$\frac{32}{4} = 8$
	Z_j	8	16	$4/5$	0		
	$C_j - Z_j$	4	0	$-4/5$	0		

Iteration - 2

CB_i	C_j	12	16	0	0	Solution	Ratio
	B.V	X_1	X_2	S_1	S_2		
16	X_2	0	1	$\frac{1}{10}$	$\frac{-1}{8}$	2	
12	X_1	1	0	$\frac{-1}{10}$	$\frac{1}{4}$	8	
	Z_j	12	16	$\frac{2}{5}$	1	128	
	$C_j - Z_j$	0	0	$-\frac{2}{5}$	-1		

$$\text{New value} = \text{old value} - \frac{\text{corr. Key column value} \times \text{Corr. Key row value}}{\text{Key element}}$$

$$= \frac{1}{2} - \left(\frac{\frac{1}{2} \times 4}{4}\right) = 0$$

$$= 1 - \left(\frac{\frac{1}{2} \times 0}{4}\right) = 0$$

$$= \frac{1}{20} - \left(\frac{\frac{1}{2} \times \frac{-2}{5}}{4}\right) = \frac{1}{10}$$

$$= 0 - \left(\frac{\frac{1}{2} \times 1}{4}\right) = -\frac{1}{8}$$

$$\Rightarrow 6 - \left(\frac{\frac{1}{2} \times 32}{4}\right) = 2$$

Final Solution

$x_1 = 12, \; x_2 = 16$

$z(\text{optimum}) = 128.$

* Solve the following LP using simplex method.

Minimize $Z = 2x_1 - 3x_2 + 6x_3$

Subject to $3x_1 - x_2 + 2x_3 \leq 7$

$2x_1 + 4x_2 \geq -12$

$-4x_1 + 3x_2 + 8x_3 \leq 10$

x_1, x_2 and $x_3 \geq 0$

Sol: $3x_1 - x_2 + 2x_3 \leq 7$

$-2x_1 - 4x_2 \leq 12$

$-4x_1 + 3x_2 + 8x_3 \leq 10$

Standard form

Min $Z = 2x_1 - 3x_2 + 6x_3 + 0S_1 + 0S_2 + 0S_3$

$3x_1 - x_2 + 2x_3 + S_1 = 7$

$-2x_1 - 4x_2 + S_2 = 12$

$-4x_1 + 3x_2 + 8x_3 + S_3 = 10$

CB$_i$	Cj	2	-3	6	0	0	0	Solution	Ratio
	BV	x_1	x_2	x_3	S_1	S_2	S_3		
0	S_1	3	-1	2	1	0	0	7	$\frac{7}{-1} = -7$
0	S_2	-2	-4	0	0	1	0	12	$\frac{12}{-4} = -3$
0	S_3	-4	$\boxed{3}$	8	0	0	1	10	$\frac{10}{3} = \frac{10}{3}$
	Z_j	0	0	0	0	0	0	0	
	$C_j - Z_j$	2	-3	6	0	0	0		

optimality condition:

for minimization problem:

All the $c_j - z_j \geq 0$ (or) $z_j - c_j \leq 0$

for Maximization problem:

All the $c_j - z_j \leq 0$ (or), $z_j - c_j \geq 0$

→ Key column: select the Most negative value of key column.

→ Key row: select the Least positive value in Ratio.

→ Key column will be the Entering variable and Key row will be the Leaving variable.

In problem. x_2 = Entering variable
S_3 = Leaving variable

→ For new values for Entering variable

$$= \frac{\text{old value}}{\text{Key Element}}$$

→ For Key row new values

$$= \text{old value} - \frac{\text{Corr. Key column value} \times \text{Corr. Key row value}}{\text{Key element}}$$

(or)

For key row values

→ = old value − corr. key column value × new value

	C_j	2	-3	6	0	0	0		
C_{B_i}	B.V	x_1	x_2	x_3	S_1	S_2	S_3	Solution	Ratio
0	S_1	$5/3$	0	$14/3$	1	0	$1/3$	$31/3$	Key row $\frac{31}{3}\times\frac{3}{5}=\frac{31}{5}$
0	S_2	$\frac{-22}{3}$	0	$\frac{32}{3}$	0	1	$4/3$	$-76/3$	$\frac{-76}{22}=\frac{-38}{1}$
-3	x_2	$-4/3$	1	$8/3$	0	0	$1/3$	$10/3$	$\frac{-10}{4}=\frac{-5}{2}$
	Z_j	4	-3	-8	0	0	-1	-10	
	$C_j - Z_j$	$\boxed{-2}$	0	14	0	0	1		

Key column

$x_1 = E.V$
$S_1 = L.V$

	C_j	2	-3	6	0	0	0	
C_{B_i}	B.V	x_1	x_2	x_3	S_1	S_2	S_3	Solution
2	x_1	1	0	$14/5$	$3/5$	0	$1/5$	$31/5$
0	S_2	0	0	$156/5$	$22/5$	1	$14/5$	$354/5$
-3	x_2	0	1	$\frac{32}{5}$	$4/5$	0	$3/5$	$58/5$
	Z_j	2	-3	$\frac{-68}{5}$	$\frac{-6}{5}$	0	$\frac{-7}{5}$	$\frac{-112}{5}$
	$C_j - Z_j$	0	0	$\frac{98}{5}$	$\frac{6}{5}$	0	$\frac{7}{5}$	

for minimization problem, all these values are position ie $C_j - Z_j \geq 0$

$$\text{Min } z = 2x_1 - 3x_2 + 6x_3 = \frac{-112}{5}$$

$$x_1 = \frac{31}{5}, \quad x_2 = \frac{58}{5}, \quad x_3 = 0$$

$$= 2\times\frac{31}{5} - 3\left(\frac{58}{5}\right) + 6(0) =$$

$$= \frac{62}{5} - \frac{174}{5} + 0 = \frac{-112}{5}$$

Two- phase Method

* Minimization type of objective Function
→ constraints: For '$\geq$' (or) '$=$' type constraints subtract slack variable and add artificial variable
→ for '$\leq$' type constraints add slack variable only
→ phase 1 and phase 2.
→ for phase 1: Simplex method with revised objective Function.
→ at the end of phase 1 check whether the objective function value is zero in the optimal table
If yes, goto phase 2

* Min $Z = 10x_1 + 6x_2 + 2x_3$

Subject to $-x_1 + x_2 + x_3 \geq 1$

$3x_1 + x_2 - x_3 \geq 2$

x_1, x_2 and $x_3 \geq 0$

Sol: Min $Z = 10x_1 + 6x_2 + 2x_3 + 0S_1 + 0S_2 + A_1 + A_2$

Subject to $-x_1 + x_2 + x_3 - S_1 + A_1 = 1$

$3x_1 + x_2 - x_3 - S_2 + A_2 = 2$

$x_1, x_2, x_3, S_1, S_2, A_1$ and $A_2 \geq 0$

$$\text{Min } z = A_1 + A_2$$

Subject to. $-x_1 + x_2 + x_3 - S_1 + A_1 = 1$

$3x_1 + x_2 - x_3 - S_2 + A_2 = 2$

$x_1, x_2, x_3, S_1, S_2, A_1 \text{ and } A_2 \geq 0$

CB	C_j	0	0	0	0	0	1	1	Solution
	B.V	x_1	x_2	x_3	S_1	S_2	A_1	A_2	
1	A_1	-1	1	1	-1	0	1	0	1
1	A_2	3	1	-1	0	-1	0	1	2
	Z_j	2	2	0	-1	-1	1	1	3
	$C_j - Z_j$	-2	-2	0	1	1	0	0	

x_1 = Entering variable
A_2 = Leaving variable. We eliminate A_2.

Iteration-1

CB	C_j	0	0	0	0	0	1	Solution
	B.V	x_1	x_2	x_3	S_1	S_2	A_1	
0	x_1	1	1/3	-1/3	0	-1/3	0	8/3
1	A_1	0	4/3	2/3	-1	-1/3	1	$\boxed{5/3}$ most +ve
	Z_j	0	4/3	2/3	-1	-1/3	1	5/3
	$C_j - Z_j$	0	$\boxed{-4/3}$ most negative -ve	-2/3	1	1/3	0	

x_2 = Entering variable
A_1 = Leaving variable

→ For new values for entering variable

$$= \frac{\text{old value}}{\text{Key element}}$$

→ for Key Row values

$$= \text{old value} - \text{corresponding Key column value} \times \text{new value}$$

CB_i	C_j	0	0	0	0	0	Solution
	B.V	x_1	x_2	x_3	S_1	S_2	
0	x_2	0	1	1/2	-3/4	-1/4	5/4
0	x_1	1	0	-1/2	1/4	-1/4	1/4
	Z_j	0	0	0	0	0	0
	$C_j - Z_j$	0	0	0	0	0	

phase - 2 :

CB_i	C_j	10	6	2	0	0	Solution
	B.V	x_1	x_2	x_3	S_1	S_2	
6	x_2	0	1	1/2	-3/4	-1/4	5/4
10	x_1	1	0	-1/2	1/4	-1/4	1/4
	Z_j	10	6	-2	-2	-4	$\boxed{10}$
	$C_j - Z_j$	0	0	4	2	4	

"All $C_j - Z_j \geq 0$.

⇒ In objective function

$\text{Min } Z = 10x_1 + 6x_2 + 2x_3$

$= 10(\frac{1}{4}) + 6(\frac{5}{4}) + 0$

$= \frac{10}{4} + \frac{30}{4} = \frac{40}{4} = \underline{\underline{10}}$

$Z_j = 10 \quad x_1 = 1/4$

$x_2 = 5/4$

Linear programming problem using

Big 'M' Method

* Note: '$\leq$' = add slack variable (+s)

$\geq$ = subtracte Surplus variable (-s) and add Artificial variable (+A)

* Solve the following Linear programming problem using Big 'm' method.

$$\text{Minimize } Z = 7x_1 + 15x_2 + 20x_3$$

Subject to

$$2x_1 + 4x_2 + 6x_3 \geq 24$$

$$3x_1 + 9x_2 + 6x_3 \geq 30$$

$$x_1, x_2 \text{ and } x_3 \geq 0$$

Sol:

$$\text{Min } Z = 7x_1 + 15x_2 + 20x_3 + 0S_1 + 0S_2 + MA_1 + MA_2$$

subject to

$$2x_1 + 4x_2 + 6x_3 - S_1 + A_1 = 24$$

$$3x_1 + 9x_2 + 6x_3 - S_2 + A_2 = 30$$

$$x_1, x_2, x_3, S_1, S_2, A_1 \text{ and } A_2 \geq 0$$

Note: Key column = most -ve negative value in $C_j - Z_j$

Key row = Least +ve value in Ratio

CB_i	C_j	7	15	20	0	0	M	M	Solution	Ratio
	B.V	x_1	x_2	x_3	S_1	S_2	A_1	A_2		
M	A_1	2	4	6	-1	0	1	0	24	$\frac{24}{4}=6$
M	A_2	3	9 KE	5	0	-1	0	1	30	$\frac{30}{9}=\frac{10}{3}$ KR
	Z_j	5M	13M	12m	-M	-M	M	M	54M	
	$C_j - Z_j$	7-5m	15-13m ↑KC	20-12m	M	M	0	0		

x_2 = Entering variable
A_2 = Leaving variable

CB_i	C_j	7	15	20	0	0	M	M	Solution	
	B.V	x_1	x_2	x_3	S_1	S_2	A_1	A_2		
M	A_1	$2/3$	0	$10/3$ K.E	-1	$4/9$	1	-	$32/3$	$\frac{32}{3}\times\frac{3}{10}=\frac{16}{5}$ KR
15	x_2	$1/3$	1	$2/3$	0	$-1/9$	0	-	$10/3$	$\frac{10}{3}\times\frac{3}{2}=5$
	Z_j	$\frac{2}{3}m+5$	15	$\frac{10}{3}m+10$	-m	$\frac{4}{9}m-\frac{5}{3}$	m		$\frac{32m}{3}+50$	
	$C_j - Z_j$	$\frac{-2}{3}m+2$	0	$\frac{-10}{3}+10$ ↑KC	m	$\frac{5}{3}-\frac{4}{9}m$	0	-		

⊛ new value for Entering variable $= \dfrac{\text{old value}}{\text{Key Element}} = \frac{3}{9}, \frac{9}{9}, \frac{6}{9}, \frac{0}{9}, \frac{-1}{9}, \frac{30}{9}$

⊛ for Key row new value = old value − corresponding Key column value × new value.

$= 2 - 4\times\frac{1}{3} = 2-\frac{4}{3} = \frac{6-4}{3} = 2/3$

$= 4 - 4\times 1 = 0$

$= 6 - 4\times\frac{2}{3} = 6-\frac{8}{3} = \frac{18-8}{3} = 10/3$

$= -1 - 4\times 0 = -1$

$= 0-(4\times -1/9) = 4/9$

$1 - 4\times 0 = 1$

$24 - 4\times\frac{10}{3} = \frac{72-40}{3} = \frac{32}{3}$

C_{B_i}	C_j	7	15	20	0	0	M	M	Solution
	B.V	x_1	x_2	x_3	S_1	S_2	A_1	A_2	
20	x_3	$1/5$	0	1	$-3/10$	$2/5$	-	-	$16/5$
15	x_2	$1/5$	1	0	$1/5$	$-1/5$	-	-	$6/5$
	Z_j	7	15	20	-3	$-1/3$	-	-	82
	$C_j - Z_j$	0	0	0	3	$1/3$	-	-	

$x_1 = 0$

$x_2 = 6/5$

$x_3 = 16/5$

Minimize $Z = 7x_1 + 15x_2 + 20x_3$

$= 7(0) + \cancel{15}^{3}\left(\frac{6}{\cancel{5}}\right) + \cancel{20}^{4}\left(\frac{16}{\cancel{5}}\right)$

$= 0 + 18 + 64$

Min $Z = 82$

TRANSPORTATION PROBLEM

Introduction: It is a special kind of LPP in which goods are transported from a set of sources to a set of destinations subject to the supply and demand of the sources and destination respectively such that the total cost of transportation is minimized.

Types

1. Balanced transportation problem $S = D$
2. Un Balanced TP $S \neq D$

S = Supply and D = Demand.

Methods:

1. Finding the initial basic feasible solution
2. Finding optimization

		A	B	C	Supply
		Destination			
Source	I	2	7	5	200
	II	3	4	2	300
	III	5	4	7	500
Demand		200	400	400	1000

I phase: Transportation problem

1. Northwest corner cell method
2. Least cost cell method
3. Vogel's Approximation method (VAM)

(*) North - West corner Method

	A	B	C	D	Supply
Source 1	[250] ~~3~~	[50] ~~1~~	~~7~~	~~4~~	~~300~~ ~~50~~ 0
2	~~2~~	[300] ~~6~~	[100] ~~5~~	~~9~~	~~400~~ 100 ~~300~~ 0
3	~~8~~	~~3~~	[300] 3	[200] 2	~~500~~ ~~200~~ 0
Demand	~~250~~ 0	~~350~~ ~~300~~ 0	~~400~~ ~~300~~ 0	~~200~~ 0	

$= 250 \times 3 + 50 \times 1 + 300 \times 6 + 100 \times 5 + 300 \times 3 +$

200×2

$= 4,400/-$

(*) Least Cost Method

Destination

Source	A	B	C	D	Supply
1	3	$\boxed{300}$ 1	7	4	~~300~~ 0
2	$\boxed{250}$ 2	$\boxed{50}$ 6	$\boxed{100}$ 5	9	~~400~~ ~~150~~ 50 0
3	8	3	$\boxed{200}$ 3	$\boxed{200}$ 2	~~500~~ ~~300~~ 0
Demand	~~250~~ 0	~~350~~ ~~50~~ 0	~~400~~ ~~100~~ 0	~~200~~ 0	

$\Rightarrow 300\times1 + 250\times2 + 50\times6 + 100\times5 + 300\times3 + 200\times2$

$= 2,900/-$

(*) Vogel's Approximation method (VAM)

Destination

Source	A	B	C	D	Supply	Row Difference			
1	3	$\boxed{300}$ 1	7	4	~~300~~ 0	2	3	-	-
2	$\boxed{250}$ 2	6	$\boxed{150}$ 5	$\boxed{100}$ 9	~~400~~ ~~150~~ 0	3	1	1	1
3	8	$\boxed{50}$ 3	$\boxed{250}$ 3	$\boxed{200}$ 2	~~500~~ ~~300~~ ~~250~~ 0	1	1	1	-
Demand	~~250~~ 0	~~350~~ ~~50~~ 0	~~400~~ ~~150~~	~~200~~ 0					
Column Difference	1	2	2	2					
	-	2	2	2					
	-	3	2	7					
		3	2	-					

$= 300\times1 + 250\times2 + 150\times5 + 50\times3 + 250\times3 + 200\times2$

$= 2850/-$

Unbalanced Transportation problem :

Transportation

- Balanced TP → D = S
- Unbalanced TP → D ≠ S

Destination

	A	B	C	D	E	F	Supply
Source	1	5	1	8	7	5	15
	2	3	9	6	7	8	25
	3	4	2	7	6	5	42
	4	7	11	10	4	9	35
Demand		30	20	15	20	20	95 | 117 = 22

Destination D ≠ S

Source	A	B	C	D	E	F	Supply
1	5	5	8	7	5	0	15
2	3	9	6	7	8	0	25
3	4	2	7	6	5	0	42
4	7	11	10	4	9	0	35
Demand	30	20	15	20	20	22	

→ Solve the problem by using
- North west corner method
- Least cost method
- Vogel's Approximation method (VAM)

Transportation problem:

I - Finding the initial basic feasible Solution in the first phase

II - Second phase involves optimization of the initial basic feasible solution which is obtained in phase-I

→ Finding the initial Basic Solution:

1. Northwest Corner cell method
2. Least cost cell method
3. VAM

→ optimimality Test for Transportation problems:

There are basically two methods

1. Modified Distribution method (or) ModI method
2. Stepping Stone method.

Modified Distribution Method (MODI) :-

MODI (or) U-V method provides a minimum cost solution to the transportation problem. In the stepping stone method, we have to draw as many closed paths as equal to the unoccupied cells for their evaluation. To the contray, in modi method, only closed path for the unoccupied cell with highest opportunity is drawn.

Steps :

1) Determine an initial basic feasible solution using any one of three methods → North, Least, VAM.

2) Determine the values of dual variables, u_i and v_j, using $u_i + v_j = c_{ij}$

3) ~~compute~~ the ~~opportunity~~ Introduce dual variables corresponding to the row constraints and the column constraints. If there are m Supply points and n destination points then there will be m+n dual variables. Dual variables corresponding to row are represented by u_i, $i = 1, 2, 3 \ldots m$, where as the dual variable corresponding to column are represented by v_j, $j = 1, 2, 3 \ldots n$.
The value of dual variable is calculated from

Find the initial basic feasible solution of the following transportation problem by Northwest corner method, and then optimize the solution using u.v method.

Sol:

	1	2	3	4	Supply
Source 1	3	1	7	4	250
2	2	6	5	7	350
3	8	3	3	2	400
Demand	200	300	350	150	

phase-I

Sol:

	Destination 1	2	3	4	Supply
1	[200] ~~3~~	[50] ~~1~~	~~7~~	~~4~~	~~250~~ ~~50~~ 0
Source 2	~~2~~	[250] ~~6~~	[100] ~~5~~	~~7~~	~~350~~ ~~100~~ 0
3	~~8~~	~~3~~	[250] ~~3~~	[150] ~~2~~	~~400~~ ~~150~~ 0
Demand	~~200~~ 0	~~300~~ ~~250~~ 0	~~350~~ ~~250~~ 0	~~150~~ 0	1000

$= 200 \times 3 + 50 \times 1 + 250 \times 6 + 100 \times 5 + 250 \times 3 + 150 \times 2$

$= 3700$

Application of uv method to optimize the solution

[200] 3	[50] 1	7	4
2	[250] 6	[100] 5	9
8	3	[250] 3	[150] 2

$v_1 = 3 \quad v_2 = 1 \quad v_3 = 0 \quad v_4 = -1$

$u_1 = 0$	200 (−) 3	50 (+) 1	7	4
$u_2 = 5$	(+) 2	250 (−) 6	100 5	9
$u_3 = 3$	8	3	250 3	150 2

Draw closed loop with allocated cell

$m+n-1 =$

$3+4-1 = 6.$

$u_i + v_j = c_{ij}$

$u_1 + v_1 = 3$

$0 + v_1 = \underline{\underline{3}}$

$u_1 + v_2 = 1$

$0 + v_2 = 1$

$u_2 + v_2 = 6$

$u_2 + 1 = 6 \Rightarrow u_2 = 5.$

$u_2 + v_3 = 5$

$5 + v_3 = 5$

$v_3 = 0$

$u_3 + v_3 = 3$

$u_3 + 0 = 3$

$u_3 = 3.$

$u_3 + v_4 = 2$

$3 + v_4 = 2$

$v_4 = -1$

$u_1 = 0$

$u_2 = 5$

$u_3 = 3$

$v_1 = 3$

$v_2 = 1$

$v_3 = 0$

$v_4 = -1$

$$\rightarrow \boxed{\Delta_{ij} = u_i + v_j - c_{ij}}$$

$c_{13} = 0+0-7 = -7$

$c_{14} = 0+(-1)-4 = -5$

$c_{21} = 5+3-2 = 6$

$c_{24} = 5-1-9 = -5$

$c_{31} = 3+3-8 = -2$

$c_{32} = 3+1-3 = 1$

→ Select the most positive value in the P_{ij}

	$v_1=3$	$v_2=1$	$v_3=0$	$v_4=-1$
$u_1=0$	(200) 3 (−)	(50) 1 (+)	7	4
$u_2=5$	2 (+)	(250) 6 (−)	(100) 5	9
$u_3=3$	8	3	(250) 3	(150) 2

→ Select the Least (−) sign value in closed Loop and add and subtract the (+) and (−) sign

→

	$v_1=-3$	$v_2=1$	$v_3=0$	$v_4=-1$
$u_1=0$	3	(250) 1	7	4
$u_2=5$	(200) 2	(50) 6	(100) 5	9
$u_3=3$	8	3	(250) 3	(150) 2

$P_{ij} = u_i + v_j - c_{ij}$

$P_{11} = 0 - 3 - 3 = -6$

$P_{13} = 0 + 0 - 7 = -7$

$P_{14} = 0 - 1 - 4 = -5$

$P_{24} = 5 - 1 - 9 = -5$

$P_{31} = 3 - 3 - 8 = -8$

$P_{32} = 3 + 1 - 3 = 1$

If all $P_{ij} \leq 0$, If yes stop, otherwise goto step 6.

→ Select Most (+ve) value in P_{ij}

→ Select $P_{32} = 1$

	$v_1=-3$	$v_2=1$	$v_3=0$	$v_4=-1$
$u_1=0$	3	1 [250]	7	4
$u_2=5$	2 [200]	6 [50] −	5 [100] +	9
$u_3=3$	8	3 +	3 [200] −	2 [150]

Draw the closed Loop formation.

→ use same steps to find u and v value as we did previous

	$v_1=-2$	$v_2=1$	$v_3=1$	$v_4=0$
$u_1=0$	3	1 [250]	7	4
$u_2=4$	2 [200]	6	5 [150]	9
$u_3=2$	8	3 [50]	3 [200]	2 [150]

$$P_{ij} = u_i + v_j - c_{ij}$$

$P_{11} = 0-2-3 = -5$

$P_{13} = 0+1-7 = -6$

$P_{14} = 0+0-4 = -4$

$P_{22} = 4+1-6 = -1$

$P_{24} = 4+0-9 = -5$

$P_{31} = 2-2-8 = -8$

all $P_{ij} \leq 0$. condition is satisfied we can stop the procedure. optimality is reached.

Total cost $= 250(1) + 200(2) + 150(5) + 50(3) + 200(3) + 150(2)$

$= 250 + 400 + 750 + 150 + 600 + 300$

$= 2{,}450/-$

Assignment Problem

1. Balanced Assignment problem
2. unbalanced ~~Assignment~~ problem

Hungerian Method

phase 1 : Row and column reduction

step 1 : Subtract the minimum value of each row from the entries of that row.

step 2 : Subtract the minimum value of each column from the entries of that column

phase 2 : optimization of the problem.

Step 1 : Draw a minimum no. of lines to cover all the zero's of the matrix.

procedure

a) Row scanning

i) starting from the first row, ask the following is there exactly one zero in that row ?
If yes, mark as a square around that zero entry and draw a vertical line passing through that zero, otherwise skip that row.

ii) After scanning the last row, check whether all the zero's are covered with lines, If yes goto step 2 otherwise do column scanning.

b) column Scanning

i) Start from the first column, ask the following question is there exactly one zero in that column? If yes, mark a square around that zero entry and draw a horizontal line passing through that zero otherwise skip that column.

ii) After scanning the last column, check whether all the zero's are covered with lines.

Step 2: check whether the no. of square marked is equal to the no. of rows of the matrix. If yes goto step 5, otherwise goto step 3.

Step 3: Identify the minimum value of undeleted cell values.

a) add the minimum undeleted cell value at intersection points of the present matrix

b) Subtract the minimum undeleted cell value from all the undeleted cell values.

c) all other entries remain same.

Step 4: goto step 1

Step 5: Treat the solution as marked by the

→ Operator

$$
\begin{array}{cc|ccccc|}
 & & 1 & 2 & 3 & 4 & 5 \\
 & 1 & 9 & 11 & 14 & 11 & 7 \\
 & 2 & 6 & 15 & 13 & 13 & 10 \\
\text{Job} & 3 & 12 & 13 & 6 & 8 & 8 \\
 & 4 & 11 & 9 & 10 & 12 & 9 \\
 & 5 & 7 & 12 & 14 & 10 & 14
\end{array}
$$

shown in fig.

verify no of row = no of column

Sol. phase 1 row and column Reduction

Step 1

$$
\begin{bmatrix}
2 & 4 & 7 & 4 & 0 \\
0 & 9 & 7 & 7 & 4 \\
6 & 7 & 0 & 2 & 2 \\
2 & 0 & 1 & 3 & 0 \\
0 & 5 & 7 & 3 & 7
\end{bmatrix}
$$

Row Reduction.

Step 2:

$$
\begin{bmatrix}
2 & 4 & 7 & 2 & 0 \\
0 & 9 & 7 & 5 & 4 \\
6 & 7 & 0 & 0 & 2 \\
2 & 0 & 1 & 1 & 0 \\
0 & 5 & 7 & 1 & 7
\end{bmatrix}
$$

Column Reduction.

$$
\begin{array}{c|ccccc|}
1 & 2 & 4 & 7 & 2 & \boxed{0} \\
2 & \boxed{0} & 9 & 7 & 5 & 4 \\
3 & 6 & 7 & \boxed{0} & 0 & 2 \\
4 & 2 & \boxed{0} & 1 & 1 & 0 \\
5 & 0 & 5 & 7 & 1 & 7
\end{array}
$$

Row Scanning and column Scanning

No. of Rows = no. of square around

$5 \neq 4$

$$\begin{array}{cc|ccccc|}
 & & 1 & 2 & 3 & 4 & 5 \\
 & 1 & 2 & 4 & 6 & 1 & 0 \\
 & 2 & 0 & 9 & 6 & 4 & 4 \\
\text{Job} & 3 & 7 & 8 & 0 & 0 & 3 \\
 & 4 & 2 & 0 & 0 & 0 & 0 \\
 & 5 & 0 & 5 & 6 & 0 & 7
\end{array}$$

operator

$$\begin{array}{cc|ccccc|}
 & & 1 & 2 & 3 & 4 & 5 \\
 & 1 & 2 & 4 & 6 & 1 & \boxed{0} \\
 & 2 & \boxed{0} & 9 & 6 & 4 & 4 \\
\text{Job} & 3 & 7 & 8 & \boxed{0} & 0 & 3 \\
 & 4 & 2 & \boxed{0} & 0 & 0 & 0 \\
 & 5 & 0 & 5 & 6 & \boxed{0} & 7
\end{array}$$

No. of rows = No. of square around.

Optimal Solution

Job	operator.	Time
1	5	7
2	1	6
3	3	6
4	2	9
5	4	10

Total processing Time 38 hours

Travelling and Salesman problems:

→ There are a no. of cities a Salesman must visit

→ The distance/time/cost between every pair of cities is given.

→ The Salesman starts from his home city. he must visit every city exactly once and returns to his home city.

→ The problem is to find the route shortest distance/time/cost.

phase-1

1. TSP can be first solved as AP by using HM to find optimum Solution.
2. Then check the TSP condition.
3. If the condition is Satisfied, then the AP Solution will be the optimum Solution even for TSP.
4. If not goto phase-2.

→ The solution can be adjusted by Inspection

→ form a single circuit

→ The Iteration procedure
  - Branch and Bound method.

* A travelling Salesman has planned to visit 4 cities. He would like to start from a particular city, visit each city only once and return to the starting city. The Travelling cost in rupees is given below. Find the least cost route.

from \ To	A	B	C	D
A	0	25	75	45
B	35	0	150	25
C	35	40	0	15
D	65	75	130	0

Sol:

	A	B	C	D
A	∞	0	50	20
B	10	∞	125	0
C	20	25	∞	0
D	0	10	65	∞

Row Reduction

&

Column Reduction

	A	B	C	D
A	∞	$\boxed{0}$	0	20
B	10	∞	75	$\boxed{0}$
C	20	25	∞	0
D	$\boxed{0}$	10	15	∞

Row & Column Scanning

No. of rows = No. of Square marked around

$4 \neq 3$

If yes, goto step 5, otherwise goto step 3

	A	B	C	D
A	∞	0	0	30
B	10	∞	65	0
C	20	15	∞	0
D	0	0	5	∞

→ goto step.1

Step 1: Row and column Reduction.

	A	B	C	D
A	∞	$\boxed{0}$	0	30
B	10	∞	65	$\boxed{0}$
C	20	15	∞	0
D	$\boxed{0}$	0	5	∞

	A	B	C	D
A	∞	0	$\boxed{0}$	40
B	$\boxed{0}$	∞	55	0
C	10	5	∞	$\boxed{0}$
D	0	$\boxed{0}$	5	∞

Least Route : A → C → D → B → A

75 + 15 + 75 + 35

= 200/-

(*) Travelling Salesman problems

The salesman starts from his home city, he must visit every city exactly once and return to his home city.

The problem is to find the route shortest distance / time / cost.

(*) A salesman wants to visit cities A, B, C, D, E. He does not want to visit any city twice before completing his tour of all the cities and wishes to return to the point of starting journey. Cost of going from one city to another (in rupees) is given in the table below. Find the least cost route.

	A	B	C	D	E
A	∞	2	5	8	1
B	6	∞	3	9	2
C	8	7	∞	4	8
D	13	4	7	∞	5
E	1	3	2	8	∞

Sol: phase 1: Apply Hungarian Method.

Row Reducting

	A	B	C	D	E
A	∞	1	4	7	0
B	4	∞	1	7	0
C	4	3	∞	0	4
D	9	0	3	∞	1
E	0	2	1	7	∞

column Reduction

	A	B	C	D	E
A	∞	1	3	7	$\boxed{0}$
B	4	∞	$\boxed{0}$	7	0
C	4	3	∞	$\boxed{0}$	4
D	9	$\boxed{0}$	2	∞	1
E	$\boxed{0}$	2	0	7	∞

Next Row & column Scanning

No. of Rows = No. of square marked around

5 = 5.

If yes goto 5.

~~A → B → C → D → B →~~

A → E   A → E → A

E → A

B → C

C → D

D → B

If not, goto phase - II

I The solution can be adjusted by Inspection
II form a single circuit
III The Iterative procedure
- Branch and Bound method.

The solution can be adjusted by Inspection.

	A	B	C	D	E
A	∞	$\boxed{1}$	3	7	0
~~B~~	4	∞	$\boxed{0}$	7	0
C	4	3	∞	$\boxed{0}$	4
D	9	0	2	∞	$\boxed{1}$
~~E~~	$\boxed{0}$	2	0		∞

Select the least value in entire matrix and that value is marked as square around and remaining process will be same as usual.

$A \rightarrow B \rightarrow C \rightarrow D \rightarrow E \rightarrow A.$

$2 + 3 + 4 + 5 + 1$

= Rs.15

Assignment problem Maximization Hungarian method

① Solve the following assignment problem to maximize sales.

Territories

Sales man	I	II	III	IV
A	45	38	30	22
B	35	29	20	14
C	35	29	20	14
D	27	20	15	10

Sol:- 1. Convert it into Maximization problem into minimization.

2. Convert it into minimization problem by subtracting all the elements from the Largest element.

Phase 1 : Row and column Reduction.

Phase 2 : optimization.

	I	II	III	IV
A	0	7	15	23
B	10	16	25	31
C	10	16	25	31
D	18	25	30	35

Row & column Reduction

	I	II	III	IV
A	0	7	15	23
B	0	6	15	21
C	0	6	15	21
D	0	7	12	17

Row

column Reduction

	I	II	III	IV
A	0	1	3	6
B	0	0	3	4
C	0	0	3	4
D	0	1	0	0

	I	II	III	IV
A	$\boxed{0}$	1	3	6
B	0	$\boxed{0}$	3	4
C	0	0	3	4
D	0	1	$\boxed{0}$	0

No. of rows = No. of Square mark around

$4 \neq 3$

	I	II	III	IV
A	$\boxed{0}$	1	0	3
B	0	$\boxed{0}$	0	1
C	0	0	$\boxed{0}$	1
D	3	4	0	$\boxed{0}$

A → I = 45
B → II = 29
C → III = 20
D → IV = 10

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Replacement Models

Replacement policy :- If the running and maintenance cost of the machine for the next year is more than the average annual cost of selected year.
Then replace at the end of the selected year.

Replacement Models :

I. Replacement of items that deteriorate i.e. whose maintenance costs increase with time, ignoring changes in the value of money during the period.

II. Replacement of items whose maintenance costs increase with time and value of money also changes with time

III. Group Replacement policy

) The cost of a machine is Rs 10,500 and its scrap value is 500 Rs. The maintenance costs found from experience are as follows.

Year	1	2	3	4	5	6	7	8
Maintenance Cost	300	500	700	1000	1400	1900	2400	3000

When should the machine be replaced.?

① Years of service	② Resale value (or) Scrap value	③ Purchase price − Resale value (10,500 − 500)	④ Annual Maintenance Cost	⑤ Cummilative maintance cost	⑥ Total cost 3+5	⑦ Avg. Annual cost 6/1
1	500	10,000	300	300	10,300	10300
2	500	10,000	500	800	10,800	5400
3	500	10,000	700	1500	11,500	3,833
4	500	10,000	1000	2500	12,500	3,125
5	500	10,000	1400	3900	13,900	2,780
6	500	10,000	1900	5800	15,800	2,633
$\boxed{7}$	500	10,000	2400	8200	18,200	$\boxed{2,600}$
8	500	10,000	$\boxed{3000}$	11,200	21,200	2,650

If the running or maintenance cost of the machine for the next year is more than the average annual cost of selected year. Then replace at the end of the selected year.

3000 > 2600

⊛ Replacement problem when different Resale values is given.

→ The purchase price of a m/c is 9,000/- and its Installation charges amount to 1000/-. The maintance cost and resale value per year of a machine is given below. When should the machine be replaced.

Year	1	2	3	4	5	6	7	8
Maintanance cost	1000	1500	2000	2500	3000	4000	5100	7000
Resale value	6000	3500	1600	800	700	500	400	400

① Year of Service	② Resale value	③ purchase price − Resale value 10,000 − Resale	④ Annual Maintanance cost	⑤ Cummilative Maintanance cost	⑥ Total Cost = 3+5	⑦ Avg. Annual Cost 7 = 6/1
1	6000	4,000	1000	1000	5,000	5000
2	3500	6500	1500	2500	9,000	4500
3	1600	8,400	2000	4500	12,900	4300
4	800	9,200	2500	7000	16,200	4050
$\boxed{5}$	700	9300	3000	10,000	19,300	$\boxed{3860}$
6	500	9500	4000	14,000	23,500	3917
7	400	9600	5100	19,100	28,700	4,100
8	400	9,600	7000	26,100	35,100	4,388

4000 > 3860

Replacement problem in Operation Research:

Running cost and value of money also changes with Time.

(*) purchase price of a Machine is Rs. 3,000 and its running cost is Rs. 500 for each of the first 5 years and increase by Rs 100. every subsequent year. If the discount rate is 10% per year. when should the machine be replaced? Assume that there is no Salvage value.

Sol: Computation Discount factor

Discount rate of money is 0.1 ie 10%

Discount Factor $= v^{r-1}$ $r =$ Year.

$$V = \frac{1}{1+i} \qquad i = \text{rate of Discount}$$

Year $\quad v = \frac{1}{1+0.1} = \frac{1}{1.1} = 0.9091$

Year	Discount Factor	
1	$(0.9091)^{1-1} =$	1
2	$(0.9091)^{2-1} =$	0.9091
3	$(0.9091)^{3-1} =$	0.8264
4	$(0.9091)^{4-1} =$	0.7513
5	$(0.9091)^{5-1} =$	0.6830

① Year	② Depreciation cost	③ Running cost	④ Discount factor 10%	⑤ Discount Running cost ③ × ④	⑥ Cummilative Discount Running cost	⑦ Total cost ② + ⑥	⑧ Cum. Discount Factor	⑨ weighted average annual cost ⑦/⑧
1	3000	500	1	500	500	3500	1	3500
2	3000	500	0.9091	454.55	954.55	3954.55	1.9091	2,071.42
3	3000	500	0.8264	413.20	1367.75	436775	2.7355	1,599.98
4	3000	500	0.7513	375.65	1743.40	4743.40	3.4868	1360.39
5	3000	500	0.6830	341.50	2084.90	5,08490	4,1698	1219.46
6	3000	600	0.6209	372.54	2,457.44	5457.44	4,7907	1,139.17
7	3000	700	0.5645	395.15	2,852.59	5,852.59	5.3552	1092.88
8	3000	800	0.5132	410.56	3,263.15	6,263.15	5.8684	1,067.27
9	3000	900	0.4665	419.85	3,683.00	6,683.00	6.3349	1,054.95
10	3000	1000	0.4241	424.10	4,107.10	7,107.10	6.7590	1051.50
11	3000	1100	0.3855	424.05	4,531.55	7,531.15	7.1445	1054.12

current year weighted Average Annual Cost < The running cost of the next year.

1051.00 < 1100.

Replace at 10th year

Numerical based upon Replacement problem of items that Fails Suddenly:

* It is usually very difficult to predict the time when particular equipment will fail suddenly.
* This problem can be overcome by determining the probability distribution of Failures. Also it is presumed that the failure occurs only at the end of the period.
* Individual Replacement policy: under this policy, an item is replaced immediately upon its Failure.
* Group Replacement policy: under this policy, It is decided to replace all the items after a certain time period irrespective of the Facts that items have failed (or) have not Failed with an option that if any item before the optimal time, it may be individually replaced.

(*) The following failures have been observed for a certain type of transistors in a digital computer.

End of week	1	2	3	4	5	6	7	8
probability of failure to date	0.05	0.13	0.25	0.43	0.68	0.88	0.96	1.0

The total no. of transistors at the beginning of assembly is 1000 units. The cost of replacing the individual failed transistors is Rs. 1.25. The decision is made to replace all these transistors simultaneously at fixed intervals and to replace the individual transistors as they fail in service. If the cost of group replacement is 30 paise per transistor what is the best interval between group Replacement

Sol: Let p_i be the probability that a transistors which was new when placed in position for use, fails during the i^{th} week of its life

$P_1 = 0.05$

$P_2 = 0.13 - 0.05 = 0.08$

$P_3 = 0.25 - 0.13 = 0.12$

$P_4 = 0.43 - 0.25 = 0.18$

$P_5 = 0.68 - 0.43 = 0.25$

$P_6 = 0.88 - 0.68 = 0.20$

$P_7 = 0.96 - 0.88 = 0.08$

$P_8 = 1.00 - 0.96 = 0.04$

Let N_i denotes the number of Replacement made at the end of ith week. Then we have,

N_0 = No. of transistors at begining $= 1000$

$N_1 = N_0 P_1 = 1000 \times 0.05 = 50$

$N_2 = N_0 P_2 + N_1 P_0 = 1000 \times 0.08 + 50 \times 0.05 = 82$

$N_3 = N_0 P_3 + N_1 P_2 + N_2 P_1$
$= 1000 \times 0.12 + 50 \times 0.08 + 82 \times 0.05 = 128$

$N_4 = N_0 P_4 + N_1 P_3 + N_2 P_2 + N_3 P_1$
$= 1000(0.18) + 50(0.12) + 82(0.08) + 128(0.05) = 199$

$N_5 = N_0 P_5 + N_1 P_4 + N_2 P_3 + N_3 P_2 + N_4 P_1 = 289$

$N_6 = N_0 P_6 + N_1 P_5 + N_2 P_4 + N_3 P_3 + N_4 P_2 + N_5 P_1 = 272$

$N_7 = N_0 P_7 + N_1 P_6 + N_2 P_5 + N_3 P_4 + N_4 P_3 + N_5 P_2 +$
$N_6 P_1 = 194$

$N_8 = N_0 P_8 + N_1 P_7 + N_2 P_6 + N_3 P_5 + N_4 P_4 + N_5 P_3$
$+ N_6 P_2 + N_7 P_1 = 195$

Now, as we know that group replacement of all 1000 transistors at one go cost 30 paisa per transistor and the replacement of individual transistor on failure cost Rs. 1.25, The average cost for different group replacement policies are given as under

End of week	Individual Replacement	Total cost [Individual + Group Replacement]	Average cost
1	50	50×1.25 + 1000×0.30 = 363	363
2	50+82 = 132	132×1.25 + 1000×0.30 = 465	232.50
3	132+128 = 260	260×1.25 + 1000×0.30 = 625	208.30
4	260+199 = 459	459×1.25 + 1000×0.30 = 874	218.50
5	459+289 = 748	748×1.25 + 1000×0.30 = 1235	308.75
6	748+272 = 1020	1020×1.25 + 1000×0.30 = 1575	262.5
7	1020+193 = 1214	1214×1.25 + 1000×0.30 = 1817.5	259.64
8	1214+195 = 1409	1409×1.25 + 1000×0.30 = 2061.25	257.65

Since the Average cost is Lower at week-3 hence the optimum interval between group replacement is 3 weeks.

(*) The following morality rates have been observed for a certain type of light bulb.

Week	1	2	3	4	5
percent failing by the end of the week	10	25	50	80	100

There are 1000 bulbs in use and it cost Rs1.00 to replace an individual bulb which has burnt out. If all bulbs were replaced simultaneously it would cost 25 paise per bulb. It is proposed to replace all bulbs at fixed interval, whether (or) not they have burnt out and to continue replacing burnt out bulbs as they fail. At what Intervals should all the bulbs be replaced.

Sol: Let P_i be the probability of failure of a new bulb in i^{th} week.

$$P_1 = \frac{10}{100} = 0.10$$

$$P_2 = \frac{25}{100} = 0.25 \Rightarrow 0.25 - 0.1 = 0.15$$

$$P_3 = \frac{50}{100} = 0.5 \Rightarrow 0.5 - 0.25 = 0.25$$

$$P_4 = \frac{80}{100} = 0.8 \Rightarrow 0.8 - 0.5 = 0.30$$

$$P_5 = \frac{100}{100} = 1 \Rightarrow 1 - 0.8 = 0.20.$$

Let N_i be the no. of replacements at the end of ith week, while all 1000 bulbs were new initially, then we have.

N_0 = No. of bulbs in begining = 1000

N_1 = No. of burnt out bulbs replaced at the end of 1st week

$= N_0 P_1 = 1000 \times 0.1 = 100$

$N_2 = N_0 P_2 + N_1 P_1 = 160$

$= 1000(0.15) + 100(0.1)$

$N_3 = N_0 P_3 + N_1 P_2 + N_2 P_1 = 281$

$= 1000(0.25) + 100(0.15) + 160(0.1)$

$N_4 = N_0 P_4 + N_1 P_3 + N_2 P_2 + N_3 P_1$

$= 1000(0.3) + 100(0.25) + 160(0.15) + 281(0.1) = 377$

$N_5 = N_0 P_5 + N_1 P_4 + N_2 P_3 + N_3 P_2 + N_4 P_1 = 350$

$N_6 = N_0 P_6 + N_1 P_5 + N_2 P_4 + N_3 P_3 + N_4 P_2 + N_5 P_1 = 230$

$N_7 = N_0 P_7 + N_1 P_6 + N_2 P_5 + N_3 P_4 + N_4 P_3 + N_5 P_2 + N_6 P_1 = 230$

End of week	Individual Replacement	Total cost (Individual + group Replacement)	Average cost
1	100	$100 \times 1 + 1000 \times 0.25 = 350$	350
2	$100 + 160 = 260$	$260 \times 1 + 1000 \times 0.25 = 510$	255
3	$260 + 281 = 541$	$541 \times 1 + 1000 \times 0.25 = 791$	263.66
4	$540 + 377 = 918$	$918 \times 1 + 1000 \times 0.25 = 1168$	292
5	$918 + 350 = 1268$	$1268 \times 1 + 1000 \times 0.25 = 1518$	303.6.

The minimum cost per week is 255.00. if the bulbs are replaced as group after every two week and this cost is also less than average cost of weekly individual replacement policy. Hence for minimum monthly cost all the bulbs should be replaced after every two weeks.

Sequencing.

~~Principal~~ Assumptions

1. No machine can process more than one operation at a time.
2. Each operation once get started must be performed till completion.
3. There is only one machine of each type.
4. The time required to transfer the Jobs b/w machine is negligible.

problems with n Jobs through 2 machines.

Johnson's Algorithm

Job	1 2 3 ... n
machine A	A_1 A_2 A_3 ... A_n
M/c B	B_1 B_2 B_3 ... B_n

Steps:

1. Select the Least processing time occuring in the List $A_1, A_2, A_3 \ldots A_n$ and $B_1, B_2, B_3 \ldots B_n$
2. If the shortest processing time is for M/c A then place it in the begining of the sequence. If it is for M/c B then place it in the end of the sequence.

(3) When there is a tie in selecting the minimum processing time, then there are may be three solutions.

(a) If equal minimum values occur only for machine A, select the Job with smallest processing time in machine B to be placed in the Job sequence.

(b) If equal min. value occur only for machine B, select the Job with smallest processing time in A to be placed last in the Job sequence.

(c) If there are equal min values, one for each machine then place the Job in machine A first and the one in the machine B last.

(4) Delete the Job already sequenced. If all the Job have been sequenced, goto the next step otherwise repeat step 1 to step 3.

(5) Determine the overall (or) Total elapsed Time and also the Idle Time on machine A and machine B.

(*) Find the Sequence that minimizes the total elapsed time (in hours) required to complete the following task on two machines

Job	A	B	C	D	E	F	G	H	I
M/c A	2	5	4	9	6	8	7	5	4
M/c B	6	8	7	4	3	9	3	8	11

Sol:

A	C	I	B	H	F	D	G	E

$\rightarrow$ Machine A

$\leftarrow$ M/c B

Jobs	Machine A In	Machine A out	machine B In	machine B out
A	0	2	2	8
C	2	6	8	15
I	6	10	15	26
B	10	15	26	34
H	15	20	34	42
F	20	28	42	51
D	28	37	51	55
G	37	44	55	58
E	44	50	58	61

Total elapsed Time = 61 hours

IDLE Time for A = 61 − 50 = 11 hours

B = (61 − 61) + 2 = 2 hours

problems with n Jobs through 3 machines :

Convert the problem into two machine problem and then Solve using Johnson's Algorithm

Step1: Find Minimum processing time for first and Last machine, and maximum processing time for the Second machine.

ie find $\text{Min}(A_i, C_i)$ $(i = 1, 2, 3 \ldots n)$

and $\max(B_i)$

Step2: check the following inequality $(\text{Min } A_i \geq \text{Max } B_i)$

(or) $\text{Min } C_i \geq \text{Max } B_i$

Step3: If none of the inequalities in Step2 are Satisfied, this method cannot be applied.

Step4: If atleast one of the inequalities in step2 are satisfied, we define two machines G and H, Such that the processing time on G and H are given by

$$G_i = A_i + B_i$$
$$H = B_i + C_i$$

Step5: for the converted machine G and H we obtain the optimum sequencing using two machine algorithm.

(*) Determine the sequence that will minimize the total elapsed time. also find the Idle time of all machines.

Jobs	1	2	3	4	5	6
Machine A	3	12	5	2	9	11
" B	8	6	4	6	3	1
" C	13	14	9	12	8	13

Sol:- Min (A) = 2 , Max (B) = 8

Min (C) = 8

Min (A) ≥ Max (B) (or) Min (C) ≥ Max (B)

2 ≱ 8 (F) 8 ≥ 8 (T)

We define two machines G and H

Such ~~that~~ G = A+B

H = B+C

Job	1	2	3	4	5	6
G	11	18	9	8	12	12
H	21	20	13	18	11	14

optimal sequence for the Job is

4	3	1	6	2	5

G H

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To find the Minimum total elapsed time and Idle time for machine A, B and C

Jobs	Machine A		Machine B		Machine C	
	In	out	In	out	In	out
4	0	2	2	8	8	20
3	2	7	8	12	20	29
1	7	10	12	20	29	42
6	10	21	21	22	42	55
2	21	33	33	39	55	69
5	33	42	42	45	69	77

Total Elapsed time = 77 hours

<u>Idle Time for</u>

Machine A = 77 - 42 = 35 hours

Machine B = (77 - 45) + 2 + 1 + 11 + 3
= 49 hours.

Machine C = (77 - 77) + 8 + = 8 hours.

problems with 'n' Jobs through 'M' machines

Convert the 'M' machines into Two machine problem and then solve using Johnson's Algorithm.

Step1: Find Minimum M_1 and M_k and maximum of each $M_2, M_3 \dots M_{k-1}$ (M_k is last machine)

Step2: check whether

$$\text{Min } M_1 \geq \text{Max. } M_j \quad (j = 2, 3, \dots k-1)$$

(or)

$$\text{Min } M_K \geq \text{Max } M_j$$

Step3: If the inequalities in Step2 are not satisfied, ~~the~~ method fails, otherwise goto next step.

Step4: In addition to Step 2, if

$M_2 + M_3 + \dots M_{k-1} = C$ where C is positive constant

for all $i = 1, 2, \dots n$.

Then determine the optimal sequence for n Jobs where two machines are M_1 and M_K by using optimal sequence problem.

Step 5: If the condition $M_2 + m_3 + \cdots + m_{K-1} \neq C$ we define two machine G and H such that

$$G_i = m_1 + m_2 + \cdots m_{K-1}$$

$$H_i = m_2 + m_3 + \cdots m_K$$

Determine the optimal sequence using two machine algorithm by Johnson's Algorit

(*) Four Jobs are to be processed on each of the 5 machines. find the total minimum elapsed time if no passing of Job is permitted. Also find the Idle time for each machine.

Machines	Jobs			
	1	2	3	4
A	7	6	5	8
B	5	6	4	3
C	2	4	5	3
D	3	5	6	2
E	9	10	8	6

Sol: Since the problem is to be sequenced on five machines, we convert the problem into a two machine problem.

$$\text{Min}(A) = 5$$

$$\text{Min}(E) = 6$$

$$\text{Max}(B, C, D) = (6, 5, 6)$$

$$\text{Min}(A) \geq \max(B, C, D)$$

$$5 \geq \text{Max}(6, 5, 6) \Rightarrow 5 \geq 6 \quad F$$

(or)

$$\text{Min}(E) \geq \text{Max}(B, C, D)$$

$$6 \geq \max(6, 5, 6)$$

$$6 \geq 6 \quad T$$

Step 4: Since $B_1 + C_1 + D_1 = 5+2+3 = 10$

$$B_2 + C_2 + D_2 = 6+4+5 = 15$$

$$B_i + C_i + D_i \neq C$$

We define two machines G and H, Such that

$$G = A+B+C+D$$

$$H = B+C+D+E$$

Jobs	1	2	3	4
G	17	21	20	16
H	19	25	23	14

optimal Sequence order is

1	3	2	4

G → ← H

Jobs	Machine A		Machine B		machine C		machine D	
	In	out	In	out	In	out	In	out
1	0	7	7	12	12	14	14	17
3	7	12	12	16	16	21	21	27
2	12	18	18	24	24	28	28	33
4	18	26	26	29	29	32	33	35

Total elapsed time = 51 hours

Idle Time for M/c. A = (51-26) = 25 units

B = (51-29) + 7 + 2 + 2 = 33 units

C = (51-32) + 12 + 2 + 3 + 1 = 37 units

D = (51-35) + 14 + 4 + 1 + 0 = 35 units

E = (51-51) + 17 + 1 = 18 units

(*)

Job	Machine			
	M_1	M_2	M_3	M_4
A	24	7	7	29
B	16	9	5	15
C	22	8	6	14
D	21	6	8	32

problem with 2 Jobs through m machines.

(*) Use graphical method to minimize the time needed to process the following Jobs on the machines shown below. Also calculate the Total time need to complete both the Jobs.

Job 1	Sequence of	A	B	C	D	E
	machine Time	3	4	2	6	2
Job 2	Sequence of	B	C	A	D	E
	machine time	5	4	3	2	6

procedure: each machine can perform only one Job at a time. The objective is to determine the optimal sequence of processing the Jobs so as to minimize the total elapsed time. The optimal sequence in these case can be obtained by making use of graph.

Step 1: first draw a set of axes, where horizontal axis represent processing time on Job 1 and the vertical axis represents processing time on Job 2.

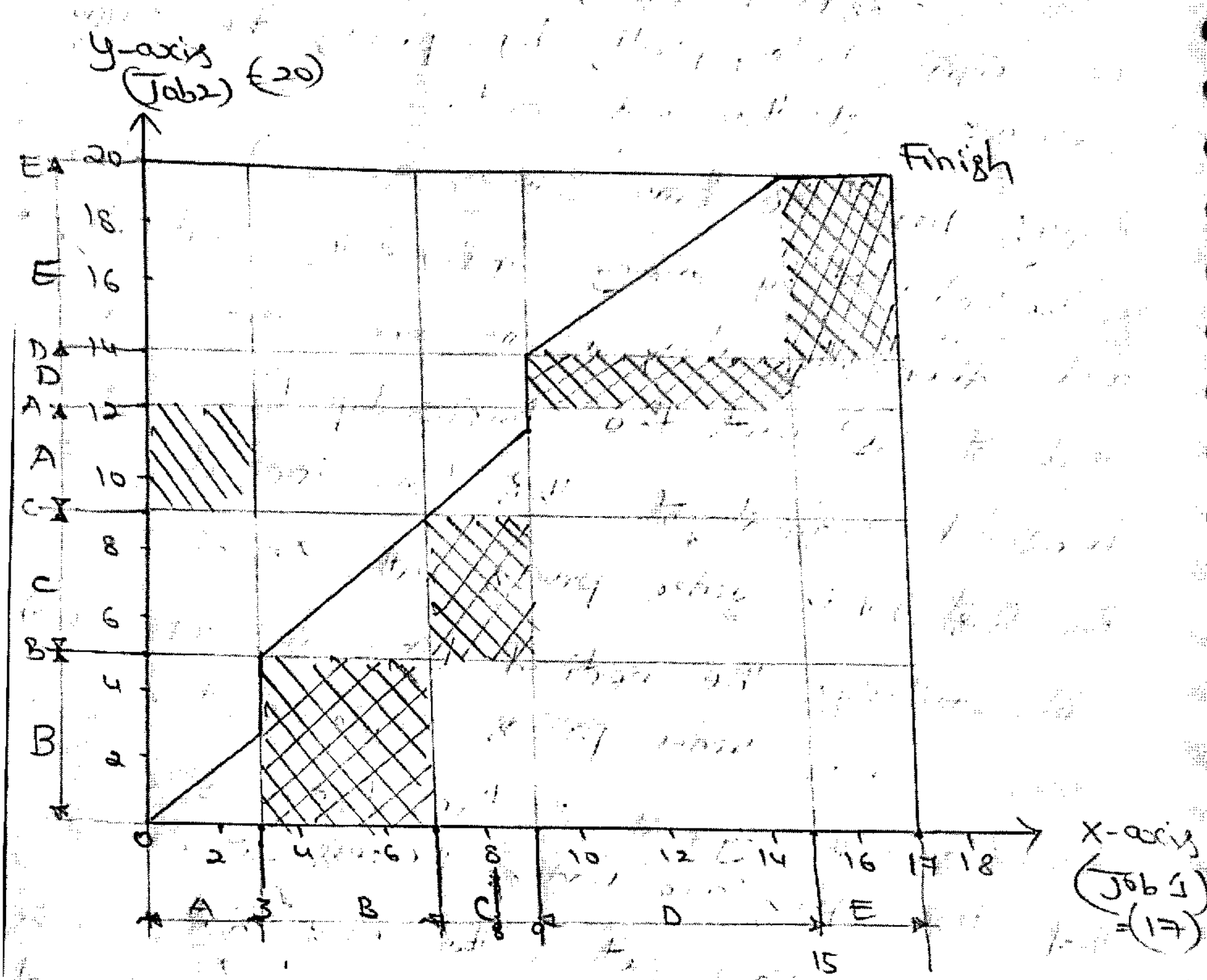
Step 2:- Mark the processing time for Job 1 and Job 2 on the horizontal and Vertical Lines, respectively. according to given order of machine.

Step 3 :- construct various blocks starting from the origin (Starting point), by pairing the same machines until the end point.

Step 4 : Draw the Line Starting from the origin to the end point by moving horizontally, vertically and diagonally along a line which makes an angle of 45° with the horizontal Line. The horizontal segment of this Line, indicates that the first Job is under process with Second Job idle. Similarly, the vertical Line indicates that Second Job is under process while first is idle. The diagonal segment of the Line shows that the Jobs are under process simultaneously.

Step 5 :- An optimal path is the one that minimize the Idle time for both the Jobs. Thus we must choose the path on with diagonal movement is maximum.

Step 6 :- The total elapsed time is obtained by adding the Idle time for either Job to the processing time for that Job.



The given information is shown in figure. The shaded blocks represents the overlaps ~~that~~ are to be avoided. An optimal path is one that minimizes the Idle time for Job 1. Similarly an optimal path is one that minimizes the Idle time for Job 2.

Job 1 : under process
Job 2 : Idle

Job 1 : Idle
Job 2 : Under process

Job 1 & Job 2 running Simultaneously

Totol elapsed time for Job 1 = processing time for Job 1 + Idle Time for Job 1

$$= 17 + (2 + 3) = 22 \text{ units}$$

Totol elapsed time for Job 2 = processing time for Job 2 + Idle time for Job 2

$$= 20 + (2) = 22 \text{ units.}$$

Waiting Line Theory

(or)

Queuing Theory

→ Queuing theory is the study of Waiting Lines.

Ex:- Human beings queue to ~~by~~ buy "Koko"
products queue up in the production plants.
Machinery waits in Line to be Serviced.
planes wait to take off and land
students wait to register.

→ quick service defines "quality customer Service"
managers use it to decide
we can reduce queues by adding more server
But there is a monetary cost.

Problems :

(*) An airlines "Come Air" has one reservation clerk on duty in its local branch at any given time. The clerk handles information regarding passenger reservation and flight timings. Assume that the no. of customers arriving during any given period is poisson distributed with an arrival rate of eight per hour and that the reservation clerk can serve a customer in six minutes on an average, with an exponentially distributed service time.

i) what is the probability that the system is busy.

ii) what is the avg. time a customer spends in the system

iii) what is the avg. length of the queue and what is the no. of customer in the system.

Sol:- Given data

Arrival rate $\lambda = 8/hr$

Service rate $\mu = \frac{60}{6} = 10/hr.$

a) Utilization Factor.

$$= \frac{\lambda}{\mu} = \frac{8}{10} = 0.8$$

b) The avg. time a customer spends in the system.

$$W_s = \frac{1}{\mu-\lambda} = \frac{1}{10-8} = \frac{1}{2} = 0.5$$

c) The avg. no. of customers in the queue.

$$L_q = L_s \times \frac{\lambda}{\mu}$$

$$= \frac{\lambda}{\mu-\lambda} \times \frac{\lambda}{\mu}$$

$$= \left(\frac{8}{10-8}\right) \times \left(\frac{8}{10}\right) = 3.2$$

d) The avg. no. of customers in the queuing system.

$$L_s = \frac{\lambda}{\mu-\lambda} = \frac{8}{10-8}$$

$$= \frac{8}{2} = 4$$

(*) The 'LMART' has a Single Cashier. During the peak hours, customers arrive at a rate of 20 customers per hour. The avg. no. of customers that can be processed by the cashier is 24 per hour. calculate

a) The probability that the cashier is Idle.

b) The avg. no. of customer in the queuing system

c) The avg. time a customer spends in the system.

d) The avg. no. of customer in the queue.

e) The avg. time a customer spends in the queue waiting for Service

Sol. Given Data

Arrival rate $\lambda = 20/hr.$

Service rate $\mu = 24/hr.$

Utilization Factor $= \frac{\lambda}{\mu} = \frac{20}{24} = 0.833$

a) $P_0 = 1 - \frac{\lambda}{\mu} = 1 - \frac{20}{24} = 0.1667$

b) $L_q = L_s \times \left(\frac{\lambda}{\mu}\right) = \left(\frac{\lambda}{\mu-\lambda}\right) \times \left(\frac{\lambda}{\mu}\right) = 4.166$

c) $W_s = \frac{1}{\mu-\lambda} = \frac{1}{24-20} = 0.25$ hrs.

d) $L_s = \frac{\lambda}{\mu-\lambda} = \frac{20}{24-20} = 5.$

e) $W_q = W_s \times \frac{\lambda}{\mu}$

$= \left(\frac{1}{\mu-\lambda}\right)\left(\frac{\lambda}{\mu}\right)$

$= \frac{1}{(24-20)} \left(\frac{20}{24}\right) = 0.208$ hr.

(*) A harbor has a single dock to unload the containers from the incoming ships. The arrival rate of ships at the harbor follows poisson distribution and unloading time for the ships follow exponential distribution and hence, the service rate also follows poisson distribution. The arrival rate and service rate are 8 ships per week and 14 ships per week, respectively, find the following.

a) Utilization Factor of dock
b) Avg. no. of waiting ships in queue
c) Avg. no. of waiting ships in system
d) Avg. waiting time per ship in the queue
e) Average waiting time per ship in the System.

(*) A Self Service Store Employee has one cashier at its counter. Nine customer arrive on an average every five minutes while the cashier can Serve 10 custermers in 5 minutes. Assuming poisson distribution of arrival rate. Find

a) Avg. no. of customers in the system.

b) Avg. no. of customers in the queue.

c) Avg time a customer spends

(*) In a department store one cashier is there to serve the customers. And the customers pick up their needs by themselves the arrival rate is 9 customers for every 5 minutes and the cashier can serve 10 customers in 5 minutes. Assuming poisson's arrival rate and and exponential distribution for service rate.

Find following

i) Avg. no. of customers in the systems.

ii) Avg. no. of customers in queue and average queue length

iii) Avg. time a customer spends in the system.

iv) Avg. time a customer spends in the queue.

Network models.

S.no	Critical path method (CPM)	project Evaluation and Review Technique (PERT)
1	CPM stands for critical path method	1. PERT stands for project Evaluation and Review Technique.
2.	CPM is a activity oriented Technique	2. pert is a Event oriented Technique
3.	CPM manages the predictable activities	3. PERT manages unpredictable activities.
4.	It Focus on cost optimization	It is Focused on Time control
5.	It is a single Time Estimate	It is a three-time Estimate.
6.	It is a deterministic model	It is a probability model

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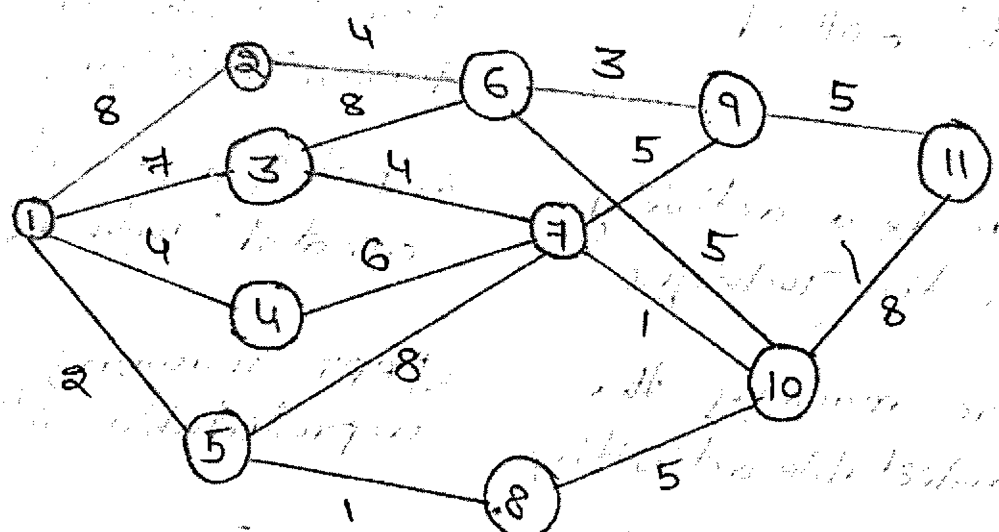
(*) A distance network consists of eleven nodes which are distributed as shown in figure. Find the shortest path from node 1 to node 11 and also corresponding distances.



Sol: paths

1-2-6-9-11 = 8+4+3+5 = 20

1-3-6-9-11 = 7+8+3+5 = 23

1-3-7-9-11 = 7+4+5+5 = 21

1-4-7-9-11 = 4+6+5+5 = 20

1-4-7-10-11 = 4+6+1+8 = 19

1-3-6-10-11 = 7+8+5+8 = 28

1-5-8-10-11 = 2+1+5+8 = 16

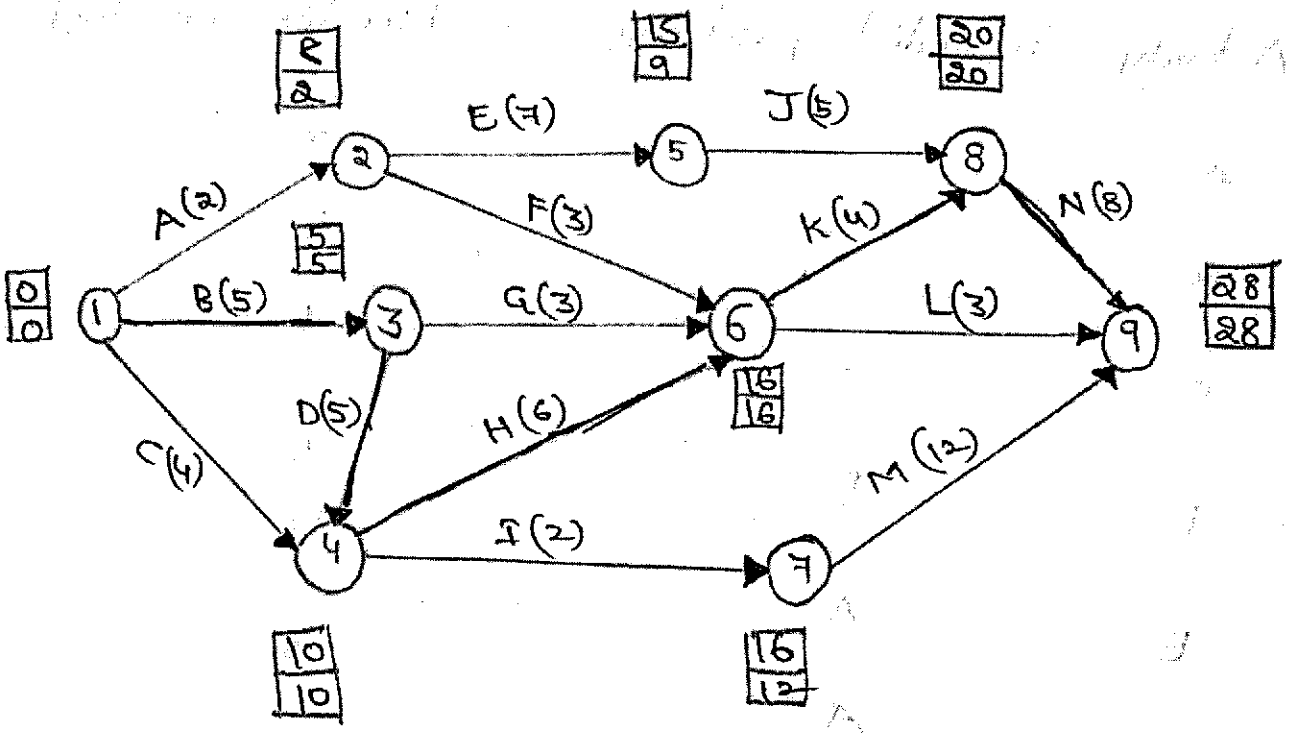
1-5-7-9-11 = 4+6+5+5 = 20

* Consider the details of a project as shown in the table

Activity	Immediate predecessor (s)	Duration (months)
A	–	2
B	–	5
C	–	4
D	B	5
E	A	7
F	A	3
G	B	3
H	C, D	6
I	C, D	2
J	E	5
K	F, G, H	4
L	F, G, H	3
M	I	12
N	J, K	8

a) construct the CPM network
b) Determine the critical path and and project completion Time
c) compute total floats and free floats for non-critical activities

Sol:



Guidelines for network construction:

1. The starting event and ending event of an activity are called tail event and head event respectively.
2. The network should have a unique starting node (tail event)
3. The network should have unique completion node (head event)
4. No activity should be represented by more than one arc in the network.
5. No two activities should have the same starting node and the same ending node.
6. Dummy activity is an Imaginary activity indicating precedence relationship only. Duration of a dummy activity is zero.

Critical path: The critical path of a project network is the longest path in the network.

This can be identified by simply listing out all the possible paths from the starting node of the project to the end node of the project and then selecting the path with the maximum sum of activity times on that path.

The following are the possible paths.

1-2-3-8-9	= 2+7+5+8 =	22
1-3-6-9	= 5+3+3 =	11
1-2-6-8-9	= 2+3+4+8 =	17
1-2-6-9	= 2+3+3 =	8
1-3-4-7-9	= 5+5+2+12 =	24
1-3-4-6-9	= 5+5+6+3 =	19
1-4-6-9	= 4+6+3 =	13
1-4-7-9	= 4+2+12 =	18
~~1-4-3~~-6-9	= ~~6~~ 5	
1-3-4-6-8-9	= 5+5+6+4+8 =	**28 months**

Two phases

1. Determine earliest start times (E_s) of all the nodes. This is called Forward pass.
2. Determines Latest completion times (L_c) of various nodes. This is called Backward pass.

For each nodes we create two squares

upper square = Latest completion time (L_C)

Lower square = Earliest start time (E_S)

Determination of earliest start times (ES_j)

$$ES_j = \max_i \left(ES_i + D_{ij}\right)$$

i = starting Activity
j = Ending Activity

for node 1 $ES_1 = 0$

node 2 $ES_2 = 0 + 2 = 2$

node 3 $ES_3 = 0 + 5 = 5$

node 4 $= 5+5 = 10$

node 5 $= 2+7 = 9$

node 6 $= 16$

$2+3 = 5$
$5+3 = 8$
$10+6 = 16$ ✓

Consider maximum value

node 7 $= 10+2 = 12$

node 8 $= 16+4 = 20$

node 9 $= 20+8 = 28$.

Determination of Latest completion times (LC_i)

$$LC_i = \min_j (LC_j - D_{ij})$$

Node 9 = $28 - 28 = 0$

Node 8 = $LC_9 - D_{8,9} = 28 - 8 = 20$

Node 7 = $28 - 12 = 16$

Node 6 = $28 - 3 = 25$
$20 - 4 = 16$ ✓ select Least value (minimum)

Node 5 = $20 - 5 = 15$

Node 4 = $16 - 2 = 14$
$16 - 6 = 10$ ✓

Node 3 = $16 - 3 = 13$
$10 - 5 = 5$ ✓

Node 2 = $15 - 7 = 8$ ✓
$16 - 3 = 13$

Node 1 = $8 - 2 = 6$
$10 - 4 = 6$
$5 - 5 = 0$ ✓

conditions for critical path :-

$$ES_i = LC_i$$

$$ES_j = LC_j$$

$$ES_j - ES_i = LC_j - LC_i = D_{ij}$$

a) critical path

1 – 3 – 4 – 6 – 8 – 9

b) B – D – H – K – N = 5 + 5 + 6 + 4 + 8 = 28 months

c) Total floats : It is the amount of time that the completion time of an activity can be delayed without affecting the project completion Time.

$$TF_{ij} = LC_j - ES_i - D_{ij}$$

A 1-2 ⇒ 8 - 0 - 2 = 6

B 1-3 ⇒ 5 - 0 - 5 = 0

C 1-4 ⇒ 10 - 0 - 4 = 6

D 3-4 ⇒ 10 - 5 - 5 = 0

E 2-5 ⇒ 15 - 2 - 7 = 6

F 2-6 ⇒ 16 - 2 - 3 = 11

Activity (i,j)	Duration (D_{ij})	Total float (TF_{ij})	Free float (FF_{ij})
(A) 1-2	2	6	0
(B) 1-3	5	0	0
(C) 1-4	4	6	6
(D) 3-4	5	0	0
(E) 2-5	7	6	0
(F) 2-6	3	11	11
(G) 3-6	3	8	8
(H) 4-6	6	0	0
(I) 4-7	2	4	0
(J) 5-8	5	6	6
(K) 6-8	4	0	0
(L) 6-9	3	9	9
(M) 7-9	12	4	4
(N) 8-9	8	0	0

Free floats: It is the amount of time that the activity completion time can be delayed without affecting the earliest start time of immediate successor activities in the network.

$$FF_{ij} = ES_j - ES_i - D_{ij}$$

A 1-2 = $2 - 0 - 2 = 0$

B 1-3 = $5 - 0 - 5 = 0$

C 1-4 = $10 - 0 - 4 = 6$

D = $10 - \cancel{5} - 5 = 0$

E = $9 - 2 - 7 = 0$

F = $16 - 2 - 3 = 11$

PERT: project Evaluation and Review Technique

consider the following table summarizing the details of a pro

Activity	Predecessor(s)	Duration in weeks		
		O	m	P
A	-	5	6	7
B	-	1	3	5
C	-	1	4	7
D	A	1	2	3
E	B	1	2	9
F	C	1	5	9
G	C	2	2	8
H	E,F	4	4	10
I	D	2	5	8
J	H,G	2	2	8

a) Construct project network

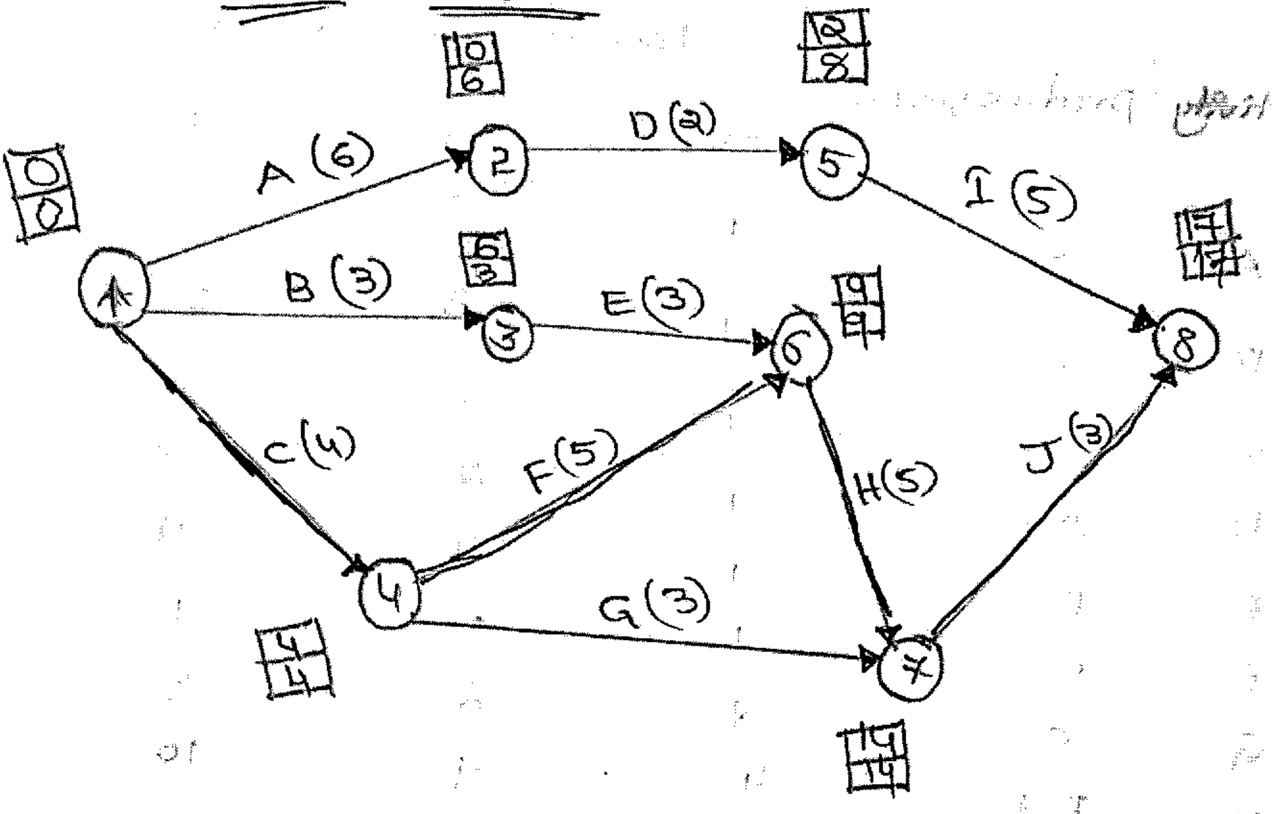
b) Find the Expected duration and variance of each Activity

c) Find the critical path and Expected project completion Time

d) what is the probability of completing the proj on or before 22 weeks?

Sol

Network Diagram



Activity	Duration in week			Mean	Variance, σ^2
	o	m	p		
A	5	6	7	6	0.11
B	1	3	5	3	0.44
C	1	4	7	4	1.00
D	1	2	3	2	0.11
E	1	2	9	3	1.78
F	1	5	9	5	1.78
G	2	2	8	3	1.00
H	4	4	10	5	1.00
I	2	5	8	5	1.00
J	2	2	8	3	1.00

Mean t_e = expected duration (or) time

$$= \frac{t_o + 4t_m + t_p}{6}$$

Variance $\sigma^2 = \left[\frac{t_p - t_o}{6}\right]^2$

Critical path :

Earliest start time = Forward pass

Latest completion time = Backward pass

$$ES_j = \max_i \left(ES_i + D_{ij}\right)$$

node 1 = 0

node 2 = 0+6 = 6

node 3 = 0+3 = 3

node 4 = 0+4 = 4

node 5 = 6+2 = 8

node 6 = 4+5 = 9 ✓ select maximum value
3+3 = 6

node 7 = 4+3 = 7
9+5 = 14 ✓

node 8 = 8+5 = 13
14+3 = 17 ✓

Latest completion time:

$$LC_i = \min(LC_j - D_{ij})$$

node 8 = $17 - 0 = 17$

node 7 = $17 - 3 = 14$

node 6 = $14 - 5 = 9$

node 5 = $17 - 5 = 12$

node 4 =

critical path condition

i) $ES_i = LC_i$

ii) $ES_j = LC_j$

iii) $ES_j - ES_i = LC_j - LC_i = D_{ij}$

1 - 4 - 6 - 7 - 8

C - F - H - J = $4 + 5 + 5 + 3 = 17$ weeks

d) what is the probability of completing the project on or before 22 weeks

Sol:

Activity	mean	variance
C	4	1.00
F	5	1.78
H	5	1.00
J	3	1.00
	17	4.78

$$\sigma^2 = 4.78$$

$$\sigma = \sqrt{4.78} = 2.19$$

$$P(x \leq 22) = P\left[\frac{x-\mu}{\sigma} \leq \frac{22-17}{2.19}\right]$$

$$= P(z \leq 2.28)$$

from standard normal distribution table

$$= 0.9887.$$

This value is obtained from standard normal distribution table. therefore the probability of completing the project on or before 22 weeks is 0.9887

i.e. 98.87%.

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Dynamic programming

* Dynamic programming is an mathematical techniqu dealing with the optimization of multistage decision process.
* Richard Bellman has developed this technique
* This technique can be called Recursive optimizat

State: The variable that link upto two stages is called state variable. At any stage, the status of the problem can be decided by the values of state variable can take. These values are referred as st

stage: The point at which decision called ~~for~~ stages. Each state can be through of having a beginning and an end. The different stages come in sequen

Decision Tree: A multistage decision system in which decision and state variable can take only finite number of values can be represente graphically by a decision tree.

Bellman's principle of optimality:

An optimal policy (Set of decisions) has the property that whatever the initial state and decisions are the remaining decisions must constitute an optimal policy with regards to the state resulting from the first decision.

Mathematical representation:

$$f_N(x) = \max_{d_n \in \{x\}} \left[r(d_n) + f_{n-1} \{ T(x, dx) \} \right]$$

Where

$f_N(x)$ = The optimal return from an N-stage process where initial state is x.

$r(dx)$ = Immediate return due to decision d_n

$T(x, dx)$ = The Transfer function which gives resulting states.

$\{x\}$ = Set of admissible decision.

(*) Solve the following LPP using DP.

$$\text{Max } Z = 3x_1 + 5x_2$$

Subject to
$$x_1 \le 4$$
$$x_2 \le 6$$
$$3x_1 + 2x_2 \le 18$$
$$x_1 \text{ and } x_2 \ge 0$$

Sol:- State = 3 (no. of constraints)

Stage = 2 (no. of decision variable)

Objective Function = Max Z

Resources = 3 (RHS of constraints)

↳ $b_1 = 4$
$b_2 = 6$
$b_3 = 18$

Stage 1 $\quad F_1(b_1, b_2, b_3) = \text{Max } 3x_1$
$$0 \le x_1 \le b$$

To calculate b

$$b = \text{Min}\left\{\frac{b_1}{cx_1}, \frac{b_2}{cx_1}, \frac{b_3}{cx_1}\right\}$$

$$= \text{Min}\left\{\frac{4}{1}, \frac{6}{0}, \frac{18}{3}\right\}$$

$$= \text{Min}\{4, \infty, 6\}$$

$$\boxed{b = 4}$$

$$F_1(b_1, b_2, b_3) = \text{Max } 3x_1$$
$$0 \le x_1 \le 4$$

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from Equations

① $x_1 \leq 4$

② $x_1 = 0$

③ $x_1 = \dfrac{18 - 2x_2}{3}$

$$x_1 = \min\left\{4, \frac{18 - 2x_2}{3}\right\}$$

Stage 2: $F_2(b_1, b_2, b_3) = \underset{0 \leq x_2 \leq b}{\text{Max}}\ 3x_1 + 5x_2$

$$\text{Max}\ 5x_2 + 3\ \min\left\{4, \frac{18 - 2x_2}{3}\right\}$$

To calculate b ~~for x_2~~:

$$b = \text{Min}\left\{\frac{b_1}{cx_2}, \frac{b_2}{cx_2}, \frac{b_3}{cx_3}\right\}$$

$$= \text{Min}\left\{\frac{4}{0}, \frac{6}{1}, \frac{18}{2}\right\}$$

$$= \text{Min}\{\infty, 6, 9\}$$

$x_2 = 0$
$x_2 = 6$

$\boxed{b = 6}$ $\quad 0 \leq x_2 \leq 6$

$$\text{Min}\left\{4, \frac{18 - 2x_2}{3}\right\}$$

$$= \min\left\{4, \frac{18 - 2(0)}{3}\right\} \Rightarrow \min\{4, 6\}$$

$$= \text{Min}\left\{4, \frac{18 - 2(6)}{3}\right\} = \text{Min}\{4, 2\}$$

$$= \text{Min}\{4, 2\}$$

$\boxed{x_1 = 2}$ $\quad \boxed{x_2 = 6}$

$$\text{Max}\ z = 3x_1 + 5x_2$$
$$= 3(2) + 5(6)$$
$$= 6 + 30$$
$$= \underline{36}$$

(*) To solve the LPP by using Dynamic programming

$$\text{Max } z = 2x_1 + 5x_3$$

Subject to $\quad 2x_1 + x_2 \leq 430$

$$2x_2 \leq 460$$

$$x_1 \text{ and } x_2 \geq 0$$

Sol: state $= 2$ (no. of constraints)

stage $= 2$ (no. of decision variable)

Resources $= 2$ (RHS of constraints)

$$b_1 = 430$$
$$b_2 = 460$$

stae 1 : $F_1(b_1 \cdot b_2) = \text{Max } 2x_1$

$$0 \leq x_1 \leq b$$

To calculate b for x_1:

$$b = \text{Min}\left\{ \frac{b_1}{cx_1}, \frac{b_2}{cx_1} \right\}$$

$$= \text{Min}\left\{ \frac{430}{2}, \frac{460}{0} \right\}$$

$$= \text{Min}\{215, \infty\}$$

$$\boxed{b = 215}$$

$$\therefore 0 \leq x_1 \leq 215$$

$$2x_1 + x_2 = 430 \quad \text{—(1)}$$

$$2x_1 = 430 - x_2$$

$$x_1 = \frac{430 - x_2}{2}$$

$$2x_2 = 460$$

$$\boxed{\therefore x_1 = 0}$$

$x_1 = 100$

$x_2 = 230$

$$\text{Max } z = 2x_1 + 5x_2$$

$$= 2(100) + 5(230)$$

$$= 200 + 1150$$

$$\boxed{z_{max} = 1350}$$

$$\min\{x_1, x_1\} = \min\left\{\frac{430-x_2}{2}, 0\right\}$$

$$x_1 = \frac{430-x_2}{2}$$

For stage 2:

$$F_2(b_1, b_2) = \max_{0 \le x_2 \le b} 2x_1 + 5x_2$$

$$= \max\ 5x_2 + 2\min\left\{\frac{430-x_2}{2}\right\}$$

To calculate b for x_2:

$$b = \min\left\{\frac{b_1}{cx_2}, \frac{b_2}{cx_2}\right\}$$

$$= \min\left\{\frac{430}{1}, \frac{460}{2}\right\}$$

$$= \min\{430, 230\}$$

$$\boxed{b = 230}$$

$$\therefore\ 0 \le x_2 \le 230$$

$$\min\left\{\frac{430-x_2}{2}\right\}$$

$$\min\left\{\frac{430-230}{2}\right\} = \min\left\{\frac{200}{2}\right\} = 100$$

$$\min\left\{\frac{430-0}{2}\right\} = \min\left\{\frac{430}{2}\right\} = 215$$

Game theory,

⇒ pure strategy = $P_1 = 0, P_2 = 1, P_3 = 0$ ⇒ Total = 1

mixed strategy = $P_1 = 0.3, P_2 = 0.7, P_3 = 0$ ⇒ Total = 1

⇒ Maximin: Maximizes the minimum guaranteed gain of player A.

⇒ minimax: minimizes the maximum Losses.

⇒ Saddle point: ~~Maximin~~ = Minimax.

value of the game: If the game has a Saddle point then the value of the cell at the Saddle point is called the value of the game.

Two persons Zero Sum game

In a game with two players, If the gain of one player is equal to the loss of another player, then that game is called two person zero Sum game.

Game with pure Strategies.

* Find the optimum strategies of the players in the following games.

		Player B 1	2	3
Player A	1	25	20	35
	2	50	45	55
	3	58	40	42

Sol

		Player B 1	2	3	Row Minimum
Player A	1	25	20	35	20
	2	50	45	55	$\boxed{45}$ Max min
	3	58	40	42	40
Column maximum		58	$\boxed{45}$ Minmax	55	

Minmax = Maxmin ∴ Saddle point

45 = 45

Value of the game $v = 45$.

Hence, the game has saddle point at the cell corresponding to row 2 and column 2.

optimal probabilities

A $[p_1, p_2, p_3] = [0, 1, 0]$

B $[q_1, q_2, q_3] = [0, 1, 0]$

Game with mixed Strategies: (2x2)

Consider the following payoff matrix with respect to player A and solve it optimally.

$$\begin{array}{cc} & \text{player } B \\ \text{player } A & \begin{bmatrix} 9 & 7 \\ 5 & 11 \end{bmatrix} \end{array}$$

Row min

Sol:

			Row min	
	9	7	$\boxed{7}$	max min
	5	11	5	
column max	$\boxed{9}$	11		
	min max			

min max $\boxed{\ne}$ maxmin

$9 \neq 7$

This game no saddle point. Then it is a mixed strategy.

			oddments	probability
	9	7	6	$P_1 = \frac{6}{2+6} = \frac{6}{8} = \frac{3}{4}$
	5	11	2	$P_2 = \frac{2}{2+6} = \frac{2}{8} = \frac{1}{4}$
oddments	4	4		

$q_1 \quad q_2 = \frac{4}{4+4} = \frac{4}{8} = 1/2$

$q_1 = \frac{4}{4+4} = \frac{4}{8} = 1/2$

Value of the game.

$$V = \frac{(9\times6)+(5\times2)}{6+2} = \frac{54+10}{8} = \frac{64}{8} = 8$$

$$= \frac{(7\times6)+(11\times2)}{6+2} = \frac{42+22}{8} = \frac{64}{8} = 8$$

$$= \frac{(9\times4)+(7\times4)}{4+4} = \frac{36+28}{8} = 8$$

$$= \frac{(5\times4)+(11\times4)}{4+4} = \frac{20+44}{8} = 8$$

Hence, the Strategies of

player A $\left(\frac{3}{4}, \frac{1}{4}\right) = \frac{3}{4}+\frac{1}{4} = \frac{4}{4} = 1$

player B $\left(\frac{1}{2}, \frac{1}{2}\right) = \frac{1}{2}+\frac{1}{2} = \frac{2}{2} = 1$

value of the game $v = 8$

(*)

Player B

			Row min
player A	1	5	1
	4	2	$\boxed{2}$ maxmin
column max	$\boxed{4}$	5	
	min max		

Sol:

maxmin = minmax

$2 \neq 5$ (no saddle point)

oddments

	1	5	$4-2=2$
	4	2	$5-1=4$
oddments	$5-2=3$	$4-1=3$	

probabilities for player A $\Rightarrow$ $p_1 = \frac{2}{2+4} = \frac{2}{6} = 1/3$

$p_2 = \frac{4}{2+4} = \frac{4}{6} = 2/3$

player B $\Rightarrow$ $q_1 = \frac{3}{3+3} = \frac{3}{6} = 1/2$

$q_2 = \frac{3}{3+3} = \frac{3}{6} = 1/2$

Value of the game:

$$V = \frac{(1\times2) + (4\times4)}{2+4} = \frac{2+16}{6} = \frac{18}{6} = 3$$

$$= \frac{(5\times2) + (2\times4)}{2+4} = \frac{10+8}{6} = 3$$

$$= \frac{(1\times3) + (5\times3)}{3+3} = \frac{3+15}{6} = \frac{18}{6} = 3$$

$$= \frac{(4\times3) + (2\times3)}{3+3} = \frac{12+6}{6} = \frac{18}{6} = 3$$

⊛ Solve the payoff matrix.

player B

	I	II	III	IV		Row min
player A I	-2	0	0	5	3	-2
II	3	2	1	2	2	$\boxed{1}$ max min
III	-4	-3	0	-2	6	-4
IV	5	3	-4	2	-6	-6
column max	5	3	$\boxed{1}$ min max	5	6	

max min = min max

1 = 1

Hence Saddle point exist.

probabilities

for player A [0, 1, 0, 0] = II

player B [0, 0, 1, 0, 0] = III

Value of the game = 1

Dominance Method:

In some games, it is possible to reduce the size of the payoff matrix by elimating rows (or) columns which are determined by other rows (or) colums respectively.

Dominance property for rows & columns

Row: If all the entries in a row should be lesser than (or) equal to the corresponding entries of another row, If yes that row can be deleted. $x \leq y$

Columns: If all the entries in a column should be greater than (or) equal to the corresponding entries of another column column, If yes that column can be deleted.

(4) The following table represents the payoff matrix with respect to player A. Solve it optimally using dominance property.

Sol:

		Player B 1	2	3	4	5	Row Min
Player A	1	4	6	5	10	6	4
	2	7	8	5	9	10	5
	3	8	9	11	10	9	$\boxed{8}$ maxmin
	4	6	4	10	6	4	4
column max		$\boxed{8}$	9	11	10	10	

minmax

Minmax = Maxmin

8 = 8   Hence, Saddle point is exist.

Value of game $v = 8$

strategies of player A = [0, 0, 1, 0]

B = [1, 0, 0, 0, 0]

Dominance principle

		Player B 1	2	3	4	5	Total
Player A	~~1~~	~~4~~	~~6~~	~~5~~	~~10~~	~~6~~	31
	2	7	8	5	9	10	39
	3	8	9	11	10	9	47
	~~4~~	~~6~~	~~4~~	~~10~~	~~6~~	~~4~~	30

select the Row Least Total

A

$$\begin{array}{cc|ccccc}
 & & 1 & 2 & 3 & 4 & 5 \\
\hline
\text{player A} & 2 & 7 & 8 & 5 & 9 & 10 \\
 & 3 & 8 & 9 & 11 & 10 & 9 \\
\hline
 & & 15 & 17 & 16 & 19 & 19
\end{array}$$

player B

$$\begin{array}{cc|cc|c}
 & & 1 & 3 & \\
\hline
\text{player A} & 2 & 7 & 5 & 12 \\
 & 3 & 8 & 11 & 19
\end{array}$$

player A = $[0, 0, 1, 0]$

B = $[1, 0, 0, 0, 0]$

Value of the game $V = 8$

Dominance property with mixed strategy

Player B

		1	2	3	4	Row min
Player A	1	5	-3	3	4	-3 max min
	2	-4	5	4	5	-4
	3	4	-4	-3	3	-4
column max		5	5	4	5	

minmax

minmax = Maxmin (No saddle point)

$-3 \neq 5$

Row Reduction

Player B

		1	2	3	4	Total Row
Player A	1	5	-3	3	4	9
	2	-4	5	4	5	10
	~~3~~	~~4~~	~~-4~~	~~-3~~	~~3~~	0

Column Reduction

	1	2	3	4
1	5	-3	3	4
2	-4	5	4	5
Total =	1	2	7	9

Select Highest Total

player
B

$$\begin{array}{cc} & \begin{array}{ccc} 1 & 2 & 3 \end{array} \\ \begin{array}{c} \text{player} \\ A \end{array} \begin{array}{c} 1 \\ 2 \end{array} & \begin{bmatrix} 5 & -3 & \cancel{3} \\ -4 & 5 & \cancel{4} \end{bmatrix} \end{array}$$

$$\begin{bmatrix} 1 & 3 \\ 1/2 & 4 \end{bmatrix} \begin{array}{c} 8 \\ 5 \end{array} \quad (x \le y)$$

Select first 2 column and Take Average 2

$$\frac{5-3}{2} = \frac{2}{2} = 1$$

$$\frac{-4+5}{2} = 1/2$$

player
B

$$\begin{array}{cc} & \begin{array}{cc} 1 & 2 \end{array} \\ \begin{array}{c} \text{player} \\ A \end{array} \begin{array}{c} 1 \\ 2 \end{array} & \begin{bmatrix} 5 & -3 \\ -4 & 5 \end{bmatrix} \end{array}$$

oddments	probablite
$5-(-4)=9$	$\frac{9}{8+9}$
$5-(-3)=8$	$\frac{8}{8+9}$

oddments $\quad 5-(-3) = 8 \quad 5-(-4) = 9$

probability $\quad \frac{8}{8+9} \quad \frac{9}{8+9}$

$$p_1 = \frac{9}{17}, \quad q_1 = \frac{8}{17}$$

$$p_2 = \frac{8}{17}, \quad q_2 = \frac{9}{17}$$

Value of the game

$$\begin{bmatrix} 5 & -3 \\ -4 & 5 \end{bmatrix} \begin{array}{c} 9 \\ 8 \end{array}$$
$$\begin{array}{cc} 8 & 9 \end{array}$$

$$V = \frac{(5 \times 9) + (-4 \times 8)}{9+8} = \frac{45-32}{17} = \frac{13}{17} = 0.7$$

player A $\left[\frac{9}{17}, \frac{8}{17}, 0\right]$

B $\left[\frac{8}{17}, \frac{9}{17}, 0, 0\right]$

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Game theory: Graphical method

I. 2xn game - 2 rows × n columns

II. mx2 game - m rows × 2 columns

Graphical method for mx2 game:

Steps

1. Reduce the size of the pay off matrix of player A by applying the dominance property ~~if it~~ exist.

2. Let y be the probability of selection of Alternative 1 by player B and (1-y) be the probability of selection of Alternative 2 by player B.

   Derive the expected gain ~~function~~ of player B with respect to each of alternative of player A.

3. Find the value of the gain when y=0 and y=1

4. plot the gain function on a graph by assuming a suitable scale. Keep y on x-axis and the gain on y-axis

5. Find the Lowest Intersection point in the upper boundary of the graph → minimax point.

6. If the no. of lines passing through the minimax point are only two, form a 2x2 payoff matrix, goto step 8, otherwise goto step 7.

7. Identify any two lines with opposite slopes passing through that point, Then form a 2x2 payoff matrix

8. Solve the 2x2 game using oddments and find the Strategies for player A & B and also the value of the game.

(*)

$$\begin{array}{c|cc|} & 1 & 2 \\ \hline 1 & 6 & -7 \\ 2 & 1 & 3 \\ 3 & 3 & 1 \\ 4 & 5 & -1 \\ \hline & y & 1-y \end{array}$$

Expected payoff function and Expected gain of player B

A's Alternative	B's Expected payoff function	B's Expected gain $y=0$	$y=1$
1	$6(y)-7(1-y) = 6y+7y-7 = 13y-7$	-7	6
2	$1(y)+3(1-y) = 1y-3y+3 = -2y+3$	3	1
3	$3(y)+1(1-y) = 3y-y+1 = 2y+1$	1	3
4	$5(y)-1(1-y) = 5y+y-1 = 6y-1$	-1	5

$$\begin{array}{ccc} & & \text{player B} \\ & & \begin{array}{cc} 1 & 2 \end{array} \\ \text{player A} & \begin{array}{c} 2 \\ 4 \end{array} & \boxed{\begin{array}{cc} 1 & 3 \\ 5 & -1 \end{array}} \end{array}$$

oddments

$5-(-1)=6$ $\qquad \dfrac{6}{6+2}=\dfrac{6}{8}=3/4$

$3-1=2$ $\qquad \dfrac{2}{6+2}=\dfrac{2}{8}=1/4$

oddments $3-(-1)$ $=4$ $\quad 5-1$ 4

$\dfrac{4}{4+4}$ $\quad \dfrac{4}{4+4}$

$1/2 \quad 1/2$

Value of the game

$$= \frac{(1\times 6)+(5\times 2)}{6+2} = \frac{6+10}{8} = \frac{16}{8} = 2$$

probabilities

player A $[0, 3/4, 0, 1/4]$

player B $(1/2, 1/2)$

value of the game $= 2$

graphical method for (2xn)

steps

1. player A by applying dominance property if it exist.
2. Let x be the probability of selection of alternative 1 by player A and $1-x$ be the probability of selection of Alternative 2 by player A.

   Derive expected gain function of player A with respect to each of the alternatives of player B
3. find the value of the game when $x=0$, $x=1$
4. plot the gain function on a graph by assuming a suitable scale [Keep x on axis and the gain on y-axis]
5. Find the highest interaction point in the lower boundary of the graph (maximum point)
6. If the no. of lines passing through the maxmin point is only two, form a 2x2 pay off matrix, goto step 8, otherwise goto step 7.
7. Identify the any two lines with opposite slopes passing through that point. then form a 2x2 payoff matrix.
8. solve the 2x2 game using oddments and find strategies for player A and B and also value of the game.

Expected payoff functions and gain of player A

B's alternative	A's Expected payoff function	A's Expected gain $x=0$	$x=1$

NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

MID & ASSIGNMENT EXAMINATION QUESTION PAPERS WITH SCHEME AND SOLUTIONS

NARASARAOPET ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET
DEPARTMENT OF MECHANICAL ENGINEERING

III B.TECH I - SEMESTER ASSIGNMENT TEST – I, - 2022

SUBJECT: OPERATIONS RESEARCH	
DURATION: 30 MIN	**DATE:** 03-09-2022
	MAX MARKS: 5

Q. No	Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
1	A company is manufacturing two different types of products, A and B. Each product has to be processes on two machines M1 and M2, Product A requires 2 hours on machine M1 and 1 hour on machine M2, product B requires 1 hour on machine M1 and 2 hours on machine M2. The available capacity of machine M1 is 104 hours and that of machine M2 is 76 hours. Profit per unit for product A is Rs.6 and that for B is Rs.11. Calculate i) Formulate the problem ii) Find out the optimal solution by Graphical method	1	Applying(K3)	5
2	Old hens can be bought at Rs 50 each and young ones at Rs 80 each. The old hens lay 4 eggs per week and the young ones lay 5 eggs per week, each egg being worth Rs.1.5 paise. A hen (young or old) costs Rs 4 per week to feed. I have only Rs. 150 to spend for hens. How many of each kind should I buy to give a profit of more than Rs 8 per week, assuming that I cannot house more than 30 hens?	1	Applying (K3)	5
3	Solve the following linear programming problem by the simplex method. Maximize $Z=5x_1+3x_2$ subject to constraints $3x_1+5x_2 \leq 15$, $5x_1+2x_2 \leq 10$ and $x_1, x_2 \geq 0$	1	Applying (K3)	5
4	Minimize $Z = 10x_1+6x_2+2x_3$, Subject to: $-x_1+x_2+x_3 \geq 1$ $3x_1+x_2+x_3 \geq 2$ and $x1, x2, x3 \geq 0$ Solve the LPP problem by using the Two-Phase method.	1	Applying (K3)	5
5	Solve the following linear programming problem by the Big-M method. Maximize $Z=7x_1+15x_2+20x_3$ and subject to constraints $2x_1+4x_2+6x_3 \geq 24$, $3x_1+9x_2+6x_3 \geq 30$, and $x_1, x_2, x_3, \geq 0$.	1	Applying (K3)	5

NARASARAOPET ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET
DEPARTMENT OF MECHANICAL ENGINEERING
III B.TECH I - MID – I, SEP- 2022

SUBJECT: OPERATIONS RESEARCH	
DURATION: 90 MIN	**DATE:** 23-09-2022
	MAX MARKS: 25M

Q. No	Questions	(CO)	KL	Marks
1	A company is manufacturing two different types of products, A and B. Each product has to be processes on two machines M1 and M2, Product A requires 2 hours on machine M1 and 1 hour on machine M2, product B requires 1 hour on machine M1 and2 hours on machine M2. The available capacity of machine M1 is 104 hours and that of machine M2 is 76 hours. Profit per unit for product A is Rs.6 and that for B is Rs.11.Calculate i) Formulate the problem ii) Find out the optimal solution by Simplex method.	1	Evaluating (K5)	10M
2	Find the Feasible solution to the Transportation schedule by using VAM method (table A below)	2	Applying (K3)	5M
	Solve the assignment problem: (table B below)	2	Applying (K3)	5M
3	A firm is considering replacement of a machine, whose cost price is Rs. 12,200 and the scrap value is Rs. 200. The running (maintenance and operating) cost are found from experience are as follows (table C below). When should the machine be replaced?	3	Evaluating (K5)	5M

Table A (Q2):

Company	Retail R1	R2	R3	Supply
P1	10	7	8	45
P2	15	12	9	15
P3	7	8	12	40
Demand	25	55	20	

Table B (Q2):

	1	2	3	4	5
A	6	5	8	11	16
B	1	13	16	1	10
C	16	11	8	8	8
D	9	14	12	10	16
E	10	13	11	8	16

Table C (Q3):

year	1	2	3	4	5	6	7	8
Running cost	200	500	800	1200	1800	2500	3200	4000

When should the machine be replaced?

NARASARAOPET ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET
DEPARTMENT OF MECHANICAL ENGINEERING

III B.TECH I - SEMESTER ASSIGNMENT TEST – II, - 2022

SUBJECT: OPERATIONS RESEARCH	**DATE:** 14-10-2022
DURATION: 30 MIN	**MAX MARKS:** 10

<table>
<tr><th>Q. No</th><th>Questions</th><th>Course Outcome (CO)</th><th>Knowledge Level as Per Bloom's Taxonomy</th><th>Marks</th></tr>
<tr><td>1</td><td>What is a sequencing problem? Explain the following Basic Terminologies in context of sequence problems: i) Total elapsed time and Idle time ii) no passing rule iii) processing order.</td><td>3</td><td>Evaluating(K5)</td><td>10</td></tr>
<tr><td>2</td><td>Write the General Assumptions for sequencing problems and what are the Types of Job Sequencing Problem.</td><td>3</td><td>Evaluating(K5)</td><td>10</td></tr>
<tr><td>3</td><td>The following morality rates have been observed for a certain type of light bulb
<table>
<tr><td>week</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Percent failing by the end of the week</td><td>10</td><td>25</td><td>50</td><td>80</td><td>100</td></tr>
</table>
There are 1000 bulbs in use and it cost Rs.1.00 to replace an individual bulb which has burnt out .If the all bulbs were replaced simultaneously it would cost 25 paisa per bulb.It is proposed to repace all bulbs at fixed interval whether or not they have burnt out and to continue replacing burnt out bulbs as they fails.At what intervals should all the bulbs to be replaced.</td><td>4</td><td>Applying (K3)</td><td>10</td></tr>
<tr><td>4</td><td>Purchase price of a machine is RS.3000 and its running cost is Rs.500 for each of the first 5 years and increase by Rs.100 every subsequent year. if the discount rate is 10% per year. When should be machine be replaced? Assume that there is no salvage value.</td><td>4</td><td>Applying (K3)</td><td>10</td></tr>
<tr><td>5</td><td>Explain the Types of Replacement Problems and mention the individual and group replacement policy.</td><td>4</td><td>Evaluating(K5)</td><td>10</td></tr>
</table>

NARASARAOPET ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET
DEPARTMENT OF MECHANICAL ENGINEERING
III B.TECH I - MID – II, NOV- 2022

SUBJECT: OPERATIONS RESEARCH	**DATE:** 22-11-2022
DURATION: 90 MIN	**MAX MARKS:** 25M

<table>
<tr><th>Q. No</th><th>Questions</th><th>(CO)</th><th>KL</th><th>Marks</th></tr>
<tr><td>1</td><td>A Bookbinder company has one printing machine and one binding machine. There are manuscripts of a number of different books. Processing time (in hours) for printing and binding are given in the following table.
<table>
<tr><td>Books/ Jobs</td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td></tr>
<tr><td>Printing</td><td>5</td><td>1</td><td>9</td><td>3</td><td>10</td></tr>
<tr><td>Binding</td><td>2</td><td>6</td><td>7</td><td>8</td><td>4</td></tr>
</table>
Determine the sequence in which books should be processed on the machine so that the total time required in minimized.</td><td>3</td><td>Evaluating (K5)</td><td>5M</td></tr>
<tr><td rowspan="2">2</td><td>A harbor has a single dock to unload the containers from the incoming ships. The arrival rate of ships at the harbor follows Poisson distribution and the unloading time for the ships follow exponential distribution and hence, the service rate also follows Poisson distribution. The arrival rate and service rate are 8 ships per week and 14 ships per week, respectively.
Determine the following
a) Utilization factor of the dock
b) Average number of Waiting ships in the queue
c) Average number of Waiting ships in the system
d) Average waiting time per ship in the queue
e) Average waiting time per ship in the system</td><td>4</td><td>Evaluating (K5)</td><td>5M</td></tr>
<tr><td>Distinguish between CPM and PERT</td><td>4</td><td>Analyzing (K4)</td><td>5M</td></tr>
<tr><td rowspan="2">3</td><td>Solve the following pay-off matrix. Also, determine optimal strategies and the Value of the game.
4 -4
-4 4</td><td>5</td><td>Applying (K3)</td><td>5M</td></tr>
<tr><td>Explain the Bellman's principle of optimality</td><td>5</td><td>Evaluating (K5)</td><td>5M</td></tr>
</table>

NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

III B.Tech I SEM I - Assignment Examination Scheme

1. Given Data & formulate LPP - 2M
   Optimal solution - 3M

2. Problem Solution - 5 M

3. Iteration table 1 & Iteration table 2 and optimal solution- 5M

4. Iteration table 1 & Iteration table 2 and optimal solution- 5M

5. Iteration table 1 & Iteration table 2 and optimal solution- 5M

NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

III B.Tech I SEM II - Assignment Examination Scheme

1. a) Total elapsed time and no passing time - 3M

   b) Processing order - 2M

2. a) Definition and sequencing assumptions -2 M

   b) Types of sequencing problems -3M

3. Derive table and solution - 5 M

4. Derive table and solution - 5 M

5. Definition and replacement problems - 5 M

NARASARAOPETA
NEC ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

III B.Tech I SEM I - Mid Examination Scheme

1. a) Formulate the LPP - 5 M

   b) Optimal solutions - 5 M

2. a) feasible solution using VAM - 5 M

   b) Assignment Problem Using HM - 5 M

3. a) find out the machine replaced year - 5 M

NARASARAOPETA
NEC ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

II B.Tech I SEM II - Mid Examination Scheme

1. a) determine the sequence order and total time - 5 M
2. a) find out the each one - 5 M

   b) Compare the CPM and PERT - 5 M
3. a) Saddle Point & Value of the game - 5M

   b) Definition and Explanation - 5 M

NARASARAOPET ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET

DEPARTMENT OF MECHANICAL ENGINEERING

III B. TECH I - SEMESTER ASSIGNMENT TEST – IV, September - 2019

SUBJECT: OPERATIONS RESEARCH	**DATE:** 7-09-2019
DURATION: 30 MIN	**MAX MARKS:** 10

Q. No	Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
1	a) Write the Characteristics of Game Theory b) Solve the following pay-off matrix. Also determine optimal strategies and value of the game.	CO4	Applying (K3)	10
2.	Solve the following pay-off matrix. Also determine optimal strategies and value of the game.	CO4	Applying (K3)	10
3	Solve the following pay-off matrix. Also determine optimal strategies and value of the game.	CO4	Applying (K3)	10
4	Solve the following 2Xn game graphically.	CO4	Applying (K3)	10

Q1 (b):

	B1	B2	B3	B4
A1	20	15	12	35
A2	25	14	8	10
A3	40	2	10	5
A4	-5	4	11	0

Q2:

B

A	5	-10	9	0
	6	7	8	1
	8	7	15	1
	3	4	-1	4

Q3:

Player B

	I	II	III	IV
I	19	6	7	5
II	7	-3	14	6
III	12	8	18	4
IV	8	7	13	-1

Q4:

	B1	B2	B3	B4
A1	2	1	0	-2
A2	1	0	3	2

<table>
<tr>
<td>5</td>
<td>Solve the following mX2 game graphically.

<table>
<tr><th></th><th>B1</th><th>B2</th></tr>
<tr><td>A1</td><td>-6</td><td>7</td></tr>
<tr><td>A2</td><td>4</td><td>-5</td></tr>
<tr><td>A3</td><td>-1</td><td>-2</td></tr>
<tr><td>A4</td><td>-2</td><td>5</td></tr>
<tr><td>A5</td><td>7</td><td>-6</td></tr>
</table>
</td>
<td>CO4</td>
<td>Applying (K3)</td>
<td>10</td>
</tr>
</table>

<table>
<tr><th>Q. No</th><th>Questions</th><th>Course Outcome (CO)</th><th>Knowledge Level as Per Bloom's Taxonomy</th><th>Marks</th></tr>
<tr><td>1</td><td>b) Write the Characteristics of Game Theory
b) Solve the following pay-off matrix. Also determine optimal strategies and value of the game.
<table>
<tr><th></th><th>B1</th><th>B2</th><th>B3</th><th>B4</th></tr>
<tr><td>A1</td><td>20</td><td>15</td><td>12</td><td>35</td></tr>
<tr><td>A2</td><td>25</td><td>14</td><td>8</td><td>10</td></tr>
<tr><td>A3</td><td>40</td><td>2</td><td>10</td><td>5</td></tr>
<tr><td>A4</td><td>-5</td><td>4</td><td>11</td><td>0</td></tr>
</table></td><td>CO4</td><td>Applying (K3)</td><td>10</td></tr>
</table>

<table>
<tr><th>Q. No</th><th>Questions</th><th>Course Outcome (CO)</th><th>Knowledge Level as Per Bloom's Taxonomy</th><th>Marks</th></tr>
<tr><td>2.</td><td>Solve the following pay-off matrix. Also determine optimal strategies and value of the game.
B
<table>
<tr><td>5</td><td>-10</td><td>9</td><td>0</td><td rowspan="4">A</td></tr>
<tr><td>6</td><td>7</td><td>8</td><td>1</td></tr>
<tr><td>8</td><td>7</td><td>15</td><td>1</td></tr>
<tr><td>3</td><td>4</td><td>-1</td><td>4</td></tr>
</table></td><td>CO4</td><td>Applying (K3)</td><td>10</td></tr>
</table>

<table>
<tr><th>Q. No</th><th>Questions</th><th>Course Outcome (CO)</th><th>Knowledge Level as Per Bloom's Taxonomy</th><th>Marks</th></tr>
<tr><td>3</td><td>Solve the following pay-off matrix. Also determine optimal strategies and value of the game.
Player B
<table>
<tr><th></th><th>I</th><th>II</th><th>III</th><th>IV</th></tr>
<tr><td>I</td><td>19</td><td>6</td><td>7</td><td>5</td></tr>
<tr><td>II</td><td>7</td><td>-3</td><td>14</td><td>6</td></tr>
<tr><td>III</td><td>12</td><td>8</td><td>18</td><td>4</td></tr>
<tr><td>IV</td><td>8</td><td>7</td><td>13</td><td>-1</td></tr>
</table></td><td>CO4</td><td>Applying (K3)</td><td>10</td></tr>
</table>

Q. No	Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
4	Solve the following 2Xn game graphically. <table><tr><td></td><td>**B1**</td><td>**B2**</td><td>**B3**</td><td>**B4**</td></tr><tr><td>**A1**</td><td>2</td><td>1</td><td>0</td><td>-2</td></tr><tr><td>**A2**</td><td>1</td><td>0</td><td>3</td><td>2</td></tr></table>	CO4	Applying (K3)	10

Q. No	Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
5	Solve the following mX2 game graphically. <table><tr><td></td><td>**B1**</td><td>**B2**</td></tr><tr><td>**A1**</td><td>-6</td><td>7</td></tr><tr><td>**A2**</td><td>4</td><td>-5</td></tr><tr><td>**A3**</td><td>-1</td><td>-2</td></tr><tr><td>**A4**</td><td>-2</td><td>5</td></tr><tr><td>**A5**</td><td>7</td><td>-6</td></tr></table>	CO4	Applying (K3)	10

NARASARAOPET ENGINEERING COLLEGE:: NARASARAOPET
(AUTONOMOUS)
DEPARTMENT OF MECHANICAL ENGINEERING
III B.TECH I - SEMESTER ASSIGNMENT TEST – II, JULY - 2019

SUBJECT: OPERATIONS RESEARCH	**DATE:** 26-07-2019
DURATION: 30 MIN	**MAX MARKS:** 10

<table>
<tr><th>Q. No</th><th>Questions</th><th>Course Outcome (CO)</th><th>Knowledge Level as Per Bloom's Taxonomy</th><th>Marks</th></tr>
<tr><td>1</td><td>Find the sequence ,total elapsed time &idle time
<table>
<tr><th>Task</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th></tr>
<tr><td>M/C A</td><td>4</td><td>8</td><td>3</td><td>6</td><td>7</td><td>5</td></tr>
<tr><td>M/C B</td><td>6</td><td>3</td><td>7</td><td>2</td><td>8</td><td>4</td></tr>
</table></td><td>3</td><td>Solving & Applying (K2, K3)</td><td>10</td></tr>
<tr><td>2</td><td>Find the sequence ,total elapsed time &idle time
<table>
<tr><th>Task</th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th><th>G</th></tr>
<tr><td>M₁</td><td>3</td><td>8</td><td>7</td><td>4</td><td>9</td><td>8</td><td>7</td></tr>
<tr><td>M₂</td><td>4</td><td>3</td><td>2</td><td>5</td><td>1</td><td>4</td><td>3</td></tr>
<tr><td>M₃</td><td>6</td><td>7</td><td>5</td><td>11</td><td>5</td><td>6</td><td>12</td></tr>
</table></td><td>3</td><td>Solving & Applying (K2, K3)</td><td>10</td></tr>
</table>

3	Consider the following table summarizing the details of a project. Draw the project network ,Expected duration, variance of each activity, critical path <table><tr><th>Activity</th><th>predecessor</th><th>O</th><th>M</th><th>P</th></tr><tr><td>A</td><td>---</td><td>5</td><td>6</td><td>7</td></tr><tr><td>B</td><td>---</td><td>1</td><td>3</td><td>5</td></tr><tr><td>C</td><td>---</td><td>1</td><td>4</td><td>7</td></tr><tr><td>D</td><td>A</td><td>1</td><td>2</td><td>3</td></tr><tr><td>E</td><td>B</td><td>1</td><td>2</td><td>9</td></tr><tr><td>F</td><td>C</td><td>1</td><td>5</td><td>9</td></tr><tr><td>G</td><td>C</td><td>2</td><td>2</td><td>8</td></tr><tr><td>H</td><td>E,F</td><td>4</td><td>4</td><td>10</td></tr><tr><td>I</td><td>D</td><td>2</td><td>5</td><td>8</td></tr><tr><td>J</td><td>H,G</td><td>2</td><td>2</td><td>8</td></tr></table>	3	Solving & Applying (K2, K3)	10
4	Consider the following data for activities in a given project. Draw arrow diagram, list the activities on critical path, project completion time. <table><tr><th>Activity</th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th></tr><tr><th>predecessor</th><td>---</td><td>A</td><td>---</td><td>B,C</td><td>C</td><td>D,E</td></tr><tr><th>Time (days)</th><td>5</td><td>4</td><td>7</td><td>3</td><td>4</td><td>2</td></tr></table>	3	Solving & Applying (K2, K3)	10
5	Consider the following table. Draw network diagram, determine minimum total time and corresponding cost. <table><tr><th>Activity</th><th>Normal time</th><th>Crash time</th><th>Normal cost</th><th>Crash cost</th></tr><tr><td>1-2</td><td>9</td><td>6</td><td>640</td><td>700</td></tr><tr><td>1-3</td><td>8</td><td>5</td><td>500</td><td>575</td></tr><tr><td>1-4</td><td>15</td><td>10</td><td>400</td><td>550</td></tr><tr><td>2-4</td><td>5</td><td>3</td><td>100</td><td>120</td></tr><tr><td>3-4</td><td>10</td><td>6</td><td>200</td><td>260</td></tr><tr><td>4-5</td><td>2</td><td>1</td><td>100</td><td>140</td></tr></table>	3	Solving & Applying (K2, K3)	10

Q. No	Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
1	Find the sequence ,total elapsed time &idle time	3	Solving & Applying (K2, K3)	10

Task	1	2	3	4	5	6
M/C A	4	8	3	6	7	5
M/C B	6	3	7	2	8	4

Q. No	Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
2	Find the sequence ,total elapsed time &idle time	3	Solving & Applying (K2, K3)	10

Task	A	B	C	D	E	F	G
M_1	3	8	7	4	9	8	7
M_2	4	3	2	5	1	4	3
M_3	6	7	5	11	5	6	12

<table>
<tr><th>Q. No</th><th>Questions</th><th>Course Outcome (CO)</th><th>Knowledge Level as Per Bloom's Taxonomy</th><th>Marks</th></tr>
<tr><td>3</td><td>Consider the following table summarizing the details of a project. Draw the project network ,Expected duration, variance of each activity, critical path
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<tr><td>B</td><td>---</td><td>1</td><td>3</td><td>5</td></tr>
<tr><td>C</td><td>---</td><td>1</td><td>4</td><td>7</td></tr>
<tr><td>D</td><td>A</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>E</td><td>B</td><td>1</td><td>2</td><td>9</td></tr>
<tr><td>F</td><td>C</td><td>1</td><td>5</td><td>9</td></tr>
<tr><td>G</td><td>C</td><td>2</td><td>2</td><td>8</td></tr>
<tr><td>H</td><td>E,F</td><td>4</td><td>4</td><td>10</td></tr>
<tr><td>I</td><td>D</td><td>2</td><td>5</td><td>8</td></tr>
<tr><td>J</td><td>H,G</td><td>2</td><td>2</td><td>8</td></tr>
</table></td><td>3</td><td>Solving & Applying (K2, K3)</td><td>10</td></tr>
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<table>
<tr><th>Q. No</th><th>Questions</th><th>Course Outcome (CO)</th><th>Knowledge Level as Per Bloom's Taxonomy</th><th>Marks</th></tr>
<tr><td>4</td><td>Consider the following data for activities in a given project. Draw arrow diagram, list the activities on critical path, project completion time.
<table>
<tr><th>Activity</th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th></tr>
<tr><td>predecessor</td><td>---</td><td>A</td><td>---</td><td>B,C</td><td>C</td><td>D,E</td></tr>
<tr><td>Time (days)</td><td>5</td><td>4</td><td>7</td><td>3</td><td>4</td><td>2</td></tr>
</table></td><td>3</td><td>Solving & Applying (K2, K3)</td><td>10</td></tr>
</table>

<table>
<tr><th>Q. No</th><th>Questions</th><th>Course Outcome (CO)</th><th>Knowledge Level as Per Bloom's Taxonomy</th><th>Marks</th></tr>
<tr><td>5</td><td>Consider the following table. Draw network diagram, determine minimum total time and corresponding cost.
<table>
<tr><th>Activity</th><th>Normal time</th><th>Crash time</th><th>Normal cost</th><th>Crash cost</th></tr>
<tr><td>1-2</td><td>9</td><td>6</td><td>640</td><td>700</td></tr>
<tr><td>1-3</td><td>8</td><td>5</td><td>500</td><td>575</td></tr>
<tr><td>1-4</td><td>15</td><td>10</td><td>400</td><td>550</td></tr>
<tr><td>2-4</td><td>5</td><td>3</td><td>100</td><td>120</td></tr>
<tr><td>3-4</td><td>10</td><td>6</td><td>200</td><td>260</td></tr>
<tr><td>4-5</td><td>2</td><td>1</td><td>100</td><td>140</td></tr>
</table></td><td>3</td><td>Solving & Applying (K2, K3)</td><td>10</td></tr>
</table>

NARASARAOPET ENGINEERING COLLEGE:: NARASARAOPET
(AUTONOMOUS)
DEPARTMENT OF MECHANICAL ENGINEERING
III B.TECH I - SEMESTER ASSIGNMENT TEST – I, JULY - 2019

SUBJECT: OPERATIONS RESEARCH	**DATE:** 05-07-2019
DURATION: 30 MIN	**MAX MARKS:** 10

<table>
<tr><th>Q. No</th><th>Questions</th><th>Course Outcome (CO)</th><th>Knowledge Level as Per Bloom's Taxonomy</th><th>Marks</th></tr>
<tr><td>1</td><td>Solve following Transportation problem by using VAM method and test for optimality.
<table>
<tr><th></th><th>D1</th><th>D2</th><th>D3</th><th>supply</th></tr>
<tr><td>A</td><td>2</td><td>7</td><td>4</td><td>5</td></tr>
<tr><td>B</td><td>3</td><td>3</td><td>1</td><td>8</td></tr>
<tr><td>C</td><td>5</td><td>4</td><td>7</td><td>7</td></tr>
<tr><td>D</td><td>1</td><td>6</td><td>2</td><td>14</td></tr>
<tr><td>Demand</td><td>7</td><td>9</td><td>18</td><td></td></tr>
</table></td><td>2</td><td>Solving & Applying (K2, K3)</td><td>10</td></tr>
<tr><td>2</td><td>Solve following Transportation problem and find out minimum cost of Transportation.
<table>
<tr><th></th><th>X</th><th>Y</th><th>Z</th><th>supply</th></tr>
<tr><td>A</td><td>8</td><td>7</td><td>5</td><td>60</td></tr>
<tr><td>B</td><td>6</td><td>8</td><td>9</td><td>70</td></tr>
<tr><td>C</td><td>9</td><td>6</td><td>5</td><td>80</td></tr>
<tr><td>Demand</td><td>50</td><td>80</td><td>80</td><td></td></tr>
</table></td><td>2</td><td>Solving & Applying (K2, K3)</td><td>10</td></tr>
</table>

<table>
<tr>
<td>3</td>
<td>Solve following Transportation problem and obtain IBFS by using Least Cost Method and Vogels approximation method
<table>
<tr><th></th><th>D1</th><th>D2</th><th>D3</th><th>D4</th><th>Supply</th></tr>
<tr><td>A</td><td>270</td><td>230</td><td>310</td><td>690</td><td>100</td></tr>
<tr><td>B</td><td>100</td><td>450</td><td>400</td><td>320</td><td>80</td></tr>
<tr><td>C</td><td>300</td><td>540</td><td>350</td><td>570</td><td>80</td></tr>
<tr><td>Demand</td><td>60</td><td>120</td><td>50</td><td>40</td><td></td></tr>
</table>
</td>
<td>2</td>
<td>Solving & Applying (K2, K3)</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>The Assignment costs of four operators to four machines are given in the following table. Find the optimal Assignment using Hungarian method.
<table>
<tr><th></th><th>I</th><th>II</th><th>III</th><th>IV</th></tr>
<tr><td>A</td><td>10</td><td>5</td><td>13</td><td>15</td></tr>
<tr><td>B</td><td>3</td><td>9</td><td>18</td><td>3</td></tr>
<tr><td>C</td><td>10</td><td>7</td><td>3</td><td>2</td></tr>
<tr><td>D</td><td>5</td><td>11</td><td>9</td><td>2</td></tr>
</table>
</td>
<td>2</td>
<td>Solving & Applying (K2, K3)</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Solve the travelling salesman problem with the following cost matrix.
<table>
<tr><th></th><th>A</th><th>B</th><th>C</th><th>D</th></tr>
<tr><td>A</td><td>œ</td><td>46</td><td>16</td><td>40</td></tr>
<tr><td>B</td><td>41</td><td>œ</td><td>50</td><td>40</td></tr>
<tr><td>C</td><td>82</td><td>32</td><td>œ</td><td>60</td></tr>
<tr><td>D</td><td>40</td><td>40</td><td>36</td><td>œ</td></tr>
</table>
</td>
<td>2</td>
<td>Solving & Applying (K2, K3)</td>
<td>10</td>
</tr>
</table>

Q. No	Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
1	Solve following Transportation problem by using VAM method and test for optimality.	2	Solving & Applying (K2, K3)	10

	D1	D2	D3	supply
A	2	7	4	5
B	3	3	1	8
C	5	4	7	7
D	1	6	2	14
Demand	7	9	18	

Q. No	Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
2	Solve following Transportation problem and find out minimum cost of Transportation.	2	Solving & Applying (K2, K3)	10

	X	Y	Z	supply
A	8	7	5	60
B	6	8	9	70
C	9	6	5	80
Demand	50	80	80	

Q. No	Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
3	Solve following Transportation problem and obtain IBFS by using Least Cost Method and Vogels approximation method	2	Solving & Applying (K2, K3)	10

	D1	D2	D3	D4	Supply
A	270	230	310	690	100
B	100	450	400	320	80
C	300	540	350	570	80
Demand	60	120	50	40	

<table>
<tr><th>Q. No</th><th>Questions</th><th>Course Outcome (CO)</th><th>Knowledge Level as Per Bloom's Taxonomy</th><th>Marks</th></tr>
<tr><td>4</td><td>The Assignment costs of four operators to four machines are given in the following table. Find the optimal Assignment using Hungarian method.
<table>
<tr><th></th><th>I</th><th>II</th><th>III</th><th>IV</th></tr>
<tr><td>A</td><td>10</td><td>5</td><td>13</td><td>15</td></tr>
<tr><td>B</td><td>3</td><td>9</td><td>18</td><td>3</td></tr>
<tr><td>C</td><td>10</td><td>7</td><td>3</td><td>2</td></tr>
<tr><td>D</td><td>5</td><td>11</td><td>9</td><td>2</td></tr>
</table></td><td>2</td><td>Solving & Applying (K2, K3)</td><td>10</td></tr>
</table>

<table>
<tr><th>Q. No</th><th>Questions</th><th>Course Outcome (CO)</th><th>Knowledge Level as Per Bloom's Taxonomy</th><th>Marks</th></tr>
<tr><td>5</td><td>Solve the travelling salesman problem with the following cost matrix.
<table>
<tr><th></th><th>A</th><th>B</th><th>C</th><th>D</th></tr>
<tr><td>A</td><td>œ</td><td>46</td><td>16</td><td>40</td></tr>
<tr><td>B</td><td>41</td><td>œ</td><td>50</td><td>40</td></tr>
<tr><td>C</td><td>82</td><td>32</td><td>œ</td><td>60</td></tr>
<tr><td>D</td><td>40</td><td>40</td><td>36</td><td>œ</td></tr>
</table></td><td>2</td><td>Solving & Applying (K2, K3)</td><td>10</td></tr>
</table>

NARASARAOPET ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET

DEPARTMENT OF MECHANICAL ENGINEERING

III B. TECH I-SEMESTER MID EXAMINATION-II, OCT-2019

SUBJECT: OPERATIONS RESEARCH	**DATE:** 18-10-2019
DURATION: 90 MIN	**MAX MARKS:**30

Q. No	Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
1.	a) The capacity of queueing system is 4. Inter-arrival time of the units is 20min and service time is 36min per unit. Find the probability that a new arrival enters into service with out waiting. Also find the average number of units in the system. b) In a car wash station car arrive for service according to passion distribution with mean 4per hr. The average service time of the car is 10min. Determine the probability that an arriving car has to wait. Find the average time a car stays in the station.	**CO4**	Applying (K3)	**5+5**
2.	Solve the following pay-off matrix. Also determine optimal strategies and value of the game. **Player B** (see matrix below)	**CO5**	Applying(K3)	**10**
3.	The cost of machine A is Rs 45000 and the maintenance cost is Rs 1000 it is increased by 10000 every year. The cost of machine B is Rs 50000 and the maintenance cost is Rs 2000 it is increased by 4000 every year. Determine which machine should be replaced by other.	**CO6**	Applying(K3)	**10**

	I	II	III	IV
I	19	6	7	5
II	7	-3	14	6
III	12	8	18	4
IV	8	7	13	-1

NARASARAOPET ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET

DEPARTMENT OF MECHANICAL ENGINEERING

III B. TECH I-SEMESTER MID EXAMINATION-I, AUGUST-2019

SUBJECT: OPERATIONS RESEARCH	**DATE:** 19-08-2019
DURATION: 90 MIN	**MAX MARKS:30**

<table>
<tr><th>Q. No</th><th>Questions</th><th>Course Outcome (CO)</th><th>Knowledge Level as Per Bloom's Taxonomy</th><th>Marks</th></tr>
<tr><td>1.</td><td>a) Define OR.
b) Solve the following LPP
$MaxZ=12x_1+16x_2$ subject to $10x_1+20x_2\leq 120$, $8x_1+8x_2 \leq 80$ where $x_1, x_2 \geq 0$</td><td>CO1</td><td>Solve (K2)</td><td>2+8</td></tr>
<tr><td>2.</td><td>Find initial basic feasible solution by using VAM method and test for optimality for the following Transportation Problem.
<table>
<tr><td></td><td>P</td><td>Q</td><td>R</td><td>Demand</td></tr>
<tr><td>A</td><td>2</td><td>2</td><td>3</td><td>10</td></tr>
<tr><td>B</td><td>4</td><td>1</td><td>2</td><td>15</td></tr>
<tr><td>C</td><td>1</td><td>3</td><td>1</td><td>40</td></tr>
<tr><td>Demand</td><td>20</td><td>15</td><td>30</td><td></td></tr>
</table></td><td>CO2</td><td>Apply(K3)</td><td>10</td></tr>
<tr><td>3.</td><td>A project consists of different activities as mentioned in the below table. Draw the network diagram and find the minimum time of completion of the project.
<table>
<tr><td>Activity</td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td><td>G</td><td>H</td><td>I</td></tr>
<tr><td>Preceding activity</td><td>-</td><td>-</td><td>-</td><td>A</td><td>A</td><td>B,D</td><td>C</td><td>B</td><td>F,G</td></tr>
<tr><td>Duration</td><td>23</td><td>8</td><td>20</td><td>16</td><td>24</td><td>18</td><td>19</td><td>4</td><td>10</td></tr>
</table></td><td>CO3</td><td>Identify(K3)</td><td>10</td></tr>
</table>

NARASARAOPET ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET

DEPARTMENT OF MECHANICAL ENGINEERING

III B. TECH I-SEMESTER MID EXAMINATION-II, OCT-2019

SUBJECT: OPERATIONS RESEARCH	**DATE:** 18-10-2019
DURATION: 90 MIN	**MAX MARKS:**30

Q. No	Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
1.	a) The capacity of queueing system is 4. Inter-arrival time of the units is 20min and service time is 36min per unit. Find the probability that a new arrival enters into service with out waiting. Also find the average number of units in the system. b) In a car wash station car arrive for service according to passion distribution with mean 4per hr. The average service time of the car is 10min. Determine the probability that an arriving car has to wait. Find the average time a car stays in the station.	CO4	Applying (K3)	5+5
2.	Solve the following pay-off matrix. Also determine optimal strategies and value of the game. **Player B** <table><tr><td></td><td>I</td><td>II</td><td>III</td><td>IV</td></tr><tr><td>I</td><td>19</td><td>6</td><td>7</td><td>5</td></tr><tr><td>II</td><td>7</td><td>-3</td><td>14</td><td>6</td></tr><tr><td>III</td><td>12</td><td>8</td><td>18</td><td>4</td></tr><tr><td>IV</td><td>8</td><td>7</td><td>13</td><td>-1</td></tr></table>	CO5	Applying(K3)	10
3.	The cost of machine A is Rs 45000 and the maintenance cost is Rs 1000 it is increased by 10000 every year. The cost of machine B is Rs 50000 and the maintenance cost is Rs 2000 it is increased by 4000 every year. Determine which machine should be replaced by other.	CO6	Applying(K3)	10

NARASARAOPET ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET

DEPARTMENT OF MECHANICAL ENGINEERING

III B. TECH I-SEMESTER MID EXAMINATION-I, AUGUST-2019

Common to A,B,C SECTIONS

SUBJECT: OPERATIONS RESEARCH	**DATE:** 19-08-2019
DURATION: 90 MIN	**MAX MARKS:**30

Q. No	Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
1.	a) Define OR and write objectives of OR. b) Solve the following LPP MaxZ=$12x_1+16x_2$ subject to $10x_1+20x_2 \leq 120$, $8x_1+8x_2 \leq 80$ where $x_1, x_2 \geq 0$	CO1	Solve (K2)	2+8
2.	Find initial basic feasible solution by using VAM method and test for optimality for the following Transportation Problem. (table below)	CO2	Apply(K3)	10
3.	A project consists of different activities as mentioned in the below table. Draw the network diagram and find the minimum time of completion of the project. (table below)	CO3	Identify(K3)	10

Question 2 table:

	P	Q	R	Demand
A	2	2	3	10
B	4	1	2	15
C	1	3	1	40
Demand	20	15	30	

Question 3 table:

Activity	A	B	C	D	E	F	G	H	I
Preceding activity	-	-	-	A	A	B,D	C	B	F,G
Duration	23	8	20	16	24	18	19	4	10

NARASARAOPET ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET
DEPARTMENT OF MECHANICAL ENGINEERING
II B.TECH II - SEMESTER ASSIGNMENT TEST – I, JUNE – 2021

SUBJECT: OPERATIONS RESEARCH **DATE:** 19-06-2021

DURATION: 30 MIN **MAX MARKS:** 10

<table>
<tr><th>Q. No</th><th>Questions</th><th>Course Outcome (CO)</th><th>Knowledge Level as Per Bloom's Taxonomy</th><th>Marks</th></tr>
<tr><td>1</td><td>An auto parts company produces three types of parts A , B, C. the capacity of the machines and the number of machine hours required for one unit of each part is given below
<table>
<tr><td>Machine Type</td><td>Available machine hours per week</td><td colspan="3">Productivity in machine hours</td></tr>
<tr><td></td><td></td><td>A</td><td>B</td><td>C</td></tr>
<tr><td>Hobbling</td><td>250</td><td>8</td><td>2</td><td>3</td></tr>
<tr><td>shaping</td><td>150</td><td>4</td><td>3</td><td>0</td></tr>
<tr><td>Grinding</td><td>50</td><td>2</td><td>-</td><td>1</td></tr>
</table>
The profit is Rs 20, Rs 6 and Rs 8 for one unit of A, B and C respectively.
a) Formulate LPP model
b) Find out how much of each part the company should produce per week in order to Maximize the profit</td><td>1</td><td>Creating (K6)</td><td>3+7</td></tr>
<tr><td rowspan="2">2</td><td>a).Minimize $Z = x_1 - 3x_2 + 2x_3$ subjected to constrains $3x_1 - x_2 + 2x_3 \leq 7$, $-2x_1 + 4x_2 \leq 12$, $-4x_1 + 3x_2 + 8x_3 \leq 10$, $x_1, x_2, x_3 \geq 0$</td><td>1</td><td>Creating (K6)</td><td>7</td></tr>
<tr><td>b).List out the characteristics of operation research</td><td>1</td><td>Analyzing (K4)</td><td>3</td></tr>
<tr><td rowspan="2">3</td><td>a) Explain different types of models in operation research.</td><td>1</td><td>Evaluating (K5)</td><td>7</td></tr>
<tr><td>b).List out the applications of operation research</td><td>1</td><td>Analyzing (K4)</td><td>3</td></tr>
<tr><td rowspan="2">4</td><td>a).Maximize $Z = 2x_1 + 4x_2 + x_3$ subjected to constrains $x_1 + 3x_2 \leq 4$, $2x_1 + x_2 \leq 3$, $x_2 + 4x_3 \leq 3$, $x_1, x_2, x_3 \geq 0$</td><td>1</td><td>Creating (K6)</td><td>7</td></tr>
<tr><td>b).Classification of models in operations Research.</td><td>1</td><td>Evaluating (K5)</td><td>3</td></tr>
<tr><td rowspan="2">5</td><td>a).Maximize $Z = 3x_1 + 2x_2$ subjected to constrains $4x_1 + 3x_2 \leq 12$, $4x_1 + x_2 \leq 8$, $x_1 - x_2 \leq 8$, $x_1, x_2 \geq 0$</td><td>1</td><td>Creating (K6)</td><td>7</td></tr>
<tr><td>b) Explain phases of operations Research.</td><td>1</td><td>Evaluating (K5)</td><td>3</td></tr>
</table>

NARASARAOPET ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET
DEPARTMENT OF MECHANICAL ENGINEERING
II B.TECH II - SEMESTER ASSIGNMENT TEST – II, MAY – 2021

SUBJECT: OPERATIONS RESEARCH **DATE:** 12-05-2021

DURATION: 30 MIN **MAX MARKS:** 10

<table>
<tr><th>Q. No</th><th>Questions</th><th>Course Outcome (CO)</th><th>Knowledge Level as Per Bloom's Taxonomy</th><th>Marks</th></tr>
<tr><td>1</td><td>The assignment costs of four operators to four machines are given in the following table
<table>
<tr><th></th><th></th><th colspan="4">Operators</th></tr>
<tr><th></th><th></th><th>I</th><th>II</th><th>III</th><th>IV</th></tr>
<tr><td rowspan="4">Machines</td><td>A</td><td>10</td><td>5</td><td>13</td><td>15</td></tr>
<tr><td>B</td><td>3</td><td>9</td><td>18</td><td>3</td></tr>
<tr><td>C</td><td>10</td><td>7</td><td>3</td><td>2</td></tr>
<tr><td>D</td><td>5</td><td>11</td><td>9</td><td>7</td></tr>
</table>
Find the optimal assignment using Hungarian method.</td><td>2</td><td>Creating (K6)</td><td>5</td></tr>
<tr><td>2</td><td>Solve the following assignment problems
<table>
<tr><th></th><th></th><th colspan="4">Machines</th></tr>
<tr><th></th><th></th><th>M_1</th><th>M_2</th><th>M_3</th><th>M_4</th></tr>
<tr><td rowspan="4">Jobs</td><td>J_1</td><td>18</td><td>26</td><td>17</td><td>11</td></tr>
<tr><td>J_2</td><td>13</td><td>28</td><td>14</td><td>26</td></tr>
<tr><td>J_3</td><td>38</td><td>19</td><td>18</td><td>15</td></tr>
<tr><td>J_4</td><td>19</td><td>26</td><td>24</td><td>10</td></tr>
</table></td><td>2</td><td>Creating (K6)</td><td>5</td></tr>
<tr><td>3</td><td>Solve the following assignment problems
<table>
<tr><th></th><th></th><th colspan="5">Machines</th></tr>
<tr><th></th><th></th><th>1</th><th>2</th><th>3</th><th>4</th><th>[illegible]</th></tr>
<tr><td rowspan="5">Operators</td><td>A</td><td>5</td><td>5</td><td>[illegible]</td><td>[illegible]</td><td>[illegible]</td></tr>
<tr><td>B</td><td>7</td><td>4</td><td>2</td><td>3</td><td>[illegible]</td></tr>
<tr><td>C</td><td>9</td><td>3</td><td>5</td><td>[illegible]</td><td>[illegible]</td></tr>
<tr><td>D</td><td>7</td><td>2</td><td>6</td><td>7</td><td>[illegible]</td></tr>
<tr><td>E</td><td>6</td><td>5</td><td>7</td><td>9</td><td>[illegible]</td></tr>
</table></td><td>2</td><td>Creating (K6)</td><td>5</td></tr>
<tr><td>4</td><td>A company has four salesmen A,B,C and D . These salesmen are to be allotted four districts 1,2,3 and 4.the estimated profit per day for each salesmen in each district is given in the following table
<table>
<tr><th></th><th>1</th><th>2</th><th>[illegible]</th><th>4</th></tr>
<tr><td>I</td><td>16</td><td>10</td><td>[illegible]</td><td>[illegible]</td></tr>
<tr><td>II</td><td>14</td><td>11</td><td>[illegible]</td><td>[illegible]</td></tr>
<tr><td>[illegible]</td><td>[illegible]</td><td>[illegible]</td><td>[illegible]</td><td>[illegible]</td></tr>
<tr><td>D</td><td>[illegible]</td><td>[illegible]</td><td>[illegible]</td><td>[illegible]</td></tr>
</table>
What is the optimal assigment which will yield maximum profite?</td><td>2</td><td>Creating (K6)</td><td>5</td></tr>
</table>

5	Three jobs are to be done by 4 machines. Each job can be assigned to one and only one machine. The cost of each job on each machine in the following table.	2	Creating (K6)	5

Job	M_1	M_2	M_3	M_4
J_1	18	24	28	32
J_2	8	13	17	19
J_3	10	15	19	22

What are the job assignments which will **minimize** the total cost?

6	**Solve** the travelling salesman problem with the following cost matrix	2	Creating (K6)	5

Cities

Cities	A	B	C	D
A	∞	46	16	[illegible]
B	41	∞	50	[illegible]
C	82	32	∞	[illegible]
D	40	40	36	[illegible]

7	**Solve** the following assignment problems	2	Creating (K6)	5

WORKERS		Jobs			
		J_1	J_2	J_3	J_4
	W_1	10	15	24	30
	W_2	16	20	28	10
	W_3	12	18	30	16
	W_4	9	24	32	18

8	**Explain** step by step procedure of Hungarian Method	2	Evaluating (K5)	5

9	**Obtain** an initial basic feasible solution, using the north-west corner rule for the following transportation problem	2	Evaluating (K5)	5

	D_1	D_2	D_3	D_4	Availability
S_1	6	8	8	5	30
S_2	5	11	9	7	40
S_3	8	9	7	13	50
Demand	35	28	32	25	120

NARASARAOPET ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET

DEPARTMENT OF MECHANICAL ENGINEERING

II B.TECH II - SEMESTER ASSIGNMENT TEST – III, JUNE – 2021

SUBJECT: OPERATIONS RESEARCH **DATE:** 08-06-2021

DURATION: 30 MIN **MAX MARKS:** 10

<table>
<tr><th>Q. No</th><th>Questions</th><th>Course Outcome (CO)</th><th>Knowledge Level as Per Bloom's Taxonomy</th><th>Marks</th></tr>
<tr><td>1</td><td>Find the sequence that minimizes the total elapsed time (in hours) required to complete the following tasks on two machines
<table>
<tr><td>Task</td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td><td>G</td><td>H</td><td>I</td></tr>
<tr><td>M1</td><td>2</td><td>5</td><td>4</td><td>9</td><td>6</td><td>8</td><td>7</td><td>5</td><td>4</td></tr>
<tr><td>M2</td><td>6</td><td>8</td><td>7</td><td>4</td><td>3</td><td>9</td><td>3</td><td>8</td><td>11</td></tr>
</table></td><td>3</td><td>Creating (K6)</td><td>10</td></tr>
<tr><td>2</td><td>We have five jobs, each of which must go through the machines A, B and C in the order ABC. Determine the sequence that will minimize the total elapsed time.
<table>
<tr><td>Job No.</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Machine A</td><td>5</td><td>7</td><td>6</td><td>9</td><td>5</td></tr>
<tr><td>Machine B</td><td>2</td><td>1</td><td>4</td><td>5</td><td>3</td></tr>
<tr><td>Machine C</td><td>3</td><td>7</td><td>5</td><td>6</td><td>7</td></tr>
</table></td><td>3</td><td>Creating (K6)</td><td>10</td></tr>
<tr><td>3</td><td>Four Jobs 1, 2, 3 and 4 are to be processed on each of the five machines A, B, C, D and E in the order ABCDE. Find the total minimum elapsed time if no passing of jobs is permitted. Also find the ideal time for each machine.
<table>
<tr><td rowspan="2">Machines</td><td colspan="4">Jobs</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>A</td><td>7</td><td>6</td><td>5</td><td>8</td></tr>
<tr><td>B</td><td>5</td><td>6</td><td>4</td><td>3</td></tr>
<tr><td>C</td><td>2</td><td>4</td><td>5</td><td>3</td></tr>
<tr><td>D</td><td>3</td><td>5</td><td>6</td><td>2</td></tr>
<tr><td>E</td><td>9</td><td>10</td><td>8</td><td>6</td></tr>
</table></td><td>3</td><td>Creating (K6)</td><td>10</td></tr>
<tr><td>4</td><td>A project schedule has the following characteristics.
<table>
<tr><td>Activity</td><td>1-2</td><td>1-3</td><td>2-4</td><td>3-4</td><td>3-5</td><td>4-9</td><td>5-6</td><td>5-7</td><td>6-8</td><td>7-8</td><td>8-10</td><td>9-10</td></tr>
<tr><td>Time (Days)</td><td>4</td><td>1</td><td>1</td><td>1</td><td>6</td><td>5</td><td>4</td><td>8</td><td>1</td><td>2</td><td>5</td><td>7</td></tr>
</table>
From the above information ,Obtain :
i. Construct a network diagram.
ii. Compute the earliest event time and latest event time.
iii. Determine the critical path and total project duration
iv. Compute total and free float for each activity.</td><td>3</td><td>Evaluating (K5)</td><td>10</td></tr>
<tr><td rowspan="2">5</td><td>a)A T.V machine finds that the time spent on his jobs has an exponential distribution with mean 30 minutes, if he repairs sets in the order in which they come in. if the arrival of sets is approximately poisson with average rate of 10 per eight-hour day, What is the mechanics expected idle time each day? How many jobs are ahead of the average set just brought in?</td><td>4</td><td>Evaluating (K5)</td><td>5</td></tr>
<tr><td>b)Explain the arrival pattern ,service pattern, queue discipline ,customer behavior</td><td>4</td><td>Evaluating (K5)</td><td>5</td></tr>
</table>

NARASARAOPET ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET
DEPARTMENT OF MECHANICAL ENGINEERING
II B.TECH II - SEMESTER ASSIGNMENT TEST – IV, July – 2021

SUBJECT: OPERATIONS RESEARCH **DATE:** 29-07-2021

DURATION: 30 MIN **MAX MARKS:** 10

<table>
<tr><th>Q.No</th><th>Questions</th><th>Course Outcome (CO)</th><th>Knowledge Level as Per Bloom's Taxonomy</th><th>Marks</th></tr>
<tr><td rowspan="2">1</td><td>a)A truck owner finds from his past records that the maintenance cost per year of a truck whose purchase price is Rs.8000, are given below:
<table>
<tr><td>Year</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td></tr>
<tr><td>Maintenance cost</td><td>1000</td><td>1300</td><td>1700</td><td>2200</td><td>2900</td><td>3800</td><td>4800</td><td>6000</td></tr>
<tr><td>Resale Price</td><td>4000</td><td>2000</td><td>1200</td><td>600</td><td>500</td><td>400</td><td>400</td><td>400</td></tr>
</table>
Determine at what time it is profitable to replace the truck?</td><td>5</td><td>Evaluating (K5)</td><td>5</td></tr>
<tr><td>b)A machine owner finds from his past records that the costs per year of maintaining a machine whose purchase price is Rs. 6000/- are as given below.
<table>
<tr><td>Year</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td></tr>
<tr><td>Maintenance cost</td><td>1000</td><td>1200</td><td>1400</td><td>1800</td><td>2300</td><td>2800</td><td>3400</td><td>4000</td></tr>
<tr><td>Resale price</td><td>3000</td><td>1500</td><td>750</td><td>375</td><td>200</td><td>200</td><td>200</td><td>200</td></tr>
</table>
Determine at what age a replacement is due.</td><td>5</td><td>Evaluating (K5)</td><td>5</td></tr>
<tr><td rowspan="2">2</td><td>a) The cost of a machine is Rs 61,000 and its scrap value is Rs 1,000. The maintenance costs found from past experiences are as follows.
<table>
<tr><td>Year</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td></tr>
<tr><td>Maintenance cost in Rupees</td><td>1000</td><td>2500</td><td>4000</td><td>6000</td><td>9000</td><td>12000</td><td>16000</td><td>20000</td></tr>
</table>
Determine the optimum replacement period of a machine.</td><td>5</td><td>Evaluating (K5)</td><td>5</td></tr>
<tr><td>b) A machine costs Rs 15,000. The running cost for different years are given bellow.
<table>
<tr><td>Year</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>Running cost</td><td>2500</td><td>3000</td><td>4000</td><td>5000</td><td>6500</td><td>8000</td><td>10000</td></tr>
</table>
Determine the optimum replacement period. if the capital is worth 10 percent per annum and has no salvage value.</td><td>5</td><td>Evaluating (K5)</td><td>5</td></tr>
<tr><td rowspan="2">3</td><td>a)List the characteristics of game theory?</td><td>5</td><td>Analyzing (K4)</td><td>5</td></tr>
<tr><td>b)Solve the following payoff matrix, also determine the optimal strategies and value of Game.
$$\begin{array}{cc} & B \\ A & \begin{bmatrix} 5 & 1 \\ 3 & 4 \end{bmatrix} \end{array}$$</td><td>5</td><td>Applying (K3)</td><td>5</td></tr>
</table>

<table>
<tr><td rowspan="2">4</td><td>a).solve the game whose payoff matrix is given below
$$\begin{bmatrix} -2 & 0 & 0 & 5 & 3 \\ 3 & 2 & 1 & 2 & 2 \\ -4 & -3 & 0 & -2 & 6 \\ 5 & 3 & -4 & 2 & -6 \end{bmatrix}$$</td><td>5</td><td>Applying (K3)</td><td>5</td></tr>
<tr><td>b) Explain different types of Games in Game theory.</td><td>5</td><td>Evaluating (K5)</td><td>5</td></tr>
<tr><td rowspan="2">5</td><td>a)The following mortality rates have been observed for a certain type of light bulbs.
<table><tr><td>Week</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr><tr><td>Percent failing by the end of week</td><td>10</td><td>25</td><td>50</td><td>80</td><td>100</td></tr></table>There are 1000 bulbs in use and its costs Rs.2 to replace an individual bulbs, which has burnt out. If all the bulbs were replaced simultaneously, it would cost 50 paise per bulb. It is proposed to replace all the bulbs at fixed intervals, whether or not they have burnt out and to continue replacing burnt out bulbs as they fail. Determine at what intervals should all the bulbs be replaced?</td><td>5</td><td>Evaluating (K5)</td><td>5</td></tr>
<tr><td>b)The probability P_n of failure just before age n is shown below. If individual replacement costs Rs.12.50 and group replacement costs Rs.3 per item. Determine the optimal replacement policy.
<table><tr><td>n</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr><tr><td>P_n</td><td>0.1</td><td>0.2</td><td>0.25</td><td>0.3</td><td>0.15</td></tr></table></td><td>5</td><td>Evaluating (K5)</td><td>5</td></tr>
</table>

NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET
DEPARTMENT OF MECHANICAL ENGINEERING
II B.TECH II-SEMESTER II-MID EXAMINATION, Aug- 2021

Subject: OPERATIONS RESEARCH　　　　　　Date :17-08-2021

Duration : 90 Min　　　　　　Max Marks: 25M

Answer All Questions

<table>
<tr><th colspan="2">Q. No</th><th>Questions</th><th>Course Outcome (CO)</th><th>Knowledge Level as Per Bloom's Taxonomy</th><th>Marks</th></tr>
<tr><td>1</td><td>a</td><td>A project schedule has the following characteristics.
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<tr><td>Activity</td><td>1-2</td><td>1-3</td><td>2-4</td><td>3-4</td><td>3-5</td><td>4-9</td><td>5-6</td><td>5-7</td><td>6-8</td><td>7-8</td><td>8-10</td><td>9-10</td></tr>
<tr><td>Time (Days)</td><td>4</td><td>1</td><td>1</td><td>1</td><td>6</td><td>5</td><td>4</td><td>8</td><td>1</td><td>2</td><td>5</td><td>7</td></tr>
</table>
From the above information ,Obtain :
i. Determine the critical path and total project duration
ii. Compute total and free float for each activity.</td><td>3</td><td>Evaluating (K5)</td><td>5</td></tr>
<tr><td>2</td><td>a</td><td>a)A T.V machine finds that the time spent on his jobs has an exponential distribution with mean 30 minutes, if he repairs sets in the order in which they come in. if the arrival of sets is approximately poisson with average rate of 10 per eight-hour day, What is the mechanics expected idle time each day? How many jobs are ahead of the average set just brought in?</td><td>4</td><td>Evaluating (K5)</td><td>5</td></tr>
<tr><td></td><td>b</td><td>Solve for the following LPP by Dynamic programming
Maximize $Z = 3x_1 + 5x_2$ subjected to constrains
$x_1 \le 4$, $x_2 \le 6$, $3x_2 + 2x_3 \le 18$, $x_1, x_2, x_3 \ge 0$</td><td>4</td><td>Applying (K3)</td><td>5</td></tr>
<tr><td>3</td><td>a</td><td>a)A truck owner finds from his past records that the maintenance cost per year of a truck whose purchase price is Rs.8000 are given below:
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$$\begin{array}{cc} & B \\ A & \begin{bmatrix} 5 & 1 \\ 3 & 4 \end{bmatrix} \end{array}$$</td><td>5</td><td>Applying (K3)</td><td>5</td></tr>
</table>

NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET
DEPARTMENT OF MECHANICAL ENGINEERING
II B.TECH II-SEMESTER I-MID EXAMINATION, Aug- 2021

Subject: OPERATIONS RESEARCH Date :17-08-2021

Duration : 90 Min Max Marks: 25M

Answer All Questions

Q. No		Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
1	a	**Explain** different types of models in operation research.	1	Evaluating (K5)	5
	b	a).**Maximize** $Z = 2x_1 + 4x_2 + x_3$ subjected to constrains $x_1 + 3x_2 \leq 4$, $2x_1 + x_2 \leq 3$, $x_2 + 4x_3 \leq 3$, $x_1, x_2, x_3 \geq 0$	1	Creating (K6)	5
2	a	**Explain** step by step procedure of Hungarian Method	2	Evaluating (K5)	5
	b	**Obtain** an initial basic feasible solution, using the north-west corner rule for the following transportation problem (see table below)	2	Evaluating (K5)	5
3	a	**Find** the sequence that minimizes the total elapsed time (in hours) required to complete the following tasks on two machines (see table below)	3	Creating (K6)	5

Table for Q2(b):

	D_1	D_2	D_3	D_4	Availability
S_1	6	8	8	5	30
S_2	5	11	9	7	40
S_3	8	9	7	13	50
Demand	35	28	32	25	120

Table for Q3(a):

Task	A	B	C	D	E	F	G	H	I
M1	2	5	4	9	6	8	7	5	4
M2	6	8	7	4	3	9	3	8	11

NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS) : NARASARAOPET

(R20) 2020 BATCH III B.TECH I SEM ASSIGNMENT TEST MARKS - AWARD LIST -2022

Branch : ME-B Subject: OR Date: 03/9/2022

SNO.	H.T.NO.	Q.NO.	CO	MARKS	Q.NO.	CO	MARKS	TOTAL MARKS (10M)	REDUCED MARKS (5M)
1	20471A0357				AB				
2	20471A0358	5	1	5	5	1	5	10	5
3	20471A0359	2	1	4	2	1	4	8	4
4	20471A0360				AB				
5	20471A0361				AB				
6	20471A0362	1	1	5	1	1	5	10	5
7	20471A0363							AB	AB
8	20471A0364							AB	AB
9	20471A0365							AB	AB
10	20471A0366							AB	AB
11	20471A0367							AB	AB
12	20471A0368							AB	AB
13	20471A0369							AB	AB
14	20471A0370							AB	AB
15	20471A0371	4	1	5	4	1	5	10	5
16	20471A0372	5	1	5	5	5	1	10	5
17	20471A0373							AB	AB
18	20471A0374							AB	AB
19	20471A0375							AB	AB
20	20471A0376							AB	AB
21	21475A0301	1	1	5	1	1	5	10	5
22	21475A0302	4	1	5	4	1	5	10	5
23	21475A0303	3	1	5	5	3	1	10	5
24	21475A0304							A	A
25	21475A0305	5	1	5	5	1	5	10	5
26	21475A0306	1	1	5	1	1	5	10	5
27	21475A0307							A	A
28	21475A0308	4	1	5	4	1	5	10	5
29	21475A0309	4	1	5	4	1	5	10	5
30	21475A0310	5	1	5	5	1	5	10	5
31	21475A0311	1	1	4	1	1	4	8	4
32	21475A0312	3	1	5	5	1	5	10	5
33	21475A0313	1	1	5	1	1	5	10	5
34	21475A0314	1	1	4	1	1	4	8	4
35	21475A0315	3	1	5	3	1	5	10	5

Branch : ME-B Subject: OR Date: 3/9/22

SNO.	H.T.NO.	Q.NO.	CO	MARKS	Q.NO.	CO	MARKS	TOTAL MARKS (10M)	REDUCED MARKS (5M)
36	21475A0316	4	1	5					
37	21475A0317	2	1	5	4	1	5	10	5
38	21475A0318	3	1	5	2	1	5	10	5
39	21475A0319	3	1	5	3	1	5	10	5
40	21475A0320	3	1	5	3	1	5	10	5
41	21475A0321	2	1	5	3	1	5	10	5
42	21475A0322	2	1	5	2	1	5	10	5
43	21475A0323	2	1	5	2	1	5	10	5
44	21475A0324	3	1	5	2	1	5	10	5
45	21475A0325	5	1	5	3	1	5	10	5
46	21475A0326				5	1	5	10	5
47	21475A0327	5	1	5				A	A
48	21475A0328	5	1	5	5	1	5	10	5
49	21475A0329	4	1	5	5	1	5	10	5
50	21475A0330	2	1	5	4	1	5	10	5
51	21475A0331	4	1	5	2	1	5	10	5
52	21475A0332	4	1	5	4	1	5	10	5
53	21475A0333	1	1	5	4	1	5	10	5
54	21475A0334	2	1	5	1	1	5	10	5
55	21475A0335	4	1	5	2	1	5	10	5
					4	1	5	10	5

K. John Babu

Name of the Staff Member

Signature of the Staff Member

Signature of the HOD

NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS) : NARASARAOPET

(R20) 2020 BATCH III B.TECH I SEM MID-I MARKS - AWARD LIST SEPT -2022

Date: 23/9/22.

Branch : ME-A Subject: OR

SNO.	H.T.NO.							Total	Reduced Total	Quiz-II
		CO	1	2	2	3		25	15	10
		Max.Marks	10	5	5	5				
		Q.NO	1	2	2	3				
1	20471A0301					4		4	3	10
2	20471A0302		3	5	2	5		15	9	4
3	20471A0303							AB	AB	AB
4	20471A0304							0	0	6
5	20471A0305			2	4	1		7	5	7
6	20471A0306			4	3	4		11	7	7
7	20471A0307		5	4	3	4		16	10	3
8	20471A0308		1	4		4		9	6	10
9	20471A0309				1	5		6	4	8
10	20471A0310				2	4		6	4	4
11	20471A0311							0	0	AB
12	20471A0312				4	4		8	5	7
13	20471A0313			4	2	4		10	6	3
14	20471A0314							AB	AB	AB
15	20471A0315		5			4		9	6	7
16	20471A0316				3	3		6	4	5
17.	20471A0317			5	5	4		14	9	6
18	20471A0318							0	AB	AB
19	20471A0319			5	5	5		15	9	8
20	20471A0320		3					3	2	5
21	20471A0321			4	3	5		12	8	8
22	20471A0323					5		5	3	5
23	20471A0324							AB	AB	AB
24	20471A0325							0	0	5
25	20471A0326		9	5	1	5		20	12	10
26	20471A0327					5		5	3	2
27	20471A0328			1		5		6	4	6
28	20471A0329		2		4	5		11	7	6
29	20471A0330							AB	AB	AB
30	20471A0331		6		1	2		9	4	10
31	20471A0332		2	5	4	5		16	10	6
32	20471A0333			4	2	4		10	6	10
33	20471A0334									

34	20471A0336							AB	AB	AB
35	20471A0337		9	4	4	3		20	12	9
36	20471A0338		2	4		4		10	6	4
37	20471A0339							AB	AB	AB
38	20471A0341			3	2	3		8	5	5
39	20471A0342							AB	AB	AB
40	20471A0343		2			4		6	4	10
41	20471A0344							0	0	6
42	20471A0345				3	4		7	5	3
43	20471A0346							AB	AB	AB
44	20471A0347							AB	AB	AB
45	20471A0348		10	5	4	5		24	15	9
46	20471A0349		10	4	4	5		23	14	9
47	20471A0350		8	3	2	2		15	9	5
48	20471A0351							AB	AB	A[illegible]
49	20471A0352		1		4	4		9	6	7
50	20471A0353							0	0	3
51	20471A0354				4	5		9	6	9
52	20471A0356		4	3	3	3		13	8	16

K. John Babu

Name of the Staff Member

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Signature of the HOD

NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS) : NARASARAOPET

(R20) 2020 BATCH III B.TECH I SEM MID-I MARKS - AWARD LIST SEPT-2022

Branch : ME-B Subject: OR Date: 23/9/22

SNO.	H.T.NO.	CO	1	2	2	3		Total	Total	Quiz-I
		Max.Marks	10	5	5	5		25	15	10
		Q.NO	1	2	2	3				
1	20471A0357		2	2	1	2		7	5	9
2	20471A0358		7	4	4	5		20	12	8
3	20471A0359				2	5		7	5	7
4	20471A0360			4	4	4		12	8	3
5	20471A0361		4	4	4	4		16	10	9
6	20471A0362		6		4	5		15	9	9
7	20471A0363		4		4	4		12	8	10
8	20471A0364		6	3		4		13	8	8
9	20471A0365			3		1		4	3	6
10	20471A0366			4	3	4		11	7	9
11	20471A0367							AB	AB	AB
12	20471A0368		6	3		3		12	8	4
13	20471A0369		4		4	3		11	7	7
14	20471A0370				3	4		7	5	3
15	20471A0371			2		5		7	5	10
16	20471A0372		6	4	3	5		18	11	7
17	20471A0373		6	4	3	4		17	11	10
18	20471A0374					5		5	3	10
19	20471A0375							0	0	3
20	20471A0376							0	0	4
21	21475A0301		8	4	5	5		22	14	10
22	21475A0302		10	4	5	5		24	15	10
23	21475A0303			3	4	4		11	7	8
24	21475A0304							AB	AB	AB
25	21475A0305		9	5		4		18	11	7
26	21475A0306		10	5	4	5		24	15	10
27	21475A0307		6		2			8	5	8
28	21475A0308			2	3	3		8	5	7
29	21475A0309		2			4		6	4	7
30	21475A0310			5		4		9	6	7
31	21475A0311			5		3		8	5	4
32	21475A0312		6	4	2	5		17	11	5
33	21475A0313		1	3	3	3		10	6	8

Branch : ME-B Subject: OR Date: 23/9/22

SNO.	H.T.NO.	CO	1	2	2	3		Total	R Total	Quiz-I
		Max.Marks	10	5	5	5		25	15	10
		Q.NO	1	2	2	3				
34	21475A0314				4	3		7	5	3
35	21475A0315		6		3	5		14	9	7
36	21475A0316		9	5	4	5		23	14	8
37	21475A0317		7	5	2	5		19	12	6
38	21475A0318		8	4	3	4		19	12	8
39	21475A0319		4		4	4		12	8	6
40	21475A0320		10	5	4	5		24	15	10
41	21475A0321			4		4		8	5	10
42	21475A0322		10	3	3	5		21	13	9
43	21475A0323		8	4	4	5		21	13	8
44	21475A0324		8	5	4	5		22	14	9
45	21475A0325		2	1	2			5	3	9
46	21475A0326							0	0	7
47	21475A0327		5	5	4	4		18	11	8
48	21475A0328		8	4	2	5		19	12	7
49	21475A0329		5			5		10	6	4
50	21475A0330		10	5	4	5		24	15	10
51	21475A0331		8	5	4	5		22	13	6
52	21475A0332			5	3	5		13	8	6
53	21475A0333		6		4	4		14	9	10
54	21475A0334		8	4	4	4		20	12	3
55	21475A0335		6	3	3	4		16	10	6

K. John Babu

Name of the Staff Member

Signature of the Staff Member

Signature of the HOD

NARASARAOPETA ENGINEERING COLLEGE(AUTONOMOUS)
DEPARTMENT OF MECHANICAL ENGINEERING
III B.TECH I MID-II EXAMINATIONS- NOVEMBER-2022
OPERATION RESEARCH

DATE:22-11-2022

SECTION-B

S.NO	ROLL NO	CO	3	4		5		TOTAL MARKS (25)	TOTAL MARKS (15)	OBJ (10)
		Q.NO	1(a)	2(a)	2(b)	3(a)	3(b)			
		Max. Marks	5	5	5	5	5			
1	20471A0357		5	5	5	5	5	25	15	6
2	20471A0358		5	5	5	4	5	24	15	10
3	20471A0359		5	4	5	5	5	24	15	9
4	20471A0360		5	5	5	4	5	24	15	8
5	20471A0361		5	5	5	3	5	23	14	7
6	20471A0362		5	5	5	4	5	24	15	10
7	20471A0363		3	5	5	3	5	21	13	9
8	20471A0364		3	5	5	1	4	18	11	7
9	20471A0365		AB							
10	20471A0366		5	5	5	5	5	25	15	7
11	20471A0367		5	5	5	5	5	25	15	8
12	20471A0368		5	5	5	2	5	22	14	10
13	20471A0369		5	5	4	4		18	11	8
14	20471A0370		5		5	5	5	20	12	5
15	20471A0371		5	5	5		5	20	12	9
16	20471A0372		5		5		5	15	9	10
17	20471A0373		5	5	5	2	5	22	14	10
18	20471A0374		AB							
19	20471A0375		5	5	5	4	5	24	15	8
20	20471A0376		5	5	5	4	5	24	15	8
21	21475A0301		5	5	5	5	5	25	15	9
22	21475A0302		5	5	5	5	5	25	15	10
23	21475A0303		5	5	5	5	5	25	15	9
24	21475A0304		AB							
25	21475A0305		5	5	5	5	5	25	15	9
26	21475A0306		5	5	5	5	5	25	15	9
27	21475A0307		5	5	5	5	5	25	15	8
28	21475A0308		5	5	5	5	5	25	15	6
29	21475A0309		5	5	5	5	5	25	15	9
30	21475A0310		5	5	5	3	5	23	14	10
31	21475A0311		5	5	5	2	5	22	14	8
32	21475A0312		5	5	5	3		18	11	9

33	21475A0313		4	5	5	3	2	19	12	10
34	21475A0314			5	5	5		15	9	9
35	21475A0315		5	5	5	5	5	25	15	8
36	21475A0316		5	5	5	5	5	25	15	8
37	21475A0317		5	5	5	5	5	25	15	10
38	21475A0318		5	5	5	5	5	25	15	10
39	21475A0319		5	5	5	5	5	25	15	10
40	21475A0320		5	5	5	5	5	25	15	10
41	21475A0321		5	5	5	5	5	25	15	10
42	21475A0322		5	5	5	5	5	25	15	10
43	21475A0323		5	5	5	5	5	25	15	10
44	21475A0324		5	5	5	5	5	25	15	10
45	21475A0325		5	5	5	5	5	25	15	10
46	21475A0326		5	5	5	5	5	25	15	7
47	21475A0327		5	5	5	5	5	25	15	8
48	21475A0328		5	5	5	5	5	25	15	8
49	21475A0329		5	5	5	5	5	25	15	4
50	21475A0330		5	5	5	5	5	25	15	10
51	21475A0331		5	5	5	5	5	25	15	9
52	21475A0332		5	5	5	5	5	25	15	10
53	21475A0333		5	5	5	5	5	25	15	8
54	21475A0334		5	5	5	5	5	25	15	7
55	21475A0335		5	5	5	4	5	24	15	3

No.of Present: 52
No.of Absent: 03
Total No.of Students: 55

Signature of Faculty

Signature of HOD

NARASARAOPETA ENGINEERING COLLEGE(AUTONOMOUS)
DEPARTMENT OF MECHANICAL ENGINEERING
III B.TECH I MID-II EXAMINATIONS- NOVEMBER-2022
OPRATION RESEARCH

SECTION-A **DATE:22-11-2022**

S.NO	ROLL NO	CO	3	4		5		TOTAL MARKS (25)	TOTAL MARKS (15)	OBJ (10)
		Q.NO	1(a)	2(a)	2(b)	3(a)	3(b)			
		Max. Marks	5	5	5	5	5			
1	20471A0301		4	5	5	5	5	24	15	10
2	20471A0302		5	5	5	5	5	25	15	10
3	20471A0303		4		5	5	5	19	12	8
4	20471A0304		3	5		5	5	18	11	10
5	20471A0305		3		5		3	11	7	4
6	20471A0306		5	5	5		5	20	12	9
7	20471A0307		5	5	5	5	5	25	15	9
8	20471A0308		5	5	5	1	5	21	13	9
9	20471A0309		4	5	5		5	19	12	10
10	20471A0310		4	5	5		5	19	12	8
11	20471A0311		AB							
12	20471A0312		3	5	5	3	5	23	14	10
13	20471A0313		5	5	5	3	5	23	14	6
14	20471A0314		5	5	5	3	5	23	14	10
15	20471A0315		5	3	5	3	5	21	13	9
16	20471A0317		2	2	5		5	14	9	10
17	20471A0318		5	5	5		5	20	12	10
18	20471A0319		AB							
19	20471A0320		5		5	3	5	18	11	10
20	20471A0321		3	5		5		13	8	9
21	20471A0323		3		5	5	5	18	11	9
22	20471A0324				5	5	5	15	9	8
23	20471A0325		3	3	5	5	5	21	13	9
24	20471A0326		3	5	4	5	5	22	14	10
25	20471A0327		5	5	5	2	5	22	14	9
26	20471A0328		4	5	5	5	5	24	15	8
27	20471A0329		5	3	5	2	5	20	12	9
28	20471A0330		AB							
29	20471A0331		3	5	5	5	5	23	14	10
30	20471A0332		5	5	5	4	5	24	15	7
31	20471A0333		4	5	4	5	5	23	14	9
32	20471A0334		2		5	1	5	13	9	10
33	20471A0336		AB							

34	20471A0337		5	5	5	3	5	23	14	10
35	20471A0338		5	5	5	3	5	23	14	8
36	20471A0339		5	5	5	2	5	22	14	3
37	20471A0341		4	1	5	2	5	17	11	8
38	20471A0342		**AB**							
39	20471A0343		5	5	5	3	5	23	14	10
40	20471A0344			5	5	3	5	18	11	10
41	20471A0345			5	5	4	5	19	12	10
42	20471A0346		5	5	5	3	5	23	14	10
43	20471A0347		**AB**							
44	20471A0348		5	5	5	5	5	25	15	10
45	20471A0349		5	5	5	5	5	25	15	10
46	20471A0350		5		5	5	5	20	12	6
47	20471A0351		**AB**							
48	20471A0352		5	5	5	5	5	25	15	9
49	20471A0353		5	5	5	5	5	25	15	7
50	20471A0354		3	5	5	5	5	23	14	9
51	20471A0356		4	5		5	5	19	12	9

No.of Present: 44
No.of Absent: 07
Total No.of Students: 51

Signature of Faculty

Signature of HOD

NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS) : : NARASARAOPET

(R19) 2019 BATCH II B.TECH II SEM I MID EXAMINATION MARKS - AWARD LIST AUG - 2021

Branch : ME - A Subject: operations Research Date: 17/08/21

Sl.No.	H.T.NO.		DESCRIPTIVE								OBJECTIVE
		CO No.	1	1	2	2	3		Total Marks (25M)	Total Marks (20M)	Quiz-1 (10M)
		Max.Marks	5	5	5	5	5				
		Q.No.	1 (a)	1 (b)	2 (a)	2 (b)	3 (a)	3 (b)			
1	19471A0301			2		3	5		10	08	03
2	19471A0302			2		4	5		11	09	07
3	19471A0303			2		4	5		11	09	07
4	19471A0304			3		5	5		13	11	03
5	19471A0305		5	4	5	5	5		24	20	08
6	19471A0306		4		4	5	3		16	13	03
7	19471A0307		4	3	4	1	5		17	14	08
8	19471A0308		5	3	4	5	5		22	18	08
9	19471A0309			3		5	5		13	11	04
10	19471A0310		4	2		5	2		13	11	09
11	19471A0311		4	2		5	4		15	12	03
12	19471A0312			4		4	5		13	11	04
13	19471A0313		4	2	4	1	5		16	13	01
14	19471A0315		4		4	1	5		14	12	08
15	19471A0316		4	5	5	5	5		24	20	10
16	19471A0317					4	5		09	08	03
17	19471A0318				5		4		09	08	10
18	19471A0319		4	2	1	5	4		16	13	08
19	19471A0320		5	5	5	5	5		25	20	10
20	19471A0321		3	4	4		5		16	13	08
21	19471A0322		0	-	-	-	-		AB	00	AB
22	19471A0323		0		0	1			01	01	02
23	19471A0324			1		1	1		03	03	09
24	19471A0325		-	-	-	-	-		AB	00	AB
25	19471A0326		5	5	5	5	5		25	20	09
26	19471A0327		5	3	3	5	5		21	17	04
27	19471A0328		3	1	1	2	5		12	10	10
28	19471A0329		3	5	4	5	5		22	18	10
29	19471A0330			4	1	3	2		10	08	09
30	19471A0331		1	5	2	2	2		12	10	04
31	19471A0332		-	-		-	-		AB	00	AB
32	19471A0333		4	5	4	5	5		23	19	09
33	19471A0334		-	-	-	-	-		AB	00	AB
34	19471A0335		-	-	-	-	-		AB	00	AB
35	19471A0336		5	4	5	5	5		24	20	03
36	19471A0337			1	1	5	4		11	09	08

Sl.No.	H.T.NO.	CO No.	1	1	2	2	3		Total Marks (25M)	Total Marks (20M)	Quiz-1 (10M)
		Max.Marks	5	5	5	5	5				
		Q.No.	1 (a)	1 (b)	2 (a)	2 (b)	3 (a)	3 (b)			
37	19471A0338		5	5	5	5	5		25	20	10
38	19471A0339		2	5	5	5	5		22	18	09
39	19471A0340		4	3	2	2			11	09	02
40	19471A0341		2	5	4	5			16	13	08
41	19471A0342			4	5	2	5		16	13	06
42	19471A0343		0	5	5	5	5		20	16	08
43	19471A0344		4	4	4	5	5		22	18	04
44	19471A0345		-	-	-	-	-		AB	00	AB
45	20475A0354		3	1		2	5		11	09	06
46	20475A0355		5		0	5	5		15	12	08
47	20475A0356		5	2	5	5	5		22	18	10
48	20475A0357		4	4	5	4	5		22	18	05
49	20475A0358		5	1	4	5	4		19	16	05
50	20475A0359		4	3	4	5	5		21	17	07
51	20475A0360		5	2		5	5		17	14	07
52	20475A0361		4	3	4	5	5		21	17	08
53	20475A0362		2	2	2	4	5		15	12	08
54	20475A0363		5	4	5	5	5		24	20	08
55	20475A0364		4	4	4	5	5		22	18	10
56	20475A0365		5	3	5	5	5		23	19	10
57	20475A0366		5	0	4	5	4		18	15	08

Name of the Staff Member CH. SEKHAR

Signature of the Staff Member

Signature of the HOD

NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS) : : NARASARAOPET

(R19) 2019 BATCH II B.TECH II SEM I MID EXAMINATION MARKS - AWARD LIST AUG - 2021

Branch : ME - B   Subject: Operations Research   Date: 17/08/21

Sl.No.	H.T.NO.		DESCRIPTIVE						Total Marks (25M)	Total Marks (20M)	OBJECTIVE Quiz-1 (10M)
		CO No.	01	01	2	2	3				
		Max.Marks	5	5	5	5	5				
		Q.No.	1 (a)	1 (b)	2 (a)	2 (b)	3 (a)	3 (b)			
1	20475A0301			4	4	5	5		18	15	07
2	20475A0302			3	3	5	5		16	13	08
3	20475A0303		5	2	5	5	5		22	18	07
4	20475A0304		5	2	5		5		17	14	07
5	20475A0305		2		3	5	5		15	12	07
6	20475A0306		4	3	4	3	5		19	16	06
7	20475A0307		5		4	5	5		19	16	10
8	20475A0308		4	2	5	5	5		21	17	10
9	20475A0309		4	4	4	5	5		22	18	10
10	20475A0310		5	4		5	4		18	15	10
11	20475A0311		5	4	5	5	5		24	20	09
12	20475A0312		2		4	5	5		16	13	07
13	20475A0313		4	1	4	2	3		14	12	07
14	20475A0314		4	3	3	4	5		19	16	08
15	20475A0315		2	4	4	5	5		20	16	09
16	20475A0316		5	3	4	5	5		22	18	10
17	20475A0317		4	0	4	5	5		18	15	09
18	20475A0318		4	5	5	5	5		24	20	10
19	20475A0319		4	5	1	5	5		20	16	09
20	20475A0320		2	2	3	4	3		14	12	07
21	20475A0321		5	5	5	5	5		25	20	06
22	20475A0322		5	3	4	5	5		22	18	04
23	20475A0323		4	3	5	5	5		22	18	08
24	20475A0324			3	5	5	5		18	15	10
25	20475A0325		4	2		5	4		15	12	10
26	20475A0326		5	2	2	5	5		19	16	08
27	20475A0327		5	3	5	5	5		23	19	09
28	20475A0328		5	2	3	5	5		20	16	09
29	20475A0329		-	-	-	-	-	-	AB	00	AB
30	20475A0330		5	4	5	5	5		24	20	09
31	20475A0331		3	4	5	5	5		22	18	06
32	20475A0332		3	2	5	5	5		20	16	06
33	20475A0333		4	4	5	5	5		23	19	06
34	20475A0334		2	4	4	5	5		20	16	06
35	20475A0335		4	3	5	5	5		22	18	09
36	20475A0336		4	4	5	4	5		22	18	10

Sl.No.	H.T.NO.	CO No.	1	1	2	2	3		Total Marks (25M)	Total Marks (20M)	Quiz-1 (10M)
		Max.Marks	5	5	5	5	5				
		Q.No.	1 (a)	1 (b)	2 (a)	2 (b)	3 (a)	3 (b)			
37	20475A0337		4	4	4	5	5		22	18	09
38	20475A0338		4	4	5	5	5		23	19	10
39	20475A0339		3	3	2	5	5		18	15	10
40	20475A0340		2	3		4	5		14	12	10
41	20475A0341		4	2	5	5	5		21	17	10
42	20475A0342		4	1	3	4	5		17	14	08
43	20475A0343		2	2	5	5	5		19	16	10
44	20475A0344		4		2	5	5		16	13	09
45	20475A0345		4	2	4	5	5		20	16	10
46	20475A0346		3	3	2	2	4		14	12	10
47	20475A0347		4	2	4	5	5		20	16	10
48	20475A0348		4	4	4	5	5		22	18	10
49	20475A0349		3	2	4	5	5		19	16	09
50	20475A0350		4	3	4	4	5		20	16	09
51	20475A0351		5	1	4	5	5		20	16	10
52	20475A0352		4	3	3	4	4		18	15	08
53	20475A0353		4	3	4	5	5		21	17	08

CH. S[illegible]
Name of the Staff Member

Signature of the Staff Member

Signature of the HOD

NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS) : : NARASARAOPET

(R19) 2019 BATCH II B.TECH II SEM II MID EXAMINATION MARKS - AWARD LIST AUG - 2021

Branch : ME - A   Subject: Operations Research   Date: 17/08/21

Sl.No.	H.T.NO.		DESCRIPTIVE								OBJECTIVE
		CO No.	3		4	4	5	5	Total Marks (25M)	Total Marks (20M)	Quiz-2 (10M)
		Max.Marks	5		5	5	5	5			
		Q.No.	1 (a)	1 (b)	2 (a)	2 (b)	3 (a)	3 (b)			
1	19471A0301				5		5	5	15	12	04
2	19471A0302				5		5	5	15	12	07
3	19471A0303		2		5	5	5	5	22	18.	09
4	19471A0304				5	3	5	5	18	15.	09
5	19471A0305		4		5	3	5	5	22	18.	10
6	19471A0306				5		5	5	15	12	05
7	19471A0307		1		5	5	5	5	21	17.	07
8	19471A0308		1		5	4	5	5	20	16.	07
9	19471A0309				5	4	5	5	19	16.	05
10	19471A0310		4		5		5	5	19	16.	06
11	19471A0311		4		5		5	5	19	16	07
12	19471A0312		4		5	1	5	5	20	16.	09
13	19471A0313		1		4	4	5	5	19	16	07
14	19471A0315		4		5	5	4	5	23	19.	07
15	19471A0316		5		5	5	5	5	25	20.	10
16	19471A0317		4			4		4	12	10	00
17	19471A0318		1		5		5	5	16	13.	03
18	19471A0319		4		5		4	5	18	15.	08
19	19471A0320		5		5	5	5	5	25	20.	10
20	19471A0321		5		5			4	14	12	10
21	19471A0322		1			2	5	2	10	08	03
22	19471A0323		4				5	5	14	12.	10
23	19471A0324		4		5		4	5	18	15	09
24	19471A0325		–		–		–	–	AB	00.	AB
25	19471A0326		4		5	5	5	5	24	20	08
26	19471A0327		3		5	5	5	5	23	19.	08
27	19471A0328				5	3	5	4	17	14	10
28	19471A0329		1		5	4	5	5	20	16.	06
29	19471A0330								00	00,	03
30	19471A0331				5	5	5	5	20	16.	02
31	19471A0332		–		–	–	–	–	AB	00	AB
32	19471A0333		4		5	5	5	5	24	20.	10
33	19471A0334		–		–	–	–	–	AB	00	AB
34	19471A0335		4		5	2	4	3	18	15.	03
35	19471A0336		4		5	5	5	5	24	20	09
36	19471A0337		4		4	4	4	4	20	16	08

Sl.No.	H.T.NO.	CO No.	3		4	4	5	5	Total Marks (25M)	Total Marks (20M)	Quiz-2 (10M)
		Max.Marks	5		5	5	5	5			
		Q.No.	1 (a)	1 (b)	2 (a)	2 (b)	3 (a)	3 (b)			
37	19471A0338		4		5	5	4	5	23	19	10
38	19471A0339		4		5	4	5	5	23	19	09
39	19471A0340		4		5	5	5	5	24	20	09
40	19471A0341		4		5	5	5	5	24	20	10
41	19471A0342		4		5	5	5	5	24	20	09
42	19471A0343		4		5	5	5	5	24	20	09
43	19471A0344		4		5	5	5	5	24	20	10
44	19471A0345		-		-	-	-	-	AB	00	AB
45	20475A0354		4		5		5	5	19	16	08
46	20475A0355		5		5		5	5	20	16	07
47	20475A0356		4		5		4	5	18	15	08
48	20475A0357		4		5	2	5	5	21	17	05
49	20475A0358		4		4	2	5	5	20	16	10
50	20475A0359		4		5	4	5	5	23	19	09
51	20475A0360		4		5	4	5	4	22	18	10
52	20475A0361		5		5	4	5	4	23	19	09
53	20475A0362		4		5	5	4	4	22	18	08
54	20475A0363		2		5	5	5	5	22	18	10
55	20475A0364		4		5	5	5	5	24	20	10
56	20475A0365		4		4	1	4	4	17	14	10
57	20475A0366		4				4	5	13	11	10

Name of the Staff Member CH. SEKHAR

Signature of the Staff Member ch.

Signature of the HOD

NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS) : : NARASARAOPET

(R19) 2019 BATCH II B.TECH II SEM II MID EXAMINATION MARKS - AWARD LIST AUG - 2021

Branch : ME - B Subject: operations Research Date: 17/08/21

Sl.No.	H.T.NO.		DESCRIPTIVE								OBJECTIVE
		CO No.	3		4	4	5	5	Total Marks (25M)	Total Marks (20M)	Quiz-~~1~~ 2 (10M)
		Max.Marks	5		5	5	5	5			
		Q.No.	1 (a)	1 (b)	2 (a)	2 (b)	3 (a)	3 (b)			
1	20475A0301		5		5	5	5		20	16	09
2	20475A0302		5		5		5	5	20	16	09
3	20475A0303		5		5		5	5	20	16	09
4	20475A0304		5		5		5	5	20	16	10
5	20475A0305		4		5		5	5	19	16.	10
6	20475A0306		4		5	2	4	5	20	16.	10
7	20475A0307		5		5		5	5	20	16	10
8	20475A0308		5		5		5	5	20	16.	10
9	20475A0309		5		5		5	5	20	16.	10
10	20475A0310		5		5		5	5	20	16.	10
11	20475A0311		5		5	1	5	5	21	17	10
12	20475A0312		5		5	2	5	5	22	18.	09
13	20475A0313		5		5	5	5	5	25	20.	09
14	20475A0314		5		5	5	5	5	25	20.	08
15	20475A0315		5		5	5	5	5	25	20	10
16	20475A0316		5		5	5	5	5	25	20.	07
17	20475A0317		3		5		5	5	18	15.	10
18	20475A0318		5		5	5	5	5	25	20.	09
19	20475A0319		5		5	5	5	5	25	20	09
20	20475A0320		5		5	2	5	5	22	18	08
21	20475A0321		5		5	5	5	5	25	20	08
22	20475A0322		5		5	5	5	5	25	20.	10
23	20475A0323		5		5	5	5	5	25	20	10
24	20475A0324		5		5	0	5	5	20	16.	10
25	20475A0325		4		5	4	5	5	23	19.	10
26	20475A0326		5		5	3	5	5	23	19	09
27	20475A0327		5		5	2	5	5	22	18.	10
28	20475A0328		4			5	5	5	19	16.	10
29	20475A0329		-		-	-	-	-	AB	00.	AB
30	20475A0330		5		5	5	5	5	25	20	10
31	20475A0331		5		5	5	5	5	25	20	10
32	20475A0332		4		4	1	5	5	19	16.	09
33	20475A0333		4		5	5	5	5	24	20	10
34	20475A0334		3		5		4	5	17	14	07
35	20475A0335		3		5		5	5	18	15	09
36	20475A0336		4		5	1	5	5	20	16	10

Sl.No.	H.T.NO.	CO No.	3		4	4	5	5	Total Marks (25M)	Total Marks (20M)	Quiz-2 (10M)
		Max.Marks	5		5	5	5	5			
		Q.No.	1 (a)	1 (b)	2 (a)	2 (b)	3 (a)	3 (b)			
37	20475A0337		4		5	1	5	5	20	16	08
38	20475A0338		4		5	2	5	5	21	17	09
39	20475A0339		4		5	2	5	5	21	17	09
40	20475A0340		2		4		4	5	15	12	10
41	20475A0341		4		5		5	5	19	16	10
42	20475A0342		4		5		5	4	18	15	06
43	20475A0343		4		5		5	5	19	16	09
44	20475A0344		2		5		2		09	08	08
45	20475A0345		4		5	1	4	5	19	16	10
46	20475A0346		3		5		4	4	16	13	10
47	20475A0347				5	4	5	5	19	16	09
48	20475A0348		4		5	2	4	5	20	16	10
49	20475A0349		2		5	2	5	5	19	16	09
50	20475A0350				5		5	5	15	12	10
51	20475A0351				5	1		5	11	09	08
52	20475A0352				5		4	5	14	12	10
53	20475A0353		4			5	5	5	19	16	08

Name of the Staff Member CH. SEKHAR

Signature of the Staff Member

Signature of the HOD

NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS) : : NARASARAOPET

(R19) 2019 BATCH II B.TECH II SEM I-ASSIGNMENT TEST MARKS - AWARD LIST -2021

Branch : ME-A Subject: Operations Research Date:19-06-21

SNO.	H.T.NO.	Q.NO.	CO	MARKS	Q.NO.	CO	MARKS	TOTAL MARKS (10M)
1	19471A0301	4(a)	1		4(b)	1		AB
2	19471A0302	3(a)	1	7	3(a)	1	3	10
3	19471A0303	2(a)	1	3	2(a)	1	7	10
4	19471A0304	1(a)	1	7	1(a)	1	3	10
5	19471A0305	5(a)	1	7	5(a)	1	3	10
6	19471A0306	4(a)	1	7	4(b)	1	3	10
7	19471A0307	3(a)	1		3(a)	1		AB
8	19471A0308	2(a)	1	3	2(a)	1	5	8
9	19471A0309	1(a)	1	7	1(a)	1	3	10
10	19471A0310	5(a)	1	6	5(a)	1	3	9
11	19471A0311	4(a)	1	6	4(b)	1	3	9
12	19471A0312	3(a)	1	5	3(a)	1	3	8
13	19471A0313	2(a)	1	3	2(a)	1	6	9
14	19471A0315	1(a)	1	7	1(a)	1	3	10
15	19471A0316	5(a)	1	6	5(a)	1	3	9
16	19471A0317	4(a)	1		4(b)	1		AB
17	19471A0318	3(a)	1	7	3(a)	1	3	10
18	19471A0319	2(a)	1	3	2(a)	1	6	9
19	19471A0320	1(a)	1	7	1(a)	1	3	10
20	19471A0321	5(a)	1	7	5(a)	1	3	10
21	19471A0322	4(a)	1		4(b)	1		AB
22	19471A0323	3(a)	1	7	3(a)	1	3	10
23	19471A0324	2(a)	1	3	2(a)	1	7	10
24	19471A0325	1(a)	1		1(a)	1		AB
25	19471A0326	5(a)	1	7	5(a)	1	3	10
26	19471A0327	4(a)	1	7	4(b)	1	3	10
27	19471A0328	3(a)	1	6	3(a)	1	3	9
28	19471A0329	2(a)	1	3	2(a)	1	4	7
29	19471A0330	1(a)	1	6	1(a)	1	3	9
30	19471A0331	5(a)	1	7	5(a)	1	3	10
31	19471A0332	4(a)	1		4(b)	1		AB

32	19471A0333	3(a)	1	6	3(a)	1	3	9
33	19471A0334	2(a)	1		2(a)	1		AB
34	19471A0335	1(a)	1		1(a)	1		AB
35	19471A0336	5(a)	1		5(a)	1		AB
36	19471A0337	4(a)	1	7	4(b)	1	3	10
37	19471A0338	3(a)	1	7	3(a)	1	3	10
38	19471A0339	2(a)	1	3	2(a)	1	6	9
39	19471A0340	1(a)	1	6	1(a)	1	3	9
40	19471A0341	5(a)	1	6	5(a)	1		6
41	19471A0342	4(a)	1	7	4(b)	1	3	10
42	19471A0343	3(a)	1	6	3(a)	1	3	9
43	19471A0344	2(a)	1	3	2(a)	1	6	9
44	19471A0345	1(a)	1		1(a)	1		AB
45	20475A0354	2(a)	1	7	2(a)	1	3	10
46	20475A0355	1(a)	1	3	1(a)	1	5	8
47	20475A0356	5(a)	1	7	5(a)	1	3	10
48	20475A0357	4(a)	1		4(b)	1		AB
49	20475A0358	3(a)	1	5	3(a)	1	3	8
50	20475A0359	2(a)	1	5	2(a)	1	3	8
51	20475A0360	1(a)	1	6	1(a)	1	3	9
52	20475A0361	5(a)	1	6	5(a)	1	3	9
53	20475A0362	4(a)	1	2	4(b)	1		2
54	20475A0363	3(a)	1	6	3(a)	1	3	9
55	20475A0364	2(a)	1	6	2(a)	1	3	9
56	20475A0365	1(a)	1	6	1(a)	1	3	9
57	20475A0366	5(a)	1	6	5(a)	1	3	9

Name of the Staff Member CH-SEKHAR

Signature of the Staff Member

Signature of the HOD

NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS) : : NARASARAOPET

(R19) 2019 BATCH II B.TECH II SEM I ASSIGNMENT TEST MARKS - AWARD LIST -2021

Branch : ME-B Subject: Operations Research Date:19-06-21

SNO.	H.T.NO.	Q.NO.	CO	MARKS	Q.NO.	CO	MARKS	TOTAL MARKS (10M)
1	20475A0301	4(a)	1	5	4(b)	1	3	8
2	20475A0302	3(a)	1	7	3(a)	1	3	10
3	20475A0303	2(a)	1	6	2(a)	1	3	9
4	20475A0304	1(a)	1	3	1(a)	1	5	8
5	20475A0305	5(a)	1	6	5(a)	1	3	9
6	20475A0306	4(a)	1	7	4(b)	1	3	10
7	20475A0307	3(a)	1	7	3(a)	1	3	10
8	20475A0308	2(a)	1	7	2(a)	1	3	10
9	20475A0309	1(a)	1	3	1(a)	1	6	9
10	20475A0310	5(a)	1	7	5(a)	1	3	10
11	20475A0311	4(a)	1	6	4(b)	1	3	9
12	20475A0312	3(a)	1	7	3(a)	1	3	10
13	20475A0313	2(a)	1	7	2(a)	1	3	10
14	20475A0314	1(a)	1	3	1(a)	1	5	8
15	20475A0315	5(a)	1	7	5(a)	1	3	10
16	20475A0316	4(a)	1	7	4(b)	1	3	10
17	20475A0317	3(a)	1	6	3(a)	1	3	9
18	20475A0318	2(a)	1	7	2(a)	1	3	10
19	20475A0319	1(a)	1	3	1(a)	1	6	9
20	20475A0320	5(a)	1	7	5(a)	1	3	10
21	20475A0321	4(a)	1	5	4(b)	1	3	8
22	20475A0322	3(a)	1	7	3(a)	1	3	10
23	20475A0323	2(a)	1	6	2(a)	1	3	9
24	20475A0324	1(a)	1	3	1(a)	1	6	9
25	20475A0325	5(a)	1	5	5(a)	1	3	8
26	20475A0326	4(a)	1	6	4(b)	1	3	9
27	20475A0327	3(a)	1	7	3(a)	1	3	10
28	20475A0328	2(a)	1	7	2(a)	1	3	10
29	20475A0330	1(a)	1	3	1(a)	1	5	8
30	20475A0331	5(a)	1	6	5(a)	1	3	9
31	20475A0332	4(a)	1		4(b)	1	3	3

32	20475A0333	3(a)	1	7	3(a)	1	3	10
33	20475A0334	2(a)	1	6	2(a)	1	3	9
34	20475A0335	1(a)	1	3	1(a)	1	3	6
35	20475A0336	5(a)	1	7	5(a)	1	3	10
36	20475A0337	4(a)	1	7	4(b)	1	3	10
37	20475A0338	3(a)	1	7	3(a)	1	3	10
38	20475A0339	2(a)	1	7	2(a)	1	3	10
39	20475A0340	1(a)	1	3	1(a)	1	4	7
40	20475A0341	5(a)	1		5(a)	1		AB
41	20475A0342	4(a)	1	6	4(b)	1	3	9
42	20475A0343	3(a)	1	6	3(a)	1	3	9
43	20475A0344	2(a)	1	6	2(a)	1	3	9
44	20475A0345	1(a)	1	3	1(a)	1		3
45	20475A0346	5(a)	1		5(a)	1		AB
46	20475A0347	4(a)	1	5	4(b)	1	3	8
47	20475A0348	3(a)	1	6	3(a)	1	3	9
48	20475A0349	2(a)	1	6	2(a)	1	3	9
49	20475A0350	1(a)	1	3	1(a)	1	5	8
50	20475A0351	5(a)	1	6	5(a)	1	3	9
51	20475A0352	4(a)	1	6	4(b)	1	3	9
52	20475A0353	3(a)	1	7	3(a)	1	3	10

Name of the Staff Member CH.JEHHA

Signature of the Staff Member

Signature of the HOD

NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS) : : NARASARAOPET

(R19) 2019 BATCH II B.TECH II SEM II-ASSIGNMENT TEST MARKS - AWARD LIST -2021

Branch : ME-A Subject: Operations Research Date:12-05-21

SNO.	H.T.NO.	Q.NO.	CO	MARKS	Q.NO.	CO	MARKS	TOTAL MARKS (10M)
1	19471A0301	1	2	5	2	2	5	10
2	19471A0302	2	2	5	3	2	5	10
3	19471A0303	3	2	5	4	2	5	10
4	19471A0304	4	2	5	5	2	5	10
5	19471A0305	5	2	5	6	2	5	10
6	19471A0306	6	2	5	7	2	5	10
7	19471A0307	7	2	5	8	2	5	10
8	19471A0308	8	2	5	9	2	5	10
9	19471A0309	1	2	5	2	2	5	10
10	19471A0310	2	2		3	2		AB
11	19471A0311	3	2	5	4	2	5	10
12	19471A0312	4	2	5	5	2	5	10
13	19471A0313	5	2	5	6	2	5	10
14	19471A0315	6	2	5	7	2	5	10
15	19471A0316	7	2	5	8	2	5	10
16	19471A0317	8	2	5	9	2	5	10
17	19471A0318	1	2	5	2	2	5	10
18	19471A0319	2	2	5	3	2	5	10
19	19471A0320	3	2	5	4	2	5	10
20	19471A0321	4	2	5	5	2	5	10
21	19471A0322	5	2		6	2		AB
22	19471A0323	6	2	5	7	2	5	10
23	19471A0324	7	2	5	8	2	5	10
24	19471A0325	8	2		9	2		AB
25	19471A0326	1	2	5	2	2	5	10
26	19471A0327	2	2	5	3	2	5	10
27	19471A0328	3	2	5	4	2	5	10
28	19471A0329	4	2	5	5	2	5	10
29	19471A0330	5	2	5	6	2	5	10
30	19471A0331	6	2		7	2		AB
31	19471A0332	7	2		8	2		AB

32	19471A0333	8	2	5	9	2	5	10
33	19471A0334	1	2		2	2		AB
34	19471A0335	2	2		3	2		AB
35	19471A0336	3	2		4	2		AB
36	19471A0337	4	2	5	5	2	5	10
37	19471A0338	5	2	5	6	2	5	10
38	19471A0339	6	2	5	7	2	5	10
39	19471A0340	7	2		8	2		AB
40	19471A0341	8	2	5	9	2	5	10
41	19471A0342	1	2	5	2	2	5	10
42	19471A0343	2	2	5	3	2	5	10
43	19471A0344	3	2	5	4	2	5	10
44	19471A0345	4	2	5	5	2	5	10
45	20475A0354	1	2	5	2	2	5	10
46	20475A0355	2	2	5	3	2	5	10
47	20475A0356	3	2	5	4	2	5	10
48	20475A0357	4	2	5	5	2	5	10
49	20475A0358	5	2	5	6	2	5	10
50	20475A0359	6	2	5	7	2	5	10
51	20475A0360	7	2	5	8	2	5	10
52	20475A0361	8	2	5	9	2	5	10
53	20475A0362	1	2	5	2	2	5	10
54	20475A0363	2	2	5	3	2	5	10
55	20475A0364	3	2	5	4	2	5	10
56	20475A0365	4	2	5	5	2	5	10
57	20475A0366	5	2	5	6	2	5	10

Name of the Staff Member CH. SEKHAR

Signature of the Staff Member

Signature of the HOD

NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS) : : NARASARAOPET

(R19) 2019 BATCH II B.TECH II SEM II ASSIGNMENT TEST MARKS - AWARD LIST -2021

Branch : ME-B Subject: Operations Research Date:29-06-21

SNO.	H.T.NO.	Q.NO.	CO	MARKS	Q.NO.	CO	MARKS	TOTAL MARKS (10M)
1	20475A0301	5	2	5	6	2	5	10
2	20475A0302	6	2	5	7	2	5	10
3	20475A0303	7	2	5	8	2	5	10
4	20475A0304	8	2	5	9	2	5	10
5	20475A0305	1	2	5	2	2	5	10
6	20475A0306	2	2	5	3	2	5	10
7	20475A0307	3	2		4	2		AB
8	20475A0308	4	2	5	5	2	5	10
9	20475A0309	5	2	5	6	2	5	10
10	20475A0310	6	2	5	7	2	5	10
11	20475A0311	7	2	5	8	2	5	10
12	20475A0312	8	2	5	9	2	5	10
13	20475A0313	1	2	5	2	2	5	10
14	20475A0314	2	2	5	3	2	5	10
15	20475A0315	3	2	5	4	2	5	10
16	20475A0316	4	2	5	5	2	5	10
17	20475A0317	5	2	5	6	2	5	10
18	20475A0318	6	2	5	7	2	5	10
19	20475A0319	7	2	5	8	2	5	10
20	20475A0320	8	2	5	9	2	5	10
21	20475A0321	1	2	5	2	2	5	10
22	20475A0322	2	2	5	3	2	5	10
23	20475A0323	3	2	5	4	2	5	10
24	20475A0324	4	2	5	5	2	5	10
25	20475A0325	5	2	5	6	2	5	10
26	20475A0326	6	2	5	7	2	5	10
27	20475A0327	7	2	5	8	2	5	10
28	20475A0328	8	2	5	9	2	5	10
29	20475A0330	1	2	5	2	2	5	10
30	20475A0331	2	2	5	3	2	5	10
31	20475A0332	3	2	5	4	2	5	10

32	20475A0333	4	2	5	5	2	5	10
33	20475A0334	5	2	5	6	2	5	10
34	20475A0335	6	2	5	7	2	5	10
35	20475A0336	7	2	5	8	2	5	10
36	20475A0337	8	2	5	9	2	5	10
37	20475A0338	1	2	5	2	2	5	10
38	20475A0339	2	2	5	3	2	5	10
39	20475A0340	3	2	5	4	2	5	10
40	20475A0341	4	2	5	5	2	5	10
41	20475A0342	5	2	5	6	2	5	10
42	20475A0343	6	2	5	7	2	5	10
43	20475A0344	7	2	5	8	2	5	10
44	20475A0345	8	2	5	9	2	5	10
45	20475A0346	1	2		2	2		AB
46	20475A0347	2	2	5	3	2	5	10
47	20475A0348	3	2	5	4	2	5	10
48	20475A0349	4	2	5	5	2	5	10
49	20475A0350	5	2	5	6	2	5	10
50	20475A0351	6	2	5	7	2	5	10
51	20475A0352	7	2	5	8	2	5	10
52	20475A0353	8	2	5	9	2	5	10

Name of the Staff Member CH. SEKHAR

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Signature of the HOD

NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS) : : NARASARAOPET

(R19) 2019 BATCH II B.TECH II SEM III-ASSIGNMENT TEST MARKS - AWARD LIST -2021

Branch : ME-A Subject: Operations Research Date:08-06-21

SNO.	H.T.NO.	Q.NO.	CO	MARKS	Q.NO.	CO	MARKS	TOTAL MARKS (10M)
1	19471A0301	5(a)	4	5	5(b)	4	5	10
2	19471A0302	4	3	10				10
3	19471A0303	3	3	10				10
4	19471A0304	2	3	10				10
5	19471A0305	1	3	10				10
6	19471A0306	5(a)	4	5	5(b)	4	5	10
7	19471A0307	4	3	10				10
8	19471A0308	3	3	10				10
9	19471A0309	2	3	10				10
10	19471A0310	1	3					AB
11	19471A0311	5(a)	4	5	5(b)	4	5	10
12	19471A0312	4	3	10				10
13	19471A0313	3	3	10				10
14	19471A0315	2	3	10				10
15	19471A0316	1	3	10				10
16	19471A0317	5(a)	4	5	5(b)	4	5	10
17	19471A0318	4	3	10				10
18	19471A0319	3	3	10				10
19	19471A0320	2	3	10				10
20	19471A0321	1	3	10				10
21	19471A0322	5(a)	4		5(b)	4		AB
22	19471A0323	4	3	10				10
23	19471A0324	3	3					AB
24	19471A0325	2	3					AB
25	19471A0326	1	3	10				10
26	19471A0327	5(a)	4	5	5(b)	4	5	10
27	19471A0328	4	3	10				10
28	19471A0329	3	3	10				10
29	19471A0330	2	3	10				10
30	19471A0331	1	3	10				10
31	19471A0332	5(a)	4		5(b)	4		AB

32	19471A0333	4	3	10				10
33	19471A0334	3	3					AB
34	19471A0335	2	3					AB
35	19471A0336	1	3					AB
36	19471A0337	5(a)	4	5	5(b)	4	5	10
37	19471A0338	4	3	10				10
38	19471A0339	3	3	10				10
39	19471A0340	2	3	10				10
40	19471A0341	1	3					AB
41	19471A0342	5(a)	4	5	5(b)	4	5	10
42	19471A0343	4	3	10				10
43	19471A0344	3	3	10				10
44	19471A0345	2	3	10				10
45	20475A0354	4	3	10				10
46	20475A0355	3	3	10				10
47	20475A0356	2	3	10				10
48	20475A0357	1	3	10				10
49	20475A0358	5(a)	4	5	5(b)	4	5	10
50	20475A0359	4	3	10				10
51	20475A0360	3	3	10				10
52	20475A0361	2	3	10				10
53	20475A0362	1	3	10				10
54	20475A0363	5(a)	4	5	5(b)	4	5	10
55	20475A0364	4	3	10				10
56	20475A0365	3	3	10				10
57	20475A0366	2	3	10				10

Name of the Staff Member CH. SEKHAR

Signature of the Staff Member

Signature of the HOD

NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS) : : NARASARAOPET

(R19) 2019 BATCH II B.TECH II SEM III ASSIGNMENT TEST MARKS - AWARD LIST -2021

Branch : ME-B Subject: Operations Research Date:08-06-21

SNO.	H.T.NO.	Q.NO.	CO	MARKS	Q.NO.	CO	MARKS	TOTAL MARKS (10M)
1	20475A0301	5(a)	4	5	5(b)	4	5	10
2	20475A0302	4	3	10				10
3	20475A0303	3	3	10				10
4	20475A0304	2	3	10				10
5	20475A0305	1	3	10				10
6	20475A0306	5(a)	4	5	5(b)	4	5	10
7	20475A0307	4	3	10				10
8	20475A0308	3	3	10				10
9	20475A0309	2	3	10				10
10	20475A0310	1	3	10				10
11	20475A0311	5(a)	4	5	5(b)	4	5	10
12	20475A0312	4	3	10				10
13	20475A0313	3	3	10				10
14	20475A0314	2	3	10				10
15	20475A0315	1	3	10				10
16	20475A0316	5(a)	4	5	5(b)	4	5	10
17	20475A0317	4	3	10				10
18	20475A0318	3	3	10				10
19	20475A0319	2	3	10				10
20	20475A0320	1	3	10				10
21	20475A0321	5(a)	4	5	5(b)	4	5	10
22	20475A0322	4	3	10				10
23	20475A0323	3	3	10				10
24	20475A0324	2	3	10				10
25	20475A0325	1	3	10				10
26	20475A0326	5(a)	4	5	5(b)	4	5	10
27	20475A0327	4	3	10				10
28	20475A0328	3	3	10				10
29	20475A0330	2	3	10				10
30	20475A0331	1	3	10				10
31	20475A0332	5(a)	4	5	5(b)	4	5	10

32	20475A0333	4	3	10				10
33	20475A0334	3	3	10				10
34	20475A0335	2	3	10				10
35	20475A0336	1	3	10				10
36	20475A0337	5(a)	4	5	5(b)	4	5	10
37	20475A0338	4	3	10				10
38	20475A0339	3	3	10				10
39	20475A0340	2	3	10				10
40	20475A0341	1	3	10				10
41	20475A0342	5(a)	4	5	5(b)	4	5	10
42	20475A0343	4	3	10				10
43	20475A0344	3	3	10				10
44	20475A0345	2	3	10				10
45	20475A0346	1	3	10				10
46	20475A0347	5(a)	4	5	5(b)	4	5	10
47	20475A0348	4	3	10				10
48	20475A0349	3	3	10				10
49	20475A0350	2	3	10				10
50	20475A0351	1	3	10				10
51	20475A0352	5(a)	4	5	5(b)	4	5	10
52	20475A0353	4	3	10				10

Name of the Staff Member Ch.Sekhar

Signature of the Staff Member

Signature of the HOD

NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS) : : NARASARAOPET

(R19) 2019 BATCH II B.TECH II SEM IV-ASSIGNMENT TEST MARKS - AWARD LIST -2021

Branch : ME-A Subject: Operations Research Date:29-06-21

SNO.	H.T.NO.	Q.NO.	CO	MARKS	Q.NO.	CO	MARKS	TOTAL MARKS (10M)
1	19471A0301	2(a)	5	AB	2(b)	5	AB	AB
2	19471A0302	3(a)	5	5	3(b)	5	5	10
3	19471A0303	4(a)	5	5	4(b)	5	5	10
4	19471A0304	1(a)	5	5	1(b)	5	5	10
5	19471A0305	5(a)	5	5	5(b)	5	5	10
6	19471A0306	2(a)	5	5	2(b)	5	5	10
7	19471A0307	3(a)	5	5	3(b)	5	5	10
8	19471A0308	4(a)	5	5	4(b)	5	5	10
9	19471A0309	1(a)	5	5	1(b)	5	5	10
10	19471A0310	5(a)	5	5	5(b)	5	5	10
11	19471A0311	2(a)	5	5	2(b)	5	5	10
12	19471A0312	3(a)	5	5	3(b)	5	5	10
13	19471A0313	4(a)	5	5	4(b)	5	5	10
14	19471A0315	1(a)	5	5	1(b)	5	5	10
15	19471A0316	5(a)	5	5	5(b)	5	5	10
16	19471A0317	2(a)	5	5	2(b)	5	4	9
17	19471A0318	3(a)	5	5	3(b)	5	5	10
18	19471A0319	4(a)	5	5	4(b)	5	4	9
19	19471A0320	1(a)	5	5	1(b)	5	5	10
20	19471A0321	5(a)	4	5	5(b)	5	5	9
21	19471A0322	2(a)	5	AB	2(b)	5	AB	AB
22	19471A0323	3(a)	5	5	3(b)	5	5	10
23	19471A0324	4(a)	5	5	4(b)	5	5	10
24	19471A0325	1(a)	5	AB	1(b)	5	AB	AB
25	19471A0326	5(a)	5	5	5(b)	5	5	10
26	19471A0327	2(a)	5	5	2(b)	5	5	10
27	19471A0328	3(a)	5	5	3(b)	5	4	9
28	19471A0329	4(a)	5	5	4(b)	5	5	10
29	19471A0330	1(a)	5	AB	1(b)	5	AB	AB
30	19471A0331	5(a)	5	5	5(b)	5	5	10
31	19471A0332	2(a)	5	AB	2(b)	5	AB	AB

32	19471A0333	3(a)	5	5	3(b)	5	5	10
33	19471A0334	4(a)	5	AB	4(b)	5	AB	AB
34	19471A0335	1(a)	5	AB	1(b)	5	AB	AB
35	19471A0336	5(a)	5	AB	5(b)	5	AB	AB
36	19471A0337	2(a)	5	5	2(b)	5	5	10
37	19471A0338	3(a)	5	5	3(b)	5	5	10
38	19471A0339	4(a)	5	5	4(b)	5	5	10
39	19471A0340	1(a)	5	5	1(b)	5	5	10
40	19471A0341	5(a)	5	0	5(b)	5	0	0
41	19471A0342	2(a)	5	5	2(b)	5	5	10
42	19471A0343	3(a)	5	5	3(b)	5	5	10
43	19471A0344	4(a)	5	5	4(b)	5	5	10
44	19471A0345	1(a)	5	5	1(b)	5	5	10
45	20475A0354	3(a)	5	5	3(b)	5	5	10
46	20475A0355	4(a)	5	5	4(b)	5	5	10
47	20475A0356	1(a)	5	5	1(b)	5	5	10
48	20475A0357	5(a)	5	5	5(b)	5	5	10
49	20475A0358	2(a)	5	5	2(b)	5	5	10
50	20475A0359	3(a)	5	5	3(b)	5	4	9
51	20475A0360	4(a)	5	4	4(b)	5	4	8
52	20475A0361	1(a)	5	5	1(b)	5	5	10
53	20475A0362	5(a)	5	5	5(b)	5	4	9
54	20475A0363	2(a)	5	5	2(b)	5	4	9
55	20475A0364	3(a)	5	5	3(b)	5	5	10
56	20475A0365	4(a)	5	5	4(b)	5	5	10
57	20475A0366	1(a)	5	AB	1(b)	5	AB	AB

Name of the Staff Member CH. SEKHAR

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NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS) : : NARASARAOPET

(R19) 2019 BATCH II B.TECH II SEM IV ASSIGNMENT TEST MARKS - AWARD LIST -2021

Branch : ME-B Subject: Operations Research Date:29-06-21

SNO.	H.T.NO.	Q.NO.	CO	MARKS	Q.NO.	CO	MARKS	TOTAL MARKS (10M)
1	20475A0301	5(a)	5	5	5(b)	5	5	10
2	20475A0302	2(a)	5	5	2(b)	5	5	10
3	20475A0303	3(a)	5	5	3(b)	5	5	10
4	20475A0304	4(a)	5	5	4(b)	5	4	10
5	20475A0305	1(a)	5	5	1(b)	5	5	9
6	20475A0306	5(a)	5	5	5(b)	5	5	10
7	20475A0307	2(a)	5	5	2(b)	5	5	10
8	20475A0308	3(a)	5	5	3(b)	5	5	10
9	20475A0309	4(a)	5	5	4(b)	5	5	10
10	20475A0310	1(a)	5	5	1(b)	5	4	9
11	20475A0311	5(a)	5	5	5(b)	5	5	10
12	20475A0312	2(a)	5	5	2(b)	5	5	10
13	20475A0313	3(a)	5	5	3(b)	5	5	10
14	20475A0314	4(a)	5	5	4(b)	5	5	10
15	20475A0315	1(a)	5	5	1(b)	5	5	10
16	20475A0316	5(a)	5	5	5(b)	5	5	10
17	20475A0317	2(a)	5	5	2(b)	5	5	10
18	20475A0318	3(a)	5	5	3(b)	5	5	10
19	20475A0319	4(a)	5	4	4(b)	5	5	10
20	20475A0320	1(a)	5	5	1(b)	5	5	9
21	20475A0321	5(a)	5	5	5(b)	5	5	10
22	20475A0322	2(a)	5	5	2(b)	5	5	10
23	20475A0323	3(a)	5	5	3(b)	5	5	10
24	20475A0324	4(a)	5	4	4(b)	5	5	10
25	20475A0325	1(a)	5	5	1(b)	5	5	9
26	20475A0326	5(a)	5	5	5(b)	5	5	10
27	20475A0327	2(a)	5	5	2(b)	5	5	10
28	20475A0328	3(a)	5	5	3(b)	5	5	10
29	20475A0330	4(a)	5	5	4(b)	5	5	10
30	20475A0331	1(a)	5	5	1(b)	5	4	9
31	20475A0332	5(a)	5	5	5(b)	5	5	10
								10

Branch : ME-B Subject: Operations Research Date:29-06-21

SNO.	H.T.NO.	Q.NO.	CO	MARKS	Q.NO.	CO	MARKS	TOTAL MARKS (10M)
32	20475A0333	2(a)	5	5	2(b)	5	5	10
33	20475A0334	3(a)	5	5	3(b)	5	5	10
34	20475A0335	4(a)	5	5	4(b)	5	5	10
35	20475A0336	1(a)	5	5	1(b)	5	5	10
36	20475A0337	5(a)	5	5	5(b)	5	5	10
37	20475A0338	2(a)	5	5	2(b)	5	5	10
38	20475A0339	3(a)	5	5	3(b)	5	5	10
39	20475A0340	4(a)	5	5	4(b)	5	5	10
40	20475A0341	1(a)	5	5	1(b)	5	5	10
41	20475A0342	5(a)	5	5	5(b)	5	5	10
42	20475A0343	2(a)	5	5	2(b)	5	5	10
43	20475A0344	3(a)	5	5	3(b)	5	5	10
44	20475A0345	4(a)	5	5	4(b)	5	5	10
45	20475A0346	1(a)	5	AB	1(b)	5	AB	AB
46	20475A0347	5(a)	5	5	5(b)	5	5	10
47	20475A0348	2(a)	5	5	2(b)	5	5	10
48	20475A0349	3(a)	5	5	3(b)	5	5	10
49	20475A0350	4(a)	5	5	4(b)	5	5	10
50	20475A0351	1(a)	5	5	1(b)	5	5	10
51	20475A0352	5(a)	5	5	5(b)	5	5	10
52	20475A0353	2(a)	5	5	2(b)	5	4	9

CH·SEKHAR
Name of the Staff Member

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Signature of the Staff Member

Signature of the HOD

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NARASARAOPETA ENGINEERING COLLEGE::NARASARAOPET
(AUTONOMOUS)
17 BATCH III B.TECH I SEMESTER (R16) FINAL INTERNAL MARKS-2019

BRANCH/SEC - ME/A			OPERATIONS RESEARCH(R16ME3105)										
SL.NO.	H.T.NO.	STUDENT NAME	A1	A2	D1	O1	CYCLE-1	A3	A4	D2	O2	CYCLE-2	TOTAL
1	16471A0308	NALUKURTHI SUKUMAR	7	10	0	2	12	0	10	10	9	29	25
2	16471A0326	PALADUGU SRIKANTA	8	10	0	7	17	0	10	18	8	36	32
3	16471A0345	D.SAI MOHESH	A	10	0	4	14	A	A	9	6	15	15
4	16471A0367	CHALLAGUNDLA SITA RAM	10	10	9	4	23	A	10	18	5	33	31
5	17471A0301	TALLURI AKHIL SAI	10	10	20	8	38	A	10	20	9	39	39
6	17471A0302	P.SAI PRAVEEN	2	10	18	8	36	A	10	19	4	33	36
7	17471A0303	ROOPCHAND MALLELA	5	10	0	7	17	5	10	19	8	37	32
8	17471A0304	BANDI VENKATA MANIKANTA REDDY	10	9	1	6	17	0	10	20	8	38	33
9	17471A0305	GOTTIPATI NARENDRA	4	10	8	6	24	8	10	18	7	35	33
10	17471A0306	KOTRA MANI PAVAN	10	A	8	8	26	6	10	18	8	36	34
11	17471A0307	BOLE HARI KRISHNA	1	10	4	9	23	A	10	19	9	38	35
12	17471A0308	KUNDURU NAGI REDDY	6	10	0	6	16	10	10	19	8	37	32
13	17471A0309	GURIJALA VENUBABU	10	10	15	8	33	0	10	18	9	37	36
14	17471A0311	PALLAPU MALLIKHARJUNARAO	10	8	20	8	38	10	10	20	10	40	40
15	17471A0312	BANTU CHAITANYA	2	10	18	8	36	10	10	19	8	37	37
16	17471A0313	BOMMINENI ASHOK BABU	5	10	4	9	23	10	10	18	10	38	35
17	17471A0314	BALAGANI MAHESH	10	10	16	8	34	6	10	18	10	38	37
18	17471A0315	SHAIK BAJI	10	10	14	10	34	10	10	20	10	40	39
19	17471A0316	VENNAPUSALA SRIKANTH	8	10	17	8	35	A	10	18	10	38	38
20	17471A0317	GOALLAMUDI PRAKASH	3	10	9	6	25	10	9	18	10	38	35
21	17471A0318	PATAN MOHIDDEEN	1	A	2	5	8	0	10	19	9	38	31
22	17471A0320	PENTAPATI RUPANAND	5	10	0	6	16	0	10	18	9	37	32
23	17471A0321	YELLANURU KOUSHIK KUMAR	5	10	17	7	34	10	10	18	10	38	37
24	17471A0322	VASA VENKAT SHANMUKH	3	10	12	8	30	10	10	19	10	39	37
25	17471A0323	SHAIK YASIN	8	10	18	8	36	10	A	20	8	38	38
26	17471A0324	BANDI JOHNBABU	A	A	9	7	16	A	A	17	10	27	25
27	17471A0325	JETTI PURNACHANDRA RAO	6	10	14	8	32	10	10	18	8	36	35
28	17471A0326	MADALA BALA NAVEEN KUMAR	9	10	16	5	31	10	10	17	6	33	33
29	17471A0327	DARAPANENI NAGA RAJU	6	10	7	6	23	0	10	18	5	33	31
30	17471A0328	PALLAPU GOVARDHANBABU	A	10	11	7	28	0	10	20	9	39	37
31	17471A0329	AMBATI PRUDHVI	5	10	2	5	17	A	10	18	8	36	32

32	17471A0330	MEDIDA MAHESH	7	8	5	8	21	0	10	19	9	38	34
33	17471A0331	PUNATI MANIKANTA	8	10	4	8	22	10	10	19	9	38	34
34	17471A0332	SARIMALLA KAMALAKUMAR	10	10	11	7	28	A	10	19	8	37	35
35	17471A0333	MUPPERA SATHYA DURGA MAHENDRA	6	10	5	8	23	3	10	18	10	38	35
36	17471A0334	VATTIKULLA TEJA	10	10	8	8	26	A	10	12	6	28	28
37	17471A0335	TODETI PAVAN KUMAR	9	10	14	9	33	10	10	20	10	40	39
38	17471A0336	BOINA RAJU	8	10	14	9	33	A	10	19	10	39	38
39	17471A0338	DEGALA GOPI NAIDU	5	10	1	9	20	0	10	18	7	35	32
40	17471A0339	POTTURI NAGA SAI DILEEP	10	6	18	8	36	10	10	20	9	39	39
41	17471A0340	SHAIK SURAJAHMAD	A	10	14	7	31	10	10	16	7	33	33
42	17471A0341	KULLU SEKHARBABU	7	10	6	6	22	6	10	11	8	29	28
43	17471A0342	KANDULA NAGARJUNA	A	10	11	9	30	A	10	A	A	10	25
44	17471A0343	CHILAMKURU VENKATA SAI RAM	10	10	17	8	35	10	10	20	9	39	38
45	17471A0344	DAREDDY VENKATA RAMI REDDY	7	10	12	7	29	10	10	19	8	37	35
46	17471A0345	KASA RAKESH SAINATH REDDY	1	10	5	8	23	A	10	17	9	36	33
47	17471A0346	PERLA VENKAIAH	10	A	4	8	22	A	10	18	8	36	33
48	17471A0347	SIMHADRI CHETANA KRISHNA KUMARA	9	8	13	6	28	6	10	19	2	31	31
49	17471A0348	KATAM SIVA GOPI	7	10	7	8	25	2	10	18	8	36	34
50	17471A0349	KAYAKOKULA RAVINDRA	3	10	2	5	17	5	10	18	7	35	31
51	17471A0350	SYED NURUDDIN	9	10	8	7	25	A	10	18	8	36	34

NARASARAOPETA ENGINEERING COLLEGE::NARASARAOPET

(AUTONOMOUS)

17 BATCH III B.TECH I SEMESTER (R16) FINAL INTERNAL MARKS-2019

BRANCH/SEC - ME/B			OPERATIONS RESEARCH(R16ME3105)											
SL.NO.	H.T.NO.	STUDENT NAME	A1	A2	D1	O1	CYCLE-1	A3	A4	D2	O2	CYCLE-2	TOTAL
1	17471A0351	KANAGANI VENKATESH	0	10	8	8	26	6	10	18	9	37	35
2	17471A0352	SHAIK SHAHUL	6	10	10	10	30	6	10	18	8	36	35
3	17471A0353	MEDISETTY DURGA MANI PAVAN	7	10	7	0	17	6	9	18	4	31	28
4	17471A0354	KAJA VIJAY	9	0	10	7	26	7	9	17	6	32	31
5	17471A0355	PRATHIPATI SYAM BABU	9	0	8	7	24	9	9	16	6	31	30
6	17471A0356	INDLA NAVEEN	1	10	8	8	26	7	9	17	7	33	32
7	17471A0357	VANGA HEMANTH REDDY	8	7	8	9	25	6	10	18	9	37	34
8	17471A0358	ADUSUMALLI HARINATH	9	10	4	4	18	A	9	18	4	31	28
9	17471A0359	NIDUMOLU YAGNA MALLESWARA RAO	9	A	A	6	15	A	9	18	4	31	27
10	17471A0360	BURRI PRAKASH	9	8	8	4	21	0	10	17	6	33	30
11	17471A0361	NANDIKONDA LAKSHMA REDDY	9	8	10	5	24	A	10	14	7	31	30
12	17471A0362	CHOLLANGI SAI SANDEEP	9	10	4	4	18	0	10	16	8	34	30
13	17471A0363	MALLEBOYENA LOKESH	9	8	6	8	23	6	10	14	7	31	29
14	17471A0364	CHANDALURI VENKATA MANIKUMAR	4	9	0	8	17	A	9	17	7	33	29
15	17471A0365	PULI VENKATESH	3	A	7	8	18	8	9	14	8	31	28
16	17471A0366	CHINTHALA GOPI KRISHNA	9	0	8	6	23	10	10	11	10	31	29
17	17471A0367	PRATTIPATI RAGHAVENDRA BABU	7	9	4	6	19	A	9	12	6	27	25
18	17471A0368	BODDU THIRUPATHIRAO	9	8	10	7	26	5	9	8	8	25	26
19	17471A0369	DANDU ASHOK KUMAR	9	7	16	8	33	9	9	16	6	31	33
20	17471A0370	BODAPATI ESWARA VENKATA SAI YESWANTH	0	10	5	7	22	A	9	17	9	35	32
21	17471A0371	GRANDHE PAVAN KALYAN	0	8	9	6	23	10	8	16	8	34	32
22	17471A0372	EMMELA SUNIL VARMA	4	9	8	4	21	0	10	18	7	35	32
23	17471A0373	CHINTHAPALLI RAVITEJA	5	9	12	7	28	10	9	16	5	31	31
24	17471A0374	BIRUDU RAVITEJA	0	A	8	6	14	10	10	17	7	34	29
25	17471A0376	RANGISETTY BALAJI	0	10	5	7	22	A	10	14	8	32	30
26	17471A0377	YAMARTHI RAVI KUMAR	5	10	7	6	23	10	A	15	5	30	29
27	17471A0378	DASARI PRINCE VIJAYA KUMAR	5	9	10	1	20	8	9	14	6	29	27
28	17471A0379	NUTHAKKI SIVA NAGA RAJU	A	A	4	8	12	A	8	15	7	30	26
29	17471A0380	GADDE AKASH	5	9	0	9	18	9	8	16	8	33	30
30	17471A0381	BALIJEPALLI SUMANTH	9	8	4	9	22	8	9	16	8	33	31
31	17471A0382	GARLAPATI TRINADH	9	8	A	8	17	8	9	17	7	33	29

32	18475A0301	THAMMAVARAPU SRIHARI	A	9	14	4	27	A	8	17	8	33	32
33	18475A0302	DOKKU PAVAN KUMAR	8	9	12	7	28	7	A	12	7	26	28
34	18475A0303	SHAIK SATTAR	7	7	18	7	32	9	10	19	8	37	36
35	18475A0304	DEVARAKONDA SAI KRISHNA REDDY	A	6	14	6	26	8	9	16	7	32	31
36	18475A0305	PALADUGU ANJI BABU	9	9	14	7	30	A	10	17	8	35	34
37	18475A0306	RAMI REDDY GURAVA REDDY	9	6	14	9	32	A	9	16	7	32	32
38	18475A0307	SHAIK JOHN SAIDA	A	8	14	8	30	A	9	17	8	34	33
39	18475A0308	KALLAM JITHENDRA KUMAR	9	10	8	6	24	5	9	12	8	29	28
40	18475A0309	JAVVAJI BHANU PRASAD	10	6	10	7	27	8	10	18	6	34	33
41	18475A0310	ADUSUMALLI CHANDRA SEKHAR RAO	0	A	0	5	5	8	8	14	1	23	19
42	18475A0311	POSIPOGU MANI	9	8	12	8	29	A	7	18	10	35	34
43	18475A0312	AVULA SRIKANTH	7	A	2	3	12	9	A	17	8	34	29
44	18475A0313	NAYAPAMU PRAVENKUMAR	A	9	6	9	24	10	7	16	9	35	33
45	18475A0314	SHAIK ABDUL MUNAF	9	10	18	9	37	A	9	18	9	36	37
46	18475A0315	SHAIK NAGUR BASHA	9	0	14	6	29	10	8	17	8	35	34
47	18475A0316	SHAIK MASTAN VALI	A	9	12	3	24	10	9	16	6	32	30
48	18475A0317	SHAIK BAJI	a	9	10	3	22	10	10	12	8	30	28
49	18475A0318	KAVURI APPA RAO	6	10	0	9	19	A	9	15	5	29	27
50	18475A0319	CH CHANDU	8	7	3	7	18	A	10	16	6	32	29
51	18475A0320	UPPALA GANESH	0	8	0	7	15	A	10	16	1	27	24

NARASARAOPETA ENGINEERING COLLEGE::NARASARAOPET
(AUTONOMOUS)
17 BATCH III B.TECH I SEMESTER (R16) FINAL INTERNAL MARKS-2019

BRANCH/SEC - ME/C			OPERATIONS RESEARCH(R16ME3105)										
SL.NO.	H.T.NO.	STUDENT NAME	A1	A2	D1	O1	CYCLE-1	A3	A4	D2	O2	CYCLE-2	TOTAL
1	16471A0314	BOKKA RAJASHEKHAR	1	8	9	5	22	10	10	10	6	26	25
2	18475A0321	SHAIK BADULLA	8	10	14	6	30	10	10	20	7	37	36
3	18475A0322	BATHULA CHAKRAVARTHI	3	7	0	3	10	6	A	18	7	31	26
4	18475A0323	CHALLA MANIKANTA	a	7	2	4	13	10	A	20	8	38	32
5	18475A0324	VEMULA ASHOK	7	10	2	7	19	A	A	20	3	23	22
6	18475A0325	THIRUVEEDHULA KARTHEEK	5	7	5	5	17	A	10	20	5	35	31
7	18475A0326	KONDRU SATHISH	5	10	8	7	25	A	10	16	9	35	33
8	18475A0327	SYAMALA KOTI REDDY	10	10	17	8	35	10	10	20	9	39	38
9	18475A0328	REDDY RAJA NAVEEN	10	6	20	8	38	10	10	20	9	39	39
10	18475A0329	PITCHUKA VENKATA DINESH	5	10	12	4	26	8	10	19	5	34	32
11	18475A0330	BADDIGAM GANESH REDDY	10	10	8	6	24	10	10	20	8	38	35
12	18475A0331	SARIKONDA SAI RAJU	10	10	3	8	21	A	10	18	7	35	32
13	18475A0332	MEKA VENKATESH	5	4	10	6	21	8	10	18	6	34	31
14	18475A0333	BHIMAVARAPU HARI KRISHNA REDDY	10	9	2	4	16	A	10	18	6	34	30
15	18475A0334	BANAVATHU SRIKANTH NAIK	10	8	4	7	21	A	10	20	6	36	33
16	18475A0335	NUTHALAPATI ANIL	A	10	2	7	19	A	6	18	7	31	28
17	18475A0336	BOMMAREDDY NAGARJUNA REDDY	A	10	4	4	18	10	6	18	4	32	29
18	18475A0337	SHAIK AFRIDE	9	10	8	3	21	10	10	20	6	36	33
19	18475A0338	ATUKURI ANIL KUMAR	9	10	6	8	24	A	A	16	9	25	25
20	18475A0339	VAKKALAGADDA GANESH BABU	A	10	6	4	20	8	10	19	5	34	31
21	18475A0340	RAMAVATH RAMARAO NAIK	A	8	2	6	16	A	10	20	7	37	32
22	18475A0341	AKKALA CHANDRA SEKHAR REDDY	10	10	19	8	37	10	10	20	8	38	38
23	18475A0342	KOTE NITEESHKUMAR	5	5	2	7	14	8	10	14	6	30	26
24	18475A0343	PALAKAYALA SATYA SAI	10	A	6	5	21	10	10	19	8	37	33
25	18475A0344	PULICHARLA ASHOK	9	10	6	4	20	A	10	18	5	33	30
26	18475A0345	BUSI VIJAY SAI KUMAR	5	10	13	9	32	10	10	19	9	38	37
27	18475A0346	BATHULA EMMANUYEAL	10	10	8	6	24	A	10	18	7	35	33
28	18475A0347	NETTAM RAVICHANDRA	10	A	8	8	26	10	A	12	9	31	30
29	18475A0348	NETTEM PRAVEENKUMAR	1	10	10	8	28	10	10	9	9	28	28
30	18475A0349	BHANDLA VENKATAGOPINATH	10	10	7	7	24	A	10	19	5	34	32
31	18475A0350	KOMMULA SAI KUMAR	A	8	10	6	24	A	10	20	8	38	35
32	18475A0351	MANDALA OMPRAKASH REDDY	10	10	11	7	28	10	5	20	9	39	37
33	18475A0352	BHAVANAM AKHIL REDDY	10	10	6	6	22	10	10	18	7	35	32
34	18475A0353	DARLA VENKATA BHASKAR	10	10	5	5	20	10	10	20	5	35	32
35	18475A0354	SUREPALLI PAVAN KUMAR	10	10	2	6	18	A	10	18	1	29	27
36	18475A0355	MORABOINA HARISH	3	A	A	8	11	A	10	8	7	25	22
37	18475A0356	SHAIK AKBAR JANI	7	10	10	7	27	A	10	20	9	39	36

SL.NO.	H.T.NO.	STUDENT NAME	A1	A2	D1	O1	CYCLE-1	A3	A4	D2	O2	CYCLE-2	TOTAL
38	18475A0357	YEMINENI VENKAT	3	10	4	5	19	A	10	10	4	24	23
39	18475A0358	NAKKALA CHIRANJEEVULU	A	A	A	3	3	10	A	6	6	22	18
40	18475A0359	VALLABAPURAPU VIJAY	1	10	4	9	23	10	10	15	7	32	30
41	18475A0360	BATTULA HOSANNA	A	A	A	A	0	A	10	20	5	35	27
42	18475A0361	SYED MOHAMMAD ADIL	2	10	6	10	26	10	10	20	7	37	35
43	18475A0362	PAKANATI GOUTHAM KUMAR REDDY	5	10	6	7	23	10	A	18	6	34	32
44	18475A0363	GANNEBOINA SAI MAHENDHAR YADAV	2	1	3	5	10	A	10	18	3	31	26
45	18475A0364	AMBATI PRAVEEN KUMAR	5	10	4	5	19	A	10	19	4	33	30
46	18475A0365	KAKANABOYINA HARI BABU	5	10	9	5	24	10	10	20	9	39	36
47	18475A0366	POTHAVARAM MOKTHAR BHASHA	4	10	5	6	21	A	10	19	8	37	33
48	18475A0367	VIPPARLA BHUVAN CHANDAR	A	10	2	8	20	A	A	18	8	26	25
49	18475A0368	YARAGANI SAIDULU	10	8	13	8	31	A	10	20	10	40	38
50	18475A0369	PATIBANDLA KISHORE	A	10	14	8	32	A	10	20	7	37	36
51	18475A0370	VUTLA RAMALINGESWARA RAO	10	10	6	9	25	10	10	16	6	32	31
52	18475A0371	BANAVATH MAHARSHI PAVAN KALYAN NAIK	8	10	4	8	22	A	10	15	9	34	31

NEC NARASARAOPETA ENGINEERING COLLEGE

(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

UNIT WISE IMPORTANT QUESTIONS

1. Solve the following problem by Big-M method:

   Min $Z=5x_1+3x_2$

   Subject to the constraints:

   $2x_1+4x_2$_12

   $2x_1+2x_2=10$

   $5x_1-2x_2$_10

   and x_1,x_2_0

2. Solve the following LP problem graphically:

   Minimize Z=-6x1-4x2

   Subject to the constraints:

   2x1+3x2_30

   3x1+2x2_24

   x1+x2_3 and x1,x2_0

3. Solve the following LP problem by two phase method:

   Max Z=5x1+8x2

   Subject to the constraints:

   3x1+2x23

   x1+4x24

   x1+x25 and x1,x20

4. Solve by Big –M method

   Minimize Z 2 x2 + x2

   Subject to 3x 1+ x2 = 3

   4 x1 + 3 x2 > 6

   x1 + 2x2 < 4

   x1 , x2 > 0

5. Max Z=3x1+2x2+5x3

   Subject to the constraints

   x1+2x2+x3430

   3x1+2x3460

   x1+4x2420 and x1,x2,x30

UNIT-II

1. Determine the optimal solution to each of the following degenerate transportation problem:

	D1	D2	D3	D4	D5	a_i
O1	4	7	3	8	2	4
O2	1	4	7	3	8	7
O3	7	2	4	7	7	9
O4	4	8	2	4	7	2
b_j	8	3	7	2	2	

2. A company has six jobs which go through three machines X,Y and Z in the order XYZ. The processing time in minutes for each job on each machine is as follows:

		Job					
		1	2	3	4	5	6
Machine	X	18	12	29	36	43	37
	Y	7	12	11	2	6	12
	Z	19	12	23	47	28	36

What should be the sequence of the jobs?

3. Write the LP formulation of a transportation problem.

4. A salesman has to visit five cities A,B,C,D and E. The distance (in hundred miles) between the five cities are as follows:

	A	**B**	**C**	**D**	**E**
A	---	7	6	8	4
B	7	---	8	5	6
C	6	8	---	9	7
D	8	5	9	---	8
E	4	6	7	8	---

ASSIGNMENT –I

1. Solve the following problem by Big-M method:

   Min $Z=5x_1+3x_2$

   Subject to the constraints:

   $2x_1+4x_2\_12$
   $2x_1+2x_2=10$
   $5x_1-2x_2\_10$
   and x_1,x_2_0

2. Solve the following LP problem by two phase method:

   Max Z=5x1+8x2

   Subject to the constraints:

   3x1+2x23

   x1+4x24

   x1+x25 and x1,x20

3. Determine the optimal solution to each of the following degenerate transportation problem:

	D1	D2	D3	D4	D5	a_i
O1	4	7	3	8	2	4
O2	1	4	7	3	8	7
O3	7	2	4	7	7	9
O4	4	8	2	4	7	2
b_j	8	3	7	2	2	

4. A salesman has to visit five cities A,B,C,D and E. The distance (in hundred miles) between the five cities are as follows:

	A	B	C	D	E
A	---	7	6	8	4
B	7	---	8	5	6
C	6	8	---	9	7
D	8	5	9	---	8
E	4	6	7	8	---

5. Machine A costs Rs 45,000 and the operating costs are estimated at Rs 1000 for the first year, increasing by Rs 10,000 per year in the second and subsequent years. Machine B costs Rs 50,000 and operating costs are Rs 2000 for the first year, increasing by Rs 4000 in the second and subsequent years. If you have a machine of type A, should we replace with B? If so when? Assume that both machines have no resale value and future costs are not discounted.

ASSIGNMENT –II

1. Using dominance principle to simplify the rectangular game with the following pay of matrix, and solve it graphically:

Player B

		I	II	III	IV
Player A	I	18	4	6	4
	II	6	2	13	7
	III	11	5	17	3
	IV	7	6	12	2

2. Solve the following (2 x 4) game.

B

A

	I	II	III	IV
I	2	2	3	-1
II	4	3	2	6

3. Distinguish between mathematical models and simulation models.

4. Write a detailed note on applications of simulation in manufacturing systems

5. Two players A and B match coins. If the coin matches, then A wins one unit of value, if the coins do not match, then B wins one unit of value. Determine optimum strategies for the players and the value of the game.

6. Find the optimum order quantity for a product for which the price breaks are as follows:

Quantity	Unit cost(Rs)
$0 \leq q1 < 500$	10.00
$500 \leq q2$	9.25

The monthly demand for a product is 200 units, the cost of storage is 2% of unit cost and the cost of ordering is Rs.350.

OR GATE SOLUTIONS

53. For the given assembly: 25 H7/g8, match Group A with Group B

Group A	Group B
(P) H	(I) Shaft Type
(Q) IT8	(II) Hole Type
(R) IT7	(III) Hole Tolerance Grade
(S) g	(IV) Shaft Tolerance Grade

(A) P-I, Q-III, R-IV, S-II
(B) P-I, Q-IV, R-III, S-II
(C) P-II, Q-III, R-IV, S-I
(D) P-II, Q-IV, R-III, S-I

Answer: (D)

Exp: H7 is for hole where 7 indicates its tolerance grade
g8 is for shaft where 8 indicates its tolerance grade

50. Jobs arrive at a facility at an average rate of 5 in an 8 hour shift. The arrival of the jobs follows Poisson distribution. The average service time of a job on the facility is 40 minutes. The service time follows exponential distribution. Idle time (in hours) at the facility per shift will be

(A) $\frac{5}{7}$ (B) $\frac{14}{3}$ (C) $\frac{7}{5}$ (D) $\frac{10}{3}$

Answer: (B)

19. A component can be produced by any of the four processes I, II, III and IV. The fixed cost and the variable cost for each of the processes are listed below. The most economical process for producing a batch of 100 pieces is

Process	Fixed cost(in Rs.)	Variable cost per piece (in Rs.)
I	20	3
II	50	1
III	40	2
IV	10	4

(A) I (B) II (C) III (D) IV

Answer: B

Exp:

Process	Cost of production for 100
I	$F_c + \theta \times V_c = 20 + 100 \times 3 = 320$
II	$50 + 100 \times 1 = 150$
III	$40 + 100 \times 2 = 240$
IV	$10 + 100 \times 4 = 410$

Hence process (B) is most economical.

51. Consider the following data with reference to elementary deterministic economic order quantity model

Annual demand of an item	100000
Unit price of the item (in Rs.)	10
Inventory carrying cost per unit per year (in Rs.)	1.5
Unit order cost (in Rs.)	30

The total number of economic orders per year to meet the annual demand is ______

Answer: 49 to 51

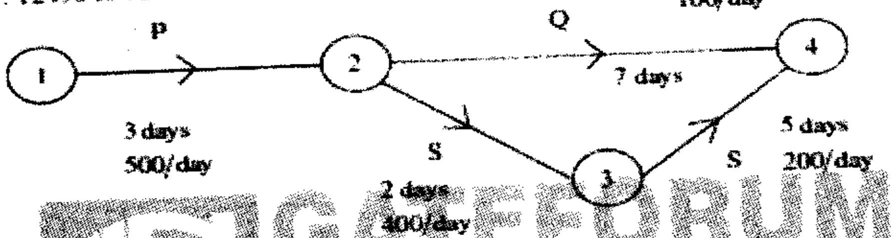
50. A project has four activities P, Q, R and S as shown below.

Activity	Normal duration (days)	Predecessor	Cost slope (Rs./day)
P	3	-	500
Q	7	P	100
R	4	P	400
S	5	R	200

The normal cost of the project is Rs. 10,000/- and the overhead cost is Rs. 200/- per day. If the project duration has to be crashed down to 9 days, the total cost (in Rupees) of the project is ______

Answer: 12490 to 12510

Exp:



Heuristic model to solve the crashing problem:

Step I - Find the normal time

Step II - Determine critical path = P-R-S = 12days.

Step III - Crash the lowest cost slope from the critical path

= crash activity 's' by 2 days

Now critical path = P – Q(10days)

∴ Total cost of the project

$= 10000 + 200 \times (10\text{days}) + \text{crashing cost}$

$= 10,000 + 2000 + 200 \times 2 = 10,000 + 2000 + 400 = 12,400.$

18. If there are m sources and n destinations in a transportation matrix, the total number of basic variables in a basic feasible solution is

(A) m + n (B) m + n + 1 (C) m + n - 1 (D) m

Answer: C

Exp:

ORIGIN \ DESTINATION	1	2	3	n	TOTAL
1	x_{11}	x_{12}	----		a_1
2	x_{21}	x_{22}	----		a_2
⋮					
m	x_{m1}	x_{m2}		x_{mn}	a_m
TOTAL	b_1	b_2	....	b_n	$\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j$

$$\sum_{j=1}^{n} x_{ij} = a_i, (i = 1, 2, \ldots m) \_\_\_\_ (1)$$

$$\sum_{i=1}^{m} x_{ij} = b_j, (J = 1, 2, \ldots n) \_\_\_\_ (2)$$

$$x_{ij} \geq 0 \_\_\_\_ (3)$$

$$\sum_{i=1}^{m} \sum_{j=1}^{n} C_{ij} x_{ij} = mn \_\_\_\_ (4)$$

It is evident from the above diagram, that m+n equations (1) and (2) constitute m+n-1 independent equations in mn unknowns.

Exp: Given D = 100000/year

unit cost = 10

$C_c = 1.5$

$C_o = 30$/order

$$\therefore EOQ = \sqrt{\frac{2 \times D \times C_o}{C_c}} = \sqrt{\frac{2 \times 100000 \times 30}{1.5}} = 2000$$

$$\therefore \text{No of order's / year} = \frac{\text{Demand}}{EOQ} = \frac{100000}{2000} = 50.$$

19. The actual sales of a product in different months of a particular year are given below:

September	October	November	December	January	February
180	280	250	190	240	?

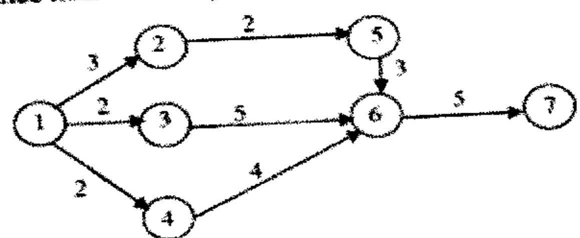
The forecast of the sales, using the 4-month moving average method, for the month of February is ______

Answer: 239 to 241

Exp: Number of periods = 4, then the past 4 months average sales is fore cast for next 4 months.

$$\text{So, } \frac{280 + 250 + 190 + 240}{4} = 240.$$

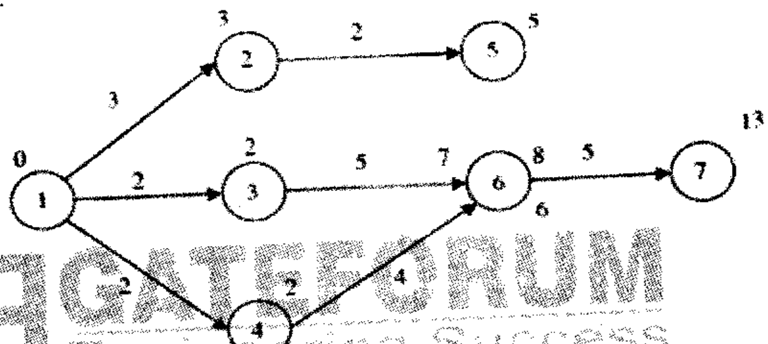
50. Consider the given project network, where numbers along various activities represent the normal time. The free float on activity 4-6 and the project duration, respectively, are



(A) 2, 13 (B) 0, 13 (C) -2, 13 (D) 2, 12

Answer: (A)

Exp:

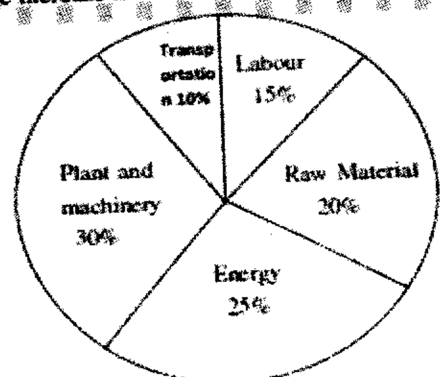


For 4-6

$F.F = (E_j - E_i) - T_{ij} = (8-2) - 4 = 2$

$\therefore$ 2, 13.

9. A firm producing air purifiers sold 200 units in 2012. The following pie chart presents the share of raw material, labour, energy, plant & machinery, and transportation costs in the total manufacturing cost of the firm in 2012. The expenditure on labour in 2012 is Rs. 4,50,000. In 2013, the raw material expenses increased by 30% and all other expenses increased by 20%. What is the percentage increase in total cost for the company in 2013?



Answer: 22

Exp.

	2012	2013
Transport (10%)	300,000	360,000
Labour (15%)	450,000	540,000
Raw material (20%)	750,000	780,000
Energy (25%)	750,000	900,000
Plant and Machinery (30%)	900,000	1,080,000
Total	**3,000,000**	**3,660,000**

Percentage increase in total cost =22%

19. Demand during lead time with associated probabilities is shown below:

Demand	50	70	75	80	85
Probability	0.15	0.14	0.21	0.20	0.30

Expected demand during lead time is ________

Answer: 74 to 75

Exp: Probability

x_i	f_i	$x_i f_i$
50	0.15	7.5
70	0.14	9.8
75	0.21	15.75
80	0.2	16
85	0.3	25.5

Expected demand during lead time = 74.55.

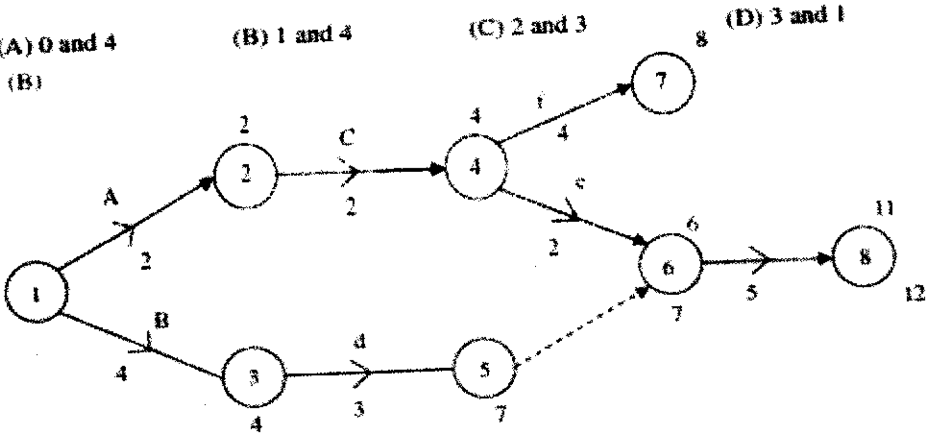
50. The precedence relations and duration (in days) of activities of a project network are given in the table. The total float (in days) of activities e and f, respectively, are

Activity	Predecessors	Duration (days)
a	-	2
b	-	4
c	a	2
d	b	3
e	c	2
f	c	4
g	d,e	5

(A) 0 and 4 (B) 1 and 4 (C) 2 and 3 (D) 3 and 1

Answer: (B)

Exp:



$(TF)_e = (L_j - E_i) - T_e = (7-4) - 2 = 1$

$(TF)_f = (8-0) - 4 = 4$

48. The dimensions of a cylindrical side riser (height = diameter) for a 25 cm × 15 cm × 5 cm steel casting are to be determined. For the tabulated shape factor values given below, diameter of the riser (in cm) is _______.

Shape Factor	2	4	6	8	10	12
Riser Volume / Casting Volume	1.0	0.70	0.55	0.50	0.40	0.35

Answer: 10.61

Exp: Shape factor $= \frac{l+w}{h} = \frac{25+15}{5} = 8$ then from the table

$$\therefore \frac{V_r}{V_c} = 0.5$$

$$V_r = 0.5 \times 25 \times 15 \times 5 = 937.5$$

$$\frac{\pi}{4} d^3 = 937.5 \text{cm}^3$$

$$\therefore d = 10.61 \text{cm}$$

37. For the linear programming problem:

$$\text{Maximize } Z = 3X_1 + 2X_2$$

Subject to

$$-2X_1 + 3X_2 \le 9$$

$$X_1 - 5X_2 \ge -20$$

$$X_1, X_2 \ge 0$$

The above problem has

(A) unbounded solution

(B) infeasible solution

(C) alternative optimum solution

(D) degenerate solution

Answer: (A)

Exp: Plotting the graph for the given constraints as shown in figure.

From figure we can see that LPP has unbounded solution.

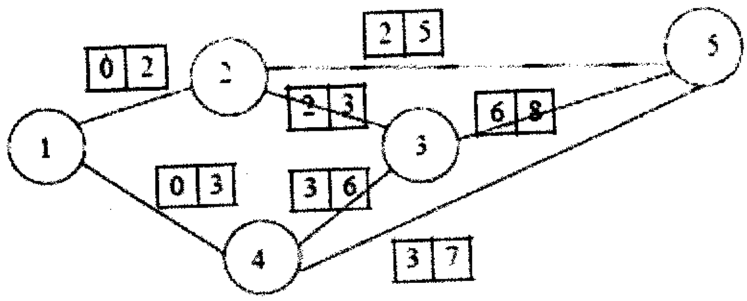
50. Following data refers to the activities of a project, where, node 1 refers to the start and node 5 refers to the end of the project

Activity	Duration (days)
1-2	2
2-3	1
4-3	3
1-4	3
2-5	3
3-5	2
4-5	4

The critical path (CP) in the network is
(A) 1-2-3-5 (B) 1-4-3-5 (C) 1-2-3-4-5 (D) 1-4-5

Answer: (B)

Exp:



Critical path-1-4-3-5

Time taken = 8 days

11. Sales data of a product is given in the following table:

Month	January	February	March	April	May
Number of unit sold	10	11	16	19	25

Regarding forecast for the month of June, which one of the following statements is **TRUE**?

(A) Moving average will forecast a higher value compared to regression

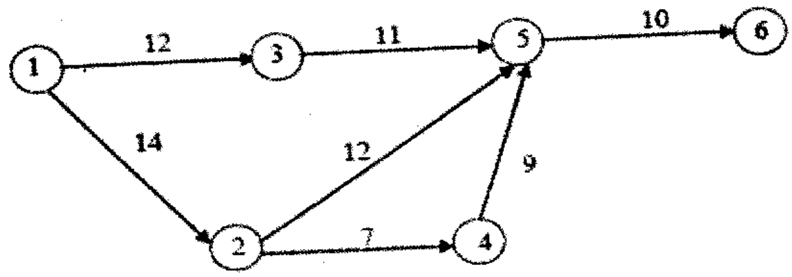
(B) Higher the value of order N, the greater will be the forecast value by moving average.

(C) Exponential smoothing will forecast a higher value compared to regression.

(D) Regression will forecast a higher value compared to moving average

Answer: (D)

54. A project consists of 7 activities. The network along with the time durations (in days) for various activities is shown in the figure.



The minimum time (in days) for completion of the project is ______

Answer: 40

Exp: Time taken for 3 paths are as follows

Path 1 = 12+11+10

Path 2 = 14+12+10

Path 3 = 14+7+9+10

∴ Path3 is longest i.e, path 3 is critical path

∴ Project duration = 40 days

31. A manufacturer has the following data regarding a product:
Fixed cost per month = Rs. 50000
Variable cost per unit = Rs 200
Selling price per unit = Rs 300
Production capacity = 1500 units per month
If the production is carried out at 80% of the rated capacity, that the monthly profit (in Rs.) is ______

Answer: 70000

Exp: Profit per month = 0.8 × 1500 × (300-200) − 50000

= 120000-50000

= 70000

10. Annual demand of a product is 50000 units and the ordering cost is Rs. 7000 per order considering the basic economic order quantity model, the economic order quantity is 10000 units. When the annual inventory cost is minimized, the annual inventory holding cost (in Rs.) is ______

Answer: 35000

Exp: At optimum total inventory cost (TIC), annual inventory hold is cost is equal to annual inventory ordering cost

= Number of orders × ordering cost per order

$= \frac{50000}{10000} \times 7000$

$= 5 \times 7000$

$= 35000$

54. The demand for a two-wheeler was 900 units and 1030 units in April 2015 and May 2015, respectively. The forecast for the month of April 2015 was 850 units. Considering a smoothing constant of 0.6, the forecast for the month of June 2015 is

(A) 850 units (B) 927 units

(C) 965 units (D) 970 units

Key: (D)

Exp:

Month	Demand	Forecast $(= \alpha D_{t-1} + (1-\alpha)F_{t-1})$
April	900	850
May	1030	$= 0.6 \times 900 + 0.4 \times 850 = 880$
June		$= 0.6 \times 1030 + 0.4 \times 880 = 970$

$F_{June} = 970$ units

55. A firm uses a turning center, a milling center and a grinding machine to produce two parts. The table below provides the machining time required for each part and the maximum machining time available on each machine. The profit per unit on parts I and II are Rs. 40 and Rs. 100, respectively. The maximum profit per week of the firm is Rs.____

Type of machine	Machining time required for the machine part (minutes)		Maximum machining time available per week (minutes)
	I	II	
Turning Center	12	6	6000
Milling Center	4	10	4000
Grinding Machine	2	3	1800

Key: 40,000

Exp: Linear program formulation is

$\max z = 40x_1 + 100x_2$

Constraints are

$12x_1 + 6x_2 \le 6000$

$4x_1 + 10x_2 \le 4000$

$2x_1 + 3x_2 \le 1800$

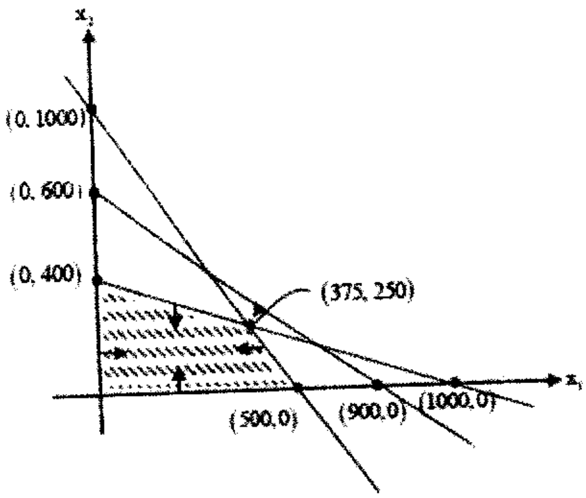
$x_1, x_2 \ge 0$

At $(0, 400)$, $z = 40,000$

At $(375, 250)$, $z = 40,000$

At $(500, 0)$, $z = 20,000$

$\therefore$ Maximum profit per week is Rs. 40,000.



55. Maximize $Z=15X_1+20X_2$

subject to

$12X_1+4X_2 \geq 36$

$12X_1-6X_2 \leq 24$

$X_1, X_2 \geq 0$

The above linear programming problem has

(A) infeasible solution (B) unbounded solution

(C) alternative optimum solutions (D) degenerate solution

Key: (B)

Exp: $\text{Max } Z=15x_1+20x_2$

Subject to

$12x_1+4x_2 \geq 36$

$12x_1-6x_2 \leq 24$

$x_1, x_2 \geq 0$

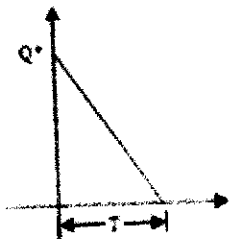
Since, there is no limitation of boundary for the feasible region therefore, the LPP has unbounded solution.

54. The annual demand for an item is 10,000 units. The unit cost is Rs. 100 and inventory carrying charges are 14.4% of the unit cost per annum. The cost of one procurement is Rs. 2000. The time between two consecutive orders to meet the above demand is ______ month(s).

Key: 2

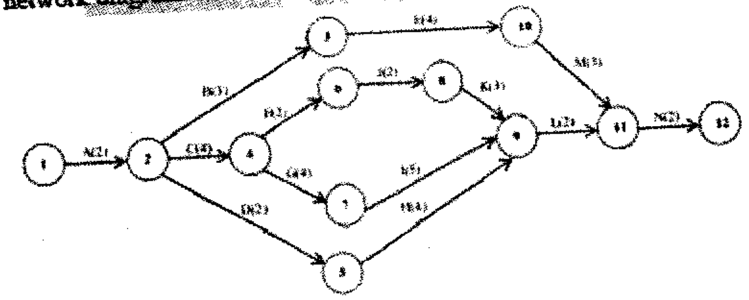
Exp: D= 10,000, Cu = Rs 100, $C_h = 0.144 \times Cu$, C_o=Rs 2,000.

$$Q^* = \sqrt{\frac{2DC_0}{C_h}} = \sqrt{\frac{2 \times 10,000 \times 2000}{0.144 \times 100}} = 1666.67 \text{ units}$$



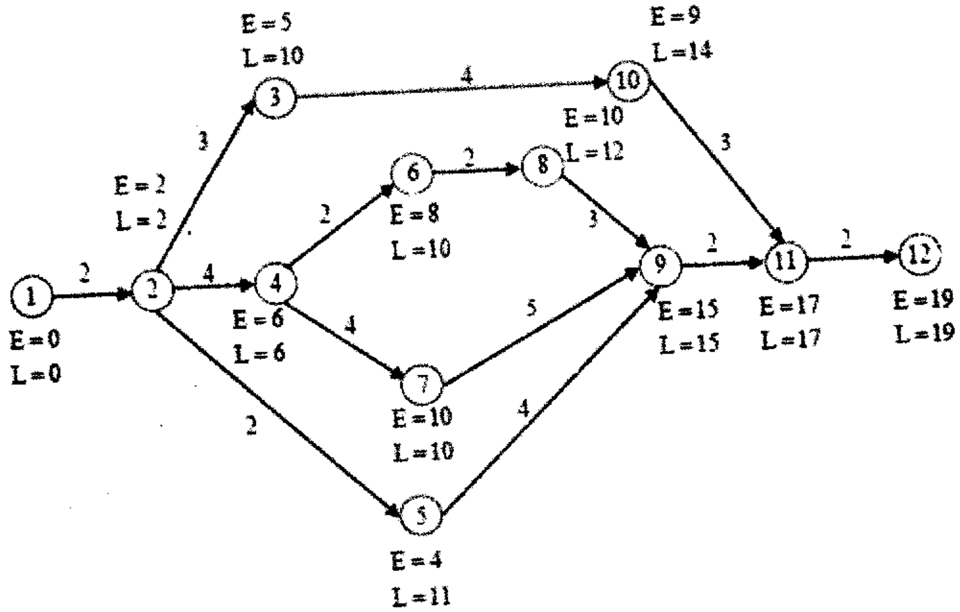
$$\text{We know } T = \frac{Q^*}{D} = \frac{1666.67}{10,000} = 0.1667 \text{ years} = 2 \text{ months}$$

55. A project consists of 14 activities, A to N. The duration of these activities (in days) are shown in brackets on the network diagram. The latest finish time (in days) for node 10 is



Key: 14

Exp:



The latest finish time for node 10 is 14 days

54. A food processing company uses 25,000 kg of corn flour every year. The quantity-discount price of corn flour is provided in the table below.

Quantity (kg)	Unit price (Rs/kg)
1-749	70
750-1499	65
1500 and above	60

The order processing charges are Rs. 500/order. The handling plus carry-over charge on an annual basis is 20% of the purchase price of the corn flour per kg. The optimal order quantity (in kg) is ______.

Key: 1500

Exp: $D = 25000$ kg, $C_0 = $ Rs 500/order, $C_h = 20\%$ of Cu

Qty (kg)	Cu (Rs/kg)	C_h (Rs/Kg/year)
$1 \le Q_1 < 750$	70	$0.2 \times 70 = 14$
$750 \le Q_2 < 1500$	65	$0.2 \times 65 = 13$
$Q_3 \ge 1500$	60	$0.2 \times 60 = 12$

This problem belongs to inventory model with two price break.

$$Q^* = \sqrt{\frac{2DC_0}{C_h}}$$

$\Rightarrow$ first checking for least unit price

$$Q_3^* = \sqrt{\frac{2 \times 25000 \times 500}{12}} = 1443.37$$

Now, 1443.37 < 1500 therefore, the company will not get the item at Rs 60/kg

Now, checking for second minimum unit price

$$Q_2^* = \sqrt{\frac{2 \times 25000 \times 500}{13}} = 1386.75$$

Since, 1386.75 lies between 750 and 1500

Therefore, we need to find

$$\text{Total cost}(Q_2^*) = 25000 \times 65 + \frac{25000}{1386.75} \times 500 + \frac{1386.75}{2} \times 13$$

$$= \text{Rs}\,1643027.755$$

$$\left[\because T.C = D \times Cu + \frac{D}{Q} \times C_0 + \frac{Q}{2} \times C_h\right]$$

$$\text{Total cost}(1500) = 25000 \times 60 + \frac{25000}{1500} \times 500 + \frac{1500}{2} \times 12 = \text{Rs } 1517333.33$$

Since, T.C (1500) < T.C(Q_2^*)

Therefore, optimal order quantity is 1500.

NARASARAOPETA
ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

PREVIOUS QUESTION PAPERS

NEC ENGINEERING COLLEGE
(AUTONOMOUS)

Subject Code: R20CC1OE07

III B.Tech. - I Semester Regular Examinations, November-2022

OPERATIONS RESEARCH
(ME)

Time: 3 hours **Max. Marks: 70**

Note: Answer All **FIVE** Questions.
All Questions Carry Equal Marks (5 X 14 =70M)

QNo		Questions	K L	CO	Marks
		Unit-I			
1	a	i) Discuss the various phases in solving an OR problem	K2	1	7M
		ii) Explain graphical method of solving an LPP.	K2	1	7M
		OR			
	b	Use simplex method to solve Maximize $Z = 5x_1 + 3x_2$ Subject to the constraints $x_1 + 2x_2 \le 2$ $5x_1 + 2x_2 \le 10$ $3x_1 + 8x_2 \le 12$ $x_1, x_2 \ge 0$	K4	1	14M
		Unit-II			
2	a	i) Solve the following transportation problem by North West corner rule? (table below)	K4	2	8M
		ii) What is degeneracy? How do you overcome degeneracy in transportation problems?	K3		6M
		OR			
	b	Consider the problem of assigning five operators to five machines. The assignment costs are given in below table. (table below) Operator A cannot be assigned to machine M3 and operator C cannot be assigned to machine M4. Find the optimum assignment schedule.	K4		14M
3		**Unit-III**			
	a	There are nine jobs, each of which must go through two machines X and Y in the order PQ, the processing times (in hours) are given below: (table below) Find the sequence that minimizes the total elapsed time T. Also calculate the total idle time for the machines in this period.	K4	3	14M

Table for 2 a i):

	F_1	F_2	F_3	Supply
W_1	2	7	4	5
W_2	3	3	1	8
W_3	5	4	7	7
W_4	1	6	2	14
Demand	7	9	18	

Table for 2 b:

	M_1	M_2	M_3	M_4	M_5
A	7	7	-	4	8
B	9	6	4	5	6
C	11	5	7	-	5
D	9	4	8	9	4
E	8	7	9	11	11

Table for 3 a:

Machine	Job(s)								
	A	B	C	D	E	F	G	H	I
X	2	5	4	9	6	8	7	5	4
Y	6	8	7	4	3	9	3	8	11

		OR			
	b	i) In a self service store with one cashier, 8 customers arrive on an average of every 5 minutes and the cashier can serve 10 in 5 minutes If both arrival and service time are exponentially distributed, then determine a) Average number of customers waiting in the queue for average. b) Expected waiting time in the queue c) What is the probability of having more than 6 customers In the system	K4	3	7
		ii) A telephone exchange has two long distant operators. The telephone company finds that during the fashion at an average rate of 15/hr. The length mean of 5 mins. (a) What is the probability that a subscriber will have to wait for his long distant dials on the peak hour of the day? (b) what is the average waiting time for the customers	K4	3	7M
		Unit-IV			
4	a	i)Find the cost period of individual replacement of an installation of 300 lighting bulbs, given the following: a) Cost of replacing individual bulb is Rs. 3 b) Conditional probability of failure is given below:	K4	4	14M
		OR			
	b	A distance network consists of eleven nodes which are distributed as shown in figure. Find the shortest path from node 1 to node 11 and also the corresponding distances.	K4	4	14M
		Unit-V			
5	a	i) Solve the following game using dominance principle.	K4	5	14M
		OR			
	b	i) Discuss the types of simulation models.	K3	5	7M
		ii) Explain the principal features of simulation languages.	K2	5	7M

Table for 4 a):

Week number	0	1	2	3	4
Conditional probability of failure	0	1/10	1/3	2/3	0

Figure for 4 b):

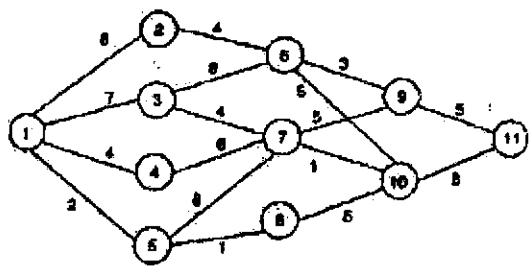


Table for 5 a):

		Player B			
		1	2	3	4
Player A	I	19	6	7	5
	II	7	3	14	6
	III	12	8	18	4
	IV	8	7	13	-1

NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

III B.Tech I Sem Regular/Supplementary Exam, DEC-2022

OPERATION RESEARCH

Answer all five questions **5*14=70**

1A)

i) **Operation research, like a scientific research is based on scientific methodology which involves following steps.**

1. Formulating the Problem
2. Constructing a Model to Represent the System under Study
3. Deriving Solution from the Model
4. Testing the Model and the Solution Derived from it
5. Establishing Controls over the Solution
6. Implementation of the Solution

ii) **Graphical Method**

1. Step 1: Formulate the LP (Linear programming) problem. ...
2. Step 2: Construct a graph and plot the constraint lines. ...
3. Step 3: Determine the valid side of each constraint line. ...
4. Step 4: Identify the feasible solution region. ...
5. Step 5: Plot the objective function on the graph. ...
6. Step 6: Find the optimum point

2a) ii) In a transportation problem, **if a basic feasible solution with m origins and n destinations has less than m +n -1 positive Xij i.e. occupied cells**, then the problem is said to be a degenerate transportation problem.

If the basic feasible solution of a transportation problem with m origins and n destinations has fewer than m + n − 1 positive x_{ij} (occupied cells), the problem is said to be a degenerate transportation problem. Degeneracy can occur at two stages: At the initial solution. During the testing of the optimal solution.

5b) i) A simulation imitates the operation of real world processes or systems with the use of models. The model represents the key behaviours and characteristics of the selected process or system while the simulation represents how the model evolves under different conditions over time.

1. **Discrete Event Simulation:** Modelling a system as it progresses through time, for example;
   - ✓ factory operations (stamping, turning, milling)
   - ✓ traffic analysis (roads, networks, queues)
2. **Dynamic Simulation:** Modelling a system as it progresses through space, for example;
   - ✓ machine kinematics
   - ✓ human ergonomics
   - ✓ aerodynamic testing
   - ✓ virtual prototyping
3. **Process Simulation:** Modelling physical interactions between two or more systems, for example;
   - ✓ in-service product modelling
   - ✓ in-manufacture product modelling
   - ✓ weather forecasting

ii) A computer simulation model is an abstract entity that describes the dynamics behavior of a target system. It can be designed according to different modeling methodologies and implemented in a computer by means of a programming language. Many specific programming languages have been developed to facilitate this implementation. These are formally designated as modeling languages. The execution of a computer model is referred to as the simulation or experimental phase. Some modern software simulation environments provide extensions to modeling languages that simplify common tasks such as parameter identification, sensitivity analysis, validation, and even the connection to external data sources and other software programs. Accordingly, specific languages used to describe, implement, and even design the subsequent experiments are called modeling and simulation languages or, simply, simulation languages. We use both modeling language and simulation language as synonymous terms throughout the text despite the fact that they are not formally the same

1b) Use Simplex method to solve

$$\text{Max } Z = 5x_1 + 3x_2$$

Subjected to $\quad x_1 + 2x_2 \leq 2$

$$5x_1 + 2x_2 \leq 10$$

$$3x_1 + 8x_2 \leq 12$$

$$x_1, x_2 \geq 0$$

Sol: $\quad \text{Max } Z = 5x_1 + 3x_2 + 0s_1 + 0s_2 + 0s_3$

Subjected to

$$x_1 + 2x_2 + s_1 = 2 \quad \text{— (1)}$$

$$5x_1 + 2x_2 + s_2 = 10 \quad \text{— (2)}$$

$$3x_1 + 8x_2 + s_3 = 12 \quad \text{— (3)}$$

x_1, x_2, s_1, s_2 and $s_3 \geq 0$

Initial Simplex Table :-

C_{B_i}	C_j	5	3	0	0	0	Solution	Ratio
	B.V	x_1	x_2	S_1	S_2	S_3		
0	S_1	1	2	1	0	0	2	1
0	S_2	5	2	0	1	0	10	2
0	S_3	3	8	0	0	1	12	4
	z_j	0	0	0	0	0	0	
	$C_j - z_j$	5	3	0	0	0		

↑ Key column

C_{B_i}	C_j	5	3	0	0	0	Solution	Ratio
	B.V	x_1	x_2	S_1	S_2	S_3		
5	x_1	1	2	1	0	0	2	
0	S_2	0	-8	-5	1	0	0	
0	S_3	0	2	-3	0	1	9	
	z_j	5	10	5	0	0	10	
	$C_j - z_j$	0	-7	-5	0	0		

$x_1 = 2, \quad x_2 = 0 \Rightarrow \text{Max } z = 5x_1 + 3x_2$

$= 5(2) + 3(0)$

2a) i)

	F_1	F_2	F_3	Supply
W_1	2	7	4	5
W_2	3	3	1	8
W_3	5	4	7	7
W_4	1	6	2	14
Demand	7	9	18	34 \ 34

Balanced Transportation problem

Demand = Supply

34 = 34.

				Supply
	2 $\boxed{5}$	7	4	~~5~~ 0
	3 $\boxed{2}$	3 $\boxed{6}$	1	~~8~~ ~~6~~ 0
	5	4 $\boxed{3}$	7 $\boxed{4}$	~~7~~ ~~4~~ 0
	1	6	2 $\boxed{14}$	14
Demand	~~7~~ ~~2~~ 0	~~9~~ ~~3~~ 0	~~18~~ 14	

$= 5(2) + 2(3) + 6(3) + 3(4) + 4(7) + 14(2)$

$= 10 + 6 + 18 + 12 + 28 + 28$

$= 102$

2

2b)

	m_1	m_2	m_3	m_4	m_5
A	7	7	-	4	8
B	9	6	4	5	6
C	11	5	7	-	5
D	9	4	8	9	4
E	8	7	9	11	11

No. of Row = No. of columns.

phase 1 : Row and column Reduction.

3	3	∞	0	4
5	2	0	1	2
6	0	2	∞	0
5	0	4	5	0
1	0	2	4	4

Row Reduction

	M_1	M_2	M_3	M_4	M_5
A	2	3	∞	$\boxed{0}$	4
B	4	2	$\boxed{0}$	1	2
C	5	0	2	∞	0
D	4	0	4	5	0
E	$\boxed{0}$	0	2	4	4

column Reduction

	m_1	M_2	m_3	M_4	m_5
A	0	1	∞	0	2
B	2	0	0	1	0
C	3	0	2	∞	0
D	2	0	4	5	0
E	0	0	4	6	4

	M1	M2	M3	M4	M5
A	0	1	∞	$\boxed{0}$	2
B	2	0	$\boxed{0}$	1	0
C	3	$\boxed{0}$	2	∞	0
D	2	0	4	5	$\boxed{0}$
E	$\boxed{0}$	0	4	6	4

A - 4
B - 3
C - 2
D - 5
E - 1

<u>optimal solution</u>

Operator	Machine	Time
A	M4	4
B	m3	4
C	m2	5
D	m5	4
E	m1	8
		25

3a)

Machine	Jobs								
	A	B	C	D	E	F	G	H	I
x	2	5	4	9	6	8	7	5	4
y	6	8	7	4	3	9	3	8	11

A	C	I	B	H	F	D	G	E

x y

Jobs	Machine X		Machine Y	
	In	out	In	out
A	0	2	2	8
C	2	6	8	15
I	6	10	15	26
B	10	15	26	34
H	15	20	34	42
F	20	28	42	51
D	28	37	51	55
G	37	44	55	58
E	44	50	58	61

Total Elapsed Time = 61 hours.

Idle Time for Machine x = 61 − 50 = 11 hours.

machine y = (61 − 61) + 2

= 2 hours

3.b) (i) arrival rate (λ) = 8 per 5 minutes

Service rate (μ) = 10 per 5 minutes

$$W_q = \frac{1}{(\mu-\lambda)}\left(\frac{\lambda}{\mu}\right)$$

$$= \frac{1}{(10-8)}\left(\frac{\cancel{8}^{4}}{\cancel{10}_{5}}\right)^{1/2} = \frac{2}{5} = 0.4$$

$$W_s = \frac{1}{\mu-\lambda} = \frac{1}{10-8} = \frac{1}{2} = 0.5$$

$$P_0 = 1-\frac{\lambda}{\mu} = 1-\frac{8}{10} = 0.2.$$

$$P_6 = P_0\left(\frac{\lambda}{\mu}\right)^6$$

$$= 0.2\left(\frac{8}{10}\right)^6 = 0.052.$$

① Avg no. of customers waiting in queue = 0.4

② Expected waiting Time queue = 0.5

③ probability of having more than 6 customers in the system = 0.0542.

④

(ii) given data

arrival rate = 15/hr

Service rate = 5 mins

$= \frac{60}{5} = 12/hr.$

i) what is probability that a subscriber will have to wait for his long distant

$$P_0 = 1 - \frac{\lambda}{\mu}$$

$$= 1 - \frac{15}{12}$$

$$= 1 - 1.25 = -0.25.$$

ii) what is the avg waiting time for the cutsomers.

$$W_q = \frac{1}{\mu - \lambda}\left(\frac{\lambda}{\mu}\right)$$

$$= \frac{1}{12-15}\left(\frac{15}{12}\right)$$

$$= 0.4166$$

4.a)

Week number	0	1	2	3	4
Conditional probability of failure	0	1/10	1/3	2/3	0

Let p_i be the probability of failure of a new bulb in the ith week

$P_0 = 0$

$P_1 = \frac{1}{10} - 0 = 0.1$

$P_2 = \frac{1}{3} - \frac{1}{10} = 0.233$

$P_3 = \frac{2}{3} - \frac{1}{3} = 0.33$

$P_4 = 0 - \frac{2}{3} = -0.667$

Let N_i be the number of Replacement made at the end of ith week. Then we have.

N_o = No. of Light bulbs in the begining = 300

$N_0 = N_o P_0 = 300(0) = 0$

$N_1 = N_o P_1 = 300(0.1) = 30$

$N_2 = N_o P_2 + N_1 P_1 = 300(0.233) + 30(0.1)$
$= 69.9 + 3$
$= 72.9$

$$N_3 = N_0P_3 + N_1P_2 + N_2P_1$$

$$= 300(0.33) + 30(0.233) + 72.9(0.1)$$

$$= 99 + 6.99 + 7.29$$

$$= 113.28.$$

$$N_4 = N_0P_4 + N_1P_3 + N_2P_2 + N_3P_3$$

$$= 300(0.667) + 30(0.33) + 72.9(0.233) + 113.28([illegible]33)$$

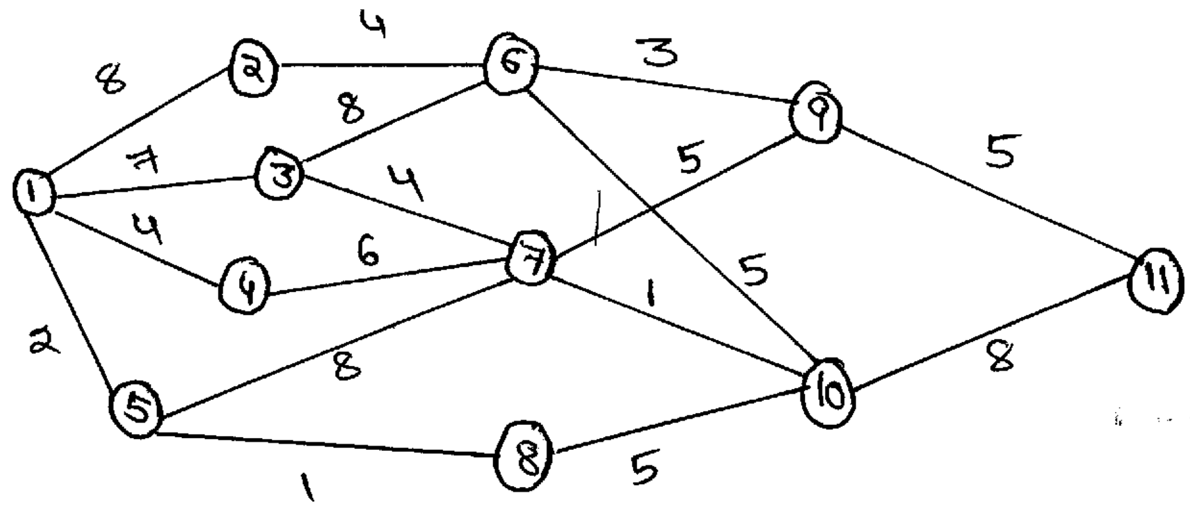
$$= -200 + 9.9 + 16.9857 + 39.0324$$

$$= -134.0819$$

End of week	Individual Replacement	Total cost	Avg. cost
0	0	0	0
1	30	30(3) = 90	90
2	102.9	308.7	154.35
3	216.18	648.54	216.18
4	82.1	246.3	61.575

Since the Average cost is Lower at week 4 hence the optimum interval between is every 4 weeks.

4.b



paths:

1-2-6-9-11 = 8+4+3+5 = 20

1-3-6-9-11 = 7+8+3+5 = 23

1-3-7-9-11 = 7+4+5+5 = 21

1-4-7-9-11 = 4+6+5+5 = 20

1-4-7-10-11 = 4+6+1+8 = 19

1-3-6-10-11 = 7+8+5+8 = 28

1-5-8-10-11 = 2+1+5+8 = 16

1-5-7-9-11 = 4+6+5+5 = 20

The shortest path is 1-5-8-10-11.

5(a)

		player B 1	2	3	4	Row minimum
player A	I	19	6	7	5	$\boxed{5}$ max min
	II	7	3	14	6	3
	III	12	8	18	4	4
	IV	8	7	13	-1	-1
column maximum		19	8	18	$\boxed{6}$ minmax	

Min max = Max min

$6 \neq 5$

Hence saddle point is not exist.

Dominance principle:

		player B 1	2	3	4	Total
player A	I	19	6	7	5	37
	~~II~~	~~7~~	~~3~~	~~14~~	~~6~~	~~30~~
	III	12	8	18	4	42
	~~IV~~	~~8~~	~~7~~	~~13~~	~~-1~~	~~27~~

player B

	1	2	3	4
player A I	19	6	7	5
III	12	8	18	4
Column Total	31	14	25	9

	4	
I	5	5
~~III~~	~~4~~	~~4~~

Value of the game = 5

strategies for

player A = [1, 0, 0, 0]

player B = [0, 0, 0, 1]

K. John Babu
Asst. professor
Dept of ME
NEC.

HOD ME

Narasaraopeta Engineering College (Autonomous)
Kotappakonda Road, Yellamanda(P.O), Narasaraopet - 522601, Guntur District, A.P.
R19 B.TECH 2 YEAR 2 SEM REGULAR EXAMINATIONS AUGUST 2021

Subject Code: 19BME4OE12 OPERATIONS RESEARCH Max.Marks:60.

Time: 3 Hours Program: B.Tech. Branch: ME.

Note: Answer All FIVE Questions.
All Questions Carry Equal Marks (5 X 12 =60M)

---

1. A) Solve the following LPP using Simplex method.

   Maximize $Z = 10x_1 + 15x_2 + 20x_3$

   Subject to $2x_1 + 4x_2 + 6x_3 \le 24$

   $3x_1 + 9x_2 + 6x_3 \le 30$

   $x_1, x_2, x_3 \ge 0$

OR

B) Use Big-M method to solve the following Linear Programming problem.

Minimize $Z = -3x_1 + x_2 + x_3$

Subject to $x_1 - 2x_2 + x_3 \le 11$

$-4x_1 + x_2 + 2x_3 \ge 3$

$2x_1 - x_3 = -1$

$x_1, x_2, x_3 \ge 0$

2. A) The ICARE Company has three plants P1, P2 and P3 located throughout a state with production capacity 50, 75 and 25 gallons respectively. Each day the firm must furnish its four retail shops R1, R2, R3, & R4 with at least 20, 20, 50, and 60 gallons respectively. The transportation costs (in Rs.) are given below. Solve the given transportation problem for minimum cost.

Company	Retail			
	R1	R2	R3	R4
P1	3	5	7	6
P2	2	5	8	2
P3	3	6	9	2

OR

B) Solve the following assignment problem for minimum cost, if the cell entries represent cost of completing a job a given worker.

Workers	Jobs				
	1	2	3	4	5
I	11	17	8	16	20
II	9	7	12	6	15
III	13	16	15	12	16
IV	21	24	17	28	26
V	14	10	12	11	13

3. A) Find the sequence for the following eight jobs that will minimize the total elapsed time for the completion of all the jobs. Each job is processed in the same order CAB. Entities give the time in hrs. on the machines.

Job	1	2	3	4	5	6	7	8
A	4	6	7	4	5	3	6	2
B	8	10	7	8	11	8	9	13
C	5	6	2	3	4	9	15	11

OR

B) The following table gives the activities in a project.

Activity	A	B	C	D	E	F	G	H
Predecessor(S)	-	-	A	A	B,C	B,C	D	D,E
Duration(days)	5	6	3	8	2	11	1	12

i. Draw the network for the project
ii. Find critical path
iii. Find free, total and independent floats for each activity

4. A) An automated car wash will wash a car in 10 minutes. Arrivals occur an average of 15 minutes apart (exponentially distributed) i) On the average, how many cars are waiting in line for a wash ii) If the car wash could be speeded up, what wash time would reduce the average waiting time to 5 minutes.

OR

B) A company has 8 salesman who have to be allocated to 4 marketing zones. The return or profit from each zone depends on no. of salesman working at that zone. The expected returns for different no. of salesman in different zones as estimated from the past records are given below. Determine the optimal allocation policy.

No. of salesman	Zone 1	Zone 2	Zone 3	Zone 4
0	45	30	35	42
1	58	45	45	54
2	70	60	52	60
3	82	70	64	70
4	93	79	72	82
5	101	90	82	95
6	108	98	93	102
7	113	105	98	110
8	118	110	100	110

5. A) Obtain the optimal strategies for both persons and the value of the game whose pay-off matrix is as follows.

Player B

		B_1	B_2	B_3	B_4	B_5
Player A	A_1	3	0	6	-1	7
	A_2	-1	5	-2	2	1

OR

B) I) A machine owner finds from his past records that the costs per year of maintaining a machine whose purchase price is Rs.6000/- are as given below:

Year	1	2	3	4	5	6	7	8
Maintenance Cost	1000	1200	1400	1800	2300	2800	3400	4000
Resale Value	3000	1500	750	375	200	200	200	200

Determine at what age a replacement is due?

II) What is time value of money? Explain

Narasaraopeta Engineering College (Autonomous)
Kotappakonda Road, Yellamanda (P.O), Narasaraopet- 522601, Guntur District, AP.

II B.Tech II Semester Supple Examinations, March-2022

Subject Code: 19BME4OE12 **OPERATIONS RESEARCH**

Time: 3 Hours Program: B.Tech. Max.Marks:60. Branch: ME.

Note: Answer All **FIVE** Questions.
All Questions Carry Equal Marks (5 X 12 =60M)

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1. A) Use Simplex method to solve the following problem:

Maximize Z = 2X1 + 5X2 , Subjected to the constraints

$3X1 + X2 \leq 21$
$X1 + 4X2 \leq 24$
$X1 + X2 \leq 9$ and
$X1, X2 \geq 0$

OR

B) Solve the following LPP by Big-M method.

Maximize Z=3x1+2x2
Subjected to the constraints
$2x1+x2 \leq 2$
$3x1+4x2 \geq 12$
And $x1, x2 \geq 0$.

2. A) Solve the following transportation problem.

	To				Supply
From	21	16	25	13	11
	17	18	14	23	13
	32	27	18	41	19
Demand	6	10	12	15	

OR

B) A batch of 4 jobs can be assigned to 5 different machines. The set up time (in hours) for each job on various machines is given below. Find the optimal assignment of jobs to machines which will minimize the total setup time.

		MACHINES				
		1	2	3	4	5
JOB	1	10	11	4	2	8
	2	7	11	10	14	12
	3	5	6	9	12	14
	4	13	15	11	10	7

3. A) I) Determine the optimal sequencing of the following 7 jobs on two machines M1 and M2.

JOB	1	2	3	4	5	6	7
M1	3	12	15	6	10	11	9
M2	8	10	10	6	12	1	3

II) Distinguish between PERT and CPM

OR

B) The following table indicates the details of a project. The durations are in days. 'a' refers to optimistic time, 'm' refers to most likely time and 'b' refers to pessimistic time duration.

Activity	**a**	**m**	**b**
1-2	2	4	5
1-3	3	4	6
1-4	4	5	6
2-4	8	9	11
2-5	6	8	12
3-4	2	3	4
4-5	2	5	7

(a) Draw the network
(b) Find the critical path
(c) What is the project length?
(d) Determine the expected standard deviation of the completion time

4. A) Arrivals at a telephone booth are considered to be following Poisson law of distribution with an average time of 10 minutes between one arrival and the next. Length of a phone call is assumed to be distributed exponentially with mean of 3 minutes.

(i) What is the probability that a person arriving at the booth will have to wait?
(ii) What is the average length of queue that forms from time to time?

OR

B) Use the dynamic Programming to solve the LPP

Maximize $Z = X1 + 9X2$, Subject to the constraints

$$2X1 + X2 \leq 25$$

$$X2 \leq 11$$

$$X1, X2 \geq 0$$

5. A) I) Solve the following game graphically.

	B1	B2	B3	B4
A1	2	1	0	-2
A2	1	0	3	2

II) Solve the following game.

	B1	B2
A1	8	-3
A2	-3	1

OR

B) I) The maintenance cost and the resale price of a machine are given below.

Year	1	2	3	4	5	6	7	8
Maintenance cost	1000	1300	1700	2200	2900	3800	4800	6000
Resale price	4000	2000	1200	600	500	400	400	400

The purchase price of the machine is Rs. 8000. Determine the time at which it is profitable to replace the machine.

II) The Cost of a product is Rs 80,000 and its Scrap value is Rs.500. The maintenance cost found from experience is as follows:

Year	1	2	3	4	5	6	7
Maintenance cost (Rs)	1,000	1,200	1,600	2,400	3,000	3,900	5000

When should the product be replaced?

Subject Code: R16ME3105

III B.Tech I Semester Supplementary Examinations, March 2022

OPERATIONS RESEARCH

(ME)

Time: 3 hours **Max Marks: 60**

Question Paper Consists of **Part-A** and **Part-B.**

Answering the question in **Part-A** is Compulsory & Four Questions should be answered from Part-B

All questions carry equal marks of 12.

PART-A

1. (a) List any two types of operation research models.

(b) What is mean by degenerate solution for a transportation problem?

(c) Explain the significance of crashing the project network.

(d) What is Kendall's notation of waiting line model?

(e) What are Maxi-min and Mini-max principles?

(f) What are advantages and disadvantages of Simulation?

[2+2+2+2+2+2]

PART-B

4 X 12 = 48

2. Solve the following Linear Programming problem.

$$\text{Minimize } Z = -3x_1 + x_2 + x_3$$

$$\text{Subject to} \quad x_1 - 2x_2 + x_3 \leq 11$$

$$-4x_1 + x_2 + 2x_3 \geq 3$$

$$2x_1 - x_3 = -1$$

$$x_1, x_2, x_3 \geq 0$$

3. Solve the following Transportation problem for minimum transportation cost. Cell entries represent unit transportation costs.

Origin	Destination				Supply
	D_1	D_2	D_3	D_4	
O_1	6	1	9	3	70
O_2	11	5	2	8	55
O_3	10	12	4	7	70
Demand	85	35	50	45	

4. The time estimates (in months) of all activities of a project are as given

Activity	1-2	1-3	1-4	2-5	3-5	4-6	5-6
t_o	1	1	2	1	2	2	3
t_m	1	4	2	1	5	5	14
t_p	7	7	8	1	14	8	15

a) Find the expected duration to complete the project

b) What is the probability that the project will be completed

  i. 4 Months earlier than expected
  ii. 4 Months later than expected

5. In a bank, with a single server there are two chairs for waiting customers. On an average one customer arrives every 10 minutes and each customer takes 5 minutes for getting served. Arrival rate is randomly distributed according to Poisson distribution.

   a. The probability that an arrival will get a chair to sit on,
   b. The probability that an arrival will have to stand, and
   c. Expected waiting time of a customer.

6. Obtain the optimal strategies for both persons and the value of the game for zero-sum two person games whose pay-off matrix is as follows

		Player B	
		B_1	B_2
	A_1	1	-3
	A_2	3	5
Player A	A_3	-1	6
	A_4	4	1
	A_5	2	2
	A_6	-5	0

7. A firm is considering replacement of equipment whose first cost is Rs.4000 and the scrap value is negligible at the end of any year. Based on experience, it has been found that the maintenance cost is zero during the first year and it is Rs.1000 for the second year. It increases by Rs. 300 every year thereafter. When the equipment should be replaced, if interest rate is 12%?

***

Model Question Paper-I

Code:R16ME3105 R16

Narasaraopeta Engineering College

(Autonomous)

Yallmanda(Post), Narasaraopet- 522601

B. Tech V Semester Regular Examinations

OPERATIONS RESEARCH

MECHANICAL ENGINEERING

[OUTCOME BASED EDUCATION PATTERN]

Time: 3 Hrs **Max. Marks: 60**

Note: 1. Question Paper consists of two parts (Part-A and Part-B)
2. Answering the question in Part-A is compulsory
3. Answer any THREE Questions from Part-B

Execution Plan

Sl. No	Activities	Time (Minutes)
1	To study the Question Paper and choose to attempt	4
2	Part-A 4 Minutes x 6 Questions	18
3	Part-B 37 Minutes x 4 Questions	148
4	Quick revision & Winding up	10
	Total	180

PART–A (12 Marks)

Answer ALL Questions.

S No		Question	Cognitive Level	CO	Marks
1	a	Define the following i) Feasible solution ii) Optimal solution iii) Basic Variables iv) Artificial variables.	K1	1	2
	b	Describe the difference between a transportation problem and an assignment problem.	K2	2	2
	c	Explain the applications of job sequencing.	K2	3	2
	d	Discuss briefly the main characteristics of a queuing system.	K2	4	2
	e	Discuss "minimax criterion" as applied to the theory of games.	K2	5	2
	f	Explain the types of replacement problems.	K2	6	2

PART–B (48 Marks)

Answer any FOUR Questions

S. No		Question	Cognitive Level	CO	Marks
1		Solve the following LPP: Minimize $Z= 4x_1+3x_2+x_3$ Subject to $x_1+2x_2+4x_3\geq 12$ $3x_1+2x_2+x_3 \geq 8$ $x_1 , x_2 ,x_3\geq 0$	K3	1	12
2	a	Find the optimal solution for the following transportation problem (table below)	K3	2	6

		Destination				
Origin		D_1	D_2	D_3	D_4	Supply
	O_1	11	13	17	14	250

O_2	16	18	14	10	300
O_3	21	24	13	10	400
Demand		225	275	250	950

b A machine operator processes five type of items on his machine each week and must choose a sequence for them. The set-up cost per change depends on items presently on the machine and the setup to be made according to the following table. If he processes each type of item once and only once in each week, how should he sequence the items on his machine in order to minimize the total set-up cost?

		To item				
		A	B	C	D	E
From item	A	-----	4	7	3	4
	B	4	-----	6	3	4
	C	7	6	-----	7	5
	D	3	3	7	-----	7
	E	4	4	5	7	-----

K3 | 2 | 6

3 a We have five jobs each of which must go through the machines A, B and in the order ABC. Determine the sequence that will minimize the total elapse time:

Job No	1	2	3	4	5
M/C A	5	7	6	9	5
M/C B	2	1	4	5	3
M/C C	3	7	5	6	7

Also determine the idle time of each machine.

K3 | 3 | 6

b With the help of following data , i) Draw the network ii) Find project duration for the following project and iii) Identify the critical path.

Activity	1-2	1-3	1-4	2-4	2-5	3-4	3-7	4-6	4-7	5-6	5-7
Time (months)	4	6	12	7	11	7	8	8	13	4	4

K2 | 3 | 8

4 a In a supermarket, the average arrival rate of customer is 10 every 30 minutes following poisons process. The average time taken by a cashier

K3 | 4 | 6

		to list and calculate the customers purchase is 2.5 minutes following exponential distribution. What is the probability that the queue length exceeds 6? What is the expected time spent by a customer in the system?			
	b	Vehicles are passing through a toll gate at the rate of 70 per hour. The average time to pass through the gate is 45 seconds. The arrival rate and service rate follow poisson distibution. There is a complaint that the vehicles wait for a long duration. The authorities are willing to install one more gate to reduce the average time to pass through the toll gate to 35 seconds if the idle time of the toll gate is less than 9% and the average queue length at the gate is more than 8 vehicle, check whether the installation of the second gate is justified?	K2	4	6
5	a	Solve the following game	K3	5	6
	b	Solve the following game graphically	K3	5	6
6	a	The following failure rates have been observed for a certain type of light bulb. The replacement of an individual bulb on failure cost Rs 1.25. The cost of group replacement is 80paise per bulb. Determine the better one among the individual and group replacement policies.	K3	6	8
	b	State the advantages and limitations of simulation	K1	6	4

Table for 5 a:

	Player B			
Player A	I	II	III	IV
I	6	8	3	13
II	4	1	5	3
III	8	10	4	12
IV	3	6	7	12

Table for 5 b:

1	2
4	5
9	-7
-3	-4
2	1

Table for 6 a:

End of the week	1	2	3	4	5	6	7
Probability failure to date	0.05	0.15	0.25	0.46	0.68	0.88	1.00

Code No: RT32031 **R13** **SET - 3**

III B. Tech II Semester Regular Examinations, April - 2016

OPERATIONS RESEARCH

(Mechanical Engineering)

Time: 3 hours Maximum Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answering the question in **Part-A** is compulsory
3. Answer any **THREE** Questions from **Part-B**

*****

PART –A

1 a) Discuss the characteristics and the limitations of OR. [4M]

b) State a transportation problem. When does it have a unique solution? Explain. [4M]

c) What are the situations which make the replacement of items necessary? [3M]

d) A game refers to a situation of business conflict. Discuss. [3M]

e) What are the assumptions of the basic inventory model? How does each affect the model? [4M]

f) What are limitations of dynamic programming problem? [4M]

PART -B

2 a) Solve the following LP problem graphically: [16M]

Minimize $Z=-6x_1-4x_2$

Subject to the constraints:

$2x_1+3x_2\geq 30$

$3x_1+2x_2\leq 24$

$x_1+x_2\geq 3$ and $x_1, x_2\geq 0$

3 a) A salesman has to visit five cities A,B,C,D and E. The distance (in hundred miles) between the five cities are as follows: [10M]

	A	B	C	D	E
A	---	7	6	8	4
B	7	---	8	5	6
C	6	8	---	9	7
D	8	5	9	---	8
E	4	6	7	8	---

If the salesman starts from city A and has to come city A, which route should he select so that the total distance travelled is minimum?

b) What are the assumptions involved in job sequencing problems? [6M]

4 a) A factory has a large number of bulbs, all of which must be in working condition. The mortality of bulbs is given in the following table: [10M]

Week	1	2	3	4	5	6
Proportion of bulbs failing during	0.10	0.15	0.25	0.35	0.12	0.03

If a bulb fails in service, it costs Rs.3.50 to replace; but if all the bulbs are replaced at a time it costs Rs. 1.20 each. Find the optimum group replacement policy.

b) What do you mean by "money value"? How do you count it? [6M]

5 a) Two competitors A and B are competing for the same product. Their different strategies are given in the following payoff matrix: [10M]

	Company B				
Company A		I	II	III	IV
	I	3	2	4	0
	II	3	4	2	4
	III	4	2	4	0
	IV	0	4	0	8

Use dominance principle to find the the optimal strategies.

b) On an average 96 patients per 24-hour day require the service of an emergency clinic. Also on average, a patient requires 10 minutes of active attention. Assume that the facility can handle only one emergency at a time. Suppose that it costs the clinic Rs. 100 per patient treated to obtain an average servicing time of 10 minutes, and that each minute of decrease in this average time would cost Rs. 10 per patient treated How much would have to be budgeted by the clinic to reduce the average size of the queue from 1⅓ to ½ patient. [6M]

6 a) Find the optimal order quantity for a product for which the price breaks are as follows: [10M]

Quantity	0≤q1<50	50≤q2<100	100≤q3
Unit cost(Rs)	10.00	9.00	8.00

The monthly demand for the product is 200 units, the cost of storage is 25% of the unit cost and ordering cost is Rs. 20 per order.

b) Distinguish between ABC and VED analyses. [6M]

7 Solve the following linear programming problem by dynamic programming: [16M]

Max Z= [illegible] x_2 subject to the constraints

$2x_1$ [illegible] 6

$X_1 \leq$ [illegible]

$X_2 \leq$ [illegible] and $x_1, x_2 \geq 0$

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||''|'''|''|'|''''||

Code No: RT32031 **R13** **SET - 2**

III B. Tech II Semester Regular Examinations, April - 2016

OPERATIONS RESEARCH

(Mechanical Engineering)

Time: 3 hours Maximum Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answering the question in **Part-A** is compulsory
3. Answer any **THREE** Questions from **Part-B**

*****

PART –A

1 a) What are the applications of OR? [4M]

b) Explain what you mean by a sequencing problem. [4M]

c) Explain the methodology of solving replacement problems. [3M]

d) Name a few applications of queuing in mechanical engineering. [3M]

e) What are the basic assumptions involved in EOQ concept? [4M]

f) Illustrate Bellman's principle of optimality with an example. [4M]

PART -B

2 a) Solve the following problem by Big-M method: [16M]

Min $Z=5x_1+3x_2$

Subject to the constraints:

$$2x_1+4x_2\le 12$$
$$2x_1+2x_2=10$$
$$5x_1-2x_2\ge 10$$
$$\text{and } x_1,x_2\ge 0$$

3 a) A company has six jobs which go through three machines X,Y and Z in the order XYZ. The processing time in minutes for each job on each machine is as follows: [10M]

		Job					
Machine		1	2	3	4	5	6
	X	18	12	29	36	43	37
	Y	7	12	11	2	6	12
	Z	19	12	23	47	28	36

What should be the sequence of the jobs?

b) Write the LP formulation of a transportation problem. [6M]

4 a) A machine owner finds from his past records that the costs per year of maintaining a machine whose purchase price is Rs.6000 are as given below: [10M]

Year	1	2	3	4	5	6	7	8
Maintenance cost(Rs)	1000	1200	1400	1800	2300	2800	3400	4000
Resale price	3000	1500	750	375	200	200	200	200

Determine at what age is a replacement due?

b) In a store customers arrive in a Poisson stream with mean 60 per hour. The service time is exponential with mean of 0.005 hours. How many clerks should be available if the expected waiting time in the system should be less than 10 minutes. [6M]

5 a) Use dominance principle to simplify the rectangular game with the following payoff matrix and then solve graphically. [10M]

Player A

Player B

	I	II	III	IV
1	18	4	6	4
2	6	2	13	7
3	11	5	17	3
4	7	6	12	2

b) Show how a game can be formulated as a linear programming problem. [6M]

6 Find the optimum order quantity for a product for which the price breaks are as follows: [16M]

Quantity	Unit cost(Rs)
$0 \leq q1 < 500$	10.00
$500 \leq q2$	9.25

The monthly demand for a product is 200 units, the cost of storage is 2% of unit cost and the cost of ordering is Rs.350.

7 a) Write a detailed note on applications of simulation in manufacturing systems. [8M]

b) Distinguish between mathematical models and simulation models. [8M]

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i

Code No: RT32031 **R13** **SET - 1**

III B. Tech II Semester Regular Examinations, April - 2016

OPERATIONS RESEARCH

(Mechanical Engineering)

Time: 3 hours Maximum Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answering the question in **Part-A** is compulsory
3. Answer any **THREE** Questions from **Part-B**

*****

PART –A

1 a) Discuss the various phases in solving an OR problem. [4M]

b) Explain the difference between a transportation problem and an assignment problem. Explain situations where an assignment problem can arise. [4M]

c) Explain replacement situations giving an example for each of them. [3M]

d) What do you understand by a queue? Give some important applications of queuing theory. [3M]

e) Why is inventory maintained? Discuss it and give a classification of inventory models. [4M]

f) What are the applications of dynamic programming problem? Explain. [4M]

PART -B

2 Max $Z=3x_1+2x_2+5x_3$ [16M]

Subject to the constraints

$x_1+2x_2+x_3 \leq 430$

$3x_1+2x_3 \leq 460$

$x_1+4x_2 \leq 420$ and $x_1,x_2,x_3 \geq 0$

3 a) Determine the optimal solution to each of the following degenerate transportation problem: [10M]

	D1	D2	D3	D4	D5	a_i
O1	4	7	3	8	2	4
O2	1	4	7	3	8	7
O3	7	2	4	7	7	9
O4	4	8	2	4	7	2
b_j	8	3	7	2	2	

b) What is no passing rule in sequencing algorithm? Explain the principle assumptions made while dealing with sequencing problems. [6M]

4 a) A computer contains 10,000 resistors. When any one of the resistor fails, it is replaced. The cost of replacing a single resistor is Rs.10 only. If all the resistors are replaced at the same time, the cost per resistor would be reduced to Rs. 3.50. The percent surviving by the end of month t is as follows: [10M]

Month(t)	0	1	2	3	4	5	6
% surviving by the end of month	100	97	90	70	30	15	0

What is the optimum plan?

b) Explain how the theory of replacement is used in the problem of replacement of items that fail completely. [6M]

5 a) Solve the following (2 x 4) game. [10M]

B

A	I	II	III	IV
I	2	2	3	-1
II	4	3	2	6

b) The XYZ company's quality control dept is managed by a single clerk, who takes on an average 5 minutes in checking parts of each of the machine coming for inspection. The machines arrive once in every 8 minutes on the average. One hour of the machine is valued at Rs15 and a clerk's time is valued at Rs.4 per hour. What are the average hourly queuing system costs associated with the quality control department? [6M]

6 a) A company uses annually 24,000 units of raw material which costs Rs. 1.25 per unit. Placing each order costs Rs. 22.50 and the carrying cost is 5.4% per year of the average inventory. Find the economic lot size and the total inventory cost (including cost of material). Should the company accept the offer made by the supplier of a discount of 5% on the cost price on a single order of 24,000 units? [10M]

b) What are the objectives that should be fulfilled by an inventory control system? [6M]

7 a) What are the prerequisites for a problem to be solved by dynamic programming? [8M]

b) A town contains six wards and they contain 170, 510, 640, 75, 250 and 960 houses respectively. Make a random selection of 8 houses using the tables of random numbers. Explain the procedure adopted by you. [8M]

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Code No: RT32031 **R13** **SET - 1**

III B. Tech II Semester Supplementary Examinations, November/December – 2016

OPERATIONS RESEARCH

(Mechanical Engineering)

Time: 3 hours Maximum Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answering the question in **Part-A** is compulsory
3. Answer any **THREE** Questions from **Part-B**

*****

PART –A

1 a) Explain fundamental principle of duality. [3M]
b) Explain what you mean by flow shop sequencing. [4M]
c) Explain the applications of group replacement. [4M]
d) What are the characteristics of game theory? [4M]
e) What are the different types of inventories? Briefly explain them. [4M]
f) What is simulation and what are the different types of it? [3M]

PART -B

2 a) Solve by Big –M method [10M]

Minimize Z $2x_2 + x_2$

Subject to $3x_1 + x_2 = 3$

$4x_1 + 3x_2 \geq 6$

$x_1 + 2x_2 \leq 4$

$x_1, x_2 \geq 0$

b) State and discuss about the characteristics of operation research. [6M]

3 a) Solve the following transportation problem. [10M]

				to			
		D1	D2	D3	D4	D5	availability
	A	4	1	2	6	9	100
from	.B	6	4	3	5	7	120
	C	5	2	6	4	8	120
	requirements	40	50	70	90	90	

b) We have five jobs, each of which has to go through the machines A and B in the order AB. Processing times are given in the table below. [6M]

Job	Ai	Bi
1	5	2
2	1	6
3	9	7
4	3	8
5	10	4

Find the sequence and total make span?

4 a) Machine A costs Rs 45,000 and the operating costs are estimated at Rs 1000 for the first year, increasing by Rs 10,000 per year in the second and subsequent years. Machine B costs Rs 50,000 and operating costs are Rs 2000 for the first year, increasing by Rs 4000 in the second and subsequent years. If you have a machine of type A, should we replace with B? If so when? Assume that both machines have no resale value and future costs are not discounted. [10M]

b) What is meant by time value of money? Explain. [6M]

5 a) Using dominance principle to simplify the rectangular game with the following pay of matrix, and solve it graphically: [8M]

Player B

Player A	I	II	III	IV
I	18	4	6	4
II	6	2	13	7
III	11	5	17	3
IV	7	6	12	2

b) In a railway station only one train is handled at a time. The railway yard is sufficient for two trains to wait while others is given signal to leave the station. Trains arrive at a station at a average of 6 per hour and the railway station can handle them at an average rate of 12 per hour. Assuming Poisson arrival and exponential service distribution, find the steady state probabilities of the various number of trains in the system. Also find the average number of trains in the system. [8M]

6 a) Find the order quantity for a product for which the price breaks are as follows [10M]

Quantity (units)	Unit cost (Rs)
$0<Q1<500$	10.00
$500 \leq Q2< 750$	9.25
$Q3 \geq 750$	8.75

The monthly demand for the product is 400 units. The storage cost is 2 percent of the unit cost and the cost of ordering is Rs350.

b) Explain VED analysis with example. [6M]

7 a) Find the non-negative real numbers such that sum of squares of these numbers is minimum with restriction that their sum is not less than 75. Show the stages in dynamic programming to solve the problem. [10M]

b) Explain the phases of simulation. [6M]

*****

Code No: RT32031 **R13** **SET - 4**

III B. Tech II Semester Regular Examinations, April - 2016

OPERATIONS RESEARCH

(Mechanical Engineering)

Time: 3 hours Maximum Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answering the question in **Part-A** is compulsory
3. Answer any **THREE** Questions from **Part-B**

*****

PART –A

1 a) What are the various types of OR models? Explain. [4M]
b) What do you mean by non-degenerate basic feasible solution of a transportation problem? [4M]
c) Discuss briefly the various types of replacement problems. [3M]
d) What is a rectangular game? Define pure strategy and mixed strategy in a game. [3M]
e) What are the advantages and disadvantages of having inventories? [4M]
f) State and explain Bellman's principle of optimality in dynamic programming. [4M]

PART -B

2 a) Solve the following LP problem by two phase method: [16M]

Max $Z=5x_1+8x_2$
Subject to the constraints:
$3x_1+2x_2\geq 3$
$x_1+4x_2\geq 4$
$x_1+x_2\leq 5$ and $x_1,x_2\geq 0$

3 a) We have five jobs each of which must go through two machines in the order AB, processing times are given in the table below: [8M]

Job No	1	2	3	4	5
Machine A	10	2	18	6	20
Machine B	4	12	14	16	8

Determine a sequence for the five jobs that will minimize the total elapsed time.

b) Solve the following cost minimizing transportation problem. [8M]

	D1	D2	D3	D4	D5	D6	Available
O1	2	1	3	3	2	5	50
O2	3	2	2	4	3	4	40
O3	3	5	4	2	4	1	60
O4	4	2	2	1	2	2	30
Required	30	50	20	40	30	10	180

4 a) A truck owner finds from his past records that the maintenance costs per year of a truck whose purchase price is Rs. 8000, are given below: [10M]

Year	1	2	3	4	5	6	7	8
Maintenance cost(Rs)	1000	1300	1700	2200	2900	3800	4800	6000
Resale price(Rs)	4000	2000	1200	600	500	400	400	400

Determine at what tine it is profitable to replace the truck.

b) Explain with examples the failure mechanism of items. [6M]

5 a) A TV repairman finds that the time spent on his jobs has an exponential distribution with mean 30 minutes. If he repairs sets in the order in which they come in, and if the arrival of sets is approximately poisson with an average rate of 10 per 8 hour day, what is repairman's expected idle time each day? How many jobs are ahead of the average set just brought in? [8M]

b) Two players A and B match coins. If the coin matches, then A wins one unit of value, if the coins do not match, then B wins one unit of value. Determine optimum strategies for the players and the value of the game. [8M]

6 a) An aircraft uses rivets at an approximately constant rate of 5,000 kg per year. The rivets cost Rs.20 per kg and the company personnel estimate that it costs Rs. 200 to place an order, and the carrying cost of inventory is 10% per year. [10M]
(i) How frequently should orders for rivets be placed, and what quantities should be ordered for?
(ii) If the actual costs are Rs. 500 to place an order and 15% for carrying cost, the optimum policy would change. How much is the company losing per year because of imperfect cost information?

b) Discuss briefly various types of inventory models. [6M]

7 a) Discuss the various types of simulation models. [8M]

b) Write a short note on the essential features of Simulation Languages. [8M]

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Code No: RT32031 **R13** **SET - 3**

III B. Tech II Semester Regular Examinations, April - 2016
OPERATIONS RESEARCH
(Mechanical Engineering)

Time: 3 hours Maximum Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answering the question in **Part-A** is compulsory
3. Answer any **THREE** Questions from **Part-B**

*****

PART –A

1 a) Discuss the characteristics and the limitations of OR. [4M]
b) State a transportation problem. When does it have a unique solution? Explain. [4M]
c) What are the situations which make the replacement of items necessary? [3M]
d) A game refers to a situation of business conflict. Discuss. [3M]
e) What are the assumptions of the basic inventory model? How does each affect the model? [4M]
f) What are limitations of dynamic programming problem? [4M]

PART -B

2 a) Solve the following LP problem graphically: [16M]

Minimize $Z=-6x_1-4x_2$
Subject to the constraints:
$2x_1+3x_2\geq30$
$3x_1+2x_2\leq24$
$x_1+x_2\geq3$ and $x_1,x_2\geq0$

3 a) A salesman has to visit five cities A,B,C,D and E. The distance (in hundred miles) between the five cities are as follows: [10M]

	A	B	C	D	E
A	---	7	6	8	4
B	7	---	8	5	6
C	6	8	---	9	7
D	8	5	9	---	8
E	4	6	7	8	---

If the salesman starts from city A and has to come city A, which route should he select so that the total distance travelled is minimum?

b) What are the assumptions involved in job sequencing problems? [6M]

4 a) A factory has a large number of bulbs, all of which must be in working condition. The mortality of bulbs is given in the following table: [10M]

Week	1	2	3	4	5	6
Proportion of bulbs failing during	0.10	0.15	0.25	0.35	0.12	0.03

If a bulb fails in service, it costs Rs.3.50 to replace; but if all the bulbs are replaced at a time it costs Rs. 1.20 each. Find the optimum group replacement policy.

b) What do you mean by "money value"? How do you count it? [6M]

Code No: RT32031 **R13** **SET - 3**

5 a) Two competitors A and B are competing for the same product. Their different strategies are given in the following payoff matrix: [10M]

		Company B			
		I	II	III	IV
Company A	I	3	2	4	0
	II	3	4	2	4
	III	4	2	4	0
	IV	0	4	0	8

Use dominance principle to find the the optimal strategies.

b) On an average 96 patients per 24-hour day require the service of an emergency clinic. Also on average, a patient requires 10 minutes of active attention. Assume that the facility can handle only one emergency at a time. Suppose that it costs the clinic Rs. 100 per patient treated to obtain an average servicing time of 10 minutes, and that each minute of decrease in this average time would cost Rs. 10 per patient treated How much would have to be budgeted by the clinic to reduce the average size of the queue from 1⅓ to ½ patient. [6M]

6 a) Find the optimal order quantity for a product for which the price breaks are as follows: [10M]

Quantity	$0 \le q1 < 50$	$50 \le q2 < 100$	$100 \le q3$
Unit cost(Rs)	10.00	9.00	8.00

The monthly demand for the product is 200 units, the cost of storage is 25% of the unit cost and ordering cost is Rs. 20 per order.

b) Distinguish between ABC and VED analyses. [6M]

7 Solve the following linear programming problem by dynamic programming: [16M]

Max $Z = 3x_1 + x_2$ subject to the constraints

$2x_1 + x_2 \le 6$

$X_1 \le 2$

$X_2 \le 4$ and $x_1, x_2 \ge 0$

*****

Code No: RT32031 **R13** **SET - 2**

III B. Tech II Semester Regular Examinations, April - 2016

OPERATIONS RESEARCH

(Mechanical Engineering)

Time: 3 hours Maximum Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answering the question in **Part-A** is compulsory
3. Answer any **THREE** Questions from **Part-B**

*****

PART –A

1 a) What are the applications of OR? [4M]
b) Explain what you mean by a sequencing problem. [4M]
c) Explain the methodology of solving replacement problems. [3M]
d) Name a few applications of queuing in mechanical engineering. [3M]
e) What are the basic assumptions involved in EOQ concept? [4M]
f) Illustrate Bellman's principle of optimality with an example. [4M]

PART -B

2 a) Solve the following problem by Big-M method: [16M]

Min $Z=5x_1+3x_2$

Subject to the constraints:

$$2x_1+4x_2\leq 12$$
$$2x_1+2x_2=10$$
$$5x_1-2x_2\geq 10$$
$$\text{and } x_1,x_2\geq 0$$

3 a) A company has six jobs which go through three machines X,Y and Z in the order XYZ. The processing time in minutes for each job on each machine is as follows: [10M]

		Job					
		1	2	3	4	5	6
Machine	X	18	12	29	36	43	37
	Y	7	12	11	2	6	12
	Z	19	12	23	47	28	36

What should be the sequence of the jobs?

b) Write the LP formulation of a transportation problem. [6M]

4 a) A machine owner finds from his past records that the costs per year of maintaining a machine whose purchase price is Rs.6000 are as given below: [10M]

Year	1	2	3	4	5	6	7	8
Maintenance cost(Rs)	1000	1200	1400	1800	2300	2800	3400	4000
Resale price	3000	1500	750	375	200	200	200	200

Determine at what age is a replacement due?

b) In a store customers arrive in a Poisson stream with mean 60 per hour. The service time is exponential with mean of 0.005 hours. How many clerks should be available if the expected waiting time in the system should be less than 10 minutes. [6M]

5 a) Use dominance principle to simplify the rectangular game with the following payoff matrix and then solve graphically. [10M]

Player A

Player B

	I	II	III	IV
1	18	4	6	4
2	6	2	13	7
3	11	5	17	3
4	7	6	12	2

b) Show how a game can be formulated as a linear programming problem. [6M]

6 Find the optimum order quantity for a product for which the price breaks are as follows: [16M]

Quantity	Unit cost(Rs)
$0 \leq q1 < 500$	10.00
$500 \leq q2$	9.25

The monthly demand for a product is 200 units, the cost of storage is 2% of unit cost and the cost of ordering is Rs.350.

7 a) Write a detailed note on applications of simulation in manufacturing systems. [8M]

b) Distinguish between mathematical models and simulation models. [8M]

*****

Code No: RT32031 **R13** **SET - 1**

III B. Tech II Semester Regular Examinations, April - 2016

OPERATIONS RESEARCH

(Mechanical Engineering)

Time: 3 hours Maximum Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answering the question in **Part-A** is compulsory
3. Answer any **THREE** Questions from **Part-B**

*****

PART –A

1 a) Discuss the various phases in solving an OR problem. [4M]

b) Explain the difference between a transportation problem and an assignment problem. Explain situations where an assignment problem can arise. [4M]

c) Explain replacement situations giving an example for each of them. [3M]

d) What do you understand by a queue? Give some important applications of queuing theory. [3M]

e) Why is inventory maintained? Discuss it and give a classification of inventory models. [4M]

f) What are the applications of dynamic programming problem? Explain. [4M]

PART -B

2 Max $Z=3x_1+2x_2+5x_3$ [16M]

Subject to the constraints

$x_1+2x_2+x_3 \leq 430$

$3x_1+2x_3 \leq 460$

$x_1+4x_2 \leq 420$ and $x_1,x_2,x_3 \geq 0$

3 a) Determine the optimal solution to each of the following degenerate transportation problem: [10M]

	D1	D2	D3	D4	D5	a_i
O1	4	7	3	8	2	4
O2	1	4	7	3	8	7
O3	7	2	4	7	7	9
O4	4	8	2	4	7	2
b_j	8	3	7	2	2	

b) What is no passing rule in sequencing algorithm? Explain the principle assumptions made while dealing with sequencing problems. [6M]

4 a) A computer contains 10,000 resistors. When any one of the resistor fails, it is replaced. The cost of replacing a single resistor is Rs.10 only. If all the resistors are replaced at the same time, the cost per resistor would be reduced to Rs. 3.50. The percent surviving by the end of month t is as follows: [10M]

Month(t)	0	1	2	3	4	5	6
% surviving by the end of month	100	97	90	70	30	15	0

What is the optimum plan?

b) Explain how the theory of replacement is used in the problem of replacement of items that fail completely. [6M]

5 a) Solve the following (2 x 4) game. [10M]

B

A	I	II	III	IV
I	2	2	3	-1
II	4	3	2	6

b) The XYZ company's quality control dept is managed by a single clerk, who takes on an average 5 minutes in checking parts of each of the machine coming for inspection. The machines arrive once in every 8 minutes on the average. One hour of the machine is valued at Rs15 and a clerk's time is valued at Rs.4 per hour. What are the average hourly queuing system costs associated with the quality control department? [6M]

6 a) A company uses annually 24,000 units of raw material which costs Rs. 1.25 per unit. Placing each order costs Rs. 22.50 and the carrying cost is 5.4% per year of the average inventory. Find the economic lot size and the total inventory cost (including cost of material). Should the company accept the offer made by the supplier of a discount of 5% on the cost price on a single order of 24,000 units? [10M]

b) What are the objectives that should be fulfilled by an inventory control system? [6M]

7 a) What are the prerequisites for a problem to be solved by dynamic programming? [8M]

b) A town contains six wards and they contain 170, 510, 640, 75, 250 and 960 houses respectively. Make a random selection of 8 houses using the tables of random numbers. Explain the procedure adopted by you. [8M]

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Code No: RT32031 **R13** **SET - 1**

III B. Tech II Semester Supplementary Examinations, November/December – 2016

OPERATIONS RESEARCH

(Mechanical Engineering)

Time: 3 hours Maximum Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answering the question in **Part-A** is compulsory
3. Answer any **THREE** Questions from **Part-B**

*****

PART –A

1 a) Explain fundamental principle of duality. [3M]

b) Explain what you mean by flow shop sequencing. [4M]

c) Explain the applications of group replacement. [4M]

d) What are the characteristics of game theory? [4M]

e) What are the different types of inventories? Briefly explain them. [4M]

f) What is simulation and what are the different types of it? [3M]

PART -B

2 a) Solve by Big –M method [10M]

Minimize Z $2x_2 + x_2$

Subject to $3x_1 + x_2 = 3$

$4x_1 + 3x_2 \geq 6$

$x_1 + 2x_2 \leq 4$

$x_1, x_2 \geq 0$

b) State and discuss about the characteristics of operation research. [6M]

3 a) Solve the following transportation problem. [10M]

				to			
		D1	D2	D3	D4	D5	availability
	A	4	1	2	6	9	100
from	B	6	4	3	5	7	120
	C	5	2	6	4	8	120
	requirements	40	50	70	90	90	

b) We have five jobs, each of which has to go through the machines A and B in the order AB. Processing times are given in the table below. [6M]

Job	Ai	Bi
1	5	2
2	1	6
3	9	7
4	3	8
5	10	4

Find the sequence and total make span?

|''|''|||''|''''|||'|

4 a) Machine A costs Rs 45,000 and the operating costs are estimated at Rs 1000 for the first year, increasing by Rs 10,000 per year in the second and subsequent years. Machine B costs Rs 50,000 and operating costs are Rs 2000 for the first year, increasing by Rs 4000 in the second and subsequent years. If you have a machine of type A, should we replace with B? If so when? Assume that both machines have no resale value and future costs are not discounted. [10M]

b) What is meant by time value of money? Explain. [6M]

5 a) Using dominance principle to simplify the rectangular game with the following pay of matrix, and solve it graphically: [8M]

Player B

Player A	I	II	III	IV
I	18	4	6	4
II	6	2	13	7
III	11	5	17	3
IV	7	6	12	2

b) In a railway station only one train is handled at a time. The railway yard is sufficient for two trains to wait while others is given signal to leave the station. Trains arrive at a station at a average of 6 per hour and the railway station can handle them at an average rate of 12 per hour. Assuming Poisson arrival and exponential service distribution, find the steady state probabilities of the various number of trains in the system. Also find the average number of trains in the system. [8M]

6 a) Find the order quantity for a product for which the price breaks are as follows [10M]

Quantity (units)	Unit cost (Rs)
$0<Q1<500$	10.00
$500 \leq Q2< 750$	9.25
$Q3 \geq 750$	8.75

The monthly demand for the product is 400 units. The storage cost is 2 percent of the unit cost and the cost of ordering is Rs350.

b) Explain VED analysis with example. [6M]

7 a) Find the non-negative real numbers such that sum of squares of these numbers is minimum with restriction that their sum is not less than 75. Show the stages in dynamic programming to solve the problem. [10M]

b) Explain the phases of simulation. [6M]

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Code No: RT32031 **R13** **SET - 1**

III B. Tech II Semester Regular Examinations, April - 2016
OPERATIONS RESEARCH
(Mechanical Engineering)

Time: 3 hours Maximum Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answering the question in **Part-A** is compulsory
3. Answer any **THREE** Questions from **Part-B**

*****

PART –A

1 a) Discuss the various phases in solving an OR problem. [4M]

b) Explain the difference between a transportation problem and an assignment problem. Explain situations where an assignment problem can arise. [4M]

c) Explain replacement situations giving an example for each of them. [3M]

d) What do you understand by a queue? Give some important applications of queuing theory. [3M]

e) Why is inventory maintained? Discuss it and give a classification of inventory models. [4M]

f) What are the applications of dynamic programming problem? Explain. [4M]

PART -B

2 Max $Z=3x_1+2x_2+5x_3$ [16M]

Subject to the constraints

$x_1+2x_2+x_3\leq 430$

$3x_1+2x_3\leq 460$

$x_1+4x_2\leq 420$ and $x_1,x_2,x_3\geq 0$

3 a) Determine the optimal solution to each of the following degenerate transportation problem: [10M]

	D1	D2	D3	D4	D5	a_i
O1	4	7	3	8	2	4
O2	1	4	7	3	8	7
O3	7	2	4	7	7	9
O4	4	8	2	4	7	2
b_j	8	3	7	2	2	

b) What is no passing rule in sequencing algorithm? Explain the principle assumptions made while dealing with sequencing problems. [6M]

4 a) A computer contains 10,000 resistors. When any one of the resistor fails, it is replaced. The cost of replacing a single resistor is Rs.10 only. If all the resistors are replaced at the same time, the cost per resistor would be reduced to Rs. 3.50. The percent surviving by the end of month t is as follows: [10M]

Month(t)	0	1	2	3	4	5	6
% surviving by the end of month	100	97	90	70	30	15	0

What is the optimum plan?

b) Explain how the theory of replacement is used in the problem of replacement of items that fail completely. [6M]

5 a) Solve the following (2 x 4) game. [10M]

B

A

	I	II	III	IV
I	2	2	3	-1
II	4	3	2	6

b) The XYZ company's quality control dept is managed by a single clerk, who takes on an average 5 minutes in checking parts of each of the machine coming for inspection. The machines arrive once in every 8 minutes on the average. One hour of the machine is valued at Rs15 and a clerk's time is valued at Rs.4 per hour. What are the average hourly queuing system costs associated with the quality control department? [6M]

6 a) A company uses annually 24,000 units of raw material which costs Rs. 1.25 per unit. Placing each order costs Rs. 22.50 and the carrying cost is 5.4% per year of the average inventory. Find the economic lot size and the total inventory cost (including cost of material). Should the company accept the offer made by the supplier of a discount of 5% on the cost price on a single order of 24,000 units? [10M]

b) What are the objectives that should be fulfilled by an inventory control system? [6M]

7 a) What are the prerequisites for a problem to be solved by dynamic programming? [8M]

b) A town contains six wards and they contain 170, 510, 640, 75, 250 and 960 houses respectively. Make a random selection of 8 houses using the tables of random numbers. Explain the procedure adopted by you. [8M]

*****

Code No: RT32031 **R13** **SET - 2**

III B. Tech II Semester Regular Examinations, April - 2016

OPERATIONS RESEARCH

(Mechanical Engineering)

Time: 3 hours Maximum Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answering the question in **Part-A** is compulsory
3. Answer any **THREE** Questions from **Part-B**

*****

PART –A

1 a) What are the applications of OR? [4M]
b) Explain what you mean by a sequencing problem. [4M]
c) Explain the methodology of solving replacement problems. [3M]
d) Name a few applications of queuing in mechanical engineering. [3M]
e) What are the basic assumptions involved in EOQ concept? [4M]
f) Illustrate Bellman's principle of optimality with an example. [4M]

PART -B

2 a) Solve the following problem by Big-M method: [16M]

Min $Z=5x_1+3x_2$

Subject to the constraints:

$$2x_1+4x_2\le12$$
$$2x_1+2x_2=10$$
$$5x_1-2x_2\ge10$$
$$\text{and } x_1,x_2\ge0$$

3 a) A company has six jobs which go through three machines X,Y and Z in the order XYZ. The processing time in minutes for each job on each machine is as follows: [10M]

		Job					
Machine		1	2	3	4	5	6
	X	18	12	29	36	43	37
	Y	7	12	11	2	6	12
	Z	19	12	23	47	28	36

What should be the sequence of the jobs?

b) Write the LP formulation of a transportation problem. [6M]

4 a) A machine owner finds from his past records that the costs per year of maintaining a machine whose purchase price is Rs.6000 are as given below: [10M]

Year	1	2	3	4	5	6	7	8
Maintenance cost(Rs)	1000	1200	1400	1800	2300	2800	3400	4000
Resale price	3000	1500	750	375	200	200	200	200

Determine at what age is a replacement due?

b) In a store customers arrive in a Poisson stream with mean 60 per hour. The service time is exponential with mean of 0.005 hours. How many clerks should be available if the expected waiting time in the system should be less than 10 minutes. [6M]

5 a) Use dominance principle to simplify the rectangular game with the following payoff matrix and then solve graphically. [10M]

Player A

Player B	I	II	III	IV
1	18	4	6	4
2	6	2	13	7
3	11	5	17	3
4	7	6	12	2

b) Show how a game can be formulated as a linear programming problem. [6M]

6 Find the optimum order quantity for a product for which the price breaks are as follows: [16M]

Quantity	Unit cost(Rs)
$0 \leq q1 < 500$	10.00
$500 \leq q2$	9.25

The monthly demand for a product is 200 units, the cost of storage is 2% of unit cost and the cost of ordering is Rs.350.

7 a) Write a detailed note on applications of simulation in manufacturing systems. [8M]

b) Distinguish between mathematical models and simulation models. [8M]

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Code No: RT32031 **R13** **SET - 3**

III B. Tech II Semester Regular Examinations, April - 2016

OPERATIONS RESEARCH

(Mechanical Engineering)

Time: 3 hours Maximum Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answering the question in **Part-A** is compulsory
3. Answer any **THREE** Questions from **Part-B**

*****

PART –A

1 a) Discuss the characteristics and the limitations of OR. [4M]

b) State a transportation problem. When does it have a unique solution? Explain. [4M]

c) What are the situations which make the replacement of items necessary? [3M]

d) A game refers to a situation of business conflict. Discuss. [3M]

e) What are the assumptions of the basic inventory model? How does each affect the model? [4M]

f) What are limitations of dynamic programming problem? [4M]

PART -B

2 a) Solve the following LP problem graphically: [16M]

Minimize $Z=-6x_1-4x_2$

Subject to the constraints:

$2x_1+3x_2\geq30$

$3x_1+2x_2\leq24$

$x_1+x_2\geq3$ and $x_1,x_2\geq0$

3 a) A salesman has to visit five cities A,B,C,D and E. The distance (in hundred miles) between the five cities are as follows: [10M]

	A	B	C	D	E
A	---	7	6	8	4
B	7	---	8	5	6
C	6	8	---	9	7
D	8	5	9	---	8
E	4	6	7	8	---

If the salesman starts from city A and has to come city A, which route should he select so that the total distance travelled is minimum?

b) What are the assumptions involved in job sequencing problems? [6M]

4 a) A factory has a large number of bulbs, all of which must be in working condition. The mortality of bulbs is given in the following table: [10M]

Week	1	2	3	4	5	6
Proportion of bulbs failing during	0.10	0.15	0.25	0.35	0.12	0.03

If a bulb fails in service, it costs Rs.3.50 to replace; but if all the bulbs are replaced at a time it costs Rs. 1.20 each. Find the optimum group replacement policy.

b) What do you mean by "money value"? How do you count it? [6M]

5 a) Two competitors A and B are competing for the same product. Their different strategies are given in the following payoff matrix: [10M]

		Company B			
Company A		I	II	III	IV
	I	3	2	4	0
	II	3	4	2	4
	III	4	2	4	0
	IV	0	4	0	8

Use dominance principle to find the the optimal strategies.

b) On an average 96 patients per 24-hour day require the service of an emergency clinic. Also on average, a patient requires 10 minutes of active attention. Assume that the facility can handle only one emergency at a time. Suppose that it costs the clinic Rs. 100 per patient treated to obtain an average servicing time of 10 minutes, and that each minute of decrease in this average time would cost Rs. 10 per patient treated How much would have to be budgeted by the clinic to reduce the average size of the queue from $1\frac{1}{3}$ to $\frac{1}{2}$ patient. [6M]

6 a) Find the optimal order quantity for a product for which the price breaks are as follows: [10M]

Quantity	$0 \le q1 < 50$	$50 \le q2 < 100$	$100 \le q3$
Unit cost(Rs)	10.00	9.00	8.00

The monthly demand for the product is 200 units, the cost of storage is 25% of the unit cost and ordering cost is Rs. 20 per order.

b) Distinguish between ABC and VED analyses. [6M]

7 Solve the following linear programming problem by dynamic programming: [16M]

Max $Z = 3x_1 + x_2$ subject to the constraints

$2x_1 + x_2 \le 6$

$X_1 \le 2$

$X_2 \le 4$ and $x_1, x_2 \ge 0$

*****

Code No: RT32031 **R13** **SET - 4**

III B. Tech II Semester Regular Examinations, April - 2016

OPERATIONS RESEARCH

(Mechanical Engineering)

Time: 3 hours Maximum Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answering the question in **Part-A** is compulsory
3. Answer any **THREE** Questions from **Part-B**

*****

PART –A

1 a) What are the various types of OR models? Explain. [4M]
b) What do you mean by non-degenerate basic feasible solution of a transportation problem? [4M]
c) Discuss briefly the various types of replacement problems. [3M]
d) What is a rectangular game? Define pure strategy and mixed strategy in a game. [3M]
e) What are the advantages and disadvantages of having inventories? [4M]
f) State and explain Bellman's principle of optimality in dynamic programming. [4M]

PART -B

2 a) Solve the following LP problem by two phase method: [16M]

Max $Z=5x_1+8x_2$

Subject to the constraints:

$3x_1+2x_2\geq3$

$x_1+4x_2\geq4$

$x_1+x_2\leq5$ and $x_1,x_2\geq0$

3 a) We have five jobs each of which must go through two machines in the order AB, processing times are given in the table below: [8M]

Job No	1	2	3	4	5
Machine A	10	2	18	6	20
Machine B	4	12	14	16	8

Determine a sequence for the five jobs that will minimize the total elapsed time.

b) Solve the following cost minimizing transportation problem. [8M]

	D1	D2	D3	D4	D5	D6	Available
O1	2	1	3	3	2	5	50
O2	3	2	2	4	3	4	40
O3	3	5	4	2	4	1	60
O4	4	2	2	1	2	2	30
Required	30	50	20	40	30	10	180

4 a) A truck owner finds from his past records that the maintenance costs per year of a truck whose purchase price is Rs. 8000, are given below: [10M]

Year	1	2	3	4	5	6	7	8
Maintenance cost(Rs)	1000	1300	1700	2200	2900	3800	4800	6000
Resale price(Rs)	4000	2000	1200	600	500	400	400	400

Determine at what tine it is profitable to replace the truck.

b) Explain with examples the failure mechanism of items. [6M]

5 a) A TV repairman finds that the time spent on his jobs has an exponential distribution with mean 30 minutes. If he repairs sets in the order in which they come in, and if the arrival of sets is approximately poisson with an average rate of 10 per 8 hour day, what is repairman's expected idle time each day? How many jobs are ahead of the average set just brought in? [8M]

b) Two players A and B match coins. If the coin matches, then A wins one unit of value, if the coins do not match, then B wins one unit of value. Determine optimum strategies for the players and the value of the game. [8M]

6 a) An aircraft uses rivets at an approximately constant rate of 5,000 kg per year. The rivets cost Rs.20 per kg and the company personnel estimate that it costs Rs. 200 to place an order, and the carrying cost of inventory is 10% per year. [10M]

(i) How frequently should orders for rivets be placed, and what quantities should be ordered for?

(ii) If the actual costs are Rs. 500 to place an order and 15% for carrying cost, the optimum policy would change. How much is the company losing per year because of imperfect cost information?

b) Discuss briefly various types of inventory models. [6M]

7 a) Discuss the various types of simulation models. [8M]

b) Write a short note on the essential features of Simulation Languages. [8M]

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NARASARAOPETA
ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

CO-POs & CO-PSOs ATTAINMENT

Course Code: C314	Course Name: OPERATIONS RESEARCH (Open Elective –I)	Year/Sem: III/I

External Examination Assessment

S.No	Q.No		1	1	1	2	2	2	3	3	3	4	4	5	5	5
			a		b	a		b	a	b		a	b	a	b	
			i	ii	i	i	ii	i	i	i	ii	i	i	i	i	ii
	COs		I	I	I	II	II	II	III	III	III	IV	IV	V	V	V
	Max. Marks		7	7	14	8	6	14	14	7	7	14	14	14	7	7
1								5	4				4			
2			5	4		5	4			6	5	8				
3																
4			4			6						8	6	8		
5					4				1				6			
6					10			10	8				7			
7			5	5				10		4			6	2		
8			4		6		5	5					8	2		
9			6			5			10							
10			4	6			4	4		4			4	2		
11			5		5		4	4					9	1		
12						4	4		5						5	5
13																
14			5	4		5	4			6		8		3		
15			6			5	5		10							
16			5	4		4	4			6		8				
17												2				
18					10			11				8		5		
19					10			5		5		5				
20					10			5		5		5				
21			6			5	5		10				2			
22					10			5		5		5				
23														12		
24			3					11		7		12		7		
25												10				
26									6			8			2	
27						1						8				
28				3								8				
29						4	4		9			10				
30			4	4				9		5		8				
31			4	4				6		5		8				
32						4										
33			3					10		6		11		6		
34			5	4				11		7		12		7		
35																
36				2		4	4		8			8				
37					10			5		5		5				
38			5			5	5		5				5			
39					10			5		5		5				

40				5									5	5		
41					5			4				7				
42			6	7		6	6			6		12			5	5
43					10			5		5		5				
44						5			5				5			
45			5							5		5				
46						4	4		9				10			
47					9				10				10			
48			5	4		5	4			6			10			
49					10			8				8				
50			6			5	5		10				2			
51					10			5		5		5				
52							0									
53			4					4					6			
54			4	4		4	4			5		8				
55					10			8				8				
56					10			6		5		5				
57												2				
58			5	4		5	4			6		8				
59			3					11		7		12		7		
60			4					4					6			
61					8				10			10				
62			4					4					6		2	
63					8				10							
64			3					11		7				11		
65			4	4		4	4			5						
66																
67																
68					10			4					8	5		
69			6	7		6	5			6			11		5	5
70			3					11		7			8	7		
71			5	5				10		4			7	2		
72					8				10				2			
73			4	6				8		4			8			
74			6	5		6	5			6			8		5	5
75			5	5				10		4			9	2		
76					8				9				8			
77			5	5				10	4	4			9	3		
78					10			8	5				4	5		
79			4	6				8	4	4			8			
80			4	5				8	4	4			8			
81			5	5				10	4	4			9	2		
82			4					3					6			
83					8				8			9				
84			3					11		7		12		7		
85			3					11		7		12		7		
86			6	7		6	5			6		11			5	5
87			4					8	4	4		7			4	
88			3					11	6	7		12		7		

89					10			5	5	5		9				
90			3					9	4	5	4		11	7		
91			3					11	6	7	4		12	7		
92			6	7		6	5			5	5		11		5	5
93			3					11		6	6		9	7		
94			3					9		5	4		11	7		
95			6	5		6	5			6	5		10		5	5
96			4					11		7	4		12	7		
97			3					11		7	4		12	7		
98			6	7		6	5			6	5	11			5	5
99			5					5		7	4	12		7		
100			4	4		4	4			5	5	8		2		
101			3					11		7	4	12		7		
102					10			4			5	9		5		
No. of Students answered			57	30	26	28	27	53	30	54	14	47	42	34	11	8
50% of Max.Marks			4	4	7	4	3	7	7	4	4	7	7	7	4	4
No. of Students crossed 50% of Max Marks			43	28	22	27	26	31	14	54	14	36	26	18	9	8
% of Students crossed 50% of Max Marks			75	93	85	96	96	58	47	100	100	77	62	53	82	100
Attainment Level			3	3	3	3	3	1	0	3	3	3	2	1	3	3

Course Outcome	I	II	III	IV	V
No.of Times repeated	3	3	3	2	3
Final CO Attainment Level	3	2	2	3	2

Rubrics:

If 50% of the students crossed 50% of the marks: Attainment Level 1
If 60% of the students crossed 50% of the marks: Attainment Level 2
If 70% of the students crossed 50% of the marks: Attainment Level 3

1. **Enter the question wise marks.**
2. **Identify the CO of each question.**
3. **Calculate the maximum marks of each CO.**
4. **Calculate the CO wise marks obtained by each student.**
5. **Calculate 50% of maximum marks of each CO.**
6. **Find number of students crossed 50% of maximum marks for each CO.**
7. **Find percentage of students crossed 50% of maximum marks for each CO.**
8. **Find the attainment level of each CO as per the above Rubrics.**

Course Code: C314	Course Name: OPERATIONS RESEARCH (Open Elective –I)	Year/Sem: III/I

Internal Examination Assessment

S.No	Roll. No	Test	Mid1				A1	Quiz 1						A2	Quiz 2	CO I	CO II	CO III	CO IV	CO V
		Q.No	1	2		3				2		3				Max. Marks	Max. Marks	Max. Marks	Max. Marks	Max. Marks
			1.a	2.a	2.b	3.a			1.a	2.a	2.b	3.a	3.b							
		COs	I	II	II	III	I		III	IV	IV	V	V							
		Max. Marks	10	5	5	5	5	10	5	5	5	5	5	5	10	25	20	35	25	20
1	20471A0301		5			3		10	4	5	5	5	5	3	10	15	10	30	23	20
2	20471A0302			5	5	5	4	4	5	5	5	5	5	3	10	8	14	27	23	20
3	20471A0303		0					0	4		5	5	5	3	8	0	0	15	16	18
4	20471A0304							6	3	5		5	5		10	6	6	19	15	20
5	20471A0305			5		3		7	3		5		3		4	7	12	17	9	7
6	20471A0306		5	5	2		5	7	5	5	5		5	5	9	17	14	26	24	14
7	20471A0307		4	4	4	4	4	3	5	5	5	5	5	5	9	11	11	26	24	19
8	20471A0308		5	5			4	10	5	5	5	1	5	5	9	19	15	29	24	15
9	20471A0309		3			4	4	8	4	5	5		5	5	10	15	8	31	25	15
10	20471A0310		3	1		3		4	4	5	5		5		8	7	5	19	18	13
11	20471A0312		3	2	1	2	4	7	3	5	5	3	5	5	10	14	10	27	25	18
12	20471A0313		5	4		1	4	3	5	5	5	3	5	5	6	12	7	20	21	14
13	20471A0314						5	0	5	5	5	3	5	0	10	5	0	15	20	18
14	20471A0315				5	5	5	7	5	3	5	3	5	5	9	12	12	31	22	17
15	20471A0317		3	3	1			5	2	2	5		5	3	10	8	9	20	20	15

16	20471A0318			5	5	5		6	5	5	5		5	5	10	6	16	31	25	15
17	20471A0319						0	0							0	0	0	0	0	0
18	20471A0320		5		5	5	4	8	5		5	3	5	5	10	17	13	33	20	18
19	20471A0321		4					5	3	5		5		1	9	9	5	18	15	14
20	20471A0323		5		4	4	5	8	3		5	5	5	5	9	18	12	29	19	19
21	20471A0324		1	4			4	5			5	5	5	5	8	10	9	18	18	18
22	20471A0325							0	3	3	5	5	5	5	9	0	0	17	22	19
23	20471A0326						4	5	3	5	4	5	5	5	10	9	5	23	24	20
24	20471A0327		5	5	5	5	5	10	5	5	5	2	5	5	9	20	20	34	24	16
25	20471A0328		3		2		5	2	4	5	5	5	5		8	10	4	14	18	18
26	20471A0329		5			2		6	5	3	5	2	5	5	9	11	6	27	22	16
27	20471A0330			4	4	4	5	6						5	0	11	14	15	5	0
28	20471A0331							0	3	5	5	5	5		10	0	0	13	20	20
29	20471A0332		4	3				10	5	5	5	4	5	4	7	14	13	26	21	16
30	20471A0333		4	4	4	4	5	6	4	5	4	5	5	5	9	15	14	28	23	19
31	20471A0334		5	5				10	2		5	1	5		10	15	15	22	15	16
32	20471A0336						4	0							0	4	0	0	0	0
33	20471A0337		5	5	5	5	5	9	5	5	5	3	5	5	10	19	19	34	25	18
34	20471A0338		5		5			4	5	5	5	3	5	5	8	9	9	22	23	16
35	20471A0339						5	0	5	5	5	2	5		3	5	0	8	13	10
36	20471A0341		4	4			5	5	4	1	5	2	5	5	8	14	9	22	19	15
37	20471A0343			4		3	5	10	5	5	5	3	5		10	15	14	28	20	18

38	20471A0344							6		5	5	3	5	3	10	6	6	19	23	18
39	20471A0345		4	4			4	3		5	5	4	5		10	11	7	13	20	19
40	20471A0346						5	0	5	5	5	3	5	5	10	5	0	20	25	18
41	20471A0348		9	5	5	5	5	9	5	5	5	5	5	5	10	23	19	34	25	20
42	20471A0349		8	5	5	5	5	9	5	5	5	5	5	5	10	22	19	34	25	20
43	20471A0350		5	5	5			5	5		5	5	5	5	6	10	15	21	16	16
44	20471A0352		5			5	5	7	5	5	5	5	5	5	9	17	7	31	24	19
45	20471A0353							3	5	5	5	5	5	5	7	3	3	20	22	17
46	20471A0354				5	5	4	9	3	5	5	5	5	5	9	13	14	31	24	19
47	20471A0356		5	5	3		5	10	4	5		5	5	5	9	20	18	28	19	19
48	20471A0357				4	4		9	5	5	5	5	5	5	6	9	13	29	21	16
49	20471A0358		5	5	5	5	5	8	5	5	5	4	5	3	10	18	18	31	23	19
50	20471A0359		4	4			4	7	5	4	5	5	5	3	9	15	11	24	21	19
51	20471A0360		4	4	1	4		3	5	5	5	4	5	5	8	7	8	25	23	17
52	20471A0361		4	4	4	4		9	5	5	5	3	5		7	13	17	25	17	15
53	20471A0362		4	4	3	4	5	9	5	5	5	4	5	5	10	18	16	33	25	19
54	20471A0363		4	4	1	4		10	3	5	5	3	5	4	9	14	15	30	23	17
55	20471A0364		4	2	4	3		8	3	5	5	1	4		7	12	14	21	17	12
56	20471A0365					5		6						4	0	6	6	15	4	0
57	20471A0366		5	5	2			9	5	5	5	5	5	5	7	14	16	26	22	17
58	20471A0367							0	5	5	5	5	5	5	8	0	0	18	23	18

59	20471A0368		4	4		4		4	5	5	5	2	5	5	10	8	8	28	25	17
60	20471A0369		4	4				7	5	5	4	4		4	8	11	11	24	21	12
61	20471A0370		4			4		3	5		5	5	5		5	7	3	17	10	15
62	20471A0371			1	3	4	5	10	5	5	5		5	5	9	15	14	33	24	14
63	20471A0372		3	5	5	5	5	7	5		5		5	4	10	15	17	31	19	15
64	20471A0373		5	5	5	3		10	5	5	5	2	5		10	15	20	28	20	17
65	20471A0374		5					10						5	0	15	10	15	5	0
66	20471A0375							3	5	5	5	4	5	0	8	3	3	16	18	17
67	20471A0376							4	5	5	5	4	5	5	8	4	4	22	23	17
68	21475A0301		8	5	5	5	5	10	5	5	5	5	5	5	9	23	20	34	24	19
69	21475A0302		9	5	5	5	5	10	5	5	5	5	5	5	10	24	20	35	25	20
70	21475A0303			4	4	4	5	8	5	5	5	5	5	5	9	13	16	31	24	19
71	21475A0304							0							0	0	0	0	0	0
72	21475A0305		8	0	4	5	5	7	5	5	5	5	5	5	9	20	11	31	24	19
73	21475A0306		9	5	5	5	5	10	5	5	5	5	5	5	9	24	20	34	24	19
74	21475A0307		4	4				8	5	5	5	5	5	5	8	12	12	26	23	18
75	21475A0308		4	4			5	7	5	5	5	5	5	5	6	16	11	23	21	16
76	21475A0309		3	4			5	7	5	5	5	5	5		9	15	11	21	19	19
77	21475A0310		5	5			5	7	5	5	5	3	5		10	17	12	22	20	18
78	21475A0311				5	3	4	4	5	5	5	2	5	5	8	8	9	25	23	15
79	21475A0312		5	5	5	3	5	5	5	5	5	3		5	9	15	15	27	24	12
80	21475A0313				5	5	5	8	4	5	5	3	2	5	10	13	13	32	25	15

81	21475A0314				3	5	4	3		5	5	5		3	9	7	6	20	22	14
82	21475A0315			5	5	5	5	7	5	5	5	5	5	5	8	12	17	30	23	18
83	21475A0316		8	5	5	5	5	8	5	5	5	5	5	5	8	21	18	31	23	18
84	21475A0317		5	5	5	5	5	6	5	5	5	5	5	5	10	16	16	31	25	20
85	21475A0318		5	5	5	5	5	8	5	5	5	5	5	5	10	18	18	33	25	20
86	21475A0319			3	5	5	5	6	5	5	5	5	5	5	10	11	14	31	25	20
87	21475A0320		9	5	5	5	5	10	5	5	5	5	5	5	10	24	20	35	25	20
88	21475A0321				4	4	5	10	5	5	5	5	5	5	10	15	14	34	25	20
89	21475A0322		6	5	5	5	5	9	5	5	5	5	5	5	10	20	19	34	25	20
90	21475A0323		6	5	5	5	5	8	5	5	5	5	5	5	10	19	18	33	25	20
91	21475A0324		8	5	5	5	5	9	5	5	5	5	5	5	10	22	19	34	25	20
92	21475A0325					5	5	9	5	5	5	5	5	5	10	14	9	34	25	20
93	21475A0326							7	5	5	5	5	5	0	7	7	7	19	17	17
94	21475A0327		5	5	5	3	5	8	5	5	5	5	5	4	8	18	18	28	22	18
95	21475A0328		5	5	5	5	5	7	5	5	5	5	5	3	8	17	17	28	21	18
96	21475A0329				5	5	5	4	5	5	5	5	5		4	9	9	18	14	14
97	21475A0330		9	5	5	5	5	10	5	5	5	5	5	5	10	24	20	35	25	20
98	21475A0331		6	5	5	5	5	6	5	5	5	5	5	5	9	17	16	30	24	19
99	21475A0332			3	5	5	5	6	5	5	5	5	5	5	10	11	14	31	25	20

100	21475A0333		5	5	5		5	10	5	5	5	5	5		8	20	20	23	18	18
101	21475A0334		5	5	5	5	5	3	5	5	5	5	5	5	7	13	13	25	22	17
102	21475A0335		4	4	4	4	5	6	5	5	5	4	5	5	3	15	14	23	18	12
50% of maximum marks																12.5	10	17.5	12.5	10
No. of Students crossed 50% of max. marks																55	65	86	94	95
% of students crossed 50% of max. marks																54	64	84	92	93
Attainment Level																1	2	3	3	3

Rubrics:

If 50% of the students crossed 50% of the marks: Attainment Level 1
If 60% of the students crossed 50% of the marks: Attainment Level 2
If 70% of the students crossed 50% of the marks: Attainment Level 3

1. Enter the question wise marks for mid examinations, assignments & quiz.
2. Identify the CO of each question.
3. Calculate the maximum marks of each CO based mid exams, assignments and quiz.
4. Calculate the CO wise marks obtained by each student.
5. Calculate 50% of maximum marks of each CO.
6. Find number of students crossed 50% of maximum marks for each CO.
7. Find percentage of students crossed 50% of maximum marks for each CO.
8. Find the attainment level of each CO as per the above Rubrics.

Course Code: C314	Course Name: OPERATIONS RESEARCH (Open Elective –I)				Year/Sem: III/I
CO Attainment					
CO	CO Attainment Level (Internal)	CO Attainment Level (External)	Direct CO Attainment Level (Internal * 30%) + (External * 70%)	Indirect CO Attainment Level	Total CO Attainment Level (Direct CO Attainment * 90% + Indirect CO Attainment * 10%)
C314.1	1	3	2.40	2.69	2.43
C314.2	2	2	2.00	2.66	2.07
C314.3	3	2	2.30	2.84	2.35
C314.4	3	3	3.00	2.50	2.95
C314.5	3	2	2.30	2.80	2.35
C314					2.43

1. Copy the Direct CO Attainment Level (Internal) and Direct CO Attainment Level (External) from the previous sheets and then find the Direct CO Attainment Level.
2. Find Direct CO attainment level using the formula:
   CO Attainment Level (Internal) * 30% + CO Attainment Level (External) * 70%
3. Copy Indirect CO Attainment Level.
4. Find the CO attainment level using the formula:
   Direct CO Attainment Level *90% + Indirect CO Attainment Level * 10%

Course Code: C314	Course Name: OPERATIONS RESEARCH (Open Elective –I)	Year/Sem: III/I

CO-PO & CO-PSO Mapping

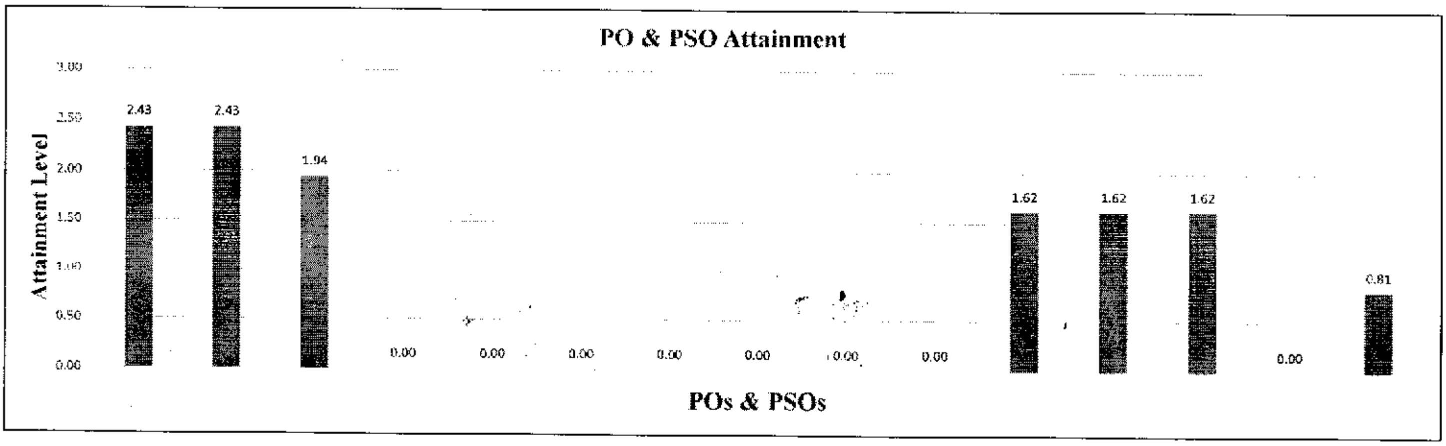
COs	POs & PSOs														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
C314.1	3	3	2	-	-	-	-	-	-	-	-	2	2	-	1
C314.2	3	3	2	-	-	-	-	-	-	-	-	2	2	-	1
C314.3	3	3	2	-	-	-	-	-	-	-	-	2	2	-	1
C314.4	3	3	3	-	-	-	-	-	-	-	2	2	2	-	1
C314.5	3	3	3	-	-	-	-	-	-	-	-	2	2	-	1
C314	3.00	3.00	2.40	-	-	-	-	-	-	-	2.00	2.00	2.00	-	1.00

Total CO Attainment through Direct & Indirect Assessment

CO Attainment	2.43

PO & PSO Attainment

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PO Attainment	2.43	2.43	1.94	-	-	-	-	-	-	-	1.62	1.62	1.62	-	0.81



1. Copy CO - PO matrix and CO attainment matrix from previous pages and find PO attainment.
2. PO attainment is calculated as per the following formula:
   POi * Total CO attainment Level / 3 where 'i' ranges from 1 to 12

1. Copy CO - PSO matrix and CO attainment matrix from previous pages and find PSO attainment.
2. PSO attainment is calculated as per the following formula:
   PSOi * Total CO attainment Level / 3 where 'i' ranges from 1 to 3