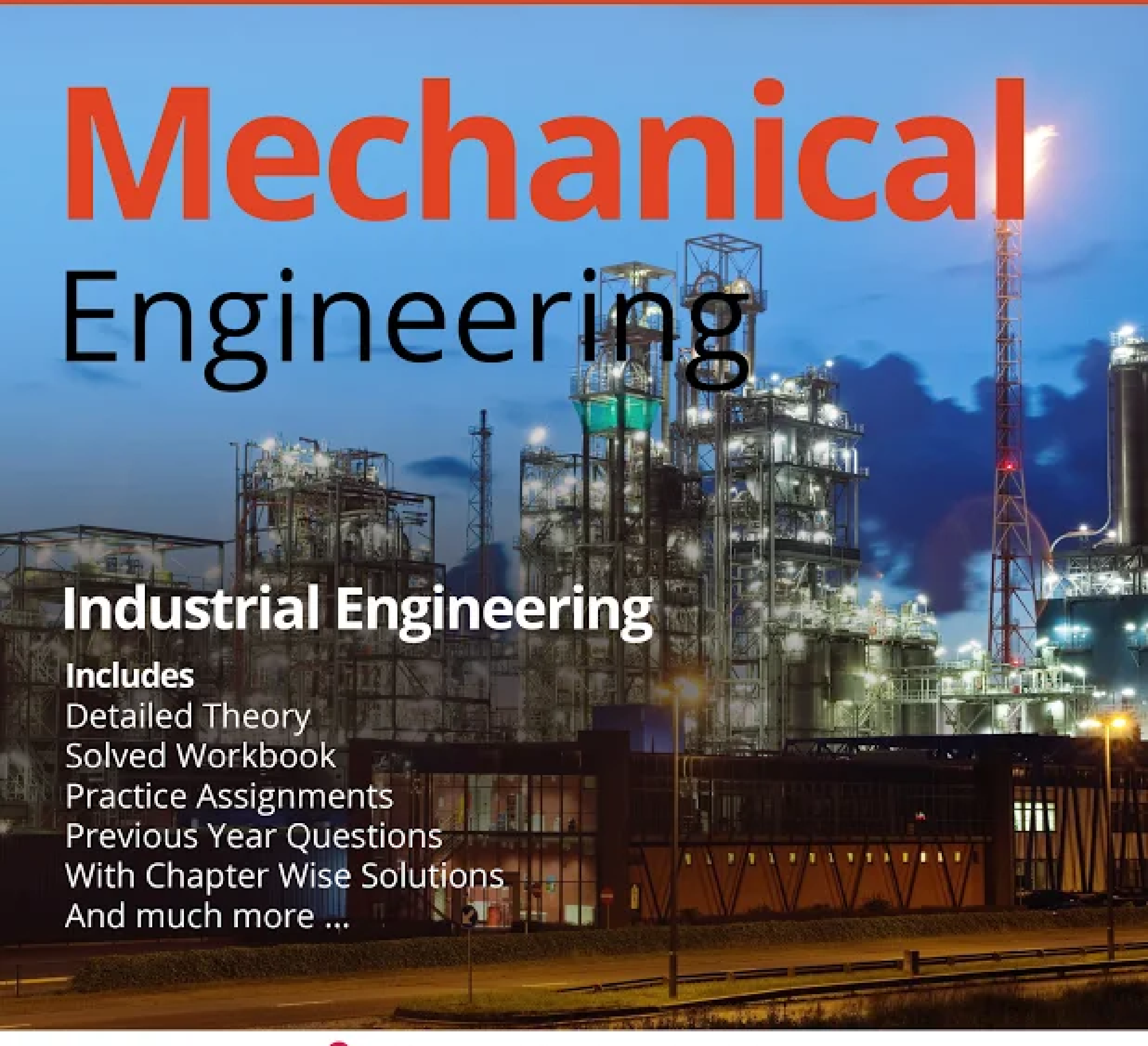
ECG Publications

AS PER NEW SYLLABUS

2019 ESE

Engineering Service Examination



Mechanical Engineering

Industrial Engineering

Includes
Detailed Theory
Solved Workbook
Practice Assignments
Previous Year Questions
With Chapter Wise Solutions
And much more ...

ENGINEERS CAREER GROUP™

ESE

2019

INDUSTRIAL ENGINEERING

MECHANICAL ENGINEERING

ECG Publications

ECG Publications

A Unit of **ENGINEERS CAREER GROUP**

Head Office: S.C.O-121-122-123, 2nd floor, Sector-34/A, Chandigarh-160022

Website: www.engineerscareergroup.in **Toll Free:** 1800-270-4242

E-Mail: ecgpublications@gmail.com | info@engineerscareergroup.in

ESE-2019: Industrial Engineering| Detailed theory with GATE & ESE previous year papers and detailed solutions.

First Edition: 2016

Price of Book: *INR 430/-*

CONTENTS

SECTION – A (INDUSTRIAL ENGINEERING)

SECTION - B (OPERATION RESEARCH)

SECTION- A
INDUSTRIAL ENGINEERING

CHAPTER - 1
LINEAR PROGRAMMING

1.1 INTRODUCTION

1.1.1 LPP (LINEAR PROGRAMMING PROBLEM)

Linear programming is a technique which allocates scare available resources under conditions of certainty in an optimum manner, (i.e. maximum or minimum) to achieve the company objectives which may be maximum overall profit or minimum overall cost.
Linear programming deals with the optimization (maximization or minimization) of linear functions subjects to linear constraints. It is a mathematical method used to determining best optimal solution from a number of possible solutions. It is used mainly for optimization of resources within limited resources.

1.1.2 Example of L.P.P

Solution by graphical method

Maximize $(z) = 3x_1 + 4x_2$ …(i)
Subject to $4x_1 + 2x_2 \geq 80$ …(ii)
$2x_1 + 5x_2 \leq 180$ …(iii)
$x_1, x_2 \geq 0$ …(iv)

1.The variable that enters into the problem are called decision variables, e.g., x_1, x_2
2.The expression showing the relationship between the manufacture's goal and the decision variables is called the objective function, e.g. $= 3x_1 + 4x_2$ (maximize)
3.The inequalities (ii); (iii); (iv) are called constraints being all linear, it is a linear programming problem (L.P.P).

1.1.3 Graphical Method

1.1.3.1 Working Procedure

Step-I
Formulate the given problem as a linear programming problem.
Step-II
Plot the given constraints as equalities on x_1. x_2 co-ordinate plane and determine the convex region formed by them.
[A region or a set of points is said to be convex if the line joining any two of its points lies completely in the region (or the set)]
Step-III
Determine the vertices of the convex region and find the value of the objective function and find the value of the objective function at each vertex. The vertex which gives the optimal value of the objective function gives the desired optimal solution the problem.

1.1.4 Otherwise

Draw a dotted line through the origin representing the objective function with z = 0. As z is increased from zero, this line moves to the right remaining parallel to itself. We go on sliding this

ASSIGNMENT

1. The while solving a LP model graphically, the area bounded by the constraints is called
(a) Feasible region
(b) Infeasible region
(c) Unbounded solution
(d) None of the above

2. While solving a LP problem, infeasibility may be removed by
(a) Adding another constraint
(b) Adding another variable
(c) Removing a constraint
(d) Removing a variable

3. Which one of the following is true in case of simple method of linear programming?
(a)The constants of constraints equation may be positive or negative
(b)In equalities are not converted into equations
(c)It cannot be used for two variable problems.
(d)The simplex algorithm is an iterative procedure

4. A feasible solution to an LP problem
(a)Must satisfy all of the problem's constraints simultaneously
(b)Need not satisfy all of the constraints
(c)Must be a corner point of the feasible region
(d)Must optimize the value of the objective function

5. The role of artificial variables in the simplex method is
(a)To aid in finding an initial solution
(b)To find optimal dual price in the final simplex table
(c)To start phases of simplex method
(d)All of the above

6. Simplex method of solving linear programming problem uses
(a)All the points in the feasible region
(b)Only the corner points of the feasible region
(c)Intermediate points within the infeasible region
(d) Only the interior points in the feasible region

7. In linear programming a basic feasible solution
(a)Satisfies constraints only
(b)Satisfies constraints and non-negativity restrictions
(c)Satisfies non-negativity
(d)Optimizes the objective function

8. A tie for leaving variables in simplex procedure implies
(a) Optimally (b) Cycling
(c) No solution (d) Degeneracy

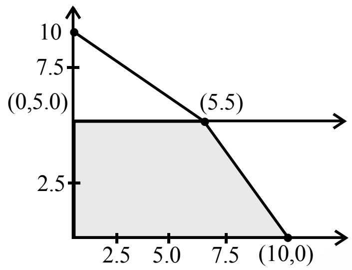
9. The steps followed for the development of linear programming model are
1.State of problem in the form of a linear programming model
2.Determine the decision variable
3.Write the objective variables
4.Developed in equations (or equations) for the constraints.
The correct order is
(a) 1,2,3,4 (b) 2,1,3,4
(c) 4,1,2,3 (d) 4,3,2,1.

10. A constraint in equation $5x_1 - 3x_2 \leq -5$ is converted as, $(3x_2 + \alpha_1) - (5x_1 + s_1) = 5$. Then '$s_1$' is called as
(a) Basic variable
(b) Artificial variable
(c) Surplus variable
(d) Non-basic variable

11. Consider the following Linear Programming Problem (LPP);
Maximize $Z = 3x_1 + 2x_2$
Subject to $x_1 \leq 4$, $x_2 \leq 6$
$3x_1 + 2x^2 \leq 18$, $x_1 \geq 0$, $x2 \geq 0$
(a) The LPP has a unique optimal solution
(b) The LPP is infeasible
(c) The LPP is unbounded
(d) The LPP has multiple optimal solution

GATE QUESTIONS

1. The problem of maximizing $z = x_1 - x_2$ subject to constrai



[GATE - 2018]

(a) No solution (b) One solution
(c) Two solution (d) More solution

2. For minimum Value of 3x + 5y
So that :
$3x + 5y \le 15$,
$4x + 9y \le 8$;
$13x + 2y \le 2$;
$x \ge 0, y \ge 0$
is________.

[GATE - 2018]

3. Maximize $Z = 5x_1 + 3x_2$
nts $x_1 + x_2 \le 10$; $x_1 \ge 0$ and $x_2 \le 5$ has Subject to $x_1 + 2x_2 \le 10$, $x_1 - x_2 \le 8$, $x_1, x_2 \ge 0$
In the starting simplex tableau, x_1 and x_2 are non - basic variables and the value of Z is zero. The value of Z in the next simplex tableau is ____

[GATE - 2017]

4. Two models, P and Q, of product earn profits of Rs. 100 and Rs. 80 per piece, respectively. Production time for P and Q are 5 hours and 3 hours, respectively, while the total production time available is 150 hours. For a total batch size of 40, to maximize profit, the number of units of P to be produced is ____.

[GATE - 2017]

5. Maximize $Z = 15X_1 + 20X_2$
Subject to
$12X_1 + 4X_2 \ge 36$
$12X_1 - 6X_2 \le 24$
$X_1, X_2 \ge 0$
The above linear programming in problem has

[GATE - 2016]

(a) Infeasible solution
(b) Unbounded solution
(c) Alternative optimum solutions
(d) Degenerate solution

6. For linear programming problem
Maximize $Z = 3X_1 + 2X_2$
Subject to
$-2X_1 + 3X_2 \le 9$
$X_1 - 5X_2 \ge -20$
$X_1, X_2 \ge 0$
The above problem has

[GATE - 2015]

(a) Unbounded problem
(b) Infeasible solution
(c) Alternative optimum solution
(d) Degenerate solution

7. Consider an objective function $Z(x_1, x_2) = 3x_1 + 9x_2$ and the constraints
$x_1 + x_2 \le 8$
$x_1 + 2x_2 \le 4$
$x_1 \ge 0, x_2 \ge 0$
The maximum value of the objective function is _________.

[GATE - 2014]

8. A linear programming problem is shown below:
Maximize
3x + 7y
Subject to
$3x + 7y \le 10$
$4x + 6y \le 7$
$X, y \ge 0$
It has

[GATE - 2013]

(a) An unbounded objective function
(b) Exactly one optimal solution

CHAPTER - 2
INVENTORY

2.1 INTRODUCTION

It is the stock of item or resources used in organization. It may be defined as the stock on hand at a given time and it may be held for purpose of letter use or sale. It is usable but idle resources having an economic value and it may include raw material, work in process inventory, semi finished inventory and finished goods.

A fundamental objective of a good system of operation control of Inventories is to be able to place an order at the right time,
From the right source
To acquire the right quantity
At right price
And right quality
"Inventory is the life blood of a production system."

2.2 CATEGORIES

1. Production inventories: go to final product
2. MRO (Maintenance, Repair and operating supplies) e.g. spare parts, oils grease.
3. In-process inventories (semi-finish products at various production stages)
4. Finished goods inventories
5. Miscellaneous inventory

2.3 ANOTHER WAY OF CLASSIFYING INDUSTRIAL INVENTORIES ARE

1. Transition inventory
2. Speculative inventory
3. Precautionary inventory

2.4 SELECTIVE INVENTORY CONTROL

2.4.1 Different type of Inventory Analysis

1. ABC analysis (class A, class B, class C)
2. VED Analysis (vital, Essential, Desirable)
3. SDE Analysis (Scarce, Difficult, Easily Available)
4. HML Analysis (High, Medium, Low Cost)
5. FSN Analysis (Fast, Slow, Non-moving items)

2.4.2 ABC Analysis

The common and important of the selective inventory control of ABC analysis. ABC Analysis is done for items on stock and the basis of analysis is the annual consumption in terms of money value.

***Control of A-item**:* 10 % of the item accounts 70% costs
***Control of B-item**:* 20% of the item accounts 20% costs
***Control of C-item**:* 70% of the items accounts 10% costs

ASSIGNMENT

1. Inventory management consists of
(a) Effective running of stores
(b) State of merchandise methods of storing and maintenance etc.
(c) Stock control system
(d) all of the above

2. Inventory can be in the form of
(a)Raw materials
(b)In process goods
(c)Brought out part, semi finished goods and subassemblies
(d)All of the above

3. Two groups of costs in inventory control are
(a) Carrying costs and ordering costs
(b) Relevant cost and ordering costs
(c) Carrying costs an total costs
(d) Relevant costs and total costs

4. In basic economic order quantity model for the optimal order quantity
(a) Holding cost is more than ordering cost
(b) Holding cost is less than ordering cost
(c) Holding cost is equal to ordering cost
(d) Holding cost is two times the ordering cost

5. In inventory planning, extra inventory is unnecessary carried to the end of the planning period when using one of the following size decision policies.
(a) Lot for lot production
(b) Economic order quantity (EQQ) lot size
(c) Period order quantity (POQ) lot size
(d) Part period total cost balancing

6. The formula for economic order quantity does not contain
(a) Order cost
(b) Carrying cost
(c) Cost of the item
(d) Annual demand

7. For a given annual consumption, the minimum total inventory cost is proportional to square root of the product of
(a) Ordering cost per order
(b) Carrying cost per until per year
(c) Both (a) and (b) above
(d) None of the above

8. When order quantity increases the ordering costs will
(a) Increase
(b) Decrease
(c) Remains same
(d) None of the above

9. One of the important reasons for carrying inventory is to
(a) Improve customer service
(b) Get quantity discounts
(c) Maintain operational capability
(d) All of the above

10. A shop owner with an annual constant demand of `R` units has ordering costs of Rs. 'C_O' per order and carrying costs Rs. 'C_O' per unit per year. The economic order quantity for a purchasing model having no shortage may be determined from
(a) $\sqrt{\dfrac{24R}{C_C R_O}}$ (b) $\sqrt{\dfrac{24RC_O}{C_C}}$
(c) $\sqrt{\dfrac{2RC_O}{C_C}}$ (d) $\sqrt{\dfrac{2RC_C}{C_O}}$

11. Which of the following is not a part of inventory Carrying Cost?
(a) Cost of storage Cost
(b) Cost of obsolescence
(c) Cost of insurance
(d) Cost of inwards goods inspection

ESE OBJ QUESTIONS

1. A particular item has a demand of 9000 units/year. The cost of one procurement is Rs. 108 and the holding cost per unit is Rs. 2.40/year. The replacement is instantaneous and no shortages are allowed. What is the optimum number of orders/year?

[ESE - 2017]

(a) 7 orders/year (b) 8 orders/year
(c) 9 orders/year (d) 10 orders/year

2. A firm's inventory turnover of Rs. 8,00,000 is 5 times the cost of goods sold. If the inventory turnover is improved to 8 with the cost of goods sold remaining the same, a substantial amount of fund is either released from, or gets additionally invested in, inventory. Which one of the following statements is correct?

[ESE - 2017]

(a) Rs.1,60,000 is released
(b) Rs.1,60,000 is additionally invested.
(c) Rs.60,000 is released.
(d) Rs.60,000 is additionally invested

3. A stockiest has to supply 400 units of a product every Monday to his customers. He gets the product at Rs. 50 per unit from the manufacture. The cost of ordering and transportation from the manufacture to the stockist's premises is Rs. 75 per order. The cost of carrying inventory is 7.5% per year of the cost of the product. What are the economic lot size and the total optimal cost (including capital cost) for the stockiest?

[ESE - 2017]

(a) 989 units/order and Rs. 20,065.80/week
(b) 912 units/order and Rs. 20,065.80/week
(c) 989 units/order and Rs. 18,574.50 /week
(d) 912 units/order and Rs. 18,574.50/week

4. The annual demand of a commodity in a supermarket is 80000. The cost of placing an order is Rs 4,000 and the inventory cost of each item is Rs 40. What is the economic order quantity?

[ESE - 2015]

(a) 2000 (b) 4000
(c) 5656 (d) 6666

5. In ABC inventory control of spare parts , the items A, B and C respectively refer to

[ESE - 2015]

(a)High stock out cost, moderate stock-out cost and low stock-out cost
(b)Low stock-out cost, high stock-out cost and low stock-out cost
(c)Moderate stock-out cost, high stock-out cost and low stock-out cost
(d)Stock out costs whose sequence depends on other factors also

6. What is the ratio of annual order cost to annual cost when the order size is determined using Economic Order quantity (EOQ) model?

[ESE - 2015]

(a) 0.5 (b) 0.25
(c) 0.75 (d) 1

7. Large size of inventory is a sign of :

[ESE - 2013]

(a) Better planning
(b) Inefficiency
(c) Reliable control of vendors
(d) Better scheduling

8. Purification of inventory means :

[ESE - 2013]

(a) Cleaning of inventories
(b) Disposing of inventories
(c) Processing of inventories
(d) Storing of inventories in bins

9. In an economic order quantity based inventory control when re-order level id greater than order quantity, the number of orders outstanding at any time is

CHAPTER - 3
TRANSPORTATION

3.1 TRANSPORTATION PROBLEM
These are used for meeting the supply and demand requirement under given conditions.
This is a special class of L.P.P. in which the objective is to transport a single commodity from various origins to different destinations at a minimum cost. The problem can be solved by simplex method. But the number of variables being large, there will be too many calculations.

3.2 FORMULATION OF TRANSPORTATION PROBLEM
There are m plant locations (origins) and n distribution centers (destinations). The production capacity of the i^{th} plant is a_i and the number of units required at the j^{th} destination bj. The Transportation cost of one unit from the i^{th} plant to the j^{th} destination c_{ij}. Our objective is to determine the number of units to be transported from the i^{th} of plant to j^{th} destination so that the total transportation cost is minimum.
Let x_{ij} be the number of units shipped from i^{th} plant to j^{th} destination, then the general transportation problem is:

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

Subjected to

$x_{i1} + x_{i2} + \text{-------} + x_{in} = a_i$ (for i^{th} origin i = 1, 2, ……..,m)

$x_{ij} + x_{2j} + \text{-------} + x_{mj} = n_j$ (for j^{th} origin i = 1, 2, ……..,n)

$x_{ij} \geq 0$

The two sets of constraints will be consistent if $\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j$, which is the conditions for a transportation problem to have a feasible solution? Problems satisfying this condition are called balanced transportation problem.

3.3 DEGENERATE OR NON-DEGENERATE
A feasible solution to a transportation problem is said to be basic feasible solution of it contains at the most (m + n – 1) strictly positive allocations, otherwise the solution will 'degenerate'. If the total number of positive (non-zero) allocations is exactly (m + n – 1), then the basic feasible solution is said to be non-degenerate, if '(m + n – 1)' $\rightarrow$ no. of allocated cell. Then put an $\varepsilon \rightarrow 0$ at a location so that all ui, vj can be solved and after optimality check put $\varepsilon = 0$.
Optimal solution: The feasible solution which minimizes the transportation cost is called an optimal solution.

3.4 WORKING PROCEDURE FOR TRANSPORTATION PROBLEMS
Step-I.
Construct transportation table: if the supply and demand are equal, the problem is balance. If supply and demand is not same then add dummy cell to balance it.

Step-II.
Find the initial basic feasible solution. For this use **Vogel's approximation Method (VAM)**. The VAM takes into account not only the least cost c_{ij} but also the costs that just exceed the least cost

ASSIGNMENT

1. The occurrence of degeneracy while solving a transportation problem means that
(a) Total supply equals total demand
(b) The solution so obtained is not feasible
(c) The few allocations become negative
(d) None of the above

2. Penalty cost method is
(a) Least cost method
(b) North West corner method
(c) Vogel's approximation method
(d) None

3. One disadvantage of using North-West corner Rule of find initial solution to the transport-tation problem is that
(a)It is complicated to use
(b)It does not take into account cost of transportation
(c)It leads to a degenerate initial solution
(d)All of the above

4. The degeneracy in the transportation problem indicates that
(a) Dummy allocation(s) needs to be added
(b) The problem has no feasible solution
(c) The multiple optimal solution exist
(d) (a) and (b) but not (c)

5. The solution in a transportation model (of dimension m x n) is said to be degenerate if it has
(a) Exactly (m + n – 1) allocations
(b) Fewer than (m + n – 1)
(c) More than (m + n -1) allocations
(d) (m x n) allocations

6. In a transportation problem, the materials are transported from 3 plants to 5 warehouses. The basic feasible solution must contain exactly, which one of the following allocated cells?
(a) 3 (b) 5
(c) 7 (d) 8

7. Which one of the following is not the solution method of transportation problems?
(a) Hungarian method
(b) Northwest corner method
(c) Least cost method
(d) Vogel's approximation method

8. The supply at three sources is 50, 40 and 60 units respectively while the demand at the four destinations is 20, 30, 10 and 50 units. In solving this transportation problem.
(a)A dummy sources of capacity 40 units is needed
(b)A dummy destination of capacity 40 units is needed
(c)No solution exists as the problem is infeasible
(d)None solution exists as the problem is degenerate.

9. Consider the following statements:
(a) For the application of optimality test in case of transportation model, the number of allocations should be equal to m + n, where m is the number of rows and n is the number of columns of the matrix.
(b) Transportation problem is a special case of a linear programming problem.
(c) In case of assignment problem the first step is to make a square matrix by adding a dummy row or dummy column.
Which of these statements is/are correct?
(a) 1, 2 and 3 (b) 1 and 2
(c) 2 and 3 only (d) 2 only

10. The linear programming is used for optimization problems which satisfy the following conditions:
1.Objective function expressed as a linear function of variables
2.Resources are unlimited
3.The decision variables are inter-related and non-negative.
Which of these statement is/are correct?
(a) 1, 2 and 3 (b) 2 and 3
(c) 1 only (d) 1 and only

CHAPTER - 4
ASSIGNMENT

4.1 INTRODUCTION

An assignment problem is a special type of transportation problem in which the objective is to assign a number of origins to an equal number of destinations at a minimum cost (for maximum profit).

Assignment problems differs from **transportation** problem on two grounds:

(i) Matrix must be always square i.e, m = n

(ii) Allocation in each row and column will be only one.

$\text{Min } Z = \sum_{i=1}^{n} \sum_{j=1}^{n} c_{ij}\, x_{ij}$ and all $a_i = 1$ and $b_j = 1$ and $x_{ij} = 0$ or 1

4.2 FORMULATION OF AN ASSIGNMENT PROBLEM

There are n new machines m_i (I = 1, 2, ….., n) which are to be installed in a machine shop. There are n vacant spaces s_i (j = 1, 2, …., n) available. The cost of installing the machine m_i at space S_j is C_{ij} rupees.

Let us formulate the problem of assigning machines to spaces so as to minimize the overall cost.

Let x_{ij} be the assignment of machine m_i to space s_j i.e. Let x_{ij} be a variable such that

$$x_{ij} = \begin{cases} 1, \text{if } i^{th} \text{ machine is installed at } j^{th} \text{ space} \\ 0, \text{ otherwise} \end{cases}$$

Since one machine can only be installed at each place, we have

$x_{i1} + x_{i2} + ...x_{in} = 1$ for $m_i (I = 1, 2, 3, ..., n)$

$x_{1i} + x_{2i} + ...x_{ij} = 1$ for $s_i (j = 1, 2, 3, ..., n)$

Thus assignment problem can be stated as follows:

Determine $x_{ij} \geq 0$ (j = 1, 2, 3, ….., n) so as to minimize $(z) = \sum_{i=1}^{n} \sum_{j=1}^{n} C_{ij} x_{ij}$

Subject to the constraints

$\sum_{i=1}^{n} x_{ij} = 1, j = 1, 2, ..., n$ and $\sum_{j=1}^{n} x_{ij} = 1, i = 1, 2, 3, ..., n$

This problem is explicitly represented by the following n × n cost matrix:

ESE OBJ QUESTIONS

1. Consider the following statements
The assignment problem is seen to be the special case of the transportation problem in which
1. m = n
2.all $a_i = 1$
3. $x_{ij} = 1$
(The symbols have the usual meaning)
Which of these statements are correct?
[ESE - 2007]
(a) 1, 2 and 3 (b) 1 and 2 only
(c) 2 and 3 only (d) 1 and 3 only

2. Consider the following statements in respect of assignment method of optimization
1.The matrix format of the method must be a square matrix
2.Some type of rating has to be given to the performance of each pairing ?
Which of these above is/are correct?
[ESE - 2006]
(a) Only 1 (b) Only 2
(c) Only 1 and 2 (d) Neither 1 nor 2

3. Which one of the following statement is NOT correct?
[ESE - 2000]
(a)Assignment model is a special case of a linear programming problem
(b)In queuing models, Poisson arrivals and exponential services are assumed
(c)In transportation problems, the non-square matrix is made square by adding a dummy row or a dummy column
(d)In linear programming problems, dual of a dual is a primal

4. The assignment algorithm is applicable to which of the following combined situations for the purpose of improving productivity
1. Identification of the sales force market.
2. Scheduling of operator machine
3. Fixing machine-location
Select the correct answer using the codes given below?
[ESE - 1998]
(a) 1, 2 and 3 (b) 1 and 3
(c) 2 and 3 (d) 1 and 2

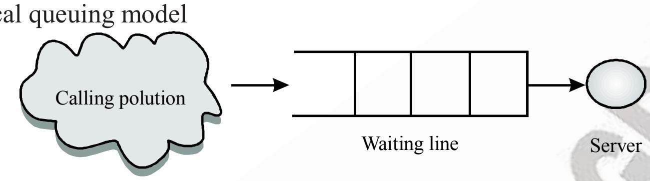
5. Match List-I (Or technique) with List-II (Application) and select the correct answer using the codes given below the lists :
List-I
A. Linear programming
B. Transportation
C. Assignment
D. Queuing
List-II
(i) Ware house location decision
(ii) Machine allocation decision
(iii) Product mix decision
(iv) Project management decision
(v) Number of servers decision
[ESE - 2000]
Codes:
(a) A-i, B-ii, C-iii, D-v
(b) A-iii, B-i, C-ii, D-v
(c) A-i, B-iii, C-iv, D-v
(d) A-iii, B-ii, C-i, D-iv

CHAPTER - 5
QUEUING THEORY

5.1 QUEUING THEORY OF WAITING LINE

The goal of queuing model is the achievement of economic balance between the cost of providing services and the cost associated with the wait required for the service. This theory is applicable in service oriented organization machine repairs shops, production system, semi-finished parts waiting for finished operation etc.

A simple but typical queuing model



Typical measures of system performance are sever utilization, length of waiting lines, and delays of customers.

5.2 KEY ELEMENTS OF QUEUING SYSTEMS

Customers

Refers to anything that arrives at a facility and requires service, e.g., people, machines, truck, emails.

Server

Refers to any resource that provides the requested service, e.g, receptionist, repairpersons, retrieval machines, runways at airport.

1. Calling Population

The population of potential customers may be assumed to be finite or infinite.

Finite Population Model

If arrival rate depends on the number of customers being served and waiting, e.g., model of one corporate jet, if it is being repaired, the repair arrival rate becomes zero.

Infinite Population Model:

If arrival rate is not affected by the number of customers being served and waiting, e.g., systems with large population of potential customers.

5.3 SOME APPLICATION OF WAITING LINE PROBLEM

S. No.	Application area	Arrival	Waiting line	Service facility
1.	Factory	Material/tools	In-process inventory (WIP)	Work stations
2.	Assembly line	Sub-assemblies	WIP	Employees currently
3.	Machine maintenance	Repair tools & equipment	Machine needing repair	Maintenance crew
4.	Airport	Plane	Planes ready to fly	Runway
5.	Bank	Customer	Deposit/withdrawal	Bank employed & computer
6.	Walk-in interview	Job seekers	Applicants	Interviewers
7.	Phone exchange	Dialed number	Caller	Switchboard

ASSIGNMENT

1. In the Kendall's notation for representing queuing models the first position represents
(a) Probability law for the arrival
(b) Probability law for the service
(c) Number of channels
(d) Capacity of the system

2. In queueing models, M/M/c denotes a Poisson arrival process and
(a)Exponentially distributed service times and c servers in series
(b)Constant service times and c servers in series
(c)Exponentially distributed service times and c servers in parallel
(d)Constant service times and c servers in parallel

3. Queuing theory is used for
(a) Inventory problems
(b) Traffic congestion studies
(c) Job-shop scheduling
(d) All of the above

4. Queuing theory is associated with
(a) Sales
(b) Inspection time
(c) Waiting time
(d) Production time

5. In a queuing problem, if the arrivals are completely random, then the probability distribution, of number of arrivals in a given time follows :
(a) Poisson distribution
(b) Normal distribution
(c) Binomial distribution
(d) Exponential distribution

6. Length of the System (L_S) in queuing is equal to
(a) $\frac{\rho}{1-\rho}$ (b) $\frac{1}{\lambda}(\frac{\rho}{1-\rho})$
(c) $\frac{1}{\mu}(\frac{\rho}{1-\rho})$ (d) $\frac{p^2}{1-\rho}$

7. Queue length(L_q) in queuing is qua to
(a) $\frac{\rho}{1-\rho}$ (b) $\frac{\rho^2}{1-\rho}$
(c) $\frac{1}{\lambda}(\frac{\rho}{1-\rho})$ (d) $\frac{1}{\mu}(\frac{\rho}{1-\rho})$

8. In a single server queuing system with arrival rate of 'λ' and mean service time of 'μ' the expected number of customers in the system is $\left(\frac{\lambda}{\mu-\lambda}\right)$
What is the expected waiting time per customer in the system?
(a) $\frac{\lambda^2}{(\mu-\lambda)}$ (b) $\frac{\lambda}{(\mu-\lambda)}$
(c) $\frac{1}{(\mu-\lambda)}$ (d) $\frac{(\mu-\lambda)}{\lambda}$

9. In a M/M 1 queue, the service rate is
(a) Poisson
(b) Exponential
(c) Linear
(d) None of the above

10. In a single server infinite population queuing model, arrivals follow a Poisson distribution with mean λ=4 per hour. The service times are exponential with mean service time equal to 12 minutes. The expected length of the queue will be
(a) 4 (b) 3.2
(c) 1.25 (d) 5

11. Patients arrive at a doctor's clinic according to the Poisson distribution. Check up time by the doctor follows an exponential distribution. If

ESE CONV QUESTIONS

1. Explain Queuing model and its applications.

[ESE - 2014]

Solution.

Customers (m/c, vehicles, students, people etc) arrive at a constant or variable rate for services at service facilities. If the service facility is free, they are served immediately. If the service facility is busy providing services to other customers, the newly arrived customers have to wait. Thus if they must wait for services, they either begin a queue or join no existing queue, and remain in the queue until they are served.

Queuing models with Poisson input-Exponential service

Model-1: Infinite queue, infinite source, single server.

Model-2: Infinite queue, infinite source, multiple server.

Model-3: Finite queue, infinite source, single server.

Model-4: Finite queue, infinite source, multiple server.

Application of queuing model:

Retail shops

1. Doctor's office
2. Airports check-in
3. Traffic congestion
4. Automobile service centers
5. Railways wagon yard

2. In a machine shop, certain type of machines break-down at an average rate of 6 per hour. The Break-downs are in accordance with Poisson process. The estimated costs of idle machine is Rs. 15 per hour. Two repairmen A and B with different skills are being considered to be hired as repairmen. Repairmen A takes six minutes on an average to repair a machine and his wages are Rs. 8 per hour, whereas the repairman B takes five minutes to repair and the wages are Rs. 10 per hour. Which repairman's service should be used and why? Assume the work shift of 8 hours.

[ESE - 2004]

Solution.

Given, λ = 6/hour, i.e., machines break-down rate

Ideal time cost of the machines = Rs. 15/hour

Repairman A: (whose wage is Rs. 8 per hour)

Service rate, $\mu_A = \frac{1}{6} / \text{min} = 10 / \text{hour}$

Average number of units in the system, $L_S = \frac{\lambda}{\mu_A - \lambda} = \frac{6}{10-6} = 1.5$

Machine hours lost in 8 hour day = 1.5 × 8 = 12 hours

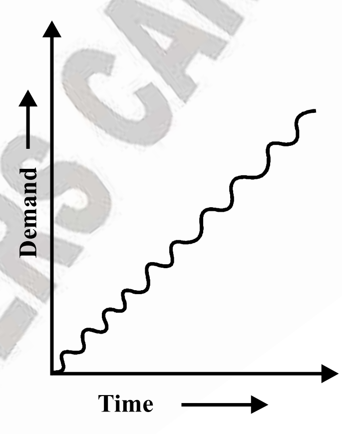
CHAPTER - 1
FORECASTING

1.1 FORECASTING
Forecasting is the prediction of future sales or demand for a product. It is defined as the estimation of future activities i.e. the estimation of time, quality, quantity of future work. These estimate provide the basis for determining the demand of man power, machines and material in future.
It is a calculated economical analysis.
It is not a guess work but a projection based on passed sales figure and human judgment.

1.2 NEED OF FORECASTING
1. It helps in determining the volume of production and production rate.
2. It forms the basis for production budget, labour budget, material budget etc.
3. It suggest the need for plant expansion
4. It helps in product design & development.
5. It helps in determining price policies.
6. Helps in determining the extent of marketing, advertisement and distribution required.

1.3 TYPES OF DEMAND VARIATION

1. Trend Variation
It shows a long term upward or downward movement in the demand or sales of a product. It shows a regular pattern.
Example.
Newspaper, Cellphones etc.



GATE QUESTIONS

1. The time series forecasting method that gives equal weightage to each of the m most recent observation is

[GATE - 2018]

(a) Moving average method

(b) Exponential smooting with linear trends

(c) Triple Exponential smoothing

(d) Kaiman Filter

2. For a canteen, the actual demand for disposable cups was 500 units in January and 600 units in February .The forecast for the month of January was 400 units .The forecast for the month of March considering smoothing coefficient as 0.75 is_______

[GATE - 2015]

3. Sales data of a product is given in the following table :

Month	January	February	March	April	May
Number of unit sold	10	11	6	19	25

Regarding forecast for the month of June, which one of the following statements is **TRUE**?

[GATE - 2014]

(a)Moving average will forecast a high value compared to regression

(b)Higher the value of order N , the greater will be the forecast value by moving a average

(c)Exponential smoothing will force cast a higher value compared to regression

(d)Regression will forecast a higher value compared to moving average

4. The actual sales of a product in different months of a particular year are given below:

Sep.	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**
180	280	250	190	240	?

The forecast of the sales, using the 4 months moving average method, for the month of February is _________

[GATE - 2014]

5. In exponential smoothening method, which one of the following is true?

[GATE - 2014]

(a) $0 \leq \alpha \leq 1$ and high value of a is used for stable demand

(b) $0 \leq \alpha \leq 1$ and high value of a used for unstable demand

(c) $\alpha \geq 1$ and high value of a is used for stable demand

(d) $\alpha \leq 0$ and high value of a is use for unstable demand.

6. In simple exponential smoothing forecasting, to give higher weight age to recent demand information, the smoothing constant must be close to

[GATE - 2013]

(a) –1 (b) zero

(c) 0.5 (d) 1.0

7. The demand and forecast for February are 12000 and 10275, respectively. Using single exponential smoothening method (smoothening coefficient = 0.25), forecast for the month of March is

[GATE - 2010]

(a) 431 (b) 9587

(c) 10706 (d) 11000

8. Which of the following forecasting methods takes a fraction of forecast error into account for the next period forecast?

[GATE - 2009]

(a) Simple average method

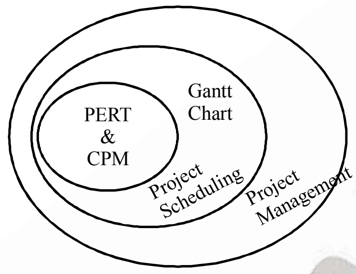
(b) Moving average method

(c) Weighted moving average method

(d) Exponential smoothening method

CHAPTER - 2
PERT AND CPM

2.1 PROJECT MANAGEMENT
(Project Planning and Scheduling)-Gantt Chart
Special Scheduling Techniques: PERT and CPM



1. Gantt Chart
Is one of the first scientific techniques for project planning and scheduling.

2. CPM
Critical Path Method.

3. PERT
Program Evaluation and Review Technique.

4. Project
Project is a group of Inter-related activities which must be executed in a certain order before the entire task can be completed. The activities are related in a Logical and sequential order in the sense that some activities cannot start until all the activities prior to them are completed. When all the activities are executed then only the project is completed.

5. Event
The event are point in time & denotes the beginning and the end point of an activity. An Event defines an accomplishment occurring at an instantaneous point of time which neither consumes any time nor resources for its completion.

6. Activity
It is a recognizable and identifiable part of a project which consumes time & resources for its completion and may involves physical or mental work.

7. Network Diagram
It represents the sequence of different activities that make a project.

2.1.1 Rules for Network Diagram
1. No activity can be started until all the activities prior to it has been completed.

ASSIGNMENT

1. The performance of a specific task in CPM is known as
(a) Dummy (b) Event
(c) Activity (d) Contract

2. In CPM network critical path denotes the
(a) Path where maximum resources are used
(b) Path where minimum resources are used
(c) Path where delay of one activity prolongs the duration of completion of project
(d) Path that gets monitored automatically

3. In PERT, the distribution of activity times is assumed to be
94.
(a) Normal (b) Gamma
(c) Beta (d) Exponential

4. A dummy activity is used in PERT network to describe
(a) Precedence relationship
(b) Necessary time delay
(c) Resource restriction
(d) Resource idleness

5. In PERT analysis a critical activity has
(a) Maximum float (b) Zero float
(c) Maximum cost (d) Minimum cost

6. The expected time(t_e) of a PERT activity in terms of optimistic time(t_o), pessimistic time(t_p) and most likely time(t_m) is give by
(a) $t_e = \frac{t_o + 4t_m + t_p}{6}$
(b) $t_e = \frac{t_o + 4t_p + t_m}{6}$
(c) $t_e = \frac{t_O + 4t_m + t_p}{3}$
(d) $t_e = \frac{t_o + 4t_p + t_m}{3}$

7. The critical path of a network is the path that
(a) Takes the shortest time
(b) Takes the longest time
(c) Has the minimum variance
(d) Has the maximum variance

8. In PERT the span of time between the optimistic and pessimistic time estimates of an activity is
(a) 3σ (b) 6σ
(c) 12σ (d) none

9. In an activity has zero slack, it implies that
(a) It lies on the critical path
(b) It is a dummy activity
(c) The project is progressing well
(d) None

10. Activity-on-Arrow (AOA) diagram s preferred over Activity on Node (AON) diagram because
(a)AOA diagrams are simple to construct
(b)AOA diagrams give a better sense of the flow of time throughout a project
(c)AOA diagrams do not involve dummy activities
(d)All of the above

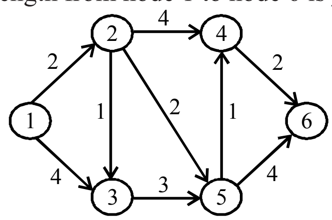
11. The most likely time (m) is `mode` of the
(a) Normal distribution
(b) Bea distribution
(c) Binomial distribution
(d) None of the above

12. Fulkerson's rule is connected with
(a) Numbering of event in PERT/CPM
(b) The simulating model
(c) Queuing theory
(d) None of the above

13. The variance of the completion time of a project in the sum of variance of
(a) All activity times

GATE QUESTIONS

1. The arc lengths of a directed graph of a project are as shown in the figure. The shortest path length from node 1 to node 6 is ________.



[GATE - 2017]

2. A project starts with activity A and ends with activity F. The precedence relation and durations of the activities are as per the following table:

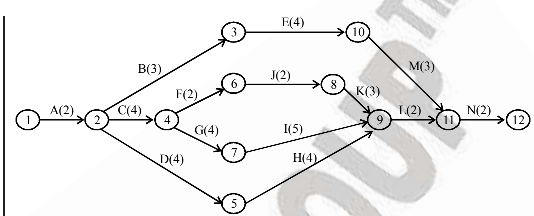
Activity	Im Predecessors	Duration (days)
A	–	4
B	A	3
C	A	7
D	B	14
E	C	4
F	D,E	9

The minimum project completion time (in days) is ________.

[GATE - 2017]

3. A project consists of 14 activities, A to N.The duration of these activities (in days) are shown in bracelets on the network diagram. The latest finish time (in days) for node 10 is

[GATE - 2016]

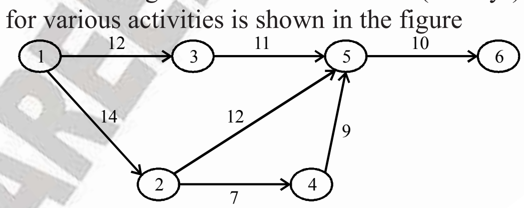


4. In PERT chart, the activity time distribution is

[GATE - 2016]

(a) Normal (b) Binomial
(c) Poisson (d) Beta

5. A project consists of 7 activities. The network along with the time durations (in days) for various activities is shown in the figure



The minimum time (in days) for completion of the project is_______.

[GATE - 2016]

6. Following data refers to the activities of a project ,where node I refers to the start and node 5 refers to the end of the project

Activity	Duration (days)
1-2	2
2-3	1
4-3	3
1-4	3
2-5	3
3-5	2
4-5	4

The critical path (CP) in the network is

[GATE - 2015]

CHAPTER - 3
ROUTING & SCHEDULING

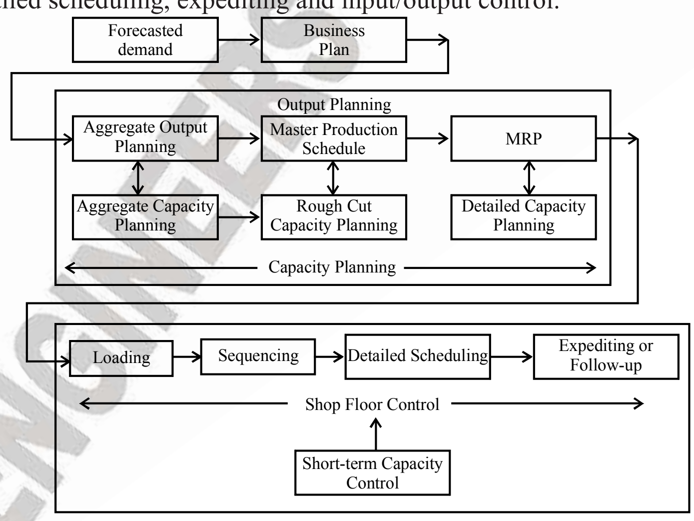
3.1 ROUTING

3.1.1 Routing includes the planning
What work shall be done on the material to produce the product or part, where and by whom the work shall be done. It also includes the determination of path that the work shall follow and the necessary sequence of operations which must be done on the material to make the product.

3.1.2 Routing procedure consists of the following steps
The finished product is analyzed thoroughly from the manufacturing stand point, including the determination of components if it is an assembly product. Such an analysis must include:
1. Material or parts needed.
2. Whether the parts are to be manufactured, are to be found in stores (either as raw materials or worked materials), or whether they are-to be purchased.
3. Quantity of materials needed for each part and for the entire order.
The following activities are to be performed in a particular sequence for routing a product
(i) Analysis of the product and breaking it down into components.
(ii) Taking makes or buys decisions.
(iii) Determination of operations and processing time requirements.
(iv) Determination of the lot size.

3.2 SCHEDULING

3.2.1 Introduction
Scheduling is used to allocate resources over time to accomplish specific tasks. It should take account of technical requirement of task, available capacity and forecasted demand. Forecasted demand determines plan for the output, which tells us when products are needed. The output plan should be translated into operations, timing and schedule on the shop-floor. This involves loading, sequencing, detailed scheduling, expediting and input/output control.



The Planning and Scheduling Function

GATE QUESTIONS

1. Processing times (including step times) and due dates for six jobs waiting to be processed at a work centre are given in the table. The average tardiness (in days) using shortest processing time rule is______(correct to two decimal places).

Job	Processing time (days)	Due date (days)
A	3	8
B	7	16
C	4	4
D	9	18
E	5	17
F	13	19

[GATE - 2018]

2. Following data refers to the jobs (P, Q, R, S) which have arrived at a machine for scheduling. The shortest possible average flow time is ______ days.

[GATE - 2015]

Job	Processing Time (days)
P	15
Q	9
R	22
S	12

Ave

Common Data for Q.3 & Q.4

Four jobs are to be processed on a machine as per data listed in the table.

Job	Processing Time (in days)	Due date
1	4	6
2	7	9
3	2	19
4	8	17

3. Using the Shortest Processing Time (SPT) rule, total tardiness is

[GATE - 2010]

(a) 0 (b) 2
(c) 6 (d) 8

4. If the Earliest Due Date (EDD) rule is used to sequence the jobs, the number of jobs delayed is

[GATE - 2010]

(a) 1 (b) 2
(c) 3 (d) 4

5. Six jobs arrived in sequence as given below:

Jobs	Processing Time (days)
I	4
II	9
III	5
IV	10
V	6
VI	8

Average flow time (in days) for the above jobs using Shortest Processing Time rule is

[GATE - 2009]

(a) 20.83 (b) 23.16
(c) 125.00 (d) 139.00

6. A set of 5 jobs is to be processed on a single machine. The processing time (in days) is given in the table below. The holding cost for each job is Rs. K per day.

CHAPTER - 4
BREAK EVEN ANALYSIS

4.1 AGGREGATE PLANNING
It is Dynamic Process and requires continuous updating. We develop an aggregate plan that identifies the best thing to do during each period of the planning horizon to optimize the long term goal of the organization. Then we implement the first passed of the plan. Now we gather more information and update and revise the plan. This is called ``Rolling Horizon``.

4.1.1 Strategies of Aggregate Planning
1. Traditional Approach
(i) Demand unalterable must be satisfied.
(ii) Subcontracting and overtime options modified.
(iii) Work force may vary.

2. Chase Strategy
(i) Production level is adjusted to match demand.
(ii) Hiring and training cost increases
(iii) Productivity losses due to poor moral of workers
(iv) Lay off cost severance pay
(v) Inventory cost decreases

3. Level Strategy
(i)Steady output
(ii)Inventory build up during the pared of row demand and repletion during period of high demand.

4. Pure Strategy
A single alternative is used rather than a combination of alternatives. It Maintain level workforce.

5. Mixed Strategy
A combination of alternatives is sued rather than a single one.

> No need of aggregate planning if demand is continuous.

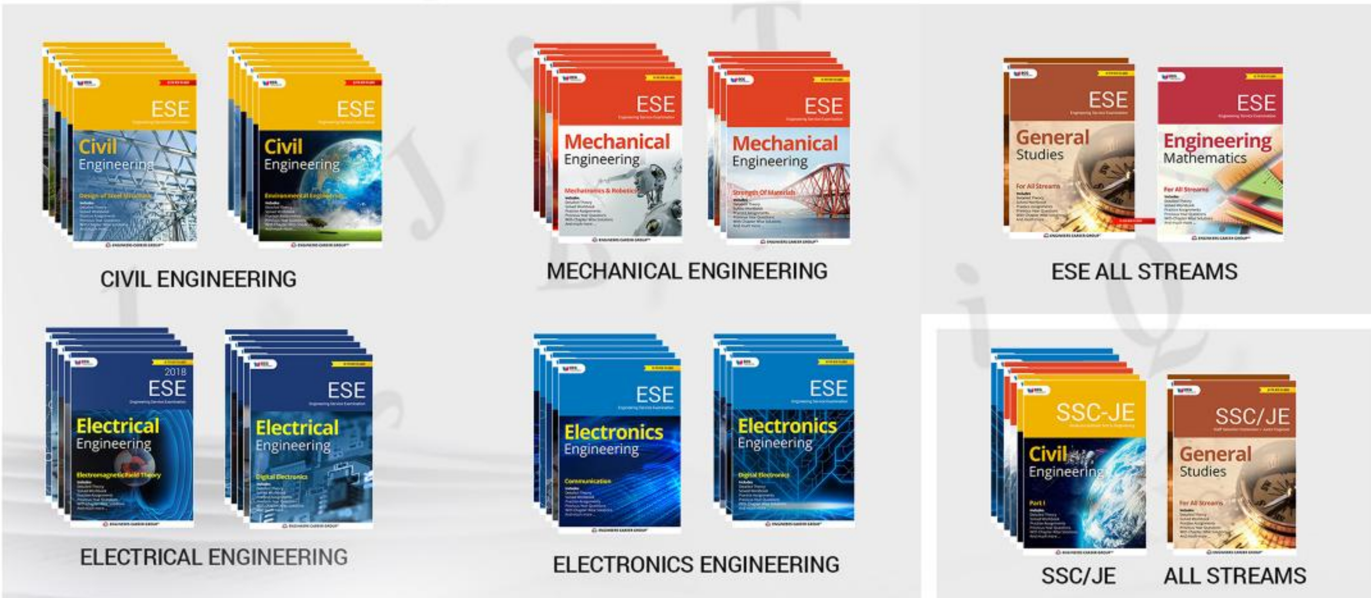
4.2 BREAK-EVEN ANALYSIS
A. It usually refers to the number of pieces for which a business neither makes a profit nor incurs a loss. In other words, the selling price of the product is the total cost of production of the component.

About ECG Publications

Engineers Career Group provides you a wide range of Printed Study Material designed specially for ESE, GATE & SSC-JE Preparation. Includes Mock Tests, Sample Papers, Previous Year Papers with Topic-Wise Solutions. Check it out today.

Our Technical & Non-Technical Books

ESE (4 STREAMS) | GATE (5 STREAMS) | SSC-JE (3 STREAMS)



ENGINEERS CAREER GROUP

Also available on:

Order online on our website **www.engineerscareergroup.in** or from our **Mobile App**