UNIT 5 NETWORKS

Structure

5.1 INTRODUCTION

Dear Learner,

In the previous unit, we discussed the application of SWOT analysis and bar charts as CSR project formulation and management tools. The networks, their terminology, rules for preparation of networks and their uses with examples are discussed in this unit for your understanding. To overcome the shortcomings in Gantt and Milestone charts, the networks are developed. The network is a logical extension of Milestone chart incorporating interrelationship between and among all the milestones in a CSR project.

After studying this unit you should be able to:

- Describe the networks as a CSR project management tool.
- Draw and analyze a project network.

5.2 NETWORKS

Two widely used tools for network analysis are:

i. Programme Evaluation and Review Technique (PERT)

ii. Critical Path Method (CPM).

The costs for various activities of the CSR project / programme are introduced by CPM. While it does not mean that PERT deliberately omits the costs, one has to assume that costs vary with the time. For a particular CSR project / programme, if time is reduced by 4 weeks, it implies that some money also saved. When time requirement for each CSR activity is estimated

accurately, then CPM is more appropriate and relevant. On the other hand, if accurate time estimation is difficult for each CSR activity and need to overcome this uncertainty, then the PERT is the best choice.

Parameter	PERT	CPM
What ?	Project management model to analyze and represent the tasks involved in project completion.	Mathematically based algorithm for scheduling set of project activities.
Purpose	Analyze time needed to complete project tasks and identify minimum time needed to complete the project	For effective project management.
Time Estimate	Probabilistic	Deterministic
Application	Scheduling and monitoring the project	Optimizing resource allocation

When each CSR activity is associated with the costs, application of CPM is more appropriate. For those projects, time is more important compared to costs because of uncertainty, then PERT is more useful. Let us discuss more about network terminology, network preparation rules and analysis of networks in the subsequent sections.

Check Your Progress 1

Note: a) Use the spaces given below for your answers.
b) Check your answer with those given at the end of the unit.

1. Expand PERT and CPM.

……

……

……

……

……

2. Write two differences between PERT and CPM.

……

……

……

……

……

……

5.3 NETWORKS TERMINOLOGY

The commonly used terms in the networks are given below for your understanding.

Activity: Is the actual performance of a task which consumes time, requires resources, and it can be understood as representing the time, effort, and resources required to move from one event to another. Activity is represented by an arrow (⟶). Every activity lies between events.

Examples: Needs assessment schedule preparation, data collection.

Dummy activity: An activity that indicates precedence relationship and requires neither time nor resource. It is usually represented by a broken arrow (⋯⋯▸)

Event: Event is a point that marks the start or completion of one or more tasks. Event is usually denoted by a circle which is divided into two equal halves. The left half is meant for event number. The right half is further divided into two segments, the top representing Earliest Starting Time (EST) and the bottom Latest Starting Time (LST) (Fig.5.1).

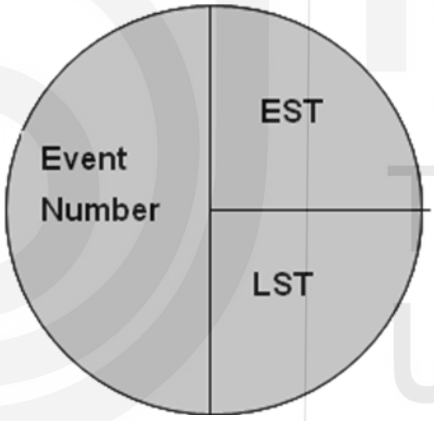


Fig 5.1. Event representation with EST and LST

Examples: Needs assessment schedule preparation completed, data collection started.

Predecessor event: An event that immediately precedes some other event without any other events intervening.

Successor event: An event that immediately follows some other event without any other events intervening.

Burst event: An event which gives rise to more than one activity.

Merge event: The event which occurs only when more than one activity are accomplished.

Earliest Start Time (EST): The earliest possible time at which the event can occur. The EST of an activity is the time before which it cannot commence without affecting the immediate preceding activity.

Latest Start Time (LST): The latest time at which the event can take place. It indicates the latest time at which an activity can begin without delaying the project completion time.

Critical Events: These are events which fall on the critical path. Every critical event will have the same EST and LST.

***Critical Path*:** The longest possible continuous pathway taken from the initial event to the terminal event. Any time delays along the critical path will delay the reaching of the terminal event by at least the same amount.

Critical Activity: An activity that has total float equal to zero.

Optimistic time (T_o): The minimum possible time required to accomplish a task, assuming everything proceeds better than is normally expected.

Pessimistic time (P_o): The maximum possible time required to accomplish a task, assuming everything goes wrong (but excluding major catastrophes).

Most likely time (T_M): The best estimate of the time required to accomplish a task, assuming everything proceeds as normal.

Expected time (T_E): The best estimate of the time required to accomplish a task, assuming everything proceeds as normal (the implication being that the expected time is the average time the task would require if the task were repeated on a number of occasions over an extended period of time) $T_E = (T_o + 4\ T_M + P_o) \div 6$

Float or Slack: Is the amount of time that a task in a project network can be delayed without causing a delay in subsequent tasks (free float) or project completion (total float).

***Event Slack*:** It is the slack time associated with an event. ES = LST – EST

Lead time: The time by which a predecessor event must be completed in order to allow sufficient time for the activities that must elapse before a specific PERT event is reached to be completed.

Lag time: The earliest time by which a successor event can follow a specific PERT event.

Fast tracking: Performing more critical activities in parallel

***Crashing critical path*:** Shortening duration of critical activities

Activity Table: Table developed after breaking the project into activities indicating their symbols, time requirement and logical relationships (preceding and succeeding activities).

***Danglers*:** Loosely attached activities. They may end abruptly without any succeeding activity / activities.

Normal Time: This is the time required when activities are performed in normal way. It is usually the longest time for the project and entails money saving is there.

Check Your Progress 2

Note: a) Write your answer in about 50 words.

b) Check your answer with possible answers given at the end of the unit.

1. Write two differences between EST and LST.

   ……

   ……

   ……

   ……

2. What do you mean by critical event?

   ……

   ……

   ……

   ……

3. Write the formula for calculating expected time (T_E) to accomplish a task.

   ……

   ……

   ……

   ……

5.4 RULES FOR PREPARATION OF NETWORKS

For your easy understanding, some basic rules for preparing networks are described below with diagrams.

- Activity is indicated by an arrow which is drawn from left to right. Neither the orientation of arrow nor its length has any significance. Every activity starts and ends with an event (Fig. 5.2)

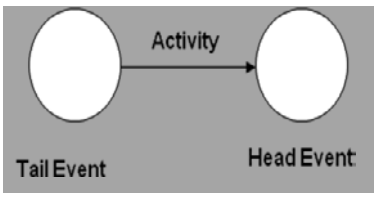


Fig. 5.2 Activity with tail and head events

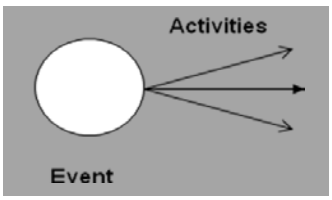


Fig. 5.3 Burst event

- Any number of activities may emerge out from an event. This event is named as burst event (Fig. 5.3).

- Any number of activities may merge with an event (Fig 5.4)

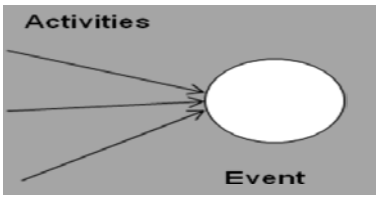


Fig. 5.4: Merging event

- When two or more activities have to be completed before the next event occurs, they should not be represented as merged activities as shown in (a), which is wrong. This can be represented as sequential activity by introducing the dummy activity as shown in (b) (Fig 5.5).

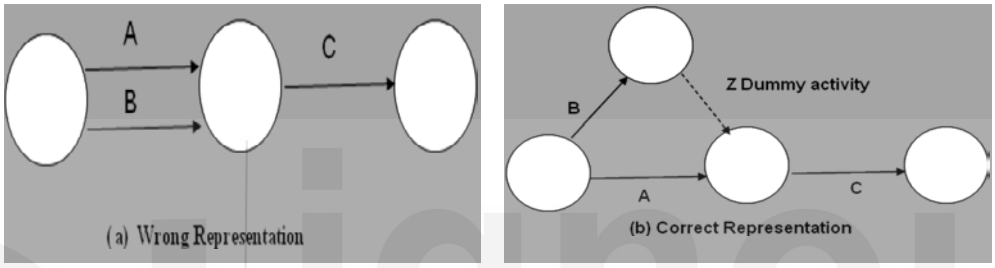


Fig. 5.5: Dummy activity representation in network

A project with 12 preceding and succeeding activities is given in Table 5.1.

Table 5.1: Preceding and succeeding activity relationships of a project activities

Activity	Preceding Activity	Activity	Preceding Activity
A	-	G	D,F
B	-	H	E
C	-	I	F
D	A,B,C	J	H
E	C	K	E,G
F	B	L	I,J,K

The network of the project is given in Fig.5.6 with dummies between B&D; C&D; F&G and E&K. The dummies are represented as Z_1, Z_2, Z_3, and Z_4 and so on.

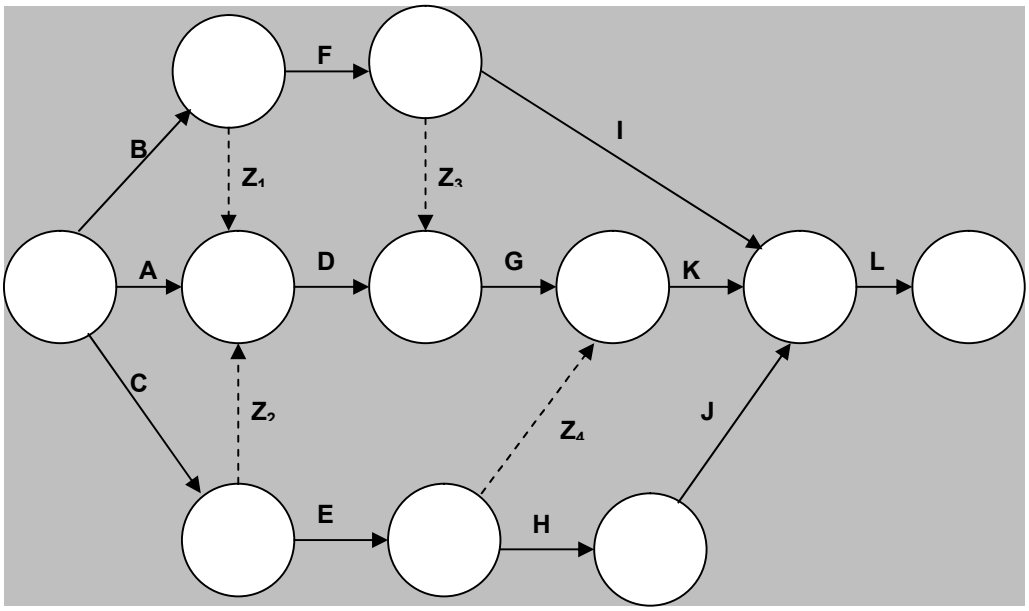


Fig.5.6: Network of the project

It is preferable to use D.R. Fulkerson's rules to give numbering as indicated below.

i. The initial event should be started with 1.

ii. Eliminate all activities emerging out from event number 1 and give number 2 to the succeeding event. If two or more events occur concurrently after the first event, give 2,3,4 and so on for succeeding events.

iii. Delete all the activities emerging out from 2,3, 4 events and so on and give the new event numbers 5,6,7 and son on.

iv. Continue this process till the entire network is completed.

This process is continued till the entire network with event numbers is completed (Fig 5.7).

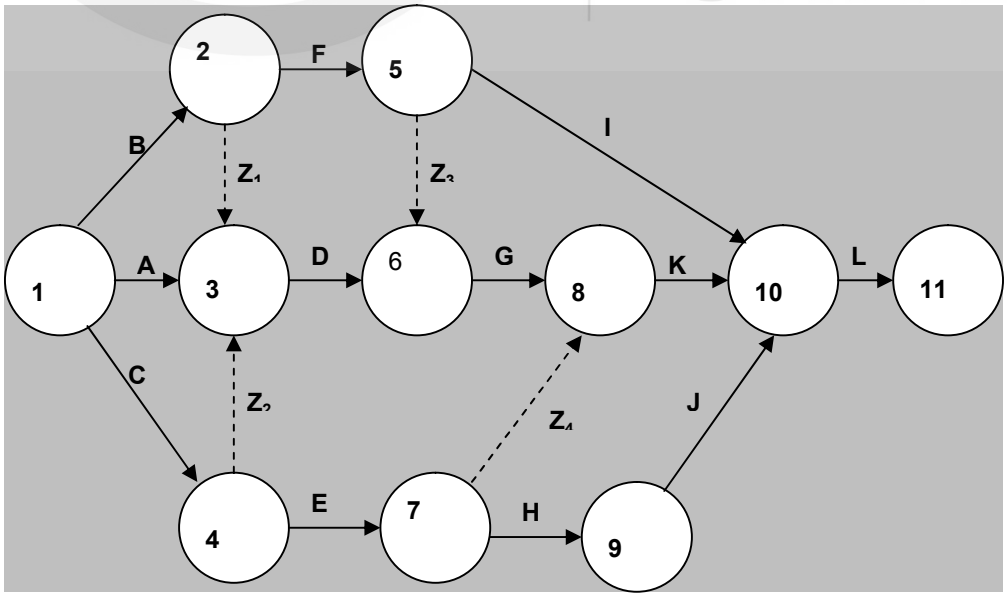


Fig.5.7: Network of the project with event numbers

- An event will occur only after all the activities merging into it are completed. Event numbers are shown in the left half of the circle and the EST and LST on the right half.
- After drawing the network, the time requirement for each activity is indicated.

Check Your Progress 3

Note: a) Use the spaces given below for your answers.
b) Check your answer with those given at the end of the unit.

1. Write D.R. Fulkersons' rules for numbering the events.

……

……

……

……

……

2. Prepare the network and give the event numbers for the following.

PERT Event	*Preceding Event*
Event No 1	–
Event No 2	1
Event No 3	2
Event No 4	2,3
Event No 5	4

……

……

……

……

……

5.5 NETWORK PREPARATION

Following steps are useful in preparing networks.

Step 1 : Write down the specific objectives of the project.

Step 2 : Based on the objectives, write technical programme details.

Step 3 : Break the technical programme into specific activities.

Step 4 : List out all the activities showing the preceding and succeeding relationships.

Step 5 : Give symbols for activities with capital letters i.e. A,B,C,D,E and so on

Step 6 : Calculate the expected time by using the following equation.

Expected Time $T_E = (T_o + 4\ T_M + P_o) \div 6$

Where,

- To is the Optimistic time,(minimum time assuming everything goes well)
- T_M is the Most likely time, (modal time required under normal circumstances)
- T_P is the Pessimistic time, (maximum time assuming everything goes wrong)

Step 7: Draw the flow chart as it helps in preparing the network

Step 8 : Draw the network by following the rules for preparation of networks as discussed in the previous section.

Step 9: Write the event numbers, EST and LST. By using forward pass (start to end) and backward pass (end to start), the network would be analysed as follows.

Event Numbers: Give numbers to various events (see the previous section for details on numbering)

Forward Pass: (a) Consider the EST of the first activity as zero (b) Start from the first event for computation of EST. Add the activity duration to the EST of preceding event to get the EST of succeeding event. Whenever an event is competing with two or more activities, the largest value must be considered to arrive at the EST of the succeeding event. EST is the result of forward pass.

Backward Pass: (a) Consider the LST value of the last event as equal to its EST value. (b) In contrast to the forward pass, start from the last event and subtract the activity duration from the LST of succeeding event to arrive at the LST of the preceding event. When two or more activities are backing to an event, the smallest of these must be taken into account for the LST of preceding event. LST is the result of backward pass.

Step 10: Compute the critical path taking into account all the critical activities. This is the longest path in terms of time for accomplishing the project.

Step 11: Calculate activity slack (total float), event slack , free float and independent float by using the following formulae

Activity slack = LST of end event – EST of starting event – Duration of reference activity

Event slack = LST of event – EST of event

Free float = EST of end event –EST of starting event – Duration of reference activity

Independent float = EST of end event – LST of starting event – Duration of reference activity

Step 12: Establish job boundary limits for all the activities which include duration of activity, event number, EST, LST, EFT, LFT, event slack, total float, free float and independent float.

Check Your Progress 4

Note: a) Write your answer in about 50 words.
b) Check your answer with possible answers given at the end of the unit.

1. How do you calculate activity slack, free float and independent float?

……

……

……

……

……

5.6 NETWORK EXAMPLE

Let us assume that as a CSR worker, you are asked to complete a 'Garden Development Project' by a Municipality with seven project activities (Table 5.2). The network diagram is prepared for your easy understanding (Source: Venkateswarlu and Raman, 1993).

Table 5.2: Time duration estimates of activities

S.No.	Activity	Symbol	Preceding activity	Time (weeks)
1	Development of land	A	-	9
2	Ploughing and minor leveling	B	A	4
3	Digging of pits for planting	C	B	5
4	Purchasing of farm yard manure	D	B	3
5	Purchasing of plants	E	B	10
6	Application of farm yard manure	F	D,C	2
7	Transplanting plants	G	E, F	2

The network after computation of EST and LST are given in Fig.5. 8

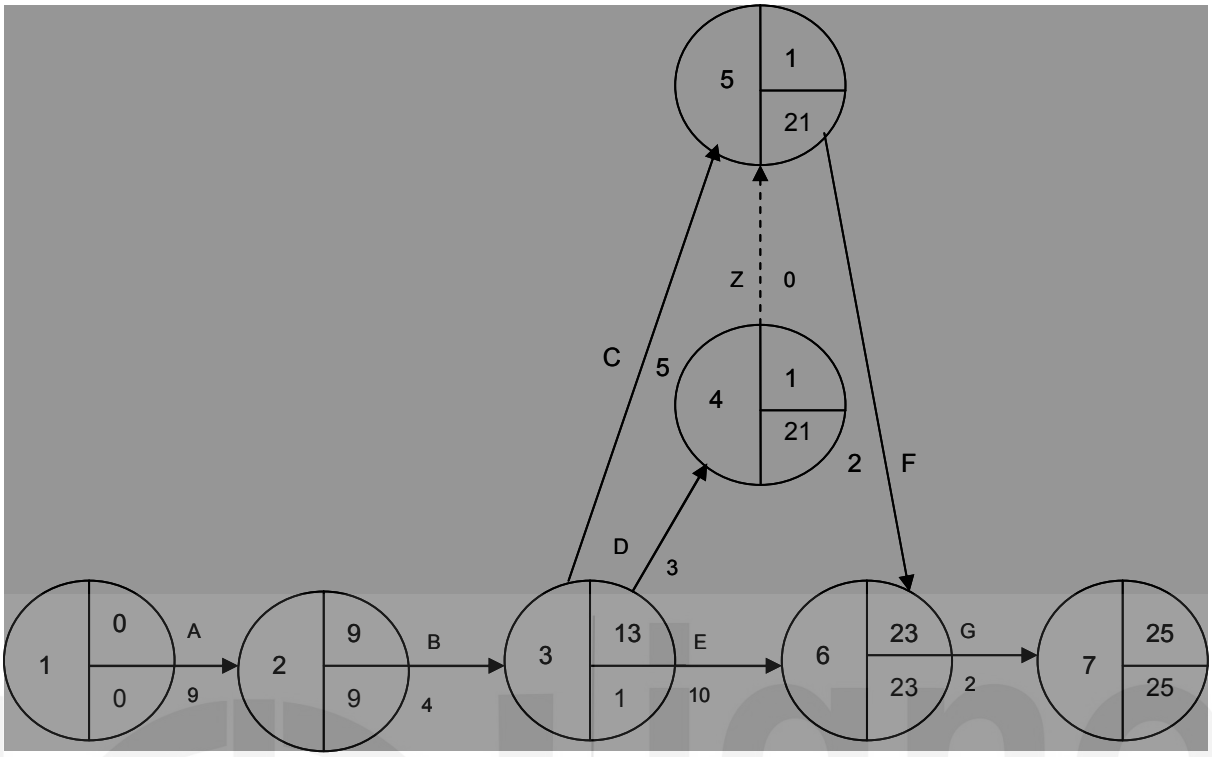


Fig. 5.8: Network after computation of LST

The analysis of the results of the network is given in Table 5.3 for your understanding

Table 5.3: Analysis of the results of the network for garden development project

S. No.	Activity	Duration (weeks)	Preceding event	Succeeding event	EST (weeks)	LST (weeks)	EFT (weeks)	LFT (weeks)	Critical Activities
1	A	9	1	2	0	0	9	9	A
2	B	4	2	3	9	9	13	13	B
3	C	5	3	5	16	16	18	21	-
4	D	3	3	4	18	18	16	21	-
5	E	10	3	6	13	13	23	23	E
6	F	2	5	6	21	21	20	23	-
7	G	2	6	7	23	23	25	25	G

Critical path is the longest path for project accomplishment. In the above example the critical path of the project is A-B-E-G (9+4+10+2) = 25 weeks

Uses of Networks

The important uses of networks are:

- Planning and scheduling of project activities
- Guidance, supervision of activities and organizing resources - personnel, money, time and material.
- Monitoring and controlling of project activities.
- Communication on costs and time in a concise manner.

- Responsibility and teamwork.
- Training, minimizing conflicts and performance appraisal.

Check Your Progress 5

Note: a) Use the spaces given below for your answers.
b) Check your answer with those given at the end of the unit.

1. What do you mean by critical path?

   ……

   ……

   ……

   ……

   ……

2. Write three uses of networks.

   ……

   ……

   ……

   ……

   ……

5.7 LET US SUM UP

In this unit we started by looking into the meaning of Networks namely PERT and CPM, important differences and their application in CSR project management. We also discussed the networks terminology and rules for preparation of networks. Later we discussed the network preparation, analysis and uses with examples and diagrams.

5.8 KEYWORDS

Activity*:* Actual performance of a task.

CPM: Mathematically based algorithm for scheduling a set of project activities.

Critical Activity*:* Activity that has total float equal to zero.

Critical Events: Events which fall on the critical path which will have the same EST and LST.

Critical Path: Longest possible continuous pathway taken from the initial event to the terminal event.

Event: Event is a point that marks the start or completion of one or more tasks.

Float or Slack: Amount of time that a task in a project network can be delayed without causing a delay in subsequent tasks (free float) or project completion (total float).

Network: Network is a logical extension of bar charts incorporating interrelationship between and among all the milestones in project.

PERT: Is a project management model designed to analyze and represent the tasks involved in completing a project.

5.9 BIBLIOGRAPHY AND SELECTED READINGS

Venkateswarlu, K and Raman, K.V. 1993. Project Management Techniques for R&D in Agriculture. Sterling Publishers Pvt.Ltd., New Delhi (Network analysis example discussed in this unit has been adopted from this book).

Srinath,L.S. 1975. PERT and CPM Principles and Applications, East-West Press, New Delhi.

5.10 CHECK YOUR PROGRESS - POSSIBLE ANSWERS

Check Your Progress 1

1. PERT : Programme Evaluation and Review Technique ; CPM : Critical Path Method.
2. PERT is a project management model designed to analyze and represent the tasks involved in completing a project. Where as CPM is a mathematically based algorithm for scheduling a set of project activities.

Check Your Progress 2

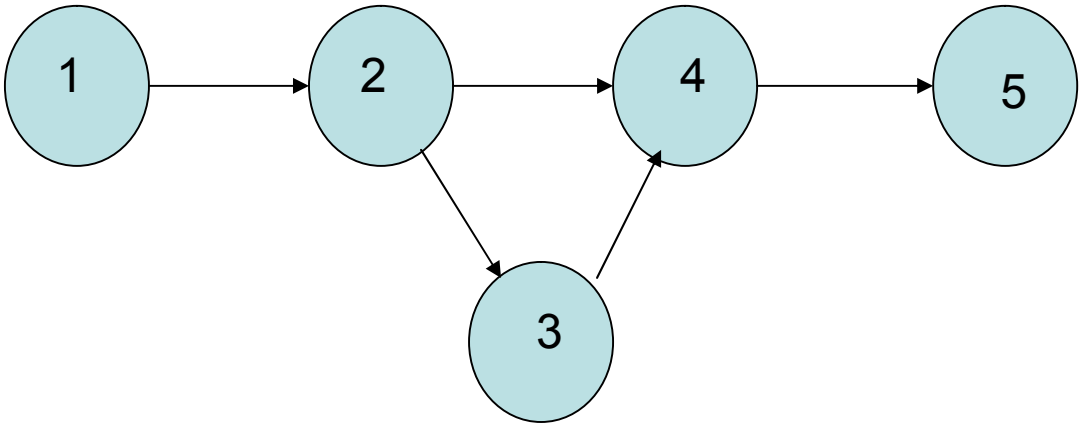
1. EST is the earliest possible time at which the event can occur. It denotes the earliest start time of an activity. LST is the latest time at which the event can take place. It indicates the latest time at which an activity can begin.
2. Critical event is the event which falls on the critical path.
3. $T_E = (T_o + 4\ T_M + P_o) \div 6$

Check Your Progress 3

1. Initial event should be started with 1; eliminate all activities emerging out from event number 1 and give number 2 to the succeeding event. If two or more events occur concurrently after the first event, give 2,3,4

and so on for succeeding events; Continue this process till the entire network is completed.

2.



Check Your Progress 4

1. Activity slack = LST of end event – EST of starting event – Duration of reference activity

   Free float = EST of end event –EST of starting event – Duration of reference activity

   Independent float = EST of end event – LST of starting event – Duration of reference activity

Check Your Progress 5

1. Critical path is the longest possible continuous pathway taken from the initial event to the terminal event.
2. Networks are useful for planning, scheduling, guidance and supervision, organizing resources, monitoring, controlling and performance appraisal.