

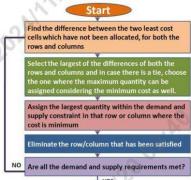
- 1. What is an operation research?** Operations Research (OR), an analytical method of decision making, solves management problems by breaking down the problem into elementary components, and solve them in well-defined steps using mathematical analysis.
- 2. What is payoff matrix?** A payoff matrix specifies the probable value of different alternatives, depending on different possible outcomes associated with each.
- 3. What is assignment problem?** An assignment problem is a particular case of transportation problem. The objective is to assign a number of resources to an equal number of activities. So as to minimize total cost or maximize total profit of allocation.
- 4. Write the concept of duality?** As hinted at by the word "dual" within it, duality refers to having two parts, often with opposite meanings, like the duality of good and evil. If there are two sides to a coin, metaphorically speaking, there's a duality.
- 5. What is simplex method?** Simplex method is an approach to solving linear programming models by hand using slack variables, tableaus, and pivot variables as a means to finding the optimal solution of an optimization problem. Simplex tableau is used to perform row operations on the linear programming model as well as for checking optimality.
- 6. What is primal problem?** In general given two dual pairs of separated locally convex spaces and and the function , we can define the primal problem as finding such that. In other words, if exists, is the minimum of the function, and the infimum (greatest lower bound) of the function is attained.
- 7. Short note on game theory.** In environmental and natural resource management, Game Theory is a helpful tool to analyze e.g., international environmental problems, situations when international environmental treaties are decided, or competition over exhaustible natural resources.
- 8. Write the expansion of PERT.** The program evaluation and review technique (PERT) is a statistical tool used in project management, which was designed to analyze and represent the tasks involved in completing a given project.
- 9. Define optimum?** Optimum utilization of resources is a concept in Economics and Management and can be applied in businesses. Management principles are helpful in the optimum utilization of resources.
- Optimum Utilization of resources** means using the resources available at hand and making best use of them.
- 10. What is CPM?** The critical path method (CPM) is a technique where you identify tasks that are necessary for project completion and determine scheduling flexibilities. A critical path in project management is the longest sequence of activities that must be finished on time in order for the entire project to be complete.
- 11. Name any two uses of replacement model?** The replacement situations may be placed into the following two main categories : (1) Replacement of capital equipment that deteriorates with time, e.g., machine tools, buses in transport organization, planes, etc. (2) Individual or group replacement of items that fail completely, e.g., light bulbs, tubes, etc.
- 12. What is graphical method?** Graphical method to solve Linear Programming problem (LPP) helps to visualize the procedure explicitly. It also helps to understand the different terminologies associated with the solution of LPP. Linear programming problems with two variables can be represented and solved graphically with ease.
- 13. What are the necessity of O.R.?** The resources you need to start a business can be broken into five broad categories: financial, human, educational, emotional and physical resources. • Financial Resources: Funding. ... • Human Resources: Employees. ... • Educational Resources: Industry Know How. ... • Physical Resources: Premises and Equipment.
- 14. List out any two applications of O.R.** Organizations use the following resource management techniques to maximize resource efficiency, often relying on software to provide transparency to help leaders make smarter resource decisions. • Resource Allocation. ... • Resource Utilization. ... • Resource Leveling. ... • Resource Forecasting.
- 15. What is Travelling Salesman problem?** The traveling salesman problem (TSP) is an algorithmic problem tasked with finding the shortest route between a set of points and locations that must be visited. In the problem statement, the points are the cities a salesperson might visit
- 16. Write the expansion of CPM?** The critical path method (CPM) is a technique where you identify tasks that are necessary for project completion and determine scheduling flexibilities. A critical path in project management is the longest sequence of activities that must be finished on time in order for the entire project to be complete.
- 17. What is Linear programming?** Linear programming is a mathematical technique that determines the best way to use available resources. Managers use the process to help make decisions about the most efficient use of limited resources – like money, time, materials, and machinery.
- 18. What is Simulation?** A simulation is a model that mimics the operation of an existing or proposed system, providing evidence for decision-making by being able to test different scenarios or process changes. This can be coupled with virtual reality technologies for a more immersive experience.
- 19. What are the two important forms of Primal-dual pairs?** 1. Symmetric: Here all constraints of both primal and dual problems are in equations and variables are non negative. 2. Un-Symmetric: Here all constraints of primal are equations and primal variables are non negative.
- 20. What are the advantages of CPM?** Advantages of Critical Path Method. The critical path method is a reliable way for project managers to budget time and allocate resources. Advantages of CPM include improved accuracy and flexibility in scheduling, clearer communication between project managers and stakeholders, easier task prioritization
- 21. What is Computer simulation?** computer simulation, the use of a computer to represent the dynamic responses of one system by the behaviour of another system modeled after it. A simulation uses a mathematical description, or model, of a real system in the form of a computer program.
- 22. What is Sequencing model?** Sequencing can be defined as the selection of an order for a series of jobs to be done on a number of service facilities (machine). In sequencing, a systematic procedure is adopted in assigning priorities to waiting jobs thereby determining the sequence in which jobs will be processed.
- 23. What are the examples of Assignment Model?** What are Assignment Models? Assignment models are used to estimate the traffic flows on a network. Traffic Assignment Models estimate the flow on a street or highway network using an input matrix of flows that indicate the volume of traffic between origin and destination (O-D) pairs
- 24. What is idle time on machines?** Idle time is a period of time in which an asset (machine or an employee) is ready and available, but is not doing anything productive. This is why idle time is sometimes referred to as waiting time. Idle time is when a machine is waiting for input material.
- 25. What are two limitations of an OR model?** Limitations of Operations Research • (i) Magnitude of Computation. • (ii) Non-Quantifiable Factors. • (iii) Distance between User and Analyst. • (iv) Time and Money Costs. • (v) Implementation.
- 26. Define zero-sum game?** What Is a Zero-Sum Game? Zero-sum is a situation, often cited in game theory, in which one person's gain is equivalent to another's loss, so the net change in wealth or benefit is zero. A zero-sum game may have as few as two players or as many as millions of participants.
- 27. What is sequencing problem?** Sequencing problems are concerned with an appropriate order (sequence) for a series of jobs to be done on a finite number of service facilities (like machines) in some well-defined technological order so as to optimize some efficiency measure such as total elapsed time or overall cost etc.
- 28. Write any two characteristics of standard form of LP?** The standard form of linear programming problem: • The standard form of linear programming is The characteristics of a standard linear program are: 1) Maximization of a program, 2) Equality constraints and 3) non-negative variables.
- 29. What is Game theory?** Game theory is a branch of applied mathematics that provides tools for analyzing situations in which parties (called players) make decisions that are interdependent. This interdependence causes each player to consider the other player's possible decisions(or strategies) in formulating strategy.
- 30. Who is salesman problem?** The travelling salesman problem (also called the travelling salesperson problem or TSP) asks the following question: "Given a list of cities and the distances between each pair of cities, what is the shortest possible route that visits each city exactly once and returns to the origin city
- 31. What is PERT?** A program evaluation review technique (PERT) chart is a graphical representation of a project's timeline that displays all of the individual tasks necessary to complete the project. As a project management tool, the PERT chart is often preferred to the Gantt chart because it identifies task dependencies.
- 32. What are the transportation models?** The transportation model addresses the concept of moving a thing from one place to another without change. It assumes that any damage en route has negative consequences, and so it's used to analyze transportation systems and find the most efficient route for resource allocation
- 33. What is Monte Carlo method?** Monte Carlo Simulation is a mathematical method for calculating the odds of multiple possible outcomes occurring in an uncertain process through repeated random sampling. This computational algorithm makes assessing risks associated with a particular process convenient, thereby enabling better decision-making
- 34. What are the objectives of Operation Research?** The central objective of operations research is optimization, i.e., "to do things best under the given circumstances." This general concept has great many applications, for instance, in agricultural planning, biotechnology, data analysis, distribution of goods and resources, emergency and rescue operations, engineering

- 35. What is the test of optimality in the simplex method?** In the standard Simplex method, the optimality test is based on a reading of the coefficients of the nonbasic variables in the zeroth row of the Simplex tableau; that is, it is based on a reading of the reduced costs.
- 36. What is Feasible solution?** A feasible solution is a set of values for the decision variables that satisfies all of the constraints in an optimization problem. The set of all feasible solutions defines the feasible region of the problem.
- 37. What is Duality problem?** The dual problem is an LP defined directly and systematically from the primal (or original) LP model. The two problems are so closely related that the optimal solution of one problem automatically provides the optimal solution to the other
- 38. What is Transportation problem?** The transportation problem is a special type of linear programming problem where the objective consists in minimizing transportation cost of a given commodity from a number of sources or origins (e.g. factory, manufacturing facility) to a number of destinations (e.g. warehouse, store)
- 39. What is Assignment problem?** Assignment problem apparent problem is assigning each task to a person that the processing time is given we should make sure that only one job is assigned to a person
- 40. What is variation of Assignment problem?** The assignment problem is classified into balanced assignment problem and unbalanced assignment problem. If the number of rows is equal to the number of columns, then the problem is termed as a balanced assignment problem; otherwise, an unbalanced assignment problem.
- 41. What is Monte Carlo method?** Monte Carlo Simulation is a mathematical method for calculating the odds of multiple possible outcomes occurring in an uncertain process through repeated random sampling. This computational algorithm makes assessing risks associated with a particular process convenient, thereby enabling better decision-making
- 42. What is sequencing problem?** Sequencing problems are concerned with an appropriate order (sequence) for a series of jobs to be done on a finite number of service facilities (like machines) in some well-defined technological order so as to optimize some efficiency measure such as total elapsed time or overall cost etc.
- 43. Define simulation?** Simulation techniques consist in sampling the input and characterizing the uncertainty of the corresponding output. This is notably the case of the crude Monte Carlo method that is well suited to characterize events whose associated probabilities are not too low with respect to the simulation budget

44. Marks:

14. Discuss any three characteristics of assignment model. A model assignment maintains a clear goal toward accomplishing a course objective. For adult online learners, course goals relate less to theory or original research and more to practical approaches for day-to-day application or career advancement. More details equals higher quality of student final product. **1. Create assignments which directly relate to accomplishing the course objective.** A model assignment maintains a clear goal toward accomplishing a course objective. For adult online learners, course goals relate less to theory or original research and more to practical approaches for day-to-day application or career advancement. **2. More details equals higher quality of student final product.** Since adult online learners come from diverse backgrounds, do not assume students will understand the purpose of the assignment. Be prepared to tell students what you expect (e.g. word count, citation format, number of sources, etc.) and how it should be done (e.g. upload to Moodle versus email attachment). **3. Give incremental due dates.** Large comprehensive assignments due at the course finality leads to unfocused, or even plagiarized, writing. Break down a large assignment into several smaller assignments due sporadically throughout the term. In turn, students receive valuable feedback incrementally as they progress throughout the course. **4. Allow students to brainstorm for topics.** Allow students to brainstorm topics or share with other students using the Moodle Discussion Board form. Or consider offering students a choice among 3-4 essay questions, case scenarios, or case studies. By allowing student choice, students will find a greater connection in their writing which in turn will lead to better final submissions. **5. Give examples.** In addition to clear directions, students also appreciate a visual piece of the final product. If you decide to use another student's work, be sure to ask permission to use from the student. Post model assignments on your Moodle course shell. **6. Share student evaluation tools.** Share rubrics, or other evaluation tool, early in the assignment rather than at the end so students may clarify expectations first-hand. Post rubrics or evaluation tools on your Moodle course shell so students may refer to it when necessary.

- 16. Explain simplex method of solving a linear programming problem.** **Simplex Method** The Simplex method is an approach for determining the optimal value of a linear program by hand. The method produces an optimal solution to satisfy the given constraints and produce a maximum zeta value. To use the Simplex method, given a linear programming model needs to be in standard form, where slack variables can then be introduced. Using the tableau and pivot variables, an optimal solution can be reached. **Slack Variable** Slack variables are additional variables that are introduced into the linear constraints of a linear program to transform them from inequality constraints to equality constraints. **Surplus Variable** Surplus variables are variables subtracted into the linear constraints of a linear program to transform them from inequality constraints to equality constraints. If the inequality is \leq (less than or equal), then we add a slack variable + S to change \leq to $=$. For example: $2x_1 + x_2 \leq 3$ is an inequality. Then, $2x_1 + x_2 + s = 3$; s is the slack variable
- If the inequality is \geq (greater than or equal), then we subtract a surplus variable - S to change \geq to $=$. For example: $2x_1 + 3x_2 \geq 5$ is an inequality. Then, $2x_1 + 3x_2 - s = 5$; s is the surplus variable
- Standard Form of a maximization problem in two variables**
- Standard form is the baseline format for all linear programs before solving for the optimal solution and has three requirements: (1) must be a maximization problem, (2) all linear constraints must be in a less-than-or-equal-to inequality, (3) all variables are non-negative.
- Example:**
 $Z = 7x_1 + 5x_2$
subject to
 $x_1 + 2x_2 \leq 6$
 $4x_1 + x_2 \leq 12$
 $x_1, x_2 \geq 0$
- Basic Solution** Given a system of m linear equations with n variables ($m < n$). Any solution which is obtained by setting for m variables keeping the remaining ($n-m$) variables zero is called a basic solution.
- Basic feasible Solution** A basic solution, which also satisfies the non-negative constraints, is called a basic feasible solution. **Bounded, Unbounded, Empty Solutions** If the value of objective function Z has both a maximum value and minimum value, such a solution is a bounded solution. If the value of the objective function Z can be increased or decreased indefinitely, such solutions are called unbounded solutions. An unbounded solution has minimum values but no maximum value. An empty solution will have no maximum or minimum value. **Fundamental Theorem of LP** The fundamental theorem of linear programming says that if there is a solution, it occurs on the boundary of the feasible region, not inside the region. **Basic Variables** Basic variables are variables that are non-negative in terms of the optimal solution. **Non-Basic Variables** Non-basic variables are variables that are zero in terms of the optimal solution. **Simplex Tableau** Simplex tableau is used to perform row operations on the linear programming model as well as for checking optimality.
- Optimality Check** Optimal solutions of a maximization linear programming model are the values assigned to the variables in the objective function to give the largest zeta value. The optimal solution would exist on the corner points of the graph of the entire model.
- 17. Explain Vogel's approximation method in detail.** The Vogel's Approximation Method or VAM is an iterative procedure calculated to find out the initial feasible solution of the transportation problem. Like Least cost Method, here also the shipping cost is taken into consideration, but in a relative sense. The following is the flow chart showing the steps involved in solving the transportation problem using the Vogel's Approximation Method:

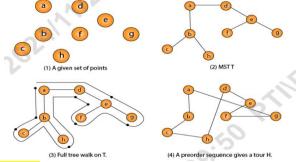


The concept of Vogel's Approximation Method can be well understood through an illustration.

18. Discuss about travelling sales man problem. In the traveling salesman Problem, a salesman must visits n cities. We can say that salesman wishes to make a tour or Hamiltonian cycle, visiting each city exactly once and finishing at the city he starts from. There is a non-negative cost $c(i, j)$ to travel from the city i to city j . The goal is to find a tour of minimum cost. We assume that every two cities are connected. Such problems are called Traveling-salesman problem (TSP). We can model the cities as a complete graph of n vertices, where each vertex represents a city. It can be shown that TSP is NPC. If we assume the cost function satisfies the triangle inequality, then we can use the following approximate algorithm. **Triangle Inequality** Let u, v, w be any three vertices, we have One important observation to develop an approximate solution is if we remove an edge from H^* , the tour becomes a spanning tree.

$$c(u,w) \leq c(u,v) + c(v,w)$$

One important observation to develop an approximate solution is if we remove an edge from H^* , the tour becomes a spanning tree. 1. Approx-TSP $G = (V, E)$ 2. { 3. 1. Compute a MST T of G ; 4. 2. Select any vertex r is the root of the tree; 5. 3. Let L be the list of vertices visited in a preorder tree walk of T ; 6. 4. Return the Hamiltonian cycle H that visits the vertices in the order L ; 7. } **Traveling-salesman Problem intuitively**, Approx-TSP first makes a full walk of MST T , which visits each edge exactly two times. To create a Hamiltonian cycle from the full walk, it bypasses some vertices (which corresponds to making a shortcut)



19. Explain PERT and CPM method. Project management can be defined as a structural way of planning, scheduling, executing, monitoring and controlling various phases of a project. To achieve the end goal of a project on time, PERT and CPM are two project management techniques that every management should implement. These techniques help in displaying the progress and series of actions and events of a project. **Meaning of PERT Program (Project) Evaluation and Review Technique (PERT)** is an activity to understand the planning, arranging, scheduling, coordinating and governing of a project. This program helps to understand the technique of a study taken to complete a project, identify the least and minimum time taken to complete the whole project. PERT was developed in the 1950s, with the aim of the cost and time of a project. **Meaning of CPM Critical Path Method or CPM** is a well-known project modelling technique in project management. It is a resource utilising algorithm that was developed in the 1950s by James Kelly and Morgan Walker. CPM is mainly used in projects to determine critical as well as non-critical tasks that will help in preventing conflicts and reduce bottlenecks. In essence, CPM is about choosing the path in a project that will help in calculating the least amount of time that is required to complete a task with the least amount of wastage. The Critical Path Method or CPM has been used in many industries starting from defence, construction, software, aerospace, etc. **PERT vs CPM Abbreviation** PERT – Project Evaluation and Review Technique. PERT – Project Evaluation and Review Technique. **What does it Mean?** PERT – PERT is a popular project management technique that is applicable when the time required to finish a project is not certain. CPM – CPM is a statistical algorithm which has a certain start and end time for a project. **Model Type** PERT – PERT is a probabilistic model. CPM – CPM is a deterministic model. **Focus** PERT – The main focus of PERT is to minimise the time required for completion of the project. PERT – The main focus of PERT is to minimise the time required for completion of the project. **Orientation type** PERT – PERT is an event-oriented technique. CPM – CPM is an activity-oriented technique. **Advantages of CPM** • Provides an outline for long term coordination and planning of a project • Recognizes critical activities • Easy to plan, schedule and control project • It improves productivity • Manages the resource needed. **Disadvantages of CPM** • For beginners it's difficult to understand • Software too expensive • Sometimes, to structure CPM is too time-consuming • It cannot control and form the schedule of a person involved in the project • Allocation of resources cannot be monitored properly

13. Discuss the essential characteristics of O.R. Three essential characteristics of operations research are a systems orientation, the use of interdisciplinary teams, and the application of scientific method to the conditions under which the research is conducted. **1. Decision making:** Operations research is a decision science which helps management to make better decisions. **2. Use of Information Technology (IT):** O.R. often requires a computer to solve the complex mathematical model or to perform a large number of computations that are involved. Use of digital computer has become an integral part of the operations research approach to decision making. **3. Quantitative solution:** Operations research provides the managers with a quantitative basis for decision making. OR attempts to provide a systematic and rational approach for quantitative solution to the various managerial problems. **4. Human factors:** In deriving quantitative solution we do not consider human factors, which doubtlessly plays a great role in the problems. So study of the OR is incomplete without a study of human factors. **5. System orientation:** O.R. study the situation or problems as a whole. This means that an activity by part of an organization has some effect on the activity of every other part. The optimum result of one part of a system may not be the optimum for some other part. Therefore, to evaluate a decision, one must identify all possible interactions and determine their impact on the organization as a whole. **6. Scientific approach:** O.R. uses scientific methods to solve the problems. Most of the scientific studies such as chemistry, physics, biology etc. can be carried out in the laboratories, without much interference from the outside world. But same is not true in the systems under study by OR teams. So, OR is a formalized process of reasoning. Under OR the problem is to be analysed ad defined clearly. Observations are made under different conditions to study the behavior of the system. On the basis of these observations a hypothesis describing how the various factors involved are believed to interact and the best solution to the problem is formulated. To test the hypothesis experiment is designed and executed. Observations are made and measurements are recorded. Finally results of the experiments are studied and the hypothesis is accepted or rejected. So, OR is the use of scientific method to solve the problem under study. **7. Inter-disciplinary team approach:** O.R. is performed by a team of scientists whose individual members have been drawn from different scientific and engineering disciplines. For example, one may find a mathematician, statistician, physicist, psychologist, economist and an engineer working together on an OR problem. **8. Uncovering new problems:** Solution of an OR problem may uncover a number of new problems. In order to derive the maximum benefit each one of them must be solved. OR is not effectively used if it is restricted to one shot problems only.

16. Discuss any four reasons for solving O.R. problems by simulation • risk-free environment. Simulation modeling provides a safe way to test and explore different "what-if" scenarios. ... • save money and time. ... • visualization. ... • insight into dynamics. ... • increased accuracy. ... • handle uncertainty. Simulation modeling solves real-world problems safely and efficiently. It provides an important method of analysis which is easily verified, communicated, and understood. Across industries and disciplines, simulation modeling provides valuable solutions by giving clear insights into complex systems.

18. Discuss Monte Carlo techniques for simulation. A Monte Carlo simulation is used to model the probability of different outcomes in a process that cannot easily be predicted due to the intervention of random variables. It is a technique used to understand the impact of risk and uncertainty. A Monte Carlo simulation is used to tackle a range of problems in many fields including investing, business, physics, and engineering. It is also referred to as a multiple probability simulation. • A Monte Carlo simulation is a model used to predict the probability of a variety of outcomes when the potential for random variables is present. • Monte Carlo simulations help to explain the impact of risk and uncertainty in prediction and forecasting models. • A Monte Carlo simulation requires assigning multiple values to an uncertain variable to achieve multiple results and then averaging the results to obtain an estimate. • Monte Carlo simulations assume perfectly efficient markets. **Monte Carlo Simulation Steps** Microsoft Excel or a similar program can be used to create a Monte Carlo simulation that estimates the probable price movements of stocks or other assets. There are two components to an asset's price movement: drift, which is its constant directional movement, and a random input, which represents market volatility. By analyzing historical price data, you can determine the drift, standard deviation, variance, and average price movement of a security. These are the building blocks of a Monte Carlo simulation. The 4 Steps in a Monte Carlo Simulation movement. By generating an arbitrary number of simulations, you can assess the probability that a security's price will follow a given trajectory.

19. Write the algorithm for dual simplex method. The Dual Simplex method is used in situations where the optimality criterion (i.e., $\sum c_j z_j \leq 0$ in the maximization case and $\sum c_j z_j \geq 0$ in minimization case) is satisfied, but the basic solution is not feasible because under the XB column of the simplex table there are one or more negative values. **What are the reasons for studying the dual simplex method?** • Sometimes it allows to easily select an initial basic solution without having to add any artificial variable. • It aids in certain types of sensitivity testing. • It helps in solving integer programming problems. **Algorithm, Example 1. Formulate the Problem** Formulate the mathematical model of the given linear programming problem. "The model is a vehicle for arriving at a well-structured view of reality." -Anonymous Convert every inequality constraint in the LPP into an equality constraint, so that the problem can be written in a standard form. 2. Find out the Initial Solution Calculate the initial basic feasible solution by assigning zero value to the decision variables. This solution is shown in the initial dual simplex table. 3. Determine an improved solution If all the values under XB column ≥ 0 , then don't apply dual simplex method because optimal solution can be easily obtained by the simplex method. On the contrary, if any value under XB column < 0 , then the current solution is infeasible so move to step 4. 4. Determine the key row Select the smallest (most) negative value under the XB column. The row that indicates the smallest negative value is the key row. 5. Determine the key column Select the values of the non basic variables in the index row ($j | c_j$), and divide these values by the corresponding values of the key row determined in the previous step. 7. Revise the Solution If all basic variables have non-negative values, an optimal solution has been obtained. If there are basic variables having negative values, then go to step 3. The rules for determining a key column and key row differentiate the dual simplex method from the standard simplex method.

13. Write the scope of Operation Research. **Scope of Operation Research** In recent years of organized development, OR has entered successfully in many different areas of research. It is useful in the following various important fields **In agriculture** With the sudden increase of population and resulting shortage of food, every country is facing the problem of optimum allocation of land to a variety of crops as per the climatic conditions **Optimum distribution of water** from numerous resources like canal for irrigation purposes Hence there is a requirement of determining best policies under the given restrictions. Therefore a good quantity of work can be done in this direction. **In finance** In these recent times of economic crisis, it has become very essential for every government to do a careful planning for the economic progress of the country. OR techniques can be productively applied **To determine the profit plan for the company** • To maximize the per capita income with least amount of resources **To decide on the best replacement policies, etc** **In industry** If the industry manager makes his policies simply on the basis of his past experience and a day approaches when he gets retirement, then a serious loss is encounter ahead of the industry. This heavy loss can be right away compensated through appointing a young specialist of OR techniques in business management. Thus OR is helpful for the industry director in deciding optimum distribution of several limited resources like men, machines, material, etc to reach at the optimum decision. **In marketing** With the assistance of OR techniques a marketing administrator can decide upon **Where to allocate the products for sale so that the total cost of transportation is set to be minimum** • The minimum per unit sale price **The size of the stock to come across with the future demand** • How to choose the best advertising media with respect to cost, time etc? **How, when and what to buy at the minimum likely cost?** **In personnel management** A personnel manager can utilize OR techniques **To appoint the highly suitable person on minimum salary** • To know the best age of retirement for the employees **To find out the number of persons appointed in full time basis when the workload is seasonal** **In production management** A production manager can utilize OR techniques **To calculate the number and size of the items to be produced** • In scheduling and sequencing the production machines **In computing the optimum product mix** • To choose, locate and design the sites for the production plans **In L.I.C OR approach is also applicable to facilitate the L.I.C offices to decide** • What should be the premium rates for a range of policies? **How well the profits could be allocated in the cases of with profit policies** **Role of Operations Research in Decision-Making** The Operation Research may be considered as a tool which is employed to raise the efficiency of management decisions. OR is the objective complement to the subjective feeling of the administrator (decision maker). Scientific method of OR is used to comprehend and explain the phenomena of operating system. The benefits of OR study approach in business and management decision making may be categorized as follows **Better control** The management of large concerns finds it much expensive to give continuous executive supervisions over routine decisions. An OR approach directs the executives to dedicate their concentration to more pressing matters. For instance, OR approach handles production scheduling and inventory control. **Better coordination** Sometimes OR has been very helpful in preserving the law and order situation out of disorder. For instance, an OR based planning model turns out to be a vehicle for coordinating marketing decisions with the restrictions forced on manufacturing capabilities.

14. Write the properties of Primal and Dual Optimal Solution. In linear programming, the primal problem refers to the problem of maximizing or minimizing an objective function subject to a set of linear constraints, while the dual problem refers to the problem of minimizing or maximizing a different objective function subject to a different set of linear constraints that are related to the primal problem. Here are the properties of primal and dual optimal solutions: **1. Primal Optimal Solution: Suppose we have the following linear programming problem:** Maximize $3x + 4y$ Subject to: $2x + y \leq 5$ $x + 3y \leq 8$, $x \geq 0$ A primal optimal solution to this problem could be $(x = 2, y = 1)$, which maximizes the objective function while satisfying all the constraints. **2. Dual Optimal Solution:** The dual problem of the example above would be: Minimize $5x + 8y$ Subject to: $2x + b \geq 3$ $a + 3b \geq 4$, $a \geq 0$ A dual optimal solution to this problem could be $(a = 3, b = 0)$, which minimizes the objective function while satisfying all the constraints. **3. Duality:** Using the example above, we can see that the optimal value of the primal problem (11) is equal to the optimal value of the dual problem (11), which confirms the duality principle. **4. Complementary Slackness:** For example, if we have the following primal problem: Maximize $2x + 3y$ Subject to: $x + y \leq 4$ $2x + y \leq 5$, $x \geq 0$ and its dual problem: Minimize $4a + 5b$ Subject to: $a + 2b \geq 2$ $a + 3b \geq 3$, $b \geq 0$ Suppose we have a primal optimal solution of $(x = 1, y = 3)$ and a dual optimal solution of $(a = 0, b = 1)$. We can see that the product of the corresponding variables in the primal and dual solutions is: $x(a+2b) = 1(0+2) = 2$ $y(a+3b) = 3(0+1) = 3$ Both of these values are non-zero, but they sum up to the optimal value of the primal problem, which satisfies complementary slackness. **5. Strong Duality:** In the example above, we can see that the primal and dual problems have optimal solutions and that they satisfy complementary slackness, which confirms the strong duality property. **6. Unboundedness:** For example, if we have the following primal problem: Maximize $x + y$ Subject to: $x \geq 0$ $y \geq 0$ $x + y \geq 1$ We can see that there is no upper limit to the objective function, as the constraints only limit the variables to be non-negative and enforce a lower bound on the difference between x and y . **7. Infeasibility:** For example, if we have the following primal problem: Maximize $x + y$ Subject to: $x \geq 2$ $y \leq 1$ $x + y \leq 1$ We can see that the constraints are conflicting and cannot be satisfied simultaneously, which makes the problem infeasible. **8. No Feasible Solution:** For example, if we have the following primal problem: Maximize $x + y$ Subject to: $x \leq -1$ $y \geq 2$ There are no feasible solutions to this problem, as both constraints cannot be satisfied by any non-negative values of x and y . Therefore, there is no primal optimal solution.

19. Write about characteristics of Game Theory. Game theory is a kind of decision theory in which one's alternative action is determined after taking into consideration all possible alternatives available to an opponent playing the similar game, rather than just by the possibilities of various outcome results. Game theory does not insist on how a game must be played but tells the process and principles by which a particular action should be chosen **Characteristics of Game Theory** **1. Competitive game** A competitive situation is known as competitive game if it has the four properties 1. There are limited number of competitors such that $n \geq 2$. In the case of $n = 2$, it is known as two person game and in case of $n > 2$, it is known as n -person game. 2. Each player has a record of finite number of possible actions. 3. A play is said to takes place when each player selects one of his activities. The choices are supposed to be made simultaneously i.e. no player knows the selection of the other until he has chosen on his own. 4. Every combination of activities finds out an outcome which results in a gain of payments to every player, provided each player is playing openly to get as much as possible. Negative gain means the loss of same amount. **2. Strategy** The strategy of a player is the determined rule by which player chooses his strategy from his own list during the game. The two types of strategy are 1. Pure strategy 2. Mixed strategy **Pure Strategy** If a player knows precisely what another player is going to do, a deterministic condition is achieved and objective function is to maximize the profit. Thus, the pure strategy is a decision rule always to choose a particular strategy. **Mixed Strategy** If a player is guessing as to which action is to be chosen by the other on any particular instance, a probabilistic condition is achieved and objective function is to maximize the expected profit. Hence the mixed strategy is a choice among pure strategies with fixed probabilities. **Repeated Game Strategies** In repeated games, the chronological nature of the relationship permits for the acceptance of strategies that are dependent on the actions chosen in previous plays of the game. • Most contingent strategies are of the kind called as "trigger" strategies. • For Example trigger strategies - In prisoners' dilemma: At start, play doesn't confess. If your opponent plays Confess, then you need to play Confess in the next round. If your opponent plays don't confess, then go for doesn't confess in the subsequent round. This is called as the "tit for tat" strategy. **3. Number of persons** When the number of persons playing is ' n ' then the game is known as ' n ' person game. The person here means an individual or a group aims at a particular objective. Two-person, zero-sum game A game with just two players (player A and player B) is known as 'two-person, zero-sum'.

21. Explain the steps involved in Monte-Carlo simulation. Monte Carlo simulation is a computational technique used to model the probability of different outcomes in a process that involves random variables. Here are the steps involved in Monte Carlo simulation with an example: 1. Define the problem and determine the random variables: The first step is to define the problem and determine the random variables that affect the outcome of the problem. For example, consider the problem of estimating the probability of rolling a sum of 7 or 11 when rolling two fair six-sided dice. The random variables in this problem are the values on each die. 2. Generate random values: The next step is to generate a large number of random values for each of the random variables. For example, we can use a random number generator to generate 1000 pairs of random values for the two dice. 3. Evaluate the function of interest: Using the random values generated in step 2, evaluate the function of interest. In this example, the function of interest is the probability of rolling a sum of 7 or 11. We can calculate this by counting the number of times the sum of the two dice is 7 or 11 and dividing by the total number of rolls (i.e., 1000 in this case). 4. Repeat steps 2 and 3: Repeat steps 2 and 3 a large number of times to obtain a distribution of the function of interest. In this example, we can repeat steps 2 and 3 10,000 times to obtain a distribution of the probability of rolling a sum of 7 or 11. 5. Analyze the results: Finally, analyze the results of the Monte Carlo simulation. In this example, we can use the distribution obtained in step 4 to estimate the mean probability of rolling a sum of 7 or 11, as well as the uncertainty associated with this estimate (e.g., by calculating the standard deviation of the distribution). For instance, let's say we generate 1000 pairs of random values for two six-sided dice, and we get the following sums: 2, 8, 4, 11, 6, 7, 9, 7, 5, 10, ... Using these sums, we can evaluate the function of interest, which is the probability of rolling a sum of 7 or 11. We can count the number of times the sum is 7 or 11 and divide by the total number of rolls (i.e., 1000): $P(\text{sum} = 7 \text{ or } 11) = (\text{number of 7's} + \text{number of 11's}) / 1000$. Suppose we obtain 320 rolls that resulted in a sum of 7 or 11. We can repeat steps 2 and 3 10,000 times to obtain a distribution of the probability of rolling a sum of 7 or 11. Finally, we can analyze the results to estimate the mean probability of rolling a sum of 7 or 11 and the uncertainty associated with this estimate.

22. Explain the difference between a Transportation problem and an assignment problem.

Transportation Problem	Assignment Problem
It is used to optimize the transportation cost.	It is about assigning finite source to finite destination (one source is allotted to one destination).
Number of Source and demand may or may not be equal.	Number of source and number of destination must be equal.
If demand and supply are not equal, then transportation problem is known as Unbalanced Transportation Problem.	If number of rows and number of columns are not equal, then the assignment problem is known as Unbalanced Assignment Problem.
It requires to step to solve: Find Initial Solution using North West, Least Cost or Vogel Approximation Find Optimal Solution using MODI method.	It requires only one step to solve. Hungarian Method is sufficient to find the optimal solutions.

22. Discuss in detail about PERT Estimation Techniques. Before any activity begins related to the work of a project, every project requires an advanced, accurate time estimate. Without an accurate estimate, no project can be completed within the budget and the target completion date. Developing an estimate is a complex task. If the project is large and has many stakeholders, things can be more complex. Therefore, there have been many initiatives to come up with different techniques for estimation phase of the project in order to make the estimation more accurate. PERT (Program Evaluation and Review Technique) is one of the successful and proven methods among the many other techniques, such as, CPM, Function Point Counting, Top-Down Estimating, WAVE, etc. PERT was initially created by the US Navy in the late 1950s. The pilot project was for developing Ballistic Missiles and there have been thousands of contractors involved. After PERT methodology was employed for this project, it actually ended two years ahead of its initial schedule.

The PERT Basics At the core, PERT is all about management probabilities. Therefore, PERT involves in many simple statistical methods as well. Sometimes, people categorize and put PERT and CPM together. Although CPM (Critical Path Method) shares some characteristics with PERT, PERT has a different focus. Same as most of other estimation techniques, PERT also breaks down the tasks into detailed activities. Then, a Gantt chart will be prepared illustrating the interdependencies among the activities. Then, a network of activities and their interdependencies are drawn in an illustrative manner. In this map, a node represents each event. The activities are represented as arrows and they are drawn from one event to another, based on the sequence. Next, the Earliest Time (TE) and the Latest Time (TL) are figured for each activity and identify the slack time for each activity. When it comes to deriving the estimates, the PERT model takes a statistical route to do that. We will cover more on this in the next two sections. **The Three Chances** There are three estimation times involved in PERT; Optimistic Time Estimate (TOPT), Most Likely Time Estimate (TLIKELY), and Pessimistic Time Estimate (TPESS). In PERT, these three estimate times are derived for each activity. This way, a range of time is given for each activity with the most probable value, TLIKELY.

Following are further details on each estimate:

- 1. TOPT** This is the fastest time an activity can be completed. For this, the assumption is made that all the necessary resources are available and all predecessor activities are completed as planned.
- 2. TLIKELY** Most of the times, project managers are asked only to submit one estimate. In that case, this is the estimate that goes to the upper management. **3. TPESS** This is the maximum time required to complete an activity. In this case, it is assumed that many things go wrong related to the activity. A lot of rework and resource unavailability are assumed when this estimation is derived. **The PERT Mathematics** BETA probability distribution is what works behind PERT. The expected completion time (E) is calculated as below:

$$E = (TOPT + 4 \times TLIKELY + TPESS) / 6$$

At the same time, the possible variance (V) of the estimate is calculated as below:

$$V = (TPESS - TOPT)^2 / 6^2$$

Now, following is the process we follow with the two values: • For every activity in the critical path, E and V are calculated. • Then, the total of all Es are taken. This is the overall expected completion time for the project. • Now, the corresponding V is added to each activity of the critical path. This is the variance for the entire project. This is done only for the activities in the critical path as only the critical path activities can accelerate or delay the project duration. • Then, standard deviation of the project is calculated. This equals to the square root of the variance (V). • Now, the normal probability distribution is used for calculating the project completion time with the desired probability