SEMESTER : IV
NON MAJOR ELECTIVE COURSE: II – Mathematics

Inst Hour	: 2
Credit	: 2
Code	: 18K4MELO2

OPERATIONS RESEARCH – II

UNIT – 1:
Introduction – Basic Terminologies - Construction of Network.
(Section : 15.1, 15.2, 15.3)
UNIT – 2:
Network Computations and Critical Path - Floats.
(Section : 15.4 – 15.5)
UNIT – 3:
PERT method
(Section : 15.6)
UNIT – 4:
Inventory Models – Introduction – Types of Inventory – Reasons for Maintaining Inventory – Cost Inventory – Variable Inventory – Lead Time – Re Order Level (ROL).
(Section : 12.1 – 12.6)
UNIT – 5:
Deterministic Inventory models.
(Section : 12.7) (Model I only)

Text Book:
[1] Prof. V. Sundaresan, Prof. K.S. Ganapathy Subramanian, Prof. K. Ganesan, Resource Management and Techniques, A.R. Publications, Fourth Edition, 2007.

Books for Reference:
[1] Operations Research by Kanti Swarup, Gupta.P.K & Manmohan. (8th edition)
[2] Problems in Operational Research by Gupta.P.K. &Manmohan.
[3] Operational Research by Hamdy A.Taha (3rd Edition).

Question Pattern (Both in English & Tamil Version)
Section A : 5 x 5 = 25 Marks, (Any 5 out of 8, No Unit should be omitted)
Section B : 5 x 10 = 50 Marks, (Any 5 out of 8, No Unit should be omitted)

9.3.18

9/3/18 9/3/18

Department of Mathematics
N. GOVERNMENT
THANJAV

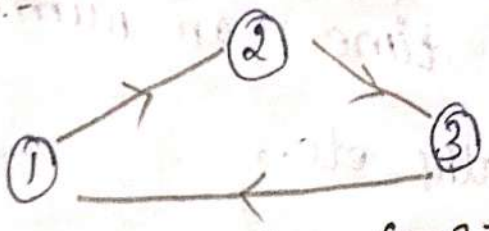
The longest path is called the

UNIT-I.

x.x.x 2m **Network :-**

A network defines a set of nodes linked by branches (or) arcs and there is a flow of some type in its branches.

example :-



Earliest start time (EST) :-

Earliest start time for an activity represents the time at which an begin at the earliest.

without delaying the ... project.

Activity :-

2m

An activity is a task (or) an activity by an arrow with its direction of progress in the project as $\xrightarrow{t}$ t over the arrow indicating the time an number of unit hours, days, months etc.,

Float :-

2m

The float of an activity is the amount of time by which it is possible ... time without

5m

Rules of Network construction :-

(i) Each activity is represent by one only arrow is the network. This means that, no single activity can be represented

twice in the network.

(i.e) only one activity can connect any two nodes.

(ii) No. two activity can be identified by the same head and tail events.

(iii) To ensure the correct precedence relationship in the network, the following questions must be every activity is added to the network.

(a) What activities must be completed immediately before this activity can start?

(b) What activity must follow this activity?

(c) What activity must occur concurrently with this activity?

(iv) Arrows should not cross each other.

(v) Every node must have atleast one activities preceding it and atleast one activity following it except for the nodes at the every beginning and at the every

end of the network.

(vi) Time follows from left to right. The arrows point in one direction. Arrows pointing is opposite direction must be avoided.

(vii) Arrows should be kept straight and not curved (or) bent.

Project :-

A project defines a combinations of inter related activities that must be certain order before the entire task can be completed. The activities are inter-relation in a logical sequence in the sense that some activities cannot until others are completed.

PERT and CPM :-

critical activity.

predecessor activities :-

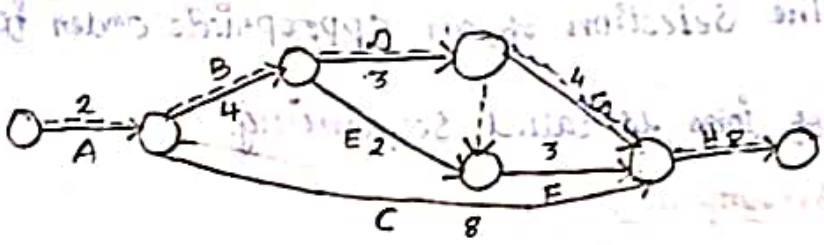
Activities which must be completed before a particular activity starts are called predecessor activities.

Successor activities:-

Activities which must follow a particular activity are called successor activities.

Activity	: A	B	C	D	E	F	G	H
Predecessors	: -	A	A	B	B	D,E	D	C,F,G
Time	: 2	4	8	3	2	3	4	8

soln:-



The Critical path:-

(26) A-B-D-G-H = 2+4+3+4+8 = 21

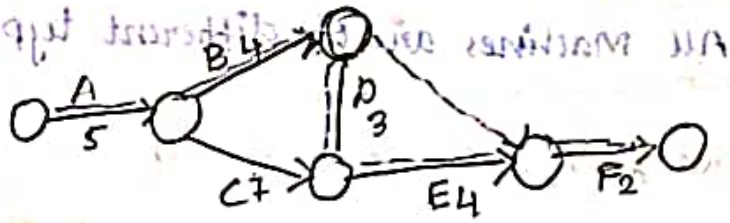
A-C-H = 2+8+8 = 18

A-B-E-F-H = 2+4+2+3+8 = 18

6. consider the following data for activities in a given pr

Activity	: A	B	C	D	E	F
Predesessor	: -	A	B,C	C	D,E	
Time	: 5	4	7	3	4	2

soln:-



The Critical path:

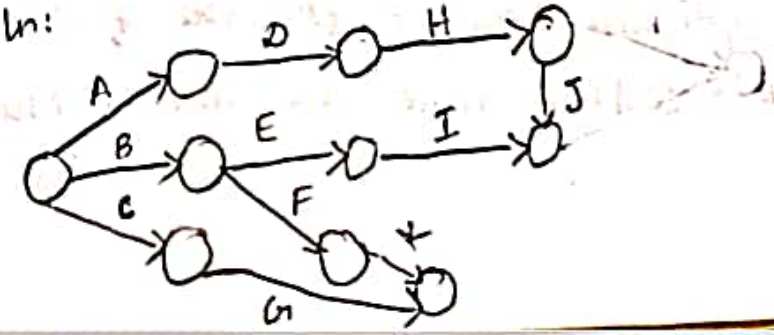
A-B-D-E-F = 5+4+3+4+2 = 18

A-B-C-E-F = 5+7+4+2 = 18

7. Activity : A B C D E F G H I J K

predeccesser: - - - A B B C D E H,I F

soln:



Step 3:

Repeat step 2 for event 2, event 3 and till the end event. The end event must have the highest number.

Two popular Methods are widely used :-

i) CPM - Critical Path Method.

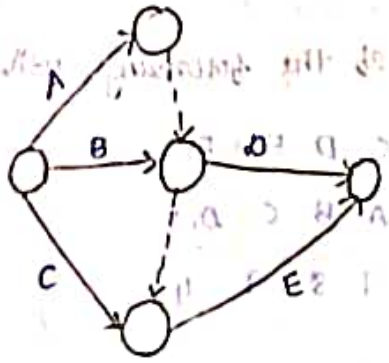
ii) PERT - Program Evaluation and Review Technique.

1. Draw a network of the following project of jobs.

(2)

Jobs	:	A	B	C	D	E
Preceded by	:	-	-	-	A,B	B,C

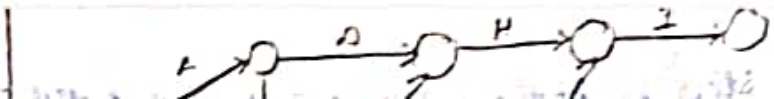
Soln:-

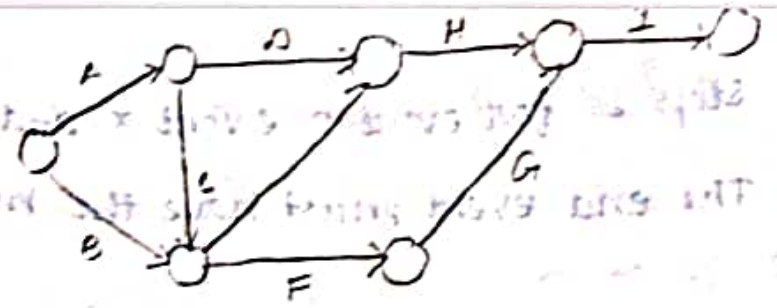


2. Draw a network to represent the following project

Activity	:	A	B	C	D	(F)	G	H	I	J
Preceded by	:	-	-	A	A	B,C	F	B,C,D	H,G	

Soln:-



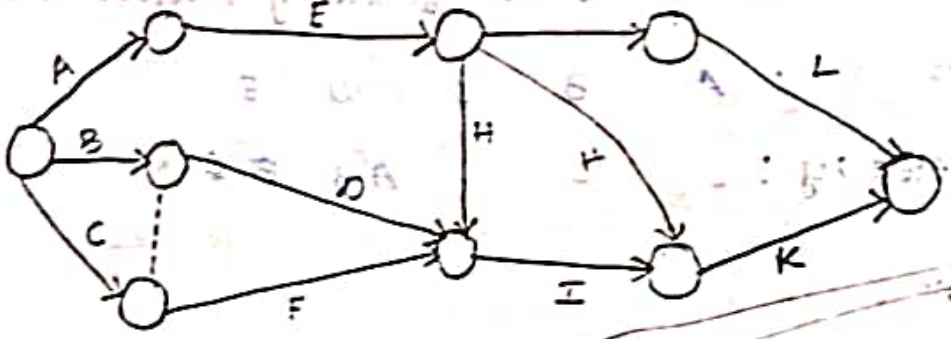


3. Draw a network of a project of 12 activities

Activity : A B C D E F G H I J K L

Dependence : - - - B, C A C E E D, F, H E, I, J G

Soln:-



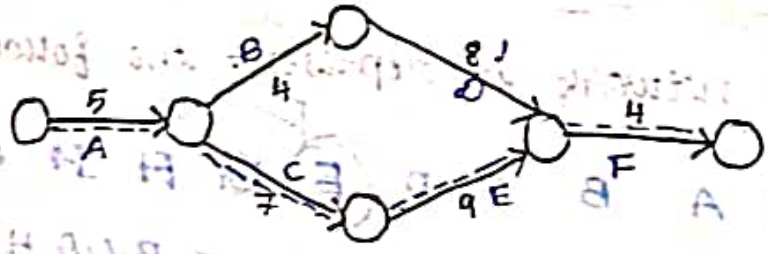
4. A Project consists of the following activities find CPM.

Activity : A B C D E F

Preceded By : - A A B C D, E

Time : 5 4 7 8 9 4

Soln:-



The Critical path:-

A - B - D - F = 5+4+8+4 = 21

A - C - E - F = 5+7+9+4 = 25

for the following Project, determine the CP & its

PERT and CPM.

X-X-X

2m

Critical path Method (CPM) : UNIT-II.

After drawing the network of all the activities of a project, we have to find the minimum time required for completion of the entire project. For this we must find the longest path with sequence of connected activities through the network. The longest path is called the critical path.

hours, days, months etc.,

2m

Float :-

The float of an activity is the amount of time by which it is possible to delay its completion time without affecting the total project completion time.

Total float :-

Total float of an activity defined as the difference between the

latest finish and earliest finish of the activity (or) The difference between the latest start and earliest start of the activities.

Total float of an activity $= [LF_{ij}] - [EF_{ij}]$ (or)

$[LS_{ij}] - [ES_{ij}]$

Free float:-

Free float of an activity is that the total float is that which can be used for that activity it can be calculated as follows,

$$\text{Free float} = ES_j - ES_i - t_{ij}$$

Independent float:-

Independent float of an activity is the amount of time which the activity can be without the proceeding activity. If can be calculated as follows.

$$\text{Independent float} - ES_j - LF_i - t_{ij}$$

X 5m Procedure of determining the critical path

(24)

↳ List all the activities (job's) and draw a network diagram.

↳ consider the activities time to be deterministic. Indicate them above the arrows representing them.

↳ calculate the earliest start time for each activity. Similarly calculate the latest start time and the latest finish time for each activity.

↳ Determine the "total slack" for each activity.

↳ connect the activities, having slack, we get the critical path.

↳ Activity, having no slack is called critical activity.

1) Calculate the Total float, free float, Independent float for the project whose activity are given below:

Activity	1-2	1-3	1-5	2-3	2-4	3-4
Duration	8	7	12	4	10	3

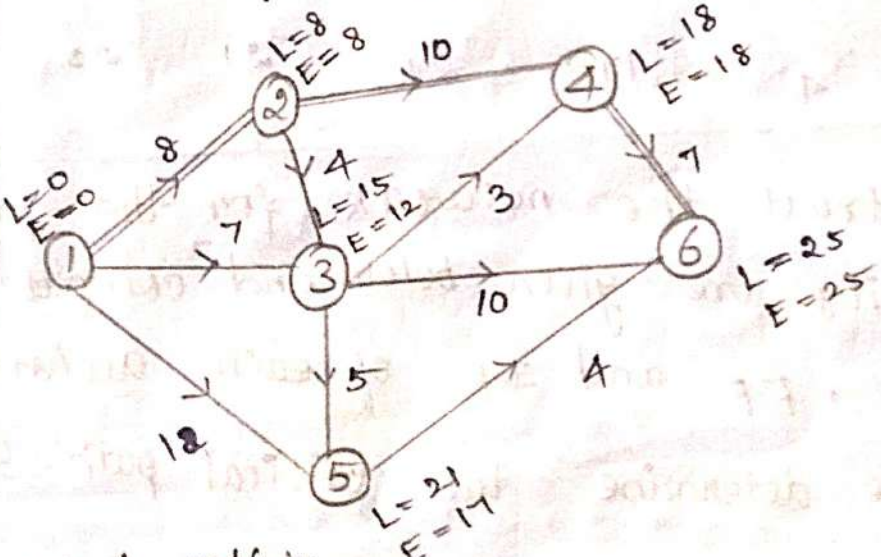
3-5	3-6	4-6	5-6
5	10	7	4

Solun:-

To find network,

FF = TF - (L-E) event of 2

IF = FF - (L-E) event of 1.



Critical path:-

= 1-2+2-4+4-6

= 8+10+7

= 25

(46)

Activity 1	Duration 2	Earliest Start 3	Earliest Finish 4 (2+3)	Latest Start 5 (6-2)	Latest Finish 6	TF 7 (6-4)	FF 8
1-2	8	0	8	0	8	0	0
1-3	7	0	7	8	15	8	5
1-5	12	0	12	9	21	9	5
2-3	4	8	12	11	15	3	0
2-4	10	8	18	8	18	0	0
3-4	3	12	15	15	18	3	3
3-5	5	12	17	16	21	4	0
3-6	10	12	22	15	25	3	3
4-6	7	18	25	18	25	0	0
5-6	4	17	21	21	25	4	4

2) construct the network for the project whose activity are given below and compute the total float, FF and IF of each activities and hence determine the critical path and project duration :-

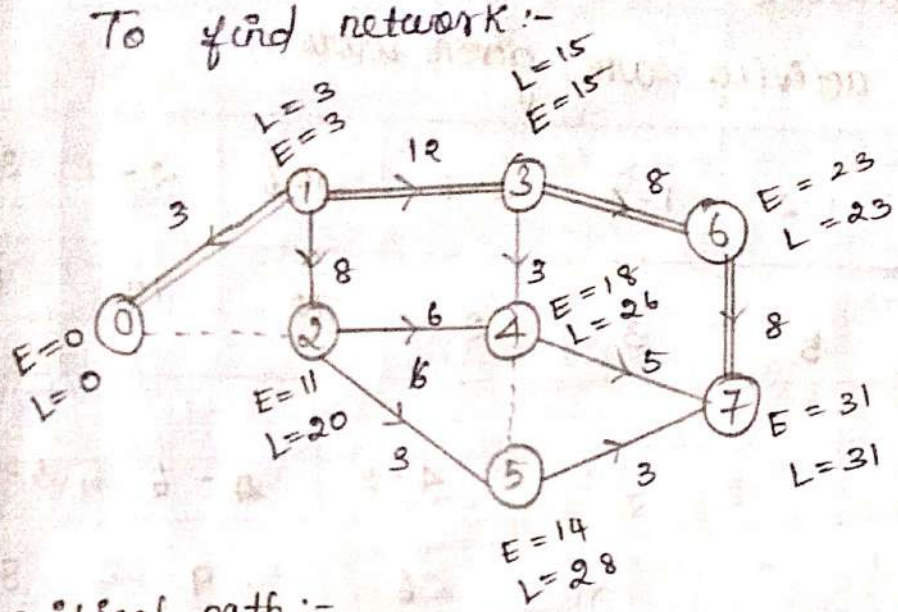
Act	0-1	1-2	1-3	2-4	2-5	3-4	3-6
Dur:	3	8	12	6	3	3	8

4-7	5-7	6-7
5	3	8

47

Solution:-

To find network:-



critical path:-

$= 0-1+1-3+3-6+6-7$

$= 3+12+8+8$

$= 31$:

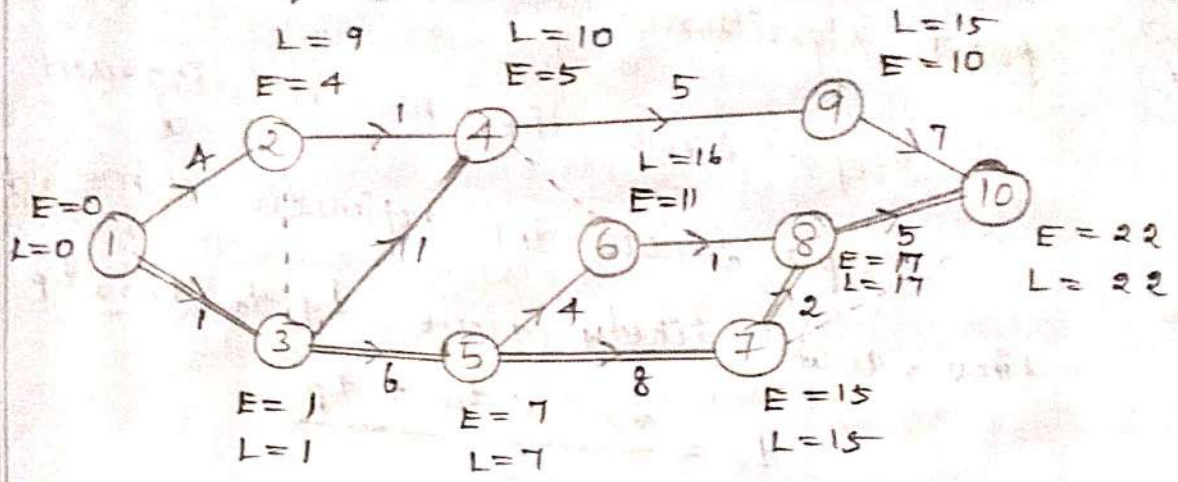
Act 1	Dur 2	Earliest		Latest		Floats		
		Start 3	Finish 4 (2+3)	Start 5 (6-2)	Finish 6	TF 7 (6-4)	FF 8	IF 9
0-1	3	0	3	3	0	0	0	0
1-2	8	3	11	20	12	9	0	0
1-3	12	3	15	15	3	0	0	0
2-4	6	11	17	26	20	9	1	-8
2-5	3	11	14	28	25	14	0	-9
3-4	3	15	18	26	23	8	0	0
3-6	8	15	23	23	15	0	0	0
4-7	5	18	23	31	26	8	8	0
5-7	3	14	17	31	28	14	14	0
6-7	8	23	31	31	23	0	0	0

5) Calculate the Total float for the given activity

Act	1-2	1-3	2-4	3-4	3-5	4-9	5-6	5-7
Dur	4	1	1	1	6	5	4	8

6-8	7-8	8-10	9-10
1	2	5	7

Q) Find network :-



critical path :-

$= 1-3 + 3-5 + 5-7 + 7-8 + 8-10$

$= 1+6+8+2+5$

$= 22$

Act 1	Duration 2	Earliest		Latest		Float
		Start 3	Finish (2+3) 4	Start (6-2) 5	Finish 6	(6-4) F 7
1-2	4	0	4	5	9	5
1-3	1	0	1	0	1	0
2-4	1	4	5	9	10	5
3-7	1	1	2	9	10	8
3-5	6	1	7	1	7	0
4-9	5	5	10	10	15	5
5-6	4	7	11	12	16	5
5-7	8	7	15	7	15	0
6-8	1	11	12	16	17	5
7-8	2	15	17	15	17	0
8-10	5	17	22	17	22	0
9-10	7	10	17	15	22	5

PERT: [Program Evaluation Review Techniques]

UNIT-III

PERT Algorithm:-

Step 1: Draw the network diagram.

Step 2: Denote the optimistic time, pessimistic time, most likely time by t_o, t_m, t_p respectively

$$t_e = \frac{t_o + 4t_m + t_p}{6}$$

Step 3:

Tabulate various time expectation activity limit, earliest and latest time.

Step 4: Determine the total float of each activity by taking the difference between the earliest and latest time.

Step 5: Identify the critical activity and connect them with the begining and ending node in the project network by a double line arrow.

They gives the critical path and expected variance of the project.

Step 6: Using values of t_p and t_o compute the variance σ^2 of each activity time estimate the using formula.

$$\sigma^2 = \left(\frac{t_p - t_o}{6}\right)^2$$

Step 7: compute the standard deviation,

$$z = \frac{\text{Due data} - \text{Expected data}}{\sqrt{\text{project variance}}}$$

Step 8: Using standard normal, lable find the probability of completing the project within the time.

Define optimistic time (t_o): 2m

↳ The optimistic time, estimate is the smallest time to complete the activity of everything goes on expectionally well (or) under best possible conditions.

↳ It may be less than the most likely time, optimistic time is denoted by t_o.

Define most likely time (t_m): 2m

↳ The most likely time estimate in the normal time an activity would take. It is the best possible time estimate that a given activity would take under.

↳ Normal condition and is denoted By t_m.

Define pessimistic time (t_p):

↳ The pesimistic time estimate is the best given of the longest (maximum) time that an activity would take under the most adverse circumstances that is everything goes on wrong.

(i) Non co-operation from the workers.

(ii) Supply of materials not in time. Transportation arrangements not being effective etc.,

↳ It is denoted by t_p.

others are completed.

*** 2m Difference between PERT and CPM :-

PERT	CPM
Used for new projects	Used for repetitive
Concerned with time	Concerned with line and cost
Event oriented	Activity oriented
Non-deterministic is nature	Deterministic is nature.

1) construct the network for the project whose activity and three time estimates of activities are given below.

Act	1-2	2-3	2-4	3-5	4-5	4-6	5-6
t_o	3	1	2	3	1	3	4
t_m	4	2	3	4	3	5	5
t_p	5	3	4	5	5	7	6

6-7	7-8	7-9	8-10	9-10
		1	4	3
6	2			
7	4	2	6	5

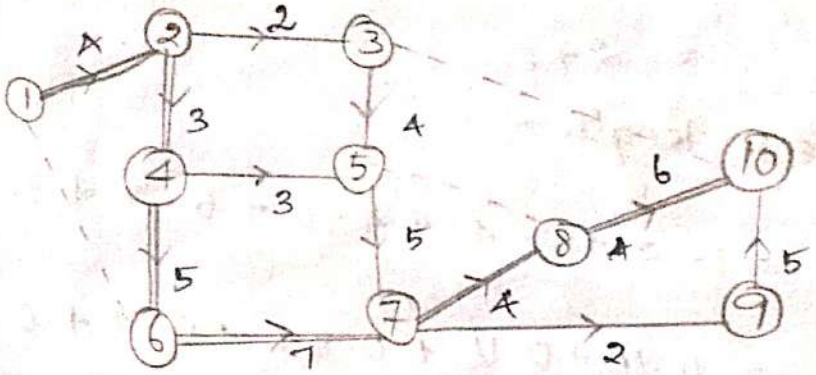
55

(i) Expected duration of each activity.

(ii) Expected variance of each activity.

(iii) Expected variance of project length.

Solun:- To find network:



Act	t_o	t_m	t_p	Expected duration $t_e = \frac{t_o + 4t_m + t_p}{6}$	Expected variance $\sigma^2 = \left(\frac{t_p - t_o}{6}\right)^2$
1-2	3	4	5	4	0.11
2-3	1	2	3	2	0.11
2-4	2	3	4	3	0.11
3-5	3	4	5	4	0.44
4-5	1	3	5	3	0.44
4-6	3	5	7	5	0.11
5-7	4	5	6	5	0.11
6-7	6	7	8	7	0.11
7-8	2	4	6	4	0.44
7-9	1	2	3	2	0.11
8-10	4	6	8	6	0.44
9-10	3	5	7	5	0.44

$= 1-2+2-4+4-6+6-7+7-8+8-10$

$= 4+3+5+7+4+6$

$= 29.$

project length:-

$= 1-2+2-4+4-6+6-7+7-8+8-10$

$= 0.11+0.11+0.44+0.11+0.44+0.44$

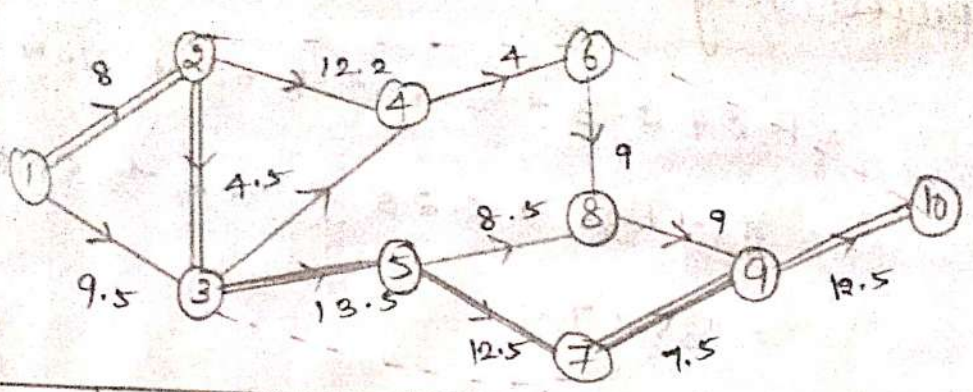
$= 1.65$

2) compute expected duration of each activity, expected variance of each activity, variance of project length, standard length.

Act	1-2	1-3	2-3	2-4	3-4	3-5	4-6	5-7
t_o	4	7	2	7	0	8	3	8
t_m	7	9	4	12	0	14	4	13
t_p	16	14	9	18	0	17	5	15

5-8	6-8	7-9	8-9	9-10
7	5	4	6	7
8	9	7	9	3
12	13	13	12	6

(57) Solun:- To find network:



Act	t_o	t_m	t_p	Exp duration $t_e = \frac{t_o + 4t_m + t_p}{6}$	Exp var $\sigma^2 = \left(\frac{t_p - t_o}{\sigma}\right)^2$
1-2	4	7	16	8	4
1-3	7	9	14	9.5	1.36
2-3	2	4	9	4.5	1.36
2-4	7	12	18	12.2	3.36
3-4	0	0	0	0	0
3-5	8	14	17	13.5	2.25
4-6	3	4	15	4	0.11
5-7	8	13	15	12.5	1.36
5-8	7	8	12	8.5	0.69
6-8	5	9	13	9	0.77
7-9	4	7	13	7.5	2.25
8-9	6	9	12	9	1
9-10	7	13	16	12.5	2.25

Critical path:-

$= 1-2 + 2-3 + 3-5 + 5-7 + 7-9 + 9-10$

$= 8 + 4.5 + 13.5 + 12.5 + 7.5 + 12.5$

$= 8.5$

(58) project length:-

$= 1-2+2-3+3-5+5-7+7-9+9-10$

$= 4+1.36+2.25+1.36+9.25+2.5$

$= 13.47$

Standard length:-

$= \sqrt{\text{project length}}$

$= \sqrt{13.47}$

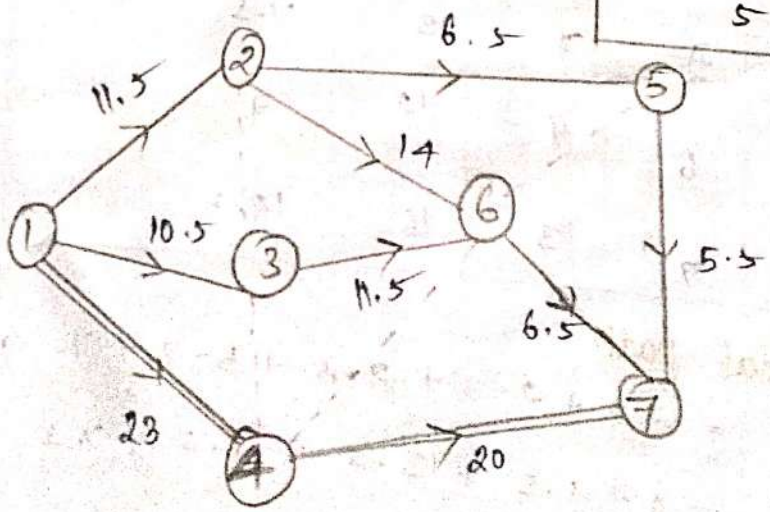
$= 3.67.$

3) Calculate the expected duration, expect variance, project length.

Act	1-2	1-3	1-4	2-5	2-6	3-6	4-7	5-7
t_o	3	2	6	2	5	3	3	1
t_m	15	14	30	8	17	15	27	7
t_p	6	5	12	5	11	6	9	4

6-7
2
8
5

Solun:- To find network:



Act	t_o	t_m	t_p	Exp dur $t_e = \frac{t_o + 4t_m + t_p}{6}$	Exp var $\sigma^2 = \left(\frac{t_p - t_o}{6}\right)^2$
1-2	3	15	6	11.5	0.25
1-3	2	14	5	10.5	0.25
1-4	6	30	12	23	1
2-5	2	8	5	6.5	0.25
2-6	5	17	11	14	1
3-6	3	15	6	11.5	0.25
4-7	3	27	9	20	1
5-7	1	7	4	5.5	0.25
6-7	2	8	5	6.5	0.25

Critical path :-

$= 1-4 + 4-9$

$= 23 + 20$

$= 43.$

project length :-

$1-4 + 4-7$

$= 1+1$

$= 2$

1) PERT [program Evalution Review Technique] :-

It is a visual tool used in project planning to help identity start and end dates, as well as required tasks and timeline.