Q.6 i. Differentiate between PERT and CPM. 3

ii. Define Network, Activity and Event in PERT/CPM. **7**

Construct the network diagram for following information:

Activity	A	B	C	D	E	F	G	H
Predecessor	-	A	A	B, C	C	D	E	F, G

OR iii. Consider the following data for the activities of a project: **7**

Activity	A	B	C	D	E	F	G	H	I
Predecessor	-	-	-	A	B	C	D, E	B	H, F
Duration	3	5	4	2	3	9	8	7	9

From the above information,

(a) Construct a network diagram,

(b) Compute earliest event time and latest event time,

(c) Determine the critical path and total project duration.

******

Total No. of Questions: 6 *Total No. of Printed Pages:4*

Enrollment No.....

Faculty of Management

End Sem (Even) Examination May-2022

MS3CO05 Operations Research

Programme: BBA Branch/Specialisation: Management

Duration: 3 Hrs. **Maximum Marks: 60**

Note: All questions are compulsory. Internal choices, if any, are indicated. Answers of Q.1 (MCQs) should be written in full instead of only a, b, c or d.

Q.1 i. In _____ models, everything is defined and the results are not uncertain. **1**

(a) Deterministic (b) Probabilistic

(c) Both (a) and (b) (d) None of these

ii. The innovative science of Operations Research was discovered during_____. **1**

(a) World War I (b) World War II

(c) Civil War (d) Industrial Revolution

iii. If the feasible region of a LPP is empty, the solution is _____. **1**

(a) Infeasible (b) Unbounded

(c) Alternative (d) None of these

iv. Which of the following is a component of a linear programming model? **1**

(a) Constraints (b) Decision variables

(c) Objective Function (d) All of these

v. A feasible solution is called a basic feasible solution if the number of non-negative allocations is equal to _____. **1**

(a) m-n+1 (b) m-n-1 (c) m+n-1 (d) None of these

vi. To test optimality by MODI method, the initial basic feasible solution of transportation problem should be- **1**

(a) Degenerate (b) Feasible

(c) Non-degenerate (d) None of these

vii. In Assignment problem, if the number of columns are greater than the number of rows then we add- **1**

(a) Dummy row (b) Dummy column

(c) Row with cost one (d) Column with cost one

viii. An assignment problem is a special form of transportation problem where all supply and demand values equal- **1**
(a) 1 (b) 2 (c) 3 (d) None of these

ix. Critical path means- **1**
(a) Maximum length in terms of duration
(b) Minimum length in terms of duration
(c) Similar to another simple path
(d) None of these

x. An arrow in a network diagram represents- **1**
(a) Event (b) Activity (c) Node (d) None of these

Q.2 i. Discuss any three limitations of operations research. **3**

ii. Write various classification schemes of operations research models. Also describe any five models of operations research. **7**

OR iii. Write any two definitions of operations research. Also discuss any five scopes of operations research. **7**

Q.3 i. Define Slack and Surplus variable in context of LPP. When do we use these variables? **3**

ii. Use Simplex method to solve the linear programming problem- **7**

Maximize $Z = 3x_1 + 4x_2$

Subject to

$x_1 + x_2 \leq 450$

$2x_1 + x_2 \leq 600$

$x_1, x_2 \geq 0$

OR iii. Use the graphical method to solve the following L.P. problem- **7**

Minimize $Z = 3x_1 + 2x_2$

Subject to

$5x_1 + x_2 \geq 10$

$x_1 + x_2 \geq 6$

$x_1 + 4x_2 \geq 12$

and $x_1, x_2 \geq 0$

Q.4 i. What is unbalanced transportation problem? How do you start in this case? **3**

ii. Find initial basic feasible solution of given Transportation problem by Vogel's Approximation method and then find the optimal solution: **7**

To→ From↓	W_1	W_2	W_3	W4	Supply
D_1	21	16	25	13	11
D_2	17	18	14	23	13
D_3	32	27	18	41	19
Demand	6	10	12	15	43

OR iii. Find the initial basic feasible solution of following Transportation problem by North West Corner Rule, Least Cost Method and Vogel's Approximation Method. **7**

Destination→ Origin↓	D_1	D_2	D_3	D_4	Supply
O_1	19	30	50	12	7
O_2	70	30	40	60	10
O_3	40	10	60	20	18
Demand	5	8	7	15	35

Q.5 i. Explain Johnson's Algorithm for processing of 'n' Jobs through two machines in Sequencing problem. **3**

ii. Solve the following assignment problem for minimization: **7**

		Jobs				
		I	II	III	IV	V
Persons	A	1	3	5	8	2
	B	7	10	12	5	10
	C	15	2	8	10	7
	D	6	5	3	2	8
	E	9	15	20	6	30

OR iii. Solve the following travelling salesman problem for cost minimization: **7**

		To City			
		A	B	C	D
From City	A	∞	46	16	40
	B	41	∞	50	40
	C	82	32	∞	60
	D	40	40	36	∞

P.T.O.

Total No. of Questions: 6 *Total No. of Printed Pages:2*

Enrollment No.....

Faculty of Management

End Sem (Even) Examination May-2018

MS3CO05 Operations Research

Programme: BBA Branch/Specialisation: Management

MCQ

Q.1

i. In ---------- models, everything is defined and the results are not uncertain,
a)Deterministic

ii. The innovative science of Operations Research was discovered during ----------
b) World War II

iii. If the feasible region of a LPP is empty, the solution is ----------
~~b) Unbounded~~ Infeasible

iv. Which of the following is a component of a linear programming model?
d) All of these

v. A feasible solution is called a basic feasible solution if the number of non-negative allocations is equal to ----------
c) $m+n-1$

vi. To test optimality by MODI method, the Initial Basic Feasible Solution of transportation problem should be
c) non-degenerate

vii. In Assignment problem, if the number of columns are greater than the number of rows then we add
a) dummy row

viii. An assignment problem is a special form of transportation problem where all supply and demand values equal to
a)1

ix. Critical path means
(a) Maximum length in terms of duration

x. A arrow in an network diagram represent
b) activity

OPERATIONS RESEARCH
MS3C005
BBA EndSem Jun 2022 scheme.

Q2 i.

Ans. Three limitation of operations research.

→ Magnitude of computation : (1)

Mordern problem involve large number of variables and hence to find interrelationship among makes it difficult. Thus use of OR is limited only to very large organizations.

→ Analysis of only Quantifiable factors: (1)

OR can evaluate only the effects of numeric and quantifiable factors.

→ Wide gap between the managers and the operation researchers. (1)

OR being specialist's job requires a mathematician or a statistician, who might not be aware of the busines problems. Similarly, a managers fails to understand the complex working of OR.

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Q2 ii) A model in the sense used in OR is defined as a representation of an actual object or situation.

Classification schemes of operations research models. (2)

1. Classification by structure.
   → Iconic model.
   → Analogue model
   → Symbolic model

2. Classification by Purpose
   → Descriptive models
   → Predictive models
   → Prescriptive models

3. Classification by nature of Environment
   → Deterministic models
   → Probabilistic models

4. Classification by Behaviour.
   → Static models.
   → Dynamic model

5. Classification by Method of Solution
   → Analytical models
   → Simulation models.

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6. Classification by use of digital computers.

→ ~~Adv~~ Analogue and Mathematical models combined
→ Function model.
→ Quantative model
→ Heuristic model.

ICONIC MODEL (1)

Iconic models represent the system as it is by scaling it up or down

Eg. a toy airplane
photographs
drawings etc.

DESCRIPTIVE MODEL (1)

A descriptive model simply describe some aspects of a situation based on observation, survey, questionnaire results or other available data. The result of an opinion poll represent a descriptive model.

PREDICTIVE MODEL (1)

Such models simply describe some aspects of a situation

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Such models can answer 'what if' type of questions. i.e they can predictions regarding certain events.
For ex, based on the survey results, television network such models attempt to explain and predict the election results before all the votes are actualy counted.

STATIC MODEL (1)

These models do not consider the impact of changes that takes place during the planning horizon i.e, they are independent to time. Also, in a static model only one decision is needed for the duration of a given time period.

DETERMINISTIC MODEL. (1)

Such models assume conditions of complete certainty and perfect knowledge.
For example, linear programming transportation and assignment model are deterministic type of models.

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2. iii) OR is scientific method of providing executive departments with a quantitative basis for decision regarding the operation under their control.

(1) OR is scientific approach to problem solving for executive management.

Five Scopes of Operations Research.

→ Finance

(1) In cash flow planning
Credit policy analysis, investment analysis
~~Estimati~~ Claim and complaint procedures

→ Marketing

(1) Best time to launch a new product
The size of stock to meet the future demand.

→ Agriculture

(1) Optimum allocation of land to various crops in accordance with climate condition.

→ Industry.

(1) In decides his policy on the basis of past experience.

→ In personal mangement.

(1) Selecting suitable employ with skill and min. salary.

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(Q3 i.) Slack variable : (1)

In optimization problem, a slack variable is a variable that is added to an inequality constraint to transform it into an equality.

eg. $8x + 10y \leq 3400$

$8x + 10y + s = 3400$

here s is a slack variable.

Surplus variable : (1)

In optimization problem, a surplus variable is a variable that is substract from an inequality constraint to transform it into an equality.

eg. $8x + 10y \geq 3400$

$8x + 10y - e = 3400$

here e is surplus variable.

use (1)

For solving the simplex method and make (less than) inequality into equality we use slack variable

& for solving Big M method and make (greater than) inequality into Equality we use surplus variable.

2 (ii)

$$\max Z = 3x_1 + 4x_2 + 0s_1 + 0s_2$$

s.t.

$$x_1 + x_2 + s_1 = 450$$
$$2x_1 + x_2 + s_2 = 600$$
$$x_1, x_2, s_1, s_2 \geq 0$$

(1/2)

	C_j	3	4	0	0		
C_B	B	x_1	x_2	s_1	s_2	b	
0	s_1	1	1	1	0	450	450 ← KR
0	s_2	2	1	0	1	600	600
	Z_j	0	0	0	0		
	$C_j - Z_j$	3	4 ↑ KC	0	0		
4	x_2	1	1	1	0	450	
0	s_2	1	0	−1	1	150	
	Z_j	4	4	4	0		
	$C_j - Z_j$	−1	0	−4	0		

(3) (3)

$\because C_j - Z_j \leq 0$

(1/2)

$x_1 = 0$
$x_2 = 450$ Ans.

optimal sol^n $Z = 1800$

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$\therefore \forall i \quad c_j - z_j \leq 0$

$\Rightarrow$ Optimal solution, $x_1 = 150$, $x_2 = 300$ — 1/2

& optimal value

$Z = 3 \times 150 + 4 \times 300$

$= 450 + 1200$

$Z = 1650$

Q3 iii) $\min Z = 3x_1 + 2x_2$

s.t. $5x_1 + x_2 \geq 10$

$x_1 + x_2 \geq 6$

$x_1 + 4x_2 \geq 12$

$x_1, x_2 \geq 0$

$5x_1 + x_2 = 10$

x_1	0	2
x_2	10	0

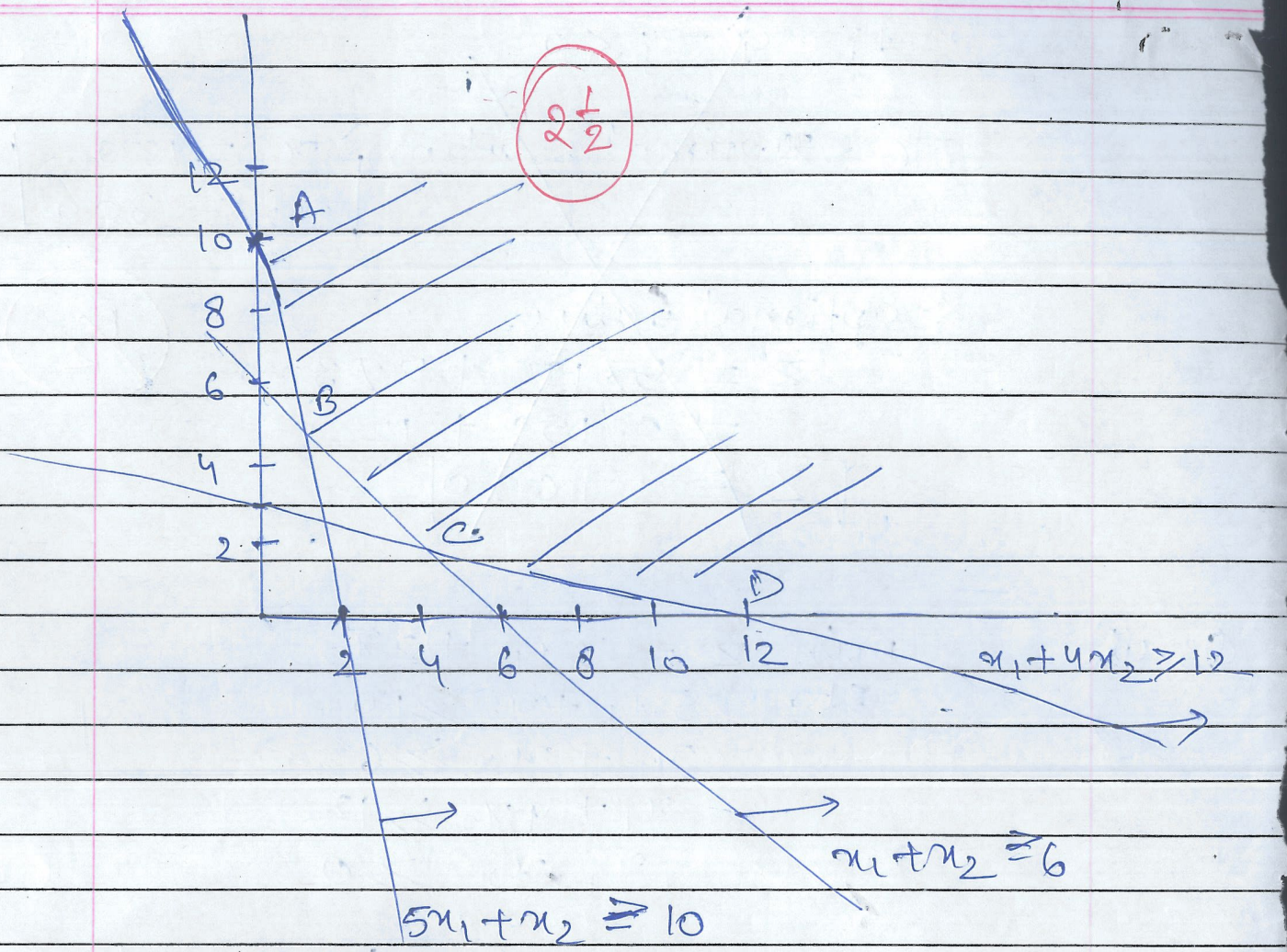
1

$x_1 + x_2 = 6$

x_1	0	6
x_2	6	0

$x_1 + 4x_2 = 12$

x_1	0	12
x_2	3	0



B. To find B. co-ordinate (1)

$$x_1 + x_2 = 6$$
$$5x_1 + x_2 = 10$$
$$-4x_1 = -4$$
$$\boxed{x_1 = 1}$$

$$x_2 = 6 - x_1 = 6 - 1 = 5$$
$$\boxed{x_2 = 5}$$

$$\boxed{B\ (1, 5)}$$

To find C (1)

$x_1 + 4x_2 = 12$

$x_1 + x_2 = 6$

$- \quad - \quad -$

$3x_2 = 6$

$\boxed{x_2 = 2}$

$x_1 = 6 - x_2 = 6 - 2 = 4$

$\boxed{x_1 = 4}$

$\boxed{C(4, 2)}$

(1)

corner point	coordinate	$\min z = 3x_1 + 2x_2$
A	(0, 10)	$z = 20$
B	(1, 5)	$z = 13$
C	(4, 2)	$z = 16$
D	(12, 0)	$z = 36$

optimal sol^n $x_1 = 1$, $x_2 = 5$ Ans.

optimal value $z = 13$ (1/2)

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Q4. i)

In transportation problem, a problem is said to be unbalanced if

(1) ~~total~~ ~~deer~~ total demand is not equal to total supply.

In the case of unbalanced transportation problem we first create dummy row or column to make total

(2) demand equal to total supply. and then apply ~~Initial basic~~ methods ~~of~~ to find Initial basic solution, then to optimise the solution we apply MODI method.

Q4 ii)

Total supply = Total demand = 43

∴ problem is balanced.

we apply VAM method to find Initial basic solution.

Unoccupied matrix. (1)

7	8	-1	—	$u_1 = -10$
—	—	9	—	$u_2 = 0$
26	—	—	32	u_3 9
$v_1 = 17$	$v_2 = 18$	$v_3 = 9$	$v_4 = 23$	

Cost opportunity. (1)

14	8	26	—
—	—	5	—
6	—	—	9

$\therefore \forall d_{ij} > 0$

$\therefore$ optimal solution is 796/-

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VAM (3)

	W_1	W_2	W_3	W_4	Supply	P_1	P_2	P_3	P_4	P_5
D_1	~~21~~	~~16~~	~~25~~	(13) 11	11	3	—	—	—	—
D_2	(17) 6	(18) 3	14	(23) 4	~~13~~ ~~9~~ 3	3	3	3	4	18
D_3	32	(27) 7	(18) 12	41	~~19~~ 7	9	9	9	(9)	(27)
Demand	~~8~~	~~10~~ 3	12	~~15~~ 4	43					
P_1	4	2	4	(10)						
P_2	15	9	4	(18)						
P_3	(15)	9	4	—						
P_4	—	9	4	—						
P_5	—	9	—	—						

Total cost = $13\times11 + 17\times6 + 18\times3 + 23\times4 + 27\times7 + 18\times12$

= $143 + 102 + 54 + 92 + 189 + 216$

= 796 /-

MODI Method.

Occupied matrix. (2)

—	—	—	13	$u_1 = -10$
17	18	—	23	$u_2 = 0$
—	27	18	—	$u_3 = 9$

$v_1 = 17$ $v_2 = 18$ $v_3 = 9$ $v_4 = 23$

$u_2 = 0$

$u_2 + v_1 = 17 \Rightarrow v_1 = 17$

$u_2 + v_2 = 18 \Rightarrow v_2 = 18$

$u_2 + v_4 = 23 \Rightarrow v_4 = 23$

$u_3 + v_2 = 27 \Rightarrow u_3 = 9$

$u_3 + v_3 = 18 \Rightarrow v_3 = 9$

$u_1 + v_4 = 13 \Rightarrow u_1 = -10$

Q4 iii

Total demand = Total supply = 35

∴ problem is balanced.

NWCR (2)

	D_1	D_2	D_3	D_4	Supply
O_1	19 (5)	30 (2)	50	12	~~7~~ 2
O_2	~~7~~0	30 (6)	40 (4)	~~6~~0	~~10~~ 4
O_3	40	10	60 (3)	20 (15)	~~18~~ 15
demand	~~5~~	~~8~~ 6	~~7~~ 3	15	35

Total cost = 19×5 + 30×2 + 30×6 + 40×4 + 60×3 + 20×15

= 95 + 60 + 180 + 160 + 180 + 300

= 975 /—

LCM (2)

	D_1	D_2	D_3	D_4	Supply
O_1	~~19~~	~~3~~6	~~50~~	12 (7)	~~7~~
O_2	70 (3)	30	40 (7)	60	~~10~~ 8
O_3	40 (2)	10 (8)	60	20 (8)	~~18~~ ~~10~~ 2
demand	~~5~~ 3	~~8~~	~~7~~	~~15~~ 8	35

Total cost : 70×3 + 12×7 + 40×~~7~~ + 40×2 + 10×8 + 20×8

= 210 + 84 + 280 + 80 + 80 + 160

= 894 /—

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VAM. (3)

	D_1	D_2	D_3	D_4	Supply	P_1	P_2	P_3	P_4	P_5
O_1	(19)^5	30	~~50~~ 7	(12)^2	~~72~~	7	18	(38)	38	–
O_2	70	30	(40)	(60)^3	~~107~~	10	10	20	20	20
O_3	40	(10)^8	~~60~~	(20)^{10}	~~18 10~~	10	10	(40)	–	–
Demand	~~5~~	~~8~~	~~7~~	~~5 15~~	35					
P_1	(21)	20	10	8						
P_2	–	(20)	10	8						
P_3	–	–	10	8						
P_4	–	–	10	(48)						
P_5	–	–	40	(60)						

Total cost = $19 \times 5 + 10 \times 8 + 40 \times 7 + 12 \times 2 + 60 \times 3 + 20 \times 10$

$= 95 + 80 + 280 + 24 + 180 + 200$

$= 859/-$

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(Q5 i) Processing time on machine | Job number 1 2 3 ... i ... n

A	A_1	A_2	A_3	...	A_i	... A_n
B	B_1	B_2	B_3	...	B_i	... B_n

Algorithm

1- Select minimum processing time out of all A_i's and B_i's

If it it is A_r then do the r^{th} job first. If it is B_s then do the s^{th} job at last.

2. If there is a tie in selecting minimum of all the processing times, then there are following three way to deal with such situation.

a) If $\min(A_i, B_i) = A_r = B_s$
Then do r^{th} job first & s^{th} job last

b) If $\min(A_i, B_i) = A_r$ but $A_r = A_m$ then select any one.

c) If $\min(A_i, B_i) = B_s$ but $B_s = B_t$ then select any one..

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3. Now eliminating the job which has already been assigned for further consideration.
If all the jobs have been sequenced, then go to the next step.
O/w repeat 1 & 2 step.

4. Determine the over all elapsed time and also the idle times on machine A & B as follow.

Idle time A = (Total elapsed time − Time when the last job in the seq finished on machine 'A')

Idle time B = (Time at which first job in seq a starts on machine B) + $\sum_{j=2}^{r}$ (Time at which first job in a seq. starts on machine B) − (Time when $(j-1)^{th}$ job in a seq finishes on machine B.

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(5ii) :: no. of rows = 5 = no. column. (1/2)
Hence, problem is balanced.

Reduction:
Row reduction

	I	II	III	IV	V
A	0	2	4	7	1
B	2	5	7	0	5
C	13	0	6	8	5
D	4	3	1	0	6
E	3	9	14	0	24

(1)

Column reduction.

	I	II	III	IV	V
A	0	2	3	7	0
B	2	5	6	0	4
C	13	0	5	8	4
D	4	3	0	0	5
E	3	9	13	0	23

(1)

Make assignment - / Revised matrix

	I	II	III	IV	V
A	[0]	2	3	7	~~0~~
B	2	5	6	[0]^1	4
C	~~13~~	[0]^2	5	~~8~~	~~4~~
D	~~4~~	~~3~~	[0]^4	~~0~~	~~5~~
E	3	9	13	~~0~~	23

(2) ✓ ✓ ✓

Revised matrix · New Developed cost

	I	II	III	IV	V	
A	~~0~~	2	3	9	[0]^{3}	
B	[0]^{4}	3	4	~~0~~	2	(2)
C	13	[0]^{1}	5	10	4	
D	4	3	[0]^{2}	2	5	
E	1	7	11	[0]^{5}	21	

∵ no. of assignment = order of matrix = 5

∴

Person		Job assigned
A	⟶	V
B	⟶	I
C	⟶	II
D	⟶	III
E	⟶	IV

Total cost = 2 + 7 + 2 + 3 + 6

= 20 /—

(1/2)

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(Q5 iii)

∵ No. of rows = no. of column
∴ matrix is square matrix. (½)

Reduction

Row reduction-

	A	B	C	D
A	∞	30	0	24
B	1	∞	10	0
C	50	0	∞	28
D	04	04	0	∞

(1)

Column reduction -

	A	B	C	D
A	∞	30	0	24
B	0	∞	10	0
C	49	0	∞	28
D	3	4	0	∞

(1)

Make assignment / Revised matrix

	A	B	C	D
A	∞	30	[0]	24
B	[0]	∞	10	~~0~~
C	~~49~~	[0]	~~∞~~	28
D	3	4	~~0~~	∞

✓ ✓ ✓

1 + 1 = 2

New developed cost-

	A	B	C	D
A	∞	27	[0]	21
B	~~0~~	∞	13	[0]
C	49	[0]	∞	28
D	[0]	1	~~0~~	∞

(1)

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∴ no. of assignment = order of matrix = 4

Path of Travelsales man

(1) A → C → B → D → A.

Total cost =

(1/2) = 16 + 40 + 32 + 40

= 128/-

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Q6 i)

PERT	CPM
PERT stands for Programme Evaluation and Review Technique	CPM stands for Critical Path Method
In PERT activities are shown as a network of precedence relationship using activity-on-arrow network construction → Multiple time estimate → Probabilistic activity times.	In CPM activities are shown as network of precedence relationship using activity-on-arrow network construction. → Single estimate of activity time → Deterministic activity time
Used in Production management for the job of repetitive in nature where the activity time estimates can be predicted with considerable certainty due to the existence of past experience,	Used in project management for non-repetitive jobs where the time and cost estimates tend to be quite uncertain.

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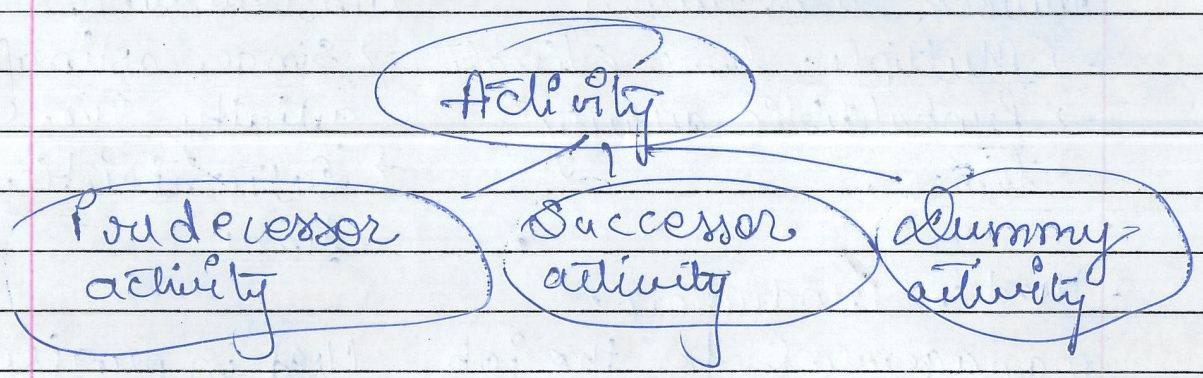
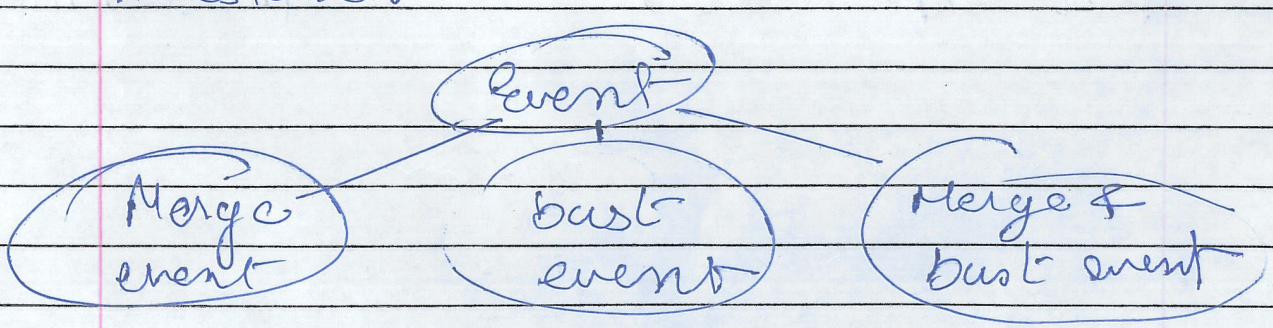
Q6 ii) Network: A network defined as a graphic representation with a flow of some type in its arrow. It represent nodes and arrow. (1)

Activity: Any individual operation which utilises resources and takes certain amount of time for completion and has an end and a beginning is called activity. (1)



Event: An event represents a point in the time signifying the completion of some activities and the beginning of new ones, i.e event represent project milestone. (1)



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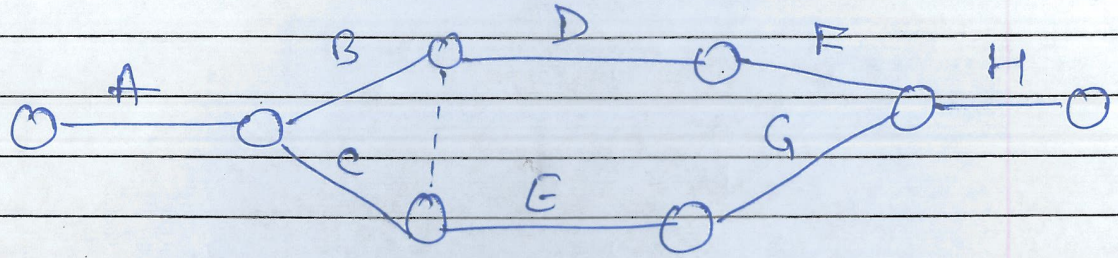
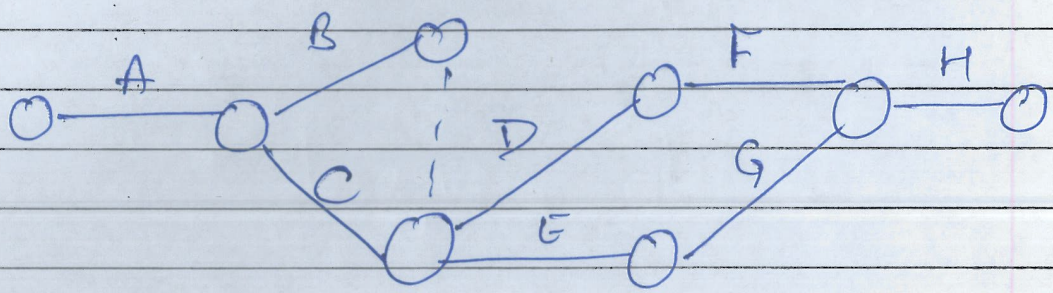
Network diag. (4)

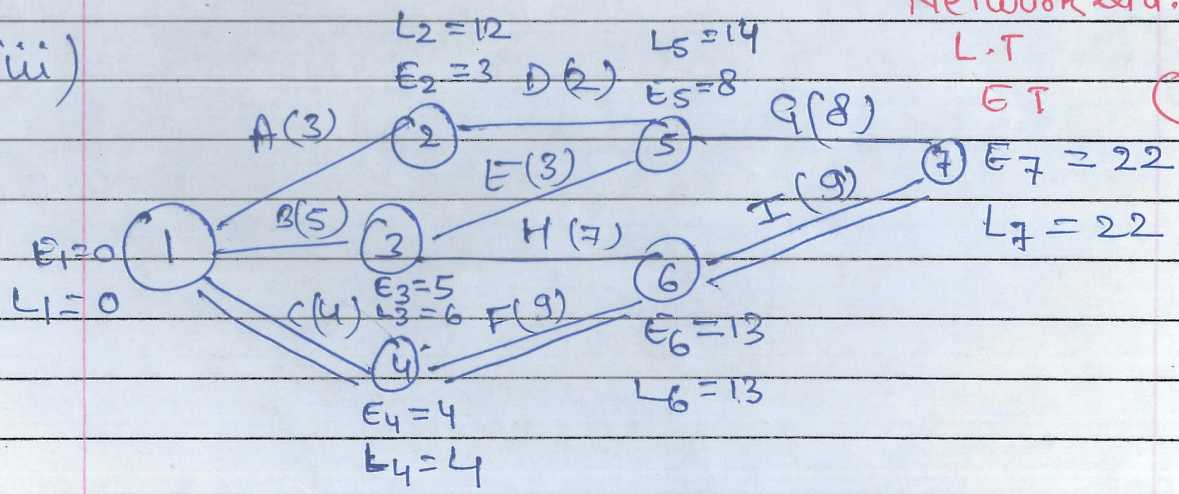


OR



Q6 iii)

Network dia. (3)
L.T (1)
ET (1)



Critical path. (1)

1 → 4 → 6 → 7

Total project duration (1)

1 → 4 + 4 → 6 + 6 → 7

4 + 9 + 9 = 22