OPERATIONS RESEARCH
(MECH 4143)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) The maximum value of Z of the following LPP is
Max Z = 4x + 6y
Subject to
$3x + 2y \leq 12$
$x + y \geq 2$
$x, y \geq 0$
(a) 24 at (6,0) (b) 36 at (0,6) (c) 24 at (0,4) (d) 16 at (4,0).

(ii) The solution to a transportation problem with 'm' rows (supplies) & 'n' columns (destination) is basic feasible if number of positive allocations are
(a) m+n (b) m*n (c) m+n-1 (d) m+n+1.

(iii) The dummy source or destination in a transportation problem is added to _____
(a) balance the transportation problem
(b) prevent solution from becoming degenerate
(c) ensure that total cost does not exceed a limit
(d) the solution not be degenerate.

(iv) In an assignment problem _____
(a) only one activity be assigned to each resource
(b) any number of activities can be assigned to each resource
(c) it depends upon how many resources are available
(d) first activity is assigned to first resource.

(v) Operations research is the application of _____ methods to arrive at the optimal solutions to the problems.
(a) scientific (b) artistic (c) rational (d) homogeneous

(vi) In decision making under _____, there are several possible outcomes for each alternative, and the decision maker knows the probability of occurrence of each outcome.
(a) risk (b) utility (c) certainty (d) probability

(vii) The number of types of time estimates involved in Program Evaluation Review Technique problem is _____
(a) 1 (b) 2 (c) 3 (d) 4.

(viii) The objective of network analysis is to_____
(a) minimize total project duration
(b) minimize total project cost by bargain
(c) minimize production delays, interruption and conflicts
(d) maximize total project duration.

(ix) In a network diagram an event is denoted by the symbol _____
(a) arrow (b) straight line (c) curve (d) circle.

(x) NLP includes problems
(a) in which the objective function is linear but some constraints are not linear
(b) in which the constraints are linear but the objective function is not linear
(c) in which both the objective function and all the constraints are not linear
(d) all of the above.

Group – B

2. (a) Define EOL and EPPI. [(CO2)(Remember/LOCQ)]

(b) A magazine seller's experience shows that the daily demand of the magazines in his area has the following probability distribution:

Daily demand	300	400	500	600	700
Probability	0.1	0.3	0.4	0.1	0.1

He sells magazines for Rs. 20 each, while he buys each at Rs. 10. Unsold copies are traded as scrap and each such copy fetches Rs. 1. Assuming that he stocks the magazines in multiple of 100 only, how many should he stock so that his expected profit is maximum? [(CO2)(Analyse/IOCQ)]

4 + 8 = 12

3. (a) A small project consist of 12 jobs as shown below.

Jobs	1-2	2-3	2-4	3-4	3-5	4-6	5-8	6-7	6-10	7-9	8-9	9-10
Duration (days)	2	7	3	3	5	3	5	8	4	4	1	7

Draw the network and mark the critical path. [(CO3)(Analyze/IOCQ)]

(b) Te following table shows the jobs of a network along with their time estimates (days).

Job	1-2	1-6	2-3	2-4	3-5	4-5	5-8	6-7	7-8
a	3	2	6	2	5	3	1	3	4
m	6	5	12	5	11	6	4	9	19
b	15	14	30	8	17	15	7	27	28

Draw the network and mark the critical path. Find the probability of the project being completed in 41 days.

-0.9	.18406	.18141	.17879	.17619	.17361	.17106	.16853	.16602	.16354	.16109
-0.8	.21186	.20897	.20611	.20327	.20045	.19766	.19489	.19215	.18943	.18673
-0.7	.24196	.23885	.23576	.23270	.22965	.22663	.22363	.22065	.21770	.21476
-0.6	.27425	.27093	.26763	.26435	.26109	.25785	.25463	.25143	.24825	.24510
-0.5	.30854	.30503	.30153	.29806	.29460	.29116	.28774	.28434	.28096	.27760
-0.4	.34458	.34090	.33724	.33360	.32997	.32636	.32276	.31918	.31561	.31207
-0.3	.38209	.37828	.37448	.37070	.36693	.36317	.35942	.35569	.35197	.34827
-0.2	.42074	.41683	.41294	.40905	.40517	.40129	.39743	.39358	.38974	.38591
-0.1	.46017	.45620	.45224	.44828	.44433	.44038	.43644	.43251	.42858	.42465
-0.0	.50000	.49601	.49202	.48803	.48405	.48006	.47608	.47210	.46812	.46414
Z	**.00**	**.01**	**.02**	**.03**	**.04**	**.05**	**.06**	**.07**	**.08**	**.09**
0.0	.50000	.50399	.50798	.51197	.51595	.51994	.52392	.52790	.53188	.53586
0.1	.53983	.54380	.54776	.55172	.55567	.55962	.56356	.56749	.57142	.57535
0.2	.57926	.58317	.58706	.59095	.59483	.59871	.60257	.60642	.61026	.61409
0.3	.61791	.62172	.62552	.62930	.63307	.63683	.64058	.64431	.64803	.65173
0.4	.65542	.65910	.66276	.66640	.67003	.67364	.67724	.68082	.68439	.68793
0.5	.69146	.69497	.69847	.70194	.70540	.70884	.71226	.71566	.71904	.72240
0.6	.72575	.72907	.73237	.73565	.73891	.74215	.74537	.74857	.75175	.75490
0.7	.75804	.76115	.76424	.76730	.77035	.77337	.77637	.77935	.78230	.78524
0.8	.78814	.79103	.79389	.79673	.79955	.80234	.80511	.80785	.81057	.81327
0.9	.81594	.81859	.82121	.82381	.82639	.82894	.83147	.83398	.83646	.83891

[(CO3)(Analyze/IOCQ)]

4 + 8 = 12

Group – C

4. Three grades of coal A, B and C contain phosphorous and ash as impurities. In a particular industrial process, fuel up to 100 ton (maximum) is required which should contain ash not more than 3% and phosphorous not more than 0.03%. It is desired to maximize the profit while satisfying these conditions. There is an unlimited supply of each grade. The percentage of impurities and the profits of grades are given below.

Coal	Phosphorous (%)	Ash (%)	Profits in rupees per ton
A	0.02	3.0	12.00
B	0.04	2.0	15.00
C	0.03	5.0	14.00

(i) Formulate the above as a linear programming problem (LPP).
(ii) Select a suitable method to solve the LPP and find the optimal solution using that method.

[(CO5)(Evaluate/HOCQ)]
4 + 8 = 12

5. (a) Write the rules to form a dual problem from the primal problem. Construct the dual of the following problem.

Minimize $Z = 3x_1 - 2x_2 + 4x_3$
Subject to the constraints
$3x_1 + 5x_2 + 4x_3 \geq 7$
$6x_1 + x_2 + 3x_3 \geq 4$
$7x_1 - 2x_2 - x_3 \leq 10$
$x_1 - 2x_2 + 5x_3 \geq 3$
$4x_1 + 7x_2 - 2x_3 \geq 2$
$x_1, x_2, x_3 \geq 0$

[(CO5)(Apply/IOCQ)]

(b) Obtain an initial basic feasible solution to the following transportation problem using Vogel's Approximation Method (VAM).

Warehouse	Stores I	Stores II	Stores III	Stores IV	Supply
A	7	3	5	5	**34**
B	5	5	7	6	**15**
C	8	6	6	5	**12**
D	6	1	6	4	**19**
Demand	**21**	**25**	**17**	**17**	**80**

[(CO4)(Apply/IOCQ)]
(3 + 3) + 6 = 12

Group – D

6. (a) Using the following cost matrix determine optimal job assignment and the associated cost:

Machinists	Jobs 1	2	3	4	5
A	10	3	3	2	8
B	9	7	8	2	7
C	7	5	6	2	4
D	3	5	8	2	4
E	9	10	9	6	10

[(CO4)(Apply/IOCQ)]

(b) Define the unbalanced assignment problem. Discuss the Hungarian method to solve an unbalanced assignment problem. [(CO4)(Understand/LOCQ)]

6 + 6 = 12

7. (a) Determine whether the following function is convex, concave or neither.
$f(x) = 3x_1 + 2x_1^2 + 4x_2 + x_2^2 - 2x_1x_2$ [(CO5)(Analyze/IOCQ)]

(b) Define the terms 'Global Maxima' and 'Local Minima'. [(CO5)(Remember/LOCQ)]

6 + 6 = 12

Group – E

8. (a) In a railway marshalling yard, goods trains arrive following an exponential distribution at a rate of 30 trains per day. Service time distribution as Poisson with an average of 36 minutes, calculate the following.
(i) The mean queue size in the system.
(ii) Probability that the queue size exceeds 10. [(CO6)(Analyze/IOCQ)]

(b) In a public telephone booth, the arrivals on an average are 15 per hour. A call on an average takes three minutes. If there is just one phone, find
(i) the proportion of the time the booth is expected to be idle,
(ii) expected length of the non empty queue. [(CO6)(Analyze/IOCQ)]

6 + 6 = 12

9. (a) Customers arrive at a one window bank according to Poisson distribution with mean 10 per hour. Service time per customer is exponential with mean five minutes.
(i) Find out the probability that the average queue length exceed six.
(ii) Find out the expected time spent by a customer in the system. [(CO6)(Analyze/IOCQ)]

(b) State the full names of the followings.
(i) FCFS (ii) FIFO (iii) LIFO (iv) SIRO [(CO6)(Remember/LOCQ)]

8 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	18.75	68.75	12.5

Course Outcome (CO):

After the completion of the course students will be able to

CO 1	**Interpret** the basic idea, history and different applications of operations research in engineering as well as managerial fields.
CO 2	**Formulate** different decision making problems and **argue** for solving them with different techniques.
CO 3	**Illustrate** different network models and **estimate** about project scheduling and completions.
CO 4	**Solve** different transportation and assignment problems.
CO 5	**Distinguish** between LPP and NLPP problems and **apply** different techniques for developing their solutions.
CO 6	**Analyze** single channel waiting line problems.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.