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 an optimum solution is degenerate, then
(a) the solution is infeasible
(b) there are alternative optimum solutions
(c) the solution is of no use for taking decisions
(d) none of the above.

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

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

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

(v) 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.

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

(vii) An integer programming problem is a mathematical optimization or feasibility program in which some or all of the variables are restricted to
(a) fraction (b) integer
(c) negative (d) imaginary quantities.

(viii) 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) $T_L{}^j - t_E{}^{ij}$.

(ix) 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) $(t_o + t_p + 4t_L)/6$

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

Group – B

2. Three grades of Coal A, B and C contain ash and phosphorous as impurities. In a particular industrial process a fuel obtained by blending the above grades containing not more than 25% ash and 0.03% phosphorous is required.
The maximum demand of fuel is 100 tons. Percentage impurities and costs of the various grades of coal are shown below. Assuming that there is an unlimited supply of each grade of coal and there is no loss in blending, formulate the blending problem to minimise the cost.

Coal Grade	% ash	% phosphorous	Cost per ton (in Rs)
A	30	0.02	240
B	20	0.04	300
C	35	0.03	280

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3. For a system of linear inequalities with objective function minimize $P(x) = -4x_1 - 5x_2$, subject to constraints $x_1 - 2x_2 <= 2$; $2x_1 + x_2 <= 6$; $x_1 + 2x_2 <= 5$; $-x_1 + x_2 >= 2$.
Discuss the algorithm to develop Simplex Method through different canonical forms.

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Group – C

4. Obtain an initial basic feasible solution to the following transportation problem using NWC Rule.

	D	E	F	G	Available
A	11	13	17	14	250
B	16	18	14	10	300
C	21	24	13	10	400
Requirement	200	225	275	250	

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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. (a) A textile company weaves a fabric on a large number of looms. They would like the looms to be homogeneous so that they can obtain a fabric of uniform strength. The process engineering suspect that, in addition to the usual variation in strength within samples of fabric from the same loom, there may also be significant variations in the strength between looms. To investigate this she selects four looms at random and makes four strength determinations on the fabric manufactured on each loom. This experiment is run in random order, and data obtained are shown in the following table:

	Observation				
Looms	1	2	3	4	y_i
1	98	97	99	96	390
2	91	90	93	92	366
3	96	95	97	95	383
4	95	96	99	98	388
				Total	1527

Prepare a suitable statistical model for conducting design of experiment. Construct a table showing sum of squares and degrees of freedom for this problem.

(b) Using F table, compute analysis of variance (ANOVA) for 95% confidence interval and draw your conclusion.

6 + 6 = 12

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

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Group – E

8. In a railway marshalling yard, goods trains arrive at a rate of 30 trains per day. Assuming that the inter-arrival time follows an exponential distribution and the service time distribution is also exponential with an average 36 minutes. Calculate the following:
   (i) The mean queue size (time length), and
   (ii) The probability that the queue size exceeds 10.

(6 + 6) = 12

9. (a) What is Fulkerson's rule? Enumerate the basic differences between PERT and CPM network.

   (b) The following activities for a seminar with their duration in days are given below:
   Fixing the dates (2); Formulate the theme (2); collect the contact details for sending brochure (4); get the brochure printed (6); finalize selection of two guest speakers (1); send invitation to the two guest speakers (1); mail brochure to all (3); collect all submitted papers (45); Review and finalize papers (10); inform the authors of the acceptance (7); arrange accommodation and refreshment (6); arrange transportation (2); arrange lecture halls, PA systems etc. (2); prepare introductory speech (1); assign duties to volunteers (2). Draw a network diagram and number the events.

(2 + 4) + 6 = 12