CTPM
ESTIMATION & COSTING

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ESTIMATION & COSTING

CTPM

TSPSC AEE SYLLABUS

Estimation, Costing and Construction Management:

Abstract estimate: Detailed estimate – centerline, long & short wall method, variousitems of Civil Engineering works as per Indian Standard, General Specifications - EarthWork, Brick / Stone Masonry in Cement Mortar, RCC, Plastering in Cement Mortar, Floorfinishes, white wash, colour wash; Standard schedule of rates, lead and lift, preparationof lead statement; Computation of earth work – Mid-ordinate, Mean Sectional area,Trepezoidal method, Prismoidal Rule; Approximate estimate – Plinth area and cubic rateestimate.

Construction Management:

Types of construction projects, Tendering and construction contracts, project planningand network analysis – PERT and CPM.

APPSC AEE SYLLABUS

Bar chart, Linked bar chart, Work break down structures, Activity – on – arrow diagrams. Critical path, Probabilistic activity durations, Event based networks.

PERT network: Time-cost study, Crashing, Resource allocation

SSC-JE SYLLABUS

Estimating, Costing and Valuation: estimate, glossary of technical terms, analysis of rates, methods and unit of measurement, Items of work – earthwork, Brick work (Modular & Traditional bricks), RCC work, Shuttering, Timber work, Painting, Flooring, Plastering, Boundary wall, Brick building, Water Tank, Septic tank, Bar bending schedule, Centre line method, Mid-section formula, Trapezodial formula, Simpson's rule, Cost estimate of Septic tank, flexible pavements, Tube well, isolates and combined footings, Steel Truss, Piles and pile-caps. Valuation – Value and cost, scrap value, salvage value, assessed valu

1 PROJECT MANAGEMENT

INTRODUCTION

- A project is composed of jobs, activities, functions or tasks that are related one to the other in some manner, and all of these should be completed in order to complete the project.
  - It starts at some specific moment and finishes when its objectives are fulfilled. For completion of a project, two basic things are required :
    - Material resources,
    - Manpower resources.
  - Many countries, rich in material resources are exceedingly poor in terms of level of production or plan achievement, while there are other countries which have very limited natural resources but have achieved higher level of productivity mainly because of talents, skills, experience and known-how of their people.
  - Availability, quality and use of human resources is a single determinant factor in accomplishing project objectives.
  - Here comes the role of management. While technology deals with material things, management deals with both material things as well as human-beings.
  - Management increases the productivity through technological innovation taking into account human factor involved in these advances.
- **Each project, whether big or small has three objectives :**
  - The project should be completed with a minimum of elapsed time.
  - It should use available manpower and other resources as sparingly as possible, without delay.
  - It should be completed with a minimum of capital investiment, without delay.
  - Project management is a highly specialised job to achieve the above objectives. Project management involves, the following three phases :
    - Project planning
    - Project scheduling
    - Project controlling.

PROJECT PLANNING

- Planning is the most important phase of project management.
  - Planning involves defining objectives of the project, listing of tasks or jobs that must be performed, determining gross requirements for material, equipment and manpower and preparing estimates of costs and durations for the various jobs or activities to bring about the satisfactory completion of the project.
- **Planning is important because :**
  - It provides direction
  - It provides unifying frame-work
  - It helps to reveal future opportunities and threats
  - It provides performance standards.

Plan :

- Plans simply list the goals (target) and define the means of achieving them.
- These listed goals are called events and means of achieving these goals are known as operations or activites in attaining final target set aside by the plan.

Strategies : Strategy is one important type of plan

- It specifies the central concept or purpose of the enterprise as well as the means by which intend to carry that purpose.

STEPS IN PROJECT PLANNING

- Following eight steps are generally recognised in the planning process of a project :

Define	:	The objectives of the project.
Establish	:	Goals and stages intermediate to attain the final target.
Develop	:	Forecast and means of achieving goals, i.e., activites.
Evaluate	:	Organization's resources - financial, managerial and opera-tional to carry out activites and to determine what is feasible and what is not.
Determine	:	Alternatives- individual courses of action that will allow to accom-plish goals.
Test	:	For consistency with company's policy.
Choose	:	An alternative which is not only consistent with its goals and con-cept but also one that can be accomplished with the evaluated resources.
Decide	:	On a plan.

Resources

- In running a project, there is a basic need of resources. These resources can be clas-sified as under :
  - Material resources (What) (including financial resources)
  - Equipment resources (How)
  - Space resources (Where)
  - Effort or manpower resources (who)
  - Time resources (when)

Scheduling

- Scheduling is the allocation of resources
  - But in practical sense time, space, equipment and effort applied to material
  - In other words, scheduling is the laying out of the actual activites of the project calculating the manpower and material requirements (or resources requirements, in general) needs at each stage of production, along with the expected completion time of each of the activity.

Steps in Project Scheduling Phase

- Scheduling is done in the following steps

Calculate	:	Detailed control information
Assign	:	Timings to events and activites.

Given : Consideration to the resources. The manager is generally concerned with those resources whose availability is limited and which thereby impose a constraint on the porject. The important ones are usually skilled, technical and supervisory manpower and capital investment.

Allocate : The resources.

Controlling

- Controlling consists of reviewing the difference between the schedule and actual performance once the project has begun.
  - Project control is the formal mechanism established to determine deviations from the basic plan, to determine the precise effect of these deviations on the plan, and to replan and reschedule to compensate for the deviations.

Steps in Control Process

- Controlling is accomplished in the following well recognised steps :

Establish : Standards or targets. These targets are generally expressed in terms of time.

Measure : Performance against the standards set down in the first step.

Identify : The deviations from the standards.

Suggest and Select : Correcting measures. This will involve all the problems-identifying decision-making and organizing and leadership skill of the decision maker.

Note : Planning and scheduling is done before start of project, where as controlling is done after start of project.

- Following are some of the tools or techniques of project management :

A) Bar charts
B) Milestone } **Tools**

C) CPM
D) PERT } **Network techniques**

BAR CHARTS

- Bar charts were introduced by Henry Gantt around 1900 AD.
- In his work on production control, Gantt developed the famous Gantt chart still used on many projects of moderate magnitude.
- A bar chart consists of two co-ordinate axes, one (usually horizontal axis) represents the time elapsed and the other (the vertical axis) represents the jobs or activites to be performed.
- Each bar represents one specific job or activity of the project. The beginning and end of each bar represent the time of start and time of finish of that activity; the length of bar, therefore, represents the time required for the completion of that job or activity.

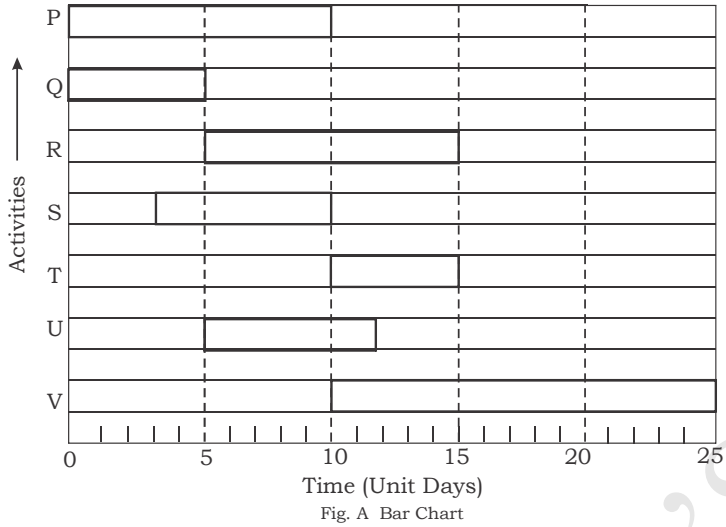


Fig. A Bar Chart

- Figure A : shows the bar chart for a project which has seven distinct jobs or activites (P, Q, R, S, T, U, V) to be performed for its completion. The time durations required for the completion of these activities are 10, 5, 10, 7, 5, 8 and 15 unit days respectively. From the chart, we conclude the following :
  - Activities P and Q can start simultaneously, at zero time. Both the activities are independent. However, activity Q is completed much earlier than activity P.
  - Activity R starts only when activity Q is complete.
  - However, activity S is independent of activity R. It starts earlier than R and is completed earlier.
  - Activity T starts only when activity S is completed.
  - Activities U and R can start simultaneously, when activity Q is completed.
  - Activity V can start when activity P and S are completed. End of activity V marks the completion of the project.

Development of Bar Chart

The following are important stages in developing a bar chart :

Break down : The project into its various activities or jobs or operations, each representing manageable unit for planning and control.

Decide : The method to be employed in execution of the project, as well as for each activity or operation or task; also decide above the sequence in which the activities are to be com-pleted.

Assign : Duration of time for the completion of each activity. Once the activities are separated and choice of method is made, it is possible to estimate the time required for the completion of each activity.

Represent : The above information in the bar chart, indicating the relative positions of the each activity.

Shortcomings of Bar Chart and Remedial Measures :

- Bar charts have following short comings. These short comings can be partly overcome by the following suggested remedial measures.

Lack of Degree of Details

- On bar chart, only major activities are shown.
- If too many activities or tasks are separately shown, it becomes clumsy.
- Due to this, bar charts are not very useful for big projects.
- A particular activity, whether big or small, is shown by one bar, without any details of sub-activites contained in it.
- These sub-activities cannot be separted out. Due to this, effective control over the activites cannot be achieved.

Review of Project Progress

- A bar chart does not shows the progress of work and hence it cannot be used as a control device. For proper control of the project, information of the progress made at a particular instant of time should be available. Controlling is essential for re-scheduling the remaining activities.
- This can be done by showing the progress of each activity, by hatched lines along the corresponding bar of the activity. Generally hatching is done in half the width of the bar.

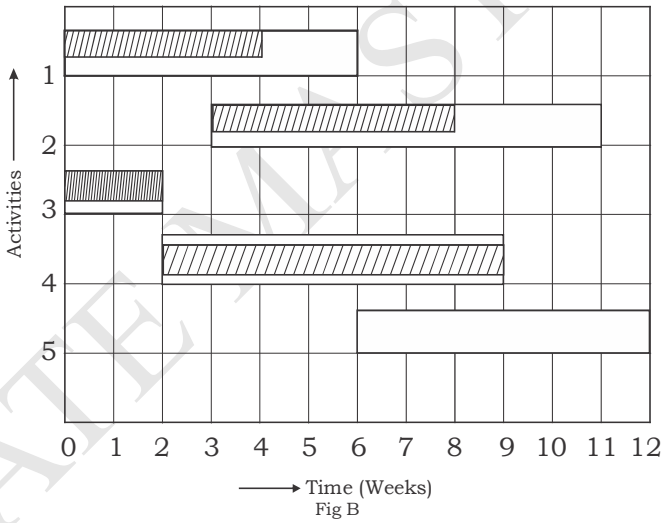


Fig B

- For example, let us mark the progress made on the bar chart of Fig. B, after 8 weeks of the start of the progress. Activity 1 had a total time allocation of 6 weeks. At the end of 8th week, only 4 week's work has been done.
- That means that activity 1 is 4 weeks behind schedule. Activity 5 was wholly dependent on the completion of activity 1; the beginning of activity 5 will now be delayed by 4 weeks. Hence rescheduling of activity 5 is essential. Activities 2 and 3 are perfectly as per schedule. However, activity 4 is 1 week ahead of the schedule.

- Sometimes, different colours are filled in the bars to show various 'control information's, as indicated below :
  - Control information Colour
  - Anticipated progress black

- Actual progress green
- Progress behind schedule red

Activity Inter-Relationships

- As indicated earlier, there are some activities of a project which are taken up concurrently, while there are others which can be taken up only after the completion of some other activity.
  - The concurrent activities are represented by bars which run parallel to each other, or which overlap.
  - The activities whose start and end depend on other activities are shown serially.
- For example, take the project of laying a pipe-line, consisting of following activites :

A. Excavating the trench	12 weeks
B. Laying and jointing the pipe	10 weeks
C. Refilling and compacting	6 weeks

- Activity C is dependent on B and A, while activity B is dependent on activity A. If all the activities are scheduled serially, it will take a very long time - 28 weeks for completion. However, the activities can be staggered as shown in Fig. C.
- From bar chart of Figure C, we find that if activity B is started 4 weeks after activity A, activity B has 2 weeks work left after completion of activity A.

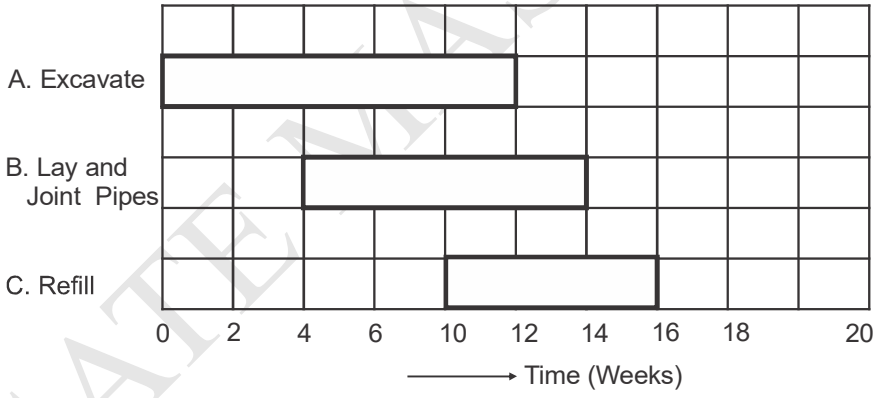


Fig. C

- Similarly, activity C has 2 weeks works left after completion of activity B. Now, if due to some circumstances, time of completion of activity A is delayed by 1 or 2 weeks, how will the activites B and C be affected? This is not clearly portayed by the bar chart, since inter-dependencies of the activities are not clearly indicated by bar charts.

Time Uncertainties :

- Bar charts are not at all useful in those projects where there are uncertainties in determination or estimation of time required for the completion of various activites. Such uncertainties are always there in all research and development projects and for space vehicle launch projects.
  - Because of uncertainties in time determinations in these projects, some of the activities may require rescheduling.

Note :

Barchart is activity oriented where as milestone is event oriented.

MILESTONE CHARTS

- Milestone chart is a modification over the original Gantt chart.
  - Milestones are key events of a main activity represented by a bar.
  - These are specific points in time which mark the completion of certain portions of the main activity.
  - These points are those which can be easily identified over the main bar.
  - We have already seen that when a particular activity, represented by a bar on a bar-chart is very long, the lack of details.

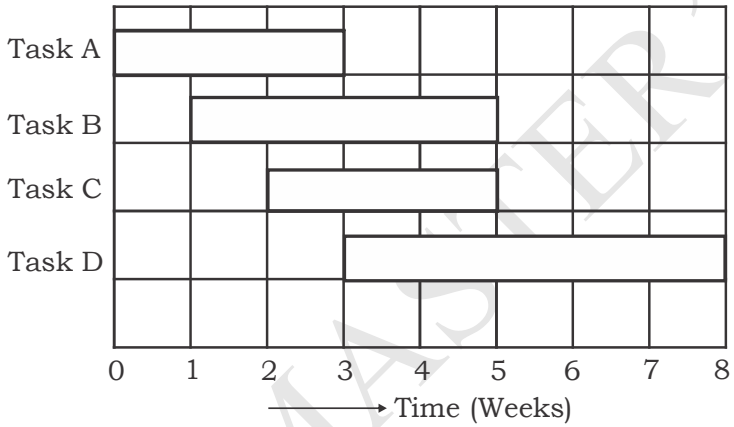


Fig. D : Gantt Bar Chart

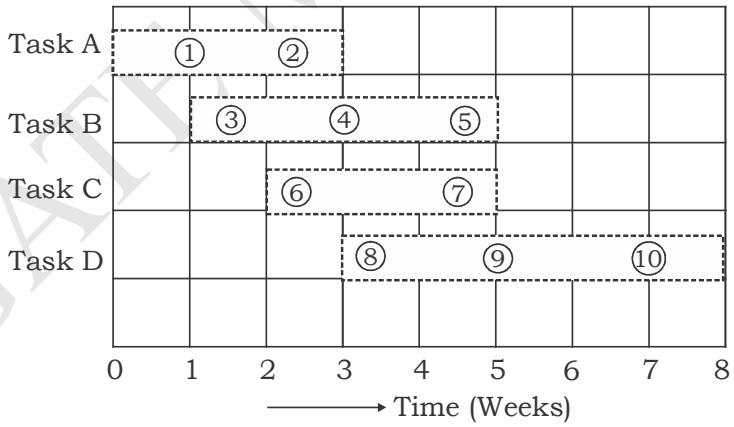


Fig. E : Gantt Milestone Chart

- If, however, the activity is broken or sub-divided into a number of sub-activities, each one of which can be easily recognised during the progress of the project, controlling can be easily done and inter relationship between other similar activities can be easily established. The beginning and end of these sub-divided activities or tasks are termed as milestones.

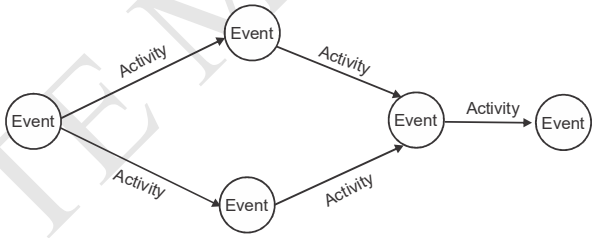
- For example, consider a bar chart diagram shown in Fig. D.
  - It consists of four jobs or tasks or activites -Task A, task B, task C and task D.

    Figure (E) shows some 'milestones' on each bar. Each main task contains some specific points in time which can be recognised, and through which controlling can be achieved. Each milestone can be considered to be specific event along the main activity or job or task. This chart is, therefore, called the milestone chart. Each milestone is represented either by a circle or by a square, and is serially marked.
  - Though controlling can be better achieved with the help of milestone chart, it still possess the same deficiency contained by the bar chart– it does not show the inter-dependencies between the events. Within a task, the relationship between two specific milestones is revealed, but the relationship between and among milestones contained in different task is not indicated on the chart.

ELEMENTS OF NETWORK

INTRODUCTION

- It is always possible to break up the entire project into a number of distinct, well defined jobs or tasks (called activites).
  - The beginning or end of each such activity constitutes an event of the project.
  - A network is a flow diagram consisting of activities and events, connected logically and sequentially. In the network diagram, an activity is represented by arrow while events are represented usually by circles, as shown in Figure below.



Types of Network :

- PERT network and CPM network : PERT network is event-oriented, while CPM network is activity oriented. Fundamentally, both CPM and PERT networks are techniques of project management involving graphical and diagramatic representation, which management can use as an aid in planning, scheduling and controlling of operations in a project.

Characteristics of CPM/ PERT Projects

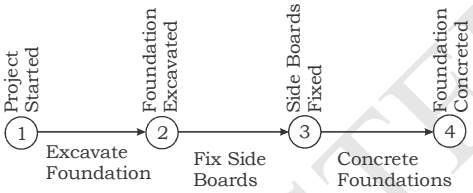
- A project to be analysed by CPM or PERT technique should have the following characteristics :
  - The project to be planned by network technique should consist of clearly recognizable jobs or operations, usually called activites.

- These jobs, operations or activities must have definite commencement and completion. The start or end of a job or operation or activity is called an event.
- The events must occur in a definite pattern and must be performed in a technological sequence.

Thus, the basic elements of a project network are :

- Event
- Activity

- As an example, consider the project of laying a foundation. The project consists of the following well defined operations :
  - Excavation of foundation
  - Laying side boards
  - Concreting foundation
- The simple network will be as shown in figure.



- In above Figure the activities (i.e. excavate foundation, fix side boards, concrete foundations) have been shown by arrows. The beginning and end of activities are events and they are shown by circles provided at the nodes. The events of the above project are :
  - Project started or excavation started,
  - Foundation excavated,
  - Side boards fixed and (4) foundation concreted.

EVENT :

- The commencement or completion of an activity is called an event. An event is that particular instant of time at which some specific part of a plan has been or is to be achieved.

Examples :

Design Completed	:	Is an event
Excavation Completed	:	Is an event
Lathe Installed	:	Is an event
Parts Assembled	:	Is an event
Excavate Foundation	:	Is not an event
Pipe Line Laid	:	Is an event

An event has three basic properties :

- An event is either the start or completion of an activity.
- An event represents a noteworthy, significant and recognizable point in the project. Events act as control points in a project.

- An event is an accomplishment occurring at an instantaneous point of time, but requiring not time or resources itself.

An event must satisfy the following requirements :

- A significant event must be positive, specific, tangible and meaningful to the project.
- It should be definitely distinguishable as a specific point in time.
- It should be readily understood by all who are concerned with the project.

Representation Events :

- In a network diagram, events are represented by nodes. The shape of the nodes may be (i) circular, (ii) square, (iii) rectangular.

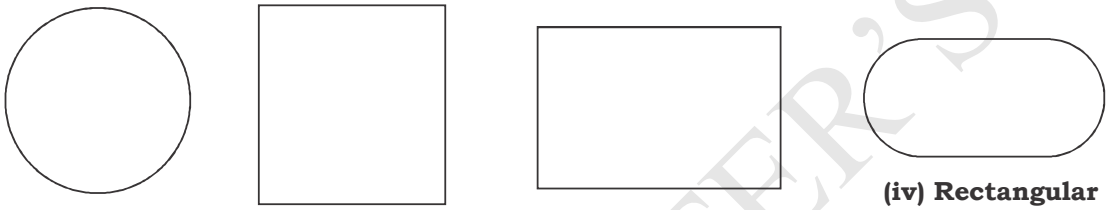


Figure: Ways of Representing Events

- Events are numbered for their identification. The number of an event is written inside the node or circle. Events may also be given verbal description whenever meaningful.

SPECIFYING THE EVENTS

- A particular event out of various events on the network diagram may be specified as : Types of Events :
  - Tail event
  - Head event
  - Dual role event.
- **Tail event :** A tail event is the one which marks the beginning of an activity.
  - If a particular tail event represents the commencement of the project, it is known as the initial event.

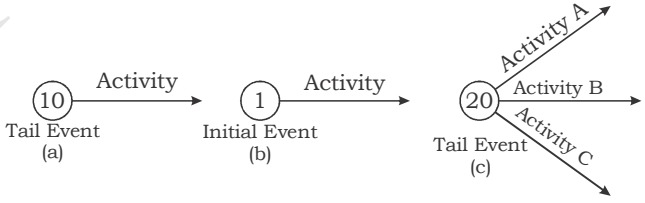
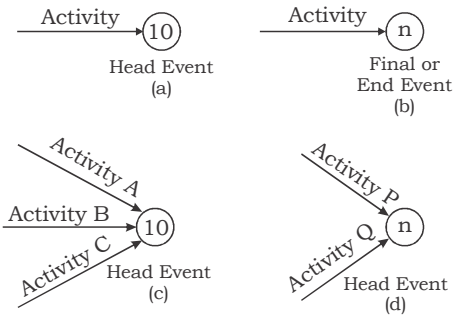


Figure : Tail Events

Head event :

- All activities have an ending i.e. a specific point of time where an activity is campleted.
  - If a particular head event marks the completion of the project it is known as the final event or end event.



Fingure : Head Events

- Above figure (c) shows a head event, marking the completion of three activities. Similarly, Figure (d) shows a final or end event, having two activities ending in it.

Dual role events :

- Actually, most of the events serve dual function i.e., they are head event to some activity and tail event to other activity. All events except initial and final events are dual role events.

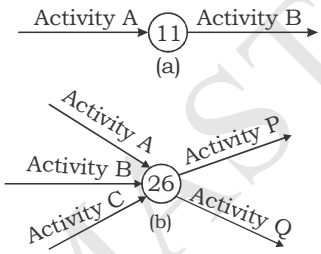
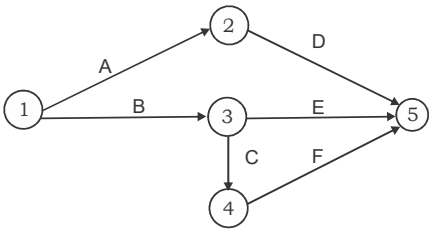


Figure : Dual Role Events.

- Another example is given in Figure in which :

Event 1 is : Initial event
Tail event for activities A and B.
Event 2 is : Head event for activity A
Tail event for activity D.
Event 3 is : Head event for activity B
Tail event for activities C and E.
Event 4 is : Head event for activity C
Tail event for activity F.
Event 5 is : Head event for activities D, E, F
Final or end event.



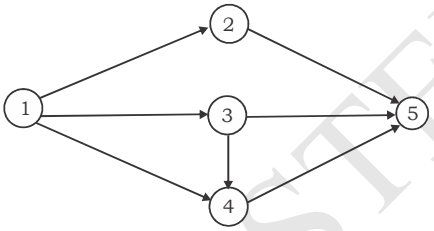
- The order or sequence relates various events as (relation between events)
  - Successor events
  - Predecessor events.

Successor events :

- The event or events follow another event are called successor events to that event.
- Also, the event or events that immediately follow another event without any intervening ones are called immediate successor events to that event.

Predecessor events :

- The event or events that occur before another event are called predecessor events to that event.
  - Also, the event or events that immediately come before another event without any intervening ones are called immediate successor events to that events.
- As an illustration, consider network of figure below.



- Events 2, 3, 4 and 5 are successor events to event 1.
- Events 2, 3 and 4 are immediate successor events to event 1.
- Event 5 is the immediate successor event to events 2, 3 and 4 each.
- Events 1, 2, 3 and 4 are predecessor events to event 5.
- Events 2, 3 and 4 are immediate predecessor events to event 5.
- Event 1 is immediate predecessor event to event 2, 3 and 4, each.

ACTIVITY :

- An activity is the actual performance of a task. It is the work required to complete a specific event. An activity is a recognizable part of a project work that requires time and resources (manpower, material, space, facilities etc.) for its completion.

Example :

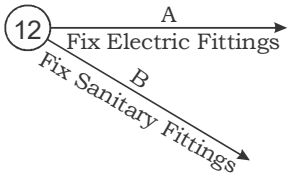
- Excavate the Trench : Is an activity
- Mix Concrete : Is an activity
- Prepare specifications : Is an activity
- Assemble Parts : Is an activity
- Lathe Installed : Is not an activity
- Design Completed : Is not an activity
- Prepare Budget : Is an activity

Inter-relationships :

- A project may consist of a number of activites or jobs. Depending upon the inter-dependency, we can categorise activities as (i) parallel activities and (ii) serial activities.

Parallel activities :

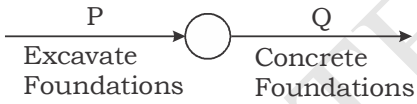
- Those activities which can be performed simultaneously and independently to each other are known as parallel activites. For example, in figure.(a), activites A and B are parallel activites since they can be taken up concurrently and executed simultaneously.



(a) Parallel Activities

Serial activities :

- Serial activities are those which are to be performed one after the other, in succession.
  - These activites cannot be performed independently to each other. For example, activites P and Q in Figure (b). are serial activites. Activity Q cannot be started,unless activity P is complete.



(b) Serial Activities

Dummy :

- A dummy is a type of operation in the network which neither requires any time nor any resources, but is merely a device to identify a dependence among operations.
- A dummy is also represented by arrow; but since it is not an activity, it is represented by dashed arrow. A dummy is identified by the numbers of the terminal node.

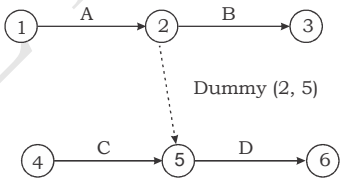


Fig. a

- For example, consider the two sets of activities shown in figure. a

  Set 1. A. A wait delivery of new machine.

  B. Install new machine.

  Set 2. C. Remove existing machine.

  D. Dispose of existing machine.

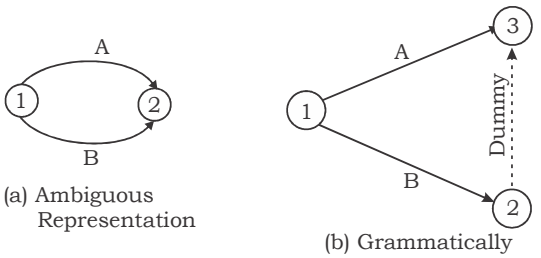
- Activities A and B are to be performed serially. Similarly, activities C and D are to be performed serially. Both the sets are performed simultaneously. However, from practical considerations, we find that activity D of set 2 cannot be performed unless activity A of set 1 is completed. Hence a dummy link is used, joining node 2 to node 5, indicating that activity D cannot be started unless event 2 is over.

Uses of dummies :

Dummies serve two purposes in a network :

- Grammatical purpose
- Logical purpose.

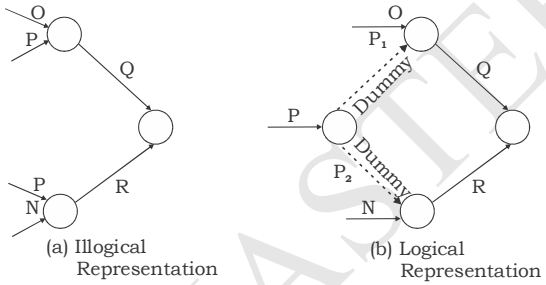
- **Grammatical Purpose :**



(a) Ambiguous Representation

(b) Grammatically Clear Representation

- **Logical purpose :**



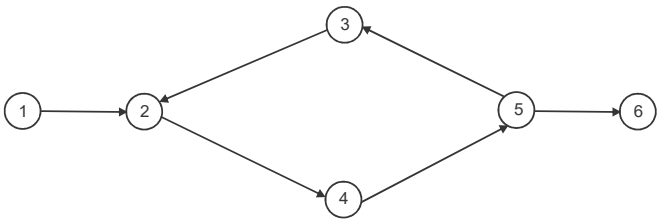
(a) Illogical Representation

(b) Logical Representation

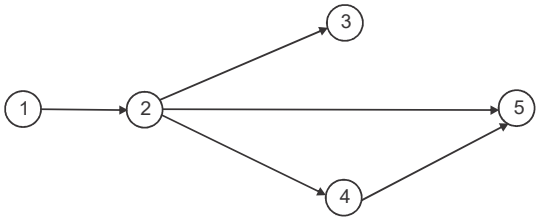
Figure : Use of Dummies

Network Rules

- The following network rules are noteworthy :
- Initial node has only outgoing arrows. There must be only single initial node in a network.
- An event cannot occur until all the activities leading to it are completed.
- An event cannot occur twice, i.e there cannot be any network path looping back to previously occured event. No event depends, for its occurence upon the occurence of a succeeding event. Thus, the network shown in figure below is wrong.



- No activity can start until its tail end event (preceding event) has occured.
- There must not be any dead end left except the final node. Final node has only incoming arrows. There must be only single final node. Thus, the network shown in figure. 3.26 is wrong because there are two final nodes.



- Any arrow should represent singular situation, i.e. individuality and separate entity of an activity must be maintained in a network diagram. Particular arrow can emanate from a single event only. Number of arrows should be equal to number of activites in the project. Thus, the network shown in Fig. a is wrong since activity 'P' has two arrows.

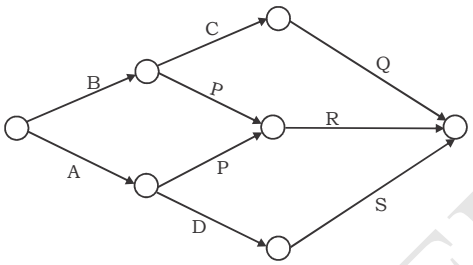


Fig. a

- Representation of the network should be such that every activity is completed to reach the end objective.
- All constraints and interdependencies should be shown properly on the network by use of appropriate dummies.
- Logic of network should always be maintained, i.e. arrow heads point correct way to indicate the true control situation.
- It is usual practice to show the time flow from left to right.

COMMON PARTIAL SITUATIONS IN NETWORK

- Figure (i) gives some common partial situations in a network.

Partial Situation :

- B is controlled by A. Operation B cannot begin until operation A is completed.

Representation :

Fig. (i)

Partial Situation :

- C is controlled by A and B. Operation C cannot begin until operations A and B are completed.

Representation :

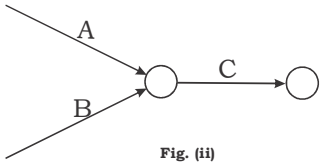


Fig. (ii)

Partial Situation :

- Activities B and C are controlled by activity A. Neither of activities B and C can start unless A is completed.

Representation :

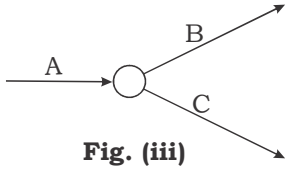


Fig. (iii)

Partial Situation :

- Activities C and D are controlled by activities A and B. Neither of activities C and D can start until A and B are completed. However, C and D can be started independent of each other.

Representation :

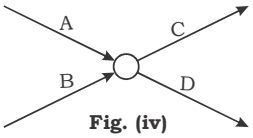


Fig. (iv)

Partial Situation :

- Activity B is controlled by A and C. However, activity D is controlled by activity C only.

Representation :

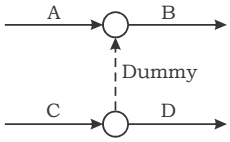


Fig. (v)

Partial Situation :

- Activity D is controlled by A and B, while activity E is controlled by activity B and C.

Representation :

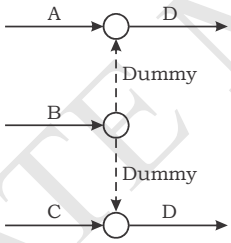


Fig. (vi)

Partial Situation :

- Activity D is controlled by A, B and C. However, activity E is controlled by B and C.

Representation :

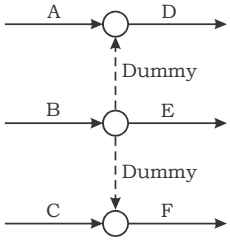


Fig. (vii)

Partial Situation :

- Activity A controls C andD, while activity B controls D and E. Thus, D is controlled by both A and B.