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Note : Remove “Table of Content” before including in CP Book
Each Course Plan shall be printed and made into a book with cover page
Blooms Level in all sections match with A.2, only if you plan to teach / learn at higher levels

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17CS653 : Operations Research

A. COURSE INFORMATION

1. Course Overview

Degree:	B.E	Program:	CS
Semester :	VI	Academic Year:	2019-20
Course Title:	OPERATIONS RESEARCH	Course Code:	17CS653
Credit / L-T-P:	3/3-0-0	SEE Duration:	3 Hours
Total Contact Hours:	40	SEE Marks:	60 Marks
CIA Marks:	40	Assignment	5
Course Plan Author:	Dr.Hemalatha K.L.	Sign:	Dt:
Checked By:		Sign:	Dt:

2. Course Content

Module	Module Content	Teaching Hours	Module Concepts	Blooms Level
1	Introduction, Linear Programming: Introduction: The origin, nature and impact of OR; Defining the problem and gathering data; Formulating a mathematical model; Deriving solutions from the model; Testing the model; Preparing to apply the model; Implementation . Introduction to Linear Programming Problem (LPP):Prototype example, Assumptions of LPP, Formulation of LPP and Graphical method various examples.	8	Formulate LPP.	L4
2	Simplex Method –1:The essence of the simplex method; Setting up the simplex method; Types of variables, Algebra of the simplex method; the simplex method in tabular form; Tie breaking in the simplex method, Big M method, Two phase method.	8	Solution of Linear Model (simplex method & graphical method)	L4
3	Simplex Method –2: Duality Theory -The essence of duality theory, Primal dual relationship, conversion of primal to dual problem and vice versa. The dual simplex method.	8	optimization techniques	L3
4	Transportation and Assignment Problems: The transportation problem, Initial Basic Feasible Solution (IBFS) by North West CornerRule method, MatrixMinima Method, Vogel's Approximation Method. Optimal solution by Modified Distribution Method (MODI). The Assignment problem; A Hungarian algorithm for the assignment problem. Minimization and Maximization varieties in transportation and assignment problems.	8	Transportation , Assignment problems	L4
5	Game Theory: Game Theory: The formulation of two persons, zero sum games;saddle point, maximin and minimax principle, Solving simple games- a prototype example; Games with mixed strategies; Graphical solution procedure. Metaheuristics: The nature of Metaheuristics, Tabu Search, Simulated Annealing, Genetic Algorithms.	8	Game Theory,Decision analysis.	L4

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3. Course Material

Module	Details	Available
1	D.S. Hira and P.K. Gupta, Operations Research, (Revised Edition), Published by S. Chand & Company Ltd, 2014	In Lib
2	Reference books	
	1. S Kalavathy, Operation Research, Vikas Publishing H ouse Pvt Limited, 01-Aug-2002	In Lib
	2. S D Sharma, Operation Research, Kedar Nath Ram Nath Publishers.	In Lib
3	Others (Web, Video, Simulation, Notes etc.)	
	1.http://vtuplanet.com/m/download.php?type=papers&dir=B.E+ %28Engineering%29%2FInformation+Science+%28ISE %29%2FSem+6%2FOperations+Research%28Elective %29&file=Operations+Research+NOTES+by+Divya+-+RNSIT+ %28www.vtuplanet.com%29.pdf	Not Available
	2.tu.allsyllabus.com/cse/sem_5/index.phpv	

4. Course Prerequisites

SNo	Course Code	Course Name	Module / Topic / Description	Sem	Remarks	Blooms Level
1	15MAT11 ,21	Mathematics-I	Students should have knowledge of equation solving, matrices, algorithms and geometry	1		L3
	-					

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

B. OBE PARAMETERS

1. Course Outcomes

#	Cos	Teach. Hours	Concept	Instr Method	Assessment Method	Blooms' Level
15CS653.1	Formulate the LPP for the given data	8	Formulate LPP.	Discussion	Assignment	L4 Analyze
15CS653.2	Apply the Graphical and Simplex method to solve the LPP, game.	8	Solution for Linear Model (simplex method & graphical method)	Problem solving	Slip test	L4 Analyze
15CS653.3	Select and apply optimization techniques for various problems.	8	optimization techniques	Lecture	Seminar	L4 Analyze
15CS653.4	Demonstrate skills in forming and solving assignment problems,Transportation problems	8	Transportation , Assignment	Problem solving	Assignment	L4 Analyze

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			problems			
15CS653.5	Apply game theory, decision analysis for decision support system to construct decision tree	8	Game Theory,Decision analysis.	Problem solving	Slip test	L4 Analyze
-	**Total**	**40**	-	-	-	-

Note: Identify a max of 2 Concepts per Module. Write 1 CO per concept.

2. Course Applications

SNo	Application Area	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	L4
2	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.		
	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.	CO3	L4
4	Efficient Manufacturing Manufacturing requires transforming raw materials into products that maximize company revenue.	CO4	L4
5	Linear programming is used to obtain **optimal** solutions for operations research. Using linear programming allows researchers to find the best, most economical solution to a problem within all of its limitations, or constraints.	CO5	L4
6	Widely used in business and economics, and is also utilized for some engineering problems Industries that use linear programming models include transportation, energy, telecommunications, and manufacturing		L4

Note: Write 1 or 2 applications per CO.

3. Articulation Matrix

(CO – PO MAPPING)

-	Course Outcomes	Program Outcomes												
#	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Level
CO1	Formulate the LPP for the given data	2	2	3	2	-	2	2	-	1			2	L4
CO2	Apply the Graphical and Simplex method to solve the LPP, game.	2	2	3	2		1	2		2			2	L4

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CO3	Select and apply optimization techniques for various problems.	1	2	2	3		2	2		2			3	L4
CO4	Demonstrate skills in forming and solving assignment problems,Transportation problems	2	3	3	1		1	2		2			2	L4
CO5	Apply game theory, decision analysis for decision support system to construct decision tree	1	2	2	2		1	2		2			2	L4
CSPC.	Average													
Note: Mention the mapping strength as 1, 2, or 3														

4. Mapping Justification

Mapping		Justification	Mapping Level
CO	**PO**	**-**	**-**
CO1	PO1	The knowledge of mathematical principles will help the students to apply the same to formulate solutions for engineering problems.	L4
CO1	PO2	Fundamental knowledge in complex analysis will help to analyze the engineering problems easily.	L4
CO1	PO3		L4
CO1	PO4		L4
CO1	PO5	No content tool, no mapping	
CO1	PO6		L4
CO1	PO7		L4
CO1	PO8	No matching for ethical principles	
CO1	PO9	Student will develop individual knowledge to work in a team or individually .	
CO1	PO10	No mapping.	
CO1	PO11	No mapping.	
CO1	PO12		L4
CO2	PO1	The knowledge of simplex and graphical method is required to find the solution of complex engineering problems	L4
CO2	PO2		L4
CO2	PO3		L4
CO2	PO4		L4
CO2	PO5	No content tool, no mapping	
CO2	PO6	Complex analysis may address various society related problems.	L4
CO2	PO7		L3
CO2	PO8	No matching for ethical principles	
CO2	PO9		
CO2	PO10	No mapping.	
CO2	PO11	No mapping.	
CO2	PO12	Study of graphical & simplex method is required if students want to start-up their companies.	L4
CO3	PO1		L4
CO3	PO2	Students can formulate the complex problem as linear programming model and obtain solution to optimize the result.	L4
CO3	PO3	Design solutions for complex engineering problems like transportation & assignment ,	L3
CO3	PO4	Students can formulate the complex problem as linear programming model ,can apply all methods obtain solution to give some conclusion.	L4
CO3	PO4	No content tool, no mapping	
CO3	PO6	By understanding mathematical principles and LPP students can apply contextual knowledge to assess solution to complex	L4

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		engineering problems	
CO3	PO7	Thorough understanding optimizing techniques they can know the environmental contexts.	L3
CO3	PO8	No matching.	
CO3	PO9	Student will develop individual knowledge to work in a team or individually as a decision analyst.	
CO3	PO10	No mapping.	
CO3	PO11	No mapping.	
CO3	PO12	Study of optimizing techniques is required.	L3
CO4	PO1	Fundamental knowledge in complex analysis will help to analyze the engineering problems very easily.	L4
CO4	PO2	Students can formulate the complex problem as mathematical model and analyze the problem .	L4
CO4	PO3	Design solutions for complex engineering problems using transportation & assignment.	L4
CO4	PO4	Thorough understanding transportation & assignment method they can conduct investigation of complex problems can be solved on .	L4
CO4	PO4	No content tool, no mapping	
CO4	PO6	Complex analysis may address various society related problems.	L4
CO4	PO7	Thorough understanding transportation & assignment they can know the environmental contexts. Problems related to assignment arise in a range of fields.	
CO4	PO8	No matching for ethical principles	
CO4	PO9	Student will develop individual knowledge to work in a team or individually.	
CO4	PO10	No mapping.	
CO4	PO11	No mapping.	
CO4	PO12	Study of transportation & assignment is required if students want to work in manufacturing ,business based companies.	L3
CO5	PO1	The knowledge of game theory and decision analysis is required to find the solution of complex engineering problems .	L4
CO5	PO2	Students can formulate the complex problem as game theory model and obtain solution .	L4
CO5	PO3	Design solutions for complex engineering problems using game theory,solution often used in political, economic, and military planning.	L4
CO5	PO4	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.	L4
CO5	PO5	No content tool, no mapping	
CO5	PO6	It has hardly been used to tackle safety management in multi-plant chemical industrial settings.	L3
CO5	PO7	Thorough understanding game theory they can know the environmental contexts. Problems related to game theory arise in a range of fields,	L4
CO5	PO8	No matching for ethical principles	
CO5	PO9	Student will develop individual knowledge to work in a team or individually .	
CO5	PO10	No mapping.	
CO5	PO11	No mapping.	
CO5	PO12	Study of game theory is required if students want to progress in analytics field.	L3

Note: Write justification for each CO-PO mapping.

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5. Curricular Gap and Content

SNo	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1					
2					
3					
4					
5					

Note: Write Gap topics from A.4 and add others also.

6. Content Beyond Syllabus

SNo	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Note: Anything not covered above is included here.

C. COURSE ASSESSMENT

1. Course Coverage

Module #	Title	Teaching Hours	No. of question in Exam						CO	Levels
			CIA-1	CIA-2	CIA-3	Asg	Extra Asg	SEE		
1	Introduction, Linear Programming: Introduction: The origin, nature and impact of OR; Defining the problem and gathering data; Formulating a mathematical model; Deriving solutions from the model; Testing the model; Preparing to apply the model; Implementation . Introduction to Linear Programming Problem (LPP):Prototype example, Assumptions of LPP, Formulation of LPP and Graphical method various examples.	8	2	-	-	1	1	2	CO1, CO2	L2,L4
2	Simplex Method –1:The essence of the simplex method; Setting up the simplex method; Types of variables, Algebra of the simplex	8	-	2	-	1	1	2	C02	L4

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	method; the simplex method in tabular form; Tie breaking in the simplex method, Big M method, Two phase method.									
3	Simplex Method –2: Duality Theory -The essence of duality theory, Primal dual relationship, conversion of primal to dual problem and vice versa. The dual simplex method.	8	-	-	2	1	1	2	CO3	L4
4	Transportation and Assignment Problems: The transportation problem, Initial Basic Feasible Solution (IBFS) by North West CornerRule method, MatrixMinima Method, Vogel's Approximation Method. Optimal solution by Modified Distribution Method (MODI). The Assignment problem; A Hungarian algorithm for the assignment problem. Minimization and Maximization varieties in transportation and assignment problems.	8	2	-	-	1	1	2	CO4	L4
5	Game Theory: Game Theory: The formulation of two persons, zero sum games;saddle point, maximin and minimax principle, Solving simple games- a prototype example; Games with mixed strategies; Graphical solution procedure. Metaheuristics: The nature of Metaheuristics, Tabu Search, Simulated Annealing, Genetic Algorithms.	8	-	2	2	1	1	2	CO5	L4
-	**Total**	**40**	**4**	**4**	**4**	**5**	**5**	**10**	**-**	**-**

Note: Distinct assignment for each student. 1 Assignment per chapter per student. 1 seminar per test per student.

2. Continuous Internal Assessment (CIA)

Evaluation	Weightage in Marks	CO	Levels
CIA Exam – 1	15	CO1,CO4	L2,L4,L3,L4
CIA Exam – 2	15	CO2, CO5	L4,L4,L3,L4
CIA Exam – 3	15	CO3, CO5	L3,L2,L3
Assignment - 1	05	CO1,CO4	L2,L4,L3,L4
Assignment - 2	05	CO2, CO5	L4,L4,L3,L4
Assignment - 3	05	CO3, CO5	L3,L2,L3
Seminar - 1			
Seminar - 2			
Seminar - 3			
Other Activities – define –		CO1 to Co5	L2, L3, L4 . ..

IS

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Slip test			
Final CIA Marks	**20**	**-**	**-**

Note : Blooms Level in last column shall match with A.2 above.

D1. TEACHING PLAN - 1

Module - 1

Title:	ntroduction to the concept of automata theory Finite state machine.	Appr Time:	16 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Formulate the LPP for the given data	CO1	L4
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
1	ntroduction, Linear Programming: Introduction: The origin, nature and impact of OR; Defining the problem and gathering data; Formulating a mathematical model; Deriving solutions from the model; Testing the model; Preparing to apply the model; Implementation .	C01	L2
2	Introduction to Linear Programming Problem (LPP):Prototype example	CO1	L3
3	Introduction to Linear Programming Problem (LPP):Prototype example	CO1	L3
4	Assumptions of LPP, Formulation of LPP.	CO1	L4
5	Assumptions of LPP, Formulation of LPP.	CO1	L4
6	Formulation of LPP.	CO1	L4
7	Formulation of LPP.	CO1	L4
8	Graphical method various examples.	CO1	L4
9	Graphical method various examples.		
10	Graphical method various examples.		
c	**Application Areas**	**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	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.	CO1	L4
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	L2
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	CO1	L2

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	of each kind of hen should he buy ? Assume that he cannot house more than 40 hens.		
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	L4
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	L4
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.	CO1	L4
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.	CO1	L2
e	**Experiences**	-	-
1		CO1	L2
2			
3			
4		CO1	L3
5			

Module – 4

Title:	Transportation and Assignment Problems	Appr Time:	10 Hrs
a	***Course Outcomes***	-	**Blooms**
-		-	**Level**
1	Demonstrate skills in forming and solving assignment problems,Transportation problems	CO4	L4
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
11	The transportation problem	CO4	L2
12	Initial Basic Feasible Solution (IBFS) by North West CornerRule method, MatrixMinima Method, Vogel's Approximation Method.	CO4	L2
13	Initial Basic Feasible Solution (IBFS) by North West CornerRule method, MatrixMinima Method, Vogel's Approximation Method.	CO4	L3

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14	Initial Basic Feasible Solution (IBFS) by North West CornerRule method, MatrixMinima Method, Vogel's Approximation Method.	CO4	L3
15	Optimal solution by Modified Distribution Method (MODI)	CO4	L4
16	The Assignment problem; A Hungarian algorithm for the assignment problem	CO4	L2
17	The Assignment problem; A Hungarian algorithm for the assignment problem	CO4	L4
18	Minimization and Maximization varieties in transportation and assignment problems.	CO4	L3
19	Minimization and Maximization varieties in transportation and assignment problems.	CO4	L4
20	Minimization and Maximization varieties in transportation and assignment problems.	CO4	L4
c	**Application Areas**	**CO**	**Level**
1	Demonstrate skills in forming and solving assignment problems, Transportation problems.	CO4	L3
d	**Review Questions**	-	-
1	Find initial Basic Feasible solution for the following T.P. Using all methods .	CO4	L3

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

2	Define degeneracy in T.P .Find optimal solution for the following T.P & formulate as a mathematical method.	CO4	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	

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.	CO4	L4

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

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.	CO4	L4

	S1	S2	S3	S4
F1	2	4	6	11
F2	10	8	7	5

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	F3 13 3 9 12 F4 4 6 8 3		
5	Explain various steps involved in Hungarian algorithm with example.	CO4	L4
e	**Experiences**	-	-
1		CO1	L2
2			
3			
4		CO	L3
5			

E1. CIA EXAM – 1

a. Model Question Paper - 1

Crs Code:	15CS653	Sem:	VI	Marks:	30	Time:	75 minutes

Course: Operations Research

-	-	**Note: Answer any 3 questions, each carry equal marks.**	**Marks**	**CO**	**Level**
1	a	What is operation research? Explain origin and the six phases of operation research.	5	CO1	L1,L4
	b	A farmer has to plant two kinds of tree P and Q in a land 4000 sq.m.area.Each P terr requires at least 25 sq.m and Q tree requires at least 40 sq.m of land.the annual water requirement of P tree is 30 units nad of Q tree is 15 units per tree,while at most 3000 units of water is available.it is also estimated that the ratio of the number of Q trees to the number of P trees should not be less than 6/19 and should not be more than 17/8.The return per tree from P is expected to be one and half times as much as from Q tree. Use mathematical formulation to the LPP.	5	CO1	L4
	c	Use graphical method to solve the the above LPP problem.	5	CO1	L4
2	a	Use graphical method to solve Min $z=3x_1+2x_2$; $5x_1+x_2>=10$; $x_1+x_2>=6$; $x_1+4x_2>=12$; $x_1,x_2>=0$	5	CO1	L4
	b	A firm manufactures two types of products A & B and sells them at a profit of Rs.2 on type A and Rs.3 on type B. Each product is processed on two machines G and H.Type A requires one minute of processing time on G and two minutes on H.Type B requires one minute on G and one minute on H.The machine G is available for not more than6hours 40 minutes while H is available for 10 hours during any working day.How many types of type A and type B should be produced so that the total profit is maximized. Use mathematical formulation to the LPP.	5	CO1	L4
	c	Use graphical method to solve the the above LPP problem.	5	CO1	L4
3	a	Find initial Basic Feasible solution for the following T.P. Using all methods .	5	CO4	L4

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

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		d			
	b	Define degeneracy in T.P .Find optimal solution for the following T.P & formulate as a mathematical method.	10	CO4	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	

4	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.	5	CO4	L4

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

	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.	10	CO4	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

b. Assignment -1

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

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Model Assignment Questions							
Crs Code:	15CS653	Sem:	VI	Marks:	5	Time:	90 – 120 minutes
Course:	Operations Research						

Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.

SNo	USN	Assignment Description	Marks	CO	Level
1		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	CO1	L4
2		Use graphical method to solve Max z=3x1+4x2 ; 5x1+4x2<=200 ; 3x1+5x2<=150 ;5x1+4x2>=100 ; 8x1+4x2>=80 x1,x2>=0	5	CO1	L4
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 dealers.determine the optimum solution to maximize the toatl returns. (table below)	5	CO1	L4
4		Explain various steps involved in Hungarian algorithm with example.	5	CO4	L2
5		Find initial Basic Feasible solution for the following T.P. Using all methods . (table below)	5	CO4	L4

Table for assignment 3:

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

Table for assignment 5:

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

D2. TEACHING PLAN - 2

Module – 5

Title:	Game Theory	Appr Time:	10 Hrs
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	L4
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
21	The formulation of two persons, zero sum games;saddle point	CO5	L2

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22	Game Theory: Game Theory: The formulation of two persons, zero sum games;saddle point	CO5	L4
23	maximin and minimax principle, Solving simple games- a prototype example;	CO5	L4
24	maximin and minimax principle, Solving simple games- a prototype example;	CO5	L4
25	Games with mixed strategies; Graphical solution procedure.	CO5	L4
26	Games with mixed strategies; Graphical solution procedure.	CO5	L4
27	Graphical solution procedure.	CO5	L2
28	Graphical solution procedure.	CO5	L4
29	Metaheuristics: The nature of Metaheuristics, Tabu Search, Simulated Annealing, Genetic Algorithms.	CO5	L4
30	Metaheuristics: The nature of Metaheuristics, Tabu Search, Simulated Annealing, Genetic Algorithms.	CO5	L4
c	**Application Areas**	**CO**	**Level**
1	Problems related to game theory arise in a range of fields, for example, healthcare, transportation and military planning.	CO5	L4
d	**Review Questions**	-	-
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 principles h)dominance principle	CO5	L2
2	Solve the following game by applying a) graphical method b)dominance rule a) (see tables below) b) (see matrix below)	CO5	L4
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	L4
5	Explain briefly the following a) tabu search b)genetic algorithm c)simulated annealing technique.	CO5	L4
e	**Experiences**	-	-
1		CO1	L2
2			
3			

Question 2 a)

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

Question 2 b)

3	-2	4
-1	4	2
2	2	6

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4		CO3	L3
5			

Module – 2

Title:	Simplex Method	Appr Time:	10 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Apply the Graphical and Simplex method to solve the LPP, game.	CO2	L3
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
31	The essence of the simplex method the simplex method in tabular form;	CO2	L2
32	The essence of the simplex method the simplex method in tabular form;	CO2	L3
33	Setting up the simplex method.	CO2	L3
34	Setting up the simplex method.	CO2	L4
35	Types of variables, Algebra of the simplex method;	CO2	L2
36	Types of variables, Algebra of the simplex method;	CO2	L2
37	Tie breaking in the simplex method.	CO2	L4
38	Tie breaking in the simplex method.	CO2	L4
39	Big M method,	CO2	L4
40	Two phase method.	CO2	L4
c	**Application Areas**	**CO**	**Level**
1	For example Although many problems in architecture, engineering, construction and urban and regional development can be modelled with linear programming.	CO2	L3
d	**Review Questions**	-	-
1	Explain the steps involved in simplex method? Explain about special case in simplex method with example.	CO2	L3
2	Solve the following using simplex method. **Max p= 2x + y , x + 4y < = 24 , x - y <= - 3 , x + 2y <= 14 , 2x - y <= 8**	CO2	L3
3	solve the following using Two Phase method MAX Z = 5X1- 4X2 + 3X3 , 2X1 + X2 - 6X3 = 20 , 6X1 + 5X2 + 10X3 <= 76 , 8X1-3X2+6X3<=50	CO2	L2
4	Write the procedure to solve LPP of Two Phase method.	CO2	L4
5	Solve the following using simplex method **Max z = 5X+8Y , 4X+6Y < = 24 , 2X+Y< =18 , 3X+9Y < = 36**	CO2	L4
e	**Experiences**	-	-
1		CO1	L2
2			
3			
4		CO3	L3
5			

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E2. CIA EXAM – 2

a. Model Question Paper - 2

Crs Code:	15CS653	Sem:	VI	Marks:	30	Time:	75 minutes
Course:	Operations Research						

-	-	**Note: Answer any 2 questions, each carry equal marks.**	**Marks**	**CO**	**Level**
1	a	Explain various steps involved in Hungarian algorithm with example.	**5**	CO2	L4
	b	Find the assignment of jobs to machines that will result in the maximum profit.	**10**	CO2	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

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	5	CO2	L4
	b	Solve the following game by applying a) graphical method b)dominance rule a) b)	5	CO5	L4

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

3	a	Find the assignment of men to jobs that will minimize the total time taken.	5	CO5	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

	b	Explain briefly the following a) tabu search b)genetic algorithm c)simulated annealing technique.	5	CO5	L3
4	a	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.	5	CO5	L3
	b	Solve the following game a)apply suitable method b)dominance rule c) apply graphical method.	5	CO5	L4

b. Assignment – 2

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

Model Assignment Questions							
Crs Code:	15CS653	Sem:	VI	Marks:	5	Time:	75 minutes
Course:	Operations Research						

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Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.

SNo	USN	Assignment Description	Marks	CO	Level
1		Solve the following using BIG-M method Min z=2x1+9x2+x3 ,x1+4x2+2x3>=5 , 3x1+x2+2x3>=4.	5	CO5	L4
2		Solve the following using Two Phase method Max z=5x1+8x2 ,3x1+2x2>=3 , x1+4x2>=4 x1+x2<=5.	5	CO5	L4
3		Solve the following using Two Phase method Max z=2x1+x2+x3 ,4x1+6x2+3x3<=8 , 3x1-6x2-4x3<=1 , 2x1+3x2-5x3>=4.		CO5	L4
4		Solve the following game by applying graphical rule 2	2	3	-1 4	3	2	6	5	CO6	L4
5		Solve the following game by applying graphical rule 2	-1	5	-2	6 -2	4	-3	1	0	5	CO7	L3

D3. TEACHING PLAN - 3

Module – 3

Title:	Simplex Method –2	Appr Time:	10 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Select and apply optimization techniques for various problems.	CO3	L2
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
41	Duality Theory -The essence of duality theory,,,.	CO3	L3
42	Duality Theory -The essence of duality theory,,,.	CO3	L2
43	Primal dual relationship	CO3	L2
44	Primal dual relationship	CO3	L2
45	conversion of primal to dual problem and vice versa	CO3	L3
46	conversion of primal to dual problem and vice versa	CO3	L2
47	The dual simplex method.	CO3	L3
48	The dual simplex method with examples.	CO3	L4
49	The dual simplex method with examples.	CO3	L4
50	The dual simplex method with examples.	CO3	L4
c	**Application Areas**	**CO**	**Level**
1	Efficient Manufacturing Manufacturing requires transforming raw materials into products that maximize company revenue.	CO3	L4
2	Linear programming is used to obtain **optimal** solutions for operations research. Using linear programming allows researchers to find the best, most economical solution to a problem within all of its limitations, or constraints.	CO3	L4
d	**Review Questions**	-	-
1	Explain the following (i)the essence of duality theory (ii) primal dual	CO3	L2

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	rlationship		
2	Write the dual of MAX Z =2X1+3X2+X3 , 4X1+3X2+X3 = 6 , X1+2X2+5X3 = 4.	CO3	L2
3	Write the dual of MIN Z = 3X1-2X2+4X3 , 3X1+5X2+4X3 >= 7 , 6X1+X2+3X3 >= 4 , 7X1-2X2-X3 <= 10 X1-2X2+5X3 >= 3 , 4X1+7X2-2X3 >= 2	CO3	L3
e	**Experiences**	-	-
1		CO1	L2
2			
3			
4		CO3	L3
5			

E3. CIA EXAM – 3

a. Model Question Paper - 3

Crs Code:	15CS653	Sem:	VI	Marks:	30	Time:	75 minutes
Course:	Operations Research						

-	-	**Note: Answer any 2 questions, each carry equal marks.**	**Marks**	**CO**	**Level**
1	a	Explain the steps involved in simplex method? Explain about special case in simplex method with example.	5	Co3	L1
	b	Solve the following using simplex method Max z = 5X+8Y , 4X+6Y < = 24 , 2X+Y< =18 , 3X+9Y < = 36	10	Co3	L3
2	a	Define the following (i)feasible solution (ii) basic solution (iii)degenerate basic feasible solution (iv)non-degenerate basic feasible solution (v)unbounded solution.	5	Co3	L1
	b	Find all basic solutions to the problem & mention basic, non-basic variables & feasible solutions at each step Max Z=3X1+4X2 , X1+X2 < = 450 , 2X1+X2 < = 600	10	Co3	L3
3	a	solve the following using Big-M method MAX Z= 2X + Y , 3X+Y=3 , X+2Y<=3, 4X+3Y>=6	6	Co3	L3
	b	solve the following using 2-phase method MAX Z = 5X1-4X2+3X3 , 2X1+X2-6X3 = 20 , 6X1+5X2+10X3 <= 76 , 8X1-3X2+6X3 <= 50	9	Co3	L3
4	a	Explain the following (i)the essence of duality theory (ii) primal dual rlationship	6	Co3	L1
	b	Write the dual of (i)MIN Z = 3X1-2X2+4X3 , 3X1+5X2+4X3 >= 7 , 6X1+X2+3X3 >= 4 , 7X1-2X2-X3 <= 10 X1-2X2+5X3 >= 3 , 4X1+7X2-2X3 >= 2 (ii) MAX Z =2X1+3X2+X3 , 4X1+3X2+X3 = 6 , X1+2X2+5X3 = 4.	9	Co3	L3

b. Assignment – 3

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

Model Assignment Questions							
Crs Code:	15cs653	Sem:	VI	Marks:	5	Time:	75 minutes

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Course:	Operations Research				
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.					
SNo	**USN**	**Assignment Description**	**Marks**	**CO**	**Level**
1		solve the following using Big-M method MAX Z= 2X + Y , 3X+Y=3 , X+2Y<=3, 4X+3Y>=6	5	CO9	L2
2		solve the following using 2-phase method MAX Z = 5X1-4X2+3X3 , 2X1+X2-6X3 = 20 , 6X1+5X2+10X3 <= 76 , 8X1-3X2+6X3 <= 50	5	CO9	L2
3			5	CO9	L2
4		Explain the following (i)the essence of duality theory (ii) primal dual rlationship	5	CO10	L4
5		Write the dual of (i)MIN Z = 3X1-2X2+4X3 , 3X1+5X2+4X3 >= 7 , 6X1+X2+3X3 >= 4 , 7X1-2X2-X3 <= 10 X1-2X2+5X3 >= 3 , 4X1+7X2-2X3 >= 2 (ii) MAX Z =2X1+3X2+X3 , 4X1+3X2+X3 = 6 , X1+2X2+5X3 = 4.	5	CO10	L4

F. EXAM PREPARATION

1. University Model Question Paper

Course:	Operations Research					Month / Year	May /2019
Crs Code:	15CS653	Sem:	VI	Marks:	80	Time:	180 minutes

-	**Note**	Answer all FIVE full questions. All questions carry equal marks.	**Marks**	**CO**	**Level**
1	a	What is operation research? Explain origin and the six phases of operation research.	2	CO1	L2
	b	A farmer has to plant two kinds of tree P and Q in a land 4000 sq.m.area.Each P terr requires at least 25 sq.m and Q tree requires at least 40 sq.m of land.the annual water requirement of P tree is 30 units nad of Q tree is 15 units per tree,while at most 3000 units of water is available.it is also estimated that the ratio of the number of Q trees to the number of P trees should not be less than 6/19 and should not be more than 17/8.The return per tree from P is expected to be one and half times as much as from Q tree. Use mathematical formulation to the LPP.	6	CO1	L4
	c	Use graphical method to solve the the above LPP problem.	8	CO1	L4
-	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.	2	CO1	L4
	b	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.	6	CO1	L4
	c	Use graphical method to solve Min z=20x1+10x2 ; x1+2x2<=40; 3x1+x2>=30 ;4x1+3x2>=60 ; x1,x2>=0	8	CO1	L4
2	a	Explain the steps involved in simplex method? Explain about special case	4	Co2	L4

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		in simplex method with example.			
	b	Solve the following using simplex method. Max p= 2x + y , x + 4y < = 24 , x - y <= - 3 , x + 2y <= 14 , 2x - y <= 8	4	CO2	L4
	c	solve the following using Two Phase method MAX Z = 5X1- 4X2 + 3X3 , 2X1 + X2 - 6X3 = 20 , 6X1 + 5X2 + 10X3 <= 76 , 8X1-3X2+6X3<=50	8	CO2	L4
-	a	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.	4	CO2	L4
	b	Solve the following using BIG-M method Max z=2x+y ,3x+y=3 , x+2y<=3, 4x+3y>=6	8	CO2	L4
	c	Find all basic solutions to the following problems Max z=x1+3x2+3x3 , x1+2x2+3x3=4 ,2x1+3x2+5x3=7	4	CO2	L4
3	a	Explain the following (i)the essence of duality theory (ii) primal dual relationship	4	CO3	L4
	b	Write the dual of MAX Z =2X1+3X2+X3 , 4X1+3X2+X3 = 6 , X1+2X2+5X3 = 4.	8	CO3	L4
	c	Write the dual of MIN Z = 3X1-2X2+4X3 , 3X1+5X2+4X3 >= 7 , 6X1+X2+3X3 >= 4 , 7X1-2X2-X3 <= 10 X1-2X2+5X3 >= 3 , 4X1+7X2-2X3 >= 2	4	CO3	L4
-	a	Briefly discuss about sensitivity analysis	6	CO3	L4
	b	Find the maximum of Z= 6X1 + 8x2, Sub to 5x1 + 2x2 <=20, x1 + 2x2 <=10, x1 & x2 >=0 by solving its dual problem using simplex method.	10	CO3	L4
4	a	Find initial Basic Feasible solution for the following T.P. Using all methods	4	CO4	L4

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

	b	Define degeneracy in T.P .Find optimal solution for the following T.P & formulate as a mathematical method.	6	CO4	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	

	c	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.	6	CO4	L4

	1	2	3	4
A	2	2	2	4

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B	3	5	3	2
C	4	3	2	1

- a 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. — 4, CO4, 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

b Explain various steps involved in Hungarian algorithm with example. — 4, CO4, L4

c Find the assignment of jobs to machines that will result in the maximum profit. — 8, CO4, 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

5 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 — 6, CO5, L2

b Solve the following game by applying a) graphical method b)dominance rule — 6, CO5, L4

b)

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

b)

3	-2	4
-1	4	2
2	2	6

c 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. — 4, CO5, L4

- 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 — 6, CO5, L3

b Explain briefly the following a) tabu search b)genetic algorithm c)simulated annealing technique. — 6, CO5, L4

c Solve the following game by applying dominance rule — 4, CO5, L4

4	5	8
6	4	6
4	2	4

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2. SEE Important Questions

Course:	Operations Research					Month / Year	May /2018
Crs Code:	15CS653	Sem:	6	Marks:	80	Time:	180 minutes

	Note	Answer all FIVE full questions. All questions carry equal marks.	-	-	
Module	Qno.		**Marks**	**CO**	**Year**
1	1	What are the different phases of OR study.Explain briefly.	6	CO1	2017
	2	Define the following:a)unbounded solution b)slack variable c)Feasible region	5	CO1	2017
	3	Solve by graphical method Min Z=20x1 + 10x2 sub to: x1 + 2x2 <=40, 3x1 + x2>=30, 4x1 + 3x2 >-60,x1,x2>=0.	5	CO1	2016
	4	Explain the 6 basic assumptions of Simplex method	6	CO1	2016
	5	Write a brief note on unbounded solution and infeasible solution of simplex emthod.	8	CO1	2007
2	1	Define slack variable, surplus variable	4	CO2	2015
	2	Solve by big M method:Max Z=2x1 + 3x2 + 10x3 sub to:x1 + 2x3=0, x2 + x3 =1,x1,x2,x3>=0	6	CO2	2016
	3	Using Two phase method :Min Z =7.5x1 – 3x2 Sub to :3x1 -x2 – x3>=3, x1 – x2 + x3>=0	10	CO2	2015
	4	Solve by Simplex method:Max Z= 2x1 + 3x2 +x3 <=240, x1 + x2 +3x3 <=300,x1 + 3x2 +x3<=300,x1,x2,x3>=0	2	CO2	2014
3	1	Give the characteristics of dual problem.	8	co3	2014
	2	Expalin the primal dual relationship.	6	CO3	2014
	3	Explain the essence of duality theory	10	CO3	2010
	4	Write the duals of Max Z =x1 + 2x	10	CO3	2009
4	1	Find the initial basic feasible solution using North-West corner method: (table below)	6	CO4	2011
	2	Explain the MODI method	4	CO4	2011
	3	Use VAM to find the intial basic feasible solutions (table below)	5	CO4	2013

Table for Module 4, Q1:

	D1	D2	D3	D4	Requirement
F1	3	3	4	1	100
F2	4	2	4	2	125
F3	1	5	3	2	75
Dem,and	120	80	75	25	

Table for Module 4, Q3:

Factories	W1	W2	w3	Availbale
F1	16	20	12	200
F2	14	8	18	160
F3	26	24	16	90
Required	180	120	170	

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	4	**Explain various steps involved in Hungarian method with an example.**	8	CO4	2012
	5	Solve the assignment problem:	12	CO4	2011

	P1	P2	P3	P4
T1	42	35	28	21
T2	30	25	20	15
T3	30	25	20	15
T4	24	20	16	12

5	1	Explain :a)Minmax and maxmin principle b)Pure and mixed strategies c)Two person zero sum game.	6	CO5	2013
	2	Solve by concept of dominance:	10	CO5	2013

6	15	30	21	6
3	3	6	6	4
12	12	24	36	3

	3	Solve the graphical method:	10	CO5	2015

	I	II	III	IV	V
I	2	-1	5	-2	6
II	-2	4	-3	1	0

	4	Give an outline of the Basic Simulated Annealing algorithm.	4	CO5	2015
	5	Explain briefly 1)Genetic algorithm 2)Tabu search	6	CO5	2005