OR iii. We have five jobs each of which must pass through three machines A, B, C in the order ABC. Processing time in hours are given below **7**

Jobs	1	2	3	4	5
Machine A	5	7	6	9	5
Machine B	2	1	4	5	3
Machine C	3	7	5	6	7

Find optimal sequence for 5 jobs that will minimize the total elapsed time. Also find idle time for machine A, B and C.

Q.6 i. Define Network, Activity and Event in PERT/CPM. **3**

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

Activity	A	B	C	D	E	F
Predecessor	-	A	A	B, C	-	E
Duration	2	3	4	6	2	8

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.

OR iii. A, B, C, ..., H, I constitute a project. Given $X < Y$ mean that Y cannot be started until X is completed i.e., X is preceding activity of Y. With the notation, **7**

$A < D, A < E, B < F, D < F, C < G, C < H, F < I, G < I$

Construct the network diagram.

******

Enrollment No.....

Faculty of Management Studies

End Sem (Even) Examination May-2019

MS3CO05 Operations Research

Programme: BBA Branch/Specialisation: Management / DM

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. Operations Research emphasizes on the overall approach to the system. This characteristic of Operations Research is often referred as **1**

(a) System Orientation

(b) System Approach

(c) Interdisciplinary Team Approach

(d) All of these

ii. Operations Research approach is typically based on the use of **1**

(a) Physical model (b) Iconic model

(c) Mathematical model (d) Descriptive model

iii. All decision variables in Linear Programming model should be **1**

(a) Negative (b) Non-negative

(c) Both (a) and (b) (d) Neither (a) nor (b)

iv. In simplex method, two variables should be set as zero are classified as **1**

(a) Basic constant (b) Non-basic constant

(c) Optimal variable (d) Non-basic variables

v. 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) Both (a) and (c)

vi. A given Transportation Problem is said to be unbalanced, if the total supply is not equal to the total _____ **1**

(a) Optimization (b) Demand

(c) Cost (d) None of these

vii. The assignment model is a special case of the _____ model. **1**

(a) Maximum-flow (b) Transportation

(c) Shortest-route (d) None of these

viii. The method used for solving an assignment problem is called **1**
(a) Inverse method (b) MODI method
(c) Hungarian method (d) None of these

ix. Any activity which does not consume either any resource or time is called _____ activity. **1**
(a) Predecessor (b) Successor
(c) Dummy (c) End

x. An event that represent the joint completion of more than one activity is known as **1**
(a) Burst event (b) Joint event
(c) Merge event (d) None of these

Q.2 Attempt any two:

i. What are Operations Research models? Explain any four Operations Research models with examples? **5**

ii. Write any two definitions and three limitations of operations research? **5**

iii. Explain any five Scope of Operations Research? **5**

Q.3 i. Define Feasible Solution, Optimal Solution and unbounded solution in context of Linear Programming Problem? **3**

ii. 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 $x_1 , x_2 \geq 0$

OR iii. Use Simplex method to solve the Linear Programming Problem **7**

Maximize $Z = 2x_1 + 5x_2$

Subject to

$x_1 + 4x_2 \leq 24$

$3x_1 + x_2 \leq 21$

$x_1 + x_2 \leq 9$

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 only Initial Basic Feasible Solution by North West Corner Rule, Least Cost Method and Vogel's Approximation Method **7**

		Distribution center				
		D_1	D_2	D_3	D_4	Supply
Plant	P_1	19	30	50	12	7
	P_2	70	30	40	60	10
	P_3	40	10	60	20	18
	Demand	5	8	7	15	35

OR iii. An organization wants to decide the optimal shipments of a product to three retailers from its three warehouses. The cost of shipment per unit from each warehouses to each retailer and the requirements and availability of the product are given below in the table. **7**

		Retail Outlet			
		R_1	R_2	R_3	Availabilities
Warehouses	W_1	5	1	7	10
	W_2	6	4	6	80
	W_3	3	2	5	15
Requirements		75	20	50	

There are penalty costs for every unsatisfied demand unit. These penalty costs are Rs. 5, 3 and 2 respectively for retail outlets R_1, R_2 and R_3. Find the optimal shipping plan.

Q.5 i. Define Assignment problem. Write assumptions of Assignment problem. **3**

ii. Solve the following Assignment problem for Minimization of cost. **7**

	J_1	J_2	J_3	J_4	J_5
P_1	6	2	5	3	6
P_2	2	5	8	7	7
P_3	7	8	6	9	8
P_4	6	2	3	4	5
P_5	9	3	8	9	7
P_6	4	7	4	6	8

Solution. [END Sem]

BBA[OR] May-2019

Sub Code - MS3C005

MCQ.

Q1
(i) (a) System orientation
(ii) (c) Mathematical Model
(iii) (b) Non- Negative
(iv) (d) Non- basic Variables
(v) (c) Non- degenerate
(vi) (b) Demand
(vii) (b) transpartation
(viii) (c) hungarian
(ix) (c) Dummy
(x) (c) Merge event

Q2 (i) OR is the application of Scientific methods, technique and tools to problems involving the operations of a system so as to provide those in Control of the system with optimum solution to the problem. A Model is a representation of reality The objective of model is to identify significant factors and their interrelationship. Various OR Models are. [do any four] +1

① Iconic model : is a pictorial representation of Various aspects of a system Ex. Toys, miniature of building +1

② Analogue : are small physical systems that has similar characteristics and work like a system it represents. +1
Ex. maps in different colors represent water, desert and other geographical feature +1

③ Mathematical model: employ a set of mathematical symbols to represent the decision Variable of a system. The variable are related by mathematical system.

4) Static model: does not take time into account
Ex. LPP, transportation, assignment +1
5) dynamic model: consider time as important factor
Ex. a dynamic prog problem
other models are Deterministic, Stochastic, Analytic, predictive, Simulation, Descriptive etc.

2.
(ii) Any two definition

(a) OR is a scientific method of providing executive departement with a quantative basis for decision regarding the operation under their control. +2
(b) OR is art of winning war without actually fighting it
(c) The art of giving bad answers to problems, wark answers are given.
(d) OR is scientific approach to problem solving for executive management

three limitation (Ans three)
① Magnitude of Computation: Modern problem involve large number of variables and hence to find interrelationship, among makes it difficult. +3
② Analysis of quantifiable factor: It can evaluate only the effects of numeric and quantifiable factors doesnot consider human behaviour

(3) A wide gap between managers and operation researchers.

(4) Money and time costs: when the basic data are subjected to frequent changes, incorpating them in to OR is costly affair.

Q2 (iii) Any five Scope of OR

1) In personnel management
2) In finance and accounting
3) In inventary Control
4) In Research and development
5) In production Management
6) In Marketing & industry
7) In agriculture
8) In LIC.

explain in 2 lines every application. +5

Q3 (1) feasible solution:- A set of variables $x_1, x_2, \ldots x_n$ is called a feasible solution to LPP if it satisfy constraints as well as non-negative restrictions. +1

Optimal Solution:- A feasible solution which optimizes (Max / Min) the value of objective function called optimal sol^n. +1

unbounded Solution:- A solution which can increase or decrease the value of objective function of given LPP indefinitely called an unbounded sol^n. +1

(4)

q3 (ii) use graphical Method to solve

Min $Z = 3x_1 + 2x_2$

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

$x_1 + x_2 \geq 6$

$x_1 + 4x_2 \geq 0$ and $x_1, x_2 \geq 0$.

Express each term (constraint) in term of eqn.

i.e. $5x_1 + x_2 = 10$ — (1) +2

$x_1 + x_2 = 6$ — (2)

$x_1 + 4x_2 = 12$ — (3)

for (1)

x_1	x_2
2	0
0	10

or (2,0) (0,10)

for (2)

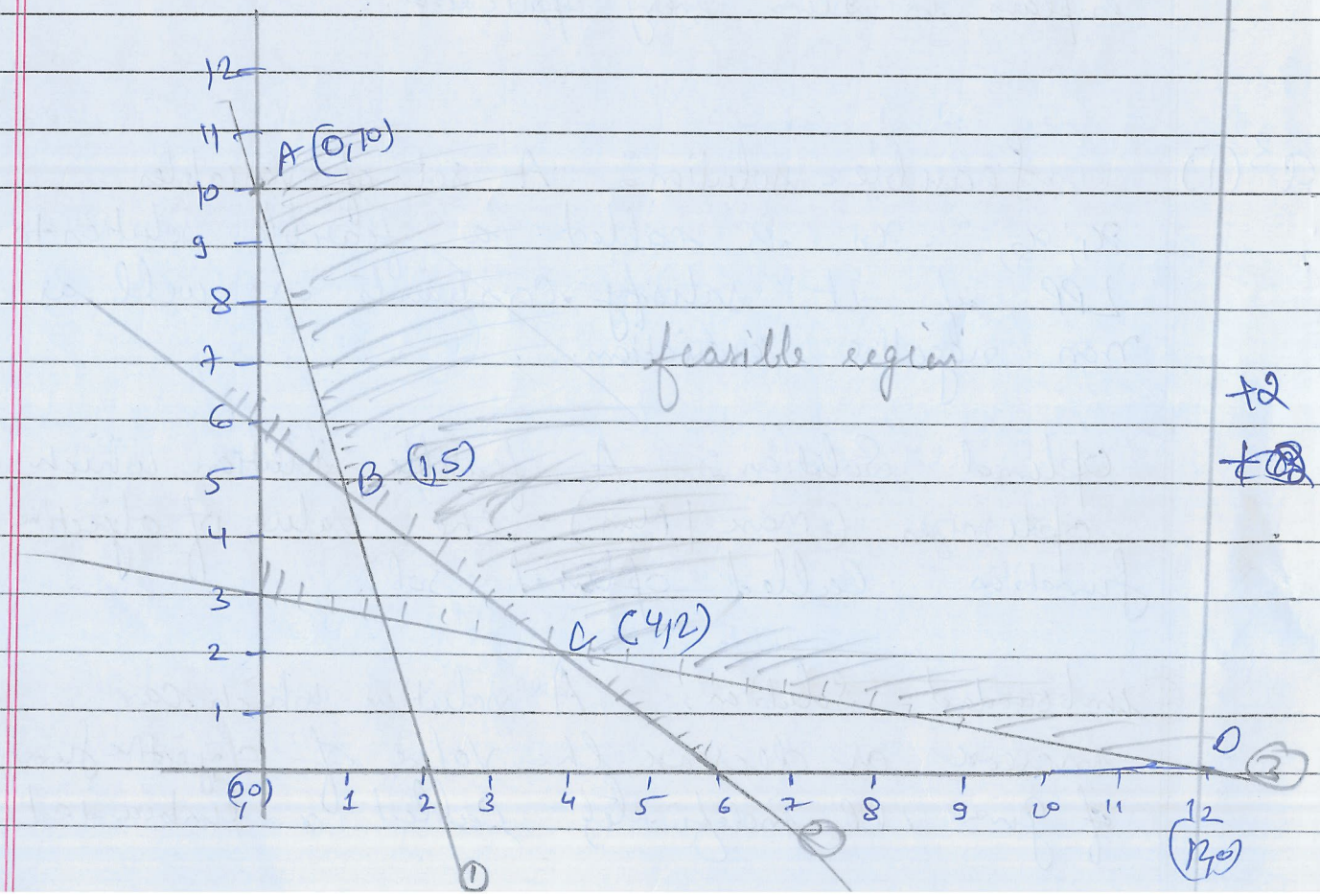
x_1	x_2
6	0
0	6

(6,0) (0,6)

for (3)

x_1	x_2
12	0
0	3

(12,0) (0,3) +1



+2

+2

Region common to all constraints is a feasible region. optimal solution exists at one of the corner point of feasible region

There are four corner point of feasible region A, B, C, D.

Find value of objective function at each of the corner point of feasible region

Corner pt	Coordinate (x_1, x_2)	value of objective function $Z = 3x_1 + 2x_2$
A	(0, 10)	$Z = 20$
B	(1, 5)	$Z = 13$
C	(4, 2)	$Z = 16$
D	(12, 0)	$Z = 36$

+2

Min z occurs at (1, 5) i.e $Z = 13$

Ans is $x_1 = 1$ $x_2 = 5$. Min $Z = 13$.

(iii) Simplex method.

Max $Z = 2x_1 + 5x_2$

St. $x_1 + 4x_2 \leq 24$

$3x_1 + x_2 \leq 21$

$x_1 + x_2 \leq 9$ $\quad x_1, x_2 \geq 0$

Soln. Express problem in standard form of LPP

Max $Z = 2x_1 + 5x_2 + 0S_1 + 0 \cdot S_2 + 0 \cdot S_3$

St $x_1 + 4x_2 + S_1 + 0 \cdot S_2 + 0 \cdot S_3 = 24$

$3x_1 + x_2 + 0S_1 + S_2 + 0S_3 = 21$

$x_1 + x_2 + 0S_1 + 0S_2 + S_3 = 9$

$x_i, S_i \geq 0.$

$i = 1, 4, 5$

+2

Find IBFS using ($x_1 = x_2 = 0$)
i.e non basic variable = 0
We get $S_1 = 24$ $S_2 = 21$, $S_3 = 9$ (basic variable)
prepare I Simplex table

		C_j	2	5		0	0	0	x_0/x_2
C_B	x_B	x_0	x_1	x_2	x_3	S_1	S_2	S_3	KC
0	S_1	24	1	(4)		1	0	0	6 → KR
0	S_2	21	3	1		0	1	0	21
0	S_3	9	1	1		0	0	1	9
									+2
	$(C_j - Z_j) \Rightarrow$		2	5		0	0	0	

all $C_j - Z_j \neq 0$ so not optimal ↑ KC
entre x_2
depart S_1 Key element = 4
KC = Key column
KR = Key row.

II Simplex Table

		C_j	2	5		0	0	0	x_0/x_1	
C_B	x_B	x_0	x_1	x_2	x_3	S_1	S_2	S_3		
5	x_2	6	1/4	1		1/4	0	0	24	
0	S_2	15	11/4	0		-1/4	1	0	15	+2
0	S_3	3	(3/4)	0		-1/4	0	1	4 → KR	
	$(C_j - Z_j) \Rightarrow$		3/4	0	←	5/4	0	0		

↑ KC
$C_j - Z_j$ are not -ve so not optimal.
3/4 = Key element
entre x_1
depart S_3

III Simplex table

		C_j	2	5		0	0	0	
C_B	x_B	x_0	x_1	x_2		s_1	s_2	s_3	x_0/x_2
5	x_2	5	0	1		1/3	0	−1/3	+1
0	s_2	4	0	0		2/3	1	−11/3	
2	x_1	4	1	0		−1/3	0	4/3	
		$(C_j - Z_j) \Rightarrow$	0	0		−1	0	−1	

Since all $C_j - Z_j \leq 0$ So current Sol^n is optimal $x_1 = 4$ $x_2 = 5$

Max $Z = 33$

Q4 (i) Unbalanced transportation problem.

When total demand = Total supply. problem is unbalanced. Then we add dummy demand or dummy supply as per requirement of the problem. which one is short. +1

& we assume cost per unit for a dummy demand or supply is zero. +2

(ii) IBFS using NWCR, LCM, VAM.

problem is already balanced.

NWCR

	D_1	D_2	D_3	D_4	
P_1	19 (5)	30 (2)	50	12	7 2
P_2	70	30 (6)	40 (4)	60	10 4
P_3	40	10	60 (3)	20 (15)	18 15
	5	8 6	7 3	15	35

+2

total cost $= 19 \times 5 + 30 \times 2 + 30 \times 6 + 40 \times 4 + 60 \times 3 + 20 \times 15$

$= 975$

(8)

classmate
Date
Page

(LCM)

	D_1	D_2	D_3	D_4	Supply
P_1	~~19~~	~~30~~	~~50~~	12 (7)	7
P_2	70 (3)	~~30~~	40 (7)	~~60~~	10 3
P_3	40 (2)	10 (8)	~~60~~	20 (8)	~~18 15~~ 2
Demand	~~5~~	~~8~~	~~7~~	~~15~~	35

+2

Using LCM Cost

$= 70 \times 3 + 12 \times 7 + 40 \times 7 + 10 \times 8 + 40 \times 2 + 20 \times 8 = 894.$

Now VAM

	D_1	D_2	D_3	D_4	Supply	P_1	P_2	P_3	P_4	P_5
P_1	19 (5)	30	~~50~~	12 (2)	~~7~~	(7)	(18)	(38)	~~-~~	(38)
P_2	70	30	40 (7)	60 (3)	10	(10)	(10)	(20)	~~60~~	(20)
P_3	40	10 (8)	~~60~~	20 (10)	~~18 10~~	(10)	(10)	(40)	~~60~~	(-)
demand	~~5~~	~~8~~	7	~~15~~ 5						

Penalty (Column)

+3

Plant

Penalty row.

P_1	(21)	(20)	(10)	(8)
P_2	↑ -	(20)	(10)	(8)
P_3	-	↑	(10)	(8)
P_4	-	-	20	48

$19 \times 5 + 12 \times 2 + 40 \times 7 + 60 \times 3 + 20 \times 10 + 10 \times 8 = 859.$

4. (iii) Total Supply ≠ Total demand

$105 \neq 145$

So we add dummy sour W_4 with penalty cost 5, 3, 2 for R_1, R_2, R_3 respectively.

and Supply = 145 − 105 = 40 (unsatisfied demand)

Retail outlet

		R_1	R_2	R_3	a_i (available)
Warehouse	W_1	5	1	7	10
	W_2	6	4	6	80
	W_3	3	2	5	15
(dummy)	W_4	5	3	2	40
	b_j (requirement)	75	20	50	145

+2

Now problem is balanced.

IBFS By VAM.

		R_1	R_2	R_3	a_i
	W_1	5	1 (10)	7	10
	W_2	6 (60)	4 (10)	6 (10)	80
	W_3	3 (15)	2	5	15
dummy	W_4	5	3	2 (40)	40
	b_j	75	20	50	145

+2

by VAM Cost = 595

Test for optimality

No of positive independent allocation.

$x_{ij} = m+n-1 = 6$ +1

∴ So Solution is non-degenerate

Apply Modi Method.

1. Set up cost matrix for occupied cells.

10

calculate u_i, v_j using $C_{ij} = u_i + v_j$

-	1 (10)	-	$u_1 = -3$
6 (60)	4 (10)	6 (10)	$u_2 = 0$
3 (18)	-	-	$u_3 = -3$
-	-	2 (40)	$u_4 = -4$

$v_1 = 6$ $v_2 = 4$ $v_3 = 6$

2) Calculate opportunity cost $d_{ij} = C_{ij} - (u_i + v_j)$ for unoccupied cell

5 (2) [3]	*	7 (4) [3]	$u_1 = -3$
*	*	*	$u_2 = 0$
*	2 (1) [1] (1)	5 (2) [3]	$u_3 = -3$
5 (5) [2]	3 (1) [0]	*	$u_4 = -4$

$v_1 = 6$ $v_2 = 4$ $v_3 = 6$

C_{ij}	Δ_{ij}
	$u_i + v_j$

+2

Since all $\Delta_{ij} \geq 0$ solution is optimal.

So, Min cost = 595

Q5. (i) Assignment problem.

The assignment problems deal with the allocation problem in which the objective is to assign 'n' number of jobs to 'n' number of persons at minimum cost +1

Assumptions of Assignment problem.

* Number of persons is equal to number of jobs +2
* Each person is assign to only one job
* Assignment criteria are clearly specified.

(11)

(11)

	I_1	I_2	I_3	I_4	I_5	I_6	
O_1	6	2	5	3	6	0	
O_2	2	5	8	7	7	0	
O_3	7	8	6	9	8	0	
O_4	6	2	3	4	5	0	
O_5	9	3	8	9	7	0	+1
O_6	4	7	4	6	8	0	

using row transformation (reduction) matrix would be same as above

	I_1	I_2	I_3	I_4	I_5	I_6	
O_1	4	0	2	0	4	0	
O_2	0	3	6	4	2	0	
O_3	5	6	4	6	3	0	
O_4	4	0	1	1	0	0	+1
O_5	7	1	6	6	2	0	
O_6	2	5	2	3	3	0	

(using column reduction)

Now. Soln is not optimal

we draw V st line covering ~~maximum~~ min^m all zeros.

If no of line = no of assignment = order of matrix

= Soln is optimal

again not optm

	I	II	III	IV	V	VI	
I	5	4	2	0	2	1	+2
II	0	3	5	3	2	0	
III	5	6	3	5	3	0	
IV	4	0	0	0	0	0	
V	7	1	5	5	2	0	
VI	2	5	1	2	3	6	

(12)

	J_1	J_2	J_3	J_4	J_5	J_6
O_1	6	1	2	[0]	2	2
O_2	[0]	2	4	2	1	~~2~~
O_3	5	5	2	4	2	[0]
O_4	5	~~5~~	~~2~~	~~4~~	[0]	1
O_5	7	[0]	4	4	1	~~2~~
O_6	2	4	[0]	1	2	~~2~~

+2

$O_1 \rightarrow J_4$
$O_2 \rightarrow J_1$
$O_3 \rightarrow J_6$
$O_4 \rightarrow J_5$
$O_5 \rightarrow J_2$
$O_6 \rightarrow J_3$

+1

Min cost = $2+2+0+5+3+4 = 16$

Q5 (iii) Here Min $(A_i)=5$ Max $B_i(=5)$, Min $(C_i)=3$.
Since Min $(A_i) \geq$ Max (B_i) satisfied
The problem can be converted into a problem of 5 jobs and two machines we define two fictitious machines Cr and H.

+2

$Cr_i = A_i + B_i$ $\quad H_i = B_i + C_i$

Job	1	2	3	4	5
Machine Cr	7	8	10	14	8
Machine H	5	8	9	11	10

Continue

(iii)

	A	B	C	D	E
Jobs	1	2	3	4	5
A	5	7	6	9	5
B	2	1	4	5	3
C	3	7	5	6	7

So far G, H we find optimal sequen. using Johnson's Algo

| 5 | 2 | 4 | 3 | 1 |

+2

The total elasped time and idle times for Machi A, B, C are as follows.

Job	Machi A In	Machi A out	Machi B In	Machi B out	Machi C In	Machi C out	Idle time for A	Idle time for B	Idle time for C
5	0	5	5	8	8	15	0	5	8
2	5	12	12	13	15	22	0	4	0
4	12	21	21	26	26	32	0	8	4
3	21	37	27	31	32	37	0	1	0
1	27	32	32	34	37	40	0	1	0

+2

Now total elasped time = 40 hrs.

Idle time for Machi A = 40 - 32 = 8 hrs.

Idle time for Machi B = 40 - 34 + 19 = 25 hrs +1

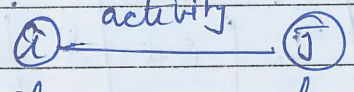
Idle time for Machi C = 40 - 40 + 12 = 12 hrs.

14

Q6 (i) Network : A network is defined as a graphic representation with a flow of some type in its arrow. It represents arrow and Nodes. Arrow represent activity and node represent event. +1

	Node	arrow	flow
Ex. Highways system	Intersection	Roads	Vehicles
Fluid Supply Sys.	Pumping station	Pipes	Fluid

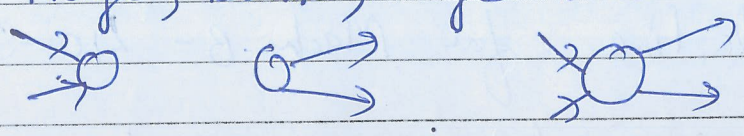
(ii) Activity : An individual operation which utilizes resources and takes certain amount of time for completion and has and end and a begining called activity. +1



three type – predecessor, Successor, dummy. +1

(iii) Event : An event represents a point in time satisfying (signifying) the completion of some activities and the begining of new ones ie it represents project milestone. This is usually represented by a circle in a Network.

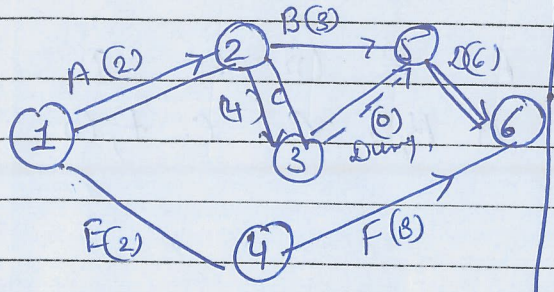
Type – Merge, Burst, Merge and burst



Q6 (ii) First we prepare network diagram

OR

Two ways to prepare



Earliest event time
forward Pass Calculation

$E_1 = 0$

$E_2 = E_1 + a_{1,2} = 2$

$E_3 = 6$

$E_4 = 2$

$E_5 = \text{Max}[2+3, 6+0]$
$= 6$

$E_6 = \text{Max}[6+6, 2+8]$
$= 12$

Latest event time
Backward Pass Calculation

$L_6 = 12$

$L_5 = 6$

$L_4 = 4$

$L_3 = 6$

$L_2 = 2$

$L_1 = 0$

Now $E_1 = L_1 = 0$

$E_2 = L_2 = 2$

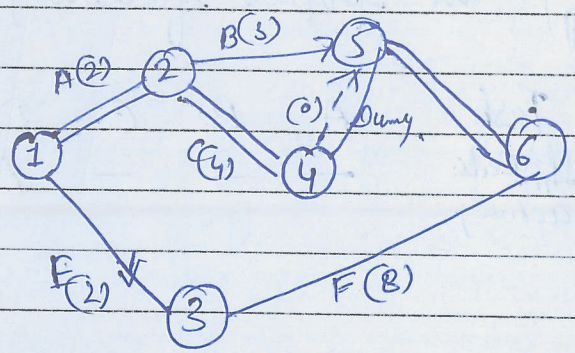
$E_3 = L_3 = 6$

$E_5 = L_5 = 6$

$E_6 = L_6 = 12$

So Path is 1-2-3-5-6

Project duration
$2 + 4 + 0 + 6 = 12$ wee



+3

Earliest event time
forward pass calculation.

$E_1 = 0$

$E_2 = E_1 + d_{1,2} = 0 + 2 = 2$

$E_3 = E_1 + d_{1,3} = 0 + 2 = 2$

$E_4 = E_2 + d_{2,4} = 2 + 4 = 6$

$E_5 = \text{Max}[E_2 + d_{2,5}; E_2 + d_{2,4}]$
$= \text{Max}[2+3, 2+4] = 6$

$E_6 = \text{Max}[6+6, 2+8] = 12$

Latest event time
Backward Pass Calculation

$L_6 = E_6 = 12$

$L_5 = L_6 - d_{5,6} = 12 - 6 = 6$

$L_4 = L_5 - d_{4,5} = 6 - 0 = 6$

$L_3 = L_6 - d_{3,6} = 4$

$L_2 = \text{Min}[L_5 - d_{2,5}, L_4 - d_{2,4}]$
$= \text{Min}[3, 2] = 2$

$L_1 = \text{Min}[2-2, 2-2] = 0$

+2

at critical path L values = E values.

critical Path = 1-2-4-5-6

Critical activity (A, C, D)

Project duration
$= 2 + 4 + 6$
$= 12$ week.

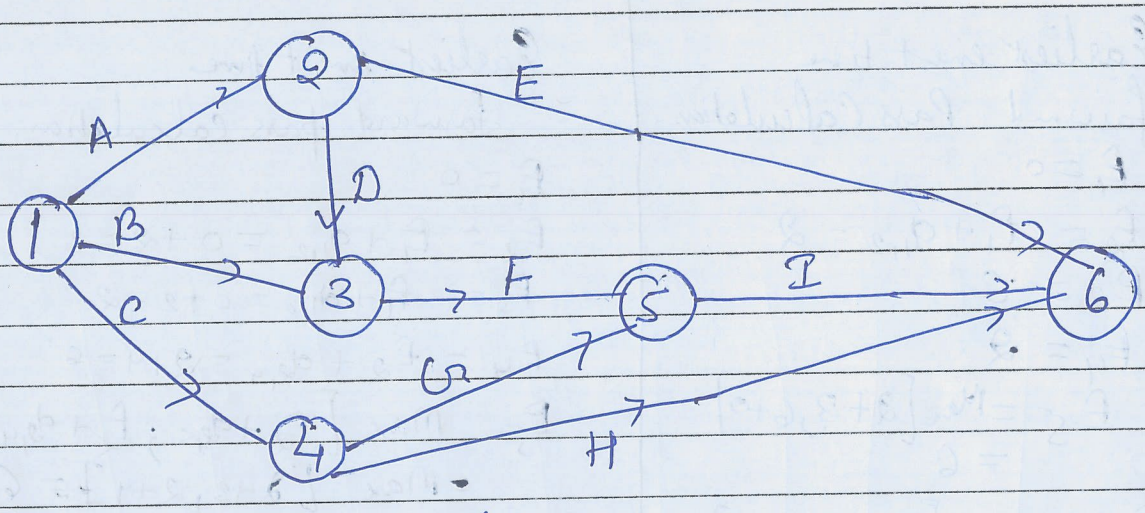
+2

16

Q.6 (iv) We prepare following table using information given.

Task	A	B	C	D	E	F	G	H	I
~~Time~~ Preceding activity	—	—	—	A	A	B, D	C	C	F, G

+2



+3

C is predecessor of G and H.
There is no predecessor for A, B, C activity +2
A is predecessor of D and E activity
B, D are predecessor of F activity
F, G are predecessor of I activity.

Complete.