

CONSTRUCTION MANAGEMENT & SAFETY ENGINEERING

(SUBJECT CODE : 5012)



**Department of Civil Engineering
Government Polytechnic College Manjeri**

NISHMA M NAIR

Lecturer in Civil dept. GPTCM

SYLLUBUS

Module 1: – Planning and Organizational aspects, Constructional planning, organizational structure

Module 2: – Execution of works, Contracts, Tender and tender notices, Measurement of works, Payment of bills

Module 3: – Introduction to Human Resource Management, Stores, Managing materials and machinery

Module 4: – Principles of safety in construction activity , Entrepreneurship and management, Introduction to small scale Industries, Introduction to quality control, T.Q.M and I.S.O 9000

MODULE 1-CONTENTS

Introduction to construction projects: – Types of construction projects – Elements of construction project – Overview of construction industry – Importance of construction projects – Functions of construction management – Planning and its importance – Details to be collected during planning and preparation of detailed project report - Scheduling – Organizing – Directing – Controlling – Increasing productivity.

Different stages in construction project: – Idea formulation – Investigation - Feasibility study/Report – Project implementation - Types of estimate – Rough cost estimate and detailed estimate – Financial management – cash flow - Budget – Seeking budget provision – Bills of appropriation – AS and TS.

Organizational structure of PWD/PSU: – Duties and responsibilities of Overseer, AE, AEE, EE, SE and CE. Types Establishment – Regular or permanent establishment – Work charged establishment –CLR and NMR workers.

Project management tools: – Bar chart – Network models – CPM – Project duration – EPO – LPO – ESTEFT – LST – LFT - Total float – Free float – Independent float – PERT – Calculation of expected time - Slack time – Comparison between Bar chart, CPM and PERT. Project crashing – Information about project management software - Resource leveling and resource smoothing - Time cost trade off - Job lay out – Modern housekeeping principles - Work study - Time and motion study.

INTRODUCTION-CONSTRUCTION INDUSTRY

- The construction industry is the largest industry in the world
- It is an indicator of the economic conditions of a country.
- Consumes a wide employment circle of labour.
- Most projects exhibit cost overruns, time extensions, and conflicts among parties.
- The construction industry is more challenging than other industries due to: its unique nature; every project is one-of a kind; many conflicting parties are involved; projects are constrained by time, money and quality; and high risk.

THE CONSTRUCTION PROJECT

A project is defined, whether it is in construction or not, by the following characteristics:-

A defined **goal or objective**. -**Specific tasks** to be performed. -A **defined beginning and end**. -**Resources** (Time, money, labour, equipment, and, materials) **being consumed**

The goal of construction project is to build something



CHARACTERISTICS OF CONSTRUCTION PROJECT

- The project should have a specific target
- The project should be unique and cannot be replicate with the same task and resources giving the same result
- The construction project should satisfy the owners requirements and expectations from the project.
- The time limit for completion of project shall be defined
- The project manager must be flexible to accommodate any change that might occur during the project
- The total cost of construction project shall be defined and project shall be completed within the given budget

CLASSIFICATION OF CONSTRUCTION PROJECTS

1. Based on cost of construction

- ❖ Minor projects –budget below 20000
- ❖ Medium projects -budget in between 20000 to 100000
- ❖ Major projects –budget above 1 lakh

2. Based on life requirement

- ❖ Permanent -constructed for a long period of life
- ❖ Semi permanent-life span is small and can be dismantled and replaced
- ❖ Temporary structures -using cheaper materials and dismantled easily.

3. Based on types and structural members and equipment

- ❖ Light construction -using light structures, having light foundation and not involving heavy machinery
- ❖ Heavy construction -using heavy structures, having massive foundation and involving heavy machinery

4. Based on the mode/agency of execution

- ❖ Public sector/government projects- Fully owned and funded by state/central govt. executed through PWD/CPWD or any other engineering wing.

- ❖ Quasi govt. /Public sector undertakings (PSU)-Major shares of these companies (>51%) are held by the govt. Eg:- Cochin Refinery, IOCL
- ❖ Public Private Participation (PPP) – Major share is with public and govt. will hold lesser share so that the burden will be less for govt. and the profit will be shared between public and govt. Eg:- CIAL
- ❖ Co-operative sector-projects undertaken by people in Co-operative organisations.
- ❖ Private sector projects: Project undertaken by private organisations. Eg:-TATA
- ❖ Build Operate and Transfer(BOT)-Fund raised by contractor, land given by govt. and contractor recovers investment and profit by collection toll. Eg:- Highway projects

- ❖ Consortium- association of different organisations to achieve a goal/execute a project. It is needed when single agency does not have an expertise to execute a big project having multidisciplinary skills. (not a permanent association)

4. Based on their nature

- ❖ Infrastructure projects like roads, railways, airport, buildings, communication and power network
- ❖ Housing projects
- ❖ Hydraulic structures like dams
- ❖ Industrial projects like factories, production centres
- ❖ It enabled projects

ELEMENTS OF CONSTRUCTION PROJECTS

- ☐ Man Power (Managers, Technocrat, Labours)
- ☐ Materials (Natural resources, Engineering materials)
- ☐ Machinery (Construction, Transporting & Earth moving Equipments)
- ☐ Money
- ☐ Space

IMPORTANCE OF CONSTRUCTION PROJECT

- It is the largest sector which provides employment
- Improved infrastructure like roads, buildings, electricity, communication networks, drinking water supply
- It is necessary to maintain existing infrastructure facilities
- Housing projects helps to eradicate slums
- Construction of dams provides energy and also water for irrigation and drinking purposes
- The roads, railway & ports addresses the transportation needs of the society

STAGES IN CONSTRUCTION PROJECT

➤ Idea formulation stage

- Scope, feasibility, benefits and revenue from commercial projects and socio-economic viability of public project were studied.

➤ Investigation , planning and scheduling

- Detailed drawings and design prepared
- Data from primary/secondary sources
- Sanctions
- EIA (Environmental impact assessment)

➤ Tendering and contracting

➤ Execution phase

➤ Completion and handing over

- Handing over to client/owner with completion drawing and occupancy fitness certificate from the local body.
- In some cases it is done after trial run/safety inspection (eg: railway/production projects)

CONSTRUCTION MANAGEMENT

The aim of project management is to successfully achieve the objective of the project by completing it **on schedule, within the cost and performance criteria with prescribed human ,physical resources and other constraints.**

NEED FOR CONSTRUCTION MANAGEMENT

- ✓ Optimization of resource utilization
- ✓ Minimises the wastage
- ✓ Helps to avoid the delay in project schedule
- ✓ Ensure quality through effective quality control
- ✓ Ensures safety at project site
- ✓ Provides better financial management
- ✓ Improves productivity and profitability

FUNCTIONS OF CONSTRUCTION MANAGEMENT

- ☐ Planning
- ☐ Organizing
- ☐ Staffing
- ☐ Directing
- ☐ Controlling
- ☐ Co-ordinating



PLANNING AND SCHEDULING

It is the process of selecting a particular method and the order of work to be adopted for a project from all the possible ways and sequences in which it could be done. It essentially covers the aspects of 'What to do' and 'How to do it'

It involves

- The choice of technology
- Defining work tasks
- Estimation of required resources
- Estimation of time duration of individual tasks
- Identification of interaction among different tasks

IMPORTANCE OF PLANNING

- 'If we fail to plan; we are planning for a failure'
- Well planned project can be executed as per the scheduled programme within the budgeted cost
- Planning helps to minimize the cost by optimum utilization of available resources
- Planning reduces irrational approaches, duplication of works and inter departmental conflicts.
- Fund flow should be ensured at this stage
- Helps in quality control and ensure safety
- Some factors like natural calamities may be beyond our control, but precaution can mitigate ill effects

MAJOR STEPS INVOLVED IN PLANNING A PROJECT

1. Collection of data

- Data includes Client requirements, Statutory requirements, preliminary details of design and quantity, specification, labour & material availability, source and lead time of material, machinery and equipment requirement, soil exploration details, climatic conditions, fund flow etc
- For mega projects (dam, highway), we need traffic data, hydraulic data, environmental data etc
- From authentic sources (rainfall data from meteorological dept.) - secondary data
- Through direct observation (traffic volume, stream discharge) – primary data

2. Planning and scheduling

- Identify the activities and arrange in logical sequence keeping their interdependencies
- Prepare schedule with time duration
- Identify the critical activity
- Prepare an accurate estimate, analyse the fund requirement and prepare a fund flow chart
- Analyse anticipated hurdles and take precautionary measures

3. Feasibility report & Detailed project report (DPR)

- Feasibility report is the preliminary report containing salient features of the project (cost and benefit, socio-economic studies) to convince client about need of project and obtain budget allocation
- But a **DPR** contain **all information** required for implementing project
 - Geographic details of the project location
 - Infrastructure connectivity by road, railway, sea port , airport etc
 - Soil exploration details
 - Availability and sources of raw materials
 - Availability of energy sources and tariff

- Availability of skilled & unskilled labours
- Availability of water
- Climatic factors
- Project details such as design, drawings and estimate
- Details of fund flow
- List of machineries and equipments
- Project schedule time line
- Environmental parameters (EIA report)

4. Obtaining sanction

- Administrative and technical sanction should be obtained from concerned authority

5. Identifying contractor and vendors

- Competency and financial stability of the contractor should be a major criterion in selecting contractor
- Past experience and special equipments are required for executing special type of projects
- Ensure availability & quality of materials while selecting vendors
- Care should be taken while making specifications and formulating the clauses of a contract

ORGANIZING

Organizing is concerned with decision of the total construction work into manageable departments/sections and systematically managing various operations by delegating specific tasks to individuals.

Organizing involves,

- ✓ Identification of activities
- ✓ Classification of grouping activities
- ✓ Assignment of duties
- ✓ Delegation of authority and creation of responsibility

STAFFING (HR MANAGEMENT)

Staffing is the provision of right people to each section / department created for successful completion of a construction project.

It involves,

- ✓ Recruiting the right people
- ✓ Arranging staff training courses
- ✓ Carryout people staff assessment

DIRECTING

It is concerned with training subordinates to carry out assigned tasks, supervising their work and guiding their efforts. It also involves motivating staff to achieve desired results. **IT IS DONE PARALLEL TO EXECUTION**

CONTROLLING

It involves a constant review of the work plan to check on actual achievements and to discover and rectify deviation through appropriate corrective measures. Controlling is necessary for ensuring effective and efficient working.

COORDINATING

It involves bringing together and coordinating the work of various departments and sections so as to have good communication. It is necessary for each section to aware of its role and the assistance to be expected from others

TYPES OF ESTIMATE

An estimate is the statement of the anticipated expenditure for various items of work involved in a project. Prepared based on design, drawings and specifications.

- ❖ Preliminary estimate/Rough cost estimate
- ❖ Detailed estimate
- ❖ Revised estimate
- ❖ Supplementary estimate

Preliminary estimate/Rough cost estimate

- It is prepared on the basis of preliminary details of the project
- It is prepared based on the unit cost incurred for a similar project completed in the recent past which is identical to the proposed project with respect to the type of construction, specification, location etc
- Unit is taken as plinth area and it is multiplied with plinth area rate in case of buildings
- In the case of canal, road, pipe line etc the total length is multiplied with unit rate per meter or kilo meter
- In the case of projects where volume is relevant , approximate volume is then multiplied with cubic rate

Detailed estimate

- Here the actual quantities are worked out from the drawings and it is multiplied with item rate analysed based on specification
- The abstract of detailed estimate gives the estimated total cost of the project
- It is prepared for the sanctions of the project

Revised estimate

- It is prepared whenever there is a change in the rates, quantities of items or specifications

Supplementary estimate

- It is prepared for the additional work which is beyond the scope of original project estimate
- These additional works become necessary due to demands from concerned department during on going project

FINANCIAL MANAGEMENT

- It is mainly concerned with the proper management of funds
- For timely completion of the project we have to ensure the availability of funds as and when it is required
- Fund planning should be realistic with accurate estimation and confirmed sources of funds
- The financial management fails either when the work exceeds estimated quantity or due to price escalation or due to non availability of funds at proper time or due to combination of these reasons

- Unforeseen events like natural calamities will also leads to financial crisis
- Very detailed planning, detailed drawings and design, accurate quantity surveying, proper market analysing and material selection, selecting reliable contractors and vendors and ensuring sources and availability of fund on time are essential factors of financial management

BUDGET

- ✓ It is the statement of anticipated income and expenditure of the state
- ✓ Budget proposals should be confidential and should not be revealed until it is presented by the financial minister in assembly or Parliament
- ✓ Heads of each department submit their fund requirements through budget proposal well in advance every year
- ✓ Finance departments consolidates these proposals and shape the budget based on probable income generation

ADMINISTRATIVE SANCTION

- This term denotes the formal acceptance by the administrative department concerned of the proposals for incurring expenditure in the Public Works Department on a work initiated by, or connected with, the requirements of such administrative department.

TECHNICAL SANCTION

- This is the responsibility of PWD. After administrative approval, PWD obtains technical sanction of authorised officer of PWD.

EXPENDITURE SANCTION

- It represents allotment of money to meet the expenditure. It is usually accorded by finance department.

ORGANIZATIONAL STRUCTURE OF PWD

The engineering department of the govt. deal with the construction and maintenance of public works such as building roads, bridges, canals, dams etc.

CENTRAL GOVERNMENT DEPARTMENTS

- Central public works departments(CPWD)
- Post and telegraph construction department
- Military engineering services(MES)
- National thermal power corporation(NTPC)
- National hydro electric power corporation ltd (NHPC)

STATE GOVERNMENT DEPARTMENTS

- Public work department
- Irrigation department
- Public health engineering department
- Roads and building department
- State electricity board -civil engineering
- Medical and health infrastructure

Chief Engineer, PWD,WRD



Superintending
Engineer, PWD,WRD



Executive Engineer,
PWD,WRD



Assistant Executive
Engineer, PWD,WRD



Assistant Engineer,
PWD,WRD

TYPES OF ESTABLISHMENT

REGULAR ESTABLISHMENT

- ✓ They are posted in department to look after all the works executed through the department
- ✓ They may be posted in project or administrative wing
- ✓ May be transferred from one place to other according to requirements of the department
- ✓ Appointed through PSC and if PSC candidate not available recruitment through employment exchange will be done.

WORK CHARGE ESTABLISHMENT

- ✓ Large number of employees may be required for major projects and for that employees are recruited and their salaries are met from project cost
- ✓ Their appointment may be on a contract basis or daily wage basis

Two Categories

1. CASUAL LABOUR ROLL (CLR)

- ❖ They are paid with out mustering the outturn; based on actual number of days they have worked in a month
Eg:- peon, watchman, driver etc

2. NOMINAL MUSTER ROLL (NMR)

- ❖ outturns of carpenter, Mason, earth workers are measurable and hence they are paid mustering the out turn
- ❖ Payment is made on the basis of actual number of days worked based on the ' Required outturn has been obtained Certificate by the engineer in charge

PROJECT MANAGEMENT TOOLS

- It can be defined as structural way of planning, scheduling, executing, monitoring and motivating and controlling various phases of a project.
- The techniques or the methodology adopted to control or manage a project can be referred as a project management tool
- It should be able to schedule and if necessary reschedule the activities forming a project using the project management tool

1. Bar charts or Gantt charts
2. Milestone charts
3. Network analysis

BAR CHARTS / GANTT CHARTS

- Introduced by Henry Gantt around 1900 AD
- It consists of two coordinate axes: one represents the jobs/activities to be performed and the other representing the time elapsed

Gantt Chart

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

Task Name	Q1 2019			Q2 2019		Q3 2019
	Jan 19	Feb 19	Mar 19	Apr 19	Jun 19	Jul 19
Planning						
Research						
Design						
Implementation						
Follow up						

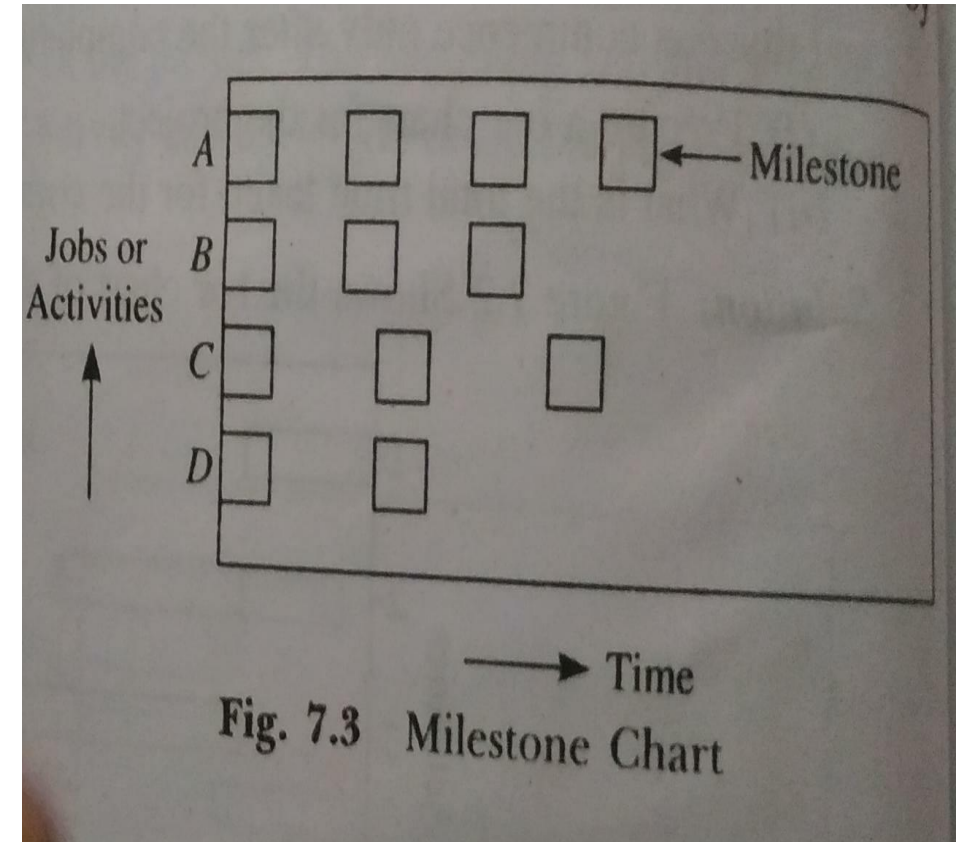
- Limitations

1. They can be used only for small projects
2. It doesn't show the interdependencies between the various activities in the project
3. Delays in work cannot be detected
4. The progress of the work in the project cannot be monitored scientifically
5. It does not indicate the critical activities of the project

Even though the bar chart is having several disadvantages still it can be successfully employed in the case of small projects where number of activities are limited

MILESTONE CHART

- It is a modification over the bar chart
- In every activity there are certain key events which are to be carried out for the completion of the activity I. Such key events are called milestone
- Limitations
 - Interdependencies between milestones is not shown



NETWORK ANALYSIS

- A network diagram is a flow chart of all tasks which make up a project.
- The chart demonstrates how each tasks relates to another.
- Commonly used.

2 common network model concepts

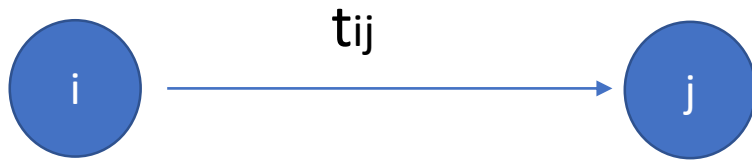
1. CRITICAL PATH METHOD (CPM)
2. PERT (Program Evaluation and Review Technique)

CRITICAL PATH METHOD

- CPM networks are usually used for repetitive type of project
- Deterministic approach
- It is a network comprising events and activities
- The network is activity oriented
- The activities are represented by arrows and circles
- The activities are connected in logical sequences
- The time allotted to each activity is related to cost

TERMS USED IN CPM

We can use the following notation to explain these terms



1. Activity (ij)

- Jobs or tasks involved in a project
- It requires time as well as one or many resources like human resource, vehicles, materials, services etc
- Represented by an arrow

2. Duration (t_{ij})

- The time required for completing an activity
- It may be hours, days, weeks depending on the project

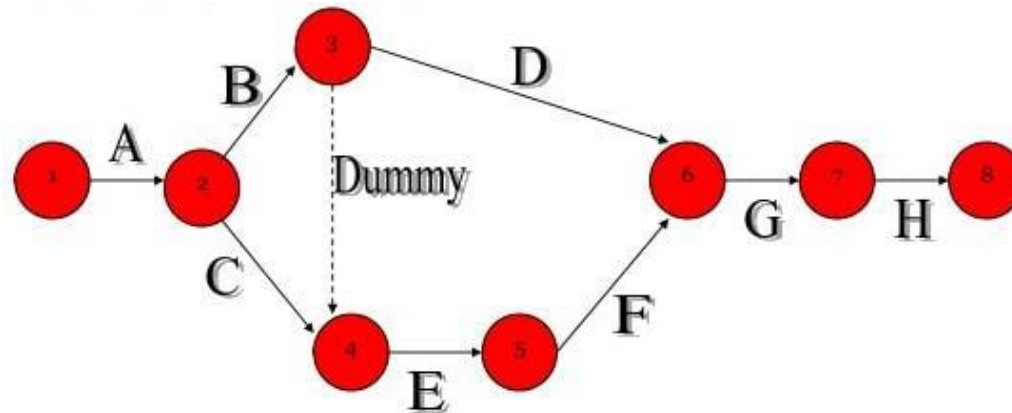
3. Event or node (i- starting node or event of activity ij j – ending node or event of activity ij)

- It refers to the start or finish of an activity.
- Denoted by a circle
- An event is said to happen when all the activities ending at that node finish
- The beginning of an activity is a tail event and completion of an activity is called head even

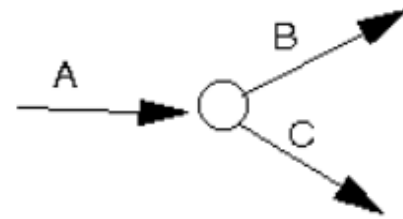
3. Successor event: the event that follows a particular event in the sequence of their completion
4. Predecessor event: the event that occurs before a particular event
5. Predecessor activity: activity or activities that are required to be performed before an activity under considerations
6. Successor activity: activity or activities that are required to be performed after completion of an activity under considerations

7. Dummy activity:

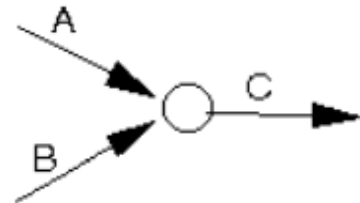
- A dummy activity is an imaginary activity.
- It does not exist in the project activities
- It is used in the network diagram to show dependency relationship or connectivity between two or more activities.
- It is represented by a dotted arrow.



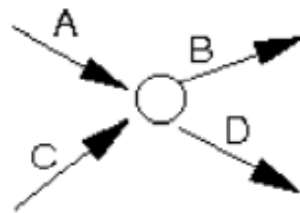
SITUATIONS IN NETWORK DIAGRAM



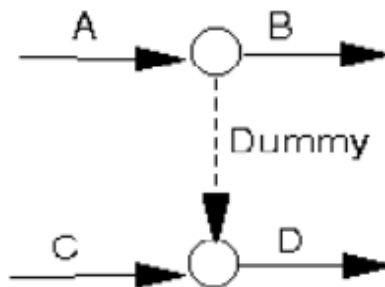
A must finish before either B or C can start



both A and B must finish before C can start



both A and C must finish before either of B or D can start



A must finish before B can start

both A and C must finish before D can start



Earliest start time(EST): it is the earliest possible time for the activity to start without changing the sequence of the activity in the network

Earliest finish time(EFT): it is the earliest time by which the activity can be completed and is denoted by EFT

$$EFT = EST + \text{duration of activity}(t_{ij})$$

Latest start time(LST): it is the latest time by which an activity can be started without delaying the project

$$LST = LFT - \text{duration of activity}(t_{ij})$$

Latest finish time(LFT): it is the latest time by which an activity can be completed without delaying the project

FLOAT

- ✓ Float is spare time associated with an activity
- ✓ It is the excess time available with an activity in addition to the minimum time required for the completion of that activity without affecting the scheduled completion of that project]
- ✓ In PERT network the term used for float is **slack time**
- ✓ Float can be divided into three
 - A. Total Float
 - B. Free Float
 - C. Independent Float
 - D. Interfering float

1. TOTAL FLOAT

- it is the difference between the maximum time allowed for an activity and its duration of time. ($LFT - EST - t_{ij}$)
- Time span by which the starting/finishing of an activity can be delayed without affecting the overall completion time of the project
- It is calculated by assuming the starting node happening at the earliest possible time and finishing node at the latest possible time
- It cannot be a negative value

$$TF = LST - EST = LFT - EFT$$

2. FREE FLOAT

- It is that duration by which an activity can be delayed without delaying any other succeeding activity
- Here both starting and finishing node happens at earliest possible time

$$FF = (EFT - EST) - t_{ij}$$

2. INDEPENDANT FLOAT

- It is the float available with an activity considering the worst situation that is with starting event of the activity happening at latest possible time and finishing event happening at its earliest possible time

$$IF = (EFT - LST) - t_{ij}$$

4. INTERFERING FLOAT

- It is the difference between total float and free float

NETWORK CONSTRUCTION

(drawing CPM network-FULKERSON'S RULE)

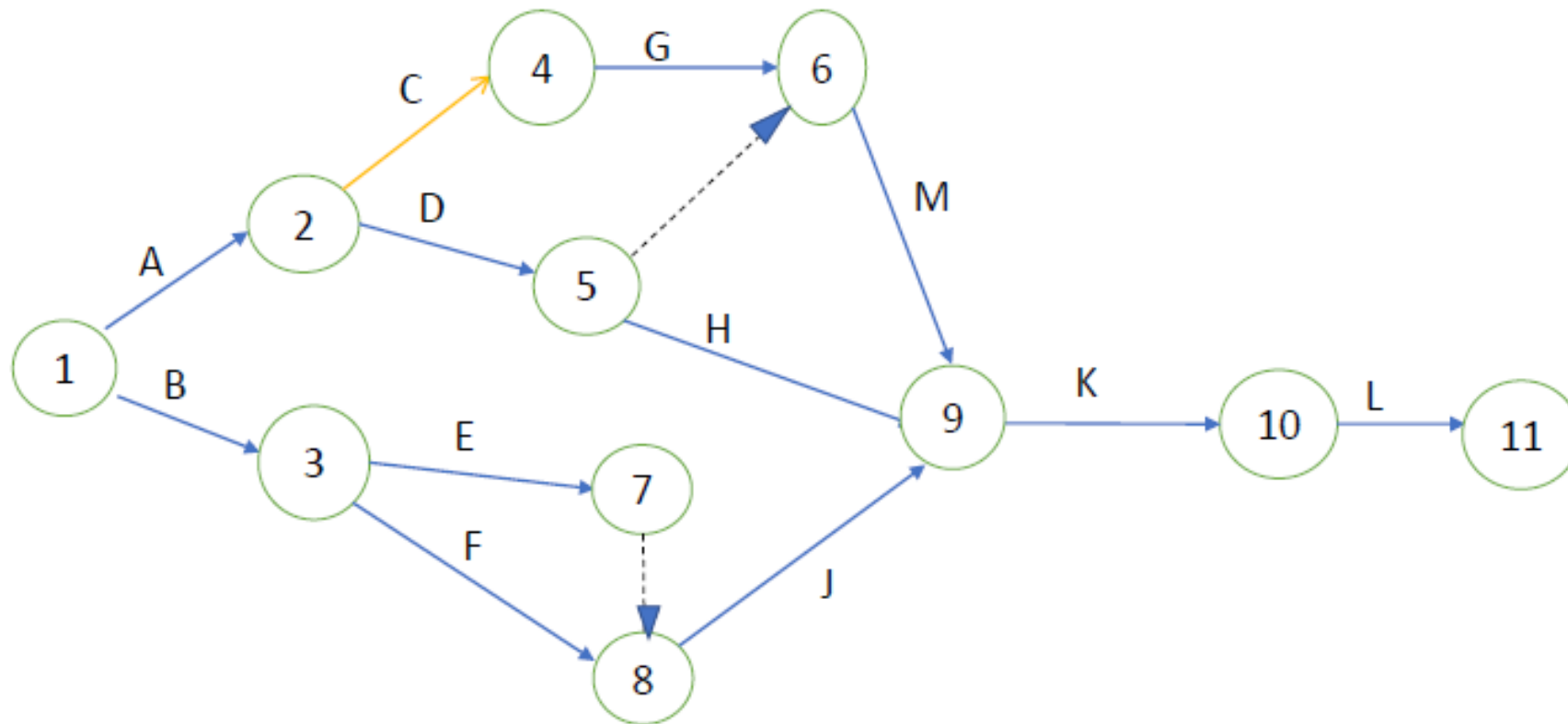
- There should not be any self loop
- There should not be any kind of loop structure that may lead to infinite cyclic operation
- There should be only one unique starting event and finishing event for a project
- The dependencies of activities should be clearly shown in the network with arrow marks or dummy activity
- The conditions applied for drawing the network must be adequate to meet the conditions. No additional constraints should be imposed other than what is stated
- While numbering events the finishing event should have a higher number than starting event
- The arrow lines showing the activity need not be straight line however these arrow lines should not cross each other
- After analysis the critical path shall be earmarked with a thick line or suitable identification

Problem 1

Draw the arrow network for a project on the following data

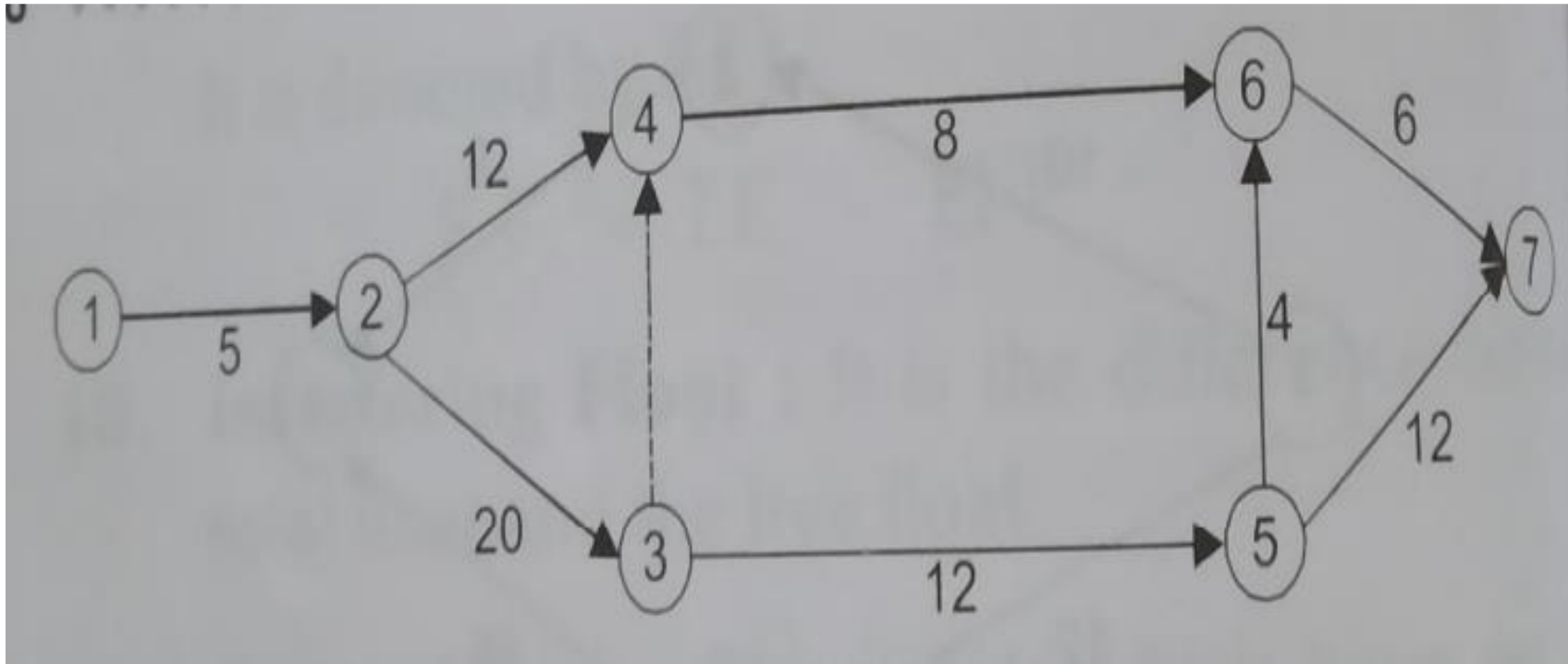
- I. A and B can be performed concurrently and start of the project
- II. A must precede C and D
- III. G must follow C
- IV. M is dependent on both D and G
- V. Neither E or F can start before B is completed but E and F can be performed concurrently
- VI. D must precede H
- VII. J is dependent on both E and F
- VIII. K can begin only after J, M and H are completed
- IX. L is the last operation which follows K

Answer (Problem 1)



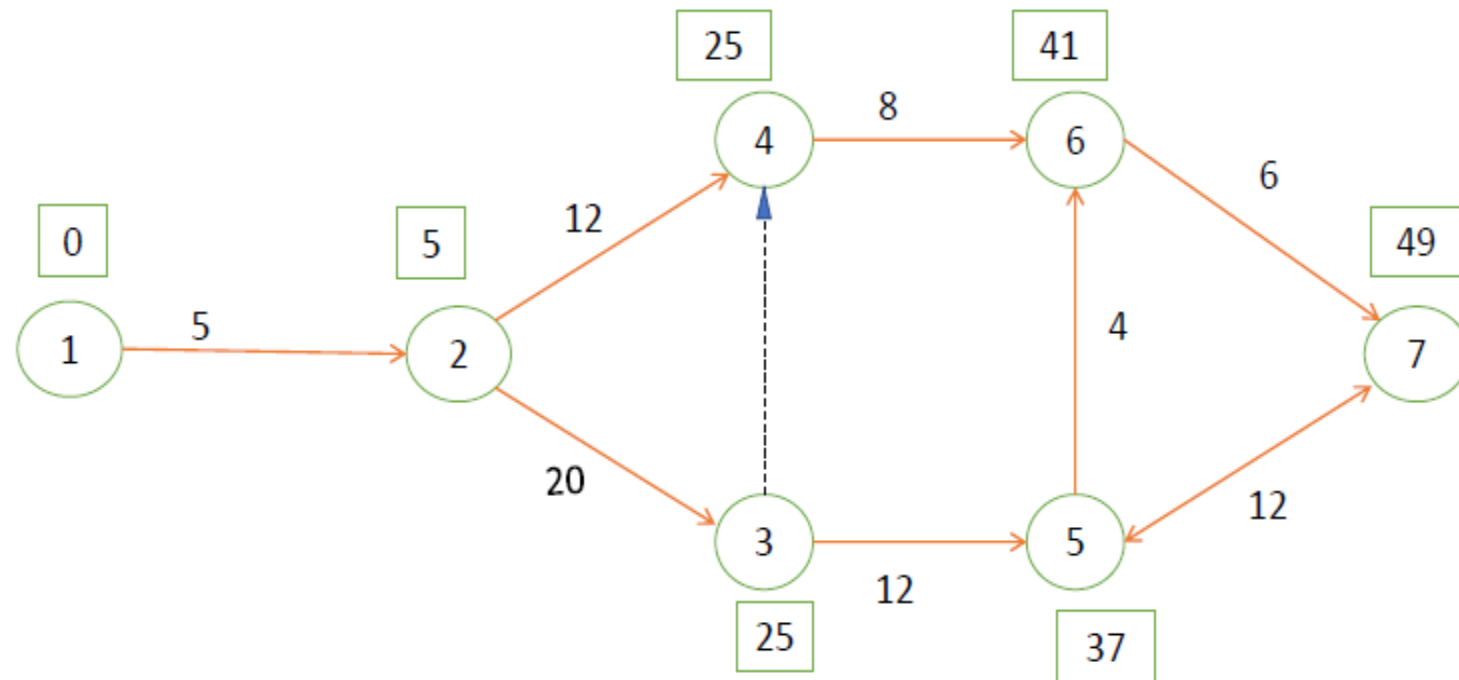
Problem 2

Calculate the earliest time for the events in the network as shown in figure



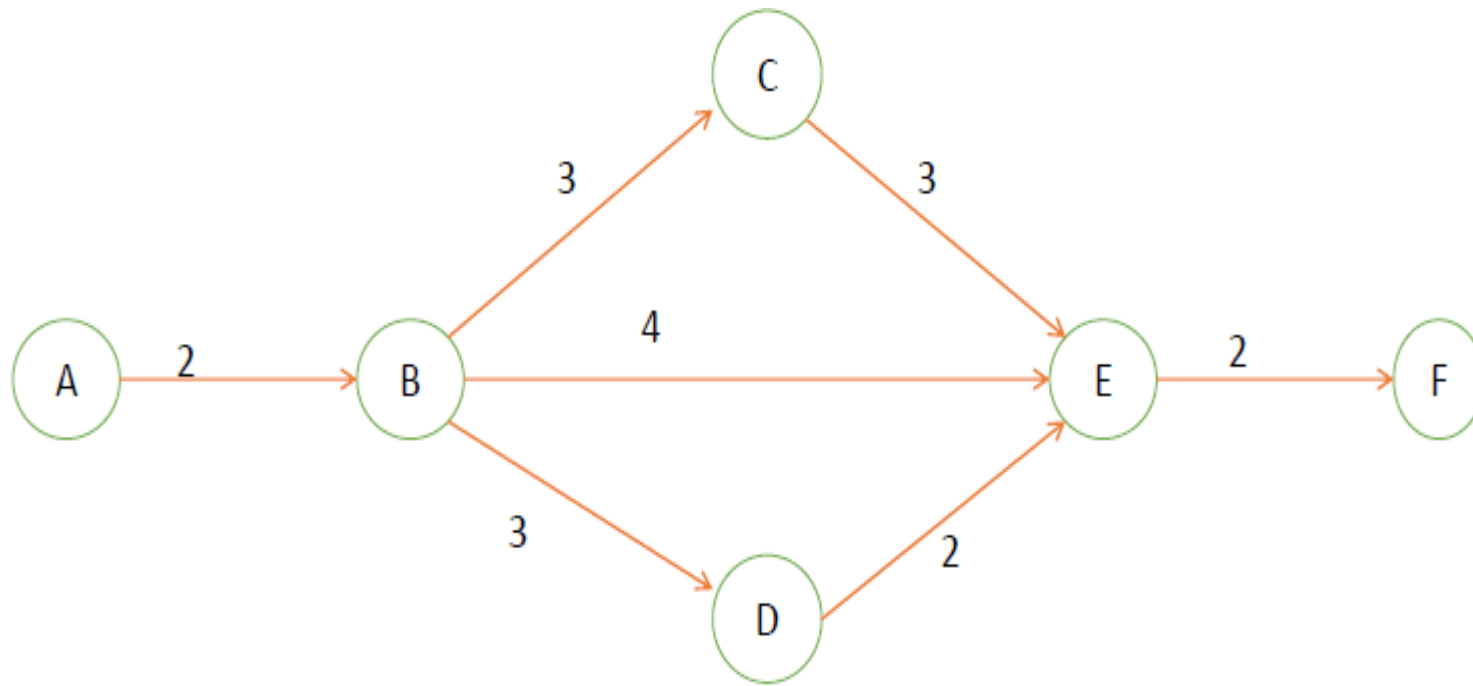
Answer (Problem 2)

- TE for the event 1 = 0
- TE for the event 2 = $0 + 5 = 5$
- TE for the event 3 = $5 + 20 = 25$
- TE for the event 4 = $5 + 12 = 17$
- **TE for the event 4 = $5 + 20 = 25$**
- TE for the event 5 = $25 + 12 = 37$
- **TE for the event 6 = $37 + 4 = 41$**
- TE for the event 6 = $25 + 8 = 33$
- TE for the event 7 = $41 + 6 = 47$
- **TE for the event 7 = $37 + 12 = 49$**



Problem 3

Find the critical path for the given diagram



Answer (Problem 3)

- TE for event A = 0
- TE for event B = $0 + 2 = 2$
- TE for event C = $2 + 3 = 5$
- TE for event D = $2 + 3 = 5$
- TE for event E = $2 + 3 + 3 = 8$
- TE for event E = $2 + 4 = 6$
- TE for event E = $2 + 3 + 2 = 7$
- TE for event F = $8 + 2 = 10$

Higher value = 8

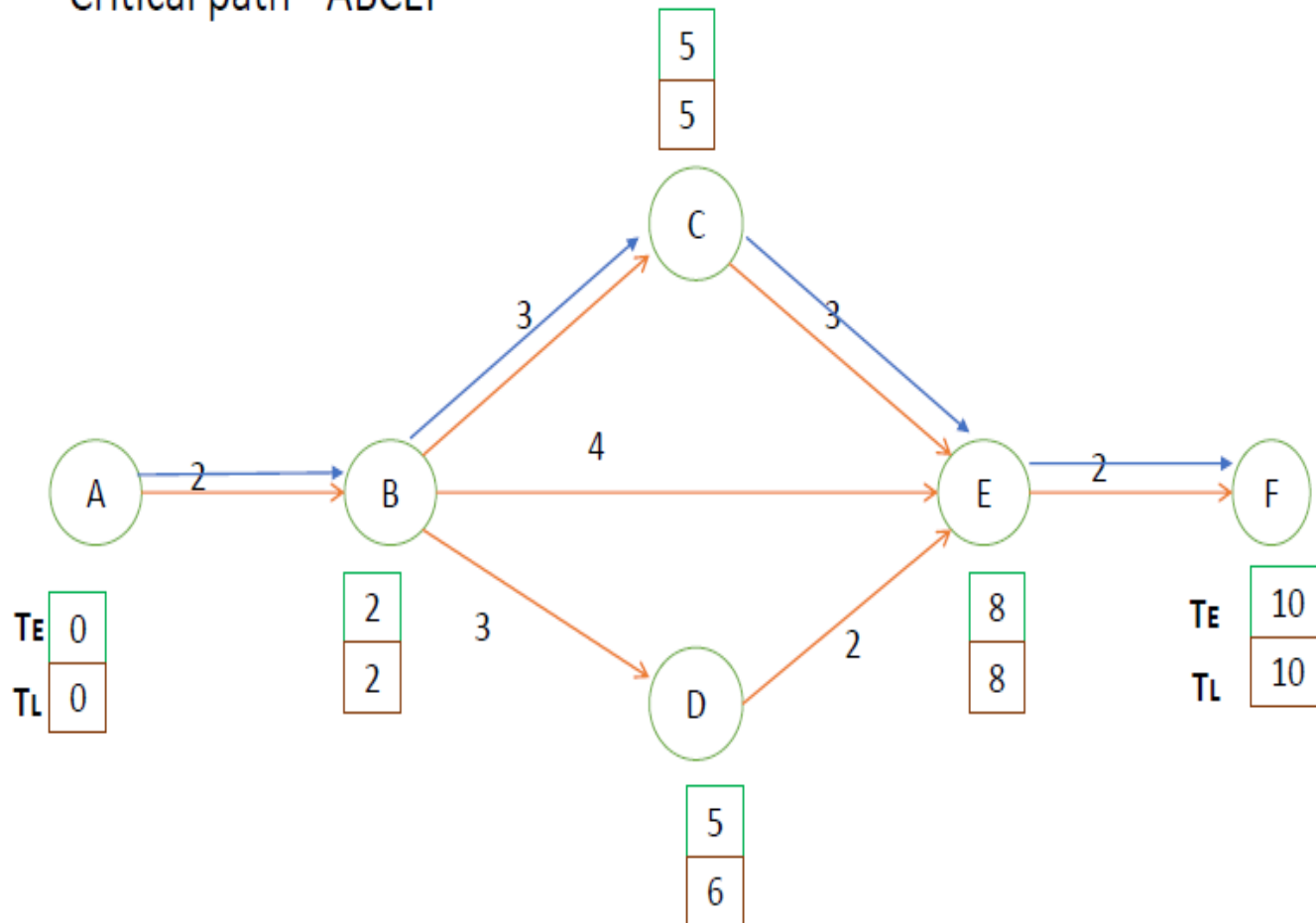
TL – latest event time

- TL for event F = 10
- TL for event E = $10 - 2 = 8$
- TL for event D = $8 - 2 = 6$
- TL for event C = $8 - 3 = 5$
- TL for event B = $6 - 3 = 3$
- TL for event B = $8 - 4 = 4$
- TL for event B = $5 - 3 = 2$
- TL for event A = $2 - 2 = 0$

Lowest value = 2

Answer (Problem 3)

Critical path - ABCEF



➤ **A-B-C-E-F**
 $2+3+3+2 = 10$

➤ **A-B-E-F**
 $2+4+2=8$

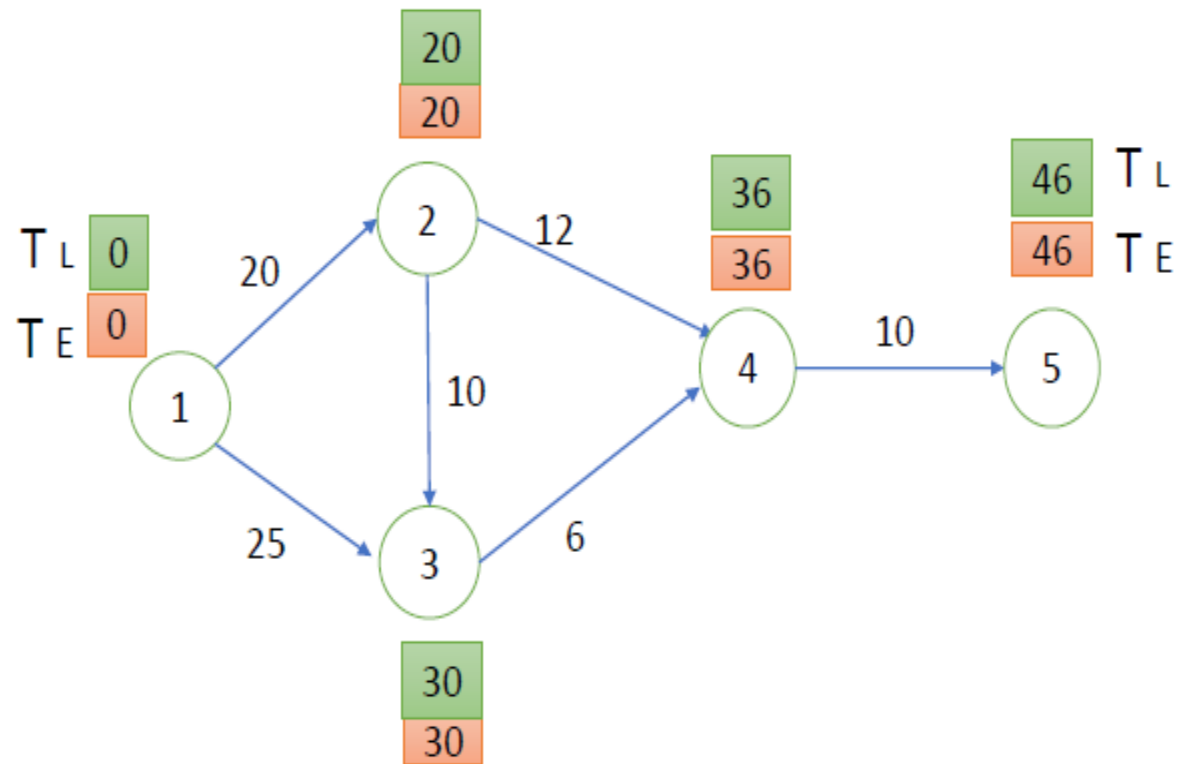
➤ **A-B-D-E-F**
 $2+3+2+2=9$

Problem 4

Draw a network diagram and find EST, EFT, LST, LFT, Critical path, Project duration, Total float, Free float, Independent float

Activity	Duration (days)
1 - 2	20
1 - 3	25
2 - 3	10
2 - 4	12
3 - 4	6
4 - 5	10

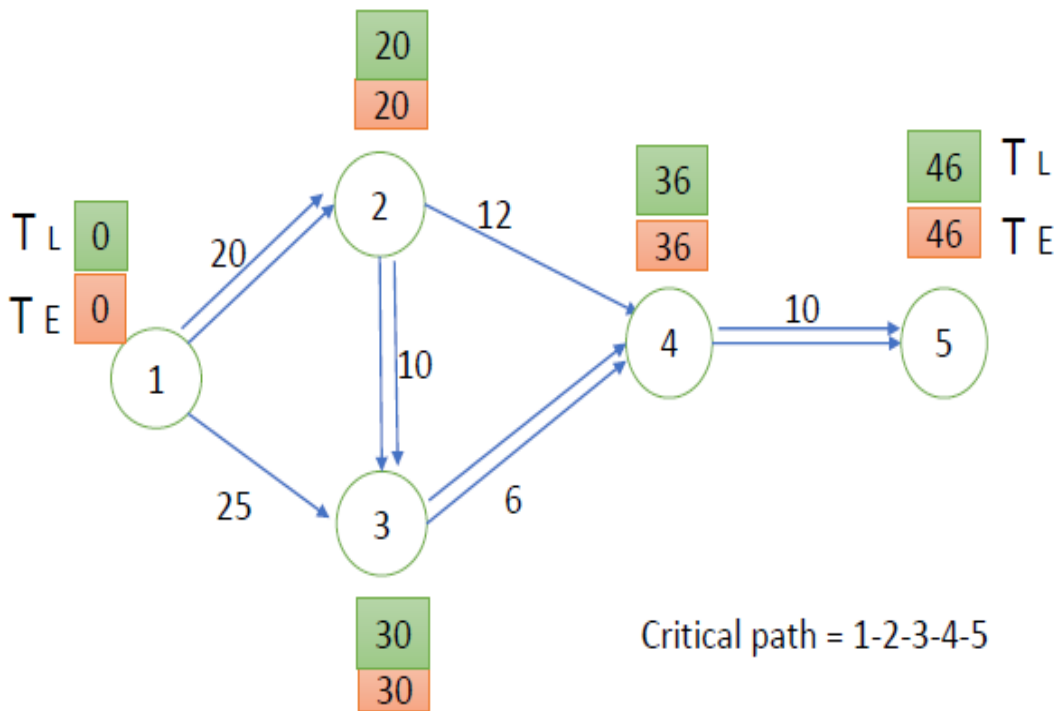
Answer (Problem 4)



Activity	Duration (days)	Earliest time	
		EST	EFT = EST+Duration
1 - 2	20	0	20
1 - 3	25	0	25
2 - 3	10	20	30
2 - 4	12	20	32
3 - 4	6	30	36
4 - 5	10	36	46

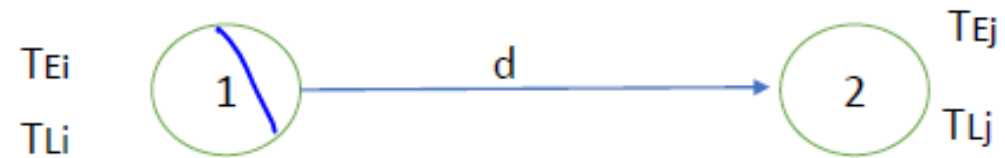
Activity	Duration (days)	Latest time	
		LFT	LST = LFT - Duration
1 - 2	20	20	$20 - 20 = 0$
1 - 3	25	30	$30 - 25 = 5$
2 - 3	10	30	$30 - 10 = 20$
2 - 4	12	36	$36 - 12 = 24$
3 - 4	6	36	$36 - 6 = 30$
4 - 5	10	46	$46 - 10 = 36$

Answer (Problem 4)



Critical path = 1-2-3-4-5

Project duration = 46 days



Activity	d	EST	LST	Total float (LST-EST)	Free float $T_{Ej} - T_{Ei} - d$	Independent Float $(T_{Ej} - T_{Li} - d)$
1 - 2	20	0	0	0	$20 - 0 - 20 = 0$	$20 - 0 - 20 = 0$
1 - 3	25	0	5	5	$30 - 0 - 25 = 5$	$30 - 0 - 25 = 5$
2 - 3	10	20	20	0	$30 - 20 - 10 = 0$	$30 - 20 - 10 = 0$
2 - 4	12	20	24	4	$36 - 20 - 12 = 4$	$36 - 20 - 12 = 4$
3 - 4	6	30	30	0	$36 - 30 - 6 = 0$	$36 - 30 - 6 = 0$
4 - 5	10	36	36	0	$46 - 36 - 10 = 0$	$46 - 36 - 10 = 0$

PROGRAM EVALUATION AND REVIEW TECHNIQUE (PERT)

- Program Evaluation and Review Technique (PERT) is a project management tool used to schedule, organize, and coordinate tasks within a project.
- It is basically a method to analyse the tasks involved in completing a given project, especially the time needed to complete each task, and to identify the minimum time needed to complete the total project
- The main objective in the analysis through PERT is to find out the completion for a particular event within specified date.
- The PERT approach takes into account the uncertainties.
- The three time values are associated with each activity

1. **Optimistic time** –It is the shortest possible time in which the activity can be finished. It assumes that every thing goes very well. This is denoted by t_0
2. **Most likely time** –It is the estimate of the normal time the activity would take. This assumes normal delays. If a graph is plotted in the time of completion and the frequency of completion in that time period, then most likely time will represent the highest frequency of occurrence. This is denoted by t_m .
3. **Pessimistic time** –It represents the longest time the activity could take if everything goes wrong. As in optimistic estimate, this value may be such that

EXPECTED TIME –It is the average time an activity will take if it were to be repeated on large number of times and is based on the assumption that the activity time follows Beta distribution, this is given by

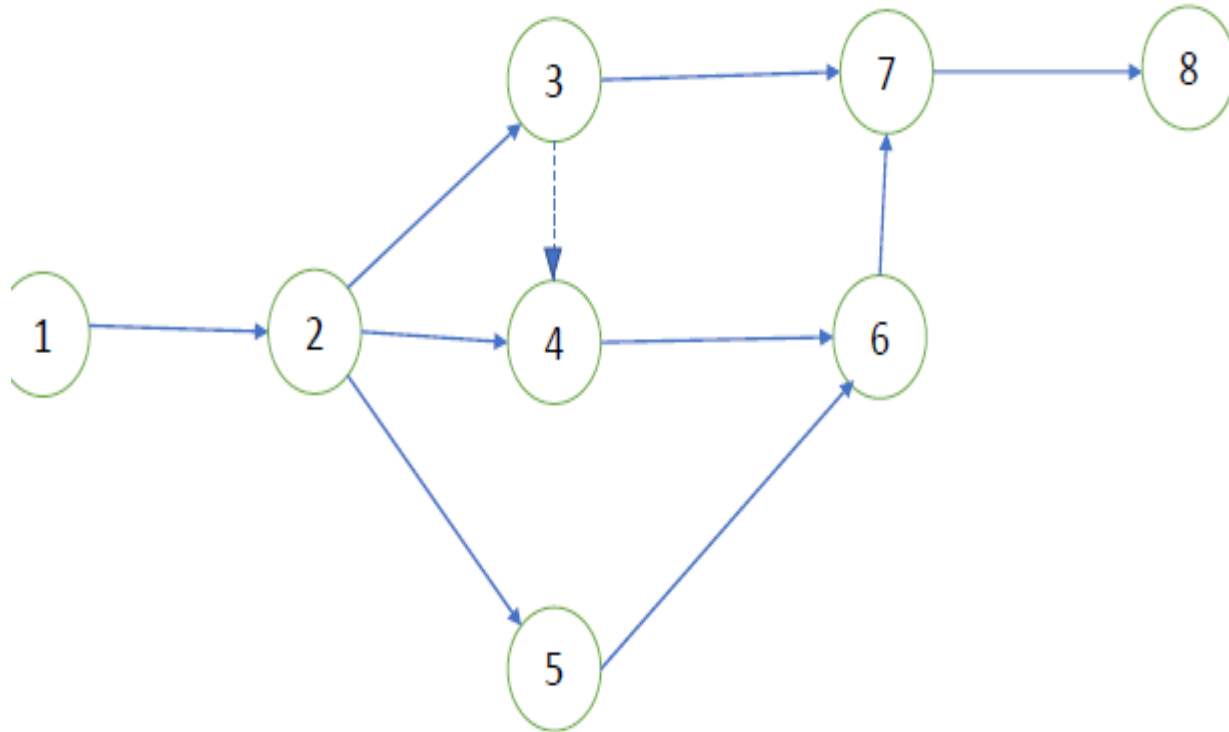
$$t_e = (t_0 + 4 t_m + t_p) / 6$$

Problem 5

A project has the following characteristics .Construct a PERT network. Find the earliest and latest expected time to each event and also critical path in the network.

Activity	t_o	t_p	t_m
1-2	2	6	4
2-3	8	20	11
2-4	4	16	7
2-5	3	17	7
3-7	3	13	5
3-4	0	0	0
4-6	2	10	3
5-6	4	20	9
6-7	7	13	10
7-8	2	8	5

Answer (Problem 5)



Activity	t_o	t_p	t_m	Expected time
1-2	2	6	4	
2-3	8	20	11	
2-4	4	16	7	
2-5	3	17	7	
3-7	3	13	5	
3-4	0	0	0	
4-6	2	10	3	
5-6	4	20	9	
6-7	7	13	10	
7-8	2	8	5	

FAST TRACKING & PROJECT CRASHING

We have to cut down the project duration

- To makeup for the delay in project execution
- Due to the occurrence of unforeseen events
- Poor estimation of activities
- To complete the project faster to meet the contractual obligation
- To achieve economic benefits due to early return
- To meet customer demand

It can be done in two ways

1. Fast tracking
2. Project crashing

FAST TRACKING

- ✓ Activities which are organized to perform sequentially are rescheduled to perform parallel or partially parallel
- ✓ But it will increase cost and risk
- ✓ When this doesn't yield the results to the expected level crashing techniques are adopted

PROJECT CRASHING

- ✓ It is done by reducing the time required for one or more critical activities by putting in more resources at the least cost possible
- ✓ Aim is to achieve the maximum decrease in schedule for minimum additional cost
- ✓ It can be achieved by
 - Putting more resources in critical path
 - Working overtime with additional supervision
 - Outsourcing of work
 - Modification of specification and design
- ✓ It will not compromise with safety or quality

RESOURCE LEVELLING	RESOURCE SMOOTHING
Resource limited scheduling technique, importance is given to the limited resources	Time limited scheduling technique. Importance is given to the duration of the project
Removes all resource conflicts	Removes as much resources conflicts as possible. But may not remove all resource conflicts
May not require additional resources	May require additional resources to address left over resource conflicts
Activities may be shifted beyond the float available while rescheduling the activities	Activities are shifted only to the extend of the float available
Generally the project duration get extended	The project duration remains the same
May change the critical path	No change in critical path

JOB LAY OUT

➤ It consists of

1. Detailed layout of the project site
2. Locations for various construction activities
3. Places for stocking of materials
4. Locations of plants and equipment
5. Lay out of roads, entry & exit points
6. Emergency assembly area
7. Service points like water, electricity, fire hydrants
8. Locations of temporary buildings like workers rest area site office stores watchman shed etc

- It is usually displayed as a legend or display board at major locations
- It ensures safety at work place
- Efficient job layouts will economise the activities by decreasing the lead distance or saving more in terms of time and money

MODERN HOUSE KEEPING PRINCIPLE - 5S

- It is a work place organization method that uses a list of five Japanese words **SEIRI, SEITON, SEISO, SEIKETSU, AND SHITSUKE**
- These have been translated as sort set in order shine standardize and sustain
- This list describes how to organize a work space for efficiency and effectiveness by identifying and storing the items used, maintaining the area and items and sustaining the new order

SORT (SEIRI)

It is sorting through all items in a location and removing everything that is unnecessary from the location

GOALS

- ✓ Reduce time loss looking for an item by reducing the number of items
- ✓ Reducing the chances of distraction by unnecessary items
- ✓ Simplify inspection
- ✓ Increase the number of available useful spaces
- ✓ Increase safety by eliminating obstacles

IMPLEMENTATION

- ✓ Check all items in a location and evaluate whether or not their presence at the location is useful or necessary
- ✓ Remove unnecessary items as soon as possible.
- ✓ Place those that cannot be removed immediately in a red tag area so that they are easy to remove later on
- ✓ Keep the working floor clear of materials except for those that are in use in production

SET IN ORDER (SEITON)

It is putting all necessary items in the optimal place for fulfilling their functions in the work place

GOAL

- ✓ Make the workflow smooth and easy

IMPLEMENTATION

- ✓ Arrange the work stations in such a way that all tooling/equipment is in close proximity
- ✓ Place components according to their uses with frequently used components being nearest to the workplace
- ✓ Assign fixed locations for items. Use clear labels marks or hints so that items easy to return to the correct location and so that it is easy to spot missing items

SHINE (SEISO)

It is sweeping or cleaning and inspecting the workplace tools and machinery on regular basis

GOALS

- ✓ Improves the production process efficiency and safety reduces waste, prevents errors and defects
- ✓ Keep the work place safe and easy to work in
- ✓ Keep the work place clean and pleasing to work in
- ✓ When in place any one not familiar to the environment must be able to detect any problems within no time

IMPLEMENTATION

- ✓ Clean workplace and equipment on a daily basis or at another appropriate cleaning interval
- ✓ Inspection the workplace and equipment while cleaning

STANDARDIZE (SEIKETSU)

It is to standardize the processes used to sort order and clean workplace

GOAL

- ✓ Establish procedures and schedulers to ensure the repetition of the first three S practices

IMPLEMENTATION

- ✓ Develop a work structure that will support the new practices and make it part of daily routine
- ✓ Ensure everyone knows their responsibilities of performing the sorting organizing and cleaning
- ✓ Review the status of 5S implementation regularly using audit checklists

SUSTAIN/SELF DISCIPLINE (SHITSUKE)

Sustain the developed processes by self discipline of the workers

GOAL

- ✓ Ensure that the 5S approach is followed

IMPLEMENTATION

- ✓ Organize training sessions
- ✓ Perform regular audits to ensure that all defined standards are being implemented and followed
- ✓ When issues arise identify their cause and implement the changes necessary to avoid recurrence

THANK YOU