SLOT: C1+TC1+TCC1

REG. NO.:

Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

SCHOOL OF MECHANICAL ENGINEERING
CONTINUOUS ASSESSMENT TEST (CAT) -II
WINTER SEMESTER 2023-2024

Programme Name & Branch : B.Tech (Mechanical Engineering)
Course Code : BMEE215L
Course Name : Engineering Optimization
Faculty Name(s) : Dr. Dega Nagaraju, Dr. Sudhakara Pandian R, Dr. Rajyalakshmi G, Dr. Sivaprasad Darla, Dr. Raviteja Buddala
Class Number(s) : VL2023240504649/4645/4643/4652/4651
Exam Duration : 90 minutes **Maximum Marks:** 50

General instruction(s):

- *Students are permitted to use non-programmable calculators.*
- *Students are permitted to use normal distribution table.*
- *Answer all the questions.*
- *Graph sheets should be provided by CAT exam cell.*
- *Demonstrate step by step procedure.*

<table>
<tr><th>Q. No</th><th>Question</th><th>Marks</th></tr>
<tr><td>1.</td><td>A multinational FMCG company wishes to launch a new Fruit Yogurt in the coming season. A brief description of the activities associated with this project, their expected duration (in days) and their immediate predecessor(s) are given in the following table.
<table>
<tr><th rowspan="2">Activity</th><th rowspan="2">Preceding Activity</th><th colspan="3">Duration (in days)</th></tr>
<tr><th>Optimistic Time</th><th>Most Likely Time</th><th>Pessimistic Time</th></tr>
<tr><td>A</td><td>None</td><td>6</td><td>9</td><td>18</td></tr>
<tr><td>B</td><td>None</td><td>5</td><td>8</td><td>17</td></tr>
<tr><td>C</td><td>A</td><td>4</td><td>7</td><td>22</td></tr>
<tr><td>D</td><td>B</td><td>1</td><td>7</td><td>16</td></tr>
<tr><td>E</td><td>A</td><td>4</td><td>7</td><td>10</td></tr>
<tr><td>F</td><td>B</td><td>2</td><td>5</td><td>8</td></tr>
<tr><td>G</td><td>C, D</td><td>4</td><td>10</td><td>22</td></tr>
</table>
a) Draw the network for the given activities?
b) Determine the average expected duration and variance of each activity?
c) Calculate the earliest expected time, latest finish time of each activity?
d) Determine the critical path and expected length of the project?
e) What is the probability of completing the project 2 days later than expected?</td><td>10</td></tr>
<tr><td>2.</td><td>The government of Andhra Pradesh has taken the decision to lay down the concrete road in a particular remote area connecting six important junctions. The network shown below indicates the distance in Kilometres between each pair of junctions. Keeping in view of the cost of the project, it is decided to lay down the road providing some connection between every pair of junctions. Using Prim’s algorithm, by considering the source node as ‘S’, determine the most economical length of the concrete road to be laid down in order to minimize the cost?</td><td>10</td></tr>
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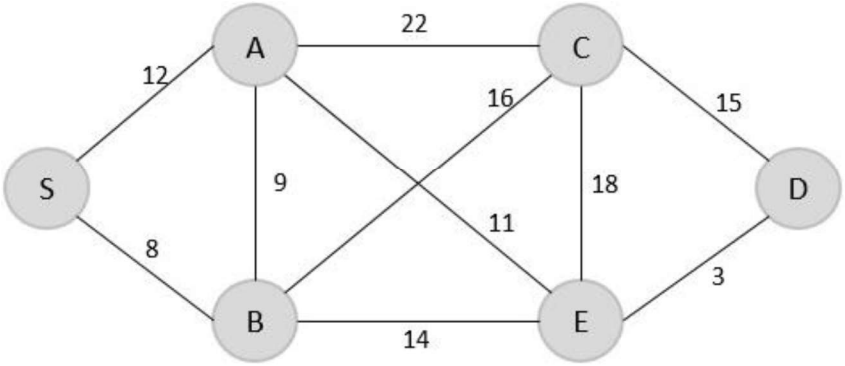
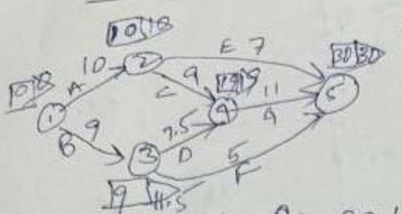
		
3.	A small furnishing company manufactures chairs and tables. Each chair requires 8 man-hours of labour while each table requires 10 man-hours of labour. If only 80 man-hours are available each week and the owner of the company would neither hire additional labour nor utilize overtime, formulate the linear goal programming problem and solve it. Both the chair and the table fetch a profit of 50 each. The owner has a target to earn a profit of 1100 per week. Also, he would like to supply 12 tables, if possible, per week to a sister concern. Consider that the priority of the goals is as per the order of the constraints, i.e. total available man-hours, target profit, supply of tables.	10
4.	A 6-ton vessel can be loaded with one or more items. The following table gives the unit weights in tons, the unit revenue in thousands of rupees for item i. How should the vessel be loaded to maximize the total return? Item, i | Weight, w_i | Revenue, r_i 1 | 4 | 70 2 | 1 | 20 3 | 2 | 40	10
5.	(a) Explain the new technology that optimizes and offers benefits in the following areas with overall reduction in cost from both business and customer perspectives. (i) Transport (ii) Health care (iii) Real-time product tracking (iv) Energy (v) Internet {Applicable to Dr. Dega Nagaraju (VL2023240504649), Dr. Sudhakara Pandian R (VL2023240504645), Dr. Rajyalakshmi G (VL2023240504643)} OR (b) Explain the role of artificial intelligence in optimisation of smart factory with case example and list out its advantages. { Applicable to Dr. Sivaprasad Darla (VL2023240504652), Dr. Raviteja Buddala (VL2023240504651) }	10

CAT-2 Key COWX1BMBB215L, SLA; G

(1)



	Te	V	EST	LFT
A	10	4	0	10
B	9	4	0	11.5
C	9	9	10	19
D	7.5	6.25	9	19
E	7	1	10	30
F	5	1	9	30
G	11	9	19	30

CPM
The Conditions C.P: A → C → G, P.D. = 30 days

$P\left(Z \le \frac{32-30}{\sqrt{4+9+9}}\right) = P(Z \le 0.426) = 0.6628$ from the table
$= 66.28\%$

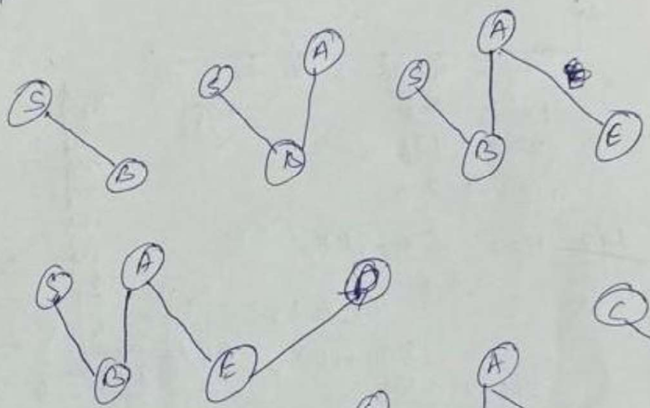
(2) Prim's Alg
Starting Node = S

Adj. Nodes S – A: 12
S – B: 8 ✓

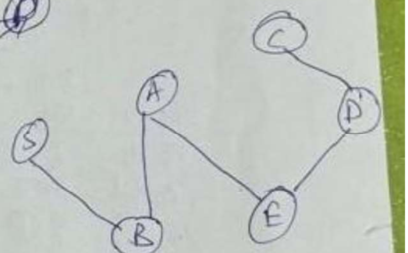
S – A: 12
Adj. → B – A: 9 ✓
B – C: 16
B – E: 14

S – A: 12
B – C: 16
B – E: 14
Adj. Node A – C: 22
A – E: 11 ✓

S – A: 12
B – C: 16
B – E: 14
A – C: 22
Adj. Node E – C: 18
E – D: 3 ✓



S-A: 12 Forms loop ✗
B-C: 16
B-E: 14 Forms loop ✗
A-C: 22
E-C: 18
Adj. Node D – C: 15 ✓



MST

Min Dist: 8 + 9 + 11 + 3 + 15 = 46 km

Chair: x_1, Table: x_2

(3) Man-hours constraint: $8x_1 + 10x_2 \le 80$
Profit constraint: $50x_1 + 50x_2 \ge 1100$
Table supply constraint: $x_2 \le 12$
Goals priority = order of constraints
G1: Min d_1^+
G2: Min d_2^-
G3: Min d_3^+
subject to $8x_1 + 10x_2 + d_1^- - d_1^+ = 80$
$50x_1 + 50x_2 - d_2^+ + d_2^- = 1100$
$x_2 + d_3^- - d_3^+ = 12$

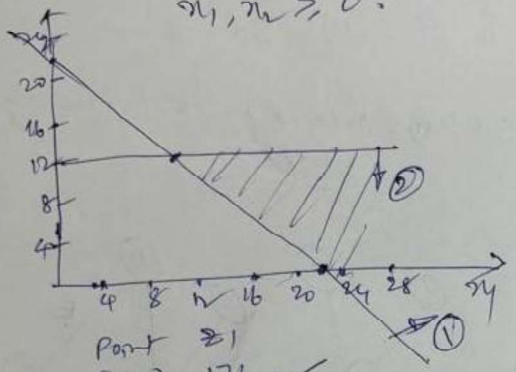
Preemptive method

LP1: Min $8x_1 + 10x_2$

s.t. $50x_1 + 50x_2 \geq 1100$ → (1)

$x_2 \leq 12$ → (2)

$x_1, x_2 \geq 0$.

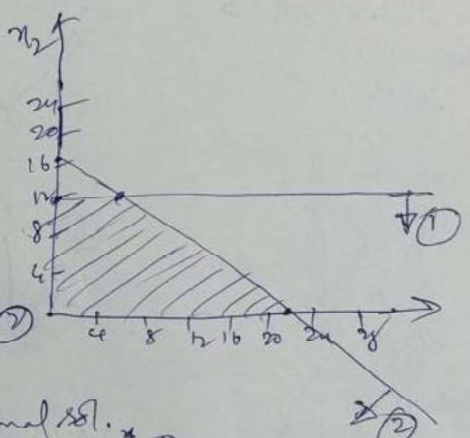


Point	Z_1
(22,0)	176 ✓
(10,12)	200

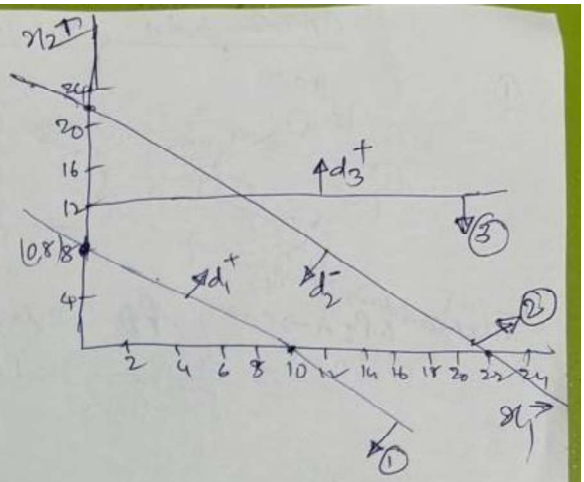
LP2 Max $50x_1 + 50x_2 = Z_2$

s.t. $x_2 \leq 12$ → (1)

$8x_1 + 10x_2 \leq 176$ → (2)



Point	Z_2
(0,0)	0
(0,12)	600
(7,12)	950
(22,0)	1100 ✓



optimal sol.

$x_1^* = 22, x_2^* = 0$

with $\min d_1^+ = 96$, $\min d_2^- = 0$, $\min d_3^+ = 0$

(4) $W = 6$ tons,

Item(i)	w_i	q_i
1	4	70
2	1	20
3	2	40

Backward Procedure

x_j = No. of units of item-i

S = state at stage j, the total weight

Recursive equation $f_j(S, x_j) = \max_{x_j} \{ v_j x_j + f_{j+1}^*(S - x_j) \}$, $j = 1, 2$

$x_j = 0, 1, 2, \ldots \left[\frac{S}{w_j}\right]$

For initial stage $j = 3$, $f_3(S, x_3) = \max \{ v_j x_j \}$

$x_j = 0, 1, 2, \ldots \left[\frac{W}{w_j}\right]$

stage $j = 3$

x_3 \ S	0	1	2	3	$f_3^*(S)$	x_3^*
0	0	–	–	–	0	0
1	0	–	–	–	0	0
2	0	40	–	–	40	1
3	0	40	–	–	40	1
4	0	40	80	–	80	2
5	0	40	80	–	80	2
6	0	40	80	120	120	3

Stage $j=2$

x_2 / s	$\max\{a_2 x_j + f_{j+1}^*(s-x_2)\}$ 0	1	2	3	4	5	6	$f_2^*(s)$	x_2^*
0	0	—	—	—	—	—	—	0	0
1	0	20	—	—	—	—	—	20	1
2	40	20	40	—	—	—	—	40	0 & 2
3	40	60	40	60	—	—	—	60	1, 3
4	80	60	80	60	80	—	—	80	1, 2, 4
5	80	100	80	100	80	100	—	100	1, 3, 5
6	120	100	120	100	120	100	120	120	0, 2, 4, 6

Stage $j=1$

x_1 / s	$\max\{a_1 x_j + f_{j+1}^*(s-x_1)\}$ 0	1	$f_1^*(s)$	x_1^*
0				
1				
2				
3				
4				
5	120	110	120	0
6				

optimal sol.

x_1^* x_2^* x_3^*

0 — 0 — 3
2 — 2
4 — 1
6 — 0

coil Max = 120000 (Rs)

(5) Role of A.I in optimization of Smart Factory : 4M

case example : 2M

Advantages : 4M