Modified

CBCS SCHEME

USN | | | | | | | | | | |

15ME81

Eighth Semester B.E. Degree Examination, June/July 2019
Operations Research

Time: 3 hrs. Max. Marks: 80

Note: ***1. Answer any FIVE full questions, choosing ONE full question from each module.***
2. Use of statistical tables is permitted.

Module-1

1 a. List and explain briefly the phases of operations research. **(06 Marks)**

b. A paper manufacturing company produces two grades of papers grade 'R' and grade 'S'. Because of raw material restrictions, not more than 450 tonnes of grade R and 240 tonnes of grade S papers can be produced per week. It requires 0.2 hours to produce 1 tonne of grade R paper and 0.4 hours to produce 1 tonne of grade S paper. There are 108 production hours per week. The profit per tonne of grade R paper is Rs 400 and per tonne of grade S paper it is Rs. 500. Formulate a mathematical model to determine how many tones of grade R and grade S papers the company has to produce per week to maximize its profit. Solve graphically. **(10 Marks)**

OR

2 a. Discuss the limitations of operations research. **(06 Marks)**

b. Solve the following LPP by graphical method and indicate the solution :

Maximize $Z = 2x_1 + 3x_2$

Subject to constraints : $x_1 - 2x_2 \leq 0$

$2x_1 - x_2 \geq 0$

$x_1 - x_2 \leq 0$

with $x_1, x_2 \geq 0$. **(10 Marks)**

Module-2

3 a. What is the significance of introducing slack, surplus and artificial variables in LPP? **(04 Marks)**

b. Solve the following LPP by Simplex Method :

Maximize $Z = 6x_1 + 4x_2$

Subject to constraints: $-2x_1 + x_2 \leq 2$

$x_1 - x_2 \leq 2$

$3x_1 + 2x_2 \leq 9$

with $x_1, x_2 \geq 0$. **(12 Marks)**

OR

4 a. Solve the following LPP by either Big–M method or two phase method :

Minimize $Z = x_1 - 2x_2 - 3x_3$

Subject to constraints : $-2x_1 + x_2 + 3x_3 = 2$

$2x_1 + 3x_2 + 4x_3 = 1$

with $x_1, x_2, x_3 \geq 0$. **(08 Marks)**

b. Solve the following by Dual Simplex Method :

Maximize $Z = -2x_1 - 2x_2 - 4x_3$

Subject to constrains: $2x_1 + 3x_2 + 5x_3 \geq 2$

$3x_1 + x_2 + 7x_3 \leq 3$

$x_1 + 4x_2 + 6x_3 \leq 5$

with $x_1, x_2, x_3 \geq 0$. **(08 Marks)**

Module-3

5 a. What is degeneracy in transportation problem? Discuss its consequence and how it is over come. **(04 Marks)**

b. Obtain the optimum solution to the following transportation problem to minimize the total transportation cost. Initial solution by Vogel's approximation method. (VAM).

Destination

		D_1	D_2	D_3	D_4	Supply
Origin	O_1	42	48	38	37	16
	O_2	40	49	52	51	15
	O_3	39	38	40	43	19
	Demand	8	9	11	16	

(12 Marks)

OR

6 a. Explain the differences between assignment problem and transportation problem. **(05 Marks)**

b. A small machine shop has five jobs to be assigned to five machines. The following matrix indicates the cost of assigning each of the five jobs to each of the five machines. Obtain the optimum assignment of jobs to machines, in order to minimize the total assignment cost.

Machines

		1	2	3	4	5
Jobs	A	11	17	8	16	20
	B	9	7	12	6	15
	C	13	16	15	12	16
	D	21	24	17	28	26
	E	14	10	12	11	15

Q6(b) Cost Matrix **(11 Marks)**

Module-4

7 a. Explain the Kendall and Lee's notations for representing queuing models. **(04 Marks)**

b. A small project consists of activities from 'A' to 'I'. The following table indicates the precedence relationship among activities and the three time estimates – optimistic, most – likely and pessimistic time for each activity in days.

Activity	Predecessor Relationship	Optimistic time 't_0'	Most likely time 't_m'	Pessimistic time 't_p'
A	–	2	5	8
B	A	6	9	12
C	A	6	7	8
D	B, C	1	4	7
E	A	8	8	8
F	D, E	5	14	17
G	C	3	12	21
H	F, G	3	6	9
I	H	5	8	11

i) Draw the project network. Determine the expected time and variance for each activity
ii) Obtain the total expected duration of the project and critical path
iii) What is the probability of completing the project in 50 days? **(12 Marks)**

OR

8 a. For the following set of activities of a project, draw the network and obtain Early Start [ES], Early Finish [EF], Late Start [LS] and Late Finish [LF] for each activity. Also, indentify the critical path and project duration.

Activity	Predecessor	Duration in days
A	–	5
B	A	8
C	A	6
D	C	5
E	B, D	9

(08 Marks)

b. The mean arrival rate to a service centre is 3 per hour. The mean service time is found to be 10 minutes per service. Assuming Poisson arrival and exponential service time, find :

i) Utilization factor for the service facility
ii) Probability of two units in the system
iii) Queue length
iv) Expected waiting time in the system **(08 Marks)**

Module-5

9 a. Apply the rules of dominance to reduce the game to (2 × 2) and solve the game to obtain game value and optimum strategies for both the players.

Player B

Player A	1	2	3
1	2	–2	4
2	–1	4	2
3	2	1	6

(08 Marks)

b. Solve the following (2 × 4) game graphically.

Player B

Player A	1	2	3
1	1	3	12
2	8	6	02

(08 Marks)

OR

10 a. There are seven jobs to be processed on a single machine. The following table indicates the jobs and corresponding processing time in hours. Obtain the optimum sequence of jobs by Shortest Processing Time [SPT] rule that minimizes the mean flow time. Also obtain average in process inventory. **(06 Marks)**

Jobs (j)	A	B	C	D	E	F	G
Processing time (t_j) in hr	8	3	5	4	3	9	6

b. There are six jobs to be processed on three machines A, B and C in the order CAB. The following table indicates the processing time in hours for the six jobs on the three machines. Obtain optimum sequence of jobs that minimizes the total elapsed time for completing all the jobs on the three machines. Also indicate the idle time of each machine.

Jobs	1	2	3	4	5	6
Processing time in hours on M/C A	4	6	7	4	5	3
Processing time in hours on M/C B	8	10	7	8	11	8
Processing time in hours on M/C C	5	6	2	3	4	9

(10 Marks)

Verified

Approved by

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Scheme & Solution

Signature of Scrutinizer

Subject Title : OPERATIONS RESEARCH **Subject Code :** 15ME81

Question Number	Solution	Marks Allocated
	Module - 1	
1 a	Phases of OR	
	i) Formulation of the problem (ii) Construction of Mathematical model (iii) Deriving Solution to model (iv) Validating the solution (v) Controlling the solution (vi) Implementation.	
	Listing —	01
	explanation in brief, the above phases. —	05
		06
1 b.	Maximize $Z = 400x_1 + 500x_2$	
	Where, x_1 = No of tonnes of Grade R paper produced/week; x_2 = — " — Grade 'S' — " — " —	02
	Subject to constraints: $x_1 \leq 450$ tonnes/week; $x_2 \leq 240$ tonnes/week; $0.2x_1 + 0.4x_2 \leq 108$ hours/week	02
	w.r.t. $x_1, x_2 \geq 0$	
	Plotting of graph (shown in next page) —	02
	$x_1 = 450 \rightarrow (1)$; $x_2 = 240 \rightarrow (2)$; $0.2x_1 + 0.4x_2 = 108 \rightarrow (3)$; $x_1 = 540$; $x_2 = 270$	

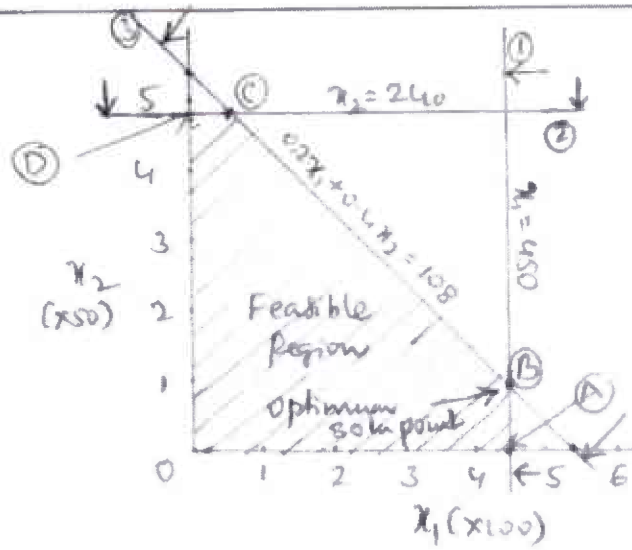
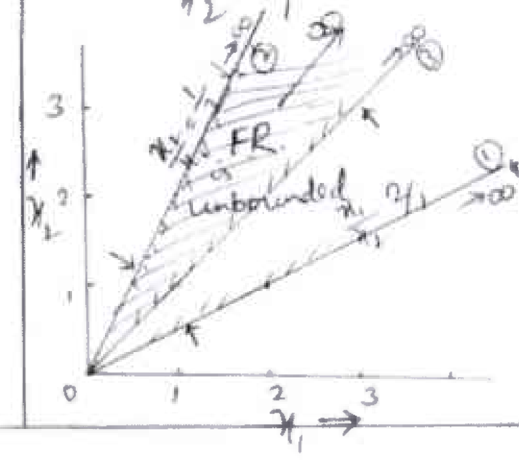
" APPROVED "

Registrar (Evaluation)

Visvesvaraya Technological University

BELAGAVI - 590018

Subject Title : Operations Research **Subject Code :** 15ME81

Question Number	Solution	Marks Allocated
		
	At (A) $x_1 = 450$, Max $Z_A = 1,80,000/-$	
	At (B) $x_1 = 450$, $x_2 = 45$, Max $Z_B = 2,02,500/-$	
	At (C) $x_1 = 60$, $x_2 = 240$, Max $Z_C = 1,44,000/-$	04
	At (D) $x_1 = 240$, Max $Z_D = 120,000/-$	
	Optimum Solution at (B) $x_1 = 450$, $x_2 = 45$, Max Z = Rs 2,02,500/-	
		(10)
2 a.	Limitations of OR	
	(i) Dependency on Computer ii) Non-Quantifiable factors. (iii) Distance between Manager and OR incharge iv) Money and time costs (V) Implementation	01
	Brief Explanation of the above	05
		(06)
b.	$x_1 \le 2x_2$, $\frac{x_1}{x_2} = \frac{2}{1} \rightarrow (1)$; $2x_1 \geq x_2$, $\frac{x_2}{x_2} = \frac{1}{2} \rightarrow (2)$; $x_1 \le x_2$, $\frac{x_1}{x_2} = \frac{1}{1} \rightarrow (3)$	04
	 Plotting of Graph	04
	Solution: Feasible Region is Unbounded ∴ Solution is Unbounded	02
		(10)

Subject Title : Operations Research **Subject Code :** 15ME81

Question Number	Solution	Marks Allocated

Module - 2

3a. Slack and Surplus variables are added in the constraint inequations in the LHS to convert them to equality form. — 01

As Slack variable has +ve coefficient of 1 it can be used as one of the basic variables as it provides feasible solution. Sulplus variable has -ve coefficient of 1 & therefore makes initial solution infeasible, if it is used as Basic variable. — 02

Therefore Artificial variable is introduced in such constraint equations that do not contain a Slack variable to generate IBFS — 01

(04)

3b Introducing Slack variables in each of the three constraints to generate IBFS

IBFS BV $\begin{cases} S_1 = 2 \\ S_2 = 2 \\ S_3 = 9 \end{cases}$ — 02

Table 1

C_b	BV	x_1 (EV)	x_2	S_1	S_2	S_3	RHS	Min +ve Ratio RHS/EV
0	S_1	-2	1	1	0	0	2	×
0	S_2 (DV)	$\boxed{1}$ PE	-1	0	1	0	2	2 ✓ ← KR
0	S_3	3	2	0	0	1	9	3
	$(Z_j - C_j)$	-6 (KC)	-4	0	0	0	0	

— 03

Subject Title : Operations Research   Subject Code : 15ME81

Question Number	Solution	Marks Allocated
	Table 2	

↓EV

BV	x_1	x_2	S_1	S_2	S_3	RHS	Minimum Ratio
S_1	0	-1	1	2	0	6	X
x_1	1	-1	0	1	0	2	X
LV ← S_3	0	$\boxed{5}$ PE	0	-3	1	3	3/5 ✓ ← KR
(Z_j-C_j)	0	-10	0	6	0	12	

↑KC

— 03

Table 3

BV	x_1	x_2	S_1	S_2	S_3	RHS
S_1	0	-1	1	2	0	6
x_1	1	0	0	2/5	1/5	13/5
x_2	0	1	0	-3/5	1/5	3/5
(Z_j-C_j)	0	0	0	0	2	18

— 02

In Table 3 all $(Z_j - C_j) \geq 0$ for optimality $(Z_j - C_j)$ row element must be zero or positive

∴ Solution is optimum

$x_1 = 13/5$; $x_2 = 3/5$ Max Z = 18 — 02

(12)

4a. Solution by Big-M method

$\text{Max } Z' = -x_1 + 2x_2 + 3x_3 - MA_1 - MA_2$

S.T.C. $-2x_1 + x_2 + 3x_3 + A_1 = 2$

$2x_1 + 3x_2 + 4x_3 + A_2 = 1$

A_1 & A_2 → Artificial variables

IBFS ⇒ $A_1 = 2$

$A_2 = 1$ — 01

Subject Title : Operations Research Subject Code : 15ME51

Question Number	Solution	Marks Allocated

Table 1

C_B	BV	x_1	x_2	x_3 ↓EV	A_1	A_2	RHS	Min +ve Ratio
−M	A_1	−2	1	3	1	0	2	2/3 = 0.67
−M	A_2 ← DV	2	3	$\boxed{4}$ PE	0	1	1	1/4 = 0.25 ✓
	$(Z_j - C_j)$	1	(−4M−2)	(−7M−3) ↑ MC	0	0	−3M	

— 03

Table 2

BV	x_1	x_2	x_3	A_1	A_2	RHS	Min +ve Ratio
A_1	$-7/2$	$-5/4$	0	1	X	$3/2$	
x_3	$1/2$	$3/4$	1	0	X	$1/4$	
$(Z_j - C_j)$	$\frac{(7M+5)}{2}$	$\left(\frac{5M+1}{4}\right)$	0	0	X	$\frac{(-5M+3)}{4}$	

— 03

In Table 2, All $(Z_j - C_j) \geq 0$ ∴ Solution is optimum. However A_1 an artificial var, is present as B.V. in final solution with +ve value. $A_1 = 3/2$ ∴ $\text{Max } Z' = \left(\frac{-5M+3}{4}\right)$ becomes −ve & infeasible

∴ The problem has Infeasible Solution — 01

(08)

(OR) Solve by Two phase Method

In Phase I, Table 2 All $(Z_j - C_j) \geq 0$ But $\text{Max } Z' < 0$ & Artificial variable appears as B.V. with +ve value ∴ Cannot proceed to Phase II ∴ Solution is 'INFEASIBLE'

Subject Title : Operations Research Subject Code : 15ME81

Question Number	Solution	Marks Allocated
4.b	Solution by Dual Simplex Method	

Max $Z = -2x_1 - 2x_2 - 4x_3$

$$-2x_1 - 3x_2 - 5x_3 + S_1 = -2$$
$$3x_1 + x_2 + 7x_3 + S_2 = 3$$
$$x_1 + 4x_2 + 6x_3 + S_3 = 5$$

Initial Infeasible Basic Solution

$S_1 = -2,\ S_2 = 3,\ S_3 = 5$ — 02

Table 1

Non Basic Variables

C_b	BV	x_1	x_2 EV	x_3	S_1	S_2	S_3	RHS
0	S_1 DV	-2	$\boxed{-3}$ PE	-5	1	0	0	-2 ← KR
0	S_2	3	1	7	0	1	0	3
0	S_3	1	4	6	0	0	1	5
	$(Z_j - C_j)$	2	2	4	0	0	0	0

— 02

Min $\left|\frac{(Z_j - C_j)}{KR}\right|$ $\left|\frac{2}{-2}\right|$ $\left|\frac{2}{-3}\right|$ $\left|\frac{4}{-5}\right|$ × × × -

KR<0 1 0.67 0.8

↑KC

Table 2

BV	x_1	x_2	x_3	S_1	S_2	S_3	RHS
x_2	2/3	1	5/3	-1/3	0	0	2/3
S_2	7/3	0	16/3	1/3	1	0	7/3
S_3	-5/3	0	-2/3	4/3	0	1	7/3
$(Z_j - C_j)$	2/3	0	2/3	2/3	0	0	-4/3

— 02

In Table 2 All RHS elements are ≥0 (i.e +ve)
∴ Solution is Feasible and Optimum

Subject Title: Operations Research **Subject Code:** 15ME81

Question Number	Solution	Marks Allocated
	∴ Final Feasible and optimum Solution is $x_1 = 0,\ x_2 = 2/3\ \ \text{Max } Z = -4/3$	02
		08
	Module-3	
5a	For optimality Test by MODI method, the two conditions to be satisfied are i) Number of Allocations $= (m+n-1)$ m = Number of origins & n = Number of Destinations ii) All these allocations must be in independent positions. Therefore, if the number of allocations is Less Than $(m+n-1)$, then it is called Degeneracy in Transportation problem.	02
	Consequence is that we can not obtain Net Evaluation values for some of the Non-Basic cells and cannot proceed further towards optimality.	01
	To overcome degeneracy, Add a small +ve allocation 'E' $(E \to 0)$ in a non basic independent cell. ∴ Allocation $= (m+n-1)$	01
		04

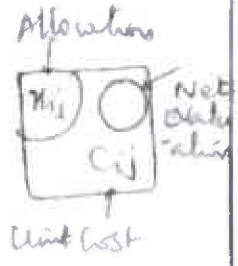
Subject Title: Operations Research **Subject Code:** 15ME81

Question Number	Solution	Marks Allocated
5 b	Problem is Unbalanced Supply > Demand Create Dummy destination	02

IBFS by VAM

Table 1

	D_1	D_2	D_3	D_4	D_5 (Dummy)	Supply
O_1	42	48	(2) 38	(16) 37	0	16
O_2	(8) 40	49	(1) 52	51	(6) 0	15
O_3	39	(9) 38	(10) 40	43	0	19
Demand	8	9	11	16	6	$\boxed{50}$



Legend

IBFS ⇒ Rs 1706/- — 03

Optimality Test by MODI method or U V method

No. of allocations = (3+5−1) = 7 ✓

& all are independent

Solve for Basic cells $u_i + v_j = C_{ij}$

Non Basic cells Net Evaluation (NE) $= C_{ij} - (u_i + v_j)$

If all NE ≥ 0 Allocation optimum.

Table 2 — 03

Table 3 (Final Table)

						u_i
	(+ve) 42	(+ve) 48	(2) 38	(16) 37	(+ve) 0	−13
	(8) 40	(1) 49	(+ve) 52	(+ve) 51	(6) 0	0
	(+ve) 39	(8) 38	(11) 40	(+ve) 43	(+ve) 0	−11
v_j	40	49	51	50	0	

Allocation

$O_1 - D_4 \to 16$
$O_2 - D_1 \to 8$
$O_2 - D_2 \to 1$
$O_2 \to D_5 \to 6$ Dummy
$O_3 \to D_2 \to 8$
$O_3 \to D_3 \to 11$

Optimum cost = Rs 1703/- — 04

All net evaluations NE $= C_{ij} - (u_i + v_j) \geq 0$

Optimum allocation.

Total: 12

Subject Title : Operations Research **Subject Code :** 15ME81

Question Number	Solution	Marks Allocated
6a	Indicate atleast 3 differences	→ 05
6b	After Row and Column Manipulation	

Table 2

	1	2	3	4	5
A	2	9	0	8	8
B	2	1	6	0	5
C	0	4	3	0	0
D	3	7	0	11	5
E	3	0	2	1	1

→ 04

Table 3 Modified Matrix → 02

Table 4. (Final Table)

	1	2	3	4	5
A	0	8	0	8	6
B	0	0	6	0	3
C	0	5	5	2	0
D	1	6	0	11	3
E	2	0	3	2	0

Optimum Assignment

A – 1 → 11
B – 4 → 6
C → 5 → 16
D → 3 → 17
E → 2 → 10

Rs 50 60

No of Assignment = Matrix order = 5
It is optimum — 05

(11)

Module-4

7a. Kendall and Lee's Notations for Queue models $(a/b/c):(d/e)$

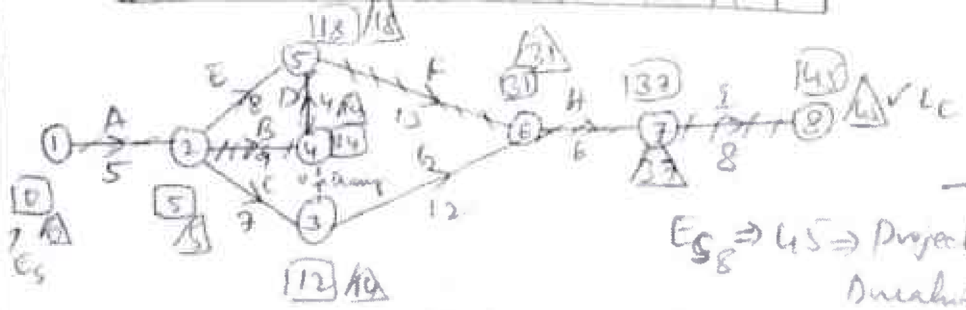
where a = Inter arrival distribution
b = Departure or Service time distribution
c = No of channels
d = capacity of the system
e = Queue discipline → 04.

Subject Title : operations Research   Subject Code : 15ME81

Question Number	Solution	Marks Allocated
7b.	Find First t_e = expected time of completion for each activity & Variance	
	$t_e = \frac{t_o + 4t_m + t_p}{6}$ & $\sigma_T^2 = \left(\frac{t_p - t_o}{6}\right)^2$	

Activity	A	B	C	D	E	F	G	H	I
t_e	5	9	7	4	8	13	12	6	8
σ_T^2	1	1	0.44	1	-	4	9	1	1

— 03



→ 03

$E_{S_8} \Rightarrow 45 \Rightarrow$ Project Duration

Total Expected Time of Completion

$T_E = \underline{45 \text{ days}}$ →01

Critical path $A \to B \to D \to F \to H \to I$ — 02

Variance σ_T^2 for C.P. $\to 1+1+1+4+1+1$

$\sigma_T^2 = 9$

$\therefore \sigma_T = \sqrt{9} = 3$

Prob. of completing project in 50 days

$T_S = 50$ days

Normal variate $Z = \frac{T_S - T_E}{\sigma_T} = \frac{50-45}{3}$

$= 1.67$

From Normal distribution Table for

$Z = 1.67$ Probability $= 95.25\%$ — 03

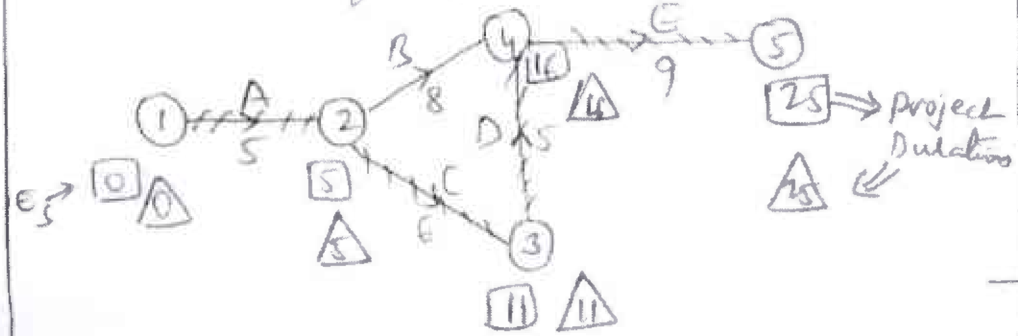
12

Subject Title : operations Research **Subject Code :** 15ME81

Question Number	Solution	Marks Allocated

8 a

Network of the project



Project Duration = 25 days → 01

Activity	Pr...	Duration days	ES	EF	LS	LF
A	—	5	0	5	0	5
B	A	8	5	13	8	16
C	A	6	5	11	5	11
D	C	5	11	16	11	16
E	B, D	9	16	25	16	25

— 04

(08)

8 b

Mean arrival rate = λ = 3/hr

Mean service rate = μ = $\frac{1}{10} \times 60$ = 6/hr

i) Utilization factor $\rho = \lambda/\mu = 3/6 = 0.5$ — 02

ii) probability of two units in the system $P_2 = P_0(\lambda/\mu)^2 = 0.5 \times (0.5)^2$

$P_0 = 1 - \rho = 0.5$ $P_2 = 0.125 = 1/8$ — 02

iii) Queue Length = $L_Q = \frac{(\lambda/\mu)^2}{(1-\lambda/\mu)} = \frac{0.5^2}{(1-0.5)} = 0.5$ — 02

OR (iii) OR $\frac{\lambda^2}{\mu(\mu-\lambda)} = \frac{3 \times 3}{6(6-3)} = 0.5$

(iv) Expected waiting time in the system

$= W_S = W_Q + \frac{1}{\mu}$

$= L_Q/\lambda + 1/\mu = 0.5/3 + \frac{1}{6} = 1/3$ — 02

(08)

OR $W_S = \frac{1}{\mu-\lambda} = \frac{1}{(6-3)} = 1/3$ = 20 minutes

Subject Title : Operations Research **Subject Code :** 15ME81

Question Number	Solution	Marks Allocated
9.a	Applying Rules of Dominance Row wise and Column wise	

$$\begin{array}{cc|ccc|c} & & & B & & \\ & & 1 & 2 & 3 & \text{Row Min} \\ \hline & 1 & 2 & -2 & 4 & -2 \\ A & 2 & -1 & 4 & 2 & -1 \\ & 3 & 2 & 1 & 6 & 1 \text{ Maximin} \\ \hline & \text{Column Max} & 2 \text{ Minimax} & 4 & 6 & \end{array}$$

No Saddle point
Maximin ≠ Minimax — 01

Row Dominance Compare R_1 with R_3

Element in $R_3 \geq$ Element in R_1

R_3 dominates R_1 Eliminate R_1

Compare R_2 & R_3

— No Dominance — 02

Column Dominance

Compare Column C_1 with C_2 — No Dominance

Compare Column C_1 with C_3

Element in Column $C_1 \leq$ Element in C_3

∴ C_1 dominates C_3 Delete C_3 → 02

Reduced Matrix

$$\begin{array}{cc|cc|c} & & B & & \\ & & 1 & 2 & \text{Prob.} \\ \hline A & 2 & -1 & 4 & x_2 \\ & 3 & 2 & 1 & x_3 \\ \hline \text{Prob.} & & y_1 & y_2 & \end{array} \Rightarrow \text{Oddment Matrix} \begin{array}{|cc|} \hline a_{21} & a_{22} \\ a_{31} & a_{32} \\ \hline \end{array} \; y_1, \; x_2$$

$$\text{Prob. } x_2 = \frac{a_{32} - a_{31}}{(a_{21}+a_{32}) - (a_{31}+a_{22})} = \frac{1-2}{(-1+1)-(2+4)} = \frac{-1}{-6} = \frac{1}{6}$$

$$x_3 = 1 - 1/6 = 5/6 \quad \underline{(x_1, x_2, x_3)} = \left(0, \frac{1}{6}, \frac{5}{6}\right)$$

$$\text{Prob } y_1 = \frac{a_{32} - a_{22}}{(a_{21}+a_{32}) - (a_{31}+a_{22})} = \frac{1-4}{(-1+1)-(2+4)} = \frac{-3}{-6} = \frac{1}{2}$$

$$\underline{y_1 = 1/2}, \; \underline{y_2 = 1 - 1/2} = 1/2$$

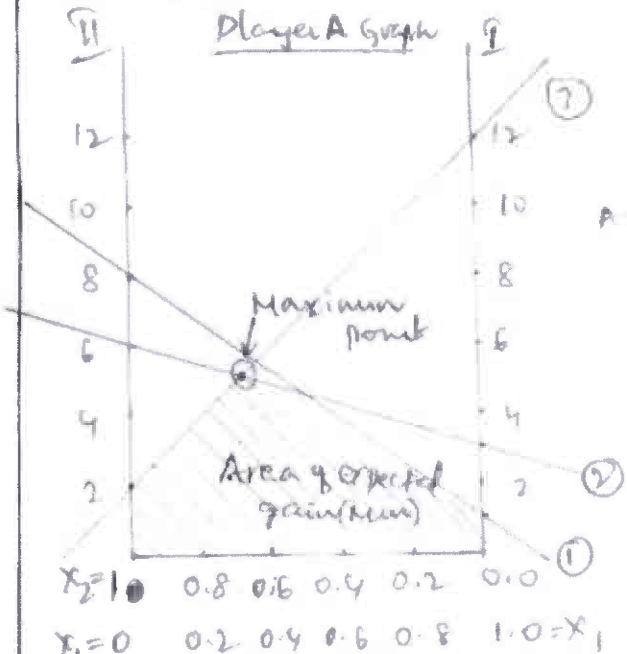
Subject Title : Operations Research **Subject Code :** 15ME81

Question Number	Solution	Marks Allocated
	Prob. $(x_1, x_2, x_3) = (0, \frac{1}{6}, \frac{5}{6})$	
	Prob $(y_1, y_2, y_3) = (\frac{1}{2}, \frac{1}{2}, 0)$	
	Value $= \dfrac{(a_{21} \cdot a_{32}) - (a_{22} \cdot a_{31})}{(a_{21}+a_{32}) - (a_{31}+a_{22})}$	03
	$= \dfrac{(-1 \times 1) - (4 \times 2)}{(-1+1) - (2+4)} = \dfrac{-1-8}{-6} = \dfrac{-9}{-6}$	
	$\boxed{V = 3/2}$ ✓	08
9b.	Expected gain Matrix for A	

Player B Strategy	Expected gain for A	
1	$1x_1 + 8x_2$	→ ①
2	$3x_1 + 6x_2$	→ ②
3	$12x_1 + 2x_2$	→ ③

— 02

Player A Graph



Graph & Reduced Matrix — 04

$$\begin{array}{cc|cc|c} & & \multicolumn{2}{c}{B} & \\ & & 2 & 3 & \\ \hline A & 1 & 3 & 12 & x_1 \\ & 2 & 6 & 2 & x_2 \\ \hline & & y_2 & y_3 & \end{array}$$

Prob $(x_1, x_2) = (\frac{4}{13}, \frac{9}{13})$

Prob $(y_2, y_3) = (\frac{10}{13}, \frac{3}{13})$ — 02

Value $= \frac{66}{13} = 5.1$

08

Subject Title : Operations Research Subject Code : 15ME81

Question Number	Solution	Marks Allocated
10a.	Optimum Jobs sequence based on SPT rule	

Sequence I: | B | E | D | C | | | |

Sequence II: | E | B | D | C | | | | → 01

Job Sequence	P.T t_j	t_i	t_o	Completion time C_j - Flow Time F_j
B	3	0	3	3
E	3	3	6	6
D	4	6	10	10
C	5	10	15	15
G	6	15	21	21
A	8	21	29	29
F	9	29	38	38

$\sum_1 t_j = 38$ $\sum_1 F_j = 122$ → 02

$\sum P.T. = \sum_1 t_j = 38$

Mean Flow Time $\bar{F} = \frac{1}{n}\sum_{j=1}^{n} F_j$ $n = 7$

$= \frac{1}{7} \times [122]$

$= 17.43 \text{ hrs}$ → 02

Average inprocess inventory $= \frac{\sum_1 F_j}{\sum_1 t_j}$

$= \frac{122}{38} = 3.21$ or 4 Jobs → 01

(06)

Subject Title : Operations Research Subject Code : 15ME81

Question Number	Solution	Marks Allocated
10 b.	Problem on 'n' Jobs 3 machines n = 6 & 3 Machines A B C in the order CAB To convert this problem into n Jobs 2 m/cs any one of the following conditions to be satisfied. I) Min processing Time on 1st Machine 'C' ≥ Maximum processing Time on 2nd machine A 2 ≱ 7 × Not Satisfied II) Min processing time on 3rd M/c i.e. B ≥ Max processing time on 2nd M/c 'A' ✓ 7 ≥ 7 Both are Equal Create two Imaginary Machine G and H.	→ 02

M/c G = (C+A)	M/c H = (A+B)
9	12
12	16
9	14
7	12
9	16
12	11

Optimum Job Sequence

1.	4	3	1	5	2	6
2.	4	1	3	5	2	6
3.	4	5	1	3	2	6
4.	4	1	3	5	6	2

→ 03

(16)

Subject Title : Operations Research Subject Code : 15ME81

Question Number	Solution	Marks Allocated
	To find Total Elapsed Time	

Job Sequence	Machine C t_i	Machine C t_o	Machine A t_i	Machine A t_o	Machine B t_i	Machine B t_o
4	0	3	3	7	7	15
3	3	5	7	14	15	22
1	5	10	14	18	22	30
5	10	14	18	23	30	41
2	14	20	23	29	41	51
6	20	29	29	32	57	59

→ 03

t_o of Job 6 (last Job) on M/C B (last machine) = 59 hrs = Total Elapsed Time (TET)

Idle Time Of M/c C ⇒ TET − PT on M/C C

= 59 − 29 = 30 hrs

— " — M/C A ⇒ TET − PT on M/C A

= 59 − 29 = 30 hrs

— " — M/C B ⇒ 59 − 52 = 7 hrs

→ 02

(10)

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— x —

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