CHAPTER 01

# Project Management and Network Theory

## 1.1 Introduction

'Project management' deals with both 'material' as well as 'human factors' to increase the productivity.

*Objectives of a Project:*

- It should be completed in minimum time with minimum capital investment.
- It should use available manpower and other resources optimally.

## 1.2 Phases of Project Management

### 1.2.1 Planning

*Planning involves:*

1. Defining objectives of the project.
2. Listing of jobs that have to be performed.
3. Determining gross requirements for materials, equipments and man power and preparing estimates of costs and duration for various jobs.
4. To bring about the satisfactory completion of project.

### 1.2.2 Scheduling

Scheduling is the allocation of resources such as time, material, space, equipment and human and technological effort.

*It involves:*

1. Finalizing the planned functions mechanically.
2. Assigning starting and completion dates to each activity to proceed in a logical sequence and in a systematic manner.

### 1.2.3 Controlling

*Controlling involves:*

1. Determination of deviations from basic plan and their effects on the project.

2. Replanning and rescheduling of activities to compensate for the deviations which is called "updating".
   - It should be noted that planning and scheduling are accomplished before the actual project starts while controlling is operative during execution of the project.

**Do You Know ?**

The method of planning and controlling that was originally developed was called Project Planning and Scheduling (PPS). PPS was later on converted into Critical Path Method (CPM), so the CPM involves the deterministic approach and is used for the repetitive types of projects.

## 1.3 Techniques Used for Project Management

### 1.3.1 Bar Chart

Firstly introduced by Henry Gantt around 1900 AD.

*Features of bar chart are:*

1. It is a pictorial chart
2. It has two coordinate axes, the horizontal coordinate represents the elapsed time and vertical coordinate represents the job or activity to be performed.
3. The beginning and end of each bar represents starting and finishing time of a particular activity respectively.
4. The length of bar shows the time required for completion.
   - Jobs can be concurrent or can be started one after other. So some bars can run parallel or overlap each other or may run serially.

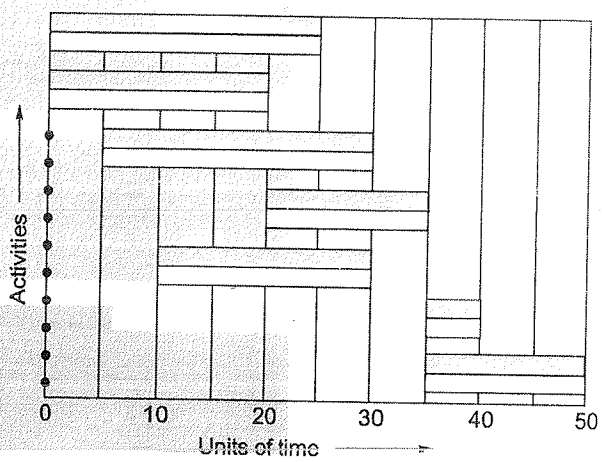



*Fig. 1.1 Bar Chart*

*Limitations of bar chart :*

1. *Lack of degree of details*: Only major activities are shown in bar chart and sub-activities can not be separated out. Hence effective control over the activities in big projects can not be achieved.
2. A bar chart does not show progress of work and hence it can not be used as a control device.
3. A bar chart is unable to depict interdependencies of various activities clearly.
4. Bar charts are not useful in the projects where there are uncertainties in determination of estimation of time required for completion of various activities such as in R&D projects.
5. Bar chart can not distinguish between critical and noncritical activities and hence resource smoothening and resource levelling can not be done.

   Bar chart diagrams are useful for only smaller and simpler conventional projects, especially construction and manufacturing projects, in which time estimates can be made with fair degree of certainty.

### 1.3.2 Mile-Stone Chart

- It is a modification over original Gantt chart. Milestones are key events of main activities represented by bar. Therefore they give idea about completion of sub-activities.

**Do you know?** Controlling can be better achieved with the help of milestone charts, but still activity interrelationship and accountability of time uncertainty can not be depicted which can be overcome in network technique.

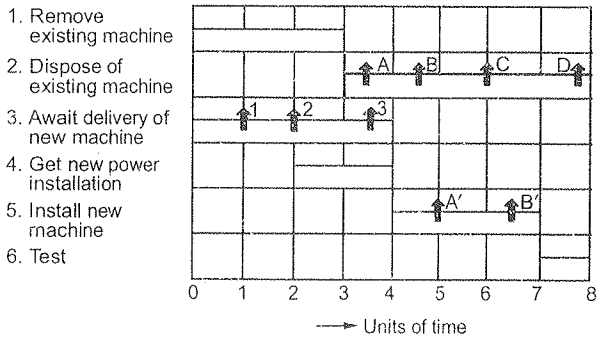



*Fig. 1.2 Mile-stone chart*

### 1.3.3 Network Methods

- It is an outcome of the improvements in the milestone charts.
- They are called by various names such as PERT, CPM, UNETICS, LESS, TOPS and SCANS.
- However all these have emerged from the two major network systems viz.:
  1. PERT
  2. CPM

## 1.4 Network Diagram and Techniques

*Network:*

- It is the flow of diagram consisting of activities and events connected logically and sequentially.
- Network diagram are of two types:
  (i) Activity-on-Arrow Network (A-O-A)
  (ii) Activity-on-Node Network (A-O-N)

*Advantages of network method over bar chart and milestone chart:*

1. Interrelationships between activities and events of a project are clearly shown.
2. The project can be treated as an integrated whole with all its sub-activites clearly related with each other. It helps in controlling the project.
3. Network method is useful for very complicated projects having large number of activities.
4. It indicates the time required in between two activities in which rescheduling of a project is possible.
5. Time uncertainty is accounted for and so it is also useful for research and development projects.

## 1.5 Elements of a Network

### 1.5.1 Event

- An event is either start or completion of an activity.
- Events are significant points in a project which act as control points of the project.
- An event is an instant of time and it does not require time or resources.

*Following are examples of an event :*

1. All parts assembled
2. A budget prepared
3. Construction completed

*Following can not be events :*

1. Prepare budget 2. Assemble parts 3. Excavate trench

- Events are represented by nodes in a network. It may have any of the following shapes.

*(i) Circular* *(ii) Square* *(iii) Rectangular* *(iv) Oval*

*Fig. 1.3 Different Shapes for Events*

Most commonly adopted shape for events is circular shape.

- **Tail event or the start event:**

  It makes the beginning of an activity.

  If it is the first event of project then known as "initial as start event".

  It has only outgoing arrow.

  e.g: Event 10 is a tail event. Arrows represent job or activity of the project.

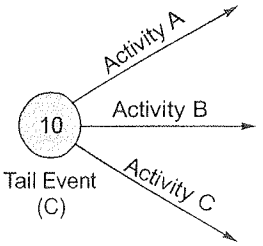



*Fig. 1.4 Tail Event*

- **Head event or the final event :**

  The event which marks the completion of an activity is known as "head event".

  If this event represents completion of entire project then it is called "Finish event".

  It has only incoming arrows.

  e.g.: Event 20 is a head event.

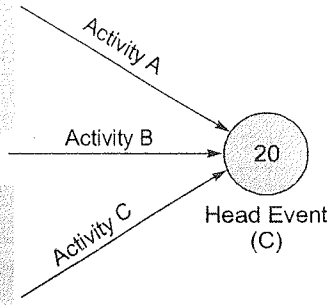



*Fig. 1.5 Head Event*

**NOTE**

(i) When a tail event represents beginning of more than one activity, then the event is said to occur when the first activity starts from it.

(ii) Similarly, when a head event occurs at end of more than one activity, the event is said to have occurred only when all the activities leading to it are completed.

- **Dual role events** : All events except the first and the last event of a project are dual role events. They have both incoming and outgoing arrows.

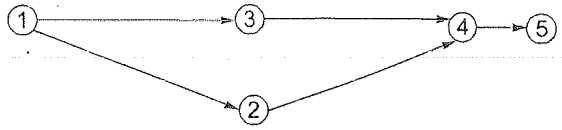



*Fig. 1.6 Dual Role Events*

e.g.: Events 2, 3 and 4, are dual role events.

- **Successor events :** The event or events that follow another event are called successor events to that event.

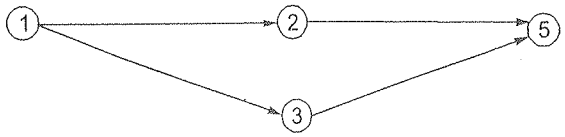



*Fig. 1.7 Successor Events*

e.g.: Event 2 and 3 are successor events of event 1.

- **Predecessor events :** The event or events that occur before another event are called predecessor event to that event.

  In above figure, events 2, 3 are predecessor to event 5.

**Do you know?** It should be noted there can be only one tail event and one head event in a project.

### 1.5.2 Activity

Activity is actual performance of a job. It requires time and resources for its completion.

***Following are examples of an activity:***

1. Excavate trench
2. Mix concrete
3. Prepare budget

**Do You Know ?**

In A-O-A system (Activity On Arrow network system), activity is represented by arrows between events while in A-O-N (Activity On Node system), activities are represented by nodes. In A-O-N system, events have no places.

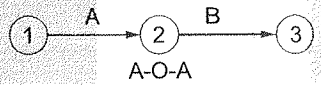



*Fig. 1.8*

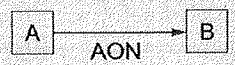
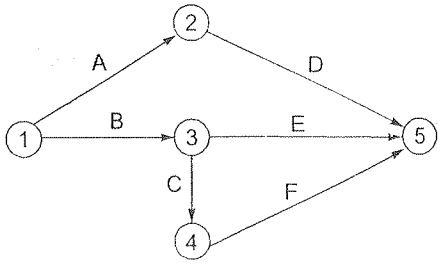



*Fig. 1.9*

Here *A* & *B* activities are represented in two different systems.

- The activities which can be performed simultaneously are and independent of each other called as **parallel activities**. In above figure, activities *A* & *B* are parallel activities.
- Activity or activities that can be performed after performance of other activity are known as **successor activities** to that activity. Activity *F* is successor activity to activity *C* in above figure.




- Similarly activities that are required to be performed before another activity can begin are called predecessor activities to that activity. Activity (A) is predecessor activity to activity D.

### 1.5.3 Dummy

- A dummy is a type of operation which neither requires time nor any resource, but it denotes dependency among the activities.
- It is represented by dashed arrow.

In the figure shown below, a dummy activity is shown.

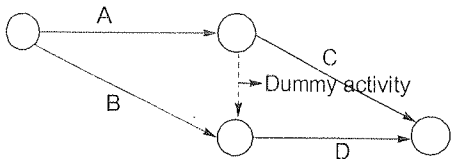
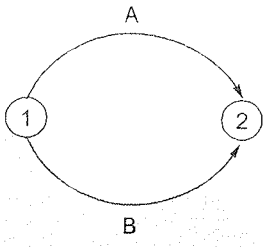


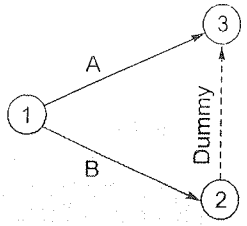

*Fig. 1.10 Dummy Activity*

- Dummy is used to serve following purposes:

1. ***Grammatical purpose*** : To prevent two arrows having common beginning and common end.

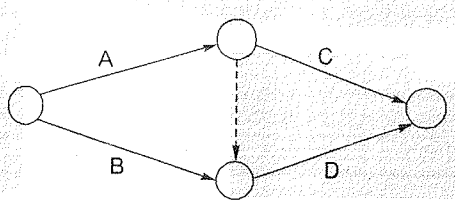



*(a) Ambiguous Representation*




*(b) Grammatically Clean Representation*

2. ***Logical purpose*** : To show relationship with other activities.
   Here dummy is required to show that activity *D* can start after completion activities of *A* & *B* both.




- Unnecessary dummies should be avoided.

**Do You Know ?**

- Dummies are used to show predecessor relation but if that relation is already established in the network, then that dummy is redundant and has to be removed.
- If dummy is only incoming/outgoing arrow to/from a node then it can be remove provided there is no logical or grammatical error.

## 1.6 Rules of a Network

1. There can be only one initial and one final event.
2. An event can not occur unless all preceding activities are completed.
3. An event can not occur twice.
4. Number of arrows should be equal to number of activities.
5. Time should always flow from left to right.
6. Length of arrow does not show any magnitude. Straight arrows should be taken as far as possible.

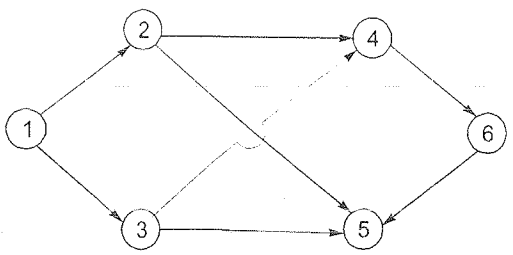



*Fig. 1.11 Crossing Acvities*

7. Arrows should normally not cross each other. If it is necessary to cross, one should be bridged over the other.
8. No activity can start until its tail event has occurred.

***Fulkersons's rule for numbering the events:***

1. The single initial event is numbered as 0, 1, 10 etc.
2. All arrows emerging out of the initial event are neglected. Doing so, the created one or more new initial events are numbered as 2,3,4 or 20, 30, 40 etc.
3. Step - 2 is repeated unless all events are numbered.

Errors in Network

1. *Looping error* : Loops should not be formed.

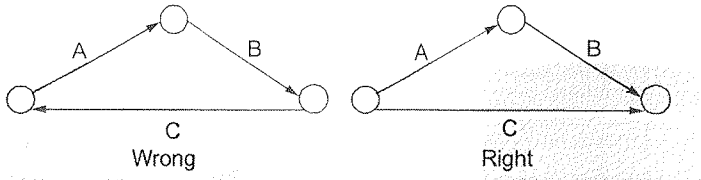



*Fig. 1.12 Looping Error*

2. *Dangling error* : Project is complete only when all its activities are complete but the duration of activity '*R*' has no effect on the project time as shown in figure.

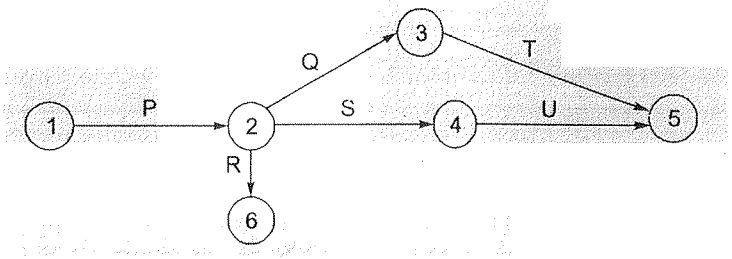



*Fig. 1.13 Dangling Error*

To avoid dangling error, the network must be examined in such a manner that all events except initial and final events must have at least one activity entering and one activity leaving them.

3. *Wagon wheel error* : As shown in figure, each of the activities *P*, *Q* and *R* cannot start until all the three activities *A*, *B* and *C* are completed. But in reality, this may not be the situation. There is no error visible in the construction of diagram but logical error has crept into it.

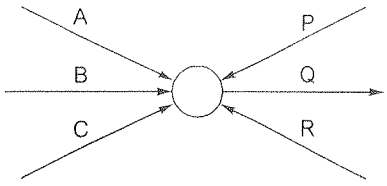



*Fig. 1.14 Wagon Wheel Error*

## Objective Brain Teasers

**Q.1** In arriving at a resource based schedule bar-chart for a construction project, the following stages for planning of the work are involved:

1. Finalizing a network of activities.
2. Determining the optimal activity durations considering all the relevant parameters.
3. Computation of time and floats.
4. Developing the resource-based bar-chart and the corresponding histograms and mass curves of resources.
5. Identification of the critical constraining resource.
6. Deciding the criteria for optimization.

The correct sequence of these stages in the planning of the work will be

(a) 1, 6, 2, 3, 5, 4
(b) 6, 2, 1, 3, 4, 5
(c) 1, 2, 3, 6, 5, 4
(d) 2, 1, 3, 5, 6, 4

**Q.2** Consider the following statements:

1. A dummy activity is artificially introduced in a network when necessary.
2. A dummy activity consumes some time.
3. A dummy activity is represented by a dotted arrow.
4. A dummy activity must necessarily be introduced in every network.

Which of the above statements are correct?

(a) 1, 2 and 3 (b) 1 and 3
(c) 2, 3 and 4 (d) 1 and 2

**Q.3** Match **List-I** (Activity type) with **List-II** (Represented by) and select the correct answer:

**List-I**

A. Artificially introduced
B. Critical
C. Noncritical type
D. Dangler

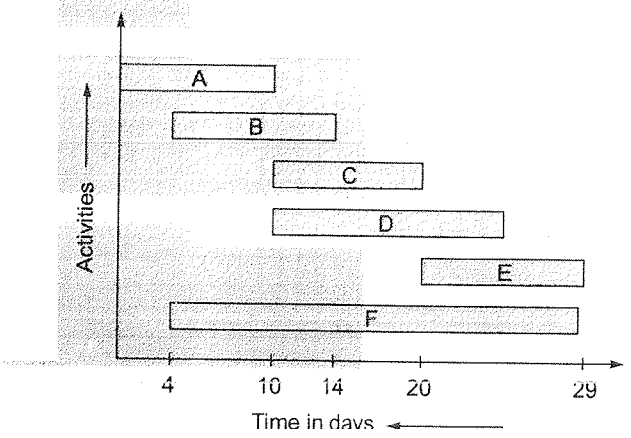
**List-II**

1. A single thick arrow
2. A single arrow
3. An arrow emerging from and event and ending into an event which is not finish event and yet no emerging arrow from that event.
4. A dotted arrow

**Codes:**

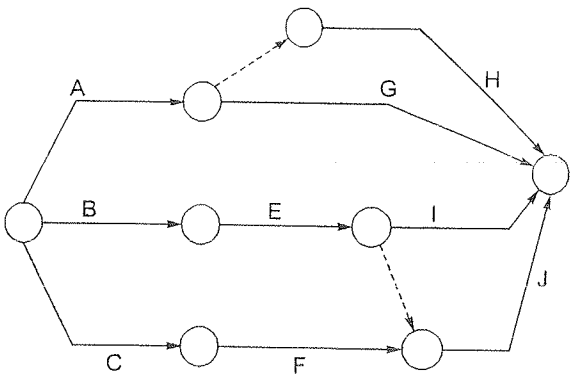
| | A | B | C | D |
|---|---|---|---|---|
| (a) | 4 | 1 | 2 | 3 |
| (b) | 2 | 3 | 4 | 1 |
| (c) | 4 | 3 | 2 | 1 |
| (d) | 2 | 1 | 4 | 3 |

**Q.4** Which of the following are critical activities of the bar chart shown below:




(a) Activities *B* and *E*
(b) Activities *A*, *D* and *F*
(c) Activities *A*, *C* and *E*
(d) Activities *A* and *F*

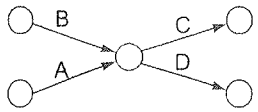
**Q.5** Consider the *AOA* diagram as shown below:

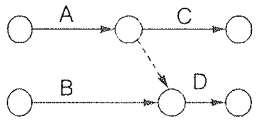


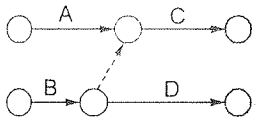
What is the number of dummy links required to convert it into the most concise *AON* diagram?

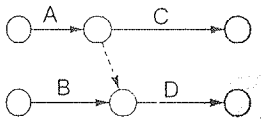
(a) 8 (b) 7
(c) 6 (d) 5

**Q.6** Activity '*C*' follows activity '*A*' and activity '*D*' follows activities '*A*' and '*B*'. The correct network for the project is

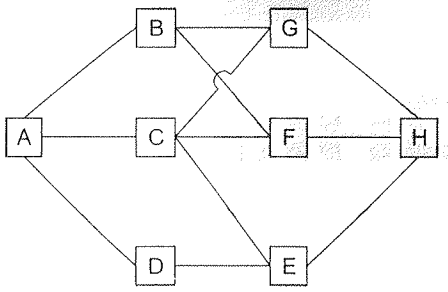
(a)



(b)



(c)



(d)



**Q.7** Consider the *AON* diagram shown below:
What is the minimum number of dummy arrows required for conversion into *AOA* diagram?

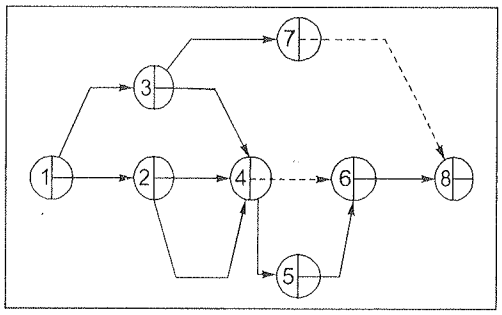



(a) 3 (b) 4
(c) 5 (d) 6

**Q.8** Which of the following is the correct sequence to analyze a project for implementation?

(a) Time-cost study, Network, WBS, Scheduling with resource allocation
(b) Network, Time-cost study, Scheduling with resource allocation, WBS
(c) WBS, Network, Scheduling with resource allocation, Time-cost study
(d) WBS, Time-cost study, Network, Scheduling with resource allocation

**Q.9** The total number of errors in the given *AOA* network is




(a) 1 (b) 2
(c) 3 (d) 4

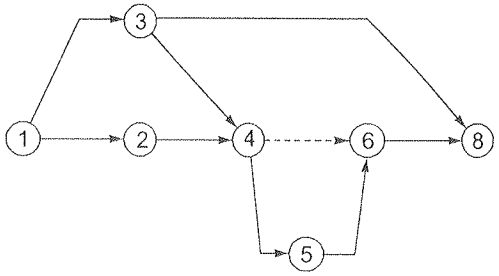
## Answers

1. (c) 2. (b) 3. (a) 4. (c) 5. (b)
6. (b) 7. (c) 8. (c) 9. (b)

## Hints & Solution

4. **(c)**
Try to find those activities delay in which causes delay in whole project.

9. **(b)**
There is an extra dummy between events (7) and (8).
There are two arrows joining events (2) and (4).
The correct diagram will be




So there are two errors.

■■■■