MEASI
Institute *of* Management

APPLIED OPERATIONS RESEARCH-434C2A

STUDY MATERIAL/BATCH 2024-26

2nd SEMESTER (FULL TIME)
NEW REGULATION SYLLABUS 2023
MASTER OF BUSINESS ADMINISTRATION
UNIVERSITY OF MADRAS

VISION & MISSION STATEMENTS

VISION

- To be an oasis of knowledge to the seeker, to nurture one's creativity and research acumen, and to instil a unique blend of leadership, innovative spirit and empathy in response to the ever-evolving business ecosystem.

MISSION

- Provide a pedagogy that blends academic rigor and experiential learning.
- Inculcate an entrepreneurial mindset through curated activities.
- Establish a conducive environment for research.
- Foster a culture of innovation and collaboration to progress in a dynamic business landscape.
- Promote humanistic values to produce socially responsible leaders.

Program Educational Objectives (PEOs)

PEO 1 – Employability

To develop students with industry specific knowledge & skills to meet the industry requirements and also join public sector undertaking through competitive examinations.

PEO 2 - Entrepreneur

To create effective business service owners, with a growth mindset by enhancing their critical thinking, problem solving and decision-making skills.

PEO3 – Research and Development To instil and grow a mindset that focusses efforts towards inculcating and encouraging the students in the field research and development.

PEO 4 – Contribution to Business World

To produce ethical and innovative business professionals to enhance growth of the business world.

PEO 5 – Contribution to the Society: To work and contribute towards holistic development of society by producing competent MBA professionals.

PROGRAM OUTCOMES

PO1: Problem Solving Skill: Application of tools & techniques relevant to management theories and practices in analyzing & solving business problems.

PO2: Decision Making Skill: Fostering analytical and critical thinking abilities for data-based decision making.

PO3: Ethical Value: Ability to develop value-based leadership attributes.

PO4: Communication Skill: Ability to understand, analyze and effectively communicate global, economic, legal and ethical aspects of business.

PO5: Individual and Team Leadership Skill: Ability to be self-motivated in leading & driving a team towards achievement of organizational goals and contributing effectively to establish industrial harmony.

PO6: Employability Skill: Foster and enhance employability skills through relevant industry subject knowledge.

PO7: Entrepreneurial Skill: Equipped with skills and competencies to become a global entrepreneur.

PO8: Contribution to Society: Strive towards becoming a global influencer and motivating future generation towards building a legacy that contributes to overall growth of humankind.

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
434C2A	**Applied Operations Research**	Core	3	1	-	-	4	60	25	75	100

Course Objectives	
C1	To provide the students with introduction on OR and its models to aid in understanding its applicability in the various functional areas of management.
C2	To understand the concept of linear programming models in determining profit maximization and cost minimization
C3	To learn about various methods adopted in transportation and Assignments models.
C4	To determine about inventory models, replacement models, job sequencing, networking model and Queuing model
C5	To throw light on dynamic model and game models and the application of pure and mixed strategies in competitive environment.

SYLLABUS

UNIT	Details	No. of Hours	Course Objectives
I	Introduction: Overview of operations research – Origin – Nature, scope & characteristics of OR – Models in OR – Application of operations research in functional areas of management	08	C1
II	Linear Programming Problem: Linear programming problem model – Formulation – Maximization & Minimization problem – Graphical method – Simplex method – Artificial variable –- Primal & Dual.	12	C2
III	Transportation problem: Basic Solution – North / West corner Solution, LCM, VAM, Matrices method – Optimal Solution – Stepping stone method – Vogel's approximation method – Modi method – Degeneracy – Imbalance matrix. Assignment model: Hungarian method – Traveling salesmen problem.	12	C3
IV	Project Scheduling and Resource Management: Deterministic Inventory models – Purchasing & Manufacturing models – Probabilistic inventory models – Replacement model – Sequencing – Brief Introduction to Queuing models. Networking – Programme Evaluation and Review Technique (PERT) and Critical Path Method (CPM) for Project	18	C4

	Scheduling- Crashing – Resource allocation and Resource Scheduling.		
V	Game Theory and Strategies: Games theory – two player zero sum game theory – Saddle Point –Mixed Strategies for games without saddle points – Dominance method – Graphical and L.P Solutions- Goal Programming; Simulation; Integer programming and Dynamic programming.	10	C5
	Total	**60**	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	**Program Outcomes**
CO1	Obtain insight on the origin and nature of OR and also the application of various models of OR.	PO4, PO6
CO2	Learn about the graphical, Simplex, Big M and dual methods of Linear programming problem.	PO1, PO2, PO6, PO7
CO3	Be well versed with the concept of transportation and Assignments models	PO1, PO2, PO6, PO7
CO4	Have better understanding on inventory models, replacement models, job sequencing, networking model and Queuing model	PO1, PO2, PO6, PO7
CO5	Be imparted knowledge on the various methods of game model	PO2, PO7

Reading List	
1.	www.cbom.atozmath.com
2.	http://www.pondiuni.edu.in/storage/dde/downloads/mbaii_qt.pdf
3.	http://164.100.133.129;81/econtent/Uploads/Operations_Research.pdf
4.	https://www.journals.elsevier.com/operations-research-perspectives

References Books	
1.	Anderson, D.R., Sweeney, D.J., Williams, T.A. and Martin, K., An Introduction to Management Science: Quantitative Approach to Decision Making, 14th Edition Paperback – 1, Cengage Learning India Pvt. Ltd., 2019
2.	Gupta, P.K., and Comboj, Introduction to Operations Research, S. Chand, 2014
3.	Hiller, F., Liebermann, Nag and Basu, Introduction to Operations Research, 11th Edition Paperback, Tata McGraw-Hill Publishing Co. Ltd., 2021
4.	Khanna, R.B., Quantitative Techniques for Managerial Decision Making, 3rd Edition – Paperback, New Age International Publishers, 2018
5.	Taha, H.A., Operations Research: An Introduction, 10th Edition, Pearson, 2019
6.	Vohra,N.D., Quantitative Techniques in Management, 5th Edition, Tata McGraw Hill Education Pvt. Ltd., 2017.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1				2		2		
CO 2	3	2				2	2	
CO 3	3	3				3	2	
CO 4	3	3				2	2	
CO 5		3					2	

ONE MARKS AND FIVE MARKS THEORY QUESTIONS

UNIT-I

INTRODUCTION TO OPERATION RESEARCH

1. What is operation research?

- It is the study of optimization technique.
- It is the scientific method to problem solving for executive management.

2. What are the main Features/ Natures/characteristics of operation research?(Five Marks)

- Its system orientation.
- The use of inter-disciplinary forms.
- Application of scientific method.
- Uncovering of new problem.
- Decision making
- Objectives.
- Scientific operation.

3. Mention the classification/ types of Operation Research? (Five Marks)

A mathematical model is a description of a system using mathematical concepts and language.

- Language model
- Concrete model
- Iconic model
- Analogue model
- Mathematical model
- General model
- Specific model
- Static model
- Dynamic model
- Descriptive model
- Predictive model
- Normative model
- Deterministic model
- Probabilistic model.

4. Mention the Techniques of operation Research?

- Linear programming
- Dynamic programming
- Goal programming
- Integer programming
- Queuing theory
- Game theory

- Transportation problems
- Assignment problems
- Sequencing model
- Allocate model & Routine model.

5. Mention the Phases/ Process/Methodology of Operation Research?

- Observe the problem environment
- Analysis and defining the problem
- Develop a model
- Collection Data required by the model
- Qualifying the model
- Implement the model

6. Mention the importance of Operation Research?

- Complexity
- Scattered responsibility & Authority
- Uncertainty
- Knowledge

7. Mention the limitation of Operation Research?

- Magnitude of Computation
- Gap between manager and operation Researchers.
- Money and time costs
- Implementation situation
- Selection of technique.

8. Mention the Assumption of Operation Research?

- Certainty
- Linearity
- Additivity
- Divisibility
- Optimality
- Non negative variable.

9. State the Scope/ Uses/ applications of operational research? (Five Marks)

(OR)

Role of operation Research in Business management?

A. Marketing Function:

- It deals with production and distribution problems, marketing institutions, marketing policies and practices.
- A list of marketing areas is given below:

1. **Marketing Policy**
    - Pricing
    - Advertising
    - Channel of distribution
    - Customer relation's
    - International operations
2. **Product Research**
    - New product ideas
    - Packaging
    - Customers preferences
    - Brand names & Trade marks
3. **Market research**
    - Economic forecasts
    - Industry forecasts
    - Technology forecasts
    - Sales forecasts
4. **Advertising & Sales Promotion Research**
    - Promotion research
    - Consumer motivation studies
    - Media selection
    - TV commercial measurements
    - Copy testing

B. Finance Function:

- Research in financial management includes operations of specialized financial institutions as well as the financial side of regular business firms.
- A list of finance areas is given below:

1. **Financial analysis**
    - Capital structure, Ratio analysis
    - Acquisitions, Mergers.
    - Valuation of companies
2. **Rationing Resources**
    - Sources of funds
    - Cost of capital
    - Liquidity constraints.
3. **Financial market & Intermediaries**
    - New issue market
    - Market regulations
    - Capital market

C. Production Function:

- It is also known as manufacturing research has tended to focus on materials and equipments rather than on the human aspects.

- The information from the production system may include details of raw materials, inventory, and finished goods and work in process.
- Equipment purchase & replacement
- Cost reduction research &Work measurement.
- Processes improvement studies & Quality control studies
- Inventory control research

D. Personnel functions:

- It provides wide scope for research than any other functional areas, because human behavoiur is prone to constant changes**.**
- A list of personnel areas is given below:
- Personnel policies
- Organization structure
- Job & Manpower requirements
- Job evaluation, Recruiting, selecting & Placement of employees.
- Promotion, Transfer
- Morales and Attitudes, Labour relations & Wages and salary administration.

10. Describe the origin / History/Background of operational research? (Five Marks)

- It is generally accepted that the field originated in England during the World War II.
- Some say that Charles Babbage (1791-1871) is the Father of O.R because his research into the cost of transportation and sorting of mail led to England's University Penny Post in 1840.
- Modern Operations Research originated at the Bowdsey Research Station in U.K. in 1937 to analyse and improve the working of the UK's Early Warning Rador System.
- In 1941, an Operational Research Section (ORS) was established in Coastal Command which was to carry out some of the most well-known OR work in World War II.
- After World War II, Military Operational Research in U.K. became Operational Analysis (OA) within the U.K. Ministry of Defence with expanded techniques and graving awareness.

UNIT-II

LINEAR PROGRAMMING PROBLEM

1. Define Linear Programming Problem (LPP)?

- It deals with the optimization of a function of decision variable of the problem known as objectives, subject to a set of Simultaneous linear equations is known as constraints.

2. Write the Requirement/ Formulation/ Components of LPP?

- Decision variable/ Structural variable
- Objective function
- Constraints/ Restrictions
- Non negative constraints.

3. What do you mean by a general LPP/ Standard formof LPP? (Five Marks)

The general LPP is given by,

Max (or min) $Z = c_1x_1 + c_2x_2 + \ldots + c_nx_n$

subject to the constraints

$$a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + \ldots + a_{1n}x_n \leq \text{or} = \text{or} \geq b_1$$
$$a_{21}x_1 + a_{22}x_2 + a_{23}x_3 + \ldots + a_{2n}x_n \leq \text{or} = \text{or} \geq b_2$$
$$a_{m1}x_1 + a_{m2}x_2 + a_{m3}x_3 + \ldots + a_{mn}x_n \leq \text{or} = \text{or} \geq b_m$$

$$\text{where } x_1 \geq 0,\ x_2 \geq 0,\ \ldots\ldots,\ x_n \geq 0$$

$c_1, c_2, \ldots C_n, a_{11}, a_{12}, \ldots a_{mn}$ are all known constants .

Z is called the "objective function" of the LPP.

4. Write the basic Assumption of LPP? (Five Marks)

- Proportionality
- Divisibility
- Certainty
- Finiteness.
- Optimally

5. Write the Merits and Demerits of LPP?

Merits:

- Gives optimal solution
- Scientific process
- Formulate different strategies
- Changing situations

Demerits:

- Non Negativity

- Divisibility
- All parameters are constants
- Decision variable are meangingful.
- Complex for large firms.

6. Mention the Application of LPP?

- Applied in product mix
- Applied in Diet problems
- Portfolio Selection problems
- Media selection problems
- Funds application problems.

7. List and explain the terminology in LPP?

Decision Variable	It is the Quantity of resources to be allocated.
Objectives Function	The Aim of LPP is written in Linear equations called objective Function.
Constraints/ Restrictions	The condition expressing the relation between variable called constraints.
Unrestricted/ Unconstrained Variable	Any Equality constraint in an LP problem is called Unrestricted Variable
Solution	A set of values x_1, x_2. xn which satisfies the constraints of Lpp is called solution.
Feasible solution	Any solution which satisfies Non negativity restriction of Lpp is Called Feasible solution.
Feasible Region	The region which is common to all the constraints of the given Lpp.
Optimal solution	Any feasible solution which optimizes the objective function of Lpp is called optimum solution.
Basic solution	The solution of m basic variables when each of the (n-m) non-basic variable is set to zero is called basic solution
Basic/ Initial feasible solution	A basic solution in which all the basic variables are p0nis called a basic feasible solution.
Non-degenerate solution	It is the basic feasible solution which has exactly m positive xi (i = 1,2….m), i.e., none of the basic variables are zero.
Degenerate solution	A basic feasible solution is said to be degenerate if one or more basic variables are zero.

unbounded solution	If the value of the objective functions Z can be increased or decreased indefinitely solutions are called unbounded solutions."
Multiple/ infinite/Alternat Solution	LPP having more than one optimal solution is called Multiple Solution.
Infeasible/ No solution	It means "No feasible solution"
Redundant constraint	It is one which does not affect the feasible region.

8. List and explain the terminology in Simplex Method?

Basic variable	It is that specific variable that corresponds to the pivot column.
Slack variable	When the constraints of a LPP is in ≤ type, add slack variable to convert Inequalities to equalities.
Surplus variable	When the constraints of a LPP is in≥ type, add surplus variable to convert Inequalities to equalities.
Artificial variable	When the constraints of a LPP is in(≥/ =)type, add artificial variable to Convert Inequalities to equalities.
Entering variable	The variable goes from zero to non zero, it is said to enter the basis and is called Entering variable.
Leaving variable	The variable goes from non zero to zero, it is said to leave the basis and is called Entering variable.
Pivot Element/ Equation	The element that lies at the intersection of the key Row and key Column of the simplex table is called Pivot element.

9. Define Duality?

The associated with any LPP is another LPP called its dual. The first way of stating Linear Programming Problem is called the primal and the second way of stating Linear Programming Problem is called the dual**.**

10. Write the relationship of the primal and dual problems?

S.No	Primal	Dual
1	Maximization	Minimization
2	No of variables	No of Constraints
3	No of Constraints	No of variables
4	Coefficient for j^{th} variable in i^{th} constraint	Coefficient for i^{th} variable j^{th} constraint

UNIT-III

ASSIGNMENT AND TRANSPORTATION PROBLEM

1. Write the difference between TP & AP? (Five Marks)

S.No	Transportation Problem	Assignment problem
1	It is a special class of LPP in which the transport of commodity from the sources to the destination such that the cost Incurred is Minimum.	It is one in which n-jobs to n-persons such that each job can be assigned to only one person so that time taken by all the persons to complete the job are Minimum.
2	Supply at any source be positive Quantity.	Supply at any source will be one.
3	Demand at any destination be postive Quantity.	Demand at any destination will be one.
4.	One or More source to any number of destination	One source to only one destination.

2. Mention the Application of Assignment Problems?

- Scheduling deliveries to customers.
- Assigning Accountants to auditing jobs
- Matching buildings plans to potential builders.
- Assigning sales person to territories.
- Manufacturing Personnel to Machines.
- Allocate Nurses to Duty.

3. Mention the Assumption of Assignment Problems?

- The number of workers and the number of jobs to be same.
- Each worker is to be assigned to exactly one job.
- Each job is to be performed by exactly one worker.

4. What is unbalanced Problem?

If the number of rows is not equal to number of column, it is called as unbalanced problem.

5. What is a Transshipment problem?

- It is defined as the transfer of stock between two locations at the same level of the inventory/distribution system

6. What is traveling Salesman problem?

- It is the problem to the find the shortest possible route that visits each city exactly once and returns to the origin city.

7. Write the mathematical model of Transportation / Assignment problem? (Five Marks)

If x_{ij} is the number of units shipped from source i to destination j, then

Find x_{ij} such that

Minimize $$z = \sum_{i=1}^{m} \sum_{j=1}^{n} C_{ij} x_{ij}$$

Subject to $$\sum_{j=1}^{n} x_{ij} = a_i \qquad i = 1, 2, 3, \ldots, m$$

and $$\sum_{i=1}^{m} x_{ij} = b_j \qquad J = 1, 2, 3, \ldots, n$$

where $$x_{ii} \geq 0$$

8. What is a forbidden assignment problem/ Prohibited or Restricted Assignment problem?

- A restricted assignment problem is the one in which one or more allocations are prohibited or not possible.

UNIT-IV

NETWORKING-REPLACEMENT-SEQUENCING-QUEUING-INVENTORY MODELS

PROJECT MANAGEMENT

1. Define Project?

It is defined as a combination of interrelated activities all of which must be executed in a certain order to achieve a goal.

2. What is an Event and activity?

- It represents an instant of time at which an activity of a project starts or finishes.
- It is a task or an item of work to be done in a project. What is?

3 What is Dummy Activity?

It is an activity which takes no time in completion and requires no resources.

4 What is Arrow Diagram and AON Diagram?

- The diagram in which arrow represents an activity is called arrow diagram.
- There is another representation of a project network representing activities on nodes called AON Diagram.

5. What is Looping and Dangling?

- It is known as cycling error and creates an impossible situation and it appears that none of the activities could ever be completed.
- It is a loose activity in your project schedule, and it has neither a predecessor activity neither a successor activity.

6 What is Slack and total float?

- It is the difference between its latest and earliest event time.
- It is the difference between the latest start and earliest start of the activity.

7. Define free float, Independent and Interference float?

Free Float: it is the portion of the total float within which an activity can be manipulated without affecting the floats of the subsequent activities.
Independent Float: it is the potion of the total float within which an activity can be delayed for start without affecting floats of the preceding activities.
Inference float: it is nothing but the slack of the head event j.

8. What is critical path?

The longest path in the network is called the critical path.

9. What is Critical activities / Bottle Neck activities?

All the activities on the critical path are called bottleneck activities.

10. What is time/ Gannt Chart?

It is a type of bar chart that shows both the scheduled and completed work over a period of time.

11. What is crashing? Mention its purpose?

It is a method for shortening the project duration by reducing the time of one or more of the critical project activities to less than its normal activity time.

Purpose:

- To reduce the scheduled completion time to reap the results of the project sooner.
- As project continues over time, the team consumes indirect costs.
- To reduce project duration while minimizing the cost of crashing.

12 Define Cost slope/ Define Slope in Crashing?

It indicates the additional cost incurred per unit of time saved in reducing the duration of an activity.

Cost Slope = {Crash cost - Normal cost}/ {Normal time – Crash time}

13. Define Crash and Normal Time?

- Crash time is the minimum time required to complete an activity.
- Normal time is the minimum time required to complete an activity at normal cost.

14 Mention the objectives of Network Analysis?

- Reduction of time.
- Inter relationship of various activities.
- Cost control.
- Minimization of maintenance time.
- Helpful in planning.

15 Mention the rules / Guideline for Project Network Analysis? (Five Marks)

- There must be no loops.
- No dangling should appear in a project network.
- Each activity must start and end in a node.
- ⟶ Arrow represents activities.
- ○ Circle represents activities.
- Events should be numbered in ascending order.
- An event number should be repeated.

16 Mention the Stages/ Phases of Project Management?

- Planning stage
- Scheduling stage
- Control stage.

17 Write the difference between CPM AND PERT? (Five Marks)

S.NO	CPM	PERT
1	It is called Critical Path Method	It is called Program Evaluation Review Technique
2	It is deterministic model.	It is probabilistic model.
3	It is activities oriented.	It is Event oriented.
4	Resources materials are Unlimited.	Resources materials are limited
5	It was developed for conventional projects	It was developed in a brand New R& D Project.
6	It is used for Repetitive jobs	It is used for Non-Repetitive jobs
7	It deals with Well Known time.	It deals with Uncertain time.
8	It deals with the concept of crashing	It does not deals with the concept of crashing
9	It cannot be used as a control devices	It is used as control devices.
10	It does not make use of statistical devices.	It makes use of statistical devices
11	It does not make use of Dummy Activities.	It makes use of Dummy Activities.
12	Time is fixed.	Three times a, b, m are given.

REPLACEMENT MODEL

1. What is replacement?

- It is concerned with situations that arise when some items such as machine, men, lights or any other equipment need replacement due to their decreasing efficiency, failure or breakdown.
- In such cases the old items have to be replaced by new ones to prevent any further increase in expenditure. This is called replacement.

2. Mention some of the replacement policies?

- Replacement policy for items whose maintenance cost increases with time and money is the counted.
- Replacement policy for items whose maintenance cost increase with time and the money value changes with constant rate.
- Replacement policy for items that fail completely, which includes
  (a) Individual replacement policy
  (b) Group replacement policy.

3. What are the situations which make the replacement of items necessary?

- When equipment or machine becomes worse with time.
- When items like light bulbs, electronic resistors etc. fail completely.
- Problems of mortality and staffing.
- The old item has failed and does not work at all.
- The old item is expected to fail shortly.

4. Mention the Assumption of Replacement theory?

- The quality of the output remains constant
- Replacement and maintenance cost remains constant.
- The operational efficiency of the equipment remains constant.

5. What is Replacement Decision?

- Time of replacement
- How much to replace
- How to replace.

6. What is preventive replacement?

Preventive replacement is a procedure which provides for replacement after a time when the effect of ageing has become sufficiently critical even of the actual failure has not yet occurred.

7. Distinguish between Individual replacement and Group replacement Policy?

Individual replacement	**Group replacement**
• Items are replaced as and when they fail	All items are replaced after certain period Irrespective of their condition in addition to individual replacement as and when they fail.
• Cost of individual replacement Is high.	Cost is low
• Failure probability is not Needed for replacement.	Failure probability is used to fine Replacement period.

8. What are the types of failures?

A. Gradual failure
B. Sudden failure

A. Gradual failure: It means slow as the life of the item increases, its efficiency decreases resulting in (i) Increased expenditure for operating costs
(ii) Decreased output of the machine
(iii) Decreased in resale value of the machine.

B.Sudden failure: It means those items which ultimately fail after a period of use.
(i) Progressive failure – The probability of failure increase with the age of the item.
(ii) Retrogressive failure- There are items having greater probability of failure in early life.
(iii) Random failure – There are items where in failure may occur randomly independent of the age.

9. What is salvage value?

Salvage or resale value is the actual worth or cost of any machine at a given period of time. When the age of the machine increases, the salvage value decreases.

10. Define discount factor?

Let r per cent be the rate at which money value decreases. The present worth factor of unit amount to be spent after one year is given by

V = (1+r)^-1 where V is called the discount rate or discount factor.

11. Define simulation?

The representation of reality in some physical form or in some form of mathematical equations may be called simulation.

12. Monte-Carlo technique?

It is a simulation technique in which statistical distribution functions are created by using a series of random numbers.

SEQUENCING PROBLEMS

1. What is sequencing problems?

It is the problem of determining an appropriate order for a series of a jobs to be done on finite number of machine, so as to minimize the total time taken for all the jobs.

2. Mention the Assumption in sequencing problems? (Five Marks)

- Only one operation is carried out on a machine at a time.
- Each operation as well as job once started must be completed.
- Processing time are known and do not change.
- An operation must be completed before its succeeding operation can start.
- All machines are of different types.

3. Narrate the Terminology in sequencing problems?

a. **Idle time:** it is the time the machine remains idle during the total elapsed time.
b. **Elapsed time**: it is the time between the first job and completing the last one.
c. **Number of Machine:** It is a process through which a job must pass before its is completed in the shop.
d. **Processing Time**: Every operation requires certain time at each of machine.
e. **No Passing rule**: this rule means that each job will go to Machine A first and then Machine B.

QUEUING THEORY

1. Mention the terminology in Queuing theory?

1. **Queuing theory**: It is concerned with the study of waiting lines/ Queue.
2. **Queue**: A group of people waiting to receive service are known as Queue.
3. **Waiting Line:** A line formed by customers waiting to get service is known as Waiting Line.
4. **Length of the Queue:** It indicates the average number of customers waiting in the line.
5. **System:** It means Maximum capacity of the Queue.
6. **Waiting Time:** This is the average time that a customer has to wait to get service.
7. **Idle Time:** It refers to the situation where the system remains idle.
8. **Service time**: The time taken in providing service to customers.
9 **Customer:** A unit coming for service to the service station is known as Customers.
10. **Service Channel:** it provides a service to the incoming customer is known as Service channel.

2. What is Queue Discipline?

The order in which the customers are selected from the Queue for service is known as Queue discipline.

a. FIFO – First In, First Out.
b. LIFO - Last in, First Out.
c. SIRO – Service in Random order.
d. SIP – Service in Priority.

3. Mention Queue behaviors?

a. Balking: A customer may leave the Queue, if there is no waiting space.
b. Jockeying: A customer may jump from one waiting line to another.
c. Reneging: This occurs when the waiting customers leave the Queue due to Impatience.
d. Collusion: When one customer represents a group of customers is called as Collusion.
e. Cycling: A customer returning to the Queue immediately after obtaining services.

4. What is Transient and Steady State?

- A system is said to be in **Transient state**, when its operating characteristic are dependent on time.
- A system is said to be **Steady state,** when the behaviors of the system is independent of time.

5. State Possion Axioms?

A Possion distribution is a discrete probability distribution, which predicts the number of arrivals in a given time.

6. Define traffic intensity or utilization factor.

An important measure of a simple queue is its traffic intensity given by

$$\rho = \frac{\text{mean arrival rate } \lambda}{\text{Mean service rate } \mu}$$

7. Mention the features/ Characteristic/ Components/ Elements/ Process/Structure of Queuing System or Waiting line system? (Five Marks)

A. Arrival / Input pattern:

a. Source (i) Finite – People visiting hospital.
(ii) Infinite: People visiting Taj mahal.
b. Size of Arrival (i) Single – People arrival at Railway station.
(ii) Batch – People arrival at hotel.
c. Arrival Control (i) Controllable
(ii) Non controllable
d. Arrival rate

B. Service /Departure/ output pattern:

a. System Configuration (i) single channel
(ii) Multi channel
b. Service Rate

C. Actual Queues / Waiting lines:

a. FIFO – First In, First Out.
b. LIFO - Last in, First Out.
c. SIRO – Service in Random order.
d. SIP – Service in Priority.

Queue behaviors

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b. Jockeying: A customer may jump from one waiting line to another.
c. Reneging: This occurs when the waiting customers leave the Queue due to Impatience.
d. Collusion: When one customer represents a group of customers is called as Collusion.
e. Cycling: A customer returning to the Queue immediately after obtaining services

8.Mention the Application of Queuing Theory?

- Access to telecommunication Networks.
- Number of Runways at Airport.
- Number of flight between 2 cities.
- Number of Traffic signal lights.
- Number of Elevators in building.
- Size of Restaurant.
- Scheduling work in large computer System.
- Problems of machine break down and repairs.
- Applied to Wages, Incentives plans.

9. Mention Kendall's Notation? (Five Marks)

Kendall's notation is used for representing queuing models. Generally model may be completely specified in the following symbol form (a/b/c) :(d/ e/ f)

a = Arrival Distribution
b = Departure Distribution
c = number of service channel
d = Service Discipline
e = Maximum Number of Customers allowed in the system.
f = Calling population / Source.

INVENTORY MODELS

1. **What is meant by inventory?**
   - It is an idle resources that posses Economic value.
   - It is a stock of materials kept on hand by the firm for use in the future time.

2. **Mention the types of Inventories?**

A. Direct Inventories:
- Raw material
- Work in progress
- Finished goods.

B. Indirect Inventories:
- Movement inventories
- Buffer inventories
- Lot size inventories
- Fluctuation inventories.

3. **What are the main objectives/functions of an inventory model?**
   - It provides adequate service to the customers.
   - It reduces the possibility of duplication of orders.
   - It helps in minimizing the loss due to deterioration, obsolescence, damage, etc.
   - It optimizes the cost associated with inventory.
   - It helps in deciding whether to avail price discount or bulk purchases.

4. **Mention the importance/ Reasons for maintain Inventory?**
   - It takes care of Economic fluctuation.
   - It acts as a buffer stock.
   - To meet possible shortage in future.
   - To absorb variation in demand and production.
   - It helps in smooth and efficient running of business.

5. Mention two inventory decisions?

- How much to order?
- When should the order be placed?
- How much safety stock should be kept?

6. Distinguish between deterministic model and probabilistic model?

Deterministic model	Probabilistic model
1. Demand is either static or dynamic.	Demand is stationary or non-stationary.
2. Lead time is constant	Lead time is not constant
3. Lead time demand is known and fixed	Lead time demand is assumed to follow nor distribution.

7. Mention various inventory models? (Five Marks)

- Purchasing model with no shortages
- Manufacturing model with no shortages
- Purchasing model with Shortages
- Manufacturing model with Shortages.

8. What are the different costs that are involved in the inventory problem? (Five Marks)

a. Carrying / Holding cost: The cost associated with holdings the goods in stock is Known as carrying cost.
Ex: Auditing cost, production cost. Insurance costs.

b. Ordering / set up costs: The costs associated with obtaining goods through placing an order Or setting up machinery before starting production.
Ex: Postage, Telephone, Inspection.

c. Shortage/ Stock out costs: The penalty costs that are incurred as a result of running out of stock are called Shortage.

9. Define the terminology in Inventory?

a. Lead time: The time gap between placing of an order and its actual arrival in the inventory is known as lead time.

b. Order cycle: The time period between placements of two successive orders is referred to as an order cycle.

c. Time horizon: The time period over which the inventory level will be controlled is known as time horizon.

d. Re-order level (ROL): The level between maximum and minimum stock at which purchasing activities must start for replenishment is known as re- order level.

e. Safety / Buffer Stock: It means the extra inventory maintained in addition to the inventory required corresponding to normal consumption levels

f. Price Break: Some discount in unit price is offered to large purchasing quantity**.**

g. Economic life: The expected period of time during which an asset is useful to the average owner.

10. What is economic order quantity(EOQ)?

- It is the quantity of materials to be ordered at the point where to minimize the ordering costs and carrying costs.
- Assumption Of EOQ:
  - i. Demand is known and costant
  - ii. Lead time is known and constant
  - iii. Quantity discount are not availed.
  - iv. Constant unit price, ordering and carrying costs.

11. What is inventory control?

- It is a system which ensures the provision of the required quantity of inventories at appropriate time and at reasonable price.

12. Mention two inventory control System?

A. Fixed order Quantity (Q) system: A fixed qty is ordered at variable interval of time.
B. Periodic Review (P) system: A variable Qty is ordered at fixed time intervals.

13. Mention various Inventory Control Techniques? (Five Marks)

TECHNIQUES	EXPANSION
ABC CLASSIFICATION	Always Better Control
VED CLASSIFICATION	Vital , Essential, Desirable
HML CLASSIFICATION	High, Medium, Low value items
FNSD CLASSIFICATION	Fast, Normal, slow, Non moving items
SDE CLASSIFICATION	Scarce, Difficult, Easily available items
SOS CLASSIFICATION	Seasonal, Off seasonal items
GOLF CLASSIFICATION	Govt, Open, Local , Foreign market Supplies

UNIT-V

GAME THEORY

1. Define a game?

The competitive situation will be called a game, if it has the following properties:

- There is a finite number of participants called players.
- Each player has a finite number of strategies available to him.
- Every game results in an outcome.
- Every outcome involves stakes.

2. What is Game theory?

A mathematical theory based on which strategy steps are employed to win a game played in a conflicting situation to maximize the profit or minimize the loss.

3. Mention the features/Characteristic and Limitation of Game theory?

CHARACTERISTIC:

- Finite number of Competitors.
- Finite number of action.
- Choice of opponent
- Knowledge of Alternatives.
- Outcome.

LIMITATION:

- Infinite number of strategy.
- Knowledge about strategy.
- Zero outcomes.
- Risk and uncertainty.
- Certainty of Pay off.

4. Mention the Assumption of Game Theory?

- The existence of conflicts.
- A set of rule exists.
- Pay off is fixed before the game.
- Decision once taken cannot be reversed.
- Each side has its plan and strategies.

5. What is meant by Minimax, Maximin?

Minimax: Maximum of row minima.
Maximin: Minimum of column maxima.

6. Define strategy.

A finite number of possible causes of action, available to a player are called strategies.

7. What is Pure Strategy?

The decision of a player to use only one particulars course of action, during every play, he is said to use a pure strategy.

8. What is Mixed Strategy?

The decision of a player to choose atleast two of his course of action with fixed probabilities is called mixed strategy.

9. What is Optimal strategy?

A particular strategy by which a player optimizes his gain or loss without knowing the competitors strategies is called "Optimal strategy".

10. What is Pay off Matrix?

The gains resulting from a game presented in the form of a table is called pay off matrix.

11. Define Saddle Point?

It is an element of Pay off matrix, which is the smallest element in its row and the largest element in its column.

12. Define Value of the Game and Fair of the game?

The Pay off at the saddle point is called the Value of the game.
If the value is zero, it is called the fair of the game.

13. Define Zero sum Game?

If the algebraic sum of gains and losses of all the players is zero then it is said to be Zero sum game.

14. Define Two person Zero sum Game?

A game with two players, where a gain of one player equals the loss of the other is known as a two-person zero sum game.

15. What is Rectangular game?

Two people zero sum game is also called rectangular game because their pay off matrix is with the rectangular form.

16. Define Dominance Rule/ Property?

It states that ineffective rows and column can be deleted from the game matrix and only effective rows and columns of the matrix are retained in the reduced matrix.

SIMULATION

1. Define Simulation?

- It means experimentation based on a mathematical model which imitates a real life situation.
- The representation of reality in some physical form or in some form of mathematical equations may be called simulation. Example:Testing of medicines on animals in laboratories .

2.What is Stochastic and deterministic model ?

- A stochastic model contains one or more random variables
- A deterministic model contains no random variables

3. State the types of Simulation?

- Probabilistic simulation
- Visual simulation
- Time dependent and Time Independent Simulation
- Large System Simulation
- Business Games

4.When to use Simulation?

- This is used because one is satisfied with sub-ptimal results for decision-making.
- It also representation by a mathematical model is beyond the capabilities of the analyst.

5.Write down the steps involved in Simulation Process?

- Formulate the problem and plan the study
- Collect Data and Develop the simulation Model
- Check the Accuracy of the simulation Model
- Select the software and construct a computer program
- Test the validity of the simulation problem
- Plan the siumlations to be performed
- Conduct the siumluation run and analyse the results
- Present Recommendations to Management

6.State the application /uses of Simulation?

- New product development
- Airline Researvation
- Inventory Policy
- Waiting lines
- Financial Risk Analysis
- Traffic flow
- Health care applications

7.What are the advantages of simulation?

- Mathematically less complicated.
- flexible
- Modification
- Time saving
- Bifurcation system

8.what are the limitation of simulation?

- quantification of the variables may be difficult.
- simulation may not yield optimum results.
- simulation may not always be cheap.
- simulation may not always be less time comsuming.
- the results obtained from simulation models cannot be completely relied upon.

9. Explain Monte-Carlo technique(5 marks)

- When the system being simulated includes data inputs that are random variables, a technique known as monte carlo simulation.
- It is a simulation technique in which statistical distribution functions are created by using a series of random numbers.
- The steps involved in monte carlo simulation are as follows
  - ✓ Establishing probability distribution
  - ✓ Cummulative probability distribution
  - ✓ Setting Random Number Intervals
  - ✓ Generating Random Numbers
  - ✓ Simulating a series of trails

10. Define random number?

Random number is a number whose probability of occurrence is the same as that of any other number in the collection.

11. Define Pseudo-random number?

Random numbers are called Pseudo-random numbers when they are generating by some deterministic process and they qualify the pre- determined statistical test for randomness.

INTEGER LINEAR PROGRAMMING

1. What do you mean by integer programming problem?

An LPP in which some or all of the variables in the optimal solution are restricted to assume non-negative integer values is called an integer programming problem.

2. Define a pure integer programming problem?

In a LPP, if all the variables in the optimal solution are restricted to assume non- negative values, then it is called a pure IPP.

3. Define a mixed integer programming problem?
In an LPP, if only some of the variables in the optimal solution are restricted to assume non-negative integer values, while the remaining variables are free to take any non- negative values, then it is called a mixed integer programming problem.

4. Differentiate between pure and mixed IPP?
In a pure IPP all the variables in the optimal solution are restricted to assume non- negative integer values. Whereas in mixed IPP, only some of the variables in the optimal solution are restricted to assume non- negative integer values.

5. Give some applications of IPP?
(i) In product mix problem
(ii) Sequencing and routing decisions
(iii) All allocation problems involving the allocation of goods, men and machine.

6. What are the methods used in solving IPP?
There are two methods, namely,
(iv) Cutting methods (Gomary's cutting plane algorithm)
(v) Search method (Branch and bound technique)

7. Define gomarian constraints or fractional cut constraints.
A new constraints introduced to the problem such that the new set of feasible solution includes all the original feasible integer solution but does not include the optimum non- integer solution initially found. This new constraint is called fractional cut or gomarian's constraint.

8. Why not found off the optimum values instead of resorting programming? Explain.
If the non- integer variable is rounded off, then it violates the feasibility and also there is no guarantee that the rounded solution will also be optimal.

9. Where is Branch and Bound method used?
This method is an enumeration method which is used when all feasible integer points are not enumerated.

DYNAMIC PROGRAMMING

1.What is Dynamic Programming Problem ?

It is a technique used to solve a multi-stage decision problem where decisions have to be made at successive stages.

2.State features/ Characteristics of Dynamic Programming Problem ?

- Multi stages decision making
- Number of states
- Principle of optimality
- Less number of variables at each stages

3.What are the applications of Dynamic Programming Problem ?

- Captibal budgeting techniques
- Optimal routing problem
- Production scheduling
- Inventory management
- Allocation of scarce resources to different alternative uses

GOAL PROGRAMMING

1.What is Goal Programming ?

- Goal programming is a powerful technique that is capable of handling multiple decision criteria.
- In other words, goal programming is a powerful tool to tackle multiple and incompatible goals of an enterprise.

2.What are the steps involved in the formation of goal programming ?

- Define variable
- Formulate constraints
- Develop the objective functions

3.What are the applications of Goal Programming Problem ?

- Product Mix decisions
- Portfolio Selection
- Production scheduling and planning
- Manpower planning
- Medical care planning