CEPM-44

Fresh

MODULE - I

Unique features of construction projects ; Identification of components - Principles of preparing DPR - Construction planning and scheduling - Bar charts, Network techniques, Use of CPM and PERT for planning - Drawing network diagrams - time estimates - slack - critical path - Examples.

CONSTRUCTION PROJECT.

A project is defined as a temporary endeavor under taken to provide a unique product or service. The product in case of a construction project is the constructed facility such as building, infrastructure so on.

Construction projects involve varying manpower and their duration can range from a few weeks to more than 5 years. Each one of them is 'unique' and 'temporary'. Unique means every project is different in some way from other projects and temporary means that every project has a definite beginning and an end.

UNIQUE FEATURES OF A CONSTRUCTION PROJECT.

- One - time activity — it must be performed correctly the first time every time.
- Complexity - it is multi disciplinary because it involves a set of interrelated tasks to be done by specialists.
- High cost and time for execution.
- High risk of failure.
- Difficulty in defining quality standards.
- Uniqueness of people relationship. Right Coordination
- Feed back mechanism → Improvement in Communication between the diff. parties. Demand of improvement or cognisance between understanding of problems evaluation of progress, knowledge sharing etc.
- Lack of experience of client or owner
- Untrained work force.

Lack of knowledge

A project involves a series of complex or inter related activities and tasks that consume resources to achieve some specific objectives. It has to be completed within a set of specifications under a limited budget.

A project may involve a single unit of one organisation or may extend across organizational boundaries, as in case of partnership.

CHARACTERISTICS OF A CONSTRUCTION PROJECT.

- The project should have a specific target
- The project should be unique and cannot be replicated with the same task and resources giving the same results.
- The construction project should satisfy the owners requirement and expectations from the project
- The construction project shall consists of a number of associated activities contributing to the project as a whole.
- The construction project should not be a routine work, although there are some aspects that are routine.
- The time limit for completion of project shall be defined.
- Construction project is complex and it involves a number of individuals from different departments. So, right coordination shall be set up within departments.
- The project manager must be flexible to accomodate any change that might occur during the project.

- There are factors of uncertainity such as performance of individuals, how their skills adapt to unfamiliar work and other unknown external influences.
- The total cost of construction project shall be defined and project shall be completed within the given budget.
- The project should provide unique opportunities to aquire new skills.
- The project gives impetus to the project manager to adapt to working under changing circumstances, as the nature of project is changed.
- There are risks with each step of the project and the project manager should manage those risk to reach the project goal.

IDENTIFICATION OF COMPONENTS / PHASES OF CONSTRUCTION PROJECT.

Phases can be defined as the top-level breakdown of an entity and a construction project is distinctly characterized by a number of phases during its life cycle.

Different project phases are classified under 3 broad categories as -

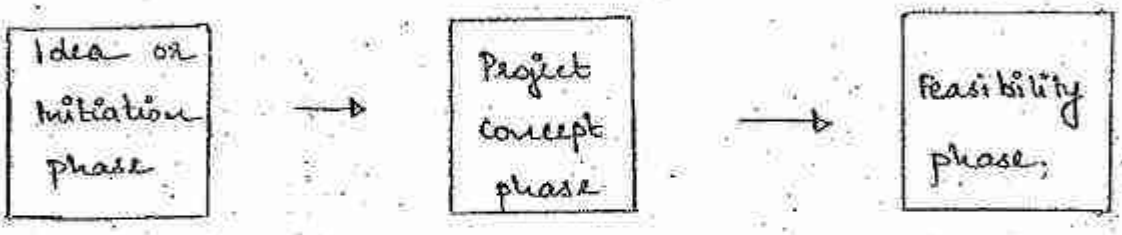
(i) Pre - project phase

(ii) Project phase

(iii) Post - project phase.

(i) Pre - project phase.

The three general phases under the pre - project phase are :-



Idea or initiation phase :- This phase aims to identify all possible projects based on the examination of needs and the possible options.

Project concept phase : The initiation phase aims to sort out all the mentioned information to identify some 'project concepts'. This is the most important phase, since decision taken in this phase tend to have a significant impact on final cost.

Feasibility phase :- This phase aims to analytically appraise project concepts in the context of organisation, taking into consideration factors such as needs, strategic charter and capabilities and know-how of organisation. With this phase, decision makers should be able to decide whether or not to go ahead with the proposed project concept.

The feasibility phase is broadly characterized as follows -

a) Conceptual - For the selected project concepts, preliminary process diagrams and layouts are prepared. Design basis or briefs are also formulated.

b) Project strategy - The strategy in terms of selection of an in-house design team or contractor's design team is deliberated upon.

c) Estimate - A preliminary estimate is prepared with reasonable accuracy by first breaking down the projects into work packages / elements.

d) Approval - Approval consists of financial evaluation, identifying details of funding and their timing, capital / revenue etc, besides evaluation

(ii) Project phase

There are five general phases under project phase :

Basic design phase → Detailed design phase → Tendering phase → Execution phase → Closure phase

Basic design phase - During this phase, documentation for tendering and contracting the physical construction or for procuring equipment is prepared.

Detailed design phase - It may be carried out in house or through contracting, before starting the tendering process.

Tendering phase - The tender preparation includes preparing the specifications and agreement conditions, preparing bill of quantities and estimating the contract value

Execution or construction phase - After awarding contract, construction phase begins. Based on all the prepared detailed design and drawing, construction is followed

Closure or completion phase - In this phase, the major equipment are tested and commissioned and the constructed facility in totality is handed over to client for use.

Post - project phase

Two general phases under this phase are -

utilization phase ⟶ Close down phase.

Utilization phase - the client or end user makes use of the finished project

Close - down phase - Once the project has lived its intended life, it is dismantled and disposed off

PROJECT MANAGEMENT.

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. For completion of a project, requires 2 basic things :-

(i) material resources
(ii) manpower resources.

Role of management :- Technology deals with material things, management deals with both material things as well as human beings.

Project management is a highly specialised job, to achieve certain objectives. Project management involves three phases :-

1. Project Planning } before project
2. Project Scheduling } starts
3. Project controlling } during execution of project.

Resources — In a project, there is a basic need of resources.

(i) material resources (iv) manpower resources
(ii) Equipment " (v) Time resources.
(iii) Space "

1. PROJECT PLANNING

It is the most important phase of project management. Planning involves :-

a) defining objectives of the project

b) listing of tasks or jobs that must be performed

c) determining gross requirements for material equipment and manpower

d) preparing estimates of costs and durations for the various jobs to being about the satisfactory completion of the project.

In planning phase, plan is made, and strategies are set taking into consideration the company's policies, procedures and rules.

Plan

It is a statement of intent ie, what is to be done. It is interpreted in terms of what has to be done to resources to achieve the intent.

Plans are detailed methods, formulated before hand for doing or making something

Plans list the goals / targets and define the means of achieving them. The listed goals are called events and achieving these goals are called as activity / operation.

The size of the activity depends on the nature and scale of project and should be sufficiently well defined for the work to proceed without interruption from other tasks.

Activities are those operations of the plan which take time to carry out and on which resources are expended.

Strategies

It is one important type of plan. It specifies the central concept or purpose of the enterprise as well as the means by which it intend to carry that purpose.

Policies, procedures and rules.

They differ from each other in degree of specificity

Policies – usually set broad guidelines for the enterprise.

Procedure – specify how to proceed in some situation.

Rule – is even more specific guide for action

Steps in project Planning

1. Define – the objectives of the project in definite words.
2. Establish – goals and stages intermediate to attain the final taeget.
3. Develop – forecast and means of achieving goals / activities
4. Calcate – organization's resources to carry out activities and to determine the feasibility
5. Determine – alternatives - individual courses of action that will allow to accomplish goals.
6. Test – for consistency with company's policy
7. Choose – an alternative which is consistent

8. Decide — on a plan.

During planning phase, the information needed is about all those operations or activities which have to be carried out before the project is completed, their sequence and their logical inter relationship.

2. PROJECT SCHEDULING.

Scheduling is the allocation of resources. The resources are time, space, equipment and effort applied to material.

Scheduling is the mechanical process of formalising the planned functions, assigning the starting and completion dates to each part (or activity) of the work in such a manner that the whole work (or project) proceeds in a logical sequence and in an orderly and systematic manner.

Scheduling is the laying out of the actual activities of the project in time order in which they are to be performed and calculating the manpower and material requirements needed at each stage of production time and expected completion for all the activities.

Steps in Project scheduling Phase

1. Calculate - detailed control information.
2. Assign - timings to events and activities.
3. Give - consideration to resources.
4. Allocate - the resources.

3. PROJECT CONTROLLING.

Controlling phase of a project is undertaken during the actual project operations.

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 Project Controlling

1. Establish - standards or targets in terms of time.
2. Measure - performance against the standards

3. Identify – the deviations from the standards.

4. Suggest and select – correcting measures

METHODS OF PLANNING AND PROGRAMING.

Project managers have the means to plan and control the schedules and costs of the work required to achieve the technical performance objectives.

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

1. Bar charts and milestone charts
2. Network diagrams.

1. Bar charts and milestone charts.

Bar charts →

Bar charts were introduced by Henery Gantt. Bar charts represent pictorial representation in two dimension of a project by breaking it down into a number of manageable units or activities for planning and control shown on one dimensions or axis and the duration assigned to these activities on the other - dimension or axis.

In other words, a bar chart consists of two coordinate axes – one representing jobs / activities to be performed and other representing the time elapsed.

Each bar represents one specific job / activity of the project.

The beginning and end of each bar represents the time of start and time of finish of that activity.

Length of the bar represents the time required for the completion of that job or activity

Bar charts represent the activities.

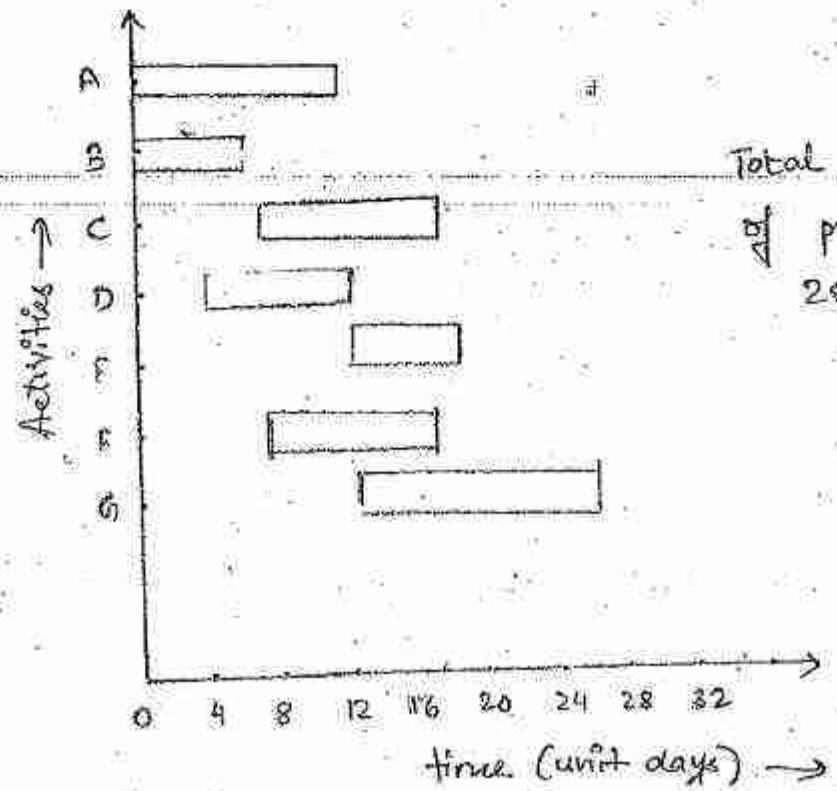
Steps in preparing bar chart / Gantt chart

1. Divide the project into many activities
2. List out the activities
3. find out the inter-relationship among these activities.
4. Arrange the activities in a systematic way
5. Calculate the quantity of work and the time required.
6. Draw it according to scale

Eg. 1: A project has 7 distinct activities A, B, C, D, E, F, and G. The time required for the completion of activities are 11, 6, 11, 8, 6, 9 and 16 units of time respectively such that, ⑨

a) Activity A and B can start simultaneously
b) Activity C can start only when B is complete.
c) Activity D is independent of C. (It starts earlier than C and is also completed earlier.)
d) Activity E starts only when D is completed.
e) F starts when B is completed.
f) G is the last activity and is dependent on completion of D.

answer:



Limitations of Bar charts.

1) It can be used only for small projects
2) It does not show the inter dependencies between various activities in the projects.
3) Progress of work in the project cannot be monitored scientifically
4) Delays in the work cannot be detected.
5) It does not indicate the critical activities of the project.
6) It gives some idea about the physical progress of the project but not the financial aspect.
7) Bar charts cannot be used as a controlling device by the project manager to take any timely action.

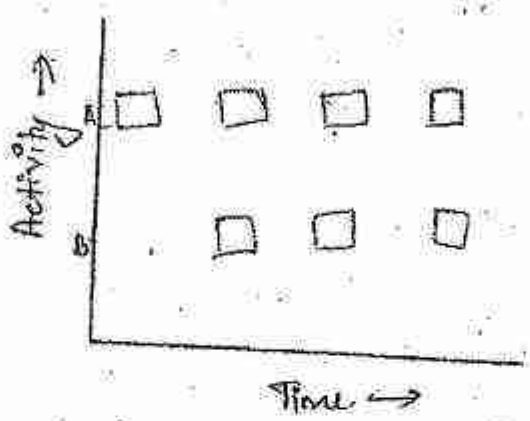
Milestone Chart →

Milestone chart are a modification to bar charts.

In every activity, there are certain key events which are to be carried out for the completion of the activity. Such key events are called milestones and they are represented by a square or circle.

These events are those which can be easily identified over the main bar representing the activity.

Eg - Activity A is divided into 4 key events or milestones, and B into 3 milestone and so on..



Limitations of milestone chart

i) Though controlling can be better achieved with the help of the milestone chart still it possess the same deficiency as the bar chart ie, inter dependencies between the milestone is not shown.

ii) Within an activity, relationship between two specific milestones is revealed by the milestone chart but relationship between and among milestones contained in different activities is not indicated.

2. NETWORK DIAGRAMS.

Network diagram is an outcome of the improvements in the milestone charts. This technique is based on the basic characteristics of all projects, that all works must be done in well-defined steps.

The network diagram exploits the characteristics by representing the steps of the project objective graphically in the form of a network or arrow diagram.

Two major network systems are —

i) PERT

ii) CPM

i) PERT — Program Evaluation and Review Technique.

PERT system uses a network diagram consisting of events which must be established to reach project objectives (event oriented).

An event is that particular instant of time at which some specific part of a plan is to be achieved. It indicates a point in time and does not require any resources.

PERT uses event oriented network diagrams in which successive events are joined by arrows. (11)

PERT system is preferred for those projects or operations which are of non-repetitive nature or for those projects in which precise time determination for various activities cannot be made.

In such projects, management cannot be guided by the past experience. They are referred to as 'once-through' operations or projects.

For such a project the range of possible technical problem is immense in such research and development projects, the time estimates made for use may be little more than guesses. PERT is best suited for such projects.

PERT is a management tool used for planning, controlling and reviewing a project.

An important characteristic of any project is duration. The estimation of time duration can be done in two ways -

① Deterministic approach — in which the planner with enough knowledge about the project gives a single estimate of the duration which is sufficiently accurate.

② Probabilistic approach — in which accurate information is available hence only the limits within which the duration will lie is estimated.

PERT follows probabilistic approach.

PERT uses an activity duration called expected mean time together with an associated measure of the uncertainity of this activity duration.

TIME ESTIMATES

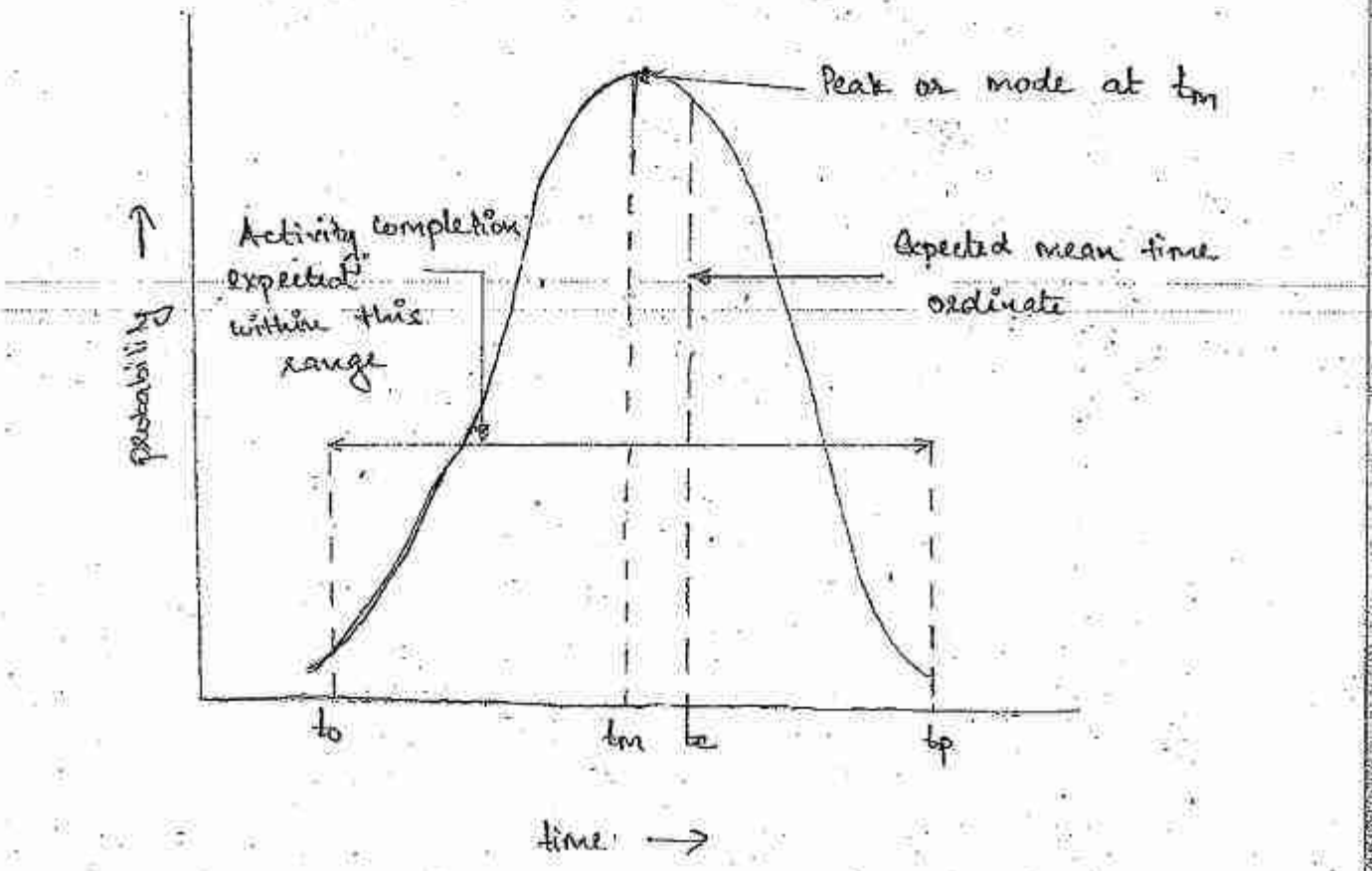
3 time are estimated in PERT

① Optimistic time (tp) — It is an estimate of the minimum time required for an activity if everything goes as per the ideal condition.

② Pessimistic time (t_p) – It is an estimate of the maximum time required if unusually bad luck is experienced. It may be due unforeseen happenings which are inherent in the activity

③ Most likely time (t_m) – It is based on experience and judgement being the time required if normal conditions prevail. It lies between t_o and t_p.

Based on the three time estimates, the general shape of the probability distribution curve for the activity is shown below.



A probability distribution curve that can represent this situation is called the Beta distribution.

The expected mean time is derived from following equation -

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

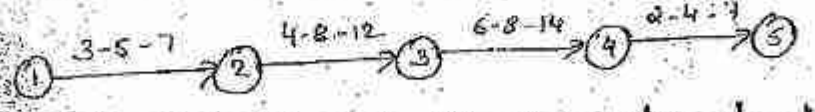
Standard deviation is given by -

$$\sigma_t = \frac{t_p - t_o}{6}$$

Variance is defined as square of standard deviation -

$$V_t = (\sigma_t)^2 = \frac{(t_p - t_o)^2}{36}$$

Eg :-



answer :

Activity	t_o	t_m	t_p	t_e
1-2	3	5	7	5
2-3	4	8	12	8
3-4	6	8	14	8.66
4-5	2	4	7	4.16

Σt_e = 25.83 units

In a network with many paths, there will be expected times. The path consuming the

PERT is an event oriented network and the importance is for the occurence of events Hence, time durations associated with the occurence of events is used. (13)

The 2 time estimates are —.

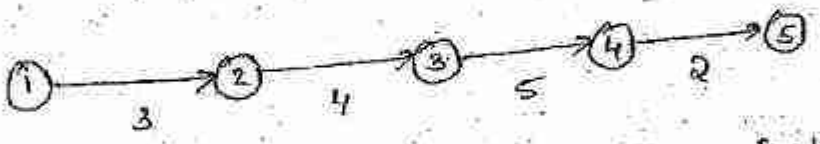
(1) Earliest Expected time (T_E)

(2) Latest allowable occurance time (T_L)

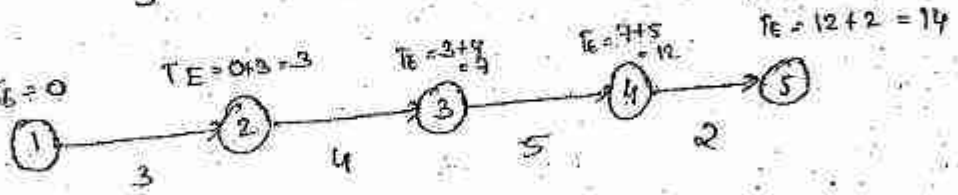
(1) Earliest Expected time (T_E)

It is the time when an event can be expected to occur. It is written either above or below node.

Eg :



Soln :



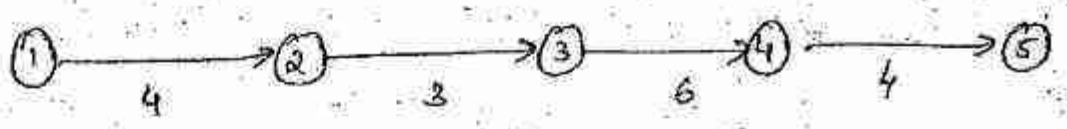
(2) Latest Allowable Occurance time (T_L)

The other event time of equal significance is the latest allowable occurance time.

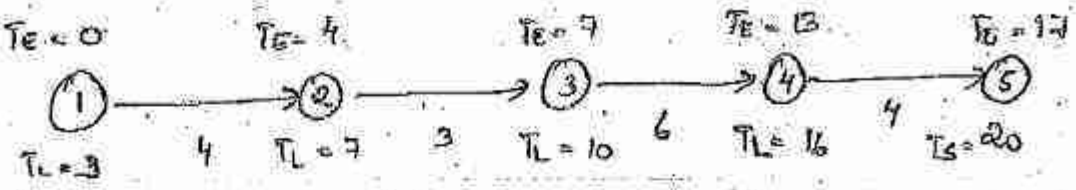
The latest time by which an event must occur to keep the project on schedule is called latest allowable occurance time.

The time by which a project has to be completed is called scheduled completion time. (T_S)

Eg:



Soln



let $T_S = 20$

*SLACK

CRITICAL PATH METHOD (CPM)

→ CPM networks are usually used for repetitive type of projects, where fairly accurate estimates of time can be made for the activities of the project.

CPM networks are often refered to as activity oriented diagrams in which activity is represented by an arrow.

In CPM, 2 time estimates are used -

① Earliest Event time

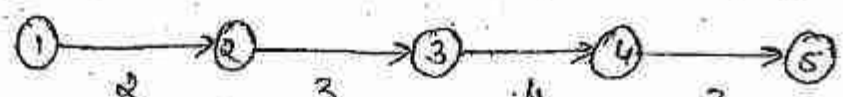
② Latest Event time

① Earliest Event time (T_E)

Earliest event time or the earliest occurance time is the earliest time at which an event can occur.

T_E is similar to earliest expected time used in

Eg



Soln

(2) Latest Event Time (T_L)

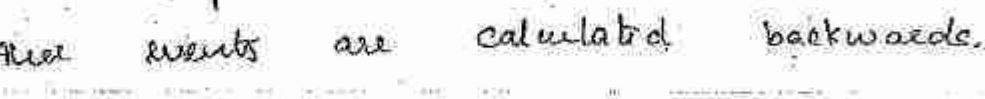
The latest event time or the latest allowable occurance time is the latest time by which an event must occur to keep the project on schedule

If schedule time of completion of project is T_S, then T_L of last event is taken to be equal to T_S.

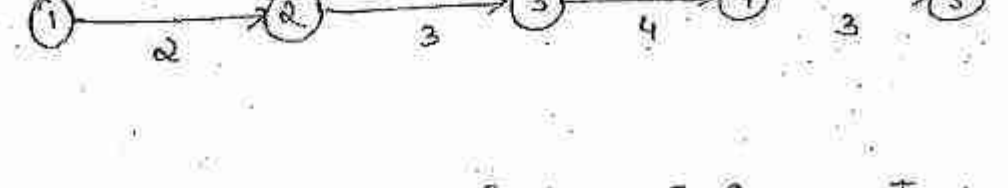
If T_S not given, then T_L is taken to be equal to T_E of last event.

Once T_L of last event is obtained, T_L of other events are calculated backwards.

Eg:



Soln :



NOTE: If there are more than one T_L value which can arise if there are more than one path succeeding the event, then the smallest value is taken as the T_L of the event.

ACTIVITY TIMES

Various activity times are —

1. Earliest start time (EST)
2. Earliest Finish time (EFT)
3. Latest start time (LST)
4. Latest finish time (LFT)

① Earliest start time (EST)

EST of an activity is the earliest time by which an activity can start. It is equal to the earliest event time of the tail event of the activity.

$$EST = T_E^i$$

② Earliest Finish time (EFT)

EFT of an activity is the earliest time by which an activity can be completed.

$$EFT = EST + t^{ij}$$

(3) Latest start time (LST)

LST is the latest time by which an activity can start without delaying the completion of the project as a whole.

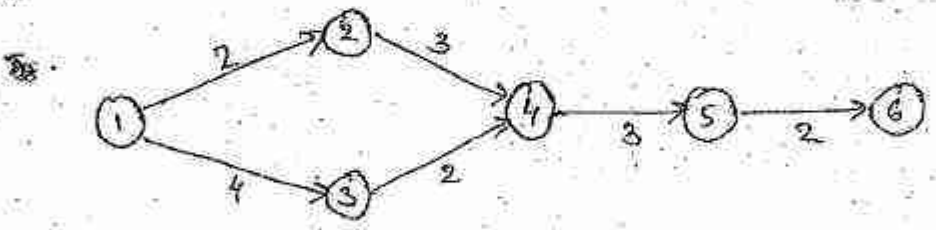
$$LST = LFT - t_{ij}$$

(4) Latest finish time (LFT)

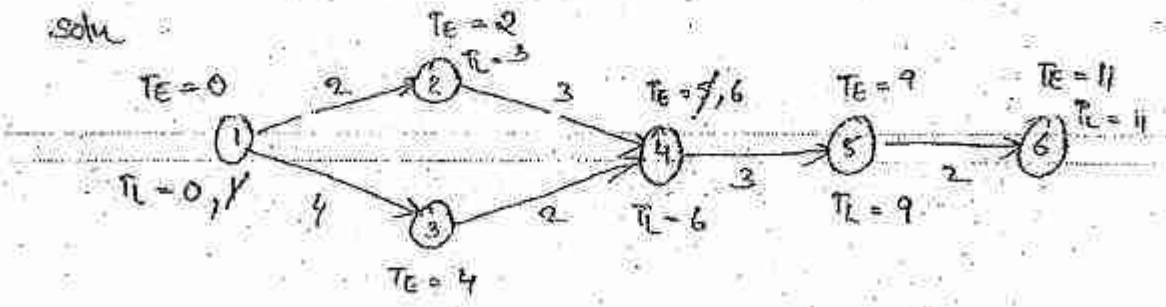
It is the latest time by which an activity can be completed without delaying the project.

$$LFT = T_L^j$$

Eg.



Soln



for Act 1 – 2 :

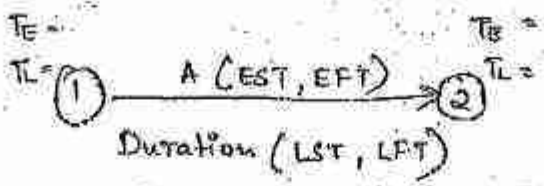
$EST = T_E^i - 0$

$EFT = EST + t_{ij} = 0 + 2 = 2$

$LST = LFT - t_{ij} = 3 - 2 = 1$

$LFT = T_L^j = 3$ #

Values are represented as :-



PROBS.

SLACK.

T_E of an event is defined as the earliest time at which an event can be expected to occur. T_L is the latest time at which it can be occured without disturbing the project duration.

If there is a difference in these two times of an event, it indicates that the particular event can be delayed by that difference without changing the project duration.

This difference between the earliest expected time and latest allowable occurance time of an event is called slack of that event.

$$\text{Slack} = T_L - T_E$$

Slack means that, time is there to spare for that particular event. Events with slack are less urgent. Events without slack denotes potential trouble spots.

Slack can be positive, zero or negative

Positive slack :- It is obtained when T_L is more than T_E. It indicates an ahead of schedule condition.

Zero slack : It is obtained when T_L is equal to T_E. This indicates on schedule condition.

Negative slack : Occurs when T_L is less than T_E. This indicates behind the scheduled condition.

CRITICAL PATH

A critical path is the path that connects the events having zero slack or minimum slack in a network. All the events in a critical path are considered to be critical and any delay in their

will result in a delay in the scheduled completion of the project. Also, critical path is the longest path (time wise) in the project network. A critical path is distinctly marked in network — usually by a thick line.

FLOAT.

Float is similar to slack in PERT. The difference is that float is associated with the activity times while slack is associated ~~which~~ with event times.

Float denotes the flexibility range within which the activity start and finish times may fluctuate without affecting the total project duration.

There are 4 types of floats —

1. Total float
2. Free float
3. Independent float
4. Interfering float.

① Total float – It is the time span by which the starting or finishing of an activity can be delayed without affecting the overall completion time of the project.

$$F_T = LFT - EFT / LST - EST$$

② Free float – It is the duration by which an activity can be delayed without delaying any other succeeding activity.

$$F_F = T_E^j - EFT.$$

$$\therefore F_F = F_T - S_j$$

③ Independent Float – It is the excess time available if the preceding activity ends as late as possible and the succeeding activity starts as early as possible.

$$f_{ID} = \left(T_E^j - T_L^i\right) - t^{ij}$$

$$f_{ID} = F_F - S_i$$

(ii) Interfering float – It is the difference between the total float and free float.

$$F_{IT} = F_T - F_F$$

$$F_{IT} = S_j$$

CRITICALITY AND CRITICAL ACTIVITY

The degree of total float provides information regarding the criticality of the activity

Since total float is the difference between the maximum available time and activity duration, there are 3 possibilities :-

i) The difference is +ve, ie excess time is available for an activity

ii) The difference is zero, no excess time is available.

iii) The difference is -ve, time availability is less than the required time.

This leads to the classification of activities as follows —

i) Subcritical activities — when float is the activity needs normal attention but has some flexibility

ii) Critical activity — when float is zero, the activity needs extra attention.

iii) Supercritical activity — when float is -ve, activity needs very special attention and care.

COMPARISON OF PERT and CPM.

PERT	CPM
• PERT uses event oriented network diagram. ie, emphasis is given on events	• CPM uses activity oriented network diagram. ie, emphasis given on activities.
• time estimates for completion of activities are not so accurate and definite	• Time estimates for completion of activities are with fair degree of accuracy.
• In PERT, cost varies directly with time. Time is the controlling factor.	• Cost optimisation is given prime importance The cost is not directly proportional to time. Cost is the controlling factor

• PERT is preferred, where there is an extreme degree of uncertainity.	• CPM is preferred, where time can be estimated fairly well and when costs can be calculated in advance.
• PERT is used for research and development type of projects	• CPM is used in long developed and well seasoned components

: Detailed Project Report (DPR)

- It is a complete document for investment, decision making approval, planning.
- DPR ~~project~~ is base document for planning the project and implementing the project.

Objectives

- to understand the importance of developing a DPR that assure performance for a reliable quality within opt. cost
- to appreciate the projects are site specific
- to understand importance of optimization of schemes, detailed cost estimate, pay back period and return on investment
- to describe how bankable project can help to achive reqd performance
- to understand methodology of project appraisal.

Brief discription of project area

- Name of utility
- district / village / town covered
- Location
- area, popn, boundary
- climatic condition
- Status of dept
- economic structure
- urban / rural

Project Cost details

- Basic equipment cost
- consultant charges
- duties, taxes + freight
- Excise duty / customs duty / sales tax
- freight + transit insurance
- raw materials
- man power cost
- engg. project mgmt, supervision
- Interest during construction

Benefits of DPR:

- cost - benefit analysis
- Investment criteria
  - pay back period
  - DCF technique
    - NPW
    - BC Ratio
    - IRR

Project Investment criteria

Pay back period - length of time reqd by cumulative net cash inflow to cover up fixed capital investment

PBP is easy to understand

Investment should include fixed capital & working capi

net benefits to be adjusted for interest + tax liabilities

- DCF Technique
  - It brings past & future cost benefits to their present worth (PW)
  - Past benefits cost - compounding
  - future " " - discounting

DPR structure

- title pg, name, affiation, data etc
- acknowledgement
- content
- abbreviation
- executive summary
- Introduction
- main technical & financial analysis
- recommended action plan
- appendies.

DPR should provide :-

- final cost details & benefits expected
- detailed specification of equip & material
- all info to prepare tender
- list of eqmt & material manufacturers
- project mngmt process

Parameters of Project Appraisal

- Project eligibility
- ascertain project profile

Review Project

- existing + proposed system
- demand supply scenario
- alternative considered
- study carried out by state govt / utility
- status + preparedness
- procurement procedure + competitiveness
- O + M arrangements

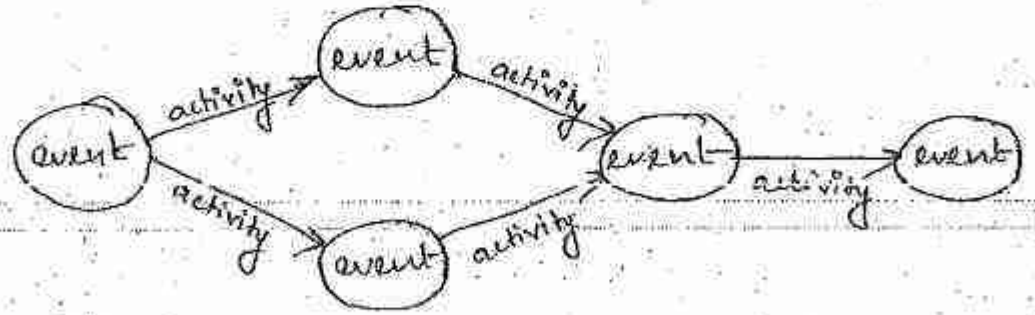
check availability of approvals + clearances

- Statutory clearances
  - land availability + acquisition
  - forest clearance
  - highway clearance
  - electricity "
  - fund related "
  - pollution control board "
- Approvals
  - board approval - state govt
  - approval of PPA

ELEMENTS OF NETWORK

Network technique is one of the most modern tools of project management. An entire project is broken up into a number of distinct, well defined jobs / tasks called activities. 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 a network, activity is represented by arrows while events are represented by circles.



Basic elements of a project network are -

(i) Event

(ii) Activity

Eg: Project of laying a foundation.

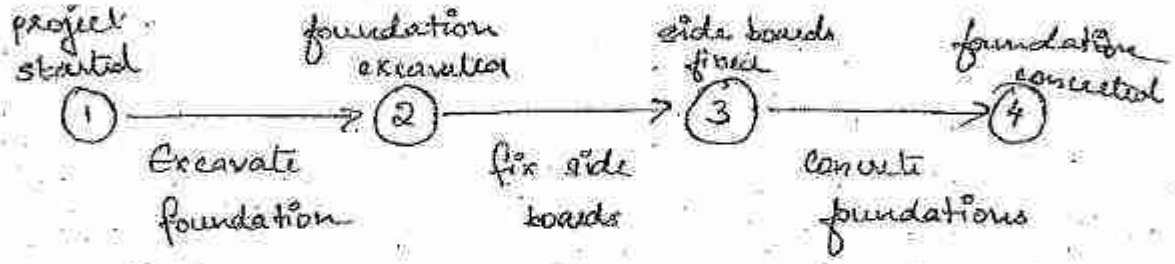
following are the well-defined operations -

a) Excavation of foundation

b) laying side boards

c) concreting foundation

network is drawn as -



So in this network, activities are - excavate foundation, fix side boards, concrete foundation (represented by arrows)

Beginning and end of activities are known and represented by circles provided at the nodes.

So the events are - project started, foundation excavated, side boards fixed, foundation concreted.

Events

The starting or completion of an activity is called an event.

3 basic properties of event :-

i) An event is either start or completion of an activity

ii) An event represent, recognizable point in the project.

iii) An event is an accomplishment occuring at an instantaneous point in time.

An event must satisfy following requirements :-

i) An event must be positive, specific, tangible and meaningful in project.

ii) should be definitely distinguishable at a specific point in time.

iii) Should be readily understood by all concerned with the project.

Events are represented by nodes. The shape of nodes may be circular, square, rectangular, oval etc. Commonly used is circle

Specifying the events

An event may be specified as -

i) Tail event

ii) Head event

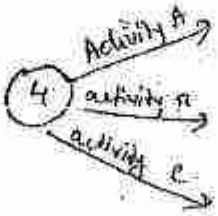
iii) Dual role - event.

i) Tail Event -- is the one which marks the beginning of an activity

If particular tail event represent starting of project, it is known as initial event

eg:

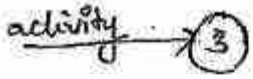
tail event initial event



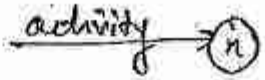
ii) Head Event - All activities have an ending at a specific point of time, and is marked by an event. Such event is called head event.

If particular head event marks the completion of project, it is known as final/end event

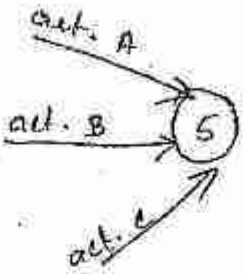
Eg:



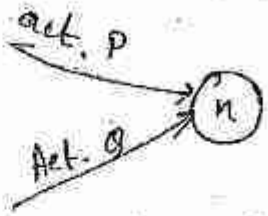
head event



final event



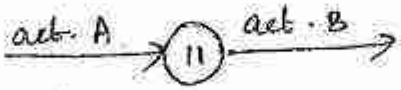
head event

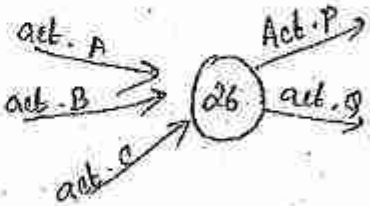


Final event.

3) Dual role Events — most of the events serves dual function ie head event to some activity and tail event to other activity. All events except initial and final events are dual role events.

Eg





Inter-relationship between Events

The completion of a project, which has been split into a number of activities passes through a number of events. These events must occur at definite time and in a particular sequence or order

The order or sequence relates various events as —

a) Successor events

b) Predecessor events.

a) Successor Events

The event or events that follow another event are called successor event to that event.

Event or events that immediately follow another ~~one~~ event without any intervening ones are called Immediate successor events to that event.

b) Predecessor Events

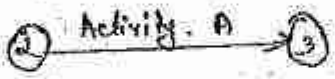
The event or events that occur before another event are called predecessor events to that event.

Event or events that immediately come before another event without any intervening ones are called immediate predecessor events.

ACTIVITY

An activity is the actual performance of a task. It is the work required to complete a specific event. An activity requires time and resources for its completion.

In network diagram, activities are represented by simple arrows. It is not a vector quantity. The length of arrow is chosen to suit the drafting convenience



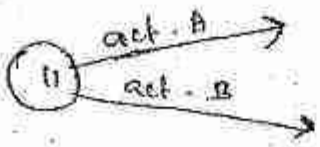
Inter-relationship between Activity

Catagorised into -

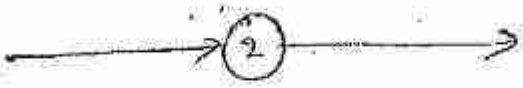
a) Parallel activity

b) Serial activity

a) Parallel activity - those activity which can be performed simultaneously and independently to each other.



Serial activity – those activity which are to be performed one after the other in succession. these activities cannot be performed independently to each other.



Predecessor activity

Activity that are required to be performed before another activity can begin are called predecessor activity to that activity

Successor activity

Activity that can be performed after the performance of other activity are called successor activity of that activity

Immediate predecessor / successor activity is indicated by a *

DUMMY

A dummy is a type of operation in the network which neither requires any time nor any resources.

A dummy is a connecting link for control purpose or for maintaining uniqueness of activity

A dummy is represented by a dashed arrow.

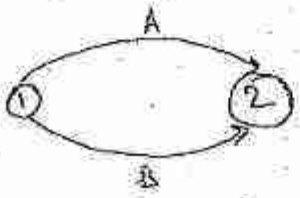
Use of dummies

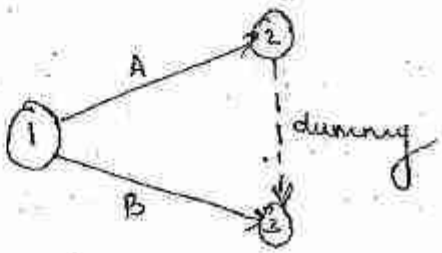
Dummies serve two purposes in a network :-

a) Grammatical purpose

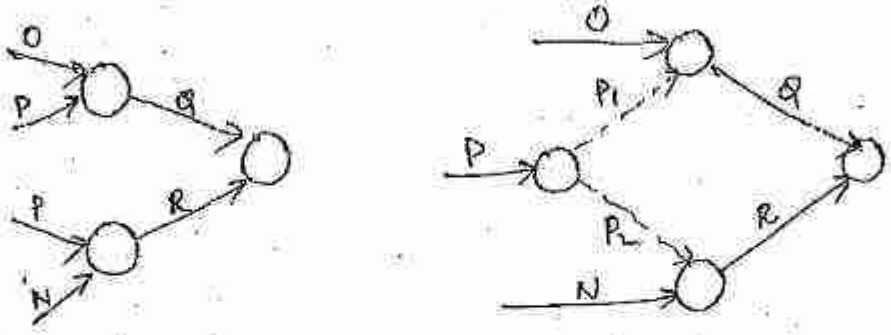
b) Logical purpose

a) Grammatical purpose — A dummy is used to prevent two arrows having common beginning and end points.





b) Logical purpose. → dummies are also used to give logical clear representation in a network having an activity common to two sets of operations running parallel to each other



Rules for providing dummies:

1. If dummy job is the only one emanating from its initial node, it can be removed and the activity terminating at that node can be directly connected to that node to which the dummy was terminating

2. If dummy is the only one terminating into a node, the dummy can be removed and the two node at the two ends of the dummy can be merged into one.

3. If two or more activities, emanating from different nodes, have identical set of predecessor some of which also appear in different

4. activities should emanate from a single node. This node can then be connected to their predecessor activities by dummies.

5). If two or more activities, terminating into different nodes, have identical set of successors, the latter having other predecessors as well, the two activities should terminate into one single node. This node can then be connected to their successor through appropriate dummies.

5) Dummies which are used to show predecessor relationship already implied by other activities are known as redundant dummies and can be removed.

NETWORK RULES.

1. Initial node has only outgoing arrows. There must be only single initial node in a network.

2. An event cannot occur until all the activities leading to it are completed

3. An event cannot occur twice. ie there cannot be any network path looping back to previously occurred event.

4. There must not be any dead end left except the final node. Final node has only incoming arrows.

5. No activity can start until its tail end event has occured

6. Any arrow should represent singular situation, individuality and separate entity of an activity must be maintained in a network

7. Representation of the network should be such that every activity is completed to reach the end objective

8. All constraints and interdependencies should be shown properly on the network by use of appropriate dummies.

9. Logic of network should always be maintained ie arrow heads points correct way to indicate the true control situation.

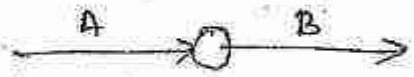
10. Network is drawn from left to right.

Graphical Guidelines for Network

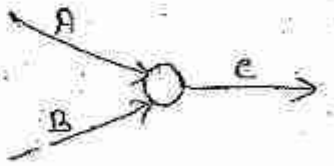
1. Arrows are not vectors.
2. Orientation between arrows should be chosen to suit drafting convenience.
3. Straight arrows are preferred.
4. Arrows should not cross each other. If so, then it should be broken to bridge over each other.

Partial Situation in Network

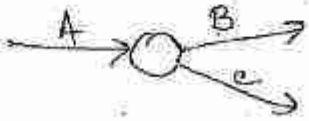
B is controlled by A.
Operation B cannot begin until A is completed.



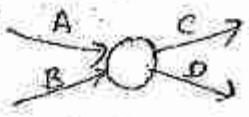
C is controlled by A & B.
C cannot begin until A, B are completed



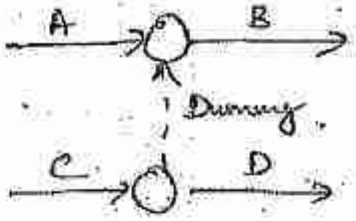
B, C controlled ~~by controlled~~ by A. B, C cannot start until A is completed



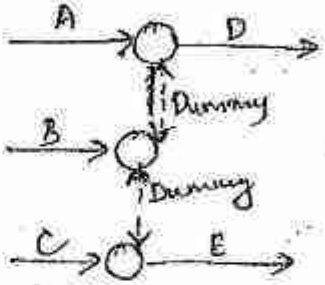
C, D controlled by A, B.
C, D cannot start until A, B are completed



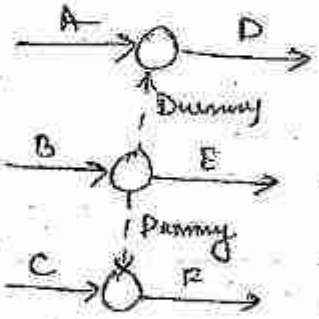
Activity B controlled by A, C. Act. D is controlled by C only



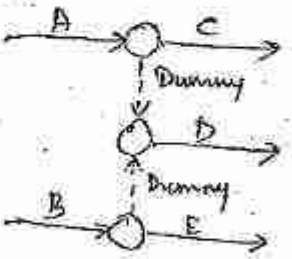
Act. D is controlled by A and B, while E is controlled by B & C.



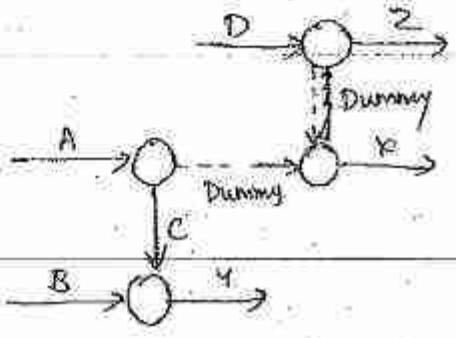
Act. D is controlled by A, B, C. Act E is controlled by B & C.



Activity A controls C, D while B controls D and E. D is controlled by A & B



Act. X controlled by D & B. Act Y controlled by A, B, C while Z controlled by D only



Numbering the Events.

1. There is a single initial event in a network diagram. Intial event is numbered as 1.
2. Number all arrows emerging out of initial event as 2, 3, 4 etc.
3. Neglect all emerging arrows from these numbered events, this will create more initial events and number it.
4. Continue till last event, which has no emerging arrows.

CSPM AA

Network Techniques

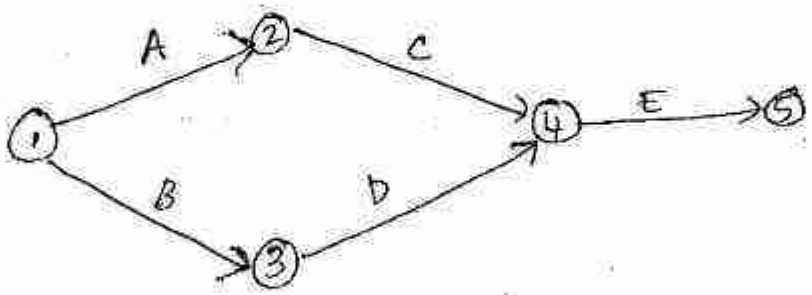
1) PERT
2) CPM.

Network Diagram

Q. Draw the n/w diagram. for the given data (AOA)

Activity	Predecessor	Successor
A	—	C*, E
B	—	D*, E
C	A*	E
D	B	E
E	A, B, C*, D*	—

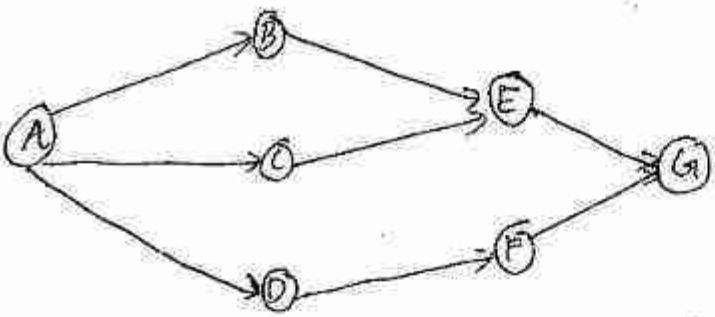
(Ans)



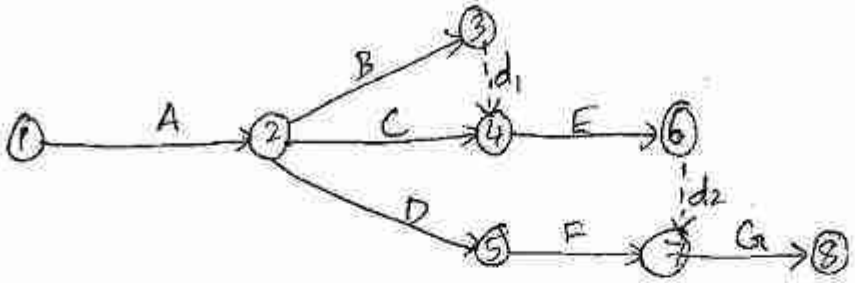
Q. Draw the PDM (AON) n/w for the following activities

Activity	I.P
A	—
B	A
C	A
D	A
E	B, C
F	D
G	E, F

(2)



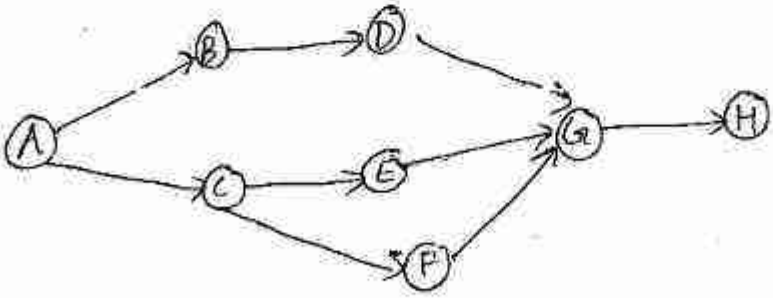
AON



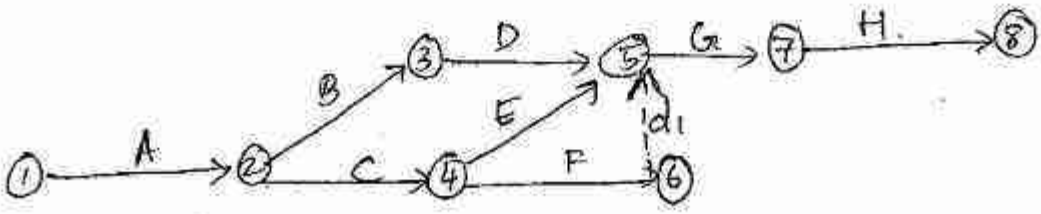
AOA.

Q. Draw AOA and AON n/w.

Activity	Predecessor
A	–
B	A
C	A
D	B
E	C
F	C
G	D, E, F
H	G



AON



PERT

Q. Calculate the expected time for the completions of two jobs, A & B.

	to	tm	tp (days)
Job A	4	6	11
Job B	5	10	12

Ans)

Job A,

Expected time, $te = \frac{to + 4tm + tp}{6} = \frac{4 + 4\times6 + 11}{6} = 6.5$ days.

SD, $\sigma = \frac{tp - to}{6} = \frac{11-4}{6} = 1.16$

Variance, $\sigma^2 = \left(\frac{tp - to}{6}\right)^2 = 1.36$.

Job B,

$te = \frac{to + 4tm + tp}{6} = \frac{5 + 4\times10 + 12}{6} = 9.5$ days.

$\sigma = \frac{12-5}{6} = 1.16$

$\sigma^2 = \left(\frac{tp - to}{6}\right)^2 = 1.36$

Q. Calculate the critical path and SD, for the following activities of the project

Activity	to	tm	tp
11-12	4	6	8
12-13	5	7	11
13-14	4	10	12

$te = \frac{to + 4tm + tp}{6}$

$\sigma = \frac{tp - to}{6}$ $\quad \sigma^2 = \left(\frac{tp - to}{6}\right)^2$

Ans)

Activity	te	σ	σ^2
11-12	6	0.66	0.44
12-13	7.33	1	1
13-14	9.33	1.33	1.77

Critical Activity = 13 — 14

(4)

Q. For a particular activity of a project the time estimates received from 2 engineers X and Y are as follows:

	to	tm	tp
Engg X	4	6	8
Engg Y	3	5	8

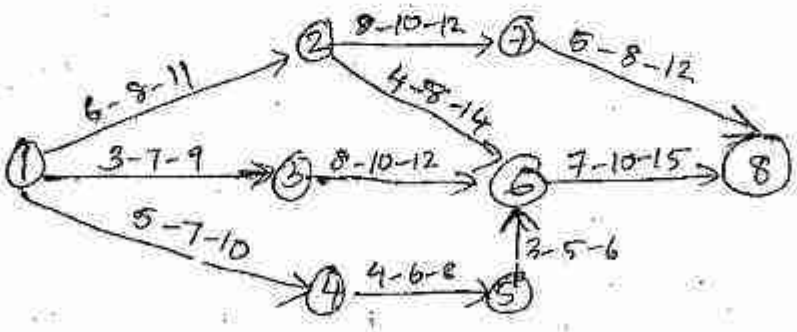
State who is more critical about the time of completion of the activity.

Ans)

	te	σ	σ^2
Engg. X	6	0.66	0.44
Engg. Y	5.16	0.833	0.69.

Engg. X is more certain since variance is less.

Q. The network for a certain project is given. Calculate the expected time for each activity of the path and find out which path is critical.



Ans)

Path A : 1-2-7-8

Path B : 1-2-6-8

Path C : 1-3-6-8

Path D : 1-4-5-6-8.

(5)

Path	Activity	t_o	t_m	t_p	t_e	Σt_e
A	1 - 2	6	8	11	8.16	
	2 - 7	8	10	12	10	26.32
	7 - 8	5	8	12	8.16	
B	1 - 2	6	8	11	8.16	
	2 - 6	4	8	14	8.33	26.82
	6 - 8	7	10	15	10.33	
C	1 - 3	3	7	9	6.66	
	3 - 6	8	10	12	10	26.99
	6 - 8	7	10	15	10.33	
D	1 - 4	5	7	10	7.16	
	4 - 5	4	6	8	6	28.32
	5 - 6	3	5	6	4.83	
	6 - 8	7	10	15	10.33	

Path D is critical since Σt_e is more.

Considering t_o, t_m and t_p individually,

	Σt_o	Σt_m	Σt_p
Path A	19	26	35
" B	17	26	40
C	18	27	36
D	19	28	39

For t_p → Path B
For t_o → A and D
For t_m → Path D.

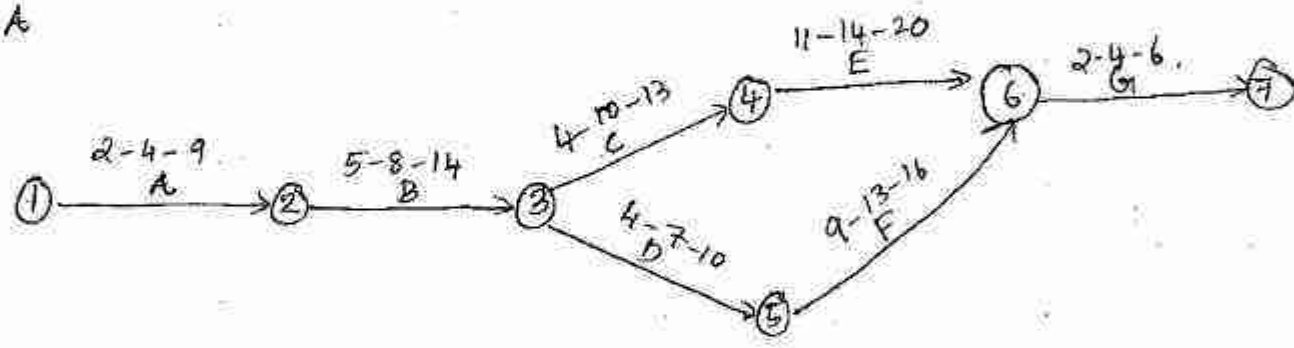
If asked in question

(6) Q. Calculate the mean, variance and standard deviation for the following project

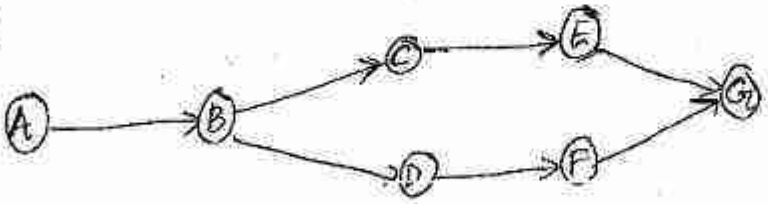
Activity	Predecessors	to	tm	tp
A	—	2	4	9
B	A	5	8	14
C	B	4	10	13
D	B	4	7	10
E	C	11	14	20
F	D	9	13	16
G	E, F	2	4	6

Ans)

AOA



AON

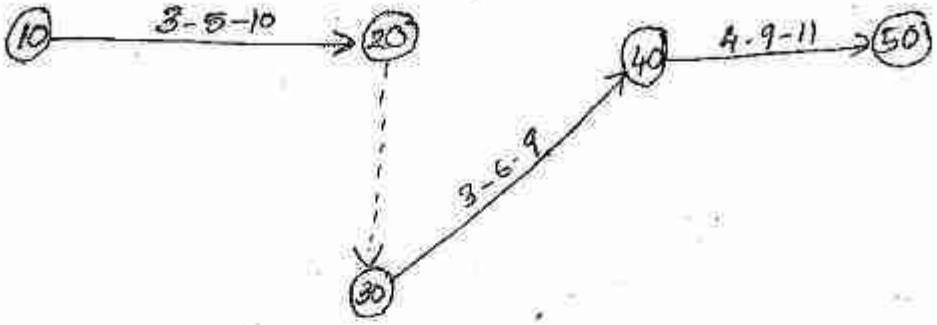


We cannot do 3 time estimation on AON.

Activity	te	σ	σ^2
A	4.5	1.16	1.36
B	8.5	1.5	2.25
C	9.5	1.5	1
D	7	1	
E	14.5	1.5	2.25
F	12.83	1.16	1.36
G	5.66	0.66	0.44
			10.99

$\Sigma te = 62.49$ $\Sigma \sigma = 8.48$

Q. A path contain n/w is shown in the fig. with the time estimates for it activities has mentioned along each activity. Determine the expected time for the path and what is the standard deviation for the path. (7)



Ans) Path A : 10 — 20 — 30 — 40 — 50.

Activity	t_o	t_m	t_p	t_e	σ	σ^2
10-20	3	5	10	5.5	1.16	1.361
20-30	0	0	0	0	0	0
30-40	3	6	9	6	1	1
40-50	4	9	11	8.5	1.66	1.36.

$\Sigma t_e = 20 \quad \Sigma\sigma = 3.33 \quad \Sigma\sigma^2 = 3.72$

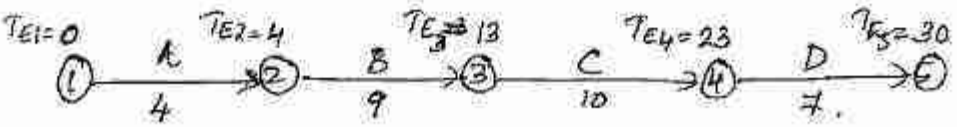
Event time Calculations

1) Earliest Occurance event Time. (T_E) $\longrightarrow T_{Ej} = T_{Ei} + t_{ij}$

2) Latest occurance allowable event time (T_L) $\rightarrow T_{Li} = T_{Lj} - t_{ij}$

$$\boxed{\text{Slack} = T_L - T_E}$$

Q. Find out the earliest event time for all the events of the simple n/w and represent in tabular form.



Ans) $T_{E2} = T_{E1} + t_{1-2} = 0 + 4 = 4$

$T_{E3} = T_{E2} + t_{2-3} = 4 + 9 = 13$

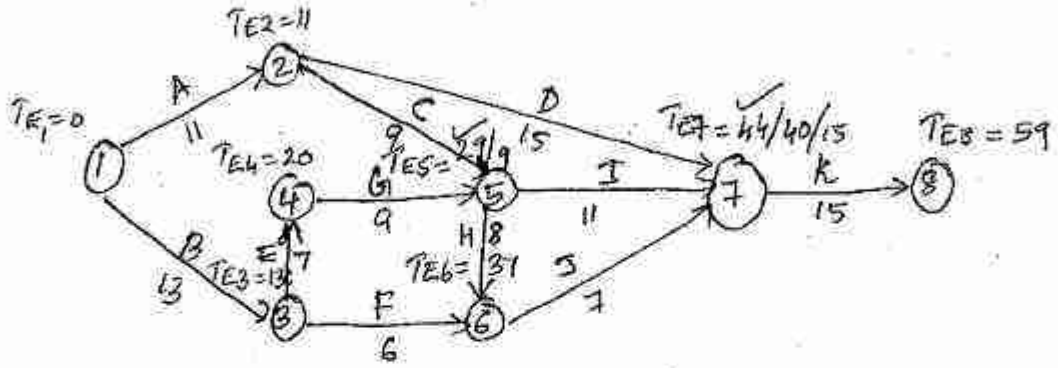
$T_{E4} = T_{E3} + t_{3-4} = 13 + 10 = 23$

$T_{E5} = T_{E4} + t_{4-5} = 23 + 7 = 30$

(4)

Node	Activity	tij	TEj
2	A	4	4
3	B	9	13
4	C	10	23
5	D	7	30

Q. Find out the earliest event time for all the events of the simple n/w and represent in tabular form.



Ans).

$T_{E1} = 0$

$T_{E2} = T_{E1} + t_{1-2} = 0 + 11 = 11$

$T_{E3} = T_{E1} + t_{1-3} = 0 + 13 = 13$

$T_{E4} = T_{E3} + t_{3-4} = 13 + 11 = 20$

$T_{E5} = T_{E4} + t_{4-5} = 20 + 9 = 29$

$T_{E5} = T_{E1} + t_{2-5} = 0 + 9 = 9$ } 29

$T_{E6} = T_{E5} + t_{5-6} = 29 + 2 = 31$

$T_{E7} = T_{E6} + t_{6-7} = 37 + 7 = 44$

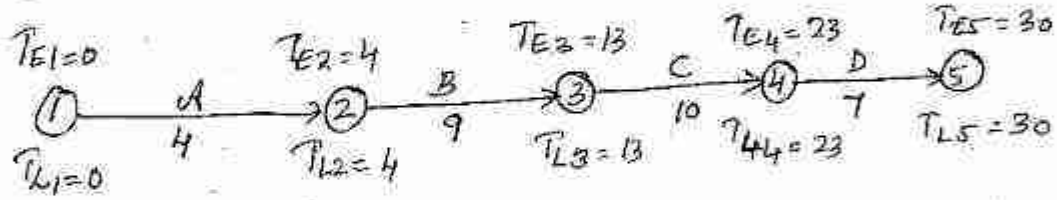
$T_{E7} = T_{E5} + t_{5-7} = 29 + 11 = 40$

$T_{E7} = T_{E1} + t_{2-7} = 0 + 15 = 15$ } 44

$T_{E8} = T_{E7} + t_{7-8} = 44 + 15 = 59.$

Node	Activity	t_{ij}	T_{Ej}	T_E
1	—	—	—	0
2	1-2	11	11	11
3	1-3	13	13	13
4	3-4	7	20	20
5	4-5	9	29	29
	2-5	9	9 (29)	
6	5-6	8	37	37
7	5-7	11	40	44
	6-7	7	24 (44)	
	2-7	15	26	
8	7-8	15	59	59

Q. Calculate the latest occurance time of all the events in the following n/w.



Ans).

$T_{E1} = 0$

$T_{E2} = T_{E1} + t_{1-2} = 0 + 4 = 4$

$T_{E3} = T_{E2} + t_{2-3} = 4 + 9 = 13$

$T_{E4} = T_{E3} + t_{3-4} = 13 + 10 = 23$

$T_{E5} = T_{E4} + t_{4-5} = 23 + 7 = 30.$

$T_{L5} = T_{E5} = 30$

$T_{L4} = T_{L5} - t_{4-5} = 30 - 7 = 23$

$T_{L3} = T_{L4} - t_{3-4} = 23 - 10 = 13$

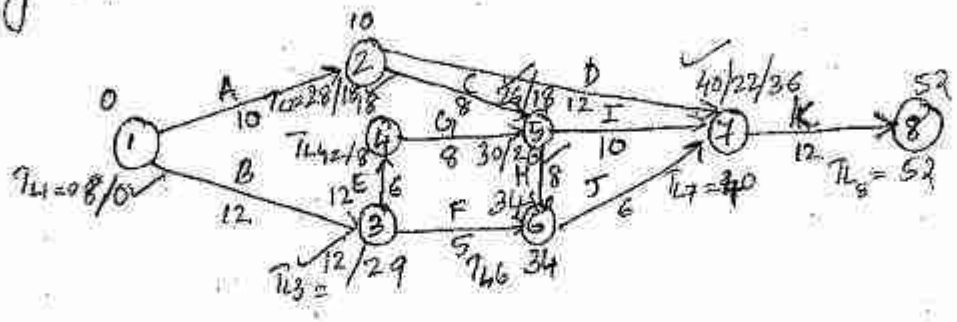
$T_{L2} = T_{L3} - t_{2-3} = 13 - 9 = 4$

$T_{L1} = T_{L2} - t_{1-2} = 4 - 4 = 0.$

(10)

Node	Activity	t_{ij}	T_E	T_L
2	1-7	4	4	4
3	2-3	9	13	13
4	3-4	10	23	23
5	4-5	7.	30	30

Q. Calculate the latest occurance time and critical path of the following nfw.



Ans). $T_{E1} = 0$

$T_{E2} = T_{E1} + t_{1-2} = 0 + 10 = 10$

$T_{E3} = T_{E1} + t_{1-3} = 0 + 12 = 12$

$T_{E4} = T_{E3} + t_{3-4} = 12 + 6 = 18$

$T_{E5} = T_{E4} + t_{4-5} = 18 + 8 = 26$
$T_{E5} = T_{E2} + t_{2-5} = 10 + 8 = 18$ } 26

$T_{E6} = T_{E5} + T_{5-6} = 26 + 8 = 34$

$T_{E7} = T_{E6} + t_{6-7} = 34 + 6 = 40$
$T_{E7} = T_{E2} + t_{2-7} = 10 + 12 = 22$
$T_{E7} = T_{E5} + t_{5-7} = 26 + 10 = 36$ } 40

$T_{E8} = T_{E7} + t_{7-8} = 40 + 12 = 52.$

$T_{L8} = T_{E8} = 52$

$T_{L7} = T_{L8} - t_{7-8} = 52 - 12 = 40$

$T_{L6} = T_{L7} - t_{6-7} = 40 - 6 = 34$

$T_{L5} = T_{L7} - t_{5-7} = 40 - 10 = 30$

$T_{L5} = T_{L7} - t_{6-5} = 34 - 8 = (26)$

$T_{L4} = T_{L5} - t_{4-5} = 26 - 8 = 18$

$T_{L3} = T_{L4} - t_{3-4} = 18 - 6 = (12)$

$T_{L3} = T_{L6} - t_{3-6} = 34 - 5 - 27$

$T_{L2} = T_{L7} - t_{2-7} = 40 - 12 = 28$

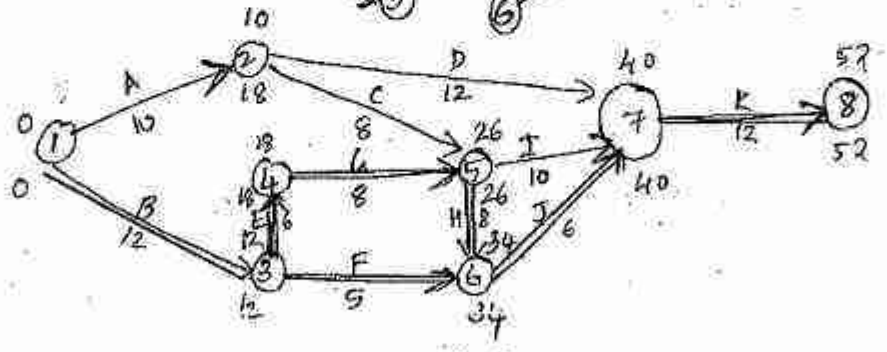
$T_{L2} = T_{L5} - t_{2-7} = 26 - 8 = (18)$

$T_{L1} = T_{L2} - t_{1-2} = 18 - 10 =$

$T_{L1} = T_{L3} - t_{1-3} = 12 - 12 = (0)$

Event/Node	Activity	t_{ij}	T_{Ej}	T_E	T_{Li}	T_L	Slack, $(T_L - T_E)$
1	–	–	0	0	18−10=8 12−12=0 } 0	0	0
2	1-2	10	10	10	40−12=28 26−8=18 } 18	18	8
3	1-3	12	12	12	18−6=12 34−5=29 } 12	12	0
4	3-4	6	18	18	18	18	0
5	2-5	8	18	26	40−10=30 34−8=26 } 26	26	0
	4-5	8	26 } 26				
6	5-6	8	34	34	34	34	0
	3-6	5	17 } 34				
7	2-7	12	22	40	40	40	0
	5-7	10	36 } 40				
	6-7	6	40				
8	7-8	12	52	52	52	52	0

Critical path : 1 → 4 → 5 → 7 → 8



CPM

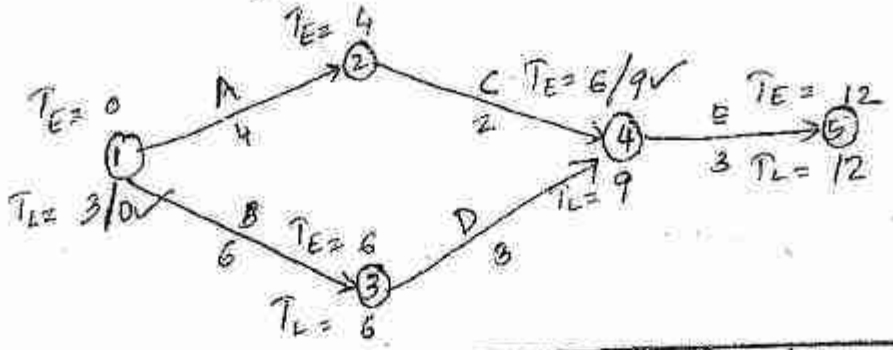
Activity Times:

1) Early Start Time (EST) = $T_E \Rightarrow T_{Ej} = T_{Ei} + t_{ij}$
2) Early Finish Time (EFT) = $T_E + t_{ij} \Rightarrow EST + t_{ij}$
3) Late Start Time (LST) = $T_L - t_{ij} \Rightarrow LFT - t_{ij}$
4) Late Finish Time (LFT) = $T_L \Rightarrow T_{Li} = T_{Lj} - t_{ij}$

(12)

Float = LST − EST / LFT − EFT

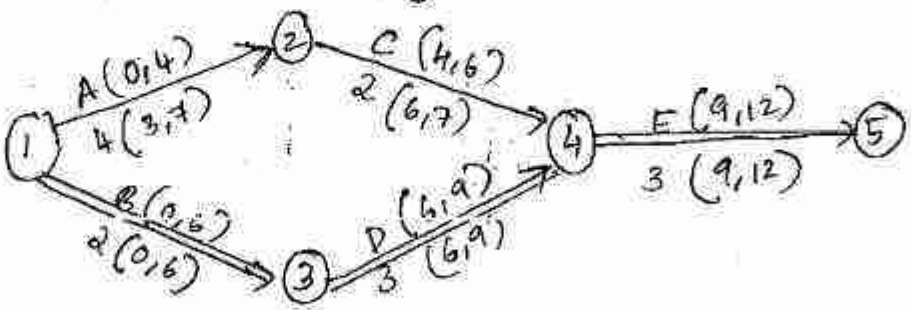
Q. Calculate the activity times and find out the critical path



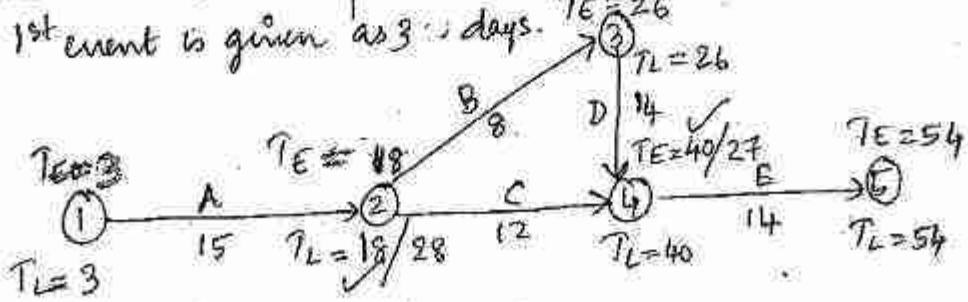
Ans.

Activity	Duration (tij)	EST (TE)	EFT (EST+tij)	LST (LFT−tij)	LFT (TL)	Float LST−EST/LFT−EFT
1-2	6	0	4	3	7	3
1-3	2	0	6	0	6	0
2-4	2	4	6	7	9	3
3-4	3	6	9	6	9	0
4-5	3	9	12	9	12	0

Critical path :- 1 → 3 → 4 → 5

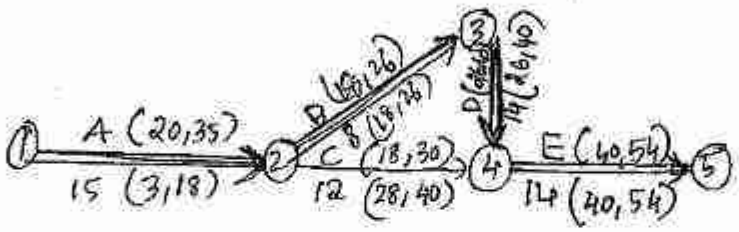


Q. Find out the critical path. Also calculate the activity times.
TE of 1st event is given as 3 days.

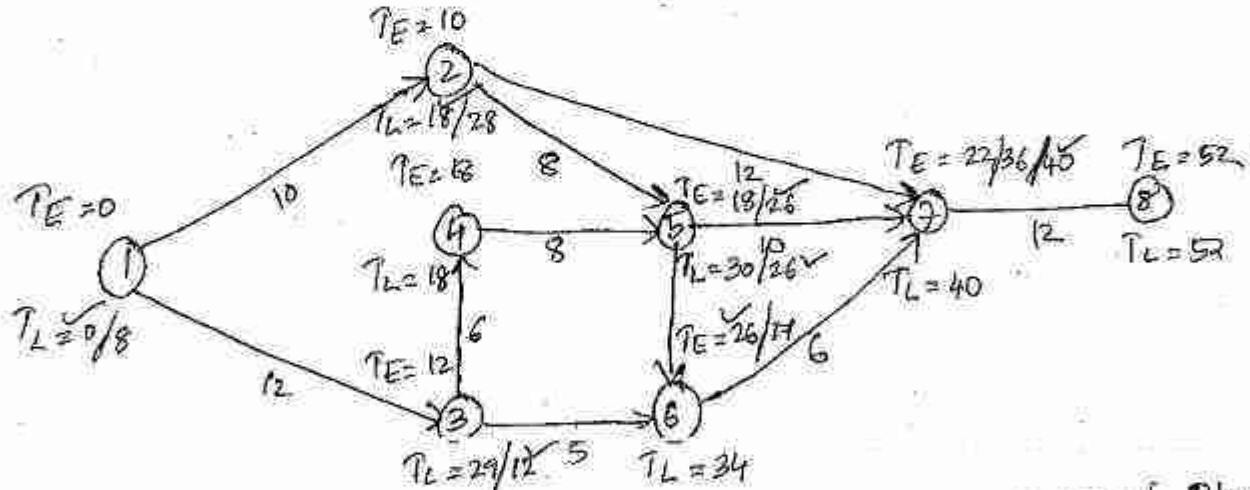


Activity	Duration t_{ij}	T_E EST	EST+t_{ij} EFT	LFT−t_{ij} LST	T_L LFT	(LFT−EFT) / (LST−EST) Float
1-2	5	20	35	3	18	-17
2-3	8	18	26	18	26	0
2-4	12	18	30	28	40	10
3-4	14	26	40	26	40	0
4-5	14	40	54	40	54	0

Critical path : 1 → 2 → 3 → 4 → 5



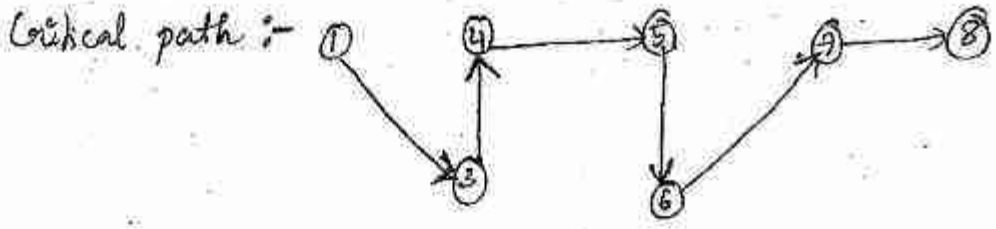
Q. Calculate EST, EFT, LST, LFT and find out the critical path

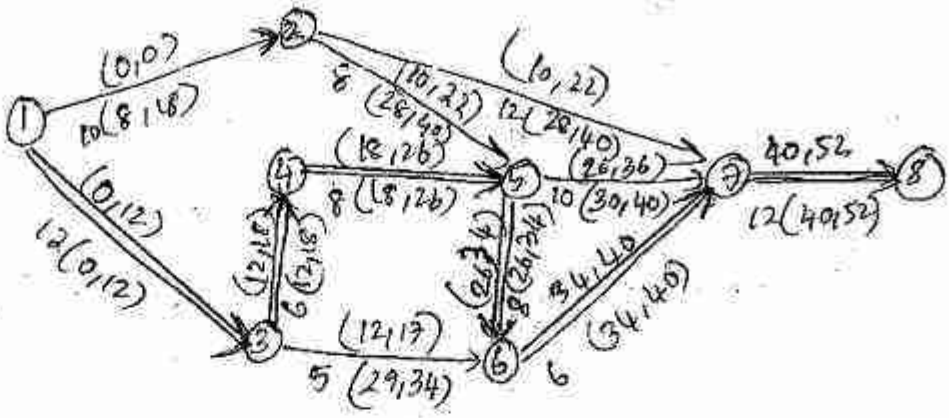


Activity	Duration (t_{ij})	EST (T_E)	EFT (EST+t_{ij})	LST (LFT−t_{ij})	LFT (T_L)	Float LFT−EFT / LST−EST
1-2	10	0	10	8	18	8
1-3	12	0	12	0	12	0
2-5	8	10	18	18	26	8
2-7	12	10	22	28	40	18
3-4	6	12	18	12	18	0
3-6	5	12	17	29	34	17
4-5	8	18	26	18	26	0
5-6	8	26	34	26	34	0
6-7	6	34	40	34	40	0
5-7	10	26	36	30	40	4
7-8	12	40	52	40	52	0

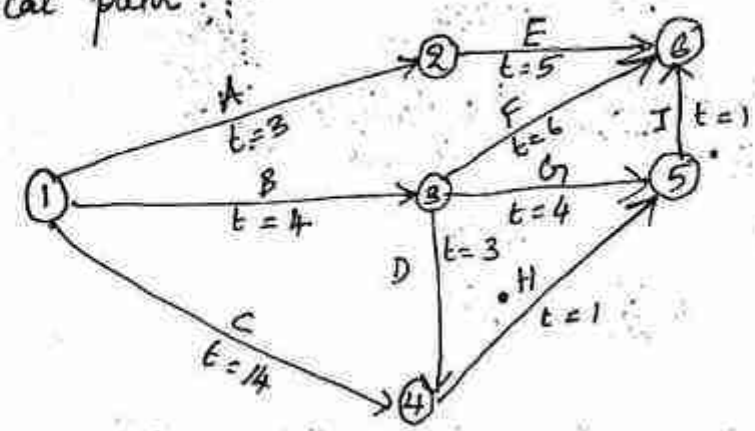
(14)

Critical path :-

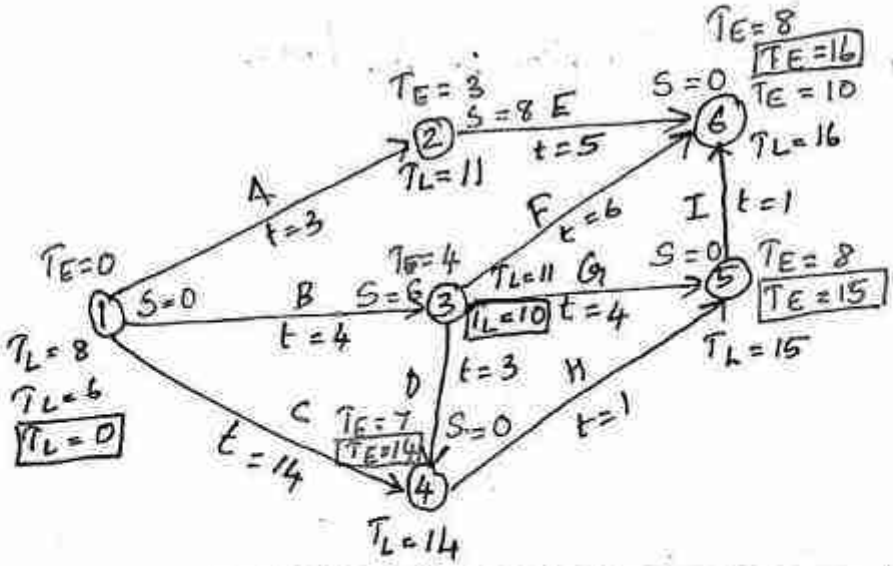




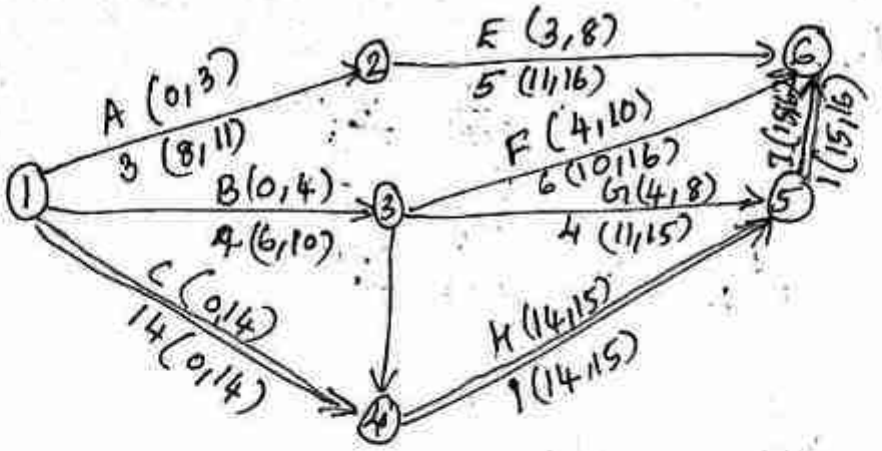
Q. Calalate EFT, LFT, LST, EST, F_F, F_F, F_{ID}, F_{IF} and identify the critical path.:



Ans:-



Activity	tij	EST (T_E)	EFT (EST+tij)	LST (LFT-tij)	LFT (T_L)	F_T (LST-EST / LFT-EFT)	F_F (T_E-S_j)	F_{ID} (F_F+S_i)	F_{IF} (S_j)
1-2	3	0	3	8	11	8	0	0	8
1-3	4	0	4	6	10	6	0	0	6
1-4	14	0	14	0	14	0	0	0	0
2-6	5	3	8	11	16	8	8	0	0
3-4	3	4	7	11	14	7	7	1	0
3-5	4	4	8	11	15	7	7	1	0
3-6	6	4	10	10	16	6	6	0	0
4-5	1	14	15	14	15	0	0	0	0
5-6	1	15	16	15	16	0	0	0	0



Critical path :- 1 → 4 → 5 → 6

Total project Duration :- 16. days.

Main advantages of the network system are as follows:

1. Detailed and thoughtful planning provides better analysis and logical thinking.

2. Identifies the critical activities and focus them to provide greater managerial attention.

3. Network technique enables to forecast project duration more accurately.

4. It is a powerful tool for optimisation of resources by using the concept of slack.

5. It provides a scientific basis for monitoring, review and control, to evaluate effect of slippages.

6. It helps in taking decision;

(i) To over-come delays,

(ii) To crashing programme,

(iii) Optimising resources, and

(iv) On other corrective actions.

7. It helps in getting better co-ordination amongst related fields.

8. It is an effective management tool through a common and simple language, providing common understanding.

Network techniques have following limitations:

(i) Network technique is simply a tool to help the management; hence its effectiveness depends on how well it is used by the management.

(ii) Its accuracy depends on the estimation of the data used in the network.

(iii) It is useful only if it is updated regularly and decisions for corrective actions are taken timely.