Roll No. | | | | | | | | | | | | |

PRESIDENCY UNIVERSITY
BENGALURU

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

SCHOOL OF ENGINEERING

TEST 1

Sem & AY: Odd Sem 2019-20
Course Code: MEC 406
Course Name: OPERATIONS RESEARCH FOR ENGINEERS
Program: B.Tech. (All Programs) & VII OE

Date: 30.09.2019
Time: 1.00 to 2.00 PM
Max Marks: 40
Weightage: 20%

Instructions:

(i) ***Use of Graph sheets are permitted.***
(ii) ***Read all the questions carefully and answer.***

Part A [Memory Recall Questions]

Answer both the Questions. Each Question carries five marks. (2Qx5M=10M)

1. Discuss the various phases in solving an OR problem. (C.O.NO.1)[Knowledge]

2. Explain the main characteristics of operations research. (C.O.NO.1) [Knowledge]

Part B [Thought Provoking Questions]

Answer the Question. The Question carries fifteen marks. (1Qx15M=15M)

3 a. Old hens can be bought at Rs 50 each but young ones cost Rs 100 each. The old hens lay 3 eggs/week and young hens 5 eggs/week. Each egg costs Rs 2. A hen costs Rs 5 per week to feed. If a person has only Rs 2000 to spend for hens, formulate the problem to decide how many of each kind of hen should he buy? Assume that he cannot house more than 40 hens. ? [5M]
(C.O.NO.1) [Comprehension]

3 b. A manufacturer of furniture makes two products – chairs and tables. Processing of this product is done on two machines A and B. A chair requires 2 hours on machine A and 6 hours on machine B. A table requires 5 hours on machine A and no time on machine B. There are 16 hours of time per day available on machine A and 30 hours on machine B. Profit gained by the manufacturer from a chair and a table is Rs 2 and Rs 10 respectively. What should be the daily production of each of two products? Solve the LPP using graphical method. [10M]
(C.O.NO.1) [Comprehension]

Part C [Problem Solving Questions]

Answer the Question. The Question carries fifteen marks. **(1Qx15M=15M)**

4. Solve the following LPP by Simplex method.

Max $Z = 3x_1 + 2x_2$
Subject to,
$4x_1 + 3x_2 \leq 12$
$4x_1 + x_2 \leq 8$
$4x_1 - x_2 \leq 8$
$x_1 \geq 0$, $x_2 \geq 0$ (C.O.NO.1) [Application]

SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE REACH GREATER HEIGHTS

Semester: VIIth

Course Code: MEC 406

Course Name: **Operations Research for Engineers**

Date: 30-09-2019

Time: 1 hour

Max Marks: 40

Weightage: 20%

Date:

Time:

Max Marks:

Weightage:

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels			Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]			Total Marks
			K			C			A			
Part A - 1,2	CO 1	Module 1	5	5								10
Part B -1a&b	CO1	Module 1				15						15

Part C - 1	CO 1	Module 1							15			15
	Total Marks											40

K =Knowledge Level   C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

I here certify that All the questions are set as per the above lines Shashi kiran]

Annexure- II: Format of Answer Scheme

SCHOOL OF ENGINEERING

SOLUTION

Semester: VIIth

Course Code: MEC 406

Course Name: **Operations Research for Engineers**

Date: 30-09-2019

Time: 1 Hour

Max Marks: 40

Weightage: 20%

Date:

Time:

Max Marks:

Weightage:

Part A

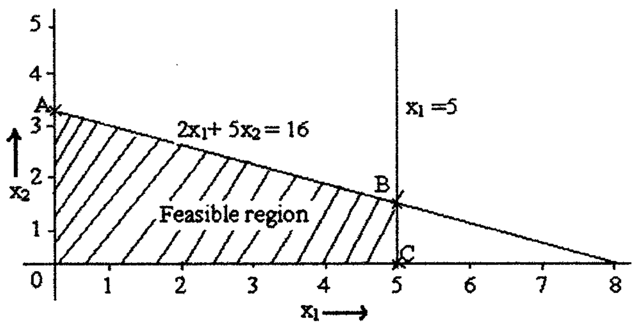
(2Q x 5M = 10Marks)

Q No	Solution	Scheme of Marking	Max. Time requ for each Quest
1	Observe the Problem Environment Analyze and Define the Problem Develop a Mathematical Model Selection of Data Input Solution and Testing Implementation of the Solution	1x5=5	5 mins
2	Decision-making Scientific Approach Inter-disciplinary Team Approach System Approach Use of Computers	1x5=5	5 mins

Part B

(1Q x 15M = 15 Marks)

Q No	Solution	Scheme of Marking	Max. Time requir each Questio
1a	$Z_{max} = x_1 + 5x_2$ (Objective function) Subject to, $50x_1 + 100x_2 \leq 2000$ (Budget constraint) $x_1 + x_2 \leq 40$ (Housing capacity constraint) $x_1 \geq 0$, $x_2 \geq 0$ (Non-negativity constraint)	2 1 1 1	5 mins
1b	$Z_{max} = 2x_1 + 10x_2$ (Objective function) Subject to,	2	

	$2x_1 + 5x_2 \leq 16$ (Machine A constraint) $6x_1 + 0x_2 \leq 30$ (Machine B constraint) $x_1 \geq 0$, $x_2 \geq 0$ (Non-negativity constraint)  Max Z = 2x1 + 10x2 At A (0, 3.2) Z = 2(0) + 10(3.2) = 32 At B (5, 1.2) Z = 2(5) + 10(1.2) = 22 At C (5, 0) Z = 2(5) + 10(0) = 10 Max Z = 32 and x1 = 0, x2 = 3.2 The manufacturer should produce approximately 3 tables and no chairs to get the max profit.	1 1 4 2	15 mins

Part C (1Q x 15M = 15 Marks)

Q No	Solution	Scheme of Marking	Max. Tim required for Question

1

First Simplex Table

↓ EV

Basis	C_B	x_1	x_2	u_1	u_2	u_3	B	Ratio (θ)
u_1	0	4	3	1	0	0	12	3
u_2	0	4	1	0	1	0	8	2
LV ← u_3	0	[4] PE	–1	0	0	1	8	2 ← PR
C_j		3	2	0	0	0	–	–
Z_j		0	0	0	0	0	0	–
$C_j - Z_j$		3	2	0	0	0	–	–

↑ PC

Second Simplex Table (First iteration)

↓ EV

Basis	C_B	x_1	x_2	u_1	u_2	u_3	B	Ratio
u_1	0	0	4	1	0	–1	4	1
LV ← u_2	0	0	[2] PE	0	1	–1	0	0 ← PR
x_1	3	1	–1/4	0	0	1/4	2	–
C_j		3	2	0	0	0	–	–
Z_j		3	– 3/4	0	0	3/4	6	–
$C_j - Z_j$		0	11/4	0	0	–3/4	–	–

↑PC

3

4

4

Third Simplex Table (Second iteration)

↓ EV

Basis	C_B	x_1	x_2	u_1	u_2	u_3	B	Ratio
LV ← u_1	0	0	0	1	− 2	[1] PE	4	4 ← PR
x_2	2	0	1	0	1 / 2	− 1/2	0	–
x_1	3	1	0	0	1 / 8	1/8	2	16
C_j		3	2	0	0	0	–	–
Z_j		3	2	0	11 / 8	− 5/8	6	–
$C_j - Z_j$		0	0	0	− 11/ 8	5/8	–	–

↑PC

Fourth Simplex Table (Third iteration)

Basis	C_B	x_1	x_2	u_1	u_2	u_3	B
u_3	0	0	0	1	− 2	1	4
x_2	2	0	[1] PE	1/2	− 1/2	0	2
x_1	3	1	0	− 1/8	3/8	0	3/2
C_j	–	3	2	0	0	0	–
Z_j	–	3	2	5/8	1/8	0	17/2
$C_j - Z_j$	–	0	0	− 5/8	− 1/8	0	–

As all $C_j - Z_j \leq 0$, the solution is optimum

$X_1 = 3/2$, $X_2 = 2$ and $Z_{max} = 17/2$

4

25 Mins

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GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST – 2

Sem & AY: Odd Sem 2019-20 **Date**: 18.11.2019

Course Code: MEC 406 **Time**: 1.00 PM to 2.00 PM

Course Name: OPERATIONS RESEARCH FOR ENGINEERS **Max Marks**: 40

Program: B.Tech. (EEE,MEC) & VII (OE) **Weightage**: 20%

Instructions:

(i) Read all the questions carefully and answer.

(ii) Use of normal distribution table is permitted.

Part A [Memory Recall Questions]

Answer the Question. The Question carries ten marks. (1Qx10M=10M)

1. Explain the steps for solving Hungarian Assignment model. [10 M] (CO2)

[Knowledge level]

Part B [Thought Provoking Questions]

Answer the Question. The question carries fifteen marks. (1Qx15M=15M)

2. A company has three factories F1, F2, F3 from which it transports to four warehouses W1, W2, W3, W4. Given the following data is unit cost of transportation, capacity of the three factories and the requirement of the four warehouses. Find the optimal allocation.

	W1	W2	W3	W4	Availability
F1	19	30	50	10	7
F2	70	30	40	60	9
F3	40	8	70	20	18
Requirement	5	8	7	14	

[15 M] (CO2)
[Comprehension Level]

Part C [Problem Solving Questions]

Answer the Question. The Question carries fifteen marks. (1Qx15M=15M)

3. Given the list of activities in a project and their time estimates (in days):

a) Draw the project network.
b) Determine the critical path(s) and the expected project duration.
c) What is the probability that project will be completed in 35 days?
d) What due date has 90% chance of being met?

Activity	t_o	t_m	t_p
1-2	6	12	30
1-3	3	6	15
1-4	3	9	27
2-6	4	19	28
3-5	3	9	27
3-6	2	5	8
4-5	1	4	7
5-6	6	12	30

[15 M] (CO3)
[Application level]

SCHOOL OF ENGINEERING

Semester: VII^th^

Course Code: MEC 406

Course Name: Operations Research for Engineers

Date: 18-11-2019

Time: 1 hour

Max Marks: 40

Weightage: 20%

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels			Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]			Total Marks
			K			C			A			
Part A - 1	CO 2	Module 2	10									10
Part B -1	CO 2	Module 2				15						15
Part C - 1	CO 3	Module 3							15			15
	Total Marks											40

K =Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

Annexure- II: Format of Answer Scheme

SCHOOL OF ENGINEERING

SOLUTION

Date: 18-11-2019

Semester: VIIth

Time: 1 Hour

Course Code: MEC 406

Max Marks: 40

Course Name: Operations Research for Engineers

Weightage: 20%

Part A (1Q x 10M = 10Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	**Step 1** Subtract the minimum of each row of the effectiveness matrix, from all the elements of the respective rows (Row reduced matrix). **Step 2** Further modify the resulting matrix by subtracting the minimum element of each column from all the elements of the respective columns. Thus first modified matrix is obtained. **Step 3** Draw the minimum number of horizontal and vertical lines to cover all the zeroes in the resulting matrix. Let the minimum number of lines be N. Now there may be two possibilities • If N = n, the number of rows (columns) of the given matrix then an optimal assignment can be made. So make the zero assignment to get the required solution. • If N < n then proceed to step 4 **Step 4** Determine the smallest element in the matrix, not covered by N lines. Subtract this minimum element from all uncovered elements and add the same element at the intersection of horizontal and vertical lines. Thus the second modified matrix is obtained. **Step 5** Repeat step 3 and step 4 until minimum number of lines	1.25x8=10	10 mins

	become equal to number of rows (columns) of the given matrix i.e. N = n. **Step 6** To make zero assignment - examine the rows successively until a row-wise exactly single zero is found; mark this zero by '□' to make the assignment. Then, mark a 'X' over all zeroes if lying in the column of the marked zero, showing that they cannot be considered for further assignment. Continue in this manner until all the rows have been examined. Repeat the same procedure for the columns also. **Step 7** Repeat the step 6 successively until one of the following situations arise • If no unmarked zero is left, then process ends • If there lies more than one of the unmarked zeroes in any column or row, then mark □ one of the unmarked zeroes arbitrarily and mark a cross in the cells of remaining zeroes in its row and column. Repeat the process until no unmarked zero is left in the matrix. **Step 8** Exactly one marked zero in each row and each column of the matrix is obtained. The assignment corresponding to these marked zeroes will give the optimal assignment.		

Part B (1Q x 15M = 15 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	1.Applying vogel's approximation method for finding the initial basic feasible solution	3	25 mins

	W_1	W_2	W_3	W_4	Availability	Penalty
F_1	**5**(19)	(30)	(50)	**2**(10)	X	X
F_2	(70)	(30)	**7**(40)	**2**(60)	X	X
F_3	(40)	**8**(8)	(70)	**10**(20)	X	X
Requirement	X	X	X	X		
Penalty	X	X	X	X		

Minimum transportation cost is 5 (19) + 2 (10) + 7 (40) + 2 (60) + 8 (8) + 10 (20) = Rs. 779

2. Check for Non-degeneracy

The initial basic feasible solution has m + n – 1 i.e. 3 + 4 – 1 = 6 allocations in independent positions. Hence optimality test is satisfied.

1

3. Calculation of u_i and v_j : - $u_i + v_j = c_{ij}$

					u_i
	* (19)			* (10)	$u_1 = -10$
			* (40)	* (60)	$u_2 = 40$
		* (8)		* (20)	$u_3 = 0$
v_j	$v_1 = 29$	$v_2 = 8$	$v_3 = 0$	$v_4 = 20$	

2

4. Calculation of cost differences for non basic cells $d_{ij} = c_{ij} - (u_i + v_j)$

c_{ij}

*	(30)	(50)	*
(70)	(30)	*	*
(40)	*	(70)	*

$u_i + v_j$

*	-2	-10	*
69	48	*	*
29	*	0	*

$d_{ij} = c_{ij} - (u_i + v_j)$

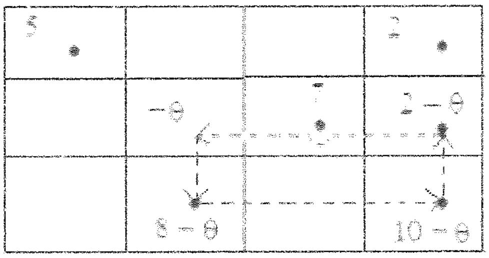
*	32	60	*
1	-18	*	*
11	*	70	*

2

5. Optimality test

$d_{ij} < 0$ i.e. $d_{22} = -18$ so x_{22} is entering the basis

6. Construction of loop and allocation of unknown quantity Θ



5 (19)			2 (10)
	2 (30)	7 (40)	
	6 (8)		12 (20)

4

Minimum transportation cost is 5 (19) + 2 (10) + 2 (30) + 7 (40) + 6 (8) + 12 (20) = Rs. 743

7. Improved Solution

				u_i
* (19)			* (10)	$u_1 = -10$
	* (30)	* (40)		$u_2 = 22$
	* (8)		* (20)	$u_3 = 0$
$v_1 = 29$	$v_2 = 8$	$v_3 = 18$	$v_4 = 20$	v_j

c_{ij}

*	(30)	(50)	*
(70)	*	*	(60)
(40)	*	(70)	*

$u_i + v_j$

*	-2	8	*
51	*	*	42
29	*	18	*

$d_{ij} = c_{ij} - (u_i + v_j)$

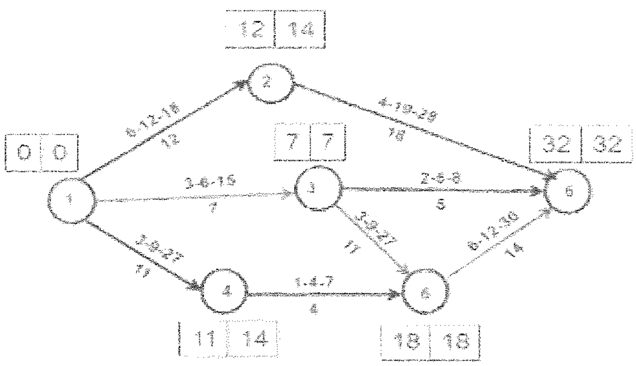
*	32	42	*
19	*	*	18
11	*	52	*

Since $d_{ij} > 0$, an optimal solution is obtained with minimal cost Rs.743

Scheme of Marking: 3

Part C (1Q x 15M = 15 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	(network diagram below)	4	15 Mins
	(activity table below)	3	



Activity	t_e
1-2	12
1-3	7
1-4	11
2-6	18
3-5	11
3-6	5
4-5	4
5-6	14

Critical path = 1 – 3 – 5 – 6

Expected project duration T_e = 32 days

Activity	t_o	t_m	t_p	CA	σ^2
1-2	6	12	18		4
1-3	3	6	15	1-3	4
1-4	3	9	27		16
2-6	4	19	28		16
3-5	3	9	27	3-5	16
3-6	2	5	8		1
4-5	1	4	7		1
5-6	6	12	30	5-6	16

3

Variance σ_p^2 = 36 days

Standard deviation σ_p = √36 = 6 days

Expected duration of the project T_e = 32 days

Std. deviation of project duration σ_p = 6 days

Scheduled duration T_s = 35 days

We know, $Z = (Ts - Te)/\sigma_p$

$= (35-32)/6 = +0.5$

The area under the normal curve (from standard normal PD table) up to Z = +0.5

= 0.6915 (i.e. 69.15 % chance)

The probability that project will be completed in 35 days is 0.6915

5

d)

We know, $Z = (T_s - T_e)/\sigma_p$

For 90% chance (probability = 0.9) area under the std. normal curve, we have Z = +1.28

$+1.28 = (T_s - 32)/6$

Hence, T_s = 39.68 days

Project duration of 39.68 days has 90% chance of being met

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BENGALURU

SCHOOL OF ENGINEERING

END TERM FINAL EXAMINATION

Semester: Odd Semester:2019-20

Course Code: MEC 406

Course Name: OPERATIONS RESEARCH FOR ENGINEERS

Program: B.Tech. (All Program) & VII (OE-II)

Date: 26 December 2019

Time: 9:30 AM to 12:30 PM

Max Marks: 80

Weightage: 40%

Instructions:

(i) Read all the questions carefully and answer.

(ii) Use of normal distribution table is permitted.

(iii) Use of graph sheet is permitted.

Part A [Memory Recall Questions]

Answer all the Question. Each Question carries 5 marks. (4Qx5M=20M)

1. Explain the phases of OR. (C.O.No.1) [Knowledge]

2. Match the following

a. $Ax + By + Cz + \ldots \leq N$	:	Objective function
b. Letter "U" is designated at	:	Hungarian method
c. $p = 3x - 2y + 4z$	:	Row in VAM
d. Letter "V" is designated at	:	Constraint
e. Matrix Reduction	:	Column in VAM

(C.O.No.2) [Knowledge]

3. Explain the terms – event, predecessor event, successor event, dummy activity, network. (C.O.No.3) [Knowledge]

4. In a game of matching coins, player A wins Rs. 5 if there are two heads, wins Rs. 1 if there are two tails and loses Rs. 2, when there is one head and one tail. Determine the payoff matrix and the value of the game to A. (C.O.No.4) [Knowledge]

Part B [Thought Provoking Questions]

Answer both the Question. Each Question carries 15 marks. (2Qx15M=30M)

5. A small project is composed of 7 activities whose time estimates are listed below. Activities are being identified by their beginning (i) and ending (j) node numbers.

Activities		*Time in weeks*		
i	*j*	t_o	t_l	t_p
1	2	1	1	7
1	3	1	4	7
1	4	2	2	8
2	5	1	1	1
3	5	2	5	14
4	6	2	5	8
5	6	3	6	15

I. Draw the network.
II. Calculate the expected variances for each.
III. Find the expected project completed time.
IV. Calculate the probability that the project will be completed at least 3 weeks than expected.
V. If the project due date is 18 weeks, what is the probability of not meeting the due date?

[15M](CO.No.3) [Comprehension]

6.

A. Solve the following game by graphical method

	B1	B2
A1	1	2
A2	5	4
A3	-7	9
A4	-4	-3
A5	2	1

[8M] (CO.No.4) [Comprehension]

B. Consider a box office ticket window being manned by a single server. Customer arrives to purchase ticket according to Poisson input process with a mean rate of 30/hr. the time required to serve a customer has an ED with a mean of 90 seconds determine:

i. Mean queue length.
ii. Mean waiting time in the system.
iii. The probability of the customer waiting in the queue for more than 10min.

[7M] (CO.No.4) [Comprehension]

Part C [Problem Solving Questions]

Answer both the Question. Each Question carries 15 marks. **(2Qx15M=30M)**

7. Solve using simplex method

   Maximize $Z = 2x - 3y + z$

   Subject to

   $3x + 6y + z \leq 6$

   $4x + 2y + z \leq 4$

   $x - y + z \leq 3$

   and $x \geq 0,\ y \geq 0,\ z \geq 0$

(C.O.No.1) [Application]

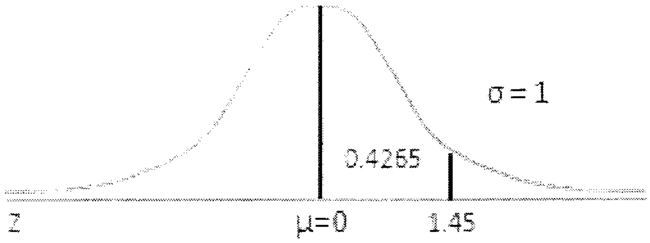
8. Solve the transportation problem when the unit transportation costs, demands and supplies are as given:

	D1	D2	D3	D4	Supply
O1	6	1	9	3	70
O2	11	5	2	8	55
O3	10	12	4	7	70
Demand	85	35	50	45	

(C.O.No.2) [Application]

Areas Under the One-Tailed Standard Normal Curve

This table provides the area between the mean and some Z score.
For example, when Z score = 1.45 the area = 0.4265.



Z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990
3.1	0.4990	0.4991	0.4991	0.4991	0.4992	0.4992	0.4992	0.4992	0.4993	0.4993
3.2	0.4993	0.4993	0.4994	0.4994	0.4994	0.4994	0.4994	0.4995	0.4995	0.4995
3.3	0.4995	0.4995	0.4995	0.4996	0.4996	0.4996	0.4996	0.4996	0.4996	0.4997
3.4	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4998
3.5	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998
3.6	0.4998	0.4998	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999
3.7	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999
3.8	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999
3.9	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000

SCHOOL OF ENGINEERING

Semester: VII[th]

Course Code: MEC 406

Course Name: **Operations Research for Engineers**

Date: 26-12-2019

Time: 9:30 am – 12:30 pm

Max Marks: 80

Weightage: 40%

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels			Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]			Total Marks
			K			C			A			
Part A – 1,2,3, 4	CO1, CO2, CO3, CO4	Module 1,2,3,4	20									20
Part B -1,2	CO3, CO4	Module 3,4				30						30
Part C – 1,2	CO1, CO2	Module 1,2							30			30
	Total Marks		20			30			30			80

K =Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

Annexure- II: Format of Answer Scheme

SCHOOL OF ENGINEERING

SOLUTION

GAIN MORE KNOWLEDGE REACH GREATER HEIGHTS

Semester: VIIth

Course Code: MEC 406

Course Name: **Operations Research for Engineers**

Date: 26-12-2019

Time: 9:30 am – 12:30 pm

Max Marks: 80

Weightage: 40%

Part A (4Q x 5M = 20Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	**Phases of OR:** 1. Defining the problem and gathering data 2. Formulating a mathematical model 3. Deriving solutions from the model 4. Testing the model and its solutions 5. Preparing to apply the model 6. Implementation	5	5 mins
2	a. $Ax + By + Cz + \ldots \leq N$: Objective function(C) b. Letter "U" is designated at : Hungarian method(E) c. $p = 3x - 2y + 4z$: Row in VAM(B) d. Letter "V" is designated at : Constraint(A) e. Matrix Reduction : Column in VAM(D)	5	5 mins
3	**Event:** It is the beginning or the end of an activity. Events are represented by circles in a project network diagram. The events in a network are called the **nodes.** **Predecessor Event:** The event just before another event is called the predecessor event. **Successor Event:** The event just following another event is called the successor event. **Dummy Activity:** A dummy activity is an activity which does not consume any time. Sometimes, it may be necessary to introduce a dummy activity in order to provide connectivity to a network or for the preservation of the logical sequence of the nodes and edges. **Network:** A network is a series of related activities and events which result in an end product or service. The activities shall follow	5	5 mins

a prescribed sequence. For example, while constructing a house, laying the foundation should take place before the construction of walls. Fitting water tapes will be done towards the completion of the construction. Such a sequence cannot be altered.

4 Pay off Matrix -

		Player B	
		H	T
Player A	H	5	-2
	T	-2	1

3 | 5 mins

Value of the game:

$$V = \frac{a_{11} * a_{22} - a_{12} * a_{21}}{(a_{11} + a_{22}) - (a_{12} + a_{21})}$$

$$V = \frac{(5 * 1) - (-2 * -2)}{(5 + 1) - (-2 - 2)}$$

2

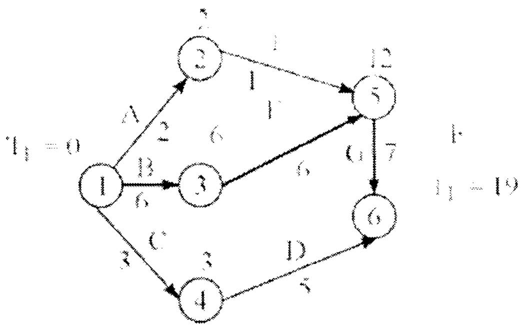
$$V = \frac{5 - 4}{6 - (-4)} = \frac{1}{10}$$

Part B

(2 Q x 15M = 30 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
5	(see table below)	4	

Activities		Weeks			$t_E = t_E + 4t_L + t_P /6$	t_E	$\sigma = (t_p - t_o)/6$	σ^2
i	j	t_O	t_L	t_P				
1	2	1	1	7	2	6	1	1
1	3	1	4	7	6	6	1	1
1	4	2	2	8	3	6	1	1
2	5	1	1	1	1	0	0	0
3	5	2	5	14	6	12	2	4
4	6	2	5	8	5	6	1	1
5	6	3	6	15	7	12	2	4



3

Critical activities	Variance
1 – 3	1
3 - 5	4
5 - 6	4
$\Sigma\sigma^2$	9

$\sqrt{\Sigma\sigma^2} = \sqrt{9} = 3$

2

30 mins

4. Probability of completing the project at least 3 weeks earlier i.e. 16 in weeks
T_L = 16 weeks, T_E = 19 weeks.
$T_L - T_E$ = –3 weeks

$$Z = (T_L - T_E) / \sqrt{\Sigma\sigma^2} = -3 / 3 = -1$$

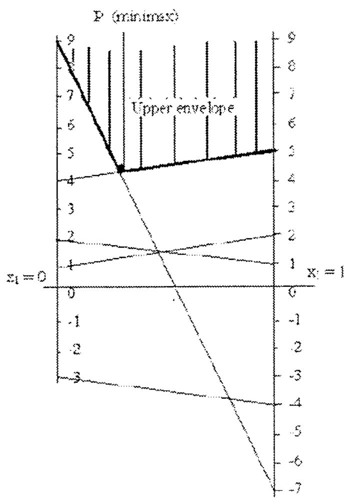
3

From table the probability of completing the project = 15.9%
5. if T_L = 18 weeks. Probability of completing in 11 weeks is (18 – 19) / 3 = –1/3
From table the probability = 38.2%
Probability of not meeting due date = 100 – 38.2 = 61.8%
i.e. 61.8% of the time the manager cannot complete the project by due date.

3

6a

A.



15 mins

2

	$\begin{array}{c c} & \begin{array}{cc} B1 & B2 \end{array} \\ \begin{array}{c} A2 \\ A3 \end{array} & \begin{bmatrix} 5 & 4 \\ -7 & 9 \end{bmatrix} \begin{array}{c} 16 \\ 1 \end{array} \\ & \begin{array}{cc} 5 & 12 \end{array} \end{array}$	2	
	$V = \dfrac{a_{11}\, a_{22} - a_{21}\, a_{12}}{(a_{11} + a_{22}) - (a_{12} + a_{21})} = \dfrac{45 + 28}{14 + 3}$	2	
2	V = 73/17 SA = (0, 16/17, 1/17, 0, 0) SB = (5/17, 12 /17)	2	
6b	B. The mean arrival rate = $\lambda = 30/hr$ The mean service rate $\mu = \frac{1}{90} \times 60 \times 60 = 40/hr$ (a) Mean queue length $L_q = \dfrac{\lambda^2}{\mu(\mu - \lambda)} \quad \dfrac{30^2}{40(40-30)} = 2.25\ customers$	2	
	(b) Mean waiting time in the system $W = W_q + \dfrac{1}{\mu}$ $= \dfrac{L_q}{\lambda} + \dfrac{1}{\mu}$ $= \dfrac{2.25}{30} + \dfrac{1}{40}$ $= 0.1hr$	2	15 mins
	(c) Probability of the customer waiting in queue for more than 10min. $W \dfrac{10}{60} = 1/6hour$ $P_{ro} = \left(\dfrac{\lambda}{\mu}\right)^{e^{(\lambda - \mu)w}}$ $= \left(\dfrac{30}{40}\right)^{e^{(30-40)/6}}$ $P_{ro} = 0.1416$	3	

Part C (2Q x 15M = 30 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
7	Maximize $Z = 2x - 3y + z + 0s_1 + 0s_2 + 0s_3$ Subject to $3x + 6y + z + s_1 = 6$ $4x + 2y + z + s_2 = 4$ $x - y + z + s_3 = 3$ $x \geq 0, y \geq 0, z \geq 0$ $s_1 \geq 0, s_2 \geq 0, s_3 \geq 0$	1	45 Mins

		$C_j \rightarrow$	2	-3	1	0	0	0	
Basic Variables	C_B	X_B	X	Y	Z	S_1	S_2	S_3	Min ratio X_B / X_k
s_1	0	6	3	6	1	1	0	0	6 / 3 = 2
s_2	0	4	[4]	2	1	0	1	0	4 / 4 = 1 → outgoing
s_3	0	3	1	-1	1	0	0	1	3 / 1 = 3
	Z = 0		↑ incoming -2	3	-1	0	0	0	← Δ_j
s_1	0	3	0	9/2	1/4	1	-3/4	0	3/1/4=12
x	2	1	1	1/2	1/4	0	1/4	0	1/1/4=4
s_3	0	2	0	-3/2	[3/4]	0	-1/4	1	8/3 = 2.6 →
	Z = 2		0	4	↑ incoming 1/2	0	1/2	0	← Δ_j
s_1	0	7/3	0	5	0	1	-2/3	-1/3	
x	2	1/3	1	1	0	0	1/3	-1/3	
z	1	8/3	0	-2	1	0	-1/3	4/3	
	Z = 10/3		0	3	0	0	1/3	2/3	← Δ_j

Marks: 3, 4, 4

Since all $\Delta_j \geq 0$, optimal basic feasible solution is obtained.
Therefore the solution is Max Z = 10/3, x = 1/3, y = 0 and z = 8/3 — 3

3

Since the total demand $\Sigma b_j = 215$ is greater than the total supply $\Sigma a_i = 195$ the problem is an unbalanced TP.

Destination

Origins		D_1	D_2	D_3	D_4	*Supply*
	O_1	6	1	9	3	70
	O_2	11	5	2	8	55
	O_3	10	12	4	7	70
	O_4	0	0	0	0	20
	Demand	85	35	50	45	215

1

45 Mins

As this problem is balanced, there exists a feasible solution to this problem. Using VAM we get the following initial solution. The initial solution to the problem is given by

	D_1	D_2	D_3	D_4
O_1	[6] (65)	[1] (5)	[9]	[3]
O_2	[11]	[5] (30)	[2] (25)	[8]
O_3	[10]	[12]	[4] (25)	[7] (45)
O_4	[0] (20)	[0]	[0]	[0]

3

There are 7 independent non-negative allocations equal to $m + n - 1$. Hence, the solution is a non-degenerate one. The total transportation cost = $6 \times 65 + 5 \times 1 + 5 \times 30 + 2 \times 25 + 4 \times 25 + 7 \times 45 + 20 \times 0$ = Rs 1010

1

To find the optimal solution We apply the steps in the MODI method to the previous table.

Initial table					
	D_1	D_2	D_3	D_4	u_i
O_1	[6] (65) –	[1] + (5)	[9] 0 9	[3] 3 0	0
O_2	[11] 10 1 –	[5] (30)	[2] + (25)	[8] 5 3	4
O_3	[10] + 12 –2	[12] 7 5	[4] – (25)	[7] (45)	6
O_4	[0] (20)	[0] –5 5	[0] –4 4	[0] –5 5	–6
v_j	6	1	–2	1	

4

Since all $\Delta_{ij} P < 0$ the solution is not optimum, we introduce the cell (3,1) as this cell has the most negative value of Δ_{ij}. We modify the solution by adding and subtracting the min allocation given by min (65, 30, 25). While doing this, the occupied cell (3, 3) becomes empty.

I Iteration Table

	D_1	D_2	D_3	D_4	u_i
O_1	[6] (40)	[1] (30)	[9] 2 11	[3] 3 0	6
O_2	[11] 10 1	[5] (5)	[2] (50)	[8] 7 1	10
O_3	[10] (25)	[12] 5 7	[4] 2	[7] (45)	10
O_4	[0] (20)	[0] –5 5	[0] –8 8	[0] –3 3	0
v_j	0	–5	–8	–3	

4

As the number of independent allocations are equal to $m+n-1$, we check the optimality.
Since all $\Delta_{ij} \geq 0$, the solution is optimal and an alternate solution exists as $\Delta_{14} = 0$. Therefore, the optimum allocation is given by
$X_{11} = 40, X_{12} = 30, X_{22} = 5, X_{23} = 50, X_{31} = 25, X_{34} = 45, X_{41} = 20$.
The optimum transportation cost is $= 6 \times 40 + 1 \times 30 + 5 \times 5 + 2 \times 50 + 10 \times 25 + 7 \times 45 + 0 \times 20 =$ Rs 960

2