TEACHING PLAN: OPERATION RESEARCH

<table>
<tr><th colspan="2">SCHOOL: Engineering & Technology</th><th>ACADEMIC SESSION: 2022 – 2023</th><th colspan="3">FOR STUDENTS' BATCH: 2020-24
B. Tech. SEM-VI</th></tr>
<tr><td>1</td><td>Course code</td><td colspan="4">PCC-ME 312</td></tr>
<tr><td>2</td><td>Course Title</td><td colspan="4">Operation Research</td></tr>
<tr><td>3</td><td>Credits</td><td colspan="4">04</td></tr>
<tr><td>4</td><td>Learning Hours</td><td colspan="4"><table><tr><td>Lectures</td><td>03</td></tr><tr><td>Assessment OR Tutorial</td><td>01</td></tr><tr><td>Guided Study</td><td></td></tr><tr><td>Total hours</td><td>04</td></tr></table></td></tr>
<tr><td>5</td><td>Course Objective</td><td colspan="4">After Studying this lesson, you should be able to:
(1) Understand the meaning, purpose, and tools of Operations Research
(2) To make the students understand the basic concepts, the history and tools of Operations Research.
(3) Explain the Applications and the Limitations of Operations Research
(4) Formulate and identify the characteristics of linear programming problem and make a graphical analysis of the linear programming problem.
(5) Identify the various types of solutions
(6) Understand the basics of simplex method and explain the simplex calculations
(7) Understand two phase and M method and Formulate a Dual Problem
(8) Formulation and solution of a Transportation Problem
(9) Determine basic feasible solution using various methods
(10) Propose the best strategy using decision making methods under uncertainty and game theory.
(11) Operational and financial management of inventory model
(12) Financial analysis based on queuing theory using constructed business models to make projections about an operational variable that may improve queuing efficiency.</td></tr>
<tr><td>6</td><td>Course Outcomes</td><td colspan="4">1. Construct linear integer programming problems or models and discuss the solution techniques.
2. Proficiency with tools from optimization, simulation, and engineering economic analysis, including fundamental applications of those tools in industry and the public sector in contexts involving uncertainty and scarce or expensive resources.
3. Facility with mathematical modeling of real decision-making problems, including the use of modeling tools and computational tools, as well as analytic skills to evaluate the problems.</td></tr>
<tr><td>7</td><td colspan="5"></td></tr>
<tr><td></td><td>Unit</td><td>Section</td><td>Introduction</td><td>Reference Number</td><td>Teaching Methods</td></tr>
<tr><td></td><td>Unit-1</td><td>(a)</td><td>Basics of operations research</td><td>TB1
1-37</td><td>White Board & PPT</td></tr>
</table>

		(b)	linear programming, scope, problem formulation	TB1 41-86	White Board & PPT
		(c)	graphical method	TB1 115-133	White Board & PPT
		(d)	simplex methods, primal and dual problem sensitivity analysis	TB1 154-191	White Board & PPT
	Unit - II	(a)	Transportation and assignment problems, deterministic dynamic programming, multistage decision problems and solution, principle of optimality.	TB1 248-303	White Board & PPT
	Unit-III	(a)	Decision theory, decision under various conditions	TB1 770-778	White Board & PPT
		(b)	game theory, two-person zero sum game, solution with/without saddle point, dominance rule, methods like algebraic, graphical, liner programming sequencing basic assumption, *n* jobs through two/three machines, jobs on *m* machines.	TB1 854-910	White Board & PPT
	Unit-IV	(a)	Stochastic inventory models - single and multi-period models with continuous and discrete demands, service level and reorder policy simulations - use, advantages& limitations	TB1 970-998	White Board & PPT
		(b)	Monte-Carlo simulation, application to queuing, inventory and other problems.	TB1 1192-1229	White Board & PPT
	Unit-V	(a)	Queuing models, characteristics of queuing model, M/M/1 and M/M/S system, cost consideration, project management concepts, rules for drawing the network diagram, Applications of CPM and PERT in project planning and control; crashing of operations; resource allocation.	TB1 1000-1051	White Board & PPT

8	**Course Evaluation**	
8.1	**CA: 40%**	
8.1.1	**Attendance**	5%
8.1.2	**Assignment & presentation**	20%
8.1.3	**Class test**	15%
8.1.4	**Any other**	--
8.2	**MTE**	20%
8.3	**End-term examination: 40%**	
9	**Text Books & References**	
9.1	**Text book**	**TB1:** Er. Prem Kumar Gupta & Dr. D. S. Hira. S. (7th Edition 2014). *Operation Research*, S. Chand

		TB2: Taha, H. A. (1997). *Operations research: An introduction.* Upper Saddle River, N.J: Prentice Hall. **TB3:** Wagner, H. M. (1975). *Principles of operations research: With applications to managerial decisions*. Englewood Cliffs, N.J: Prentice-Hall.
9.2	**References**	**RB1:**https://www.bbau.ac.in/dept/UIET/EMER-601%20Operation%20Research%20Queuing%20theory.pdf **RB2:** Goel, A., & Agarwal, R. (2021). *Operation Research*. Technical Publications. **RB3:** Winston, W. L., & Goldberg, J. B. (2004). *Operations research: applications and algorithms* (Vol. 3). Belmont: Thomson Brooks/Cole. **RB4:** Jayakara, H. A. (2013). Fundamentals of Operation Research. **RB5:** Rama, M. A., & Chandrashekar, T. (2017). Operation research. **RB6:** Atici, F. M., & Uysal, F. (2008). A production–inventory model of HMMS on time scales. *Applied Mathematics Letters*, *21*(3), 236-243.
9.3	**Video References**	[1] https://www.youtube.com/watch?v=a2QgdDk4Xjw&list=PLjc8ejfjpgTf0LaDEHgLB3gCHZYcNtsoX [2] https://www.youtube.com/watch?v=66aKgySf9vo&list=PLLy_2iUCG87Bq8RGMTdeFZiB-87V4i9p1 [3] https://www.youtube.com/watch?v=k9dhcfIyOFc&list=PLOEpD2bjMC9JsTBCafj8Fs5ChDdRqjw5j [4] https://www.youtube.com/watch?v=a2QgdDk4Xjw&t=108s

CO-PO Mapping

Course Outcome	Program Outcome												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO 1	1	3	3	3	1	2	1	1	2	2	1	2	3	1	2	2
CO 2	2	3	3	3	2	2	2	1	2	1	2	2	3	2	2	2
CO 3	2	3	3	3	2	2	1	1	2	1	2	3	3	2	2	2

Question Bank

1. Trace the history of Operations Research.
2. Give a brief account of history of Operations Research.
3. Discuss the objective of Operations Research.
4. "Operations Research is a bunch of mathematical techniques to break industrial problems". Critically comment.
5. What is a Operations Research model? Discuss the advantages of limitation of good Operations Research model.
6. Discuss three Operations Research models.
7. What is a decision and what are its characteristics.
8. Briefly explain the characteristics of Operations Research.
9. Discuss the various steps used in solving Operations Research problems.
10. Discuss the scope of Operations Research.

11. Maximise $Z = 8000a + 7000b$ S.T.

$3\ a + 1\ b \leq 66$

$1\ a + 1\ b \leq 45$

$1\ a + 0\ b \leq 20$

$0\ a + 1\ b \leq 40$ and both a and b are ≥ 0.

12. Minimise $Z = 1.5\ x + 2.5\ y$ S.T.

$1\ x + 3\ y \geq 3$

$1\ x + 6\ y \geq 2$ and both x and $y \geq 0$

13. Maximise $Z = 3\ a + 2\ b$ S.T.

$1a - 1\ b \leq 1$

$1\ a + 1b \geq 3$ and both x and y are ≥ 0

14. Maximise $Z = -3\ x + 2\ y$ S.T.

$1\ x + 0\ y \leq 3$

$1\ x - 1\ y \leq 0$ and both x and y are ≥ 0

15. An aviation fuel manufacturer sells two types of fuel A and B. Type A fuel is 25 % grade 1 gasoline, 25 % of grade 2 gasoline and 50 % of grade 3 gasoline. Type B fuel is 50 % of grade 2 gasoline and 50 % of grade 3 gasoline. Available for production are 500 liters per hour grade 1 and 200 liters per hour of grade 2 and grade 3 each. Costs are 60 paise per liter for grade 1, 120 paise for grade 2 and100 paise for grade 3. Type A can be sold at Rs. 7.50 per liter and B can be sold at Rs. 9.00 per liter. How much of each fuel should be made and sold to maximise the profit.

16. A company manufactures two products X_1 and X_2 on three machines A, B, and C. X_1 require 1 hour on machine A and 1 hour on machine B and yields a revenue of Rs.3/-. Product X_2 requires 2 hours on machine A and 1 hour on machine B and 1 hour on machine C and yields revenue of Rs. 5/-. In the coming planning period the available time of three machines A, B, and C are 2000 hours, 1500 hours and 600 hours respectively. Find the optimal product mix.

17. Maximize $Z = 1\ x + 1\ y$ S.T.

$1\ x + 2\ y \leq 2000$

$1\ x + 1\ y \leq 1500$

$0\ x + 1\ y \leq 600$ and both x and y are ≥ 0.

16. Maximize $Z = -1\ a + 2b$ S.T.

$-1\ a + 1\ b \leq 1$

$-1\ a + 2\ b \leq 4$ and both a and b are ≥ 0.

17. Maximise $Z = 3\ x - 2\ y$ S.T.

$1x + 1\ y \leq 1$

$2\ x + 2\ y \geq 4$ and both x and y are ≥ 0

18. Maximize $Z = 1x + 1\ y$ S.T.

$1\ x - 1y \geq 0$

$-3x + 1\ y \geq 3$ and both x and $y \geq 0$

Note: Solve example from 13 to 18 by graphical method.

19. A manufacturer can produce three different products *A*, *B*, and *C* during a given time period. Each of these products requires four different manufacturing operations: Grinding, Turning, Assembly and Testing. The manufacturing requirements in hours per unit of the product are given below for *A*, *B*, and *C*:

	A	B	C
Grinding	1	2	1
Turning	3	1	4
Assembly	6	3	4
Testing	5	4	6

The available capacities of these operations in hours for the given time period are as follows: Grinding 30 hours, Turning: 60 hours, Assembly: 200 hours and Testing: 200 hours.

The contribution of overheads and profit is Rs.4/– for each unit of *A*, Rs.6/– for each unit of *B* and Rs.5/– for each unit of *C*. The firm can sell all that it produces. Determine the optimum amount of *A*, *B*, and *C* to produce during the given time period for maximizing the returns.

20. A fashion company manufactures four models of shirts. Each shirt is first cut on cutting process in the trimming shop and next sent to the finishing shop where it is stitched, button holed and packed. The number of man–hours of labour required in each shop per hundred shirts is as follows:

Shop	*Shirt A*	*Shirt B*	*Shirt C*	*Shirt D*
Trimming shop	1	1	3	40
Finishing shop	4	9	7	10

Because of limitations in capacity of the plant, no more than 400 man–hours of capacity is expected in Trimming shop and 6000 man – hours in the Finishing shop in the next six months. The contribution from sales for each shirt is as given below: Shirt. *A*: Rs. 12 /– per shirt, Shirt *B*: Rs.20 per shirt, Shirt *C*: Rs. 18/– per shirt and Shirt *D*: Rs. 40/– per shirt. Assuming that there is no shortage of raw material and market, determine the optimal product mix.

22. Minimize $Z = 2x + 9y + 1z$ s.t

$1x + 4y + 2z \geq 5$

$3x + 1y + 2z \geq 4$ and x, y, z all are ≥ 0, Solve for optimal solution.

23. Minimize $Z = 3a + 2b + 1c$ s.t.

$2a + 5b + 1c = 12$

$3a + 4b + 0c = 11$ and a is unrestricted and b and c are ≥ 0, solve for optimal values of a, b and c.

24. Max $Z = 22x + 30y + 25z$ s.t

$2x + 2y + 0z \leq 100$

$2x + 1y + 1z \leq 100$

$1x + 2y + 2z \leq 100$ and x, y, z all ≥ 0 Find the optimal solution.

25. Obtain the dual of the following linear programming problem.

Maximize $Z = 2x + 5y + 6z$ s.t.

$5x + 6y - 1z \leq 3$

$-1x + 1y + 3z \geq 4$

$7x - 2y - 1x \leq 10$

$1x - 2y + 5z \geq 3$

$4x + 7y - 2z = 2$ and x, y, z all ≥ 0

Note: Solve examples 22 to 25 using simplex method

26. What is transshipment problem? In what way it differs from general transportation problem?

Explain the terms: (*a*) Opportunity cost, (*b*) Implied cost, (*c*) Row opportunity cost, (*d*) Column opportunity cost.

The DREAM - DRINK Company has to work out a minimum cost transportation schedule to distribute crates of drinks from three of its factories *X*, *Y*, and *Z* to its three warehouses *A*, *B*, and *C*. The required particulars are given below. Find the least cost transportation schedule.

Transportation cost in Rs per crate.

From / To	*A*	*B*	*C*	*Crates Available.*
X	75	50	50	1040
Y	50	25	75	975
Z	25	125	25	715
Crates required.	1300	910	520	2730

27. The demand pattern for a product at for consumer centers, A, B, C and D are 5000 units, 7000 units, 4000 units and 2000 units respectively. The supply for these centers is from three factories X, Y and Z. The capacities for the factories are 3000 units, 6000 units and 9000 units respectively. The unit transportation cost in rupees from a factory to consumer center is given below in the matrix. Develop an optimal transportation schedule and find the optimal cost.

From:	*To*			
	A	*B*	*C*	*D*
X	8	9	12	8
Y	3	4	3	2
Z	5	3	7	4

28. In a transportation problem the distribution given in the table below was suggested as an optimal solution. The capacities and requirement are given. The number in bold are allocations. The transportation costs given in Rs, per unit from a source to a destination.

(*a*) Test whether the given distribution is optimal?

(*b*) If not optimal obtain all basic optimal solution.

Source ↓ Destination	A	B	C	D	Capacity
X	9 **12**	8 **14**	12	10 **10**	36
Y	10	10 **16**	12 **28**	14	44
Z	8	9	11 **32**	12	32
Demand	12	30	60	10	

29. In each of the following cases, stock is replenished instantaneously and no shortages are allowed. Find the economic lot size, the associated total costs and length of time between orders and give your comments.

(*a*) C_3 = Rs. 100/- per order, C_1 = Re. 0.05 per unit and λ = 30 units per year.

(*b*) C_3 = Rs. 50/0 /- per order, C_1 = Re. 0.05 per unit and λ = 30 units per year.

(*c*) C_3 = Rs. 100/- per order, C_1 = 0.01 per unit and λ = 40 units per year.

(*d*) C_3 = Rs. 100/- per order, C_1 = Rs. 0.04 per unit and λ = 20 units per year.

30. The *XYZ* manufacturing company has determined from an analysis of its accounting and production data for part number 625, that its cost to purchase is Rs.36 per order and Rs. 2/- per part. Its inventory carrying charge is 18% of the average inventory cost. The demand for this part is 10,000 units per annum. Find (*a*) What is the economic order quantity; (*b*) What is the optimal number of days supply per optimum order.

31. A manufacturer receives an order for 6890 items to be delivered over a period of a year as follows:

At the end of the first week = 5 items.

At the end of the second week = 10 items.

At the end of the third week = 15 items. etc.

The cost of carrying inventory is Rs. 2.60 per item per year and the cost of set up is Rs. 450/ - per production run.

Compute the costs of following policies:

(*a*) Make all 6890 at start of the year.

(*b*) Make 3445 now and 3445 in 6 months,

(*c*) Make 1/12 th the order each month.

(*d*) Make 1/52 th order every week.