OPERATIONS RESEARCH ENGINEERING APPLICATIONS
(CHEN 4244)

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) If we convert the inequation $x_1 + x_2 \le 7$ into the equation $x_1 + x_2 + x_3 = 7$, then x_3 is a
(a) slack variable
(b) surplus variable
(c) artificial variable
(d) both artificial and surplus variable.

(ii) Hungarian algorithm is used for
(a) transportation problem (b) assignment problem
(c) queuing theory (d) simplex method.

(iii) Monte-Carlo technique is used for
(a) inversion of matrix (b) network analysis
(c) simulation (d) none of the above.

(iv) An assignment problem is a special case of a Transportation problem with
(a) non-feasible solution (b) unbounded solution
(c) degenerate solution (d) none of the above

(v) Traffic intensity of a simple queue is given by
(a) $\rho = \mu/\lambda$ (b) $\rho = \mu t/\lambda$ (c) $\rho = \mu/\lambda t$ (d) $\rho = \lambda/\mu$

(vi) Slack time ($\tau_s{}^j$) is equal to
(a) $T_L{}^j - T_E{}^j$ (b) $T_E{}^j - T_L{}^j$ (c) $T_E{}^j + t_E{}^{ij}$ (d) $T_L{}^j - t_E{}^{ij}$.

(vii) PERT Network is
(a) deterministic (b) probabilistic
(c) both (a) and (b) (d) virtual.

(viii) In PERT network σ_E is equal to
(a) $(t_p - t_o)/6$ (b) $(t_o + t_p + t_L)/3$
(c) $(t_o + t_p + 2t_L)/4$ (d) $(t_o + t_p + 4t_L)/6$.

(ix) The 95% confidence interval is same as ___ % level of significance.
(a) 0 (b) 100 (c) 5 (d) 50.

(x) The domain of Spearman's rank correlation coefficient is
(a) $-\infty$ to $+\infty$ (b) 0 to 1 (c) -1 to +1 (d) 0 to ∞.

Group – B

2. (a) Prove that a basic feasible solution of the Linear Programming problem is a vertex of the convex set of feasible solutions.

(b) Solve the following formulations:
$x_1 - x_2 >= 0$; $3x_1 - x_2 <= -3$; $x_1, x_2 >= 0$, max $z = x_1 + x_2$

6 + 6 = 12

3. Solve the following problem:
$x_1 + 3x_2 + 2x_3 + 5x_4 <= 20$; $2x_1 + 16x_2 + x_3 + x_4 >= 4$; $3x_1 - x_2 - 5x_3 + 10x_4 <= -10$;
$x_1, x_2, x_3, x_4 >= 0$; min $z = -2x_1 - x_2 - 4x_3 - 5x_4$.

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Group – C

4. A company manufacturing air-coolers has two plants located at Mumbai and Calcutta with a weekly capacity of 200 units and 100 units, respectively. The company supplies air-coolers to its 4 showrooms situated at Ranchi, Delhi, Lucknow and Kanpur which have a demand of 75, 100, 100 and 30 units, respectively. The cost of transportation per unit (in Rs.) is shown in the following table:

	Ranchi	Delhi	Lucknow	Kanpur
Mumbai	90	90	100	100
Calcutta	50	70	130	85

Plan the production programme so as to minimize the total cost of transportation.

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5. A departmental head has four subordinates, and four tasks to be performed. The subordinates differ in efficiency, and the tasks differ in their intrinsic difficulty. His estimate, of the time each man would take to perform each task, is given in the matrix below:

Tasks	Men			
	E	F	G	H
A	18	26	17	11
B	13	28	14	26
C	38	19	18	15
D	19	26	24	10

How should the tasks be allocated, one to a man, so as to minimize the total man-hours?

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Group – D

6. The calculated values of friction factor (f) as a function Reynolds number (Re) is given below:

Re	4530	5010	5780	9600	12600	15600
f	0.0097	0.0095	0.0092	0.0081	0.0075	0.0071

Obtain a Regression equation involving these parameters.

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7. A soft drink bottler is interested in obtaining more uniform fill heights in the bottles produced by his manufacturing process. The filling machine theoretically fills reach bottle to the correct target height, but in practice, there is variation around the target, and the bottler would like to understand better the sources of this variability and eventually reduce it.

The process engineer can control three variables during the filling process. The percent carbonation (A), the operating pressure in the filter (B), and the bottles produced per minute or the line speed (C). The pressure and speed are easy to control, but the percent carbonation is more difficult to control during actual manufacturing because it varies with product temperature. However, for purposes of an experiment, the engineer can control carbonation at three levels: 10, 12, & 14 percent. He chooses two levels for pressure (25 and 30 psi) and two levels for line speed (200 and 250 bpm). He decides to run two replicates of a factorial design in these three factors, with all 24 runs taken in random order. The response variable observed is the average deviation from the target fill height observed in a production run of bottles at each set of conditions. The data that resulted from the experiment are shown in below. Positive deviations are fill heights above the target, whereas negative deviations are fill heights below the target:

Operating pressure (B)					
Percent carbonation (A)	25 psi		30 psi		y_i
	Line Speed(C)		Line Speed (C)		
	200	250	200	250	
10	-3	-1	-1	1	-4
	-1	0	0	1	
12	0	2	2	6	20
	1	1	3	5	
14	5	7	7	10	59
	4	6	9	11	

Using attached F table, analyse the data using ANOVA and draw your conclusions.

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Group – E

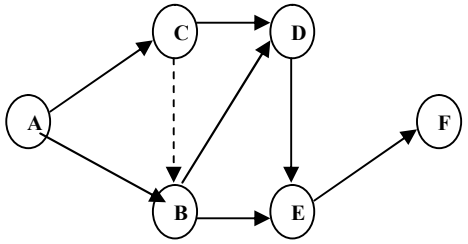
8. (a) Derive the following characteristics of an M/M/I (Model I) queuing system:

$$E(w) = \frac{\lambda}{\mu(\mu - \lambda)}$$

(b) Assume that the coal-wagons are coming in a yard at the rate of 30 wagons per day and suppose that inter-arrival times follow an exponential distribution. The service time for each wagon is assumed to be exponential with an average of 36 minutes. If the yard can admit 9 wagons at a time (there being 10 lines, one of which is reserved for shunting purposes), calculate the probability that the yard is empty and find the average queue length.

6 + (3 + 3) = 12

9. (a) For the network shown in the figure, the three time estimates (in days) for each of the activities are indicated in the following table. Number the events in the network according to the Fulkerson's rule in the steps of 10.



Activity	t_O	t_L	t_P
A-B	4	5	6
A-C	4	6	8
B-D	9	11	13
B-E	7	8	9
C-B	0	0	0
C-D	6	8	10
D-E	5	7	9
E-F	4	5	6

(b) If the schedule completion time is 30 days, determine the slack time for each event and identify the critical path. Enter the values in a tabular form.

4 + 8 = 12