O reduce buckling Of RCC column, rod tied in such a way

Fig. 3.2 Factors to consider in planning.

CEE-441: PROJECT MANAGEMENT

Dr. Md. Jahir Bin Alam

Project

Characteristics feature of a project:

1. Objectives: A project should have a fixed set of objectives.
2. Life span; A project should have a specified lifespan.
3. Life cycle: A project should have a definite life cycle comprises growth, maturity and decay.
4. Single entity: A project should have it's own identity.
5. Uniqueness: A project should have a definite uniqueness.
6. Unity in diversity: A project is a complex set of thousand of diversity.
7. Successive principle e A project should have a successive set of works.
8. Made to order: A project is always made to order according to its customer.
9. High level of sub contracting: A project comprises with a high level of sub contracting.
10. Risk and uncertainty: Every project has risk and uncertainty.

Family tree:

1. Plan
2. Program
3. Project
4. Task
5. Activity

Factors of execution of a project

1. Location
2. Types
3. Size
4. Technology
5. Scope
6. Speed of project

Categories of project:

1. Normal project:

- Adequate time is allowed for the implementation of the project
- All phases get sufficient time they normally need.
- Require minimum capital cost and no sacrifice in terms of quality.

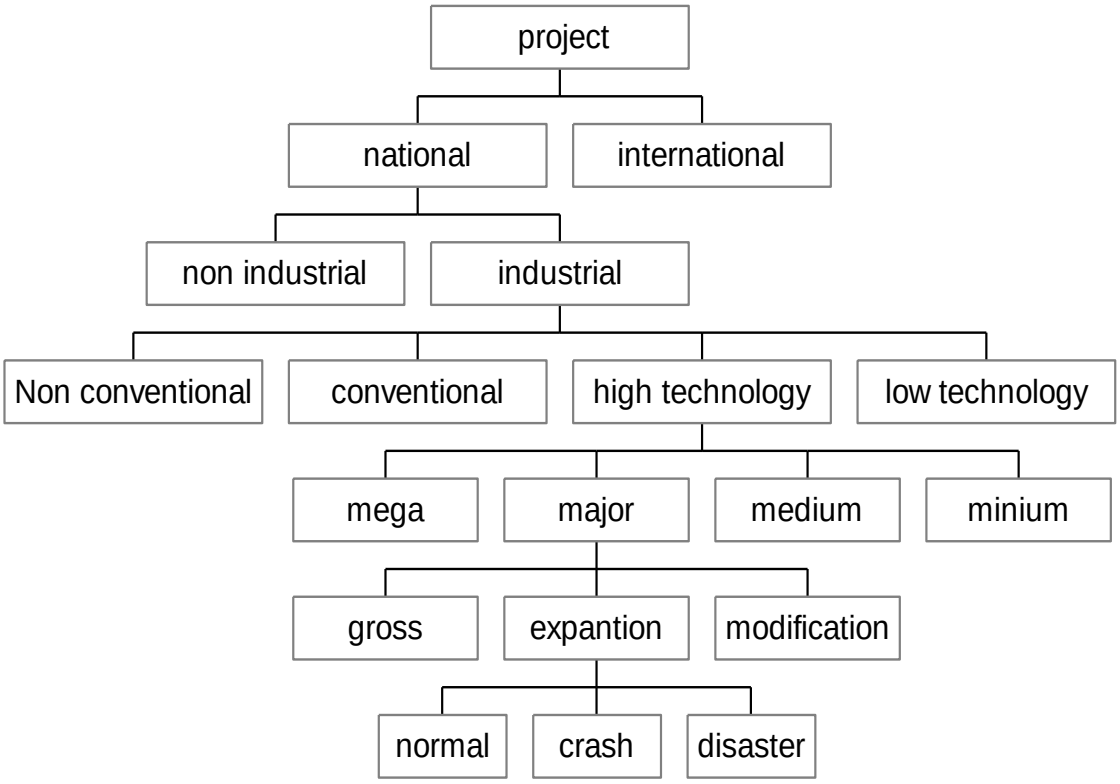
2. Crash project:

- Require additional capital cost for saving the time.
- Time is saved in procurement and construction by buying time from the vendors and the contractors paying extra money to them.

3. Disaster project:

- Anything needed to save the time is allowed in this project.
- Vendors who can supply yesterday selected irrespective.
- Cost is not a factor.
- Require high capital cost.
- Require less project time.
- Quality, a sort of failure level, is acceptable.
- Round the clock work procedure is followed.

Project flow chart



Project life cycle phase:

1. Conceptual phase:

- To generate idea
- The idea should be examined in light of objective and constraints.
- What finally become acceptable may form the future project.
- All projects are usually conceived in this way.
- If this phase is avoided the project will have innate defects.
- Ex: an operating cement industry having low capacity utilization, high power consumption, and consequently higher cost of production. In such a case it might be a good idea to introduce new technology, replace some critical items selectively. There may be financial constraints; in such a case the existing staff may need to be on ruled.

2. Definition phase:

In this phase, detail documents covering all aspects of project necessary for customers or financial institution to make up their mind on project idea will be examined.

The areas to be examined are:

1. Project layout
2. Plant capacity
3. Raw materials
4. Plant machinery
5. Location and site
6. Technology and process selection

7. Civil Engg. Work
8. Electrical and instrumentation work
9. Utilities
10. Manpower and organizational pattern
11. Financial analysis
12. Implementation schedule

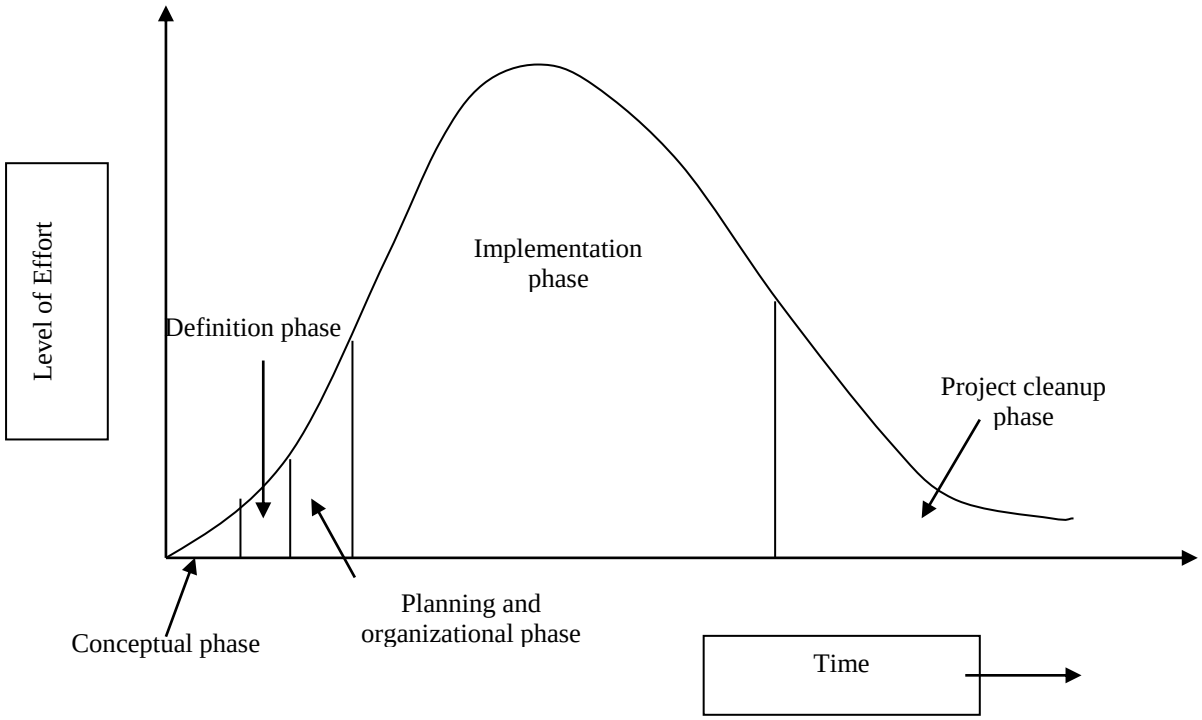
3. Planning and organization phase:

This phase can effectively starts only after definition phase. But in practice it starts much earlier; almost immediately after the conceptual phase.

This phase overlaps so much with the definition phase and the implementation phase that no former recognition is given to this by most organization.

This phase deals with the following necessary actions:

- Project infrastructure and enabling services
- System design and basic environmental packages
- Organization and man power
- Licensing and government clearance
- System and procedure
- Identification of perfect manager
- Design basis, general conditions for purchases and contracts
- Site separation and investigation
- Construction resources
- Working packages



4. Implementation phase:

This is a period of hectic activities for the project.
This phase deals with the following

- Preparation of specification
- Ordering of equipment
- Lining up construction contractors
- Construction

5. Project cleanup phase:

- This is a transition phase in which the hardware build with active involvement of various agencies is physically handed over for production to different agencies.
- Drawing, documents, file, operation-maintenance manual are handed over to the customer
- The most important issues in this phase are planning the staff and workers involve in the execution of the project.

Planning

Planning:

Concept of planning: Planning is a choosing, thinking, setting goals and specifying means. Plan is the result of planning—blue print of plan; statement of objectives.

Planning involves the decision on answer to what , when, where, how and by whom in order to attain the desire condition of specific goal.

Purposes of planning:

- To discover future opportunities and main plan to explode them. The most effective plans are those which explode opportunities and remove obstacle.

Nature of planning:

1. Planning is continuous and dynamic process.
2. Planning is a pervasive and generic extends.
3. The process of planning is the same whatever the subject matter.
4. Planning is deliberate--- it provides necessary and desirable activities.
5. Planning involves decision making and creativity.
6. Planning is structured ----- good structure of planning creates diversity.

MANAGEMENT

Processing of management:

Manager: A manager is a man who gets things done by working with people and the resources to achieve the objectives.

Managing is a social process---

- Because it includes assures of actions that lead to the accomplishment of the objective of the organization.
- Because these actions are principally concern with the relation between people.

Approaches to management

- Productivity and functional specification approaches—oldest theories of management practice were concerned with productivity –how to produce in abundance.

- Behavioral approaches—study of observable and verifiable behavior in organization.

- Rationalistic model approach—application of science.

Classification of management:

1. Classical school of management:

- A body of literature which is characterized by its earliest attempts to define and describe the field of management.
- Focuses on –formerly prescribed relationship
  --Acquiring knowledge regarding personal observation and case studies.

2. Behavioral school of management:

- A body of literature which is characterized by its concern for human behavior in the work environment
- Focus on----acquiring knowledge regarding scientific method.

3. Scientific school of management:

- A body of literature, which is characterized by its use of mathematical and statistical techniques to build models for the solution of technical operational problem.
- Examples: search method, optimization approach.

Management:

- It is the administration of an organization.
- It is a housekeeping plan, which involves decision making, innovation, risk taking and dynamic leadership.
- Management concern with organizational growth and internal and external relationship.
- Basic function of management:

-planning
-organizing
-directing
-motivating

-controlling

Planning:

- It is the task of determining what should be done and how.
- It covers a wide range of decision including setting and classification of objectives, establishing policies and programming and fixing day to day schedules.

Organizing:

- It is the task of grouping the activities into different administrative units to carry out the plans.

Directing:

- It is the task of day by day guidance of operation.

Motivation:

- It is the task of creating enthusiasm among the subordinates to carry out the plan.

Controlling:

- It is the task of establishing standard measuring performance at every level.

BASIC ASPECT OF MANAGEMENT:

1. The 1st aspect of management is coordination-coordination of the members of the organization.
2. The 2nd aspect of management is achieving the coordination by means of managerial functions of planning, organizing, directing, motivation and controlling.
3. The 3rd aspect of management is to attain the desirable goal through management.

Manager

- Manager is a person who is responsible for directing and controlling the work and personnel of an organization, or of a particular department within an organization.

Administration:

- Administration is the management of the affairs of a business or organization.
- It is housekeeping, which involves implementation of objectives, plan and regulation of internal affairs.

TASKS OF PROJECT MANAGEMENT:

1. **Managing the work:**

- Acquiring information and preparing report.
- Costs: costs are important as a planning tool, organizing tool, controlling tool motivating tool etc.
- Project preparation: Take adequate time to prepare a project if possible
  -try and warn the politicians about the weakness of the project
  -try and establish full information needs. It is generally costly and frequently demoralizes the staff because of asking more information time to time.
  -try and the plan the work load to be even.
- Project implementation:

-Use a critical path approach
-Update the critical paths as required and gain the maximum benefit by using the critical path approaches.
-Keep an eye on critical activities.

- General:

-it is concerned with work management
-get the priorities right and stay with them
-Limit the no of objectives, don't finish up with a lot of half finished work---half finished work generally represents an investment from which no benefit materialized.
-Establish clear job definition
-Give particular attention to the definition of the interface between the jobs.

2. <u>Managing the staff:</u>

- performance of the staff:

-Establish yardstick

report from the staff:

-Accept report from your staff regularly to maintain standard.

General:

-Recognize the value of person's time.
-Some rotation and movement of personal between the jobs is inevitable.

3. <u>Managing one self:</u>

- Management by exception:
  -Be concern about the problem area. Manager may be familiar with the problem area by his staff.
- Time critical operation:
  -Be selective of putting your efforts. Critical path analysis and sensitivity analysis will help you to plan your time most effectively.

<u>SUCCESS OF A PROJECT MEANS</u>

- It must be completed
- It must be completed within budget
- It must be completed within allocated time
- It must perform to satisfaction

<u>STEPS IN PROJECT MANAGEMENT</u>

There are 5 steps:

1. Grouping the works into package which acquire the properties of project:
   - This means that the works are related to each other, contributed to same goal and can be bounded by cost, time and performance target.
2. entrusting the project:
   - Entrusting the whole project to a single responsibility center (manager) for coordinating, directing and controlling the project.
3. supporting and servicing the project:
   - internally within the organization by matrixing or projectization

- externally through vendors and contractors

4. Build up commitment:

   Build up commitment through negotiation, coordination and direction through schedule, budget and contracts.

5.Ensuring adherence to goal:

- Ensuring adherence to goal through continuous monitoring and control

Matrixing ---- combination of traditional functional department.

Project management tool:

There are various tools under 8 techniques:

1. Project selection techniques-

- Cots –benefit analysis
- Internal rate of return
- Risk sensitivity
- NPV

2. Project execution plan techniques
    - Work, breakdown structure
    - Project execution plan
    - Project responsibility matrix
    - Project management manual

3. Project scheduling and management techniques
    - Bar chart
    - Life cycle curve
    - Line of balance
    - Networking technique

4. Project monitoring and progressing techniques
    - Progressing measurement technique
    - Performance monitoring technique
    - Updating and reporting technique

5. Project cost and productivity control techniques
    - Productivity budgeting technique
    - Value engineering
    - Cost

6. Project combination and clean up techniques
    - Control room
    - Computerized information system

Methods of project management:

1. Empirical method :
    -Study of experience as a means of gaining knowledge
    -it helps to establish drawing

2. Study of functions and principle:
    -Study of functions and principle that has been developed for activity of manager

3. Mathematical method:
    -Use of mathematical and statistical techniques to build models for the solution of the problems.

4. Process method:

-Study based on perception of management as a process.

5. System study:

-Study management which includes recognization of

- The place and function of the inter related sub system which create complex.
- Subsystem which consists of both some of its parts and their interactions
- Nature and extent of interaction
- Fact that the environment must be dealed with and treated as of equal importance with internal system.

Organization

Organization:

- An organization is a form of human association to attain a common human purpose.
- Its basic function is to transform certain inputs to some outputs utilizing existing technology within the environment.
- Organization is a mechanism, which enable people to work most effectively together for the purpose of achieving a specific objective.
- It is basically a human association for the achievement of a common human purpose.

According to Louise. A. Allen organization is the process

- of identifying and grouping the works to be performed
- defining and delegating responsibilities and authorities
- establishing relationship and
- Enabling people to work most effectively together in accomplishing objectives.

Management of organization:

Basic elements of an organization:

1. Division of force—identification and grouping of works.
2. Authority----------Definition and delegation of responsibilities of authority.
3. Relationship--------establishment of relationship.

Basic elements of organization:

1. The 1st step taken by a manager in an organization is to identify and group the works to be performed to achieve the goal. The works are divided in various parts to facilitate their satisfactory performance.
2. The 2nd step to be taken by the manager is to define and delegate responsibilities and authority of each member of an organization to achieve the goal.

- He is to see that whether every member of the organization is awarded for his or her works or not.

- Manager also gives descriptions about the rights and powers the member exercise in doing their woks.

3. The final step to b taken by the manager is to establish cooperative relationship between various positions and department to facilitate harmonious teamwork.

Principle of organization:

1. Objective: Clear objective and plan to attain the objectives.
2. Departmentation: Proper division of functions into department.
3. Functionalization: Division of activities according to functions.
4. Specialization: Organization device as to facilitate specialization of the activity.
5. Definiteness: Every organization must be aware about his work.
6. Balance: Balance between various unit of organization.
7. Coordination: Easy coordination of every branch of organization.
8. Clear allocation of duties and responsibilities: Clear allocation of duty and responsibility.
9. Span of control: Span of control should be rational. Control over subordinate should be balanced (Neither so large as to be unwisely nor too small for effective performance of work).
10. Provision for growth.
11. Promotion of satisfaction: Success of the organization depends on the satisfaction of the members of the organization.

Benefits of organization:

The principal benefits of an organization are

1.
    - It facilitates administration
    - It facilitates both management an operation of the enterprise or organization. by identifying and grouping the works to be performed.
2. It provides best use of human being through better distribution of work among the workers.
3. It facilitates growth and diversification—good structure of the organization provides better framework within the enterprise.
4.
    - It stimulates creativity
    - It defines and seta up the area of the work to be performed by each man or person. In this way it stimulates independent creativity thinking and initiative of man or persons.

5.

- An organization is a foundation of management
- It facilitates administration, encourage sound and balance growth and diversification, provides for best use of personal creativity and stimulates individuality and individual creativity. Organization provides such a mechanism through which management directs, coordinates and controls the business.

Departmentation

Dividing the operation work.

Characteristics are

- Margin of operation task into jobs
- Linking of such jobs into work groups.
- Combining of work groups in order to achieve goal.

Usual pattern of Departmentation:

- Grouping by locations
- Grouping by process
- Grouping by functions
- Grouping by products
- Grouping by customer
- Grouping by time

key factors in Departmentation and delegation:

1. Take advantages of specialization
   -technical specialists
   -specialized equipment
   -use of functional specialist

2. Aid in coordination---
   -grouping interrelated activities
   -grouping activities with common objectives
   -apply most used criteria

3. Facilitate control---
   -Independent check
   -Divide wherever there is clean break
   -Deadly parallel comparable operating units

4. Reorganize human and local needs---
   -Available personal characteristics
   -Environmental condition
   -Moral of people

5. Adequate attention

6. Reduce expenses

Decentralization And Centralization:

It concerns vertical allocation of management action up and down.
(The management hierarchy) Departmentation also involves a horizontal allocation of operating work.

Centralization: a system of management in which major decisions are made at higher level of management.

Decentralization: a system of management in which each level of management makes decisions. Decision making phenomena or responsibilities of the authority is pushed down to the lower level of management.

Factors for deciding on decentralization level:

1. Who knows the fact that on which decision will be made?
2. Who has the capacity to make sound decision.
3. On the spot; decisions will be made very speedy to meet local conditions.
4. Local activity must be carefully coordinate with other activity.
5. How significant is the decision?
6. How busy is the executive?
7. Will initiative and moral be significantly improved by decentralization?

Key factors of delegation:

- Responsibility and authority should go hand in hand.
- Responsibility cannot be delegated--- avoid dwell subordination.

Principle connected with Departmentation:

1. **Principle of division of work:**

- The more an organization's structure reflects a classification of the activities to attain goal and assist in their coordination; the more effective and efficient an organization structure will be.

- The more the rules are design to feed the capabilities and motivations of people available to attain the goal; the more effective and efficient organization structure will be.

2. **principle of functional definition:**

- The more a position has clear definition of results expected; the more activities to be undertaken by the authority and relationship with other position understood, the more adequately individual responsibilities can contribute to attain the goal.

3. principle of separation:

- If one activity is designed to be a checked to another, the individual charged with the former cannot adequately discharge responsibilities. (due to borocrecy; people should be honest and responsible).

Difference between delegation and Departmentation:

Delegation:

- It divides the managerial works.
- Delegation involves
  - -assigning duties
  - -granting authority
  - -creating obligation

What are the characteristics of good site supervisors?

- Alertness
- Constant awareness of the objective of the project---
  - -What is project fault?
  - -Who is it going to serve?
  - -How is it justified?
  - -How will it be used?
- A keen sense of the trade.
- Energy, flexibility and helpness.
- Ability to motivate many interest to produce a good project.

Economic evaluation of project

Basic principle of economic evaluation of project:

- Money income over a period of time.
- All the cost and benefit should be considered at a particular time.
- Interest rate of 10% to 12 % is usually chosen in the developing country.

Method of economic evaluation:

1. Discounting method
2. Cost and benefit ratio method
3. Net present value (NPV)method

Time horizon for economic analysis:

- For a route project -----it varies 20-30 years
- For a large scale project----- it varies 50 years

Present worth for a uniform series of annual payment:
$PW=A*[\{(1+I)^n-1\}/\{I*(1+I)^n\}]$

Why does project implementations fall?

1. Financial problem of the agency:

- Poor estimate of bid unit price.
- Bad or irresponsible financial management.
- Impact of exogenous factor(natural calamity,flood,oil crisis)

2. Construction problem:

- Poor management.
- Irresponsible work of contractor.
- Poor administration of contract.
- Delays in expropriation of land and building.
- Delays in making arrangement with utility company.
- Delays in interim payment to the contractors.
- Delays in issuing change order.
-

Financial and Economic analysis of a project

Project year	Investment cost (Tk)	O & M cost (Tk)	Total cost (Tk)	Total cost increased by	Discount factor @ 12%	Discounted cost @ 12% discount (Tk)	Discount factor @	Discounted cost @ discount (Tk)	Discount factor @	Discounted cost @ discount (Tk)
Total										

Project year	Benefit Tk	Benefit decreased by	Discount factor @ 12%	Discounted benefit @ 12% discount Tk	Discount factor @	Discounted benefit @ discount Tk	Discount factor @	Discounted benefit @ discount Tk	Net present worth Tk	Net present worth Tk
Total										

1. **BCR = [Benefit (pv) / Cost (pv)] =**

2. **NPV =[Benefit (pv) - Cost (pv)] =**

3. **IRR =(Discount factor or Opportunity cost for which NPV=0) =**

Contract document system

Contract document system

1. Unit price system
2. Lump sum bids
3. Force account work

A) Unit price system:

- Unit price system is a type of contract documents system where payment of the work is reimbursed to the contractors on unit price account basis of each item of the work.
- This system is very much applicable to highway construction because in this type of construction, quantities of some items of the work can not be estimated exactly during the planning phase until the construction begin. So order can be made at any time according to the requirement of items as unit price basis.
- Payment to the contractor = no of unit required * minimum unit price of the item demanding by different parties.
- Under the unit price system each unit includes
  - the material to be furnished.
  - work to be done
  - method of measurement of the work completed
  - basis on which payment is to be made.

B) Lump sum bids:

- Lump sum bids are a type of contract documents system where payment of the work is reimbursed to the contractors on lump sum account basis of each item of the work.
- this system is followed in that cases where unit prices of the works are intangible.
- this is generally applied for minor items.
- some highway organizations now use lump sum bidding to cover some items which previously have been bided on a unit price system.
- Items: clearing, grubbing and structural excavation.

C) Force account work:

- Force account work is a type of contract documents system where payment of the work is reimbursed to the contractors on force account basis.
- Payment of the work = actual cost of the work + a percentage of actual cost as contractors profits
- Actual cost is the cost of labor and materials actually required for the schedule work.

Problem Sheet

Problem 01:

A manufacturing process has operating cost of 10.90 million Tk and waste disposal cost of 3.3 million Tk. The plan manager wishes to upgrade the process by installing new equipment at a capital cost of 23.3 million Tk which will reduce the annual operating and disposal cost to 7.1 million and to 1.4 million respectively. Compare the two process on a permanent worth basis ;assuming no salvage value. Use 12% interest for 10 years as a basis of calculation.

Solution:

Permanent worth factor ,

$PWF = \{(1+i)^n - 1\}/\{i*(1+i)^n\}$
$=\{(1.12^{10}) - 1\}/\{0.12(1.12)^{10}\}$
$=5.65$

So for present process ,

PW =(10.9+3.3)*5.65=80.233 million Tk

For New process

PW =23.3+(7.1+1.4)*5.65=71.327 million Tk

Linear programming Model (LP model)

1.Graphical Method
2.Simplex Method
3.Dual Method

Problem 02:

A manufacturing farm has discontinued production of a certain unprofitable product line. This created considerable excess production capacity management is considering devoting this excess capacity to 2 products; call them product 1 and 2 .The available capacity on the machine which might limit the out put is summarized in the following table.

Machine type	Available time (machine hour /week)
Milling machine	200
Lathe machine	100

The number of machine hours required for each unit of the respective product is given below

Machine type	Productivity (machine hr/unit)	
	Product 1	Product 2
Milling machine	8	2
Lathe machine	4	3

The unit profit would be Tk 20 and Tk 6 for product 1 and product 2 respectively.

Solve it?

Problem 03:

A manufacturing farm has discontinued production of a certain unprofitable product line. This created considerable excess production capacity management is considering devoting this excess capacity to 2 products; call them product 1, 2 and 3.The available capacity on the machine which might limit the out put is summarized in the following table.

Machine type	Available time (machine hour /week)
Milling machine	430
Lathe machine	460
Grinder	420

The number of machine hours required for each unit of the respective product is given below

Machine type	Productivity (machine hr/unit)		
	Product 1	Product 2	Product 3
Milling machine	1	2	1
Lathe machine	3	-	2
Grinder	1	4	-

The unit profit would be Tk 3 , Tk 2 and Tk 5 for product 1 product 2 and product 3 respectively.

Solve it?

Problem 04:

Maximize, $Z=20X_1+6X_2+8X_3$

Subject to,

Solve it by graphical method

$8X_1 + 2X_2 + 3X_3 <= 200$
$4X_1 + 3X_2 <= 100$
$2X_1 + X_3 <= 50$

$X_1>=0, X_2>=0, X_3>=0$

Problem 05:

Maximize, $Z=4X_1 + 3X_2$

Subject to,

$X_1 + 2/3X_2 <= 6000$
$X_1 <= 4000$
$X_2 <= 6000$

$X_1>=0, X_2>=0$

Problem 06:

Minimize, $Z=7X_1 + 9X_2$

Subject to,

$3X_1 + 6X_2 >= 36$
$8X_1 + 4X_2 >= 64$

$X_1>=0, X_2>=0$

Problem 07:

Minimize, $Z=15X_1 + 12X_2$

Subject to,

$X_1 + 2X_2 >=2$
$2X_1 - 4X_2 <=5$

$X_1>=0, X_2>=0$

Problems on CPM (Critical Path Method)

Network: A network is a graphical representation of a project's operations and is composed of activities and nodes.

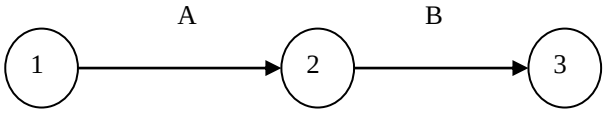
Types of Network:

1. Arrow network
2. Node or circle network

Problem 08: Some problems of network conversion:

Convert the following arrow network into circle network

1.



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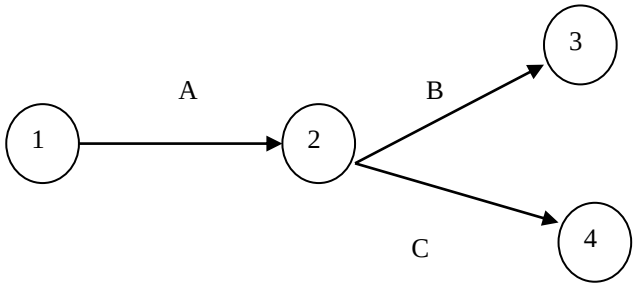

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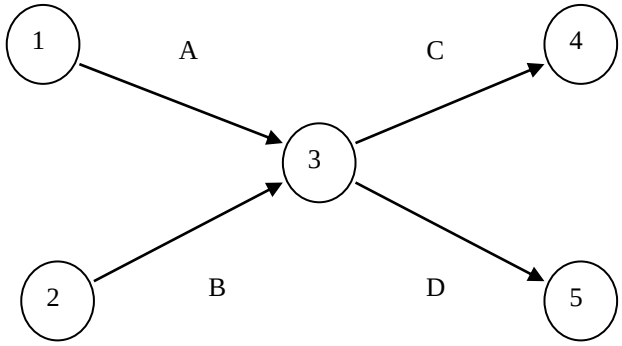

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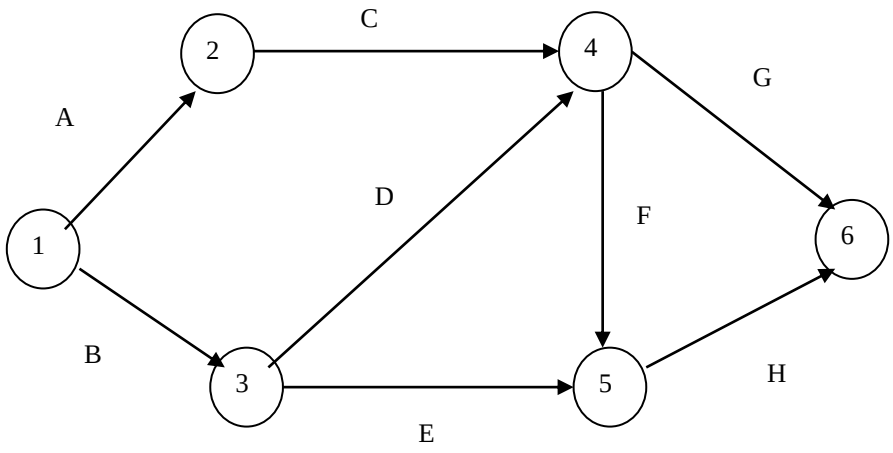
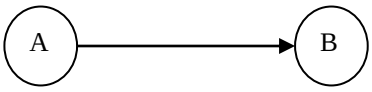
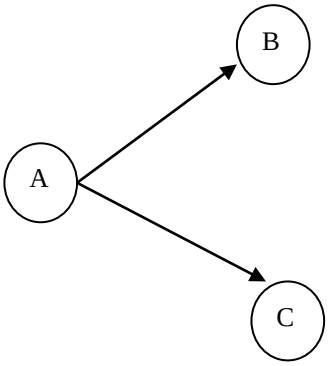


Solution:

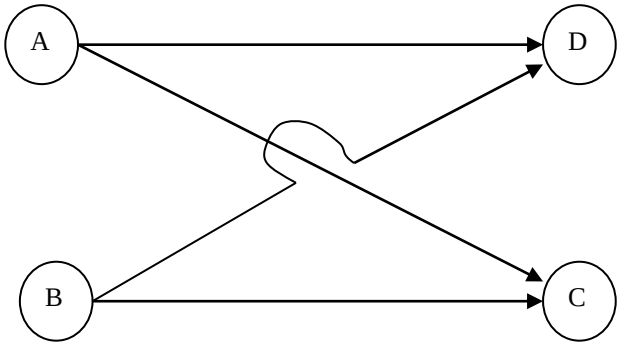


1.

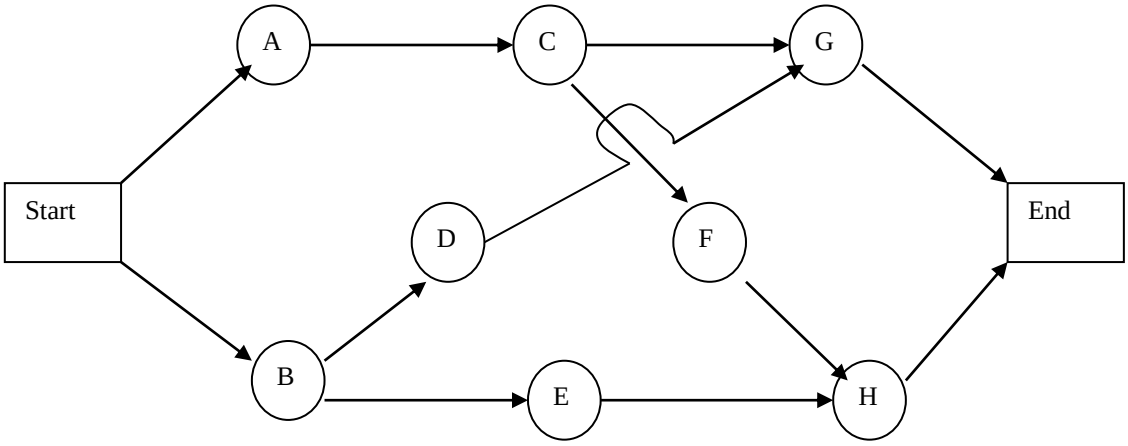
2.



3.

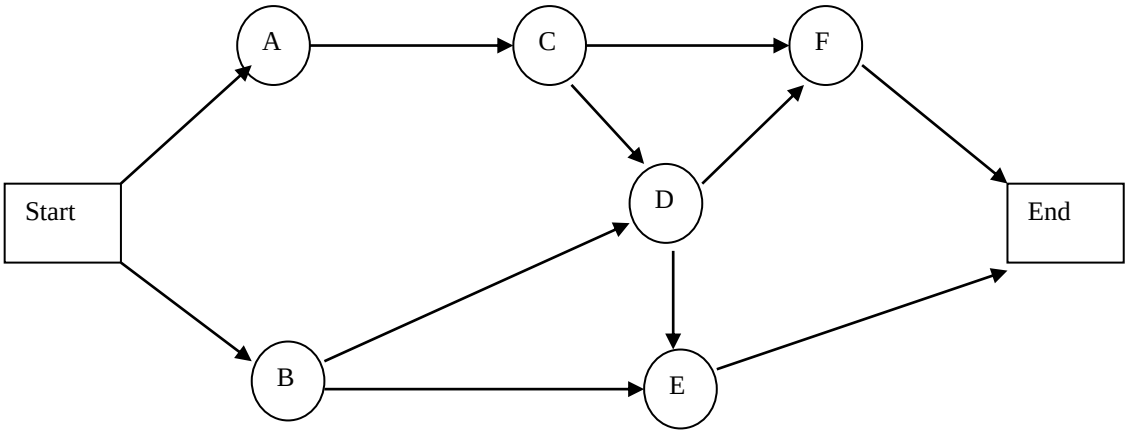


4.



Problem 09:

Find out EST, LST, EFT, LFT, FF and TF from the following figure:

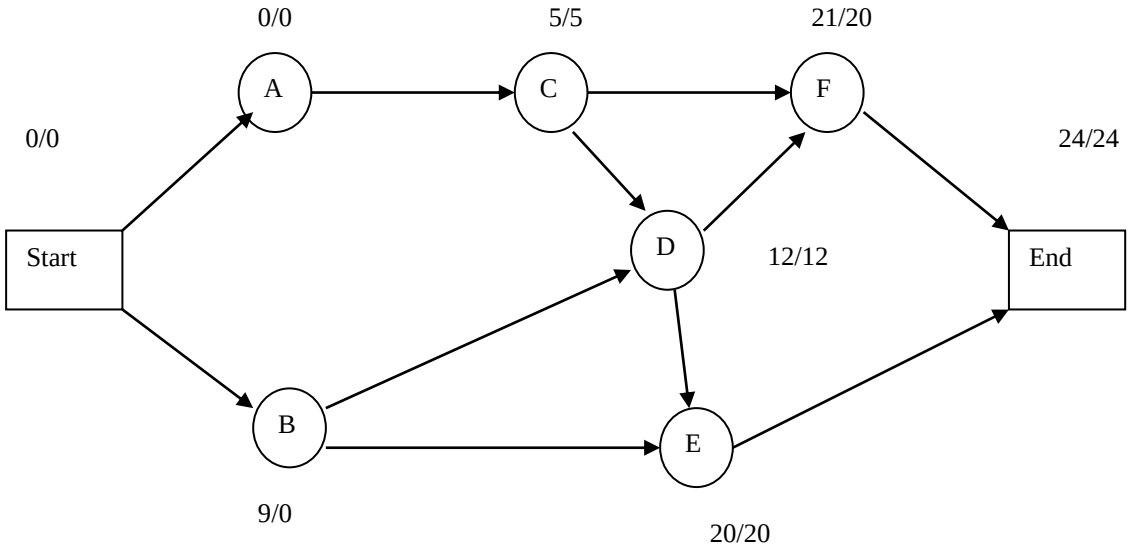


Activity	Duration (Day)
A	5

B	3
C	7
D	8
E	4
F	3

Procedure:

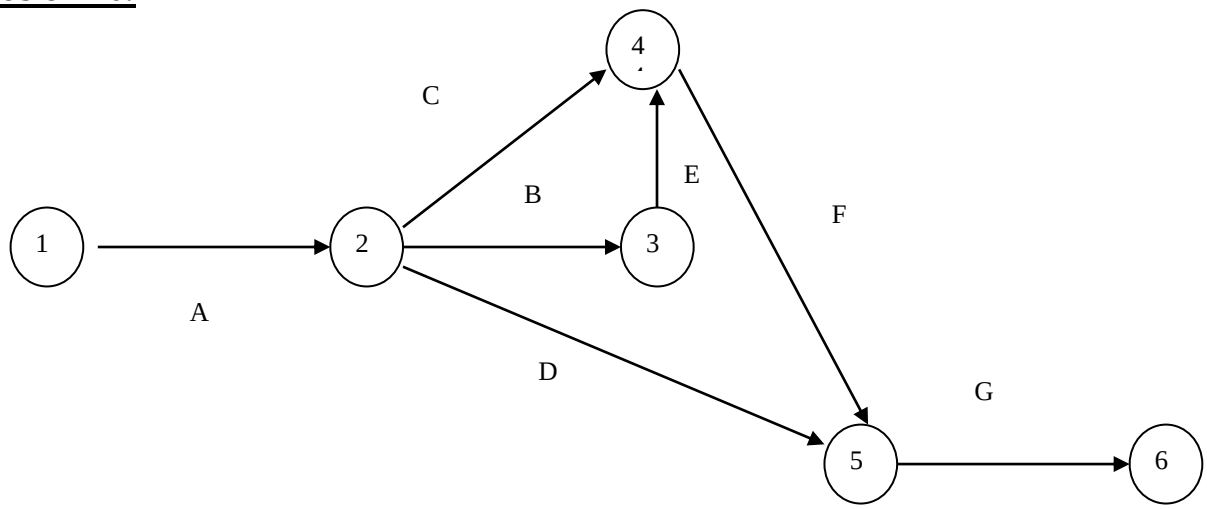
1. Draw the network
2. Determine EST (early starting time) (move along the network forwardly and consider the maximum days)
3. Determine LST (Latest starting time) (move along the network backwardly and consider the minimum days)
4. Determine EFT (It indicates the earliest time by which an activity can be completed = EST+Duration)
5. Determine LFT (It indicates the highest time by which an activity can be completed = LST+Duration)
6. Determine the TF (total float==the difference between the maximum time allowed for an activity and the time actually required by an activity = LFT-EFT)
7. Determine FF (Free float==the time by which an activity can be delayed without interfering with the starting of succeeding activity)



Activity	Duration	EST	LST	EFT (EST+Duration)	LFT (LST+Duration)	FF	TF (LFT-EFT)

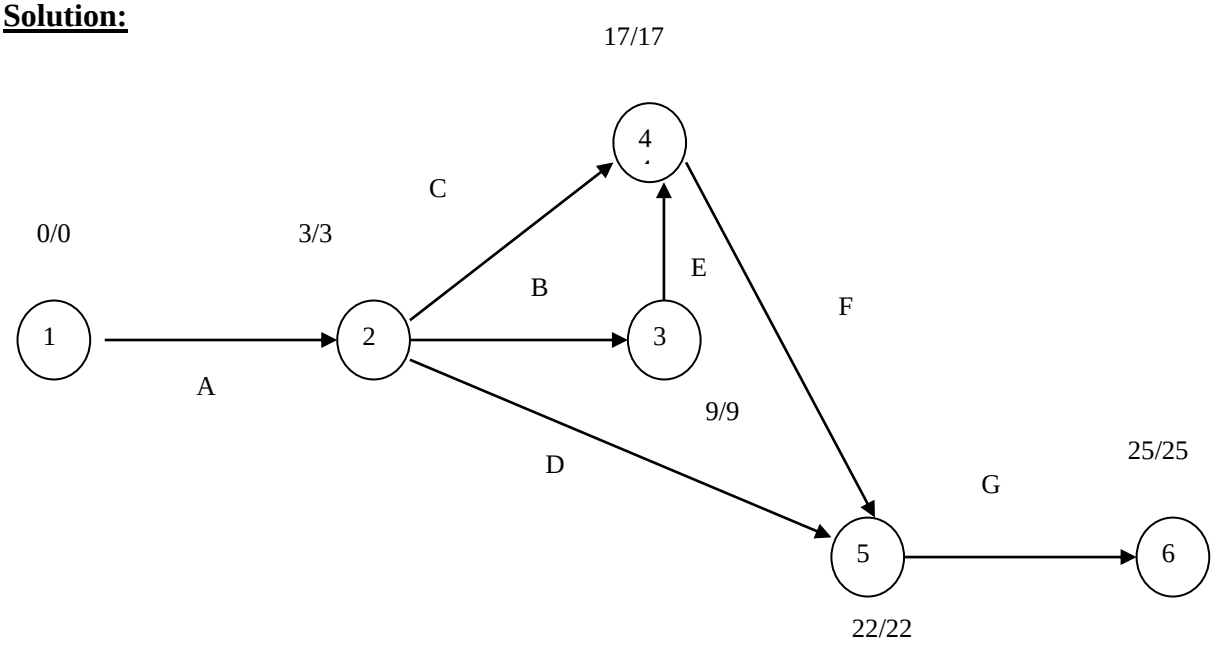
A	5	0	0	5	5	0	0
B	3	0	9	3	12	9	9
C	7	5	5	12	12	0	0
D	8	12	12	20	20	0	0
E	4	20	20	24	24	0	0
F	3	20	21	23	24	1	1

Problem 10:



Find out EST, LST, EFT, LFT, FF and TF from the above figure:

Solution:

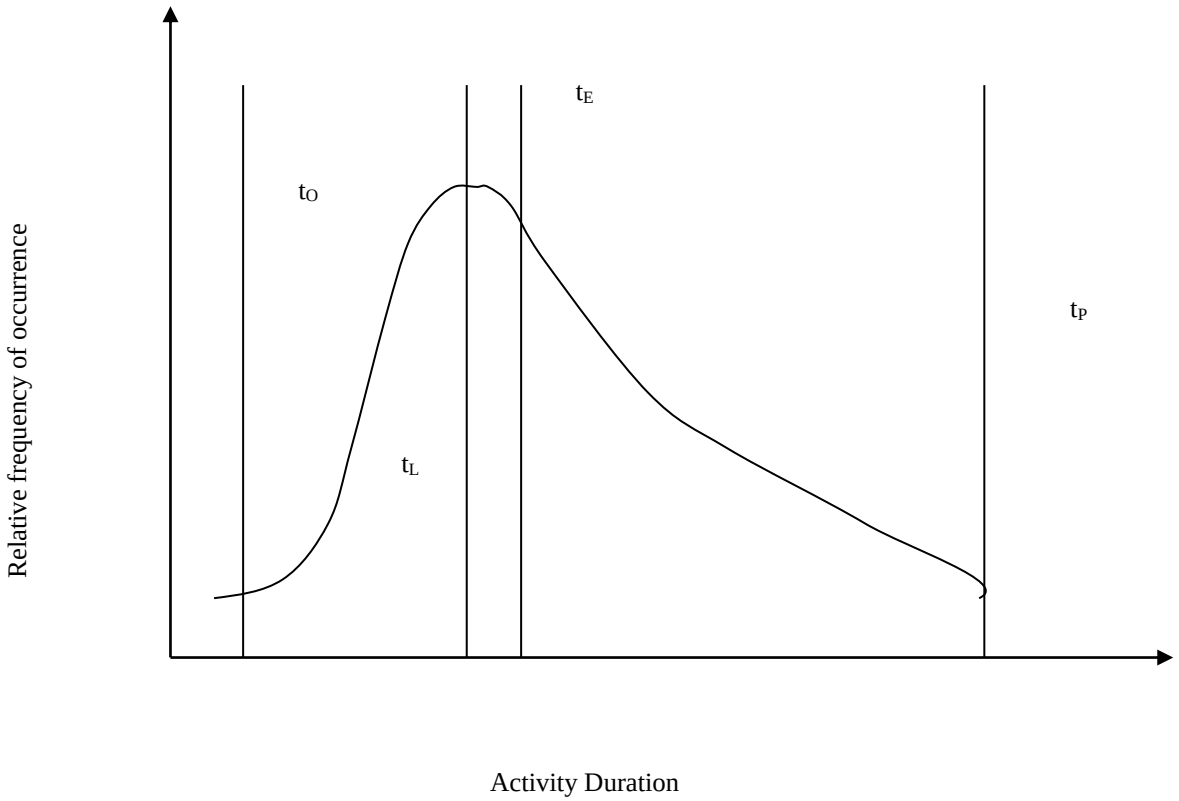


Activity	Duration	EST	LST	EFT	LFT	FF	TF

				(EST+Duration)	(LST+Duration)		(LFT-EFT)
A	3	0	0	3	3		0
B	6	3	3	9	9		0
C	9	3	8	12	17		5
D	7	3	15	10	22		12
E	8	9	9	17	17		0
F	5	17	17	22	22		0
G	3	22	22	25	25		0

PERT Method

- Pert method is usually applied for new projects with uncertain activity time.
- Example: Anew product development and marketing research projects
- Time estimates for each activity is based on three different values---
    1. t_o = Optimistic time (Everything goes extremely well)
    2. t_p = Pessimistic time (Everything goes badly)
    3. t_L = Most likely time (Everything goes normally)
- These times have beta distribution (skewed to Right/Left)



t_E ,expected time = $(t_O+4t_L+t_P)/6$

σ^2 .variance = $\{(t_P - t_O)/6\}^2$

Procedure:

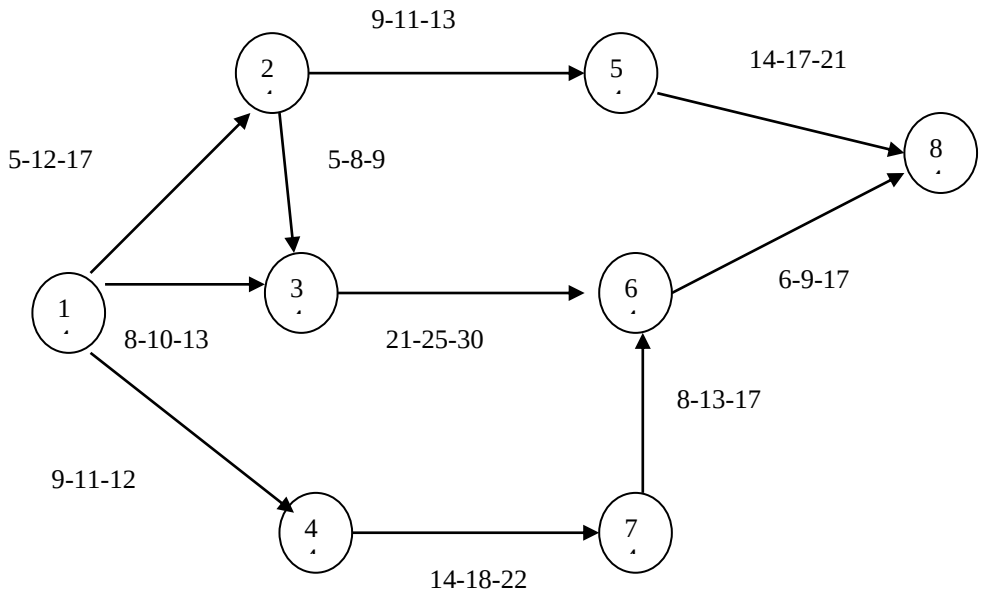
1. Determine EST and LST for the given Network diagram.
2. Determine the critical path
3. Determine t_E and $\Sigma\sigma^2$ for the critical path
4. Compute

$$Z = (t_P - t_E)/\sigma$$

5. From standard statistical table find the corresponding probability for z

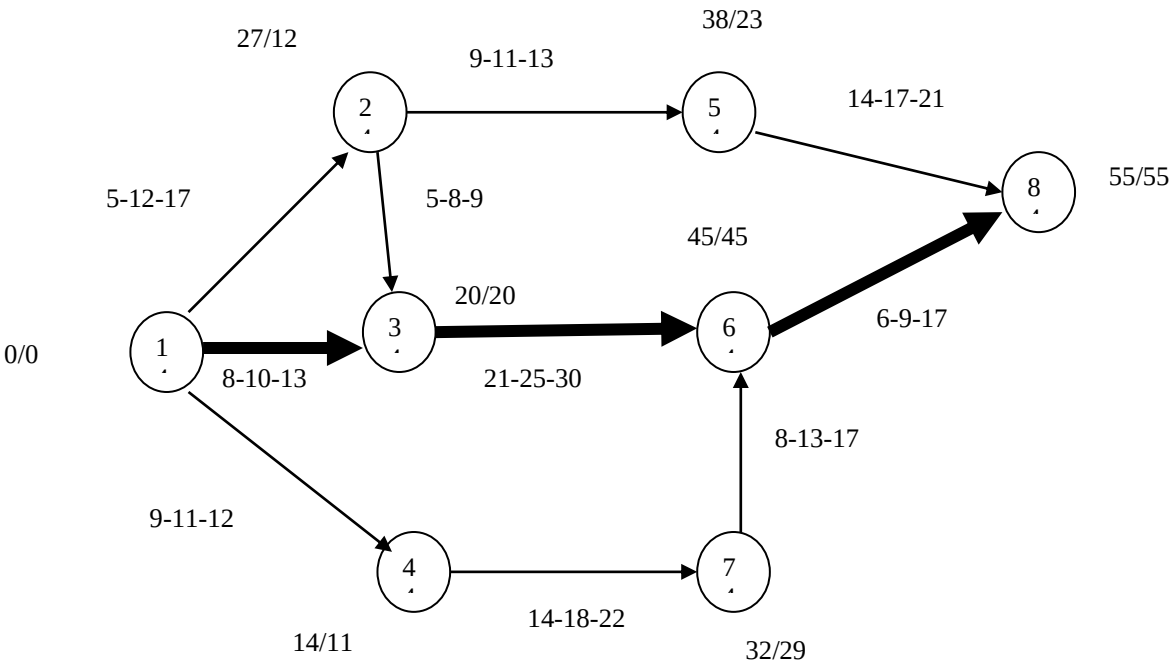
Problem 11:

The schedule completion time for the project shown by the network in following figure is 48 days.
Calculate the probability of the finishing the project within this time.



Solution:

1.



Activity	t_E	σ^2
1-2	12	
1-4	11	
2-3	08	
1-3	**10**	**0.69**
2-5	11	
5-8	17	
3-6	**25**	**2.78**
6-8	**10**	**3.36**
4-7	18	
7-6	13	

2. The critical path for the problem is 1-3-6-8

4. t_E = 10+25+10=45 days

5. $\Sigma\sigma^2$ for the critical path=0.69+2.78+3.36=6.83

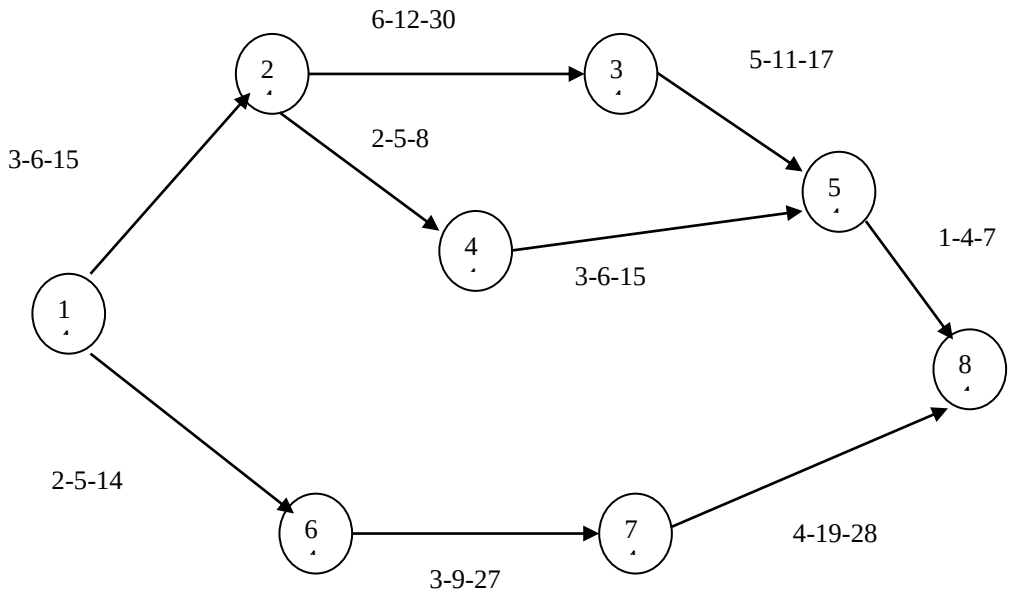
6. $Z = (t_P - t_E)/\sigma = (48-45)/\sqrt{6.83} = 1.15$

7. So the probability of the finishing the project within this time (45 days) =P (Z=1.15) = 0.8749 = 87.49%

Problem 12:

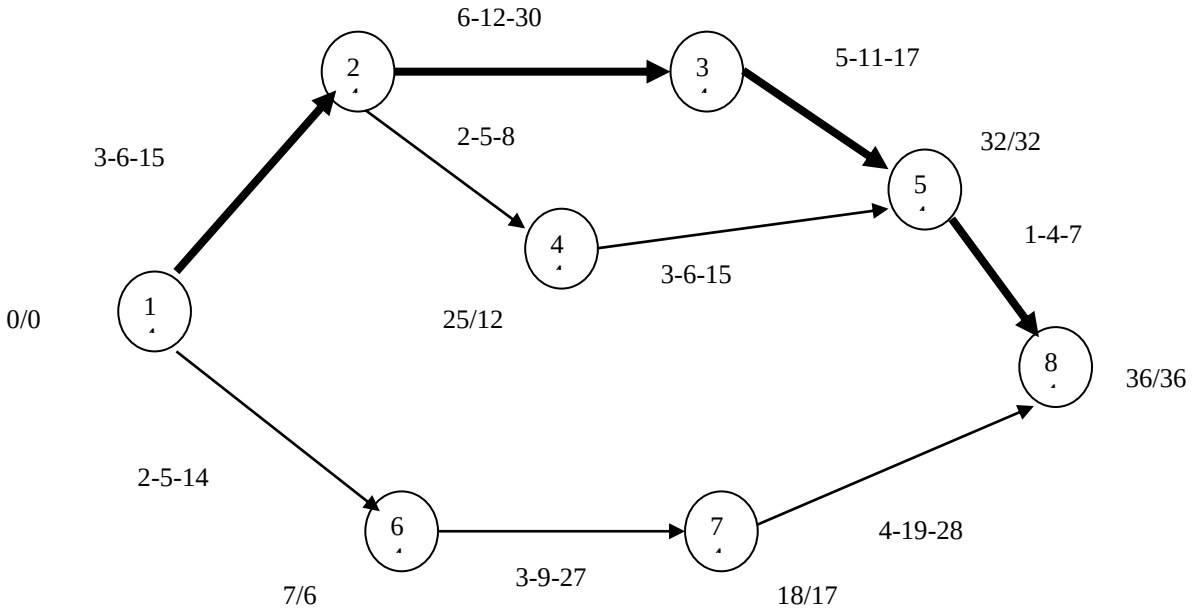
The schedule completion time for the project shown by the network in following figure is 41 days.

Calculate the probability of the finishing the project within this time.



Solution:

1.



Activity	t_E	σ^2
1-2	**7**	**4**
1-6	6	
2-3	**14**	**16**
3-5	**11**	**4**
2-4	5	
4-5	7	
5-8	**4**	**1**
6-7	11	
7-8	18	

2. The critical path for the problem is 1-2-3-5-8

3.t_E = 7+14+11+4=36 days

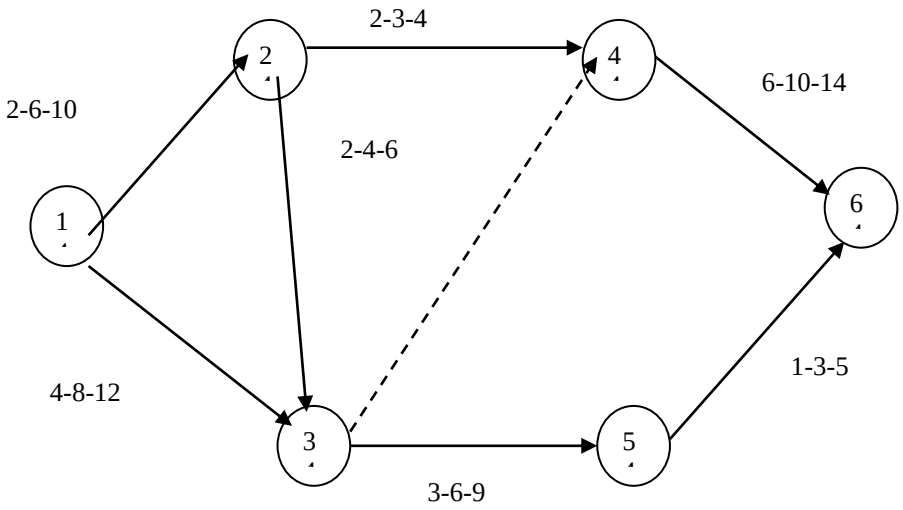
4.$\Sigma\sigma^2$ for the critical path=4+16+4+1=25

5.$Z = (t_P - t_E)/\sigma = (41-36)/\sqrt{25} = 1$

6.So the probability of the finishing the project within this time (41 days) =P (Z=1) = 0.8413 = 84.13%

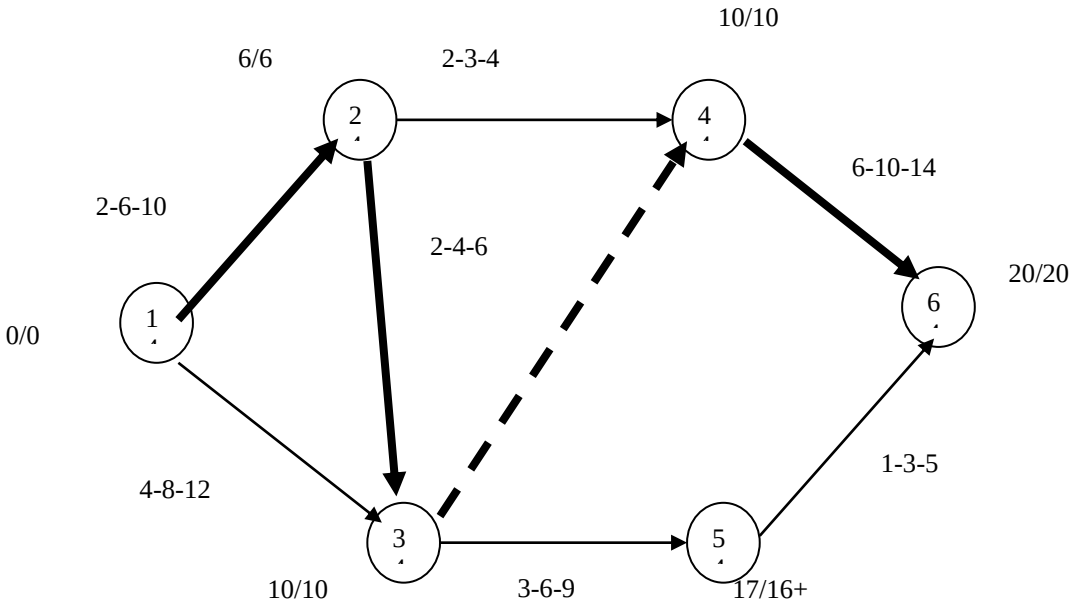
Problem 13:

The schedule completion time for the project shown by the network in following figure is 22 days.
Calculate the probability of the finishing the project within this time.



Solution:

1.



Activity	t_E	σ^2
1-2	**6**	**1.78**
1-3	8	
2-3	**4**	**0.44**
3-4	**0**	**0**
3-5	6	
5-6	3	
4-6	**10**	**1.78**

2. The critical path for the problem is 1-2-3-4-6

3. t_E = 6+4+0+10=20 days

4. $\Sigma\sigma^2$ for the critical path=1.78+0.44+1.78=4.0

5.$Z = (t_P - t_E)/\sigma = (22-20)/\sqrt{4} = 1$

6.So the probability of the finishing the project within this time

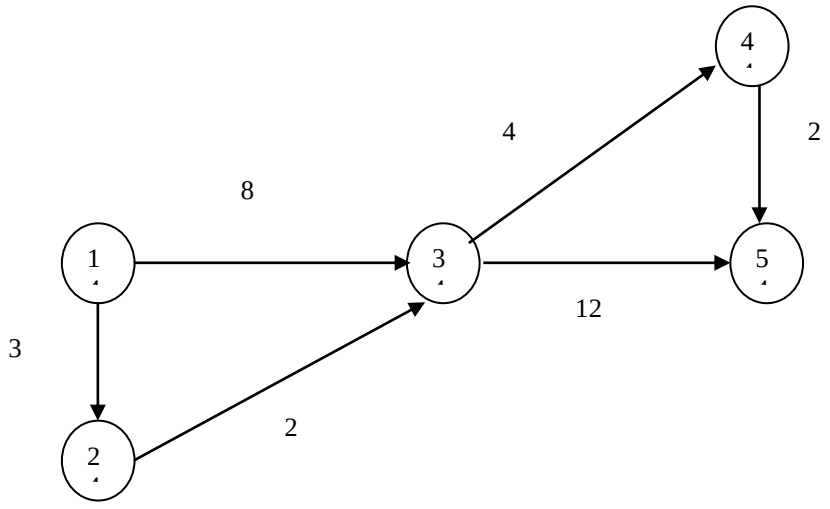
(41 days) =P (Z=1) = 0.8413 = 84.13%

Cost Analysis and Optimization

Problem 14:

The normal and crash flow of the following network are shown in the following table.Find out the total cost of the project.

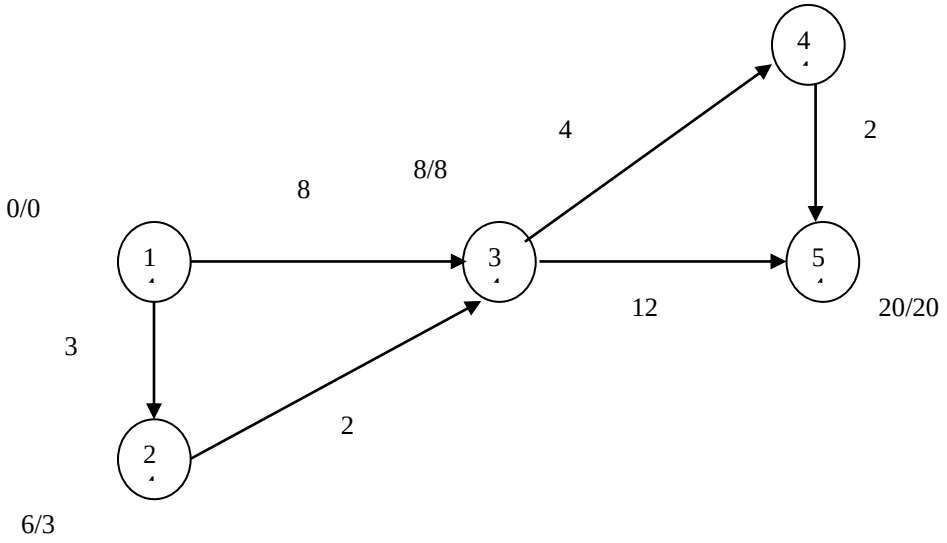
Activity	Normal		Crash	
	Duration	Cost, Tk	Duration	Cost, Tk
1-2	3	500	1	700
1-3	8	400	6	600
2-3	2	300	1	450
3-4	4	200	2	300
3-5	12	600	8	800
4-5	2	200	1	275



Solution:

18/12

1.



2. Determine different path and their duration:

Path	Duration (days)
1-3-5	20
1-2-3-4-5	11
1-3-4-5	14
1-2-3-5	17

3.So the critical path: 1-3-5 (Maximum days)

4.So normal duration of the project = 20 days

5.

Activity on critical path	ΔC Normal cost – crash cost	ΔT Normal duration – critical duration	ΔC/ΔT
1-3	200	2	100
3-5	200	4	50

Activity	ΔC/ΔT	Crash day	Crash cost	Path Duration			
				1-3-5	1-2-3-4-5	1-3-4-5	1-2-3-5
3-5	50	4	200	16	11	14	13
1-3	100	2	200	14	11	12	13

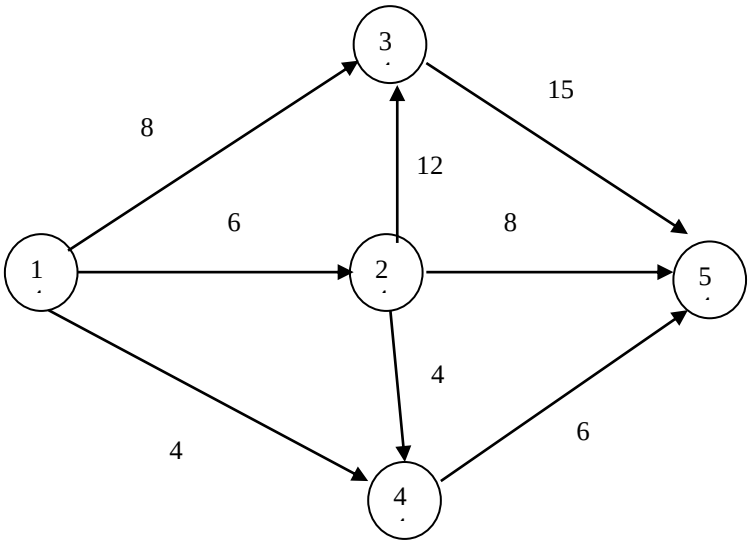
So the total cost = Direct cost + indirect cost + crash cost

=2200 + 0 +(200 + 200) = 2600 Tk

Problem 15:

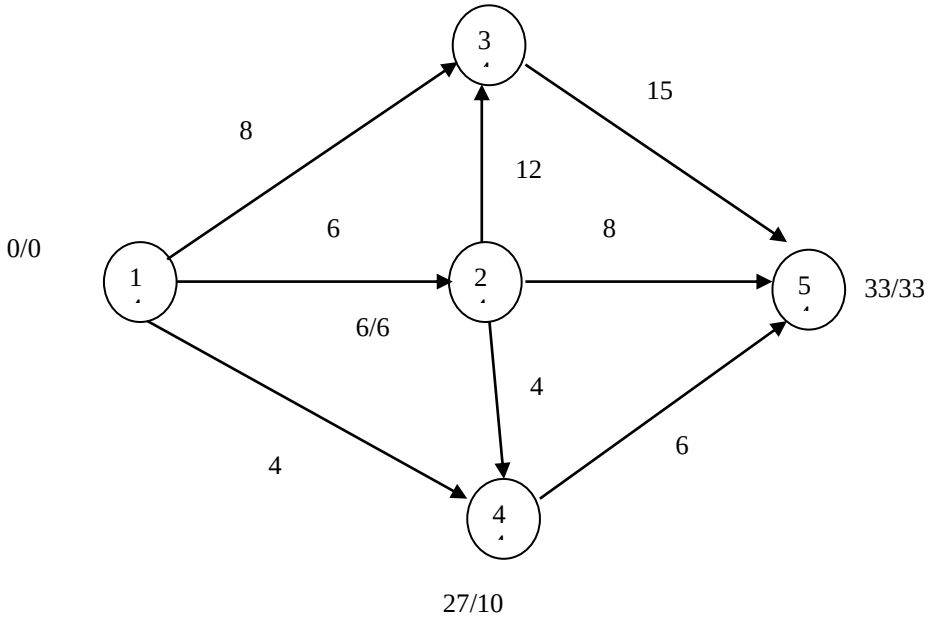
The normal and crash flow of the following network are shown in the following table.Find out the total cost of the project.

Activity	Normal		Crash	
	Duration	Cost, Tk	Duration	Cost, Tk
1-2	6	700	4	840
1-3	8	300	6	420
2-3	12	900	9	1200
1-4	4	200	2	300
2-5	8	500	7	800
3-5	15	100	9	400
4-5	6	400	4	500
2-4	4	600	2	760



Solution:

1.



2. Determine different path and their duration:

Path	Duration (days)
1-3-5	23
1-2-5	14
1-4-5	10
1-2-3-5	**33**
1-2-4-5	16

3.So the critical path: 1-2-3-5 (Maximum days)

4.So normal duration of the project = 33 days

5.

Activity on critical path	ΔC Normal cost – crash cost	ΔT Normal duration – critical duration	ΔC/ΔT
1-2	140	2	70
2-3	300	3	100
3-5	300	6	50

Activity	ΔC/ΔT	Crash	Crash	Path Duration

		day	cost	1-2-3-5	1-2-5	1-3-5	1-4-5	1-2-4-5
3-5	50	6	300	27	14	17	10	16
1-2	70	2	140	25	12	17	10	14
2-3	100	3	300	22	12	17	10	14

So the total cost = Direct cost + indirect cost + crash cost

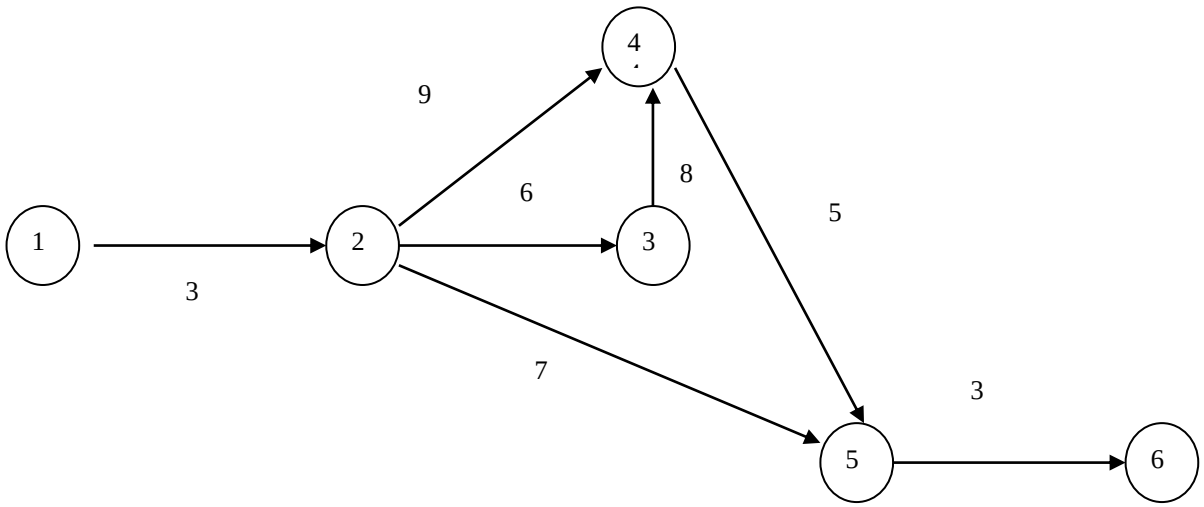
=3700+ 0 +(300+140+300) = 4440 Tk

Problem 16:

The normal and crash flow of the following network is shown in the following table. Find out the total cost of the project. The indirect cost is 160 Tk per day.

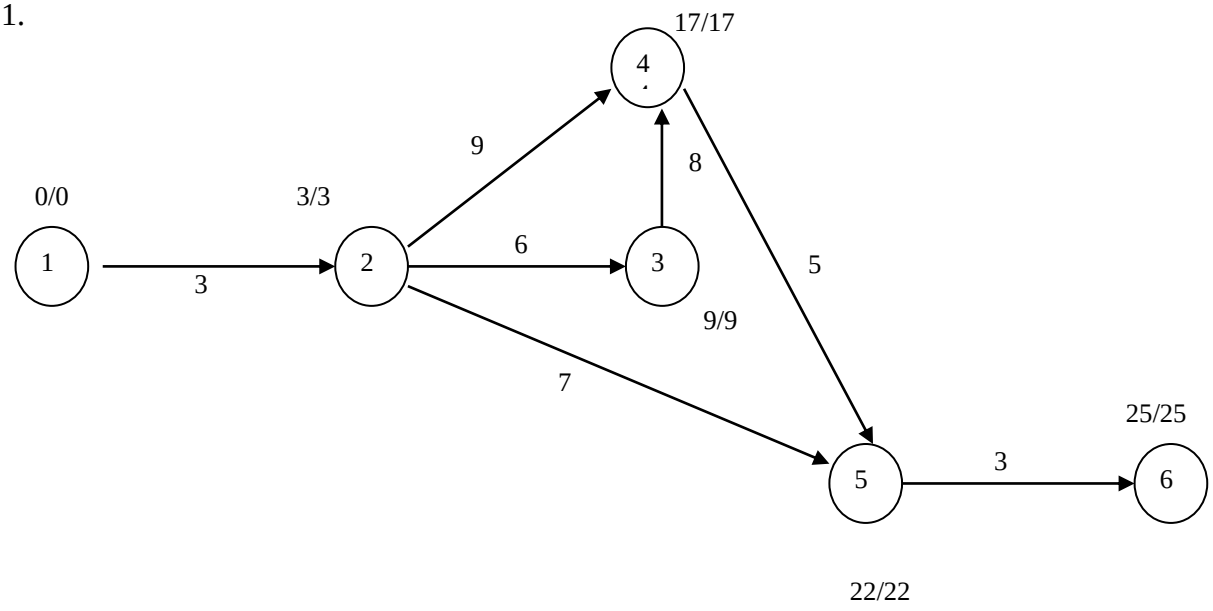
Activity	Normal		Crash	
	Duration	Cost, Tk	Duration	Cost, Tk
1-2	3	360	2	400
2-3	6	1440	4	1620
2-4	9	2160	5	2380
3-4	7	1120	5	1600
4-5	8	400	4	800
5-6	5	1600	3	1770
2-5	3	480	2	760

Direct cost: 7560 Tk



Solution:

1.



2. Determine different path and their duration:

Path	Duration (days)
1-2-3-4-5-6	25
1-2-4-5-6	20
1-2-5-6	13

3.So the critical path: 1-2-3-4-5-6 (Maximum days)

4.So normal duration of the project = 25 days

5.

Activity on critical path	ΔC Normal cost – crash cost	ΔT Normal duration – critical duration	ΔC/ΔT
1-2	40	1	40
4-5	170	2	85
2-3	180	2	90
3-4	400	4	100
5-6	280	1	280

Activity	ΔC/ΔT	Crash day	Crash cost	ΔC/ΔT	Path Duration , days		
					1-2-3-4-5-6	1-2-4-5-6	1-2-5-6
1-2	40	1	40		24	19	12
4-5	85	2	170		22	17	12
2-3	90	2	180		20	17	12
3-4	100	3	300		17	17	12

So the total cost = Direct cost + indirect cost+ crash cost

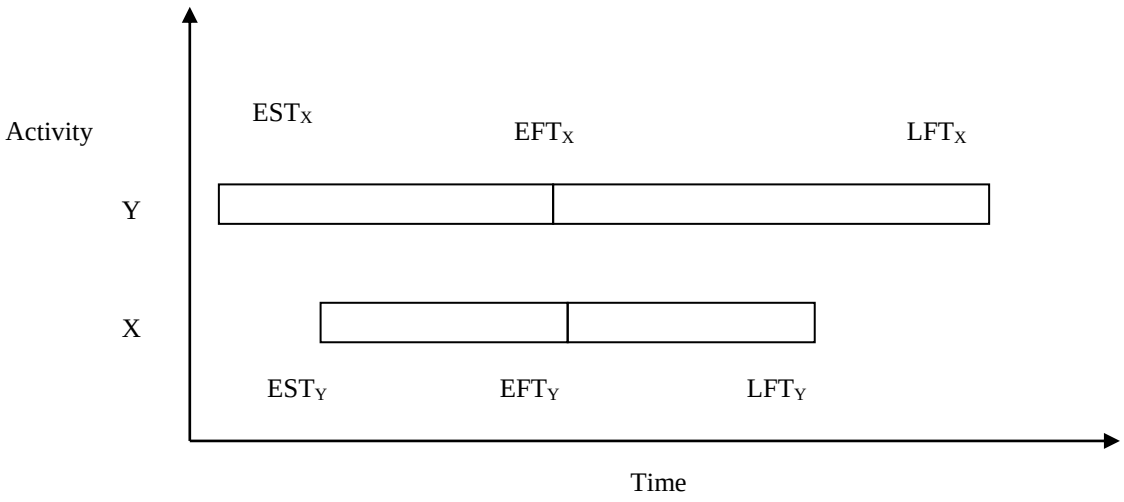
=7560+17*160 +(40+170+180+300) = 10970 Tk

Resources scheduling

- Resources scheduling means allocation of available resources to activities in the project.
- Due to resources limitation, conflict between activities is frequently encountered.
- To eliminate this conflict activities are resequenced so that increase in project duration due to resequencing is minimum.

Procedure :

- Activity i is chosen to be the one which has smallest EFT of all activities that are in conflict.
- Activity j is the one, which has largest LST.
- When the choice leads to the special case where i=j , the 2nd least EFT or LST is used.



IPD = increase in project duration

$IPD = EFT_X + DUR - LFT_Y$

$= EFT_X - (LFT_Y - DUR)$

$= EFT_X - LST_Y$

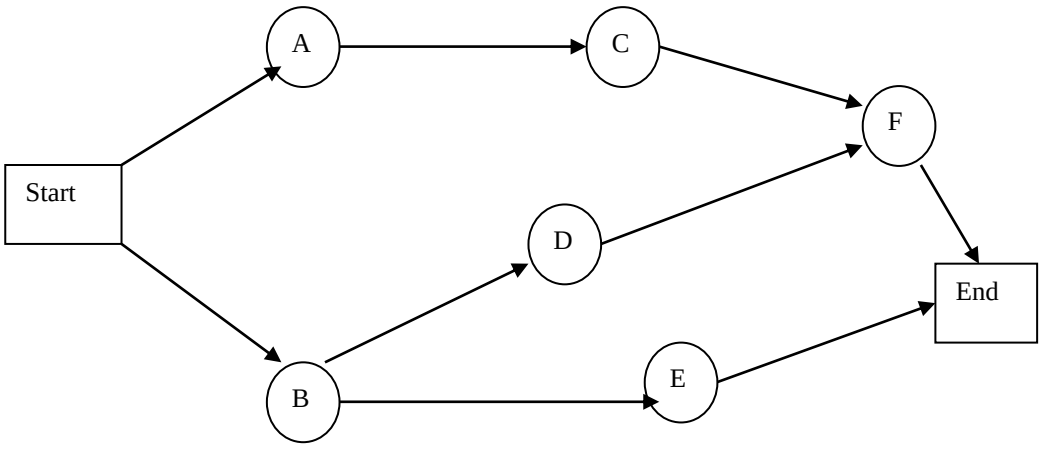
Problem 17:

From the circle network shown in the following figure and the data shown in the following table Develop a feasible project plan and schedule using resources scheduling method.

Activity	duration	Required no of plumbers	Required no of steel works
A	4	1	2
B	2	0	3
C	2	2	0
D	8	1	0
E	4	3	0
F	4	1	2

Maximum level of avail resources :

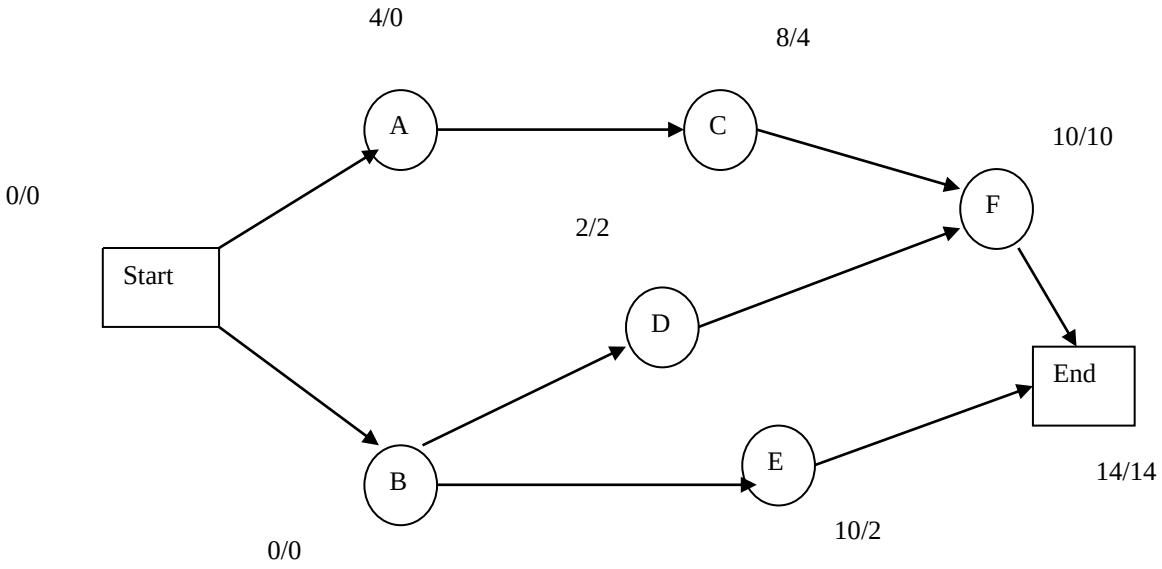
Plumbers = 4
Steel workers = 3



Solution:

1.Day 01 : A and B can begin

Total resource required :
Plumber =1+0=1<4
Worker = 2+3 = 5 >3
So conflict exit between A and B



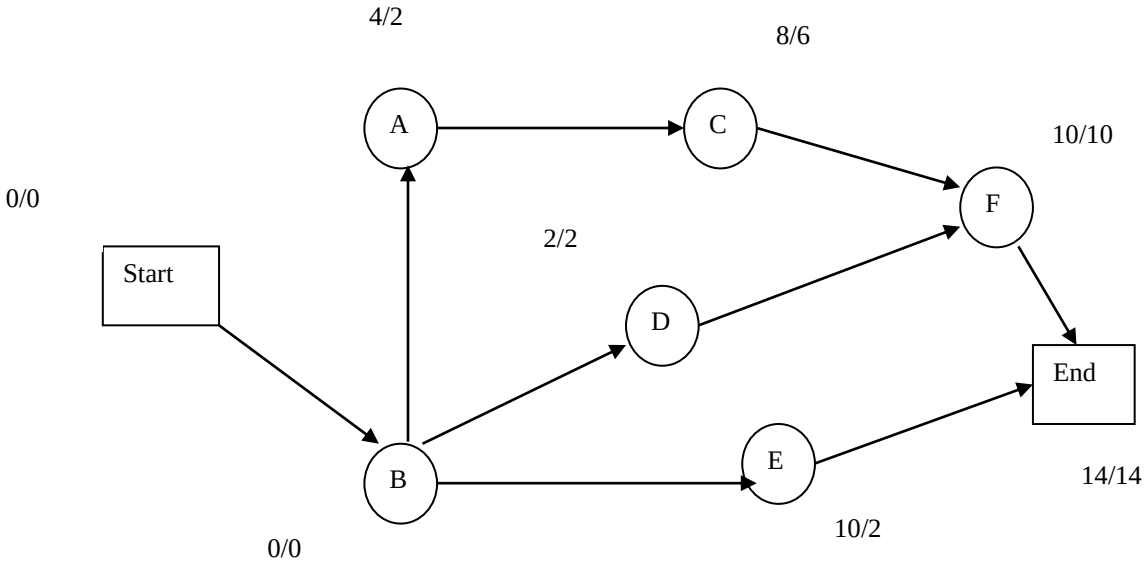
Activity	Duration	EST	LST	EFT
A	4	0	4	4
B	2	0	0	2
C	2	4	8	6
D	8	2	2	10
E	4	2	10	6
F	4	10	10	14

Lowest EFT =B
Highest LST =A
A should follow B.

2.Day 02 : No conflict exist ; B will be finished

3.Day 03: ; A, D and E can begin

Total resource required:
Plumber =1+1+3=5>4
Worker = 2+0+0 = 2<3
So conflict exit between A , D and E.



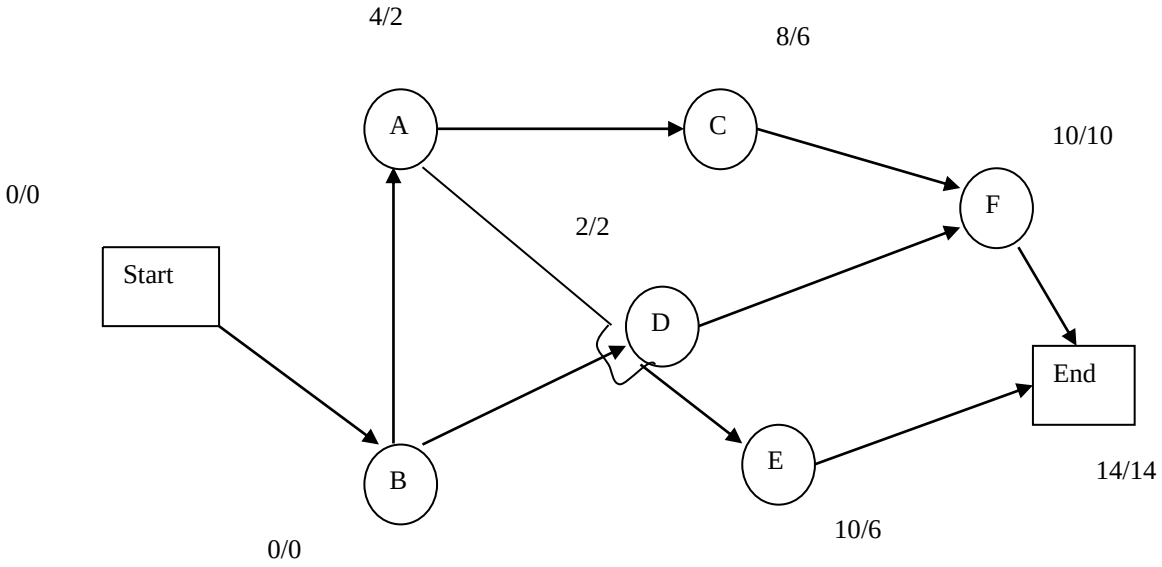
Activity	Duration	EST	LST	EFT
A	4	2	4	6
B	2	0	0	2
C	2	6	8	8
D	8	2	2	10
E	4	2	10	6
F	4	10	10	14

Lowest EFT =A/E
Highest LST =E
E should follow A.
But at the same time due to availability of resources D also begin.

4.Day 06 : “A” will be finished

5. Day 07: C and E can begin .D is going on.

Total resource required :
Plumber =1+2+3=6>4
Worker = 0+0+0 = 0<3
So conflict exit between C , E and D .



Activity	Duration	EST	LST	EFT
A	4	2	4	6
B	2	0	0	2
C	**2**	**6**	**8**	**8**
D	**8**	**2**	**2**	**10**
E	**4**	**6**	**10**	**10**
F	4	10	10	14

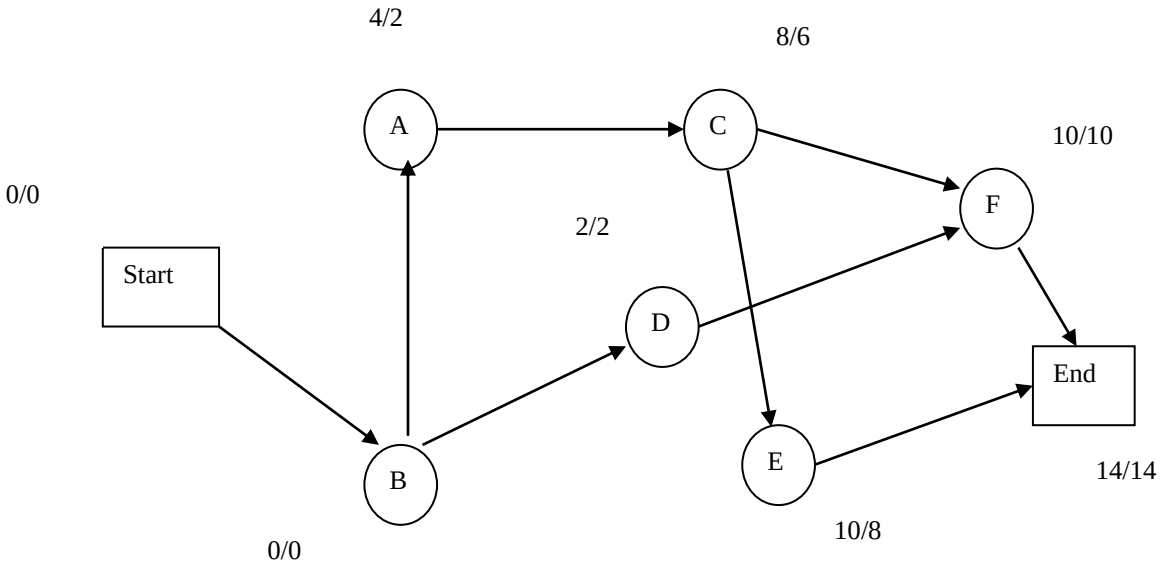
Lowest EFT =C
Highest LST =E
E should follow C.
So start C.

6.Day 08: C will be finished.

7.Day 09: D is going on (will be finished at 10^{th} (2+8) day) ; E and F can begin

Total resource required:
Plumber =1+3+1=5>4
Worker = 0+0+2=2<3

So conflict exit between D, E and F to continue together.



Activity	Duration	EST	LST	EFT
A	4	2	4	6
B	2	0	0	2
C	2	6	8	8
D	**8**	**2**	**2**	**10**
E	**4**	**8**	**10**	**12**
F	**4**	**10**	**10**	**14**

Lowest EFT =E
Highest LST =F
F should follow E.
But at the same time due to availability of resources E also begin.

So D will be continue and start E .

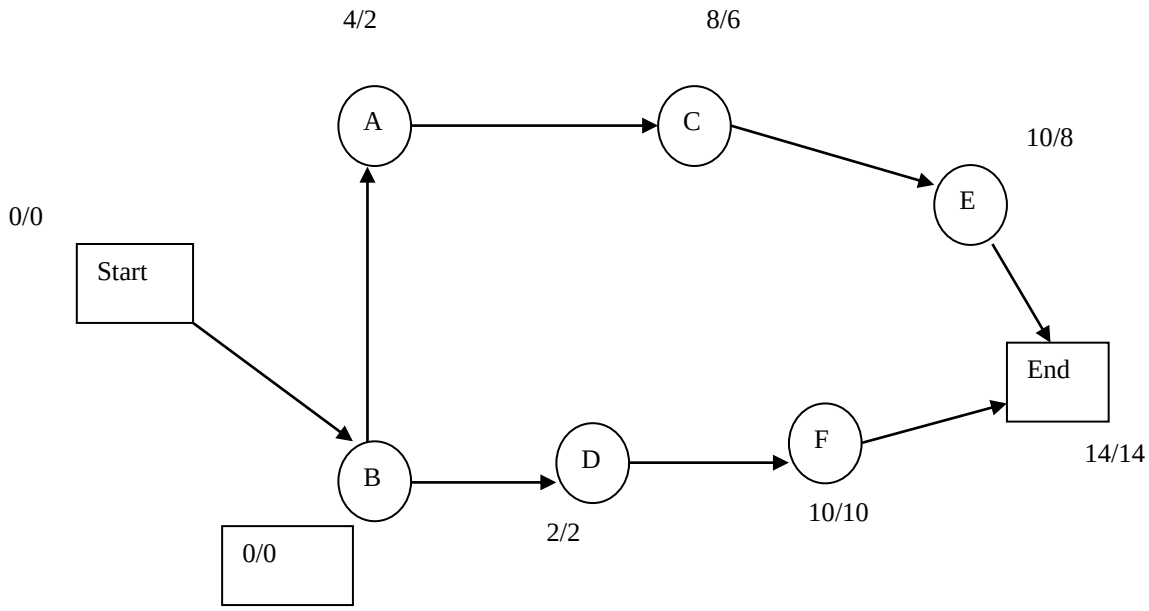
8.Day 10: D will be finished; E is going on.

9.Day 11: F will be started.

10.Day 12: E will be finished.

11.Day 14: F will be finished.

Final Network:



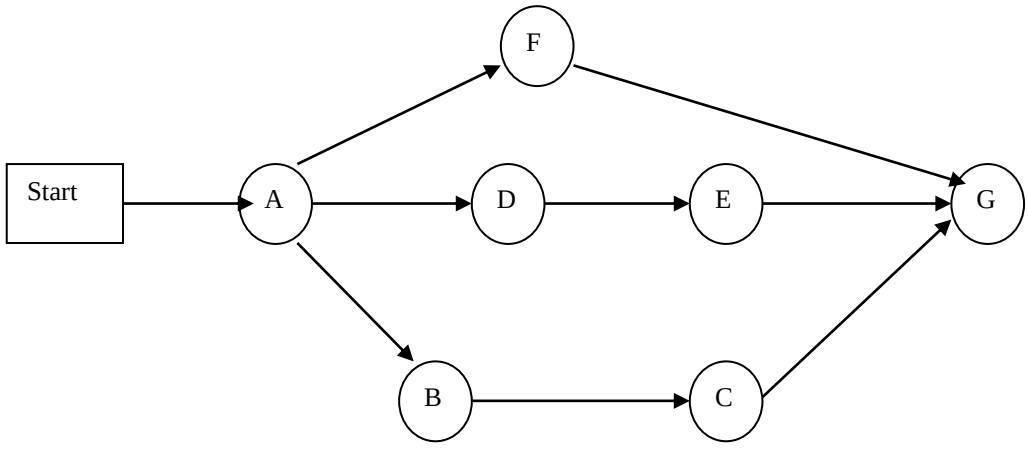
Problem 18:

From the circle network shown in the following figure and the data shown in the following table Develop a feasible project plan and schedule using resources scheduling method.

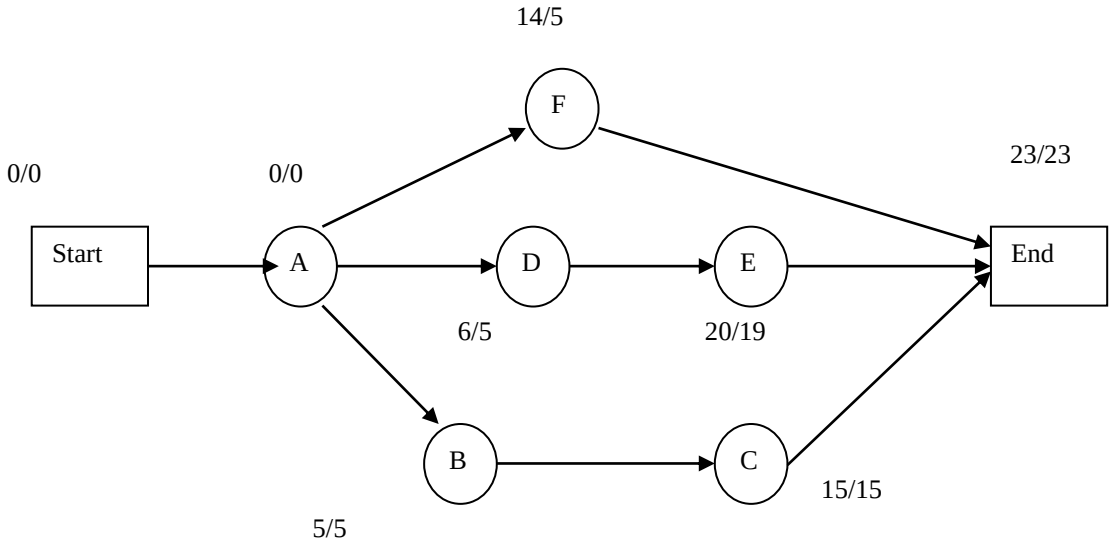
Activity	Duration	Mason	Welder	Crane
A	5	2	-	-
B	10	-	-	2
C	8	-	8	-
D	14	-	6	-
E	3	1	-	-
F	9	-	-	1
G	0	-	-	-

Maximum level of avail resources:

Mason = 2
Welder = 8
Crane = =3



Solution:



Activity	Duration	EST	LST	EFT
A	5	0	0	5
B	10	5	5	15
C	8	15	15	13
D	14	5	6	19
E	3	19	20	22
F	9	5	14	14

1.Day 01: A will be started.

2.Day 05: A will be finished.

3.Day 06: D, B and F can begin
Total resource required:
Mason = 0
Welder = 6<8
Crane = =2<3
So no conflict exit between D,B and F .

So Start job D,B and F together.

4. Day 14 : F will be finished.

5.Day 15 : B will be finished. D is going on and E and C can begin.

Total resource required:
Mason = 1<2
Welder = 8+6>8
Crane = =0<3
So conflict exit between D, E and C .
But no resources conflict between only E and D ; therefore E can begin together with D.

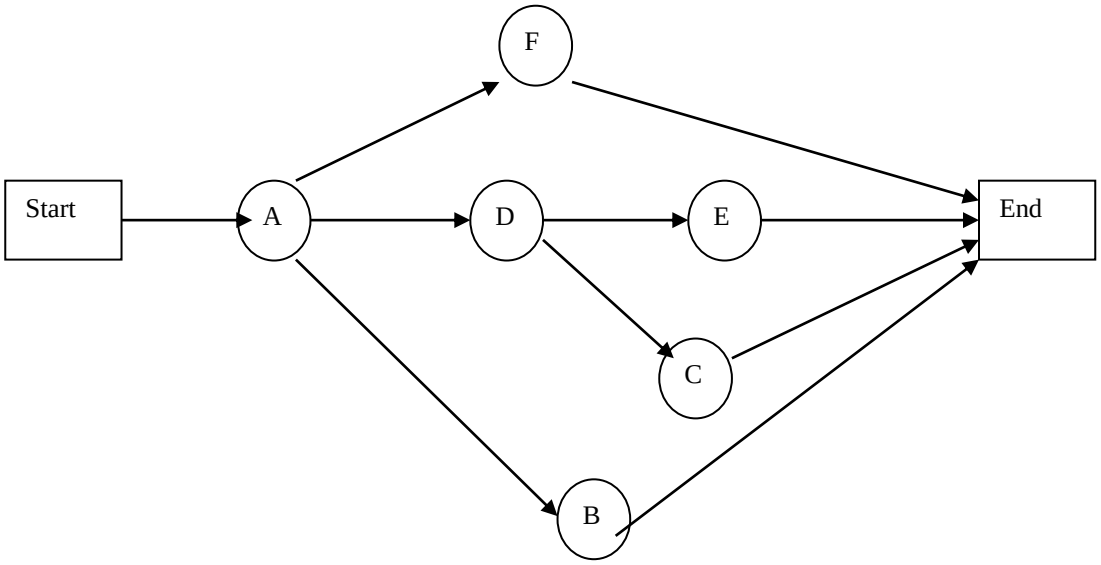
6. .Day 17 : E will be finished

6.Day 19 : D will be finished

7.Day 20 : start C

8.Day 27 : C will be finished.

Final Network:



A 3-m column with the cross section shown in Fig. is constructed from two pieces of timber. The timbers are nailed together so that they act as a unit. Determine (a) the slenderness ratio, (b) the Euler buckling load (E= 13 GPa for timber), and (c) the axial stress in the column when Euler load is applied.

First, here is the program that does the Euler method prediction.

```
> eulermethod:=proc(yin,x,h,f)
> local yout,ll,i:
> # Given the array yin of unknowns at x, uses Euler method to return
> # the array of values of the unknowns at x+h. The function f(x,y) is
> # the array-valued right hand side of the given system of ODE's.
> ll:=nops(yin):
> yout:=[]:
> for i from 1 to ll do
> yout:=[op(yout),yin[i]+h*f(x,yin,i)];
> od:
> RETURN(yout):
> end:
```

Next, here is the program that takes as input an array of guessed values of the unknowns atx+hand re

nes the guess to convergence using the trapezoidal rule.
```
> traprule:=proc(yin,x,h,eps,f)
> local ynew,yfirst,ll,toofar,yguess,i,allnear,dist;
> # Input is the array yin of values of the unknowns at x. The program
> # first calls eulermethod to obtain the array ynew of guessed values
> # of y at x+h. It then refines the guess repeatedly, using the trapezoidal
> # rule, until the previous guess, yguess, and the refined guess, ynew, agree
> # within a tolerance of eps in all components. Program then computes dist,
> # which is the largest deviation of any component of the final converged
> # solution from the initial Euler method guess. If dist is too large
```
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erential Equations
```
> # the mesh size h should be decreased; if too small, h should be increased.
> ynew:=eulermethod(yin,x,h,f);
> yfirst:=ynew;
> ll:=nops(yin);
> allnear:=false;
> while(not allnear) do
> yguess:=ynew;
> ynew:=[];
> for i from 1 to ll do
> ynew:=[op(ynew),yin[i]+(h/2)*(f(x,yin,i)+f(x+h,yguess,i))];
> od;
> allnear:=true;
> for i from 1 to ll do allnear:=allnear and abs(ynew[i]-yguess[i])<eps od:
> od; #end while
> dist:=max(seq(abs(ynew[i]-yfirst[i]),i=1..ll));
> RETURN([dist,ynew]):
> end:
```
The two programs above each operate at a single pointxand seek to compute the unknowns at the next pointx+h. Now we need a global view, that is a program that will call the above repeatedly and increment the value ofxuntil the end of the desired range ofx. The global routine also needs to check whether or not the mesh size hneeds to be changed at each point and to do so when necessary.
```
> trapglobal:=proc(f,y0,h0,xinit,xfinal,eps,nprint)
> local x,y,y1,h,j,arr,dst,cnt:
> # Finds solution of the ODE system y'=f(x,y), where y is an array
> # and f is array-valued. y0 is initial data array at x=xinit.
> # Halts when x>xfinal. eps is convergence criterion for
> # trapezoidal rule; Prints every nprint-th value that is computed.
> x:=xinit:y:=y0:arr:=[[x,y[1]]]:h:=h0:cnt:=0:
> while x<=xfinal do
> y1:=traprule(y,x,h,eps,f):
> y:=y1[2]:dst:=y1[1];
> # Is dst too large? If so, halve the mesh size h and repeat.
> while dst>3*eps do
> h:=h/2; lprint(`At x=`,x,`h was reduced to`,h);
> y1:=traprule(y,x,h,eps,f):
> y:=y1[2]:dst:=y1[1];
> od:
> # Is dst too small? If so, double the mesh size h and repeat.
> while dst<.0001*eps do
> h:=2*h; lprint(`At x=`,x,`h was increased to`,h);
> y1:=traprule(y,x,h,eps,f):
> y:=y1[2]:dst:=y1[1];
> od:
```

```
> # Adjoin newly computed values to the output array arr.
> x:=x+h; arr:=[op(arr),[x,y[2]]]:
> # Decide if we should print this line of output or not.
> cnt:=cnt+1: if cnt mod nprint =0 or x>=xfinal then print(x,y) fi;
```

```
> od:
> RETURN(arr);
> end:
```
The above three programs comprise a general package that can numerically solve systems of ordinary di
erential equations. The applicability of the package is limited mainly by the fact the Euler's method and the Trapezoidal Rule are fairly primitive approximations to the truth, and therefore one should not expect dazzling accuracy when these routines are used over long intervals of integration.