DISTRIBUTED SYSTEMS (ECS-416)

Teacher Name:

DR. RAGHWENDRA SINGH

Course Structure

Type	L	T	P	Credits
OEC (Maths)	3	1	0	4

Prerequisite:

Course Content:

Unit-1: Linear Programming Problems (LPP)

OR model, Formulation of LPP. model, Graphical LPP solution and sensitivity analysis, simplex method, M-method, Two-phase method, Special cases in simplex method application, Duality theory, Dual simplex method, Revised simplex method, Degeneracy, Sensitivity analysis, Various industrial application of LP.

Unit-2: Transportation Models, Assignment Models and Integer Programming

Formulation and Optimal solution of transportation models, Assignment models, Transshipment models, Degeneracy in TP model, Industrial application, Formulation and Solution of integer linear programming problems; Cutting-plane algorithm, Branch and Bound algorithm, 0-1 ILPP, applications, Knapsack problem, facility-location problem.

Unit-3: Sequencing and Scheduling Model

Sequencing problems- Travelling salesman problem, Machine-scheduling problem (Job shop), Network based planning models, Objectives of CPM and PERT, Characteristics of CPM/PERT projects, Network diagram, Terminology, Critical path, Project duration, PERT Network, Activity time, Probabilities of project completion, Optimal crashing of project activities.

Unit-4: Replacement and Inventory models

Replacement Problems: Optimal age of equipment replacement, capital equipment discounting cost, Replacement of items that fail, Individual and group replacement policies.

Inventory Models: Deterministic inventory models, Classic EOQ model, EOQ with price breaks, Multi-term, stochastic inventory models under probabilistic demand and lead times.

Unit-5: Dynamic Programming and Genetic Algorithms

Dynamic programming: Bellman's principle of optimality, computations in DP, Forward and Backward recursions, Dynamic Programming formulations, Investment problem, General allocation problem, Storage coach problem, Production scheduling.

Genetic Algorithms: Working principles, similarities and differences between Gas and Traditional methods, Gas for constrained optimization, Applications of Gas to solve simple problems.

Text and Reference Books:

1. S. S. Rao, "Optimization: Theory and Applications" Willey Eastern Limited.
2. H.A. Taha, "Operations Research- AN Introduction", Macmillan.
3. Hiller, F. S., G.J. Lieberman, "Introduction to Operations Research", Hoiden-Day.
4. Kalyanmoy Deb, "Optimization for Engineering Design: Algorithms & Examples "Prentice- Hall of India.
2. B. E. Gillet, Introduction Operations Research- A Computer Oriented Algorithmic Approach, McGraw Hill 1989.

Course Outcomes:

1. Operation Research is the application of modern methods of mathematical science to complex problems involving management of large systems of men, machines, materials and money in industry, business, government and defence. Operations research has wide scope and has been successfully applied in the following areas: (Apply)
   - Financial Management
   - Inventory Control
   - Simulation Technique
   - Capital Budgeting
   - Decision Making
2. Linear programming has been used to solve problems involving assignment of jobs to machines, blending, product mix, advertising media selection, least cost diet, distribution, transportation, investment portfolio selection and many others. (Apply)
3. Transportation problem is the most useful model of L.P.P. which simplify calculation to find solution of L.P.P. containing more number of variables and constraints. It deals with the transportation of a product available at several sources to a number of different destination. Transportation model can be used for a wide variety of situations such as scheduling, production, investment, plant location, inventory control, employment scheduling, personnel assignment, product mix problems and many others. (Apply)
4. Sequencing and Scheduling Model has been helpful to solve problems of appropriate selection of the number of jobs (operations) which are assigned to a finite number of service facilities (machines or equipment) so as to optimize the output in items of time, cost or profit. Network techniques of PERT and CPM have been used in planning, scheduling and controlling construction of dams, bridges, roads, highways and development and production of aircrafts, ships, computers, etc. (Analyze)
5. Inventory control models have been used to determine economic order quantities, safety stocks, reorder levels, minimum and maximum stock levels. (Understand)
6. Replacement theory has been extensively employed to determine the optimum replacement interval for three types of replacement problems. (Understand, Apply)

7. Dynamic programming has been applied to capital budgeting, selection of advertising media, employment smoothening, cargo loading and optimal routing problems. (Apply)

Lesson Plan

Lecture Delivery Plan					
Course : B. Tech (CSE)		**Year**: III		**Semester :** VI	
Subject Name & Code: Opration Research, IMA-602)				**Session:** 2018-19	
Name of Faculty : Dr. Raghwendra Singh					
Lect. No.	**Module**	**Topic**	**Sub Topic**	**Reference**	**Remarks**
1	I	Linear Programming Problems (LPP)	Introduction, Formulation of LPP, model	T1, T2	
2			Graphical solution of two variable solution	T1, T2	
3			Important geometric properties of LPPs	T1, T2	
4			sensitivity analysis	T1, T2	
5			Slac and surplus variables, Standard form of linear programming, Problem	T1, T2	
6			Matrix form of linear programming, limitations of LPP.	T1, T2	
7		Simplex method	Simplex method for solving LPP	T1, T2	
8			M-method, Two-phase method,	T1, T2	
9			Special cases in simplex method application, Sensitivity analysis,	T1, T2, R1	
10			Duality theory, Dual simplex method	T1, R1	
11			Revised simplex method, Degeneracy	T1, T2, R1	
12			Various industrial application of LP.	T1, T2, R1	
13	II	Transportation Problems	Formulation and Optimal solution of transportation models	T1, R1	
14			Matrix form of a transportation problem	T1, R1	
15			Loops in transportation table and there problem, degeneracy in transportation problem	T1, T2, R1	

16		Assignment models & Integer linear programming problems	Hungarian method for Assignment problems	T1, T2, R1	
17			Transshipment models, Degeneracy in TP model, Industrial application,	T1, T2, R1	
18			Formulation and Solution of integer linear programming problems	T1, T2, R1	
19			Cutting-plane algorithm,	T1, T3, R3	
20			Branch and Bound algorithm, 0-1 ILPP applications	T1, T3, R3	
21			Knapsack problem	T1, T3, R3	
22			facility-location	T1, T3, R3	
23	**III**	Sequencing and Scheduling Model	Travelling salesman problem,	T1, T3, R3	
24			Machine-scheduling problem (Job shop),	T1, T3, R3	
25			Network based planning models	T1, T3, R3	
26			Objectives of CPM and PERT	T1, T3, R3	
27			Characteristics of CPM/PERT projects, Optimal crashing of project activities.	T1, T3, R3	
28			Network diagram, Terminology,		
29			Critical path, Project duration, PERT Network, Activity time,	T1, T3, R3	
30			Probabilities of project completion	T1, T3, R3	
31					
32			Optimal crashing of project activities	T1, T3,	
33	**IV**	Replacement and Inventory models	Replacement models	T1, T2,	
34			Optimal age of equipment replacement,	T1, T2,	
35			capital equipment discounting cost,	T1, T2,	
36			Replacement of items that fail, Individual and group replacement policies	T1, T2,	
37			Deterministic inventory models, Classic EOQ model,	T1, T2,	
38			Classification of Inventory models		
39			EOQ with price breaks, Multiterm	T1, T2,	
40			stochastic inventory models under probabilistic demand and lead times.	T1, T2,	
41	**V**	Dynamic Programming and Genetic Algorithms	Dynamic programming	T1, T3,R3	
42			Bellman's principle of optimality	T1, T3,R3	
43			computations in DP, Forward and Backward recursions	T1, T3,R3	

44			Dynamic Programming formulations	T1, T3,R3	
45			Investment problem, General allocation problem	T1, T3,R3	
46			Storage coach problem, Production scheduling	T1, T3,R3	
47			Genetic Algorithms: Working principles	T1, T3,R3	
48			similarities and differences between Gas and Traditional methods,	T1, T3,R3	
49			Gas for constrained optimization	T1, T3,R3	
50			Applications of Gas to solve simple problems.	T1, T3,R3	

Text Books :

1. S.D Sharma, "Operations Research" Kedarnath Ram Nath Publication.
2. H.A. Taha, " Operations Research- AN Introduction", Macmillan
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3. Kalyanmoy Deb, "Optimizaton for Engineering Design: Algorithms & Examples " Prentice- Hall of India.

Tutorial/ Assignments

Tutorial/ Assignment # 1(IMA-602), Session-2018-19
Topic – OPERATIONS RESEARCH

1. A manufacturer of patent medicines is proposed to prepare a production plan for medicines A and B. There are sufficient ingredients available to make 20,000 bottles of medicine A and 40,000 bottles of medicine B, but there are only 45,000 bottles into which either of the medicines can be filled. Further, it takes three hours to prepare enough material to fill 1000 bottles of medicine A and one hour to prepare enough material to fill 1000 bottles of medicine B and there are 66 hours available for this operation. The profit is Rs. 8 per bottle for medicine A and Rs. 7 per bottle for medicine B. Formulate this Problem as a LPP.
2. Solve by graphical method, the linear programming Problems:

   (a) Minimize $Z = 20x_1 + 10x_2$

   Subject to the constraints,

$x_1 + 2x_2 \le 40,\quad 3x_1 + x_2 \ge 30,\quad 4x_1 + 3x_2 \ge 60$ and the non-negative restrictions $x_1,\ x_2 \ge 0.$

(b) Maximize $Z = 5x + 3y$

Subject to the constraints, $2x + 4y \le 20,\quad 3x + 2y \le 24,\ 4x + 2y \le 13$ and the non-negative restrictions $x_1,\ x_2 \ge 0.$

3. Solve by simplex method the following LPP

   Maximize $Z = 3x_1 + 5x_2 + 4x_3$

   subject to $2x_1 + 3x_2 \le 8,\quad 2x_2 + 5x_3 \le 10,$
   $3x_1 + 2x_2 + 4x_3 \le 15,\ x_1,\ x_2,\ x_3 \ge 0.$

4. Apply Big-M method to solve the following problems:

   Max. $Z = -2x_1 - 2x_2$, subject to, $2x_1 + x_2 \ge 2,\quad x_1 + 3x_2 \le 3,\ x_2 \le 4,$
   $x_1,\ x_2 \ge 0.$

5. Find the dual of the following LPP

   Min. $Z = 10x_1 + 20x_2$, subject to, $3x_1 + 2x_2 \ge 18,\quad x_1 + 3x_2 \ge 8,\ 2x_1 - x_2 \le 6,$
   $x_1,\ x_2 \ge 0.$

6. Prove that the dual of the given primal is the primal itself.
7. Write the dual of the following linear programming problem and hence solve it.

   Max. $Z = 3x_1 - 2x_2$, subject to, $x_1 + x_2 \ge 5,\quad x_1 \le 6,\ x_1 + x_2 \le 5, -x_2 \le -1,\quad x_1,\ x_2 \ge 0.$

8. One unit of product A contributes Rs.7 and requires 3 units of raw material and one hour of labour. Availability of the raw material at present is 48 units and there are 40 hours of labour.

   (i) Formulate the linear programming problem,

   (ii) write the dual and solve it by simplexmethod. Also find the optimal product max.

Tutorial/ Assignment # 2 (IMA-602), Session-2018-19
Topic – OPERATIONS RESEARCH

UNIT-II&III

1. Find optimal solution of the transportation problem whose cost matrix is given by the following table

	Destinations				Supply (a_i)
Origins	19	30	50	10	7
	70	30	40	60	9
	40	8	70	20	18
Demand (b_j)	5	8	7	14	

2. Find optimal solution of the transportation problem whose cost matrix is given by the following table

	Destinations				Supply (a_i)
Origins	5	2	4	3	22
	4	8	1	6	15
	4	6	7	5	8
Demand (b_j)	7	12	17	9	

3. Consider the problem of assigning five jobs to five persons. The amount of time in hours
taken by each person to do a given job is given in the table below.

Job \ Person	P_1	P_2	P_3	P_4	P_5
1	7	9	3	3	2
2	6	1	6	6	5
3	3	4	9	10	7
4	1	5	2	2	4
5	6	6	9	4	2

Determine the assignment pattern that minimizes the total time taken.

4. Given the matrics of setup costs, show how to sequence the production so as to minimize the setup cost per cycle.

Job	P_1	P_2	P_3	P_4	P_5
1	∞	2	5	7	1
2	6	∞	3	8	2
3	8	7	∞	4	7
4	12	4	6	∞	5
5	1	3	2	8	∞

5. What is a critical path? What is the role of dummy activity in a network? Compare CPM and PERT explaining similarities and mentioning where they mainly differ.

6. There are six jobs, each of which must go through machines M_1, M_2, M_3 in the order $M_1M_2M_3$. Processing times are given in the following table:

Processing Times (in hours)

Job	M_1	M_2	M_3
1	8	3	8
2	3	4	7
3	7	5	6
4	2	2	9
5	5	1	10
6	1	6	9

Determine a sequence for six jobs that will minimize the total elapsed time

7. A project consists of eleven activities whose time estimates are listed in the following table

Activity	Estimated time		
	Optimistic	Most likely	Pessimistic
1-2	7	9	17
1-3	10	20	60
1-4	5	10	15
2-5	50	10	110
2-6	30	40	50
3-6	50	55	90
3-7	1	5	9
4-7	40	48	68
5-8	5	10	15
6-8	20	27	52
7-8	30	40	50

(a) Draw the network diagram for the project. (b) Calculate slacks for each node.
(c) Determine the critical path. (d) What is the probability of completing the project in 125 days?(For standard normal variate Z, $P(Z \leq 0.84) = 0.7995$)

Tutorial/ Assignment # 3 (IMA-602), Session-2018-19
Topic – OPERATIONS RESEARCH

UNIT-IV&V

1. A computer contains 10,000 resistors. When any resistor fails, it is replaced. The cost of replacing resistor individually is Rs. 1, while cost for group replacement is Rs. 0.35/transistor. The failure rate of a resistor is given below:

Month :	1	2	3	4	5	6
Probability of failure:	0.04	0.06	0.25	0.30	0.15	0.20

If all the resistors are replaced at the same time and also replace the individual resistors as they fail during this time, then determine the best interval between group replacements.Also determine which policy of replacement is economical, i.e., individual or group replacement.

2. A production house has to supply his customer with 800 units of his product per year. Shortages are not allowed and the storage cost amounts Rs. 0.70 per unit per year. The set-up cost per run is Rs. 80. Find the optimum run-size and the minimum average yearly cost. The demand of an item is uniform at a rate of 25 units per month. The fixed cost is Rs. 15 each time a production run is made. The production cost is Rs. 1.50 per item, and the inventory carrying cost is Rs. 0.30 per item per month. If the shortage cost is Rs. 1.50 per item per month, determine how often to make a production run and of what size it should be?
3. A newspaper boy buys papers for Rs. 2.60 and sells them for Rs. 3.60 each. He cannot return unsold newspapers. Daily demand has the following distribution:

Customers :	23	24	25	26	27	28	29	30	31	32
Probability :	0.01	0.03	0.06	0.10	0.20	0.25	0.15	0.10	0.05	0.05

If each day's demand is independent of the previous day's, how many papers he should order each day?

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4. The following table gives the activities associated with a project and corresponding time duration:

Activity	Immediate predecessor	Time (days)
A	-	3
B	-	8
C	B	6
D	B	5
E	A	13
F	A	4
G	F	2
H	C, E, G	6
I	F	2

Draw a graph to represent the sequence of tasks and find the critical path and minimum time of completion of the project.

5. Find EOQ for the following data :

Annual usage=1,000 pieces	Expediting cost= Rs. 4 per order
Cost per price=Rs.250	Inventory holding cost=20% of average inventory
Order cost= Rs. 6 per order	material holding cost=Rs. 1 per piece.

6. An aircraft company uses rivets at an approximate customer rate of 2500 kg. per year. Eachunit costs Rs. 30 per kg. and the company personnel estimate that it costs Rs. 130 to place an order, and that the carrying cost of inventory is 10% per year. How frequently should orders for revets be placed? Also determine the optimum size of each other.
7. Use Bellman,s Principal of optimilty to minimize $z = y_1 + y_2 + ... + y_n$, subject to constraints: $y_1 y_2 .....y_n = d,\ y_j \geq 0 \quad for\ j = 1, 2, ...n$.
8. Solve the following problem using dynmic programming

   Maximize $z = y_1^2 + y_2^2 + y_3^2$, subject to $y_1 y_2 y_3 \leq 4$, where y_1, y_2, y_3 are positive integer.
9. State the Principle of optimality in dynamic programming and give a mathematical formulation of a dynamic programming problem.
10. State Bellman,s principal of optimality in dynamic programming.