Q.2. a. Explain the scope of Operation Research in various fields of Engineeri
Non- Engineering applications.

Ans. OR is useful in the following various important fields

In Agriculture: With explosion of population and consequent shortage of food every country is facing the problem of

a) Optimum allocation of land to various corps in accordance with e climatic conditions
b) Optimum distribution of water from various resources like can for irrigation purposes.

In Finance: OR techniques can be applied

i) to maximize the per capita income with minimum resources
ii) to find out the profit plan for the company
iii) to determine the best replacement policies

In Industry: OR is applicable in deciding optimum allocation of various limited resources such as men, machine, material, money, time to arrive at the optimal decision.

In Marketing: OR can be applied

i) Where to distribute the products for sale so that the total cost of transportation is minimum
ii) The minimum per unit sale rice
iii) The size of the stock to met the future demand
iv) How to select the best advertising media with respect to time, cost etc.
v) How, when and what to purchase at the minimum possible cost.

In Personnel management: OR can be applied

i) To appoint the most suitable persons on minimum salary
ii) To determine the best age of retirement for the employees
iii) To find out the number of persons to be appointed on full time basis when the workload is seasonal.

In Production Management: A production manager can use OR techniques

i) To find out number and size of the items to produced
ii) In scheduling and sequencing the production run by proper allocation of machines

iii) In calculating the optimum product mix
iv) To select, locate and design the sites for production plants.

Q.2. b. Solve the following LPP by graphical method

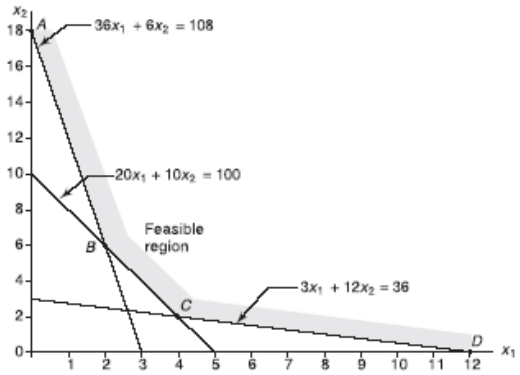
Minimize Z = 20X1 + 40X2
Subject to constraints
$36X1 + 6X2 \geq 108$
$3X1 + 12X2 \geq 36$
$20X1 + 10X2 \geq 100$
$X1\ X2 \geq 0$

Ans. The first constraint $36X1 + 6X2 \geq 108$ can be represented as follows.

We set $36X1 + 6X2 = 108$
When X1 = 0 in the above constraint, we get,
$36 \times 0 + 6X2 = 108$
$X2 = 108/6 = 18$
Similarly when X2 = 0 in the above constraint, we get,
$36X1 + 6 \times 0 = 108$
$X1 = 108/36 = 3$

The second constraint$3X1 + 12X2 \geq 36$ can be represented as follows,
We set $3X1 + 12X2 = 36$
When X1 = 0 in the above constraint, we get,
$3 \times 0 + 12X2 = 36$
$X2 = 36/12 = 3$
Similarly when X2 = 0 in the above constraint, we get,
$3X1 + 12 \times 0 = 36$
$X1 = 36/3 = 12$

The third constraint$20X1 + 10X2 \geq 100$ can be represented as follows,
We set $20X1 + 10X2 = 100$
When X1 = 0 in the above constraint, we get,
$20 \times 0 + 10X2 = 100$
$X2 = 100/10 = 10$
Similarly when X2 = 0 in the above constraint, we get,
$20X1 + 10 \times 0 = 100$
$X1 = 100/20 = 5$



Point	X1	X2	Z = 20X1 + 40X2
0	0	0	0
A	0	18	Z = 20 x 0 + 40 x 18 = 720
B	2	6	Z = 20 x2 + 40 x 6 = 280
C	4	2	Z = 20 x 4 + 40 x 2 = 160* Minimum
D	12	0	Z = 20 x 12 + 40 x 0 = 240

The Minimum cost is at point C
When X1 = 4 and X2 = 2
Z = 160

Q.3. a. Solve the following by Simplex method

Maximize $Z = 80x_1 + 55x_2$

Subject to

$4x_1 + 2x_2 \leq 40$

$2x_1 + 4x_2 \leq 32$

and $x_1 \geq 0, x_2 \geq 0$

Ans.

Maximize $Z = 80x_1 + 55x_2 + 0s_1 + 0s_2$

Subject to

$4x_1 + 2x_2 + s_1 = 40$

$2x_1 + 4x_2 + s_2 = 32$

$x_1 \geq 0, x_2 \geq 0, s_1 \geq 0, s_2 \geq 0$

			$C_j \rightarrow$ 80	55	0	0	
Basic Variables	C_B	X_B	X_1	X_2	S_1	S_2	Min ratio X_B / X_k
s_1	0	40	4	2	1	0	40 / 4 = 10 ⟶ outgoing
s_2	0	32	2	4	0	1	32 / 2 = 16
	$Z = C_B X_B = 0$		↑incoming $\Delta_1 = -80$	$\Delta_2 = -55$	$\Delta_3 = 0$	$\Delta_4 = 0$	
x_1	80	10	$(R_1 = R_1 / 4)$ 1	1/2	1/4	0	10/1/2 = 20
s_2	0	12	$(R_2 = R_2 - 2R_1)$ 0	3	-1/2	1	12/3 = 4 ⟶ outgoing
	$Z = 800$		↑incoming $\Delta_1 = 0$	$\Delta_2 = -15$	$\Delta_3 = 40$	$\Delta_4 = 0$	
x_1	80	8	$(R_1 = R_1 - 1/2R_2)$ 1	0	1/3	-1/6	
x_2	55	4	$(R_2 = R_2 / 3)$ 0	1	-1/6	1/3	
	$Z = 860$		$\Delta_1 = 0$	$\Delta_2 = 0$	$\Delta_3 = 35/2$	$\Delta_4 = 5$	

Since all $\Delta_j \geq 0$, optimal basic feasible solution is obtained

Therefore the solution is Max Z = 860, $x_1 = 8$ and $x_2 = 4$

Q.3.b. Write the Dual of the following LPP

Min Z = 4X1 + 5X2- 3X3
Subject to constraints,
X1+ X2 + X3 = 22
3X1+ 5X2 - 2X3 ≤ 65
X1+ 7X2 +4X3 ≥ 120
X1 , X2 ≥ 0 and X3 is unrestricted

Ans. Since X3 is Unrestricted, replace X3 with (X4 - X5) and bring the problem into standard form

Min Z = 4X1 + 5X2- 3(X4 - X5)
Subject to constraints,
X1+ X2 + (X4 - X5) ≥22
-X1- X2 - (X4 - X5) ≥- 22
-3X1- 5X2 + 2(X4 - X5) ≥ -65
X1+ 7X2 +4(X4 - X5) ≥ 120
X1, X2, X4, X5 ≥ 0

The Dual of the above primal is as follows
Max. G = 22(W1 -W2) - 65W3 + 120W4
Subject to constraints,
W 1 -W2 - 3W3 +W4$\leq$ 4
W 1 - W2 - 5W3 + 7W4 $\leq$ 5
W 1 - W2 + 2W3+ 4W4 $\leq$ -3
-W 1 + W2 - 2W3- 4W4 $\leq$ 3
W 1, W2, W3, W4 > 0

Max. G = 22W5 - 65W3 + 120W4
Subject to constraints,
W 5- 3W3 +W4$\leq$ 4
W5 -5W3 + 7W4 $\leq$ 5
W 1 - W2 + 2W3+ 4W4 $\leq$ -3
-W 1 + W2 - 2W3- 4W4 $\leq$ 3
W 1, W2, W3, W4 $\geq$ 0

Q.4.a. Explain the Hungarian Method used for solving assignment problems.

Ans. Since all the supplies and demands for any assignment problem are integers, all variables in optimal solution of the problem must be integers. Since the RHS of each constraint is equal to 1, each *xij* must be a nonnegative integer that is no larger than 1, so each *xij* must equal 0 or 1. Ignoring the *xij* = 0 or *xij* = 1 restrictions at the LP representation of the assignment problem, we see that we confront with a balanced transportation problem in which each supply point has a supply of 1 and each demand point has a demand of 1. However, the high degree of degeneracy in an assignment problem may cause the Transportation Simplex to be an inefficient way of solving assignment problems. For this reason and the fact that the algorithm is even simpler than the Transportation Simplex, the Hungarian method is usually used to solve assignment problems.

Remarks
1. To solve an assignment problem in which the goal is to maximize the objective function, multiply the profits matrix through by –1 and solve the problem as a minimization problem.
2. If the number of rows and columns in the cost matrix are unequal, the assignment problem is unbalanced. Any assignment problem should be balanced by the addition of one or more dummy points before it is solved by the Hungarian method.

Q.4.b.

Certain equipment needs 5 repair jobs which have to be assigned to 5 machines. The estimated time (in hours) that a mechanic requires to complete the repair job is given in the table. Assuming that each mechanic can be assigned only one job, determine the minimum time assignment.

	J1	J2	J3	J4	J5
M1	7	5	9	8	11
M2	9	12	7	11	10
M3	8	5	4	6	9
M4	7	3	6	9	5
M5	4	6	7	5	11

Ans.

Row Reduced Matrix

2	0	4	3	6
2	5	0	4	3
4	1	0	2	5
4	0	3	6	2
0	2	3	1	7

I Modified Matrix

2	0	4	2	4
2	5	0	3	1
4	1	0	1	3
4	0	3	5	0
0	2	3	0	5

$N < n$

II Modified Matrix

1	0	4	1	3
1	5	0	2	0
3	1	0	0	2
4	1	4	5	0
0	3	4	0	5

N = n

Zero assignment

1	[0]	4	1	3
1	5	[0]	2	~~0~~
3	1	~~0~~	[0]	2
4	1	4	5	[0]
[0]	3	4	~~0~~	5

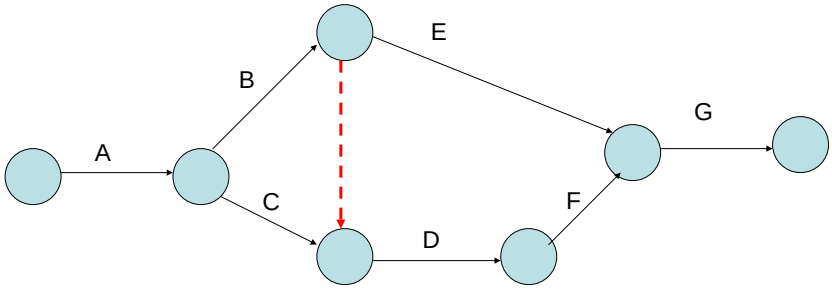
Optimal assignment	M1 – J2	M2 – J3	M3 – J4	M4 – J5	M5 – J1
Hours	5	7	6	5	4

Minimum time = 5 + 7 + 6 + 5 + 4 = 27 hours

Q.5.a. Construct an arrow diagram for the following project

Activities	Relationship
A	Precedes B,C
B	Precedes D,E
C	Precedes D
D	Precedes F
E	Precedes G
F	Precedes G

Ans.



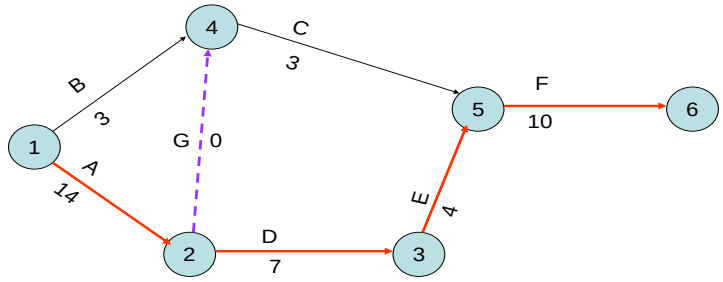
Q.5.b. Construct the Network for the following Project and determine the following

i) Critical Path
ii) ES, EF, LS, LF
iii) TF, FF

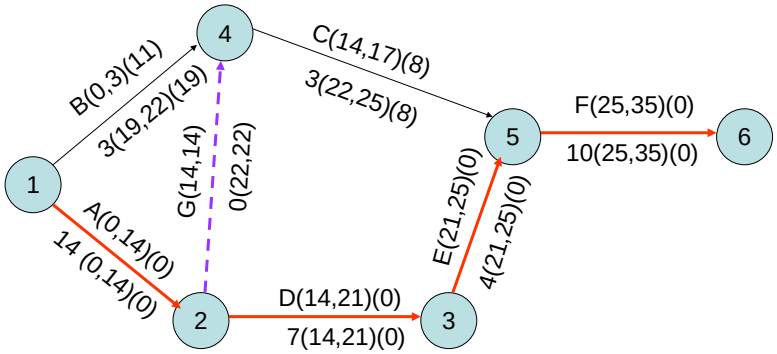
Activity	Duration
1-2	14
1-4	3
2-3	7
2-4	0
3-5	4
4-5	3
5-6	10

Ans.

Construction of the Network and Determination Critical Path



Determination of TF and FF



TF(CA) = LS (CA) - ES (CA)

FF(CA) = ES(SA) – EF (CA)

IF = (ES(SA) – LF(PA)) - Duration of CA

Key: Job (ES,EF)(FF) → Duration (LS,LF)(TS)

Activity	Duration	ES	EF	LS	LF	TF	FF
1-2	14	0	14	0	14	0	0
1-4	3	0	3	19	22	19	11
2-3	7	14	21	14	21	0	0
2-4	0	14	14	22	22	0	0
3-5	4	21	25	21	25	0	0
4-5	3	14	17	22	25	8	8
5-6	10	25	35	25	35	0	0

Q.6.a. what is the procedure to determine Saddle point?

Ans. Pg. No.508 of Text Book 1 by Hamdy A. Taha

Q.6.b. Customers arrive at the first class ticket counter of a theatre at a rate of 12 per hours. There is one clerk serving the customers at a rate of 30 per hour. Assuming the conditions for use of the single channel queuing model, evaluate

a) The probability that there is no customer at the counter (i.e. that the system is idle)
b) The probability that there are more than 20 customers at the counter
c) The probability that there is no customer waiting to be served
d) The probability that a customer is being served and no body is waiting.

Ans. Given $\lambda = 12$ customers /hr

$\mu = 30$ customers/hr

1) Ideal $=1- \rho = 1- \lambda / \mu = 1- 12/30 = 0.6$

2) At least 3 customers at counter

$$P (n>k) = \rho (k+1) = \rho (3+1) = (12/30)^4 = 0.025$$

3) Probability that no customers waiting to be served

P (at least 1 customer at the counter)

$= P_o + P_1$

$= \rho 0 (1-\rho) + \rho 1 (1-\rho) = (1- \rho) (1 + \rho) = (1- \rho^2)$

$= (1- (12/30)^{2 =} 0.84$

4) Probability that a customers being served and nobody waiting

$= P_{1 =} \rho 1 (1-\rho) = 12/30(1-12/30) = 0.24$

Q.7.a. Differentiate between traditional management versus modern management

Ans.

Traditional Management Versus Modern Management

Number	Traditional Management (Stable Environment)	Modern Management (Dynamic Environment)
1	Clear-cut single objectives	Multivalued objectives
2	Autocratic leadership	Participative and democratic leadership
3	Authority by position	Well-earned authority
4	Economic-based incentives	Economic- and intrinsic-based rewards
5	Clear-cut tasks	Multidisciplinary tasks
6	Emphasis on individuality	Emphasis on team
7	Management-based controls	Commitment and self-actuating-inclined behavior
8	Individuals trained to fit organization or company	Individuals shape the organization and its future
9	Stability inclined	Change and growth inclined
10	Conflict considered undesirable	Conflict considered unavoidable
11	Strict segmentation of labor force	Transparent multigroup dependencies

Q.7.b. List the essential Qualities and Activities of an Engineering Manager

Ans. Over the years, many professionals working in the management field have studied the qualities of engineering managers. After a careful analysis, they have developed a list of typical qualities of a good engineering manager as presented below:

Typical Qualities of a Good Engineering Manager

1 Tolerance
2 Flexibility
3 Fairness
4 Empathy
5 Ability to reason
6 Good emotional control
7 Good humor
8 Self-confidence
9 Good listening ability
10 Quickness to praise and criticize
11 Tact
12 Technical competence
13 Quickness to see good in others
14 Ability to recognize different points of view
15 Ability to self-appraise
16 Freedom from suspicion and prejudice
17 Good communication skills

Usually, a manager performs the following basic activities:

- Planning;
- Organizing;
- Staffing;
- Communicating;
- Personnel development;
- Counseling;
- Training;
- Standards.

Q.8.a. Explain Steps, Methods, and Selection Factors used in Forecasting

The success of any forecast depends on the effectiveness of the approach followed in forecasting. A useful forecasting approach is composed of the following eight steps:
· Determine the forecast application and objective.
· Choose with care the items to be forecasted.
· Determine forecast time horizon (i.e., long, short, or medium).
· Choose appropriate forecasting model(s).
· Collect the appropriate data required to make the forecast under consideration.
· Validate the forecasting model with care.
· Make all relevant forecasts.
· Implement the appropriate results.

The forecasting methods may be divided into two broad categories: qualitative and quantitative. The qualitative methods provide forecasts that incorporate factors such as the decision maker's emotions, personal experiences, and intuition. Some examples of the qualitative methods are jury of executive opinion, Delphi method, consumer market survey, and sales force opinion composite. The quantitative methods provide forecasts that were obtained by employing various mathematical models that use past data or causal variables to forecast demand. Examples of the quantitative methods include exponential smoothing, moving averages, linear-regression causal model, and trend projection.

The forecasting technique selection could be subject to one or more factors, such as the forecast development cost, the availability of historical data, the length of prediction interval, data accuracy, the time for analysis, the expected accuracy from the forecasted result, and the complexity of factors affecting operations in time to come. Two widely used quantitative methods are : Simple Average and Exponential Smoothing.

Q.8.b. How SWOT analysis helps into strategy formulation?

Ans. Pg. No. 128 of Textbook 2, Engineering management by Fraidoon Mazda

Q.9.a. Explain the Hertzberg's Theory of Motivation

Ans. Hertzberg developed a theory of motivation on the premise that human nature has two separate elements - The motivators and maintenance factors. According to this theory of motivation the items that determine job content are considered motivational factors e.g.:- Achievement, recognition, responsibility, advancement and the work itself. The elements that influence the job context are the hygiene or maintenance factors e.g.:- company policy, salary, inter-personal relations, working conditions etc. They must be adequate and if they are absent or inadequate, they will create dissatisfaction.

(a) Hygiene Factors*:* Hygiene factors represent the need to avoid pain in the environment. They are not an intrinsic part of a job, but they are related to the conditions under which a job is performed. They are associated with negative feelings. They must be viewed as preventive measures that remove sources of dissatisfaction from environment. Hertzberg believed that hygiene factors created a zero level of motivation and if maintained at proper level prevents negative type of motivation from occurring. Thus, hygiene factors, when absent, increase dissatisfaction with the job. When present, help in preventing dissatisfaction but do not increase satisfaction or motivation.

(b) Motivators*:* Motivators are associated with positive feelings of employees about the job. They make people satisfied with their job. Motivators are necessary to keep job satisfaction and job performance high. On the other hand, if they are not present they do not prove highly satisfying. Motivational factors or satisfiers are directly related to job content itself, the individual's performance of it, its responsibilities and the growth and recognition obtained from it. Motivators are intrinsic to the job. Thus, when motivators are absent, prevent both satisfaction and motivation. When, motivators are present, they lead to satisfaction and motivation. To apply the two-factor theory to the workplace, Hertzberg suggests a two-step process.

(i) The supervisor should attempt to eliminate the hygiene ... that are found to be more basic than factors that lead ... satisfaction.
(ii) Once the dissatisfies have been somewhat neutralized, the supervisor may be able to motivate workers through the introduction of motivational factors.

Q.9.b. What is Market segmentation? Explain different types of market segmentation. List the requirements for effective market segmentation.

Ans. Market Segmentation: Dividing a market into smaller groups with distinct needs, characteristics, or behaviors who might require separate products or marketing mixes. Through market segmentation; companies divide large, heterogeneous markets into smaller segments that can be reached more efficiently and effectively with products and services that match their unique needs.

Segmenting Consumer Markets:

1. Geographic Segmentation
2. Demographic Segmentation
3. Psychographic Segmentation
4. Behavioral Segmentation

1. Geographic Segmentation:
Dividing the market into geographical units such as nations, states, regions, countries, cities or neighborhoods.
Ex:
• A company shipped low calorie snack foods to stores in neighborhoods near weight watchers clinics.
• P&G introduced curry Pringles in England and Funky Soy Pringles in Asia

2. Demographic Segmentation:
Divides a market into groups based on variables as age, gender, family size, income, education, occupation, race, generation and nationality.
Ex:
Age: consumer needs and wants change with age.

3. Psychographic Segmentation:
Divides buyers into different groups based on social class, lifestyle, or personal characteristics.

4. Behavioral Segmentation
Divides buyers into groups based on their knowledge, attitudes, uses or responses to a product.
Occasions: Buyers can be grouped according to occasions when they get the idea to buy, actually make their purchase or use the purchased item.
Usage Rate: Markets can be segmented into light, medium and heavy product Users.
Loyalty Status: markets can be segmented by consumer loyalty

Segmenting International Markets:
• Companies can segment international markets using one or a combination of several variables, ex. Geographic location, grouping countries by region as Asia, Middle East or Western Europe.
• Geographic segmentation assumes that nations close to one another have common traits and behaviors. But this is not the case ex. United States and Canada.
•World markets can be segmented on the basis of economic factors. Ex. Countries might be grouped by population income levels or overall level of economic development

Requirements for Effective Segmentation
To be useful, market segments must be:
•Measurable
•Accessible
•Substantial
•Differentiable
•Actionable