Ref No:

SRI KRISHNA INSTITUTE OF TECHNOLOGY BANGALORE

COURSE PLAN

Academic Year 2019-20

Program:	B E – Mechanical Engineering
Semester :	8
Course Code:	15ME81
Course Title:	**OPERATIONS RESEARCH**
Credit / L-T-P:	04/3-2-0
Total Contact Hours:	50
Course Plan Author:	Dr SV Prakash/Mr. Harendra Kumar H V

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OPERATIONS RESEARCH

A. COURSE INFORMATION

1. Course Overview

Degree:	ME	Program:	ME
Semester:	VIII	Academic Year:	2019-2020
Course Title:	**OPERATIONS RESEARCH**	Course Code:	15ME81
Credit / L-T-P:	04/3-2-0	SEE Duration:	180 min
Total Contact Hours:	50 Hrs	SEE Marks:	80 Marks
CIA Marks:	20	Assignment	1 / Module
Course Plan Author:	Dr SV Prakash/Mr. Harendra Kumar H V	Sign	Dt:
Checked By:	Dr.S V Prakash	Sign	Dt:
CO Targets	CIA Target :90%	SEE Target:	85%

Note: Define CIA and SEE % targets based on previous performance.

2. Course Content

Content / Syllabus of the course as prescribed by University or designed by institute. Identify 2 concepts per module as in G.

Module	Content	Teaching Hours	Identified Module Concepts	Blooms Learning Levels
1	Introduction: Evolution of OR, Definitions of OR, Scope of OR, Applications of OR, Phases in OR study. Characteristics and limitations of OR, models used in OR, Linear Programming Problem (LPP), Generalized LPP-Formulation of problems as L.P.P. SolutionstoLPP by graphical method(Two Variables).	8	scope, need, phases and techniques of operations research.	L2,L3
2	LPP: Simplex method, Canonical and Standard form of LP problem, slack, surplus and artificial variables, Solutions to LPP by S implex method, Big-M Method and Two Phase Simplex Method, Degeneracy in LPP. Concept of Duality, writing Dual of given LPP. Solutions to L.P.P by Dual Simplex Method.	12	Different methods of solving OR problems	L3
3	**Transportation Problem**: Formulation of transportation problem, types, initial basic feasible solution using North-West Corner rule, Vogel's Approximation method. Optimality in Transportation problem by Modified Distribution(MODI) method. Unbalanced T.P. Maximization T.P. Degeneracy in transportation problems, application of transportation problem. **Assignment Problem**-Formulation, Solutions to assignment problems by Hungarian method, Special cases in assignment problems, unbalanced, Maximization assignment problems. **Travelling Salesman Problem** (TSP). Difference between assignment and T.S.P, Finding best route by Little's method. Numerical Problems.	12	Transportation and Assignment problems	L3
4	**Network analysis:** Introduction, Construction of networks, Fulkerson's rule for numbering the nodes, AON and AOA diagrams; Critical path method to find the expected completion time of a project, determination of floats in networks, PERT networks, determining the probability of completing a project, predicting the completion time of project; Cost analysis in networks. Crashingofnetworks- Problems.	10	critical path, floats for deterministic and PERT networks including crashing of Networks.	L3

	Queuing Theory: Queuing systems and their characteristics, Pure-birth and Pure-death models (only equations), Kendall & Lee's notation of Queuing, empirical queuing models – Numerical on M/M/1 and M/M/C Queuing models.			
5	**Game Theory:** Definition, Pure Strategy problems, Saddle point, Max-Min and Min-Max criteria, Principle of Dominance, Solution of games with Saddle point. Mixed Strategy problems. Solution of 2X2 games by Arithmetic method, Solution of 2Xn m and mX2 games by graphical method. Formulationof games. **Sequencing**: Basic assumptions, Johnson's algorithm, sequencing 'n' jobs on single machine using priority rules, sequencing using Johnson's rule-'n' jobs on 2 machines, 'n' jobs on 3 machines, 'n' jobs on 'm' machines. Sequencing of2 jobs on 'm' machines using graphical method.	8	game theory for pure and mixed strategy	L3
-	**Total**	**50**	**-**	**-**

3. Course Material

Books & other material as recommended by university (A, B) and additional resources used by course teacher (C).

1. Understanding: Concept simulation / video ; one per concept ; to understand the concepts ; 15 – 30 minutes
2. Design: Simulation and design tools used – software tools used ; Free / open source
3. Research: Recent developments on the concepts – publications in journals; conferences etc.

Modules	Details	Chapters in book	Availability
A	**Text books (Title, Authors, Edition, Publisher, Year.)**	**-**	**-**
1,2,4,5	Operations Research, P K Gupta and D S Hira,S. Chand and Company LTD.Publications, New Delhi – 2007	1,2,4,5	In Lib
3	Operations Research, An Introduction, Seventh Edition, Hamdy A. Taha, PHI Private Limited, 2006.	3	In Lib
B	**Reference books (Title, Authors, Edition, Publisher, Year.)**	**-**	**-**
3	Operations Research, Theory and Applications, Sixth Edition, J K Sharma, Trinity Press, Laxmi Publications Pvt.Ltd. 2016.	3	In dept
4	Operations Research, Paneerselvan, PHI	4	In dept
1,2,4,5	Operations Research, A M Natarajan, P Balasubramani, PearsonEducation, 2005	1,2,4,5	In dept
C	**Concept Videos or Simulation for Understanding**		
1	https://www.fmtv.com › operations research		
2	https://www.delta-t.co.uk › LPP		
3	https://www.luminousindia.com › travelling salesman		
4	https://study.com › network analysis		
5	https://www.studentenergy.org ›sequencing		

4. Course Prerequisites

Refer to GL01. If prerequisites are not taught earlier, GAP in curriculum needs to be addressed. Include in Remarks and implement in B.5.

Students must have learnt the following Courses / Topics with described Content . . .

Modules	Course Code	Course Name	Topic / Description	Sem	Remarks	Blooms Level
4	15ME51	Management and enterprener	Management programs	V		L2
3	10ME81	Operation mangement	Basic of operations	VIII		L2

5. Content for Placement, Profession, HE and GATE

The content is not included in this course, but required to meet industry & profession requirements and help students for Placement, GATE, Higher Education, Entrepreneurship, etc. Identifying Area / Content requires experts consultation in the area.

Topics included are like, a. Advanced Topics, b. Recent Developments, c. Certificate Courses, d. Course Projects, e. New Software Tools, f. GATE Topics, g. NPTEL Videos, h. Swayam videos etc.

Modules	Topic / Description	Area	Remarks	Blooms Level
1	Models used in OR	Industry and GATE	Seminar on different management systems	L2
4	PERT networks	GATE	NPTEL Videos	L2
5	Basic assumptions, Johnson's algorithm, sequencing 'n' jobs on single machine using priority rules, sequencing using Johnson's rule-'n' jobs	Industry and GATE	Seminar on different jobs of sequencing.	L3

B. OBE PARAMETERS

1. Course Outcomes

Expected learning outcomes of the course, which will be mapped to POs. Identify a max of 2 Concepts per Module. Write 1 CO per Concept.

Modules	Course Code.#	Course Outcome **At the end of the course, student should be able to . . .**	Teach. Hours	Concept	Instr Method	Assessment Method	Blooms' Level
1	15ME81.1	Understand the meaning, definitions, scope, need, phases and techniques of operations research.	8	scope, need, phases and techniques of operations research.	Lecture	Chalk and board	L2 Understand
2	15ME81.2	Formulate as L.P.P and derive optimal solutions to linear programming problems by graphical method, Simplex method, Big-M method and Dual Simplex method.	12	Different methods of solving OR problems	Lecture	Chalk and board	L3 Apply
3	15ME81.3	Formulate as Transportation and Assignment problems and derive optimum solutions for transportation, Assignment and travelling salesman problems	12	Transportation and Assignment problems			L3 Apply
4	15ME81.4	Solve waiting line problems for M/M/1 and M/M/K queuing models.	10	critical path, floats	Lecture /Tutorial	Chalk and board	L3 Apply

		Construct network diagrams and determine critical path, floats for deterministic and PERT networks including crashing of Networks.		for deterministic and PERT networks including crashing of Networks.			
5	15ME71.5	Determine minimum processing times for sequencing of n jobs-2 machines, n jobs-3machines, n jobs-m machines and 2 jobs-n machines using Johnson's algorithm and analysis of games.	8	Game theory for pure and mixed strategy	Lecture	Chalk and board	L3 Apply
-	**-**	**Total**	**50**	**-**	**-**	**-**	**L2,L3**

2. Course Applications

Modules	Application Area Compiled from Module Applications.	CO	Level
1	Food and Agriculture Farmers apply linear programming techniques to their work. By determining what crops they should grow, the quantity of it and how to use it efficiently, farmers can increase their revenue.	CO1	L2
2	using the simplex Method to solve some accounting problems in order to get optimum allocation of Scarce resources to competing activities under the assumptions of certainty, linearity and constant price. It also considers simplex method as an aid to accounting decision making used to eliminate off-the-cuff decisions based on intuition or experience by using mathematical approach to accounting problem solving	CO2	L3
3	Applications in Engineering Engineers also use linear programming to help solve design and manufacturing problems. For example, in airfoil meshes, engineers seek aerodynamic shape optimization.	CO3	L3
4	Transportation Optimization Transportation systems rely upon linear programming for cost and time efficiency. Bus and train routes must factor in scheduling, travel time and passengers.	CO4	L3
5	Game theory has many applications in subjects such as economics, international relations and politics, and psychology as it can be used to analyze and predict the behavior and decisions of the players	CO5	L3

3. Mapping And Justification

CO – PO Mapping with mapping Level along with justification for each CO-PO pair.
To attain competency required (as defined in POs) in a specified area and the knowledge & ability required to accomplish it.

Modules	Mapping		Mapping Level	Justification for each CO-PO pair	Level
-	**CO**	**PO**	-	**'Area': 'Competency' and 'Knowledge' for specified 'Accomplishment'**	-
1	**CO1**	PO1	1.5	The knowledge of mathematical principles will help the students to apply the same to formulate solutions for engineering problems. Like manufacturing problems,	L3
1	CO1	PO2	1.5	Fundamental knowledge in complex analysis will help to analyze the engineering problems easily. To show the use of Linear Programming to evaluate the performance.	L3
1	CO1	PO3	1.5	Thorough understanding mathematical principles & lpp students can give solution to complex engineering problems which may be helpful in health ,safety & societal considerations. Like The objective of these problems is either to minimize resources for a fixed level of performance, or to maximize performance at a fixed level of resources. Among all the mathematical optimization techniques, linear programming is perhaps the most used and best understood by the business and industrial community.	L3
1	CO1	PO4	1.5	Thorough understanding LPP they can conduct investigation of complex problems can be solved on the computer. For example Although many problems in architecture, engineering, construction and urban and regional development can be modeled with linear programming.	L3
1	CO1	PO6	2.5	By understanding mathematical principles and LPP students can apply contextual knowledge to assess solution to complex engineering problems which may be helpful in health ,safety & societal considerations. Like It is used for Artificial Intelligence as part of making machines more intelligent, Among all the mathematical optimization techniques, linear programming is perhaps the most used and best understood by the business and industrial community,Entertainment,finance etc.	L3
1	CO1	PO7	2.5	Thorough understanding lpp they can know the environmental contexts. From the aggregation of indicators, values for each municipality were obtained in a scale from zero to one, being one (highlighted in tables) given to municipalities that were included in "quality estimated frontier" in the respective dimension or sub-dimension. Municipalities distant from the frontier received a zero, indicating less quality.	L3
1	CO1	PO9	2	Student will develop individual knowledge to work in a team or individually as a decision analyst.	L3
1	CO1	PO12	1.5	Study of LPP is required if students want to work in manufacturing ,business based companies.	L4
2	CO2	PO1	1.5	The knowledge of mathematical principles will help the students to apply the same to formulate solutions for engineering problems. Like manufacturing problems,	L3
2	CO2	PO2	1.5	Fundamental knowledge in complex analysis will help to analyze the engineering problems easily. To show the use of Linear Programming to evaluate the performance of Oral Health in Primary Care.	L3
2	CO2	PO3	1.5	Thorough understanding mathematical principles & lpp students can give solution to complex engineering problems which may be helpful in health ,safety & societal considerations. Like The objective of these problems is either to minimize resources for a fixed level of performance, or to maximize performance at a fixed level of resources. Among all the mathematical optimization techniques, linear programming is perhaps the most used and best understood by the business and industrial	L3

				community.	
2	CO2	PO4	1.5	Thorough understanding LPP they can conduct investigation of complex problems can be solved on the computer. For example Although many problems in architecture, engineering, construction and urban and regional development can be modelled with linear programming.	L3
2	CO2	PO6	2.5	By understanding mathematical principles and LPP students can apply contextual knowledge to assess solution to complex engineering problems which may be helpful in health ,safety & societal considerations. Like It is used for Artificial Intelligence as part of making machines more intelligent, Among all the mathematical optimization techniques, linear programming is perhaps the most used and best understood by the business and industrial community, healthcare,Entertainment,finance etc.	L3
2	CO2	PO7	2.5	Thorough understanding lpp they can know the environmental contexts. From the aggregation of indicators, values for each municipality were obtained in a scale from zero to one, being one (highlighted in tables) given to municipalities that were included in "quality estimated frontier" in the respective dimension or sub-dimension. Municipalities distant from the frontier received a zero, indicating less quality.	L3
2	CO2	PO9	2	Student will develop individual knowledge to work in a team or individually as a decision analyst.	L3
2	CO2	PO12	1.5	Study of LPP is required if students want to work in manufacturing ,business based companies.	L4
3	CO3	PO1	1.5	The knowledge of mathematical principles will help the students to apply the same to formulate solutions for engineering problems. Like manufacturing problems,	L3
3	CO3	PO2	1.5	Fundamental knowledge in complex analysis will help to analyze the engineering problems easily. To show the use of Linear Programming to evaluate the performance of Oral Health in Primary Care.	L3
3	CO3	PO3	1.5	Thorough understanding mathematical principles & lpp students can give solution to complex engineering problems which may be helpful in health ,safety & societal considerations. Like The objective of these problems is either to minimize resources for a fixed level of performance, or to maximize performance at a fixed level of resources. Among all the mathematical optimization techniques, linear programming is perhaps the most used and best understood by the business and industrial community.	L3
3	CO3	PO1	1.5	The knowledge of mathematical principles will help the students to apply the same to formulate solutions for engineering problems. Like manufacturing problems,	L3
3	CO3	PO2	1.5	Fundamental knowledge in complex analysis will help to analyze the engineering problems easily. To show the use of Linear Programming to evaluate the performance of Oral Health in Primary Care.	L3
3	CO3	PO3	1.5	Thorough understanding mathematical principles & lpp students can give solution to complex engineering problems which may be helpful in health ,safety & societal considerations. Like The objective of these problems is either to minimize resources for a fixed level of performance, or to maximize performance at a fixed level of resources. Among all the mathematical optimization techniques, linear programming is perhaps the most used and best understood by the business and industrial community.	L3
3	CO3	PO4	1.5	Thorough understanding LPP they can conduct investigation of complex problems can be solved on the computer. For example Although many problems in architecture, engineering, construction and urban and regional development can be modelled with linear programming.	L3
3	CO3	PO5	-	No content tool, no mapping	L2
3	CO3	PO6	2.5	By understanding mathematical principles and LPP students can apply contextual knowledge to assess solution to complex engineering	L3

				problems which may be helpful in health ,safety & societal considerations. Like It is used for Artificial Intelligence as part of making machines more intelligent, Among all the mathematical optimization techniques, linear programming is perhaps the most used and best understood by the business and industrial community, healthcare,Entertainment,finance etc.	
3	CO3	PO7	2.5	Thorough understanding lpp they can know the environmental contexts. From the aggregation of indicators, values for each municipality were obtained in a scale from zero to one, being one (highlighted in tables) given to municipalities that were included in "quality estimated frontier" in the respective dimension or sub-dimension. Municipalities distant from the frontier received a zero, indicating less quality.	L3
3	CO3	PO8	2.5	Students can formulate the complex problem as linear programming model ,can apply all methods obtain solution to give some conclusion.	L3
3	CO3	PO9	2.5	Students can formulate the complex problem as linear programming model ,can apply all methods obtain solution to give some conclusion.	L3
3	CO3	PO10	2.5	Thorough understanding optimizing techniques they can know the environmental contexts.	L3
3	CO3	PO11	2.5	Student will develop individual knowledge to work in a team or individually as a decision analyst.	L3
3	CO3	PO12	2.5	Study of optimizing techniques is required if students want to work in manufacturing ,business based companies.	L3
4	CO4	PO1	1.5	The knowledge of game theory and decision analysis is required to find the solution of complex engineering problems like manufacturing.	L3
4	CO4	PO2	1.5	Students can formulate the complex problem as game theory model and obtain solution often used in political, economic, and military planning.	L3
4	CO4	PO3	1.5	Design solutions for complex engineering problems using game theory,solution often used in political, economic, and military planning.	L3
4	CO4	PO4	1.5	Thorough understanding game theory method they can conduct investigation of complex problems can be solved .for example much progress has been made in applying game theoretic models to a wide range of economic problems.	L3
4	CO4	PO6	2.5	It has hardly been used to tackle safety management in multi-plant chemical industrial settings.	L3
4	CO4	PO7	2.5	Thorough understanding game theory they can know the environmental contexts. Problems related to game theory arise in a range of fields, for example, health care, transportation and military planning.	L3
4	CO4	PO12	1.5	Study of game theory is required if students want to progress in analytics field.	L3
5	CO5	PO1	1.5	The knowledge of game theory and decision analysis is required to find the solution of complex engineering problems like manufacturing.	L3
5	CO5	PO2	1.5	Students can formulate the complex problem as game theory model and obtain solution often used in political, economic, and military planning.	L3
5	CO5	PO3	1.5	Design solutions for complex engineering problems using game theory,solution often used in political, economic, and military planning.	L3
5	CO5	PO4	1.5	Thorough understanding game theory method they can conduct investigation of complex problems can be solved .for example much progress has been made in applying game theoretic models to a wide range of economic problems.	L3
5	CO5	PO6	2.5	It has hardly been used to tackle safety management in multi-plant chemical industrial settings.	L3
5	CO5	PO7	2.5	Thorough understanding game theory they can know the environmental contexts. Problems related to game theory arise in a range of fields, for example, health care, transportation and military planning.	L3
5	CO5	PO12	1.5	Study of game theory is required if students want to progress in analytics field.	L3

4. Articulation Matrix

CO – PO Mapping with mapping level for each CO-PO pair, with course average attainment.

-	-	Course Outcomes	Program Outcomes															-
Modules	CO.#	**At the end of the course student should be able to . . .**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	Level
1	15ME81.1	Understand the meaning, definitions, scope, need, phases and techniques of operations research.	1.5	1.5	1.5	1.5		2.5	2.5		2			1.5				L2 Understand
2	15ME81.2	Formulate as L.P.P and derive optimal solutions to linear programming problems by graphical method, Simplex method, Big-M method and Dual Simplex method.	1.5	1.5	1.5													L3 Apply
3	15ME81.3	Formulate as Transportation and Assignment problems and derive optimum solutions for transportation, Assignment and travelling salesman problems	1.5	1.5	1.5	1.5		2.5	2.5		2			1.5				L3 Apply
4	15ME81.4	Solve waiting line problems for M/M/1 and M/M/K queuing models. Construct network diagrams and determine critical path, floats for deterministic and PERT networks including crashing of Networks.	1.5	1.5	1.5	1.5		2.5	2.5					1.5				L3 Apply
5	15ME81.5	Determine minimum processing times for sequencing of n jobs-2 machines, n jobs-3machines, n jobs-m machines and 2 jobs-n machines using Johnson's algorithm and analysis of games.	1.5	1.5	1.5													L3 Apply
-	**15ME81**	**Average attainment (1, 2, or 3)**	**1.5**	**1.5**	**1.5**	**1.5**	**-**	**2.50**	**2.5**		**2**	**-**	**-**	**1.5**				

5. Curricular Gap and Content

Topics & contents not covered (from A.4), but essential for the course to address POs and PSOs.

Modules	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
2	Simplex method, Big-M method	NPTEL Videos	11/03/2020	Self	PO2
3	Assignment and traveling salesman	NPTEL Videos	15/04/2020	Self	PO2
4	Deterministic and PERT networks	NPTEL Videos	13/05/2020	Self	PO2

6. Content Beyond Syllabus

Topics & contents required (from A.5) not addressed, but help students for Placement, GATE, Higher Education, Entrepreneurship, etc.

Modules	Gap Topic	Area	Actions Planned	Schedule Planned	Resources Person	PO Mapping
3	PHP Simplex Tool	Placement, GATE, Higher Study, .	01/03/2020		Self	PO1

4	Sequencing problems, N-jobs and one machine	Placement, GATE, Higher Stud	22/04/2020		Self	PO5

C. COURSE ASSESSMENT

1. Course Coverage

Assessment of learning outcomes for Internal and end semester evaluation. Distinct assignment for each student. 1 Assignment per chapter per student. 1 seminar per test per student.

Modules	Title	Teach. Hours	No. of question in Exam						CO	Levels
			CIA-1	CIA-2	CIA-3	Asg	Extra Asg	SEE		
1	Understand the meaning, definitions, scope, need, phases and techniques of operations research.	8	2	-	-	1	1	2	CO1	L2, L3
2	Formulate as L.P.P and derive optimal solutions to linear programming problems by graphical method, Simplex method, Big-M method and Dual Simplex method.	12	2	-	-	1	1	2	CO2	L2, L3
3	Formulate as Transportation and Assignment problems and derive optimum solutions for transportation, Assignment and travelling salesman problems	12	-	2	-	1	1	2	CO3,	L3
4	Solve waiting line problems for M/M/1 and M/M/K queuing models. Construct network diagrams and determine critical path, floats for deterministic and PERT networks including crashing of Networks.	10	-	2	-	1	1	2	CO4	L2, L3
5	Determine minimum processing times for sequencing of n jobs-2 machines, n jobs-3machines, n jobs-m machines and 2 jobs-n machines using Johnson's algorithm and analysis of games.	8	-	-	4	1	1	2	CO5	L3
-	**Total**	**50**	**4**	**4**	**4**	**5**	**5**	**10**	**-**	**-**

2. Continuous Internal Assessment (CIA)

Assessment of learning outcomes for Internal exams. Blooms Level in last column shall match with A.2.

Modules	Evaluation	Weightage in Marks	CO	Levels
1, 2	CIA Exam – 1	15	CO1, CO2	L2, L3
3, 4	CIA Exam – 2	15	CO3,CO4	L2,L3
5	CIA Exam – 3	15	CO5	L3
1, 2	Assignment - 1	05	CO1, CO2	L2, L3,
3, 4	Assignment - 2	05	CO3,CO4	L2,L3
5	Assignment - 3	05	CO5	L3
1, 2	Seminar - 1	00		
3, 4	Seminar - 2	00		
5	Seminar - 3	00		
	-			

	Final CIA Marks	**20**	CO1 to Co9	L2, L3

D1. TEACHING PLAN – 1

Module - 1

Title:	INTRODUCTION	Appr Time:	9 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Understand the meaning, definitions, scope, need, phases and techniques of operations research.	CO1	L2
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
1	Introduction: Evolution of OR, Definitions of OR,	C01	L2
2	Scope of OR,	C01	L2
3	Applications of OR, Phases in OR study.	C01	L2
4	Characteristics and limitations of OR, models used in OR.	C01	L2
5	Linear Programming Problem (LPP), Generalized LPP- Formulation of problems as L.P.P.	CO1	L3
6	SolutionstoLPP by graphical method(Two Variables).	CO1	L3
7	Numerical problems	CO1	L3
8	Numerical problems	CO1	L3
c	**Application Areas**	**CO**	**Level**
1	Among all the mathematical optimization techniques, linear programming is perhaps the most used and best understood by the business and industrial community, healthcare,Entertainment,finance etc.Food and Agriculture	CO1	L3
2	Farmers apply linear programming techniques to their work. By determining what crops they should grow, the quantity of it and how to use it efficiently, farmers can increase their revenue.	CO1	L3
d	**Review Questions**	-	-
-		-	-
1	Discuss the scope of Operations Research.	CO1	L2
2	What is operation research? Explain origin and the six phases of operation research.	CO1	L3
3	A retail store stocks two types of shirts A and B. These are packed in attractive cardboard boxes. During a week the store can sell a maximum of 400 shirts of type A and a maximum of 300 shirts of type B. The storage capacity, however, is limited to a maximum of 600 of both types combined. Type A shirt fetches a profit of Rs. 2/- per unit and type B a profit of Rs. 5/- per unit. How many of each type the store should stock per week to maximize the total profit? Formulate a mathematical model of the problem.	CO1	L2
4	Old hens can be bought at Rs. 50/- each but young ones cost Rs. 100/- each. The old hens lay 3 eggs/week and young hens 5 eggs/week. Each egg costs Rs. 2/-. A hen costs Rs. 5/- per week to fee. If a person has only Rs. 2000/- to spend for hens, formulate the problem to decide how many of each kind of hen should he buy ? Assume that he cannot house more than 40 hens.	CO1	L2
5	A computer company manufactures laptops & desktops that fetches profit of Rs. 700/- & 500/- unit respectively. Each unit of laptop takes 4 hours of assembly time & 2 hours of testing time while each unit of desktop requires 3 hours of assembly time & 1 hour for testing. In a given month the total number of hours available for assembly is 210 hours & for inspection is 90 hours. Formulate the problem as LPP in such a way that the total profit is maximum.	CO1	L3

6	A toy company manufactures two types of dolls, a basic version-doll A and a deluxe version- doll B. Each doll of type B takes twice as long to produce as one of type A and the company would have time to make maximum of 2000 dolls per day. The supply of plastic is sufficient to produce 1500 dolls per day(Both A & B combined). The deluxe version requires a fancy dress of which there are only 600 per day available. If the company makes a profit of Rs. 10/- & Rs. 18/- per doll on doll A & B respectively, then how many of each doll should be produced per day in order to maximize the total profit. Formulate the problem as LPP.	CO1	L3
7	A company manufactures two products A & B. Theses products are processed in the same machine. It takes 10 minutes to process one unit of product A and 2 minutes for each unit of product B and the machine operates for a maximum of 35 hours in a week. Product A requires 1 kg and B 0.5 kg of raw material per unit the supply of which is 600 kg per week. Market constraint on product B is known to be 800 unit every week. Product A costs Rs. 5/- per unit and sold at Rs. 10/-. Product B costs Rs. 6/- per unit and can be sold in the market at a unit price of Rs. 8/-. Determine the number of units of A & B per week to maximize the profit	CO1	L3
8	A person requires 10,12 and 12 units chemicals A,B,C respectively for his garden. One unit of liquid product contains 5,2 and 1 units of A,B and C respectively. One unit of dry product contains 1,2 and 4 units of A,B,C. If the liquid product sells for Rs. 3/- and the dry product sells for Rs. 2/-, how many of each should be purchased, in order to minimize the cost and meet the requirements.	CO1	L2
9	A paper mill produces two grades of paper namely X and Y. Because of raw material restrictions, it cannot produce more than 400 tons of grade X and 300 tons of grade Y in a week. There are 160 production hours in a week. It requires 0.2 and 0.4 hours to produce a ton of products X and Y respectively with corresponding profits of Rs. 200/- and Rs. 500/- per ton. Formulate the above as a LPP to maximize profit and find the optimum product mix.	CO1	L2
10	Use graphical method to solve Min $z=20x1+10x2$; $x1+2x2<=40$; $3x1+x2>=30$;$4x1+3x2>=60$; $x1,x2>=0$	CO1	L3
e	**Experiences**	-	-

Module – 2

Title:	LINEAR PART PROGRAMMING	Appr Time:	7Hrs
a	***Course Outcomes***	**CO**	**Blooms**
-		-	**Level**
1	Formulate as L.P.P and derive optimal solutions to linear programming problems by graphical method, Simplex method, Big-M method and Dual Simplex method.	CO2	L2
b	***Course Schedule***	-	-
Class No	**Portion covered per hour**	**-**	**-**
11	LPP: Simplex method, Canonical and Standard form of LP problem, slack, surplus and artificial variables,	CO2	L2
12	Numerical problems	CO2	L2
13	Numerical problems	CO2	L2
14	Numerical problems	CO2	L2
15	Solutions to LPP by Simplex method,	CO2	L3
16	Big-M Method	CO2	L3
17	Numerical problems	CO2	L3
18	Two Phase Simplex Method,	CO2	L3

19	Degeneracy in LPP. Concept of Duality, writing Dual of given LPP.	CO2	L3
20	Solutions to L.P.P by Dual Simplex Method.	CO2	L3
21	Numerical problems	CO2	L3
22	Numerical problems	CO2	L3
C	**Application Areas**	**CO**	**Level**
3	Food and Agriculture Farmers apply linear programming techniques to their work. By determining what crops they should grow, the quantity of it and how to use it efficiently, farmers can increase their revenue.	CO2	L3
4	Among all the mathematical optimization techniques, linear programming is perhaps the most used and best understood by the business and industrial community, healthcare, Entertainment,finance etc.	CO2	L4
d	**Review Questions**	-	-
-	The attainment of the module learning assessed through following questions	-	-
1	Define lpp	CO2	L2
2	A toy company manufactures two types of dolls, a basic version-doll A and a deluxe version- doll B. Each doll of type B takes twice as long to produce as one of type A and the company would have time to make maximum of 2000 dolls per day. The supply of plastic is sufficient to produce 1500 dolls per day(Both A & B combined). The deluxe version requires a fancy dress of which there are only 600 per day available. If the company makes a profit of Rs. 10/- & Rs. 18/- per doll on doll A & B respectively, then how many of each doll should be produced per day in order to maximize the total profit. Formulate the problem as LPP.	CO2	L3
3	The standard weight of a special purpose brick is 5Kg and it contains two ingredients B1 & B2. B1 cost Rs. 5/- per kg & B2 costs Rs. 8/- per kg. Strength considerations dictate that the brick contains not more than 4 kg of B1 & a minimum of 2 kg of B2, since the demand for the product is likely to be related to the price of the brick. Formulate the above problem as LP model.	CO2	L3
4	A marketing manager wishes to allocate his annual advertising budget of Rs. 20,000 in two media group M & N. The unit cost of the message in the media 'M' is Rs. 200 & 'N' is Rs. 300. The media M is monthly magazine & not more than two insertions are desired in one issue. At least five messages should appear in the media N. The expected effective audience per unit message for media M is 4,000 & for N is 5,000. Formulate the problem as Linear Programming problem.	CO2	L3
5	A manufacturer produces two types of models M1 & M2. Each M1 model requires 4 hours of grinding & 2 hours of polishing, whereas each M2 model requires 2 hours of grinding & 5 hours of polishing. The manufacturer has 2 grinders & 3 polishers. Each grinder works for 40 hours a week & each polisher works for 60 hours a week. Profit of M1 model is Rs. 3/- & on M2 model is Rs. 4/-. How should the manufacturer allocate his production capacity to the two types of models so as to make maximum profit in a week. Formulate the above problem as LPP.	CO2	L3
6	A company produces two types of Hats. Each hat of the first type requires twice as much labour time as the second type. The company can produce a total of 500 hats a day. The market limits daily sales of the first & second type to 150 & 250 hats. Assuming that the profits/hat are Rs. 8/- for type A & Rs. 5 for type B. Formulate the problem as LP model in order to determine the number of hats to be produced of each type so as to maximize the profit.	CO2	L3
7	An agriculturist has a farm with 126 acres. He produces Tomato, Mango and Potato. Whatever he raises is fully sold in the market. He gets Rs. 5/- for tomato/kg, Rs. 4/- for mango/kg and Rs. 5/- for potato/kg. The average yield is 1,500 kg of tomato/acre, 1800 kg of mango/acre and 1200 kg of potato/acre. To produce each 100 kg of tomato and mango and to produce each 80 kg of potato a sum of Rs. 12.50 has to be used for manure. Labour required for each acre to raise the crop is 6 man-days for tomato and potato	CO2	L3

	each and 5 man-days for mango. A total of 500 man-days of labour at a rate of Rs. 40/- per man day are available. Formulate this as a LP model to maximize the agriculturist's total profit.		
8	A company manufactures two products A & B. Theses products are processed in the same machine. It takes 10 minutes to process one unit of product A and 2 minutes for each unit of product B and the machine operates for a maximum of 35 hours in a week. Product A requires 1 kg and B 0.5 kg of raw material per unit the supply of which is 600 kg per week. Market constraint on product B is known to be 800 unit every week. Product A costs Rs. 5/- per unit and sold at Rs. 10/-. Product B costs Rs. 6/- per unit and can be sold in the market at a unit price of Rs. 8/-. Determine the number of units of A & B per week to maximize the profit	CO2	L3
9	A person requires 10,12 and 12 units chemicals A,B,C respectively for his garden. One unit of liquid product contains 5,2 and 1 units of A,B and C respectively. One unit of dry product contains 1,2 and 4 units of A,B,C. If the liquid product sells for Rs. 3/- and the dry product sells for Rs. 2/-, how many of each should be purchased, in order to minimize the cost and meet the requirements.	CO2	L3
e	**Experiences**	-	-

E1. CIA EXAM – 1

a. Model Question Paper - 1

Crs Code:	15ME81	Sem:	8	Marks:	20	Time:	75 minutes
Course:	Operations Research						

-	-	Note: Answer all questions, each carry equal marks. Module : 1, 2	Marks	CO	Level
1	a	Discuss the scope of Operations Research.	5	1	L2
	b	A retail store stocks two types of shirts A and B. These are packed in attractive cardboard boxes. During a week the store can sell a maximum of 400 shirts of type A and a maximum of 300 shirts of type B. The storage capacity, however, is limited to a maximum of 600 of both types combined. Type A shirt fetches a profit of Rs. 2/- per unit and type B a profit of Rs. 5/- per unit. How many of each type the store should stock per week to maximize the total profit? Formulate a mathematical model of the problem.	10	1	L3
		OR			
2	a	What is operation research? Explain origin and the six phases of operation research.	5	1	L2
	b	Old hens can be bought at Rs. 50/- each but young ones cost Rs. 100/- each. The old hens lay 3 eggs/week and young hens 5 eggs/week. Each egg costs Rs. 2/-. A hen costs Rs. 5/- per week to fee. If a person has only Rs. 2000/- to spend for hens, formulate the problem to decide how many of each kind of hen should he buy ? Assume that he cannot house more than 40 hens.	10	1	L3
3	a	An agriculturist has a farm with 126 acres. He produces Tomato, Mango and Potato. Whatever he raises is fully sold in the market. He gets Rs. 5/- for tomato/kg, Rs. 4/- for mango/kg and Rs. 5/- for potato/kg. The average yield is 1,500 kg of tomato/acre, 1800 kg of mango/acre and 1200 kg of potato/acre. To produce each 100 kg of tomato and mango and to produce each 80 kg of potato a sum of Rs. 12.50 has to be used for manure. Labour required for each acre to raise the crop is 6 man-days for tomato and potato each and 5 man-days for mango. A total of 500 man-days of labour at a rate of Rs. 40/- per man day are available. Formulate this as a LP model to maximize the agriculturist's total profit.	7	3	L3
	b	A company manufactures two products A & B. Theses products are	8	3	L3

		processed in the same machine. It takes 10 minutes to process one unit of product A and 2 minutes for each unit of product B and the machine operates for a maximum of 35 hours in a week. Product A requires 1 kg and B 0.5 kg of raw material per unit the supply of which is 600 kg per week. Market constraint on product B is known to be 800 unit every week. Product A costs Rs. 5/- per unit and sold at Rs. 10/-. Product B costs Rs. 6/- per unit and can be sold in the market at a unit price of Rs. 8/-. Determine the number of units of A & B per week to maximize the profit			
		OR			
4	a	The standard weight of a special purpose brick is 5Kg and it contains two ingredients B1 & B2. B1 cost Rs. 5/- per kg & B2 costs Rs. 8/- per kg. Strength considerations dictate that the brick contains not more than 4 kg of B1 & a minimum of 2 kg of B2, since the demand for the product is likely to be related to the price of the brick. Formulate the above problem as LP model.	7	4	L3
	b	A person requires 10,12 and 12 units chemicals A,B,C respectively for his garden. One unit of liquid product contains 5,2 and 1 units of A,B and C respectively. One unit of dry product contains 1,2 and 4 units of A,B,C. If the liquid product sells for Rs. 3/- and the dry product sells for Rs. 2/-, how many of each should be purchased, in order to minimize the cost and meet the requirements.	8	4	L3

b. Assignment -1

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions							
Crs Code:	15ME81	Sem:	VIII	Marks:	5	Time:	90 – 120 minutes
Course:	Operations Research				Module : 1, 2		
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.							

SNo	USN	Assignment Description	Marks	CO	Level
1		Discuss the scope of Operations Research.	5	CO1	L2
2		What is operation research? Explain origin and the six phases of operation research.	5	CO2	L3
3		A retail store stocks two types of shirts A and B. These are packed in attractive cardboard boxes. During a week the store can sell a maximum of 400 shirts of type A and a maximum of 300 shirts of type B. The storage capacity, however, is limited to a maximum of 600 of both types combined. Type A shirt fetches a profit of Rs. 2/- per unit and type B a profit of Rs. 5/- per unit. How many of each type the store should stock per week to maximize the total profit? Formulate a mathematical model of the problem.	5	CO2	L3
4		Old hens can be bought at Rs. 50/- each but young ones cost Rs. 100/- each. The old hens lay 3 eggs/week and young hens 5 eggs/week. Each egg costs Rs. 2/-. A hen costs Rs. 5/- per week to fee. If a person has only Rs. 2000/- to spend for hens, formulate the problem to decide how many of each kind of hen should he buy ? Assume that he cannot house more than 40 hens.	5	CO1	L3
5		A computer company manufactures laptops & desktops that fetches profit of Rs. 700/- & 500/- unit respectively. Each unit of laptop takes 4 hours of assembly time & 2 hours of testing time while each unit of desktop requires 3 hours of assembly time & 1 hour for testing. In a given month the total number of hours available for assembly is 210 hours & for inspection is 90 hours. Formulate the problem as LPP in such a way that the total profit is maximum.	5	CO2	L3
6		A toy company manufactures two types of dolls, a basic version-doll A and a deluxe version- doll B. Each doll of type B takes twice as long to produce as one of type A and the	5	CO2	L3

		company would have time to make maximum of 2000 dolls per day. The supply of plastic is sufficient to produce 1500 dolls per day(Both A & B combined). The deluxe version requires a fancy dress of which there are only 600 per day available. If the company makes a profit of Rs. 10/- & Rs. 18/- per doll on doll A & B respectively, then how many of each doll should be produced per day in order to maximize the total profit. Formulate the problem as LPP.			
7		The standard weight of a special purpose brick is 5Kg and it contains two ingredients B1 & B2. B1 cost Rs. 5/- per kg & B2 costs Rs. 8/- per kg. Strength considerations dictate that the brick contains not more than 4 kg of B1 & a minimum of 2 kg of B2, since the demand for the product is likely to be related to the price of the brick. Formulate the above problem as LP model.	5	CO2	L3
8		A marketing manager wishes to allocate his annual advertising budget of Rs. 20,000 in two media group M & N. The unit cost of the message in the media 'M' is Rs. 200 & 'N' is Rs. 300. The media M is monthly magazine & not more than two insertions are desired in one issue. At least five messages should appear in the media N. The expected effective audience per unit message for media M is 4,000 & for N is 5,000. Formulate the problem as Linear Programming problem.	5	CO2	L3
9		A manufacturer produces two types of models M1 & M2. Each M1 model requires 4 hours of grinding & 2 hours of polishing, whereas each M2 model requires 2 hours of grinding & 5 hours of polishing. The manufacturer has 2 grinders & 3 polishers. Each grinder works for 40 hours a week & each polisher works for 60 hours a week. Profit of M1 model is Rs. 3/- & on M2 model is Rs. 4/-. How should the manufacturer allocate his production capacity to the two types of models so as to make maximum profit in a week. Formulate the above problem as LPP.	5	CO2	L2
10		A company produces two types of Hats. Each hat of the first type requires twice as much labour time as the second type. The company can produce a total of 500 hats a day. The market limits daily sales of the first & second type to 150 & 250 hats. Assuming that the profits/hat are Rs. 8/- for type A & Rs. 5 for type B. Formulate the problem as LP model in order to determine the number of hats to be produced of each type so as to maximize the profit.	5	CO2	L3
11		An agriculturist has a farm with 126 acres. He produces Tomato, Mango and Potato. Whatever he raises is fully sold in the market. He gets Rs. 5/- for tomato/kg, Rs. 4/- for mango/kg and Rs. 5/- for potato/kg. The average yield is 1,500 kg of tomato/acre, 1800 kg of mango/acre and 1200 kg of potato/acre. To produce each 100 kg of tomato and mango and to produce each 80 kg of potato a sum of Rs. 12.50 has to be used for manure. Labour required for each acre to raise the crop is 6 man-days for tomato and potato each and 5 man-days for mango. A total of 500 man-days of labour at a rate of Rs. 40/- per man day are available. Formulate this as a LP model to maximize the agriculturist's total profit.	5	CO2	L3
12		A company manufactures two products A & B. Theses products are processed in the same machine. It takes 10 minutes to process one unit of product A and 2 minutes for each unit of product B and the machine operates for a maximum of 35 hours in a week. Product A requires 1 kg and B 0.5 kg of raw material per unit the supply of which is 600 kg	5	CO2	L3

		per week. Market constraint on product B is known to be 800 unit every week. Product A costs Rs. 5/- per unit and sold at Rs. 10/-. Product B costs Rs. 6/- per unit and can be sold in the market at a unit price of Rs. 8/-. Determine the number of units of A & B per week to maximize the profit			
13		A person requires 10,12 and 12 units chemicals A,B,C respectively for his garden. One unit of liquid product contains 5,2 and 1 units of A,B and C respectively. One unit of dry product contains 1,2 and 4 units of A,B,C. If the liquid product sells for Rs. 3/- and the dry product sells for Rs. 2/-, how many of each should be purchased, in order to minimize the cost and meet the requirements.	5	CO3	L3
14		A paper mill produces two grades of paper namely X and Y. Because of raw material restrictions, it cannot produce more than 400 tons of grade X and 300 tons of grade Y in a week. There are 160 production hours in a week. It requires 0.2 and 0.4 hours to produce a ton of products X and Y respectively with corresponding profits of Rs. 200/- and Rs. 500/- per ton. Formulate the above as a LPP to maximize profit and find the optimum product mix.	5	CO2	L3
15		Farmer furniture makes chairs, arm-chairs and sofas, the profits are $ 50 per chair, $60 per arm-chair and $ 80 per sofa. The material used to manufacture these items are fabric and wood. A supplier can provide a maximum of 300 meters of fabric and 350 units of wood each week. Each item requires a certain amount of wood and fabric as well as certain assembly time. These are given in the following tabl Item / Fabric / Wood / Ass. Time Chair / 2m / 6 units / 8 hours Armchair / 5m / 4 units / 4 hours Sofa / 8m / 5 units / 5 hours Avail./Wk / 300m / 350 units / 480 hours	5	CO2	L3
16		Use graphical method to solve Min z=20x1+10x2 ; x1+2x2<=40; 3x1+x2>=30 ;4x1+3x2>=60 ; x1,x2>=0	5	CO2	L3
17		Define the following (i)solution (ii)feasible solution (iii)basic solution (iv)basic feasible solution (v)degenerate basic feasible feasible solution (vi)optimal basic feasible solution (vii)unbounded solution (viii)feasible region.	5	CO2	L3
18		Solve the following using BIG-M method Max z=2x+y ,3x+y=3 , x+2y<=3, 4x+3y>=6	5	CO2	L3
19		Solve the following using BIG-M method Max z=3x+y ,2x+y<=12 , 3x+4y>=12.	5	CO2	L3
20		Solve the following using BIG-M method Min z=3x1+2x2+x3 ,x1+x2=7 , 3x1+x2+x3>=10.	5	CO2	L3
21		Solve the following using BIG-M method Min p=2x+y ,x+4y<=24, x-y<=-3 ,x+2y<=14 , 2x-y<=8	5	CO2	L3
22		Solve the following using BIG-M method Min z=2x1+9x2+x3 ,x1+4x2+2x3>=5 , 3x1+x2+2x3>=4.	5	CO2	L3
23		Solve the following using Two Phase method Max z=5x1+8x2 ,3x1+2x2>=3 , x1+4x2>=4 x1+x2<=5.	5	CO2	L3
24		Solve the following using Two Phase method Max z=2x1+x2+x3 ,4x1+6x2+3x3<=8 , 3x1-6x2-4x3<=1 , 2x1+3x2-5x3>=4.	5	CO2	L3

D2. TEACHING PLAN - 2

Module – 3

Title:	Transportation, Assignment and travelling salesman problems	Appr Time:	8 Hrs
a	***Course Outcomes***	**CO**	**Blooms**
-	At the end of the topic the student should be able to . . .	-	**Level**
1	Formulate as Transportation and Assignment problems and derive optimum solutions for transportation, Assignment and travelling salesman problems	CO3	L3
b			
Class No	**Portion covered per hour**	**-**	**-**
1	Find initial Basic Feasible solution for the following T.P. Using all methods .	CO5	L2

	1	2	3	Supply
1	5	1	7	10
2	6	4	6	80
3	3	2	5	15
Demand	75	20	50	

Class No	Portion covered per hour	CO	Blooms Level
2	Define degeneracy in T.P .Find optimal solution for the following T.P & formulate as a mathematical method.	CO5	L3

	1	2	3	4	5	6	Supply
1	9	12	9	6	9	10	5
2	7	3	7	7	5	5	6
3	6	5	9	11	3	11	2
4	6	8	11	2	2	10	9
Demand	4	4	6	2	4	2	

Class No	Portion covered per hour	CO	Blooms Level
3	The production capacities of the factories are 1000,700,900 units per month .the requirements from the dealers are 900,800,500 & 400 units per momth.the per unit return (excluding transportation cost) are Rs.8,7 & 9 at three factoris.the following table gives unit transportation costs from the factories to the dealers.determine the optimum solution to maximize the toatl returns.	CO5	L3

	1	2	3	4
A	2	2	2	4
B	3	5	3	2
C	4	3	2	1

Class No	Portion covered per hour	CO	Blooms Level
4	A product is produced by 4 factories f1f,2,f 3 &f4 .Their unit production costs are Rs. 2,3,1,&5.unit costs of transportation ,production capacity & requirements are given below find optimum solution for the given T.P to momimize the cost.	CO5	L4

	S1	S2	S3	S4
F1	2	4	6	11
F2	10	8	7	5
F3	13	3	9	12
F4	4	6	8	3

Class No	Portion covered per hour	CO	Blooms Level
5	Explain various steps involved in Hungarian algorithm with example.	CO5	L4
6	Find the assignment of jobs to machines that will result in the maximum profit.	CO5	L4

	M1	M2	M3	M4	M5
J1	6.2	7.8	*	10.1	8.2
J2	7.0	8.4	6.5	7.5	6.0
J3	8.7	9.2	11.1	7.0	8.2
J4	*	6.4	8.7	7.7	8.0

7	Find the assignment of men to jobs that will minimize the total time taken.	CO5	L4

	J1	J2	J3	J4	J5
A	2	9	2	7	1
B	6	8	7	6	1
C	4	6	5	3	1
D	4	2	7	3	1
E	5	3	9	5	1

8	A company produces two types of Hats. Each hat of the first type requires twice as much labour time as the second type. The company can produce a total of 500 hats a day. The market limits daily sales of the first & second type to 150 & 250 hats. Assuming that the profits/hat are Rs. 8/- for type A & Rs. 5 for type B. Formulate the problem as LP model in order to determine the number of hats to be produced of each type so as to maximize the profit.	CO5	L4
c	**Application Areas**	**-**	**-**
-	Students should be able employ / apply the Module learnings to . . .	-	-
1	Demonstrate skills in forming and solving assignment problems, Transportation problems.	CO5	L3
d	**Review Questions**	-	-
-		-	-
1	Demonstrate skills in forming and solving assignment problems, Transportation problems.	CO5	L3
2		CO5	L3
3	**Review Questions**	CO5	L4
4	Find initial Basic Feasible solution for the following T.P. Using all methods .	CO5	L4

	1	2	3	Supply
1	5	1	7	10
2	6	4	6	80
3	3	2	5	15
Demand	75	20	50	

5	Define degeneracy in T.P .Find optimal solution for the following T.P & formulate as a mathematical method.	CO5	L4

	1	2	3	4	5	6	Supply
1	9	12	9	6	9	10	5
2	7	3	7	7	5	5	6
3	6	5	9	11	3	11	2
4	6	8	11	2	2	10	9
Demand	4	4	6	2	4	2	

6	The production capacities of the factories are 1000,700,900 units per month .the requirements from the dealers are 900,800,500 & 400 units per momth.the per unit return (excluding transportation cost) are Rs.8,7 & 9 at three factoris.the following table gives unit transportation costs from the factories to the dealers.determine the optimum solution to maximize the toatl returns.	CO5	L3

	1	2	3	4
A	2	2	2	4
B	3	5	3	2
C	4	3	2	1

7	A product is produced by 4 factories f1f,2,f 3 &f4 .Their unit production costs are Rs. 2,3,1,&5.unit costs of transportation ,production capacity &	CO5	L3

	requirements are given below find optimum solution for the given T.P to momimize the cost.		

	S1	S2	S3	S4
F1	2	4	6	11
F2	10	8	7	5
F3	13	3	9	12
F4	4	6	8	3

8	Explain various steps involved in Hungarian algorithm with example.	CO5	L3
9	Find the assignment of jobs to machines that will result in the maximum profit.	CO5	L3

	M1	M2	M3	M4	M5
J1	6.2	7.8	*	10.1	8.2
J2	7.0	8.4	6.5	7.5	6.0
J3	8.7	9.2	11.1	7.0	8.2
J4	*	6.4	8.7	7.7	8.0

10	Find the assignment of men to jobs that will minimize the total time taken.	CO5	L4

	J1	J2	J3	J4	J5
A	2	9	2	7	1
B	6	8	7	6	1
C	4	6	5	3	1
D	4	2	7	3	1
E	5	3	9	5	1

e	**Experiences**	-	-

Module – 4

Title:	**Network analysis and Queuing theory**	Appr Time:	8 Hrs
a	***Course Outcomes***	**CO**	**Blooms**
-	At the end of the topic the student should be able to . . .	-	**Level**
1	Solve waiting line problems for M/M/1 and M/M/K queuing models. Construct network diagrams and determine critical path, floats for deterministic and PERT networks including crashing of Networks.	CO4	L3
b	***Course Schedule***		
Class No	**Portion covered per hour**	**-**	**-**
1	**Network analysis:** Introduction, Construction of networks,	CO4	L2
2	Fulkerson's rule for numbering the nodes, AON diagrams;	CO4	L3
3	Fulkerson's rule for numbering the nodes, AOA diagrams;	CO4	L2
4	Critical path method to find the expected completion time of a project,	CO5	L3
5	determination of floats in networks, PERT networks, determining the probability of completing a project,	CO5	L3
6	predicting the completion time of project; Cost analysis in networks. Crashingofnetworks- Problems.	CO5	L2
7	Queuing Theory: Queuing systems and their characteristics,	CO5	L2
8	Pure-birth and Pure-death models (only equations),	CO5	L3
9	Kendall & Lee's notation of Queuing,empirical queuing models –	CO5	
10	Numerical on M/M/1 and M/M/C Queuing models	CO4	
d	**Review Questions**	-	-
-	The attainment of the module learning assessed through following questions	-	-
1	Old hens can be bought at Rs. 50/- each but young ones cost Rs. 100/- each. The old hens lay 3 eggs/week and young hens 5 eggs/week. Each egg costs Rs. 2/-. A hen costs Rs. 5/- per week to fee. If a person has only Rs. 2000/- to spend for hens, formulate the problem to decide how many of each kind of	CO4	L3

	hen should he buy ? Assume that he cannot house more than 40 hens.		
2	A computer company manufactures laptops & desktops that fetches profit of Rs. 700/- & 500/- unit respectively. Each unit of laptop takes 4 hours of assembly time & 2 hours of testing time while each unit of desktop requires 3 hours of assembly time & 1 hour for testing. In a given month the total number of hours available for assembly is 210 hours & for inspection is 90 hours. Formulate the problem as LPP in such a way that the total profit is maximum. CO4	CO4	L3
3	A toy company manufactures two types of dolls, a basic version-doll A and a deluxe version- doll B. Each doll of type B takes twice as long to produce as one of type A and the company would have time to make maximum of 2000 dolls per day. The supply of plastic is sufficient to produce 1500 dolls per day(Both A & B combined). The deluxe version requires a fancy dress of which there are only 600 per day available. If the company makes a profit of Rs. 10/- & Rs. 18/- per doll on doll A & B respectively, then how many of each doll should be produced per day in order to maximize the total profit. Formulate the problem as LPP.	CO4	L3
4	The standard weight of a special purpose brick is 5Kg and it contains two ingredients B1 & B2. B1 cost Rs. 5/- per kg & B2 costs Rs. 8/- per kg. Strength considerations dictate that the brick contains not more than 4 kg of B1 & a minimum of 2 kg of B2, since the demand for the product is likely to be related to the price of the brick. Formulate the above problem as LP model.	CO4	L3
5	A marketing manager wishes to allocate his annual advertising budget of Rs. 20,000 in two media group M & N. The unit cost of the message in the media 'M' is Rs. 200 & 'N' is Rs. 300. The media M is monthly magazine & not more than two insertions are desired in one issue. At least five messages should appear in the media N. The expected effective audience per unit message for media M is 4,000 & for N is 5,000. Formulate the problem as Linear Programming problem.	CO4	L3
6	A manufacturer produces two types of models M1 & M2. Each M1 model requires 4 hours of grinding & 2 hours of polishing, whereas each M2 model requires 2 hours of grinding & 5 hours of polishing. The manufacturer has 2 grinders & 3 polishers. Each grinder works for 40 hours a week & each polisher works for 60 hours a week. Profit of M1 model is Rs. 3/- & on M2 model is Rs. 4/-. How should the manufacturer allocate his production capacity to the two types of models so as to make maximum profit in a week. Formulate the above problem as LPP.	CO4	L2
8	A company produces two types of Hats. Each hat of the first type requires twice as much labour time as the second type. The company can produce a total of 500 hats a day. The market limits daily sales of the first & second type to 150 & 250 hats. Assuming that the profits/hat are Rs. 8/- for type A & Rs. 5 for type B. Formulate the problem as LP model in order to determine the number of hats to be produced of each type so as to maximize the profit.	CO4	L3
9	An agriculturist has a farm with 126 acres. He produces Tomato, Mango and Potato. Whatever he raises is fully sold in the market. He gets Rs. 5/- for tomato/kg, Rs. 4/- for mango/kg and Rs. 5/- for potato/kg. The average yield is 1,500 kg of tomato/acre, 1800 kg of mango/acre and 1200 kg of potato/acre. To produce each 100 kg of tomato and mango and to produce each 80 kg of potato a sum of Rs. 12.50 has to be used for manure. Labour required for each acre to raise the crop is 6 man-days for tomato and potato each and 5 man-days for mango. A total of 500 man-days of labour at a rate of Rs. 40/- per man day are available. Formulate this as a LP model to maximize the agriculturist's total profit.	CO4	L3
10	A company manufactures two products A & B. Theses products are processed in the same machine. It takes 10 minutes to process one unit of product A and 2 minutes for each unit of product B and the machine operates for a maximum of 35 hours in a week. Product A requires 1 kg and B 0.5 kg of raw material per unit the supply of which is 600 kg per week. Market constraint on product B is known to be 800 unit every week. Product A costs Rs. 5/- per unit and sold at	CO4	L3

	Rs. 10/-. Product B costs Rs. 6/- per unit and can be sold in the market at a unit price of Rs. 8/-. Determine the number of units of A & B per week to maximize the profit		
11	A person requires 10,12 and 12 units chemicals A,B,C respectively for his garden. One unit of liquid product contains 5,2 and 1 units of A,B and C respectively. One unit of dry product contains 1,2 and 4 units of A,B,C. If the liquid product sells for Rs. 3/- and the dry product sells for Rs. 2/-, how many of each should be purchased, in order to minimize the cost and meet the requirements.	CO4	L3
12	A paper mill produces two grades of paper namely X and Y. Because of raw material restrictions, it cannot produce more than 400 tons of grade X and 300 tons of grade Y in a week. There are 160 production hours in a week. It requires 0.2 and 0.4 hours to produce a ton of products X and Y respectively with corresponding profits of Rs. 200/- and Rs. 500/- per ton. Formulate the above as a LPP to maximize profit and find the optimum product mix.	CO4	L3
13	Farmer furniture makes chairs, arm-chairs and sofas, the profits are $ 50 per chair, $60 per arm-chair and $ 80 per sofa. The material used to manufacture these items are fabric and wood. A supplier can provide a maximum of 300 meters of fabric and 350 units of wood each week. Each item requires a certain amount of wood and fabric as well as certain assembly time. These are given in the following table Item / Fabric / Wood / Ass. Time Chair / 2m / 6 units / 8 hours Armchair / 5m / 4 units / 4 hours Sofa / 8m / 5 units / 5 hours Avail./Wk / 300m / 350 units / 480 hours	CO4	L3

Item	Fabric	Wood	Ass. Time
Chair	2m	6 units	8 hours
Armchair	5m	4 units	4 hours
Sofa	8m	5 units	5 hours
Avail./Wk	300m	350 units	480 hours

E2. CIA EXAM – 2

a. Model Question Paper - 2

Crs Code:	15ME71	Sem:	VII	Marks:	30	Time:	75 minutes
Course:	Operations Research.						

-	-	**Note: Answer all questions, each carry equal marks. Module : 3, 4**	**Marks**	**CO**	**Level**
1	a	The production capacities of the factories are 1000,700,900 units per month .the requirements from the dealers are 900,800,500 & 400 units per momth.the per unit return (excluding transportation cost) are Rs.8,7 & 9 at three factoris.the following table gives unit transportation costs from the factories to the dealers.determine the optimum solution to maximize the toatl returns.	7	3	L3
	b	A product is produced by 4 factories f1f,2,f 3 &f4 .Their unit production costs are Rs. 2,3,1,&5.unit costs of transportation ,production capacity & requirements are given below find optimum solution for the given T.P to momimize the cost.	8	3	L3
		OR			
2	a	Find the assignment of jobs to machines that will result in the maximum profit.	7	3	L3

Table for 1 a:

	1	2	3	4
A	2	2	2	4
B	3	5	3	2
C	4	3	2	1

Table for 1 b:

	S1	S2	S3	S4
F1	2	4	6	11
F2	10	8	7	5
F3	13	3	9	12
F4	4	6	8	3

	M1	M2	M3	M4	M5
J1	6.2	7.8	*	10.1	8.2
J2	7.0	8.4	6.5	7.5	6.0
J3	8.7	9.2	11.1	7.0	8.2
J4	*	6.4	8.7	7.7	8.0

	b	Find the assignment of men to jobs that will minimize the total time taken.	8	3	L3

	J1	J2	J3	J4	J5
A	2	9	2	7	1
B	6	8	7	6	1
C	4	6	5	3	1
D	4	2	7	3	1
E	5	3	9	5	1

3	a	A company manufactures two products A & B. Theses products are processed in the same machine. It takes 10 minutes to process one unit of product A and 2 minutes for each unit of product B and the machine operates for a maximum of 35 hours in a week. Product A requires 1 kg and B 0.5 kg of raw material per unit the supply of which is 600 kg per week. Market constraint on product B is known to be 800 unit every week. Product A costs Rs. 5/- per unit and sold at Rs. 10/-. Product B costs Rs. 6/- per unit and can be sold in the market at a unit price of Rs. 8/-. Determine the number of units of A & B per week to maximize the profit	8	4	L3
	b	A person requires 10,12 and 12 units chemicals A,B,C respectively for his garden. One unit of liquid product contains 5,2 and 1 units of A,B and C respectively. One unit of dry product contains 1,2 and 4 units of A,B,C. If the liquid product sells for Rs. 3/- and the dry product sells for Rs. 2/-, how many of each should be purchased, in order to minimize the cost and meet the requirements.	7	4	L3
		OR			
4	a	A manufacturer produces two types of models M1 & M2. Each M1 model requires 4 hours of grinding & 2 hours of polishing, whereas each M2 model requires 2 hours of grinding & 5 hours of polishing. The manufacturer has 2 grinders & 3 polishers. Each grinder works for 40 hours a week & each polisher works for 60 hours a week. Profit of M1 model is Rs. 3/- & on M2 model is Rs. 4/-. How should the manufacturer allocate his production capacity to the two types of models so as to make maximum profit in a week. Formulate the above problem as LPP.	7	4	L3
	b	A company produces two types of Hats. Each hat of the first type requires twice as much labour time as the second type. The company can produce a total of 500 hats a day. The market limits daily sales of the first & second type to 150 & 250 hats. Assuming that the profits/hat are Rs. 8/- for type A & Rs. 5 for type B. Formulate the problem as LP model in order to determine the number of hats to be produced of each type so as to maximize the profit.	8	4	L3

b. Assignment – 2

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions							
Crs Code:	15ME81	Sem:	VIII	Marks:	5	Time:	90 – 120 minutes
Course:	Operations Research.				Module : 3, 4		
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.							

SNo	USN	Assignment Description	Marks	CO	Level
1		A toy company manufactures two types of dolls, a basic version-doll A and a deluxe version- doll B. Each doll of type B takes twice as long to produce as one of type A and the company would have time to make maximum of 2000 dolls	5	CO4	L3

		per day. The supply of plastic is sufficient to produce 1500 dolls per day(Both A & B combined). The deluxe version requires a fancy dress of which there are only 600 per day available. If the company makes a profit of Rs. 10/- & Rs. 18/- per doll on doll A & B respectively, then how many of each doll should be produced per day in order to maximize the total profit. Formulate the problem as LPP.			
2		The standard weight of a special purpose brick is 5Kg and it contains two ingredients B1 & B2. B1 cost Rs. 5/- per kg & B2 costs Rs. 8/- per kg. Strength considerations dictate that the brick contains not more than 4 kg of B1 & a minimum of 2 kg of B2, since the demand for the product is likely to be related to the price of the brick. Formulate the above problem as LP model.	5	CO4	L2
3		A marketing manager wishes to allocate his annual advertising budget of Rs. 20,000 in two media group M & N. The unit cost of the message in the media 'M' is Rs. 200 & 'N' is Rs. 300. The media M is monthly magazine & not more than two insertions are desired in one issue. At least five messages should appear in the media N. The expected effective audience per unit message for media M is 4,000 & for N is 5,000. Formulate the problem as Linear Programming problem.	5	CO4	L3
4		A manufacturer produces two types of models M1 & M2. Each M1 model requires 4 hours of grinding & 2 hours of polishing, whereas each M2 model requires 2 hours of grinding & 5 hours of polishing. The manufacturer has 2 grinders & 3 polishers. Each grinder works for 40 hours a week & each polisher works for 60 hours a week. Profit of M1 model is Rs. 3/- & on M2 model is Rs. 4/-. How should the manufacturer allocate his production capacity to the two types of models so as to make maximum profit in a week. Formulate the above problem as LPP.	5	CO4	L3
5		A company produces two types of Hats. Each hat of the first type requires twice as much labour time as the second type. The company can produce a total of 500 hats a day. The market limits daily sales of the first & second type to 150 & 250 hats. Assuming that the profits/hat are Rs. 8/- for type A & Rs. 5 for type B. Formulate the problem as LP model in order to determine the number of hats to be produced of each type so as to maximize the profit.	5	CO4	L3
6		An agriculturist has a farm with 126 acres. He produces Tomato, Mango and Potato. Whatever he raises is fully sold in the market. He gets Rs. 5/- for tomato/kg, Rs. 4/- for mango/kg and Rs. 5/- for potato/kg. The average yield is 1,500 kg of tomato/acre, 1800 kg of mango/acre and 1200 kg of potato/acre. To produce each 100 kg of tomato and mango and to produce each 80 kg of potato a sum of Rs. 12.50 has to be used for manure. Labour required for each acre to raise the crop is 6 man-days for tomato and potato each and 5 man-days for mango. A total of 500 man-days of labour at a rate of Rs. 40/- per man day are available. Formulate this as a LP model to maximize the agriculturist's total profit.	5	CO4	L3
7		A company manufactures two products A & B. Theses products are processed in the same machine. It takes 10 minutes to process one unit of product A and 2 minutes for each unit of product B and the machine operates for a maximum of 35 hours in a week. Product A requires 1 kg and B 0.5 kg of raw material per unit the supply of which is 600 kg per week. Market constraint on product B is known to be 800	5	CO4	L3

<table>
<tr><td></td><td></td><td>unit every week. Product A costs Rs. 5/- per unit and sold at Rs. 10/-. Product B costs Rs. 6/- per unit and can be sold in the market at a unit price of Rs. 8/-. Determine the number of units of A & B per week to maximize the profit</td><td></td><td></td><td></td></tr>
<tr><td>8</td><td></td><td>A person requires 10,12 and 12 units chemicals A,B,C respectively for his garden. One unit of liquid product contains 5,2 and 1 units of A,B and C respectively. One unit of dry product contains 1,2 and 4 units of A,B,C. If the liquid product sells for Rs. 3/- and the dry product sells for Rs. 2/-, how many of each should be purchased, in order to minimize the cost and meet the requirements.</td><td>5</td><td>CO4</td><td>L3</td></tr>
<tr><td>9</td><td></td><td>A paper mill produces two grades of paper namely X and Y. Because of raw material restrictions, it cannot produce more than 400 tons of grade X and 300 tons of grade Y in a week. There are 160 production hours in a week. It requires 0.2 and 0.4 hours to produce a ton of products X and Y respectively with corresponding profits of Rs. 200/- and Rs. 500/- per ton. Formulate the above as a LPP to maximize profit and find the optimum product mix.</td><td>5</td><td>C03</td><td>L3</td></tr>
<tr><td>10</td><td></td><td>The production capacities of the factories are 1000,700,900 units per month .the requirements from the dealers are 900,800,500 & 400
units per momth.the per unit return (excluding transportation cost) are Rs.8,7 & 9 at three factoris.the following table gives unit
transportation costs from the factories to the dealers.determine the optimum solution to maximize the toatl returns.
<table>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>A</td><td>2</td><td>2</td><td>2</td><td>4</td></tr>
<tr><td>B</td><td>3</td><td>5</td><td>3</td><td>2</td></tr>
<tr><td>C</td><td>4</td><td>3</td><td>2</td><td>1</td></tr>
</table>
C03</td><td>5</td><td>C03</td><td>L3</td></tr>
<tr><td>11</td><td></td><td>A product is produced by 4 factories f1f,2,f 3 &f4 .Their unit production costs are Rs. 2,3,1,&5.unit costs of transportation ,production capacity & requirements are given below find optimum solution for the given T.P to momimize the cost.
<table>
<tr><td></td><td>S1</td><td>S2</td><td>S3</td><td>S4</td></tr>
<tr><td>F1</td><td>2</td><td>4</td><td>6</td><td>11</td></tr>
<tr><td>F2</td><td>10</td><td>8</td><td>7</td><td>5</td></tr>
<tr><td>F3</td><td>13</td><td>3</td><td>9</td><td>12</td></tr>
<tr><td>F4</td><td>4</td><td>6</td><td>8</td><td>3</td></tr>
</table></td><td>5</td><td>C03</td><td>L3</td></tr>
<tr><td>12</td><td></td><td>Explain various steps involved in Hungarian algorithm with example.</td><td>5</td><td>C03</td><td>L3</td></tr>
<tr><td>13</td><td></td><td>Find the assignment of jobs to machines that will result in the maximum profit.
<table>
<tr><td></td><td>M1</td><td>M2</td><td>M3</td><td>M4</td><td>M5</td></tr>
<tr><td>J1</td><td>6.2</td><td>7.8</td><td>*</td><td>10.1</td><td>8.2</td></tr>
<tr><td>J2</td><td>7.0</td><td>8.4</td><td>6.5</td><td>7.5</td><td>6.0</td></tr>
<tr><td>J3</td><td>8.7</td><td>9.2</td><td>11.1</td><td>7.0</td><td>8.2</td></tr>
<tr><td>J4</td><td>*</td><td>6.4</td><td>8.7</td><td>7.7</td><td>8.0</td></tr>
</table></td><td>5</td><td>C03</td><td>L3</td></tr>
<tr><td>14</td><td></td><td>Find the assignment of men to jobs that will minimize the total time taken.
<table>
<tr><td></td><td>J 1</td><td>J 2</td><td>J 3</td><td>J 4</td><td>J 5</td></tr>
<tr><td>A</td><td>2</td><td>9</td><td>2</td><td>7</td><td>1</td></tr>
<tr><td>B</td><td>6</td><td>8</td><td>7</td><td>6</td><td>1</td></tr>
</table></td><td>5</td><td>C03</td><td>L3</td></tr>
</table>

		C | 4 | 6 | 5 | 3 | 1 D | 4 | 2 | 7 | 3 | 1 E | 5 | 3 | 9 | 5 | 1			
15		A company produces two types of Hats. Each hat of the first type requires twice as much labour time as the second type. The company can produce a total of 500 hats a day. The market limits daily sales of the first & second type to 150 & 250 hats. Assuming that the profits/hat are Rs. 8/- for type A & Rs. 5 for type B. Formulate the problem as LP model in order to determine the number of hats to be produced of each type so as to maximize the profit.		C03	L3
16			5	C03	L3
17		**Application Areas**	5	C03	L3
18		Students should be able employ / apply the Module learnings to . . .	5	C03	L3
19					
20					
		Review Questions			

D3. TEACHING PLAN - 3

Module – 5

Title:	**Game theory and sequencing**	Appr Time:	8Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Apply game theory, decision analysis for decision support system to construct decision tree	CO5	L2
2		CO5	L2
b	***Course Schedule***	-	-
Class No	**Portion covered per hour**	**-**	**-**
1	**Game Theory:** Definition, Pure Strategy problems, Saddle point, Max-Min and Min-Max criteria, Principle of Dominance, CO5	CO5	L2
2	Solution of games with Saddle point. Mixed Strategy problems.	CO5	L2
3	Solution of 2X2 games by Arithmetic method, Solution of 2Xn m and mX2 games by graphical method.	CO5	L2
4	Formulation of games.	CO5	L2
5	**Sequencing**: Basic assumptions, Johnson's algorithm,	CO5	L2
6	sequencing using Johnson's rule-'n' jobs on 2 machines, 'n' jobs on 3 machines, '	CO5	L2
7	n' jobs on 'm' machines. Sequencing of2 jobs on 'm' machines using graphical method.	CO5	L2
8	sequencing 'n' jobs on single machine using priority rules,	CO5	L2
c	**Application Areas**	CO5	**-**
-	Students should be able employ / apply the Module learnings to .	CO5	-
1	Problems related to game theory arise in a range of fields, for example, healthcare, transportation and military planning	CO5	L2
2		CO5	L2
		CO5	
d	**Review Questions**	CO5	-
-	The attainment of the module learning assessed through following questions	CO5	-
1	Define the following a)pure strategy b)mixed strategy c)saddle point d)pay-off matrix e)two person zero sum game f)strategy g)minimax & maximin	CO5	L2

	principles h)dominance principle		
2	Solve the following game by applying a) graphical method b)dominance rule a) | | B1 | B2 | B3 | | A1 | 3 | -3 | 4 | | A2 | -1 | 1 | -3 | b) 3 -2 4 -1 4 2 2 2 6	CO5	L3
3	Two player A & B are playing a game of tossing a coin simultaneously player A wins 1 unit of value when there are two heads ,wins nothing when there are two tails and looses ½ unit of value when there is one head and one tail. Determine the pay-off matrix , the best strategies for each player & value of the game.	CO5	L3
4	In A Game Of Matching coins with two players, suppose A wins one unit of value when there are two heads, wins nothing when there are two tails & losses ½ unit of value when there are one head & one tail . Determine the payoff matrix, the best strategies for each player and the value of the game	CO5	L3
5	Explain briefly the following a) tabu search b)genetic algorithm c)simulated annealing technique.	CO5	L3
6	Solve the following game by applying dominance rule 4 5 8 6 4 6 4 2 4	CO5	L3
7	Solve the following game by applying dominance rule 2 4 3 8 4 5 6 3 7 8 6 7 9 8 7 4 2 8 4 3	CO5	L3
8	Solve the following game by applying dominance rule 1 7 2 6 2 7 5 2 6	CO5	L3
9	Solve the following game by applying graphical rule 2 2 3 -1 4 3 2 6	CO5	L3
10	Solve the following game by applying graphical rule 2 -1 5 -2 6 -2 4 -3 1 0	CO5	L3
11	Solve the following game by applying graphical rule 1 2 5 6 -7 -9 -4 -3 2 1	CO5	L3

E3. CIA EXAM – 3

a. Model Question Paper - 3

Crs Code:	15ME71	Sem:	VII	Marks:	30	Time:	75 minutes

Course:		Operations Research.			
-	-	**Note: Answer any 2 questions, each carry equal marks.**	**Marks**	**CO**	**Level**
1	a	In A Game Of Matching coins with two players, suppose A wins one unit of value when there are two heads, wins nothing when there are two tails & losses ½ unit of value when there are one head & one tail . Determine the payoff matrix, the best strategies for each player and the value of the game	7	5	L2
	b	Explain briefly the following a) tabu search b)genetic algorithm c)simulated annealing technique.	8	5	L2
		OR			
2	a	Define the following a)pure strategy b)mixed strategy c)saddle point d)pay-off matrix e)two person zero sum game f)strategy g)minimax & maximin principles h)dominance principle	7	5	L2
	b	Solve the following game by applying a) graphical method b)dominance rule	8	5	L2

b)

	B1	B2	B3
A1	3	-3	4
A2	-1	1	-3

b)

3	-2	4
-1	4	2
2	2	6

			Marks	CO	Level
3	a	Solve the following game by applying dominance rule	8	5	L3

2	4	3	8	4
5	6	3	7	8
6	7	9	8	7
4	2	8	4	3

			Marks	CO	Level
	b	Solve the following game by applying dominance rule	7	5	L2

1	7	2
6	2	7
5	2	6

Solve the following game by applying graphical rule

2	2	3	-1
4	3	2	6

OR

			Marks	CO	Level
4	a	Solve the following game by applying graphical rule	8	5	L2

2	-1	5	-2	6
-2	4	-3	1	0

			Marks	CO	Level
	b	Solve the following game by applying graphical rule	7	5	L2

1	2
5	6
-7	-9
-4	-3
2	1

b. Assignment – 3

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions							
Crs Code:	15ME81	Sem:	VIII	Marks:	5	Time:	90 – 120 minutes
Course:	Operations Research.				Module : 5		

<table>
<tr><td colspan="6">Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.</td></tr>
<tr><th>SNo</th><th>USN</th><th>Assignment Description</th><th>Marks</th><th>CO</th><th>Level</th></tr>
<tr><td>1</td><td></td><td>Solve the following game by applying a) graphical method b)dominance rule
c)
<table><tr><td></td><td>B1</td><td>B2</td><td>B3</td></tr><tr><td>A1</td><td>3</td><td>-3</td><td>4</td></tr><tr><td>A2</td><td>-1</td><td>1</td><td>-3</td></tr></table>
b)
<table><tr><td>3</td><td>-2</td><td>4</td></tr><tr><td>-1</td><td>4</td><td>2</td></tr><tr><td>2</td><td>2</td><td>6</td></tr></table></td><td>5</td><td>CO5</td><td>L3</td></tr>
<tr><td>2</td><td></td><td></td><td>5</td><td>CO5</td><td>L3</td></tr>
<tr><td>3</td><td></td><td>Solve the following game by applying dominance rule
<table><tr><td>2</td><td>4</td><td>3</td><td>8</td><td>4</td></tr><tr><td>5</td><td>6</td><td>3</td><td>7</td><td>8</td></tr><tr><td>6</td><td>7</td><td>9</td><td>8</td><td>7</td></tr><tr><td>4</td><td>2</td><td>8</td><td>4</td><td>3</td></tr></table></td><td>5</td><td>CO5</td><td>L3</td></tr>
<tr><td>4</td><td></td><td>Solve the following game by applying dominance rule
<table><tr><td>1</td><td>7</td><td>2</td></tr><tr><td>6</td><td>2</td><td>7</td></tr><tr><td>5</td><td>2</td><td>6</td></tr></table></td><td>5</td><td>CO5</td><td>L3</td></tr>
<tr><td>5</td><td></td><td>Solve the following game by applying graphical rule
<table><tr><td>2</td><td>2</td><td>3</td><td>-1</td></tr><tr><td>4</td><td>3</td><td>2</td><td>6</td></tr></table></td><td>5</td><td>CO5</td><td>L3</td></tr>
<tr><td>6</td><td></td><td>OR</td><td>5</td><td>CO5</td><td>L3</td></tr>
<tr><td>7</td><td></td><td>Solve the following game by applying graphical rule
<table><tr><td>2</td><td>-1</td><td>5</td><td>-2</td><td>6</td></tr><tr><td>-2</td><td>4</td><td>-3</td><td>1</td><td>0</td></tr></table></td><td>5</td><td>CO5</td><td>L3</td></tr>
<tr><td>8</td><td></td><td>Solve the following game by applying graphical rule
<table><tr><td>1</td><td>2</td></tr><tr><td>5</td><td>6</td></tr><tr><td>-7</td><td>-9</td></tr><tr><td>-4</td><td>-3</td></tr><tr><td>2</td><td>1</td></tr></table></td><td>5</td><td>CO5</td><td>L3</td></tr>
<tr><td>9</td><td></td><td>Solve the following game by applying a) graphical method b)dominance rule
d)
<table><tr><td></td><td>B1</td><td>B2</td><td>B3</td></tr><tr><td>A1</td><td>3</td><td>-3</td><td>4</td></tr><tr><td>A2</td><td>-1</td><td>1</td><td>-3</td></tr></table>
b)
<table><tr><td>3</td><td>-2</td><td>4</td></tr><tr><td>-1</td><td>4</td><td>2</td></tr><tr><td>2</td><td>2</td><td>6</td></tr></table></td><td>5</td><td>CO5</td><td>L3</td></tr>
<tr><td>10</td><td></td><td></td><td>5</td><td>CO5</td><td>L3</td></tr>
<tr><td>11</td><td></td><td>Solve the following game by applying dominance rule
<table><tr><td>2</td><td>4</td><td>3</td><td>8</td><td>4</td></tr><tr><td>5</td><td>6</td><td>3</td><td>7</td><td>8</td></tr><tr><td>6</td><td>7</td><td>9</td><td>8</td><td>7</td></tr><tr><td>4</td><td>2</td><td>8</td><td>4</td><td>3</td></tr></table></td><td>5</td><td>CO5</td><td>L3</td></tr>
<tr><td>12</td><td></td><td>Solve the following game by applying dominance rule</td><td>5</td><td>CO5</td><td>L3</td></tr>
</table>

<table>
<tr><td></td><td></td><td><table><tr><td>1</td><td>7</td><td>2</td></tr><tr><td>6</td><td>2</td><td>7</td></tr><tr><td>5</td><td>2</td><td>6</td></tr></table></td><td></td><td></td><td></td></tr>
<tr><td>13</td><td></td><td>Solve the following game by applying graphical rule<table><tr><td>2</td><td>2</td><td>3</td><td>-1</td></tr><tr><td>4</td><td>3</td><td>2</td><td>6</td></tr></table></td><td>5</td><td>CO5</td><td>L3</td></tr>
<tr><td>14</td><td></td><td>OR</td><td>5</td><td>CO5</td><td>L3</td></tr>
<tr><td>15</td><td></td><td>Solve the following game by applying graphical rule<table><tr><td>2</td><td>-1</td><td>5</td><td>-2</td><td>6</td></tr><tr><td>-2</td><td>4</td><td>-3</td><td>1</td><td>0</td></tr></table></td><td>5</td><td>CO5</td><td>L3</td></tr>
<tr><td>16</td><td></td><td>Solve the following game by applying graphical rule<table><tr><td>1</td><td>2</td></tr><tr><td>5</td><td>6</td></tr><tr><td>-7</td><td>-9</td></tr><tr><td>-4</td><td>-3</td></tr><tr><td>2</td><td>1</td></tr></table></td><td>5</td><td>CO5</td><td>L3</td></tr>
</table>

F. EXAM PREPARATION

1. University Model Question Paper

Course:	Operations Research.					Month / Year	May /2019
Crs Code:	15ME71	Sem:	VII	Marks:	80	Time:	180 minutes

Module	Note	Answer all FIVE full questions. All questions carry equal marks.	Marks	CO	Level
1	a	Discuss the scope of Operations Research.	6	CO1	L2
	b	What is operation research? Explain origin and the six phases of operation research.	5	CO2	L2
2	a	A computer company manufactures laptops & desktops that fetches profit of Rs. 700/- & 500/- unit respectively. Each unit of laptop takes 4 hours of assembly time & 2 hours of testing time while each unit of desktop requires 3 hours of assembly time & 1 hour for testing. In a given month the total number of hours available for assembly is 210 hours & for inspection is 90 hours. Formulate the problem as LPP in such a way that the total profit is maximum.	5	CO1	L2
	b	A toy company manufactures two types of dolls, a basic version-doll A and a deluxe version- doll B. Each doll of type B takes twice as long to produce as one of type A and the company would have time to make maximum of 2000 dolls per day. The supply of plastic is sufficient to produce 1500 dolls per day(Both A & B combined). The deluxe version requires a fancy dress of which there are only 600 per day available. If the company makes a profit of Rs. 10/- & Rs. 18/- per doll on doll A & B respectively, then how many of each doll should be produced per day in order to maximize the total profit. Formulate the problem as LPP.	6	CO2	L3
3	a	A marketing manager wishes to allocate his annual advertising budget of Rs. 20,000 in two media group M & N. The unit cost of the message in the media 'M' is Rs. 200 & 'N' is Rs. 300. The media M is monthly magazine & not more than two insertions are desired in one issue. At least five messages should appear in the media N. The expected effective audience per unit message for media M is 4,000 & for N is 5,000. Formulate the problem as Linear Programming problem.	5	C03	L3
	b	A manufacturer produces two types of models M1 & M2. Each M1 model	5	CO3	L3

		requires 4 hours of grinding & 2 hours of polishing, whereas each M2 model requires 2 hours of grinding & 5 hours of polishing. The manufacturer has 2 grinders & 3 polishers. Each grinder works for 40 hours a week & each polisher works for 60 hours a week. Profit of M1 model is Rs. 3/- & on M2 model is Rs. 4/-. How should the manufacturer allocate his production capacity to the two types of models so as to make maximum profit in a week. Formulate the above problem as LPP.			
4	a	An agriculturist has a farm with 126 acres. He produces Tomato, Mango and Potato. Whatever he raises is fully sold in the market. He gets Rs. 5/- for tomato/kg, Rs. 4/- for mango/kg and Rs. 5/- for potato/kg. The average yield is 1,500 kg of tomato/acre, 1800 kg of mango/acre and 1200 kg of potato/acre. To produce each 100 kg of tomato and mango and to produce each 80 kg of potato a sum of Rs. 12.50 has to be used for manure. Labour required for each acre to raise the crop is 6 man-days for tomato and potato each and 5 man-days for mango. A total of 500 man-days of labour at a rate of Rs. 40/- per man day are available. Formulate this as a LP model to maximize the agriculturist's total profit.	5	CO3	L3
	b	A company manufactures two products A & B. Theses products are processed in the same machine. It takes 10 minutes to process one unit of product A and 2 minutes for each unit of product B and the machine operates for a maximum of 35 hours in a week. Product A requires 1 kg and B 0.5 kg of raw material per unit the supply of which is 600 kg per week. Market constraint on product B is known to be 800 unit every week. Product A costs Rs. 5/- per unit and sold at Rs. 10/-. Product B costs Rs. 6/- per unit and can be sold in the market at a unit price of Rs. 8/-. Determine the number of units of A & B per week to maximize the profit	6	CO4	L3
5	a	A paper mill produces two grades of paper namely X and Y. Because of raw material restrictions, it cannot produce more than 400 tons of grade X and 300 tons of grade Y in a week. There are 160 production hours in a week. It requires 0.2 and 0.4 hours to produce a ton of products X and Y respectively with corresponding profits of Rs. 200/- and Rs. 500/- per ton. Formulate the above as a LPP to maximize profit and find the optimum product mix.	5	CO5	L3
	b	Farmer furniture makes chairs, arm-chairs and sofas, the profits are $ 50 per chair, $60 per arm-chair and $ 80 per sofa. The material used to manufacture these items are fabric and wood. A supplier can provide a maximum of 300 meters of fabric and 350 units of wood each week. Each item requires a certain amount of wood and fabric as well as certain assembly time. These are given in the following tabl Item / Fabric / Wood / Ass. Time Chair / 2m / 6 units / 8 hours Armchair / 5m / 4 units / 4 hours Sofa / 8m / 5 units / 5 hours Avail./Wk / 300m / 350 units / 480 hours	5		L3
		OR			
6	a	A person requires 10,12 and 12 units chemicals A,B,C respectively for his garden. One unit of liquid product contains 5,2 and 1 units of A,B and C respectively. One unit of dry product contains 1,2 and 4 units of A,B,C. If the liquid product sells for Rs. 3/- and the dry product sells for Rs. 2/-, how many of each should be purchased, in order to minimize the cost and meet the requirements.	5	CO5	L3
	b	A company produces two types of Hats. Each hat of the first type requires twice as much labour time as the second type. The company can produce a total of 500 hats a day. The market limits daily sales of the first	5	CO5	L3

<table>
<tr><td></td><td></td><td>& second type to 150 & 250 hats. Assuming that the profits/hat are Rs. 8/- for type A & Rs. 5 for type B. Formulate the problem as LP model in order to determine
the number of hats to be produced of each type so as to maximize the profit.</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>7</td><td>a</td><td>The standard weight of a special purpose brick is 5Kg and it contains two ingredients B1 & B2. B1 cost Rs. 5/- per kg & B2 costs Rs. 8/- per kg. Strength considerations dictate that the brick contains not more than 4 kg of B1 & a minimum of 2 kg of B2, since the demand for the product is likely to be related to the price of the brick. Formulate the above problem as LP model.</td><td>6</td><td>CO5</td><td>L3</td></tr>
<tr><td></td><td>b</td><td>Old hens can be bought at Rs. 50/- each but young ones cost Rs. 100/- each. The old hens lay 3 eggs/week and young hens 5 eggs/week. Each egg costs Rs. 2/-. A hen costs Rs. 5/- per week to fee. If a person has only Rs. 2000/- to spend for hens, formulate the problem to decide how many of each kind of hen should he buy ? Assume that he cannot house more than 40 hens.</td><td>5</td><td>CO5</td><td>L3</td></tr>
<tr><td></td><td></td><td>OR</td><td></td><td></td><td></td></tr>
<tr><td>8</td><td>a</td><td>A retail store stocks two types of shirts A and B. These are packed in attractive cardboard boxes. During a week the store can sell a maximum of 400 shirts of type A and a maximum of 300 shirts of type B. The storage capacity, however, is limited to a maximum of 600 of both types combined. Type A shirt fetches a profit of Rs. 2/- per unit and type B a profit of Rs. 5/- per unit. How many of each type the store should stock per week to maximize the total profit? Formulate a mathematical model of the problem.</td><td>6</td><td>CO4</td><td>L3</td></tr>
<tr><td></td><td>b</td><td>A company manufactures two products A & B. Theses products are processed in the same machine. It takes 10 minutes to process one unit of product A and 2 minutes for each unit of product B and the machine operates for a maximum of 35 hours in a week. Product A requires 1 kg and B 0.5 kg of raw material per unit the supply of which is 600 kg per week. Market constraint on product B is known to be 800 unit every week. Product A costs Rs. 5/- per unit and sold at Rs. 10/-. Product B costs Rs. 6/- per unit and can be sold in the market at a unit price of Rs. 8/-. Determine the number of units of A & B per week to maximize the profit</td><td>5</td><td>CO5</td><td>L3</td></tr>
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e)<table><tr><td></td><td>B1</td><td>B2</td><td>B3</td></tr><tr><td>A1</td><td>3</td><td>-3</td><td>4</td></tr><tr><td>A2</td><td>-1</td><td>1</td><td>-3</td></tr></table>b)<table><tr><td>3</td><td>-2</td><td>4</td></tr><tr><td>-1</td><td>4</td><td>2</td></tr><tr><td>2</td><td>2</td><td>6</td></tr></table></td><td>6</td><td>CO5</td><td>L2</td></tr>
<tr><td></td><td>b</td><td>Solve the following game by applying graphical rule</td><td>5</td><td>CO5</td><td>L2</td></tr>
</table>

2. SEE Important Questions

G. Content to Course Outcomes

1. TLPA Parameters

Table 1: TLPA – Example Course

Module-#	Course Content or Syllabus (Split module content into 2 parts which have similar concepts)	Content Teaching Hours	Blooms' Learning Levels for Content	Final Blooms' Level	Identified Action Verbs for Learning	Instruction Methods for Learning	Assessment Methods to Measure Learning
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
1	Introduction: Evolution of OR, Definitions of OR, Scope of OR, Applications of OR, Phases in OR study. Characteristics and limitations of OR, models used in OR, Linear Programming Problem (LPP), Generalized LPP- Formulation of problems as L.P.P. SolutionstoLPP by graphical method(Two Variables).	5	L1,L2	L2	Understand	Chalk and board	Assignment
2	LPP: Simplex method, Canonical and Standard form of LP problem, slack, surplus and artificial variables, Solutions to LPP by Simplex method, Big-M Method and Two Phase Simplex Method, Degeneracy in LPP. Concept of Duality, writing Dual of	4	L1,L2,L3	L3	Apply	Chalk and board	Assignment

	given LPP. Solutions to L.P.P by Dual Simplex Method.						
3	**Transportation Problem**: Formulation of transportation problem, types, initial basic feasible solution using North-West Corner rule, Vogel's Approximation method. Optimality in Transportation problem by Modified Distribution(MODI) method. Unbalanced T.P. Maximization T.P. Degeneracy in transportation problems, application of transportation problem. **Assignment Problem**-Formulation, Solutions to assignment problems by Hungarian method, Special cases in assignment problems, unbalanced, Maximization assignment problems. **Travelling Salesman Problem** (TSP). Difference between assignment and T.S.P, Finding best route by Little's method. Numerical Problems.	3	L1,L2,L3	L3	Apply	Chalk and board	Assignment and Slip Test
4	**Network analysis:** Introduction, Construction of networks, Fulkerson's rule for numbering the nodes, AON and AOA diagrams; Critical path method to find the expected completion time of a project, determination of floats in networks, PERT networks, determining the probability of completing a project, predicting the completion time of project; Cost analysis in networks. Crashingofnetworks- Problems. Queuing Theory: Queuing systems and their characteristics, Pure-birth and Pure-death models (only equations), Kendall & Lee's notation of Queuing, empirical queuing models – Numerical on M/M/1 and M/M/C Queuing models.	4	L1,L2,L3	L3	Apply	Chalk and board	Assignment
5	**Game Theory:** Definition, Pure Strategy problems, Saddle point, Max-Min and Min-Max criteria, Principle of Dominance, Solution of games with Saddle point. Mixed Strategy problems. Solution of 2X2 games by Arithmetic method, Solution of 2Xn m and mX2 games by graphical method. Formulationof games. **Sequencing**: Basic assumptions, Johnson's algorithm, sequencing 'n' jobs on single machine using priority rules, sequencing using Johnson's rule-'n' jobs on 2 machines, 'n' jobs on 3 machines, 'n' jobs on 'm' machines. Sequencing of2 jobs on 'm' machines using graphical methodS.	4	L1,L2,L3	L3	Apply	Chalk and board	Assignment and slip test

2. Concepts and Outcomes:

Table 2: Concept to Outcome – Example Course

Module-#	Learning or Outcome from study of the Content or Syllabus	Identified Concepts from Content	Final Concept	Concept Justification (What all Learning Happened from the study of Content / Syllabus. A short word for learning or outcome)	CO Components (1.Action Verb, 2.Knowledge, 3.Condition / Methodology, 4.Benchmark)	Course Outcome **Student Should be able to ...**
A	*I*	*J*	*K*	*L*	*M*	*N*
1	**Introduction:** Evolution of OR, Definitions of OR, Scope of OR, Applications of OR, Phases in OR study. Characteristics and limitations of OR, models	-Operation Research -LPP	Operation Research LPP	Understand the meaning of operation research Formulation of LPP and Obtain optimal Solution using graphical method	- Understand - Operation Research - Formulate - Graphical Methods	Understand the meaning, definitions, scope, need, phases and techniques of operations research. Formulate as L.P.P and derive optimal solutions to linear programming problems by graphical method.
2	used in OR Linear Programming Problem (LPP), Generalized LPP- Formulation of problems as L.P.P. Solutions to LPP by graphical method(Two Variables). **LPP:** Simplex method, Canonical and Standard form of LP problem, slack, surplus and artificial variables, Solutions to LPP by Simplex method, Big-M Method and Two Phase Simplex Method Degeneracy in LPP.	- Simplex & Big M Method -Dual Simplex Method -	**Simplex & Big M Method** Dual Simplex Method	Using Simplex and Big M method Obtain optimal solution to LPP Using Dual Simplex method Obtain optimal solution to LPP	- Solve - Simplex method -Big M method -Solve - Dual Simplex Method	Solve for optimal solutions to linear programming problems by Simplex method & Big-M method Solve for optimal solutions to linear programming problems by Dual Simplex method.

	Concept of Duality, writing Dual of given LPP. Solutions to L.P.P by Dual Simplex Method.					
3	Transportation Problem: Formulation of transportation problem, types, initial basic feasible solution using North-West Corner rule, Vogel's Approximation method. Optimality in Transportation problem by Modified Distribution(MODI) method. Unbalanced T.P. Maximization T.P. Degeneracy in transportation problems, application of transportation problem. Assignment Problem-Formulation, Solutions to assignment problems by Hungarian method, Special cases in assignment problems, unbalanced, Maximization assignment problems. Travelling Salesman Problem (TSP). Difference between assignment	-Methods in Transportation - - -Hungarian Method	Transportation -Assignment -traveling salesman problem	Have the ability to obtain optimum solution to transportation problem Have the ability to obtain optimum solution to Assignment and Traveling salesman problems	-Formulate -Transportation -Formulate -Assignment and traveling sales man	Formulate as Transportation problem and derive optimum solutions for transportation problem Formulate as Assignment problems and derive optimum solutions for Assignment and traveling salesman problems.

	and T.S.P, Finding best route by Little's method. Numerical Problems.					
4	Network analysis: Introduction, Construction of networks, Fulkerson's rule for numbering the nodes, AON and AOA diagrams; Critical path method to find the expected completion time of a project, determination of floats in networks, PERT networks, determining the probability of completing a project, predicting the completion time of project; Cost analysis in networks. Crashing of networks-Problems. Queuing Theory: Queuing systems and their characteristics, Pure-birth and Pure-death models (only equations), Kendall & Lee's notation of Queuing, empirical	- -Network diagram - -queuing model	Network diagram Queuing model	Have ability to draw the network diagram and determine the critical path. Have ability solve problem on queuing models.	-Construct - PERT -Solve -Queuing model	**Construct network diagrams and determine critical path, floats for deterministic and PERT networks including** crashing of Networks **Solve waiting line problems for M/M/1 and M/M/K queuing models.**

	queuing models – Numerical on M/M/1 and M/M/C Queuing models.					
5	Game Theory: Definition, Pure Strategy problems, Saddle point, Max-Min and Min-Max criteria, Principle of Dominance, Solution of games with Saddle point. Mixed Strategy problems. Solution of 2X2 games by Arithmetic method, Solution of 2Xn m and mX2 games by graphical method. Formulation of games. Sequencing: Basic assumptions, Johnson's algorithm, sequencing 'n' jobs on single machine using priority rules, sequencing using Johnson's rule-'n' jobs on 2 machines, 'n' jobs on 3 machines, 'n' jobs on 'm' machines. Sequencing of 2 jobs on 'm' machines using graphical	- -Pure and mixed strategy Johnson's algorithm	Pure and mixed strategy Johnson's algorithm	Have ability to solve pure and mixed strategy problems Have ability to solve problems on sequencing for minimum processing time	-Solve - Pure and Mixed strategy -Determine -Johnson's algorithm	**Solve problems on game theory for pure and mixed strategy under competitive environment.** Determine minimum processing times for sequencing of n jobs-2 machines, n jobs-3 machines, n jobs-m machines and 2 jobs-n machines using Johnson's algorithm.

	method.					