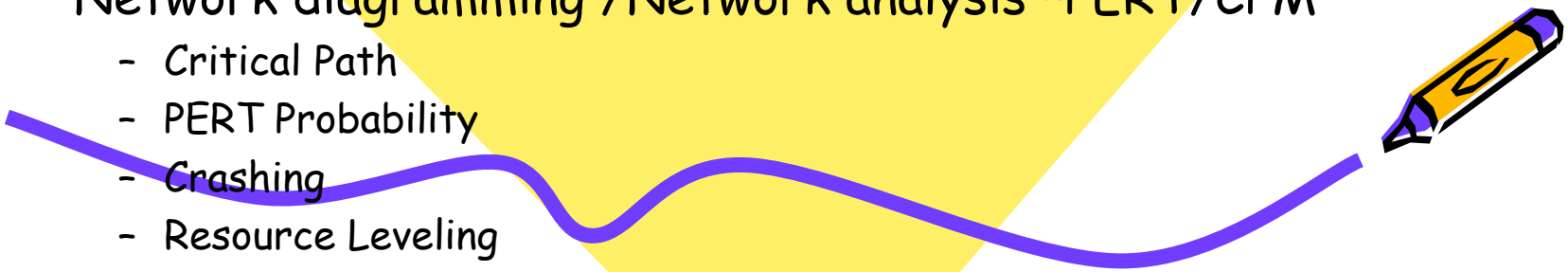
CHAPTER THREE: PROJECT PLANNING

Introduction to planning and scheduling

- Project Scope and Human Resource Planning
- Work Breakdown Structure
- Project Time and Cost Planning
  - Project management techniques/Tools.
  - Gantt charts
  - Network diagramming /Network analysis –PERT/CPM
    - Critical Path
    - PERT Probability
    - Crashing
    - Resource Leveling
    - CAPM Tools
    - Project Risk Planning and Management
    - Project Procurement Planning



Introduction

Introduction

- After initiation, the project is planned to an appropriate level of detail.
- The main purpose is to plan time, cost and resources, risk, procurement, and quality adequately to estimate the work needed and to manage risk effectively during project execution

- **Some important questions**
  - What are the various activities?
  - What is the time needed by each activity?
  - What is the total time to complete the project?
  - What are the scheduled start and finish dates for each specifies activity?
  - Which activities are "critical" and must be completed exactly as scheduled in order to keep the project on schedule? – look at activities and look which
  - How long can"non critical" activities be delayed before they cause an increase in the total project completion time?
  - What resources do I need for each activity?

INTRODUCTION CONT…..

What is project planning?

- Involves developing estimates for the work to be performed, establishing the necessary commitments and defining a schedule to perform the work
  - Project planning begins with a statement of work to be performed and other constraints and goals that define and bound the projects(established by requirement defined)
- Planning process takes the estimates produced by estimation process and uses these to produce a schedule, identify and assess risks, and negotiate commitments.

Project planning determines a project schedule based upon

- Project constraints (delivery, staff, budget).
- Project parameters (structure, size, functions).
- Project milestones and deliverable.

INTRODUCTION CONT…..

Planning and scheduling must estimate risk associated with each decision.

Project scheduling involves separating work into tasks and predicting task completion.

- There are parallel tasks.
- Coordinate parallel tasks to optimize work force.
- Allow for problems.
- Schedule must be periodically revised with progress.
- Managers are responsible for planning, scheduling and controlling projects.

Project Planning CONT..

Project Planning

- Software project planning is task, which is performed before the production of software actually starts. It is there for the software production but involves no concrete activity that has any direction connection with software production; rather it is a set of multiple processes, which facilitatessoftware production.
- Project planning may include the following:

1. **Scope Management**
   - It defines the scope of project; this includes all the activities, process need to be done in order to make a deliverable software product.

Scope management cont…

- Scope management is essential because it creates boundaries of the project by clearly defining what would be done in the project and what would not be done. This makes project to contain limited and quantifiable tasks, which can easily be documented and in turn avoids cost and time overrun.
- During Project Scope management, it is necessary to
  - Define the scope
  - Decide its verification and control
  - Divide the project into various smaller parts for ease of management.
  - Verify the scope
  - Control the scope by incorporating changes to the scope
- 2. **Project Estimation**
  - For an effective management accurate estimation of various measures is a must. With correct
  - estimation managers can manage and control the project more efficiently and effectively.

PROJECT ESTIMATION

Project estimation may involve the following:

a) Software size estimation

- Software size may be estimated either in terms of KLOC *KiloLineofCode or by calculating* number of function points in the software. Lines of code depend upon coding practices and Function points vary according to the user or software requirement.

b) Effort estimation

- The managers estimate efforts in terms of personnel requirement and man-hour required to produce the software. For effort estimation software size should be known. This can either be derived by managers' experience, organization's historical data or software size can be converted into efforts by using some standard formulae.

C) Time estimation

- Once size and efforts are estimated, the time required to produce the software can be estimated. Efforts required is segregated into sub categories as per the requirement specifications and interdependency of various components of software. Software tasks are divided into smaller tasks, activities or events by Work Breakthrough Structure *WBS. The* tasks are scheduled on day-to-day basis or in calendar months.
- The sum of time required to complete all tasks in hours or days is the total time invested to complete the project.

PROJECT ESTIMATION

d) Cost estimation

- This might be considered as the most difficult of all because it depends on more elements

A Project Plan

- **A Plan:** The listing or visual display that results when all project activities have been subjected to:-
  - Estimating.
  - Logical sequencing.
  - Time analysis.

- Project planning is iterative from initial to completion. Is not a one-off-document which is produced at the beginning of the project and remains static throughout the project life:
  - Instead it is a living document, reflecting changes as they happen and continuing to reflect the plan from a given moment until project completion.
- Some projects only include a breakdown of the project in activities and tasks(work breakdown structure- wbs) but proper project plans should in fact cover this and more under three main areas.

Major types of plan:-

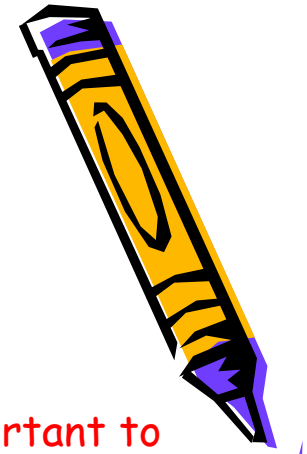
a) Management Plan

- Describes how the project will be monitored and controlled against business case. It will identify the breakdown of the project into stages.
- Shows any other periodic reporting events for the project board, and define the divisions of work between the major skills groups and the costs of work
- Must also identify the major risks associated with the project which may affect it – includes overheads e. g. reviews, meeting, documentation, organization, resources – WBS

b) Technical Plan

- Describes how resources will be used and how long each component will take to achieve. These will form the (WBS) for the project
- It is based upon selected Life Cycle Models and activities
  - Architecture –how the component will be structured and related to each other
  - The products
  - Dependent between products
  - Alternatives and variables which will be needed to be considered in every stage.

Major types of plan cont…



c) Quality Plan

- Quality plan presents the user's or customer's point of view
- Describes how the product will achieve required quality level,- it is important to list quality characteristics by stakeholders(functional and non functional requirements)
  - Validation and verification plans
  - Techniques and methodologies
  - Configuration standards

Project Plan Document

Project management plan document: should be dynamic, flexible and subject to change when the project environment or project changes.

- Functions;

i. used to coordinate and integrate information across project management knowledge area and across the organization.

Project plan Cont…

ii) documents project planning assumptions and decisions regarding choices

iii) facilitates communication among stakeholders

iv) define content, extent and timing of key management reviews

v) provide a baseline for progress measurements and project control

Content of a Project plan contents;

- **Introduction and overview of the project**;
  - Name, Project description and need addressed, sponsor name, deliverables of the project, project manager and team members etc.
- **Project organization:-**
  - organization charts, project responsibilities, other organization or process-related information
- **Management and technical approaches;-**
  - management objectives, project controls, risk management, project staffing, and technical processes.
- **Work to be performed , project schedule and budget:**
  - major work packages, key deliverables, summary schedule, detailed schedule, summary budget and details budget

Project plan Cont…

Supplementary Project Plans

Supplementary plans that focus on particular aspects of the project should be produced for incorporation into the Project Plan.

These include the following:

1. **Contingency Plan;**

   . The plan is specifically aimed at continuing the project in the event of one or more risks occurring. It is to be hoped that it will not need to be used.

2. **Business Plan;**
   - This plan contains all the relevant internal business information regarding the Project.
   - Information in the Business Plan is highly sensitive and should be available for company internal use only on a restricted distribution basis.

3. **Quality Plan;**
   - The Project Manager is responsible for the quality of the project a s well as for the quality of the solution components produced by the project.
   - Quality should be a priority throughout the project life cycle and should be planned from the outset

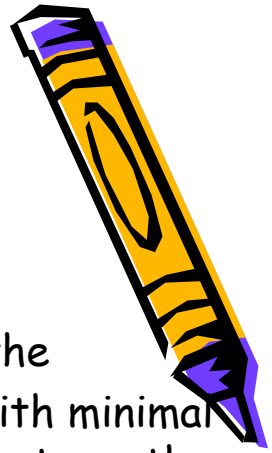
Supplementary Project Plans

4. Test Plan;

- The Test Plan should define the generic levels of testing and the basic test environment and structure needed to support the required levels of testing.
- It should be clearly understood that the test plan acts as a contractual and legal document and unless otherwise approved by the management must covers the following:-

- i) **An Acceptance Test Specification (ATS)**
  - that matches the structure of the Requirements Specification. The ATS is usually delivered together with the Requirements Specification describing WHAT tests must be carried out to verify to the user(s) that the Requirements specified have been met
- ii) **The Acceptance Test Procedures (ATP)**
  - is usually produced during the Physical Design stage/phase. The ATP converts what was specified in the ATS and describes HOW the tests will be performed, including the steps, data to be used and results to be obtained.
  - Tests should be independent where-ever possible and must be signed by both Customer and User Project Manager after successful execution. In principal the **Test Plan should**:
- **Identify:**
  - *The items to be tested*
    - » *The requirements or features to be tested*
    - » *The test pass/fail criteria based on the Requirements Specification.*
- **Include:**
  - *Test coverage, the tools and approaches to be applied', he environmental needs,the testing tasks to be performed, the organisational structure, the management controls and reporting procedures, the risks and contingencies*

Supplementary Project Plans



5. Solution Introduction Plan:

- This Plan is concerned with all aspects of introducing the solution into the
- customer's environment so that the solution becomes fully operational with minimal disruption to the customer's business. The plan covers many activities that are the responsibility of the customer.

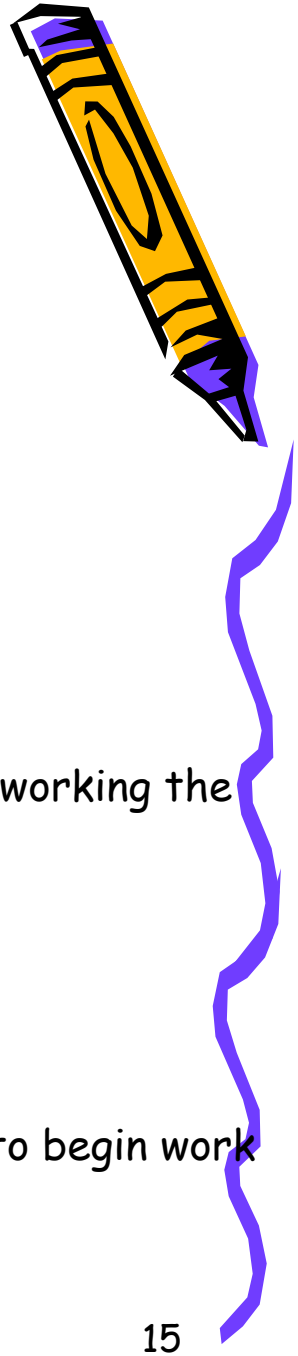
6) Service Delivery Plan:

- The plan is concerned with all aspects of providing services as part of the project. As appropriate,

  - it includes the:
  - *Delivery Plan*
  - *Installation Plan*
  - *Support Plan*
  - *Training Plan*
  - *Consultancy Plan*

7) Configuration Management Plan:

- This plan focuses on all the activities necessary to control the versions of
- the solution components, so that consistency between them is maintained.



Project planning includes:

- Developing the scope statement
- Developing the schedule (Gantt chart/pert)
- Developing the budget
- Selecting the planning team
- Allocating stakeholders and project team roles and responsibilities
- Creating a work breakdown structure
- Identifying deliverables
- identifying the activities needed to complete those deliverables and networking the activities in their logical sequence
- estimating the resource requirements for the activities;
- estimating time and cost for activities;
- Risk planning
- Communication planning

This information forms the project contract, used to gain formal approval to begin work

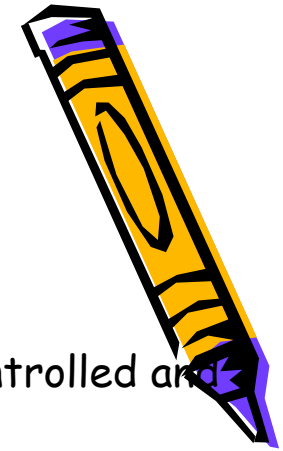
Project Scope Management Planning

Project Scope Management Planning

- **Scope:**
  - All the works involved in creating the products of the project and the processes used to create them.

- **Scope management:**
  - The processes involved in defining and controlling what is or is not included in the project. It ensures that the project team and stakeholders have the same understanding of what products the project will produce and what processes the project team will use to produce then.
  - Process involved in project scope management includes;
    - Scope Planning,
    - Scope definition,
    - Creating Work Breakdown Structures (WBS),
    - Scope Verification and
    - Scope control;

Scope management wbs cont..:



a) Scope planning

- Involves deciding how the scope will be defined, verified and controlled and how the Work Break down Structures (WBS) will be created

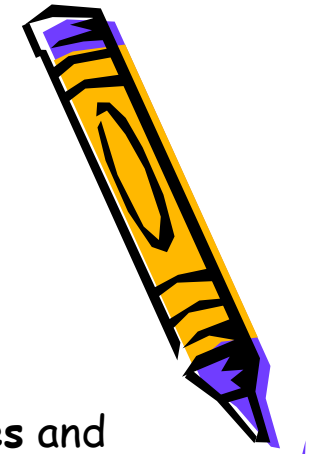
b) Scope definition

- Involves reviewing project charter and producing project scope statement, requested and updating the project management plan.
- Good scope definition is important in project management for it helps improve the accuracy of time, cost and resource estimates, defines baseline for performance measurements and project control
  - Product: Project scope statement

c) Work Breakdown Structure (WBS)

- ***The definition of tasks and their sequence.***
- A work breakdown structure (WBS) is a chart in which the critical work elements, called tasks, of a project are illustrated to portray their relationships to each other and to the project as a whole.
- A Work Breakdown Structure (WBS) is a deliverable-oriented grouping of the work involved in a project that defines the total scope of the project.
  - It is a project management tool designed to capture project tasks in a visual, organized manner.

Scope management - WBS



- Work Breakdown structure:
  - Used to divide projects into manageable tasks
    - Creating a WBS requires that **phases** are decomposed into **activities** and activities into **tasks**.
    - Each task should be defined at an appropriate level of detail.
      - Defining task in too much detail will make the management of the project unnecessarily complex.
      - Tasks having too much scope will not provide a clear sense of the state of the project or the dependencies between tasks
    - Discovering the optimal level of detail is acquired through experience.
    - Milestones are important since they are used to monitor and control the project.
    - Something deliver
    - Distribution of question as milestone and collection of them as a milestone.
    - It is concise
    - Event measurable and not ambiguous.
  - The graphical nature of the WBS can help a project manager predict outcomes based on various scenarios, which can ensure that optimum decisions are made about whether or not to adopt suggested procedures or changes.

It involves sub-dividing the major project tasks / deliverables into smaller, logical or more manageable components.

Scope management - WBS cont…

- Task in the WBS represents work that needs to be done to complete the project.
- Tasks should be clear and simply stated. If a task cannot be described in a sentence or two or completed between two hours and two weeks, you might want to break it up into two or more smaller tasks.
- Each WBS element should be identified by title and by a numbering system that performs the following functions:
  - Identifies the level of the WBS element.
  - Identifies the higher-level element into which the element will be integrated.
- These tasks are usually presented in a hierarchical form showing levels of each task.
- Some tasks may be performed in parallel while others must follow one another sequentially.
- Task sequence depends on
  - Which tasks produce deliverables needed in other tasks.
  - Constraints place on the project by the client.
  - Process outlined in the development lifecycle.

Advantages of WBS

- A large or complicated project may be considered as a collection of small projects.
  - The different phases may require different types of resource or skills.
  - The completion of a phase may be regarded as a key event or milestone.

Scope management - WBS cont…

- Example of WBS

A Web-site development project	Level 0
1.0. Concept	Level 1
1.1. Evaluate current systems	Level 2
1.2. Define requirements	
1.2.1 Define user requirements	Level 3
1.2.2 Define content requirements	
1.2.3 Define system requirements	
1.2.4 Define server owner requirements	
1.3. Define specific functionality	
1.4. Define risks and risk management approach	
1.5. Develop project plan	
1.6. Brief Web development team	
2.0. Web Site Design	
3.0. Web Site Development	
4.0. Roll-out	
5.0. Support	

Scope management - WBS cont…

WBS Common templates dictates also capturing the following attributes about a WBS element;

- Task ID field
- Task Description field
- Predecessor task ID
- Task Owner
- Role
- % Complete
- Start Date
- Finish Date
- Deliver To

- This attributes are useful in Project time management Process and are critical when representing the project tasks in a Gantt chart.

Reasons for creating WBS

i. Some widely used reasons for creating a WBS include:
ii. Assists with accurate project organization
iii. Helps with assigning responsibilities
iv. Shows the control points and project milestones
v. Allows for more accurate estimation of cost, risk and time
vi. Helps explain the project scope to stakeholders

Scope management - WBS cont…

- **Approaches to WBS Development**
  - There are several approaches to developing WBS and these includes;

a) Using guidelines:

- use predefined guidelines for the organization. Many organizations provide guidelines and templates from developing WBS

b) Analogy Approach:

- using a similar WBS as the starting point. Some organizations keep a repository of WBS and other project documentations on file to assist future project managers.

c) Top-Down and Bottom-Up Approach:

- Top-down approach start with the largest task (higher level tasks) and break them into their sub-tasks. It thus involves refining the tasks into greater and greater levels of de tails. Used by project managers with vast technical insight and big-picture perspective.

d) Bottom-up approach involves

- the project team first identifying as many as possible all the task related to the project. They then aggregate the specific tasks and organize them into summary activities, or higher level in the WBS.

Scope management

WBS Dictionary and Scope Baseline

- A WBS dictionary is a document that describes detailed information about each WBS item Scope Baseline: consists of the approved project scope statement and its associated WBS and WBS dictionary

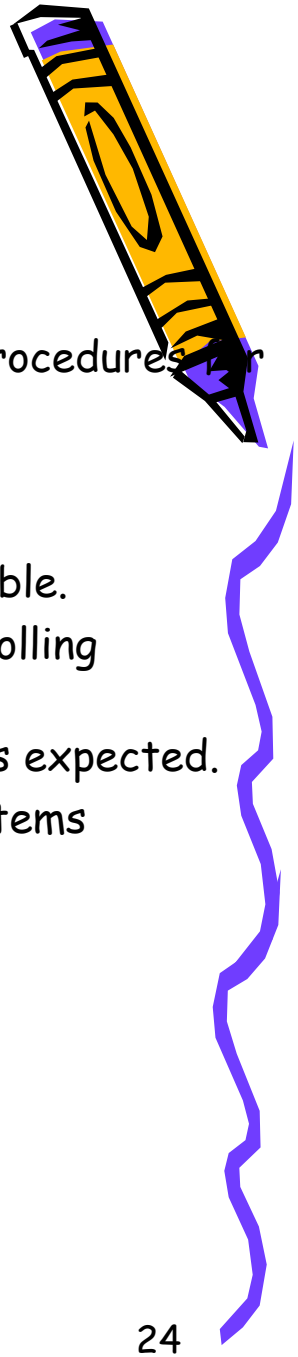
4. Scope Verification

- Involves formalizing acceptance of the project scope. It is difficult to create a good project scope statement WBS, verify and minimize scope changes for an IT project. Many IT projects suffer **Scope creep:**
  - **Scope creep:**
    - » the tendency for the project scope to keep getting bigger and bigger. Scope verification involves the project stakeholders inspecting the project; scope statement, WBS dictionary, project scope management plan and documented project deli verables and then signing-off accepting the scope.

5) Scope Control

- It involves controlling changes to project scope, which is usually a challenge in ICT projects.

Scope management



Strategies for reducing scope changes in IT projects

- Develop and follow a requirements management process that includes procedures for initial requirements determination.
- Employing Prototyping techniques, use case modeling, Joint Application Development(JAD) to understand user requirements thoroughly
- Put all requirements in writing and keep them current and readily available.
- Create a requirement management database for documenting and controlling requirements
- Provide adequate testing to verify that the project products perform as expected.
- Use a system for reviewing requested requirements changes from a systems perspective.
- Emphasize on completion dates

Success Factors part of Scope Management

- User involvement
- Executive support management
- Clear statement of requirements
- Realistic expectations
- Smaller project milestone
- Clear vision and objectives

Project planning- Risk planning

Project Risk Management

- Risk management is concerned with identifying risks and drawing up plans to minimise their effect on a project.
- A risk is a probability that some adverse circumstance will occur
  - Project risks affect schedule or resources;
  - Product risks affect the quality or performance of the software being developed;
  - Business risks affect the organisation developing or procuring the software.

Software project risks

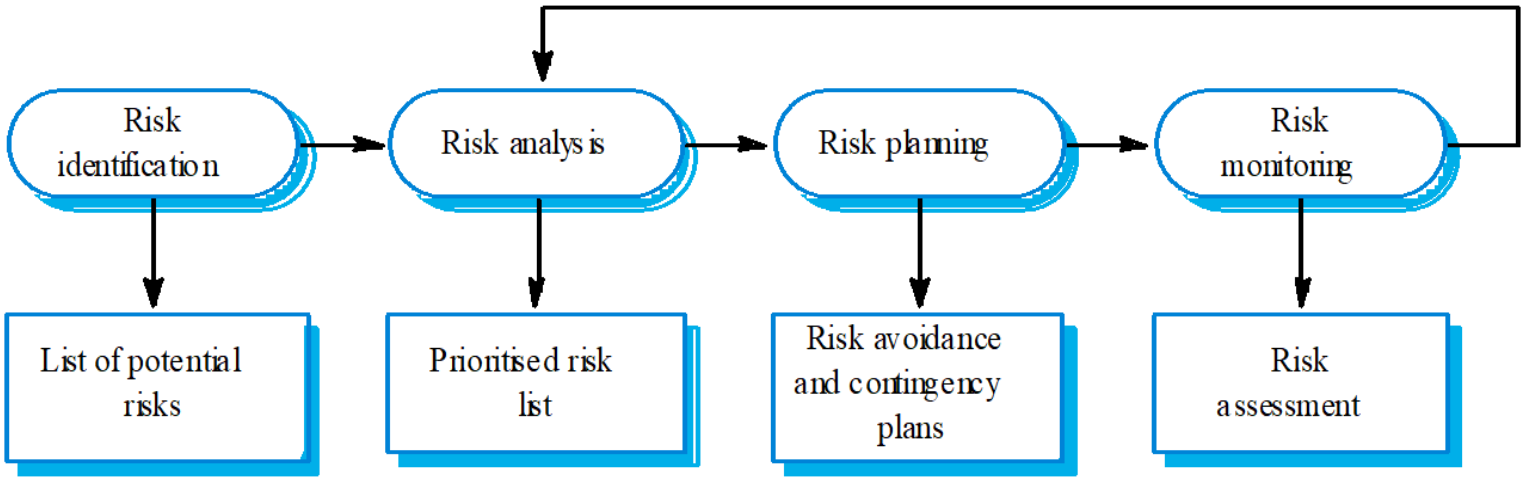
Software risks

Risk	Affects	Description
Staff turnover	Project	Experienced staff will leave the project before it is finished.
Management change	Project	There will be a change of organisational management with different priorities.
Hardware unavailability	Project	Hardware that is essential for the project will not be delivered on schedule.
Requirements change	Project and product	There will be a larger number of changes to the requirements than anticipated.
Specification delays	Project and product	Specifications of essential interfaces are not available on schedule
Size underestimate	Project and product	The size of the system has been underestimated.
CASE tool under-performance	Product	CASE tools which support the project do not perform as anticipated
Technology change	Business	The underlying technology on which the system is built is superseded by new technology.
Product competition	Business	A competitive product is marketed before the system is completed.

Risk planning Cont….

- **Risk Management Process**
  - There are following activities involved in risk management process:
    i. Risk identification
       - Identify project, product and business risks;
    ii. Risk analysis/risk evaluation/risk categorization
       - Assess the likelihood and consequences of these risks, risk proritization;
    iii. Risk avoidance
       - Draw up plans to avoid risk
    iv. Risk monitoring
       - Monitor the risks throughout the project;
    v. Risk contingency planning
       - Draw up plans to minimise the effects of the risk

Risk planning Cont….



a) Risk identification

- Technology risks.
- People risks.
- Organisational risks.
- Requirements risks.
- Estimation risks.

Risk management process

a) Risk identification

Risks and risk types

Risk type	Possible risks
Technology	✓ The database used in the system cannot process as many transactions per second as expected. ✓ Software components that should be reused contain defects that limit their functionality.
People	✓ It is impossible to recruit staff with the skills required. ✓ Key staff are ill and unavailable at critical times. ✓ Required training for staff is not available.
Organisational	✓ The organisation is restructured so that different management are responsible for the project. ✓ Organisational financial problems force reductions in the project budget.
Tools	✓ The code generated by CASE tools is inefficient. ✓ CASE tools cannot be integrated.
Requirements	✓ Changes to requirements that require major design rework are proposed ✓ Customers fail to understand the impact of requirements changes.
Estimation	✓ The time required to develop the software is underestimated. ✓ The rate of defect repair is underestimated. ✓ The size of the software is underestimated.

Risk management process

b) *Risk analysis*

- Assess probability and seriousness of each risk.
- Probability may be very low, low, moderate, high or very high.
- Risk effects might be catastrophic, serious, tolerable or insignificant

Risk	Probability	Effects
✓ Organisational financial problems force reductions in the project budget.	Low	Catastrophic
✓ It is impossible to recruit staff with the skills required for the project.	High	Catastrophic
✓ Key staff are ill at critical times in the project.	Moderate	Serious/critical
✓ Software components that should be reused contain defects which limit their functionality.	Moderate	Serious
✓ Changes to requirements that require major design rework are proposed.	Moderate	Serious
✓ The organisation is restructured so that different management are responsible for the project.	High	Serious
✓ The database used in the system cannot process as many transactions per second as expected.	Moderate	Serious
✓ The time required to develop the software is underestimated.	High	Serious
✓ CASE tools cannot be integrated.	High	Tolerable
✓ Customers fail to understand the impact of requirements changes.	Moderate	Tolerable
✓ Required training for staff is not available.	Moderate	Tolerable
✓ The rate of defect repair is underestimated.	Moderate	Tolerable
✓ The size of the software is underestimated.	High	Tolerable
✓ The code generated by CASE tools is inefficient.	Moderate	Insignificant

Risk management process Cont...

c) *Risk planning*

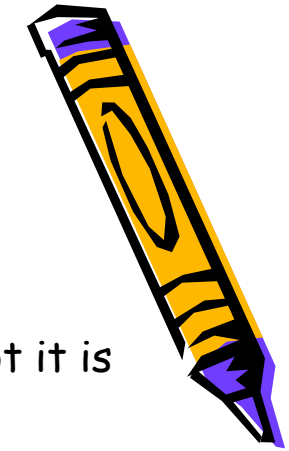
Consider each risk and develop a strategy to manage that risk.

- Avoidance strategies
  - *The probability that the risk will arise is reduced;*
- Minimisation strategies
  - *The impact of the risk on the project or product will be reduced;*
- Contingency plans
  - *If the risk arises, contingency plans are plans to deal with that risk;*

d) *Risk management strategies*

Risk	Strategy
Organisational financial problems	Prepare a briefing document for senior management showing how the project is making a very important contribution to the goals of the business.
Recruitment problems	Alert customer of potential difficulties and the possibility of delays, investigate buying-in components.
Staff illness	Reorganise team so that there is more overlap of work and people therefore understand each other's jobs.
Defective components	Replace potentially defective components with bought-in components known reliability.
Requirements changes	Derive traceability information to assess requirements change impact, maximise information hiding in the design.
Organisational restructuring	Prepare a briefing document for senior management showing how the project is making a very important contribution to the goals of the business.
Database performance	Investigate the possibility of buying a higher-performance database.
Underestimated development time	Investigate buying in components, investigate use of a program gener

Risk management process Cont...



e) *Risk monitoring*

- Assess each identified risks regularly to decide whether or not it is becoming less or more probable.
- Also assess whether the effects of the risk have changed.
- Each key risk should be discussed at management progress meetings.

Risk indicators

Risk type	**Potential indicators**
Technology	Late delivery of hardware or support software, many reported technology problems
People	Poor staff morale, poor relationships amongst team member, job availability
Organisational	Organisational gossip, lack of action by senior management
Tools	Reluctance by team members to use tools, complaints about CASE tools, demands for higher-powered workstations
Requirements	Many requirements change requests, customer complaints
Estimation	Failure to meet agreed schedule, failure to clear reported defects

Project Scheduling

- This phase is primarily concerned with attaching a timescale and sequence to the activities to be conducted within the project.
- To ensure that a project is completed on time it is necessary to prepare a detailed schedule of every activity to
  - Explore its effect on other activities
  - Monitor progress against this schedule.
- Materials and people needed at each stage of the project are determined and the time each is to take will be set.

Project Management Tools

1. Program evaluation and review techniques - PERT (uses probabilities and three-time estimates, focus is on the time)

1. Critical path method- CPM (uses probabilities and a single-time estimate, focus is on cost)

1. Work breakdown structure (does not use probabilities, provides a conceptual organization of a project)

1. Charts and tables (do not use probabilities, focus is on presentation of data)

1. Budgets (use financial data, focus is on variance analysis)

Scheduling Tools

- Two graphical tools are useful in time charting; The Gantt chart and the PERT chart.

1. The Gantt chart

- A Gantt Chart is a form of horizontal bar chart and horizontal bars are drawn against a time scale for each project activity, the length of which represents the time taken to complete. To construct a Gantt Chart the following steps are necessary:
  - Use the horizontal axis to represent time
  - Use the vertical axis to represent activities
  - Represent each activity by a horizontal bar of appropriate length
  - Take activity procedures into account by starting each activity bar to an appropriate point along the time axis after its preceding activities.
    - » Normally the start point for an activity is the earliest time that it could start after its preceding activities had finished.

A Gantt Chart is a simple technique that can be used to attach a time scale and sequence to a project.

The Gantt chart/Scheduled bar Cont…

- Gantt charts, also commonly known as milestone plans, are a low cost means of assisting the project manager at the initial stages of scheduling.
- They ensure that:
  - all activities are planned for,
  - the sequence of activities is accounted for,
  - the activity time estimates are recorded; and
  - the overall project time is recorded.

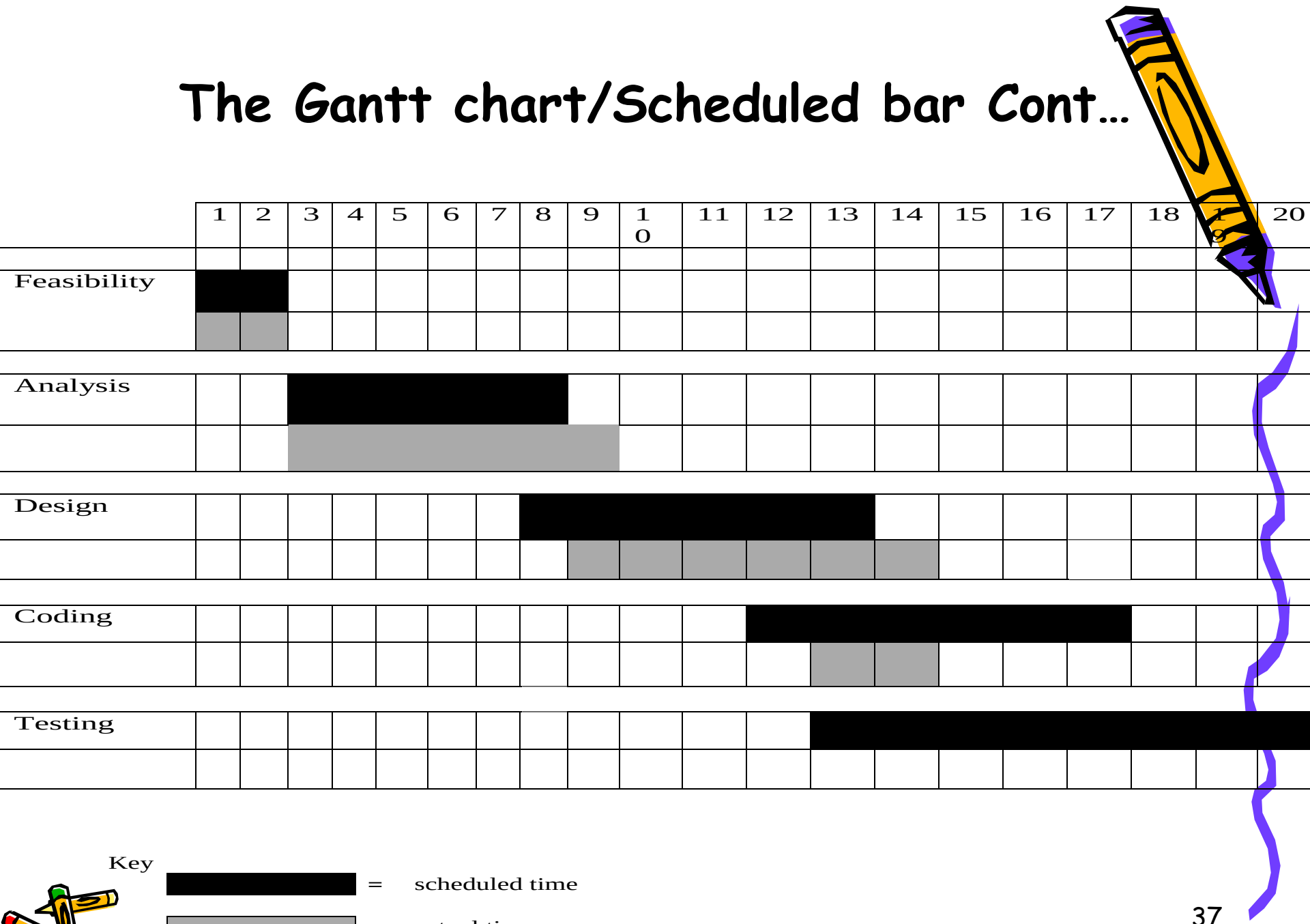
The Gantt chart/Scheduled bar Cont…

- It is possible to enhance the Gantt Chart in several ways.
  - For instance the number of staff required to do a task can be entered into the bar on the diagram.

Constructing Gantt chart/scheduled bar

- the various activities are listed on a vertical axis and the horizontal axis is used to represent time.
- Activity precedencies are taken into account by starting a horizontal bar to represent the next activity at an appropriate point after its preceding activities,
  - i.e. those activities which must take place before the next activity can start, have taken place.
  - Normally this would be at the earliest time that it could start after its preceding activities had finished.

The Gantt chart/Scheduled bar Cont…



The Gantt chart/Scheduled bar Cont…

Weaknesses

- Not easy to show interdependence.
  - Vertical lines would help but would soon lead to a complicated and difficult to read diagram.
- Modifications are not easy to incorporate as re-drawing is often required.
  - Computer packages will undertake this task but a re-draw is still necessary.
- For these reasons, on large projects the bar chart is superseded by Network Techniques.
  - However, even on large projects ad team leader may find that a bar chart is an easy and convenient method for planning and recording progress fro his part of job.

Examples of Gantt charts

- Examples of Gantt charts

- **A project comprises the following activities:**

Activity	Immediate Predecessors	Activity Time (weeks)
A	-	3
B	-	4
C	-	3
D	C	12
E	B	5
F	A	7
G	E, F	3

- Draw a Gannt chart to represent the project; determine those activities comprising the critical path; and estimate the project duration

Scheduling Tools

- **NETWORK ANALYSIS**
  - The two most common and widely used project management techniques that can be classified under the title of :-
    - Network Analysis are Programme Evaluation and review Technique (PERT) and
    - Critical Path Method (CPM).
    - Both were developed in the 1950's to help managers schedule, monitor and control large and complex projects.
      - CPM was first used in 1957 to assist in the development and building of chemical plants within the DuPont Corporation.
      - Independently developed, PERT was introduced in 1958 following research within the Special Projects Office of the US Navy.
    - It was initially used to plan and control the Polaris missile programme which involved the coordination of thousands of contractors. The use of PERT in this case was reported to have cut eighteen months off the overall time to completion.

Network Analysis Cont…

The PERT/CPM Procedure

- There are six stages common to both PERT and CPM:
  - Define the project and specify all activities or tasks.
  - Develop the relationships amongst activities. Decide upon precedences.
  - Draw network to connect all activities.
  - Assign time and/or costs to each activity.
  - Calculate the longest time path through the network: this is the "critical path".
  - Use network to plan, monitor and control the project.

Benefits of the technique

- The method has the following benefits for controlling and monitoring a project:
- Provides a consistent framework for planning, scheduling, monitoring and controlling the project.
- Highlights the interdependence of work groups and activities that make up the scope of the project.
- Assists in inter-functional communication.
- Maintains a relevant project completion date.
- Identifies activities that may jeopardize the project completion date.
- Identifies activities that have some degree of flexibility to allow more efficient work practices to be implemented.
- Fixes starting and completion dates for activities.
- May be used to avoid timing and resource conflicts.
- Determines which activities may be run sequentially and those activities that must run in parallel.
- Allow analysis of probalistic completion dates.

PERT Assumptions

- Interrelationships of activities are depicted in a network of directed arcs (arcs with arrows, which denote the sequence of the activities they represent).
- The **nodes,** called events, represent instants in time when certain activities have been completed and others can then be started. All inwardly-directed activities at a node must be completed before any outwardly-directed activity of that node can be started. A **path** is defined as an unbroken chain of activities from the origin node to some other node. The origin node is the beginning of the project. An **event** is said to have occurred when all activities on all paths directed into the node representing that event have been completed.

Network Analysis Cont…

- Methods
- There are two basic types of networking techniques, Activity on Node (AON) and Activity on Arrow (AOA). Each system has some minor advantages and disadvantages over the other. The following table suggests the current stage of the debate

Activity on Arrow	Activity on Node
Easier to prepare and modify	Easier to show complex relationships
Non-experts are more likely to understand network	No dummy activities
Milestones events are readily visible	All information on an activity is readily found in one location on the diagrams
Diagrams a lot clearer with multiple precedent relationships	Most inexpensive computer packages use this method

- There seems to be very little real differences to suggest that one should be used over the other, it is largely a matter of choice. Most modern programs allow both but are favoured for AON.

Activity Diagram - Scheduling diagram

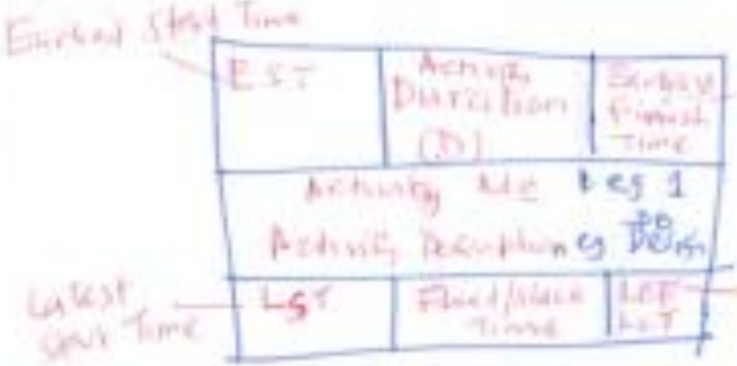
Project Evaluation and Review Technique (PERT)

Two types

(1) Activity on Arrow AOA
- Activity is represented by an arrow diagram - node ⊕ = link

(2) Activity ON NODE
- Activity is represented by a node

A node represent Activity and Arrow represent link



Activity of Arrow(AOA)

(a) Activity on arrow (AoA) Network

(1) Activity is represented by an arrow — Activity / Duration →

(2) Activity Must end/start on a node/Event — node marks beginning/end of a node.

(3) A node — Node Number - distinct No e.g. 1, 2, 3 ... or 1.1, 1.2, 1.3 ... or 0, 5, 10, 15 ...

(4) All activities Must end and start on a node
- Starting node = zero node

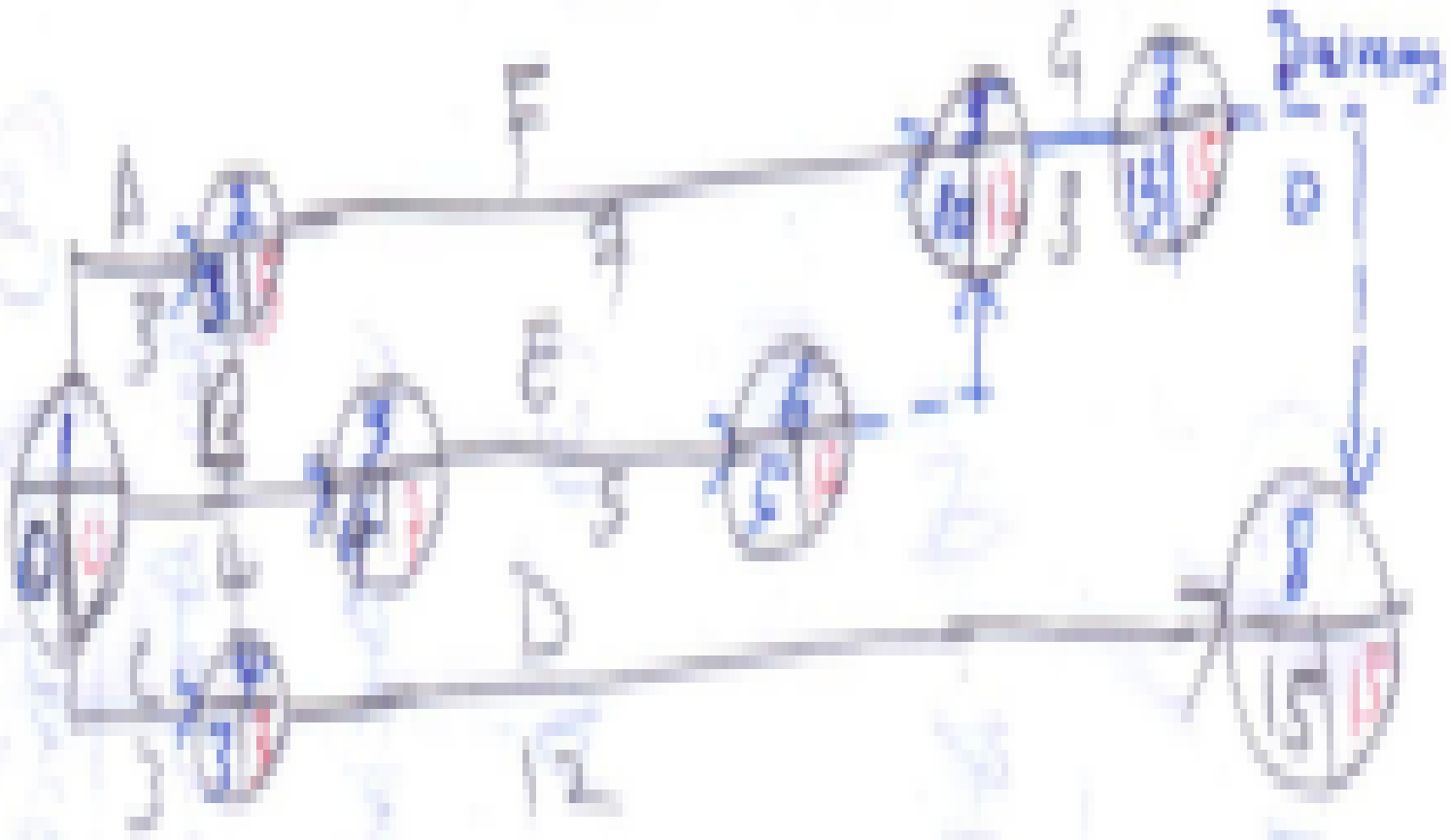
(5) No dangling a node — all hanging node Must terminate on

(6) ~~Duration~~ EST is calculated from start 0 → end node
Forward Scheduling
LCT = Backward Scheduling

AoA Cont…..

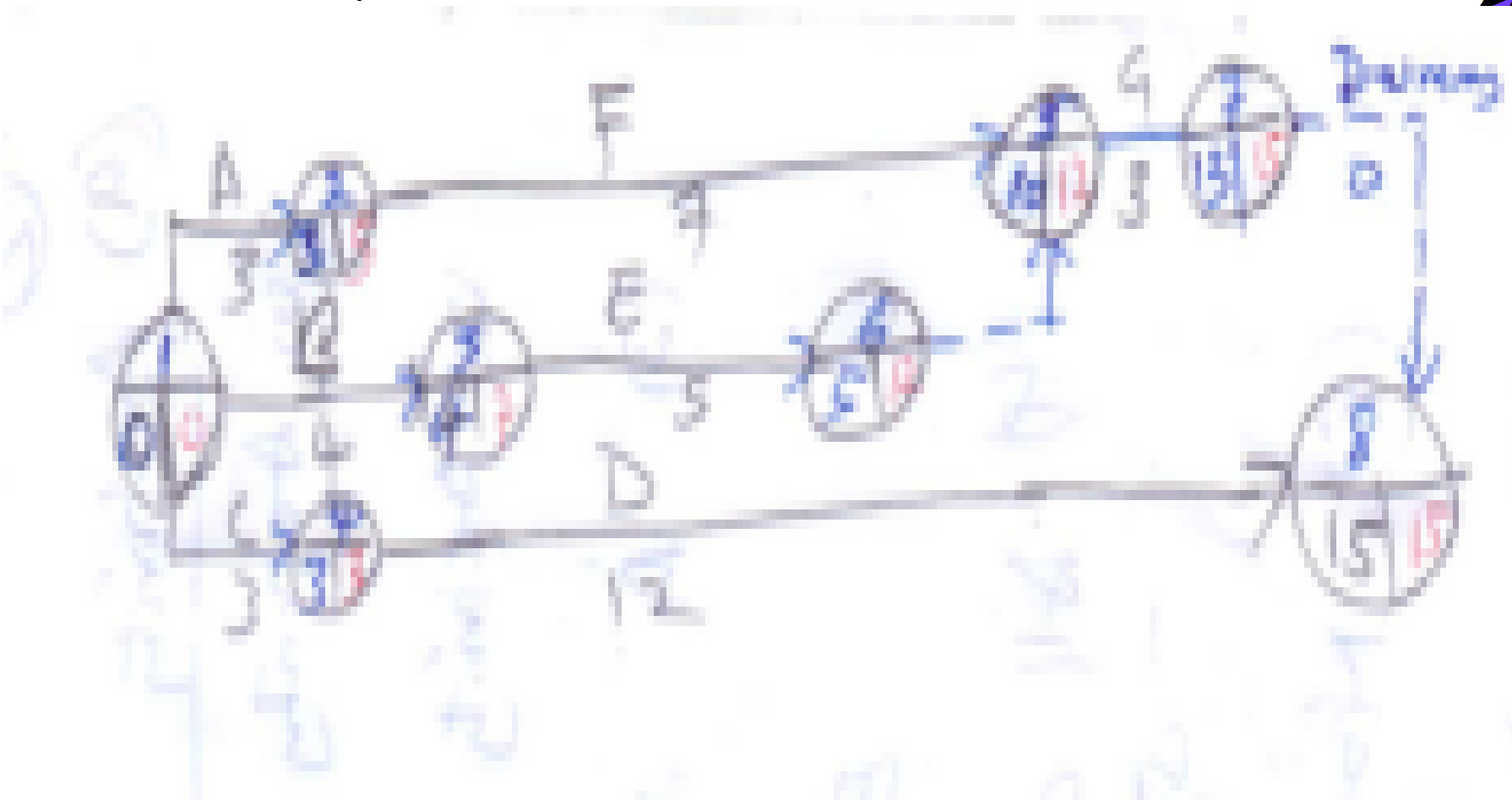
- Example

Activity	Immediate predecessors	Activity Time (weeks)
A	—	3
B	—	4
C	—	3
D	C	12
E	B	5
F	A	7
G	E, F	3



AoA Cont…..

- Example



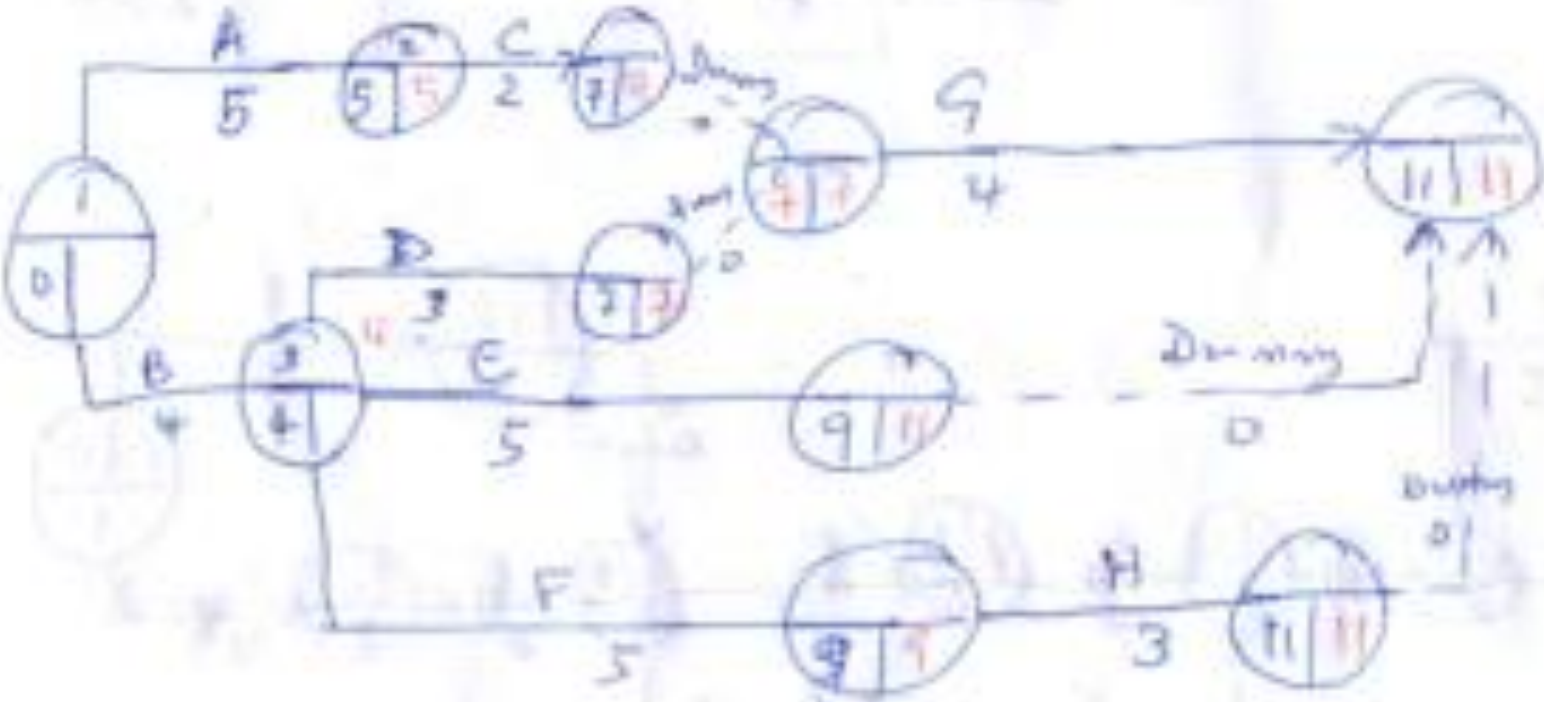
Network Analysis Cont…

Example 2

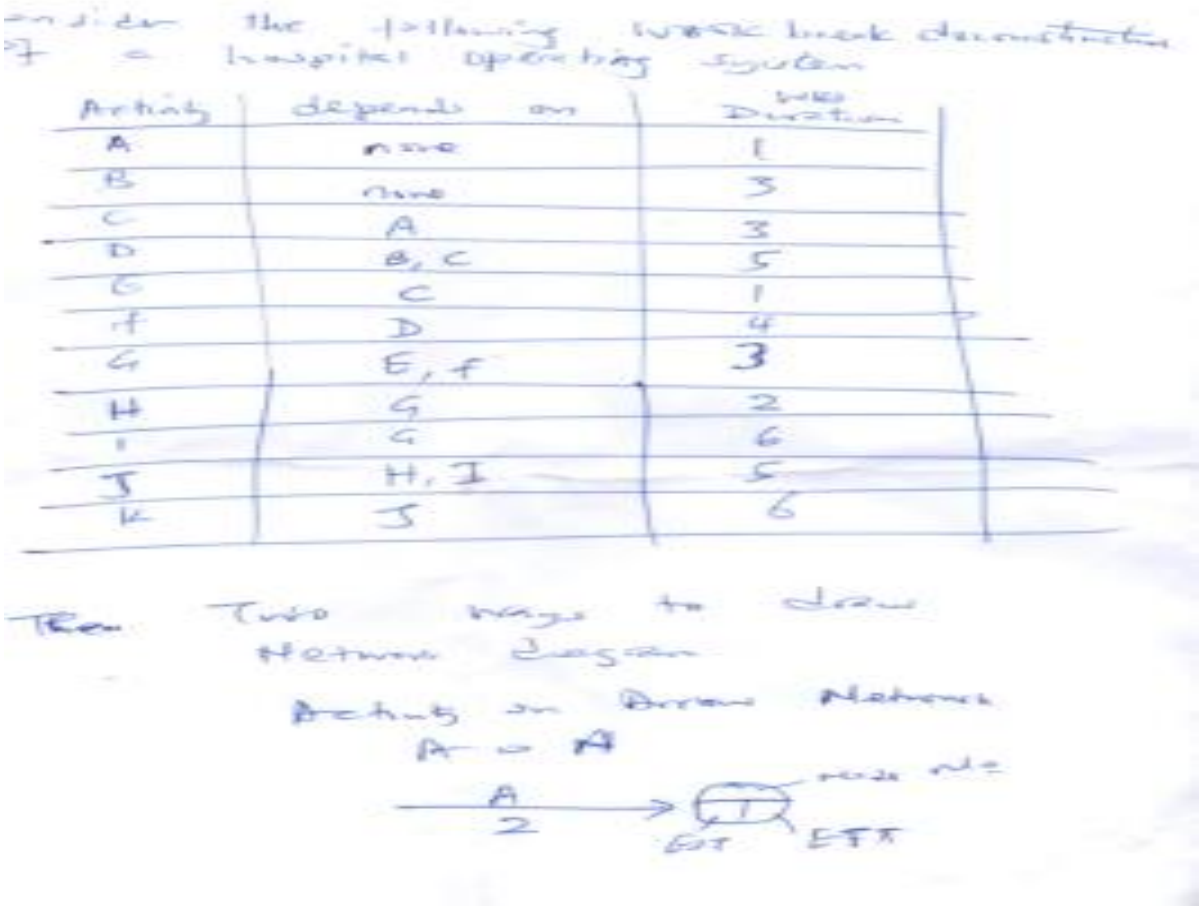
Activity	Preceding activity	Duration (Weeks)
A	-	5
B	-	4
C	A	2
D	B	3
E	B	5
F	B	5
G	C, D	4
H	F	3

NETWORK ANALYSIS Cont…

Example 2

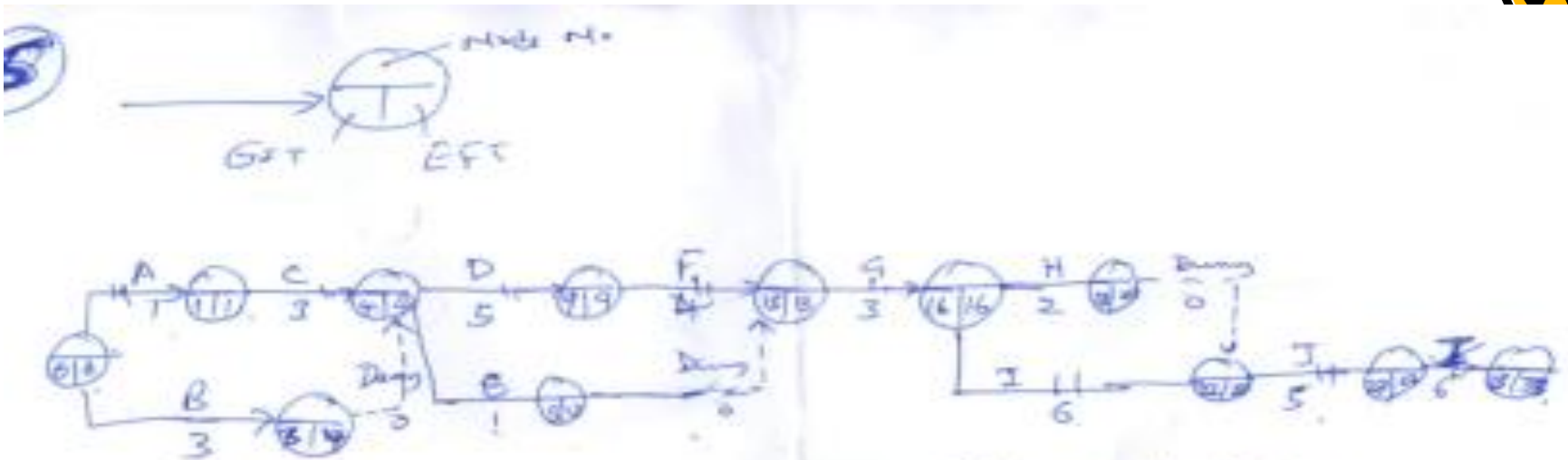


AOA EXAMPLE 3



Activity	depends on	Duration
A	none	1
B	none	3
C	A	3
D	B, C	5
E	C	1
f	D	4
G	E, f	3
H	G	2
I	G	6
J	H, I	5
K	J	6

AOA EXAMPLE 3



Critical Activity

↳ These are activities which can not be delayed.

Path = Link btn Activities

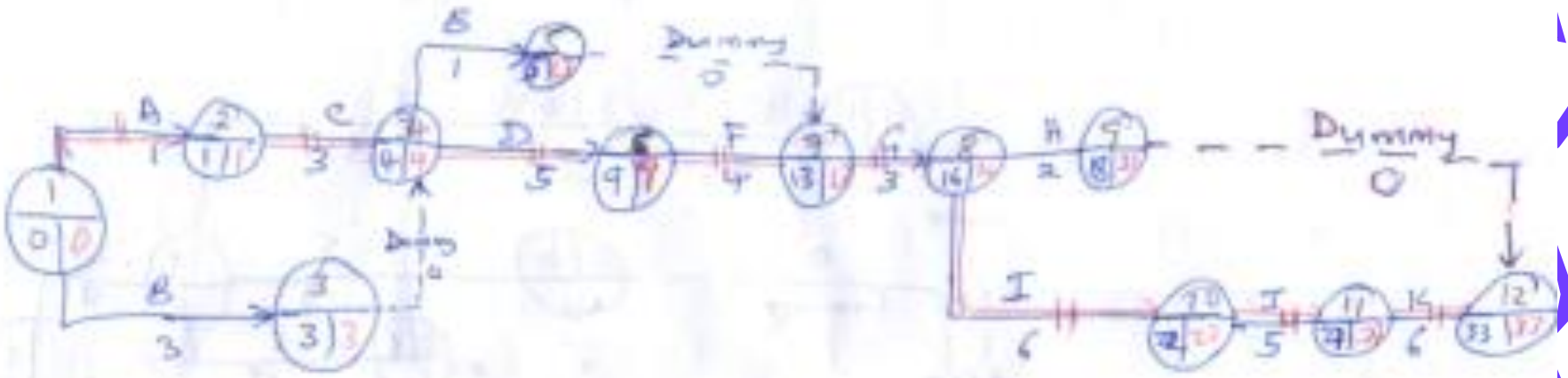
A C D G I J K

Duck 1 + 3 + 5 + 6 + 3 + 6 + 5 + 6

= 33 weeks

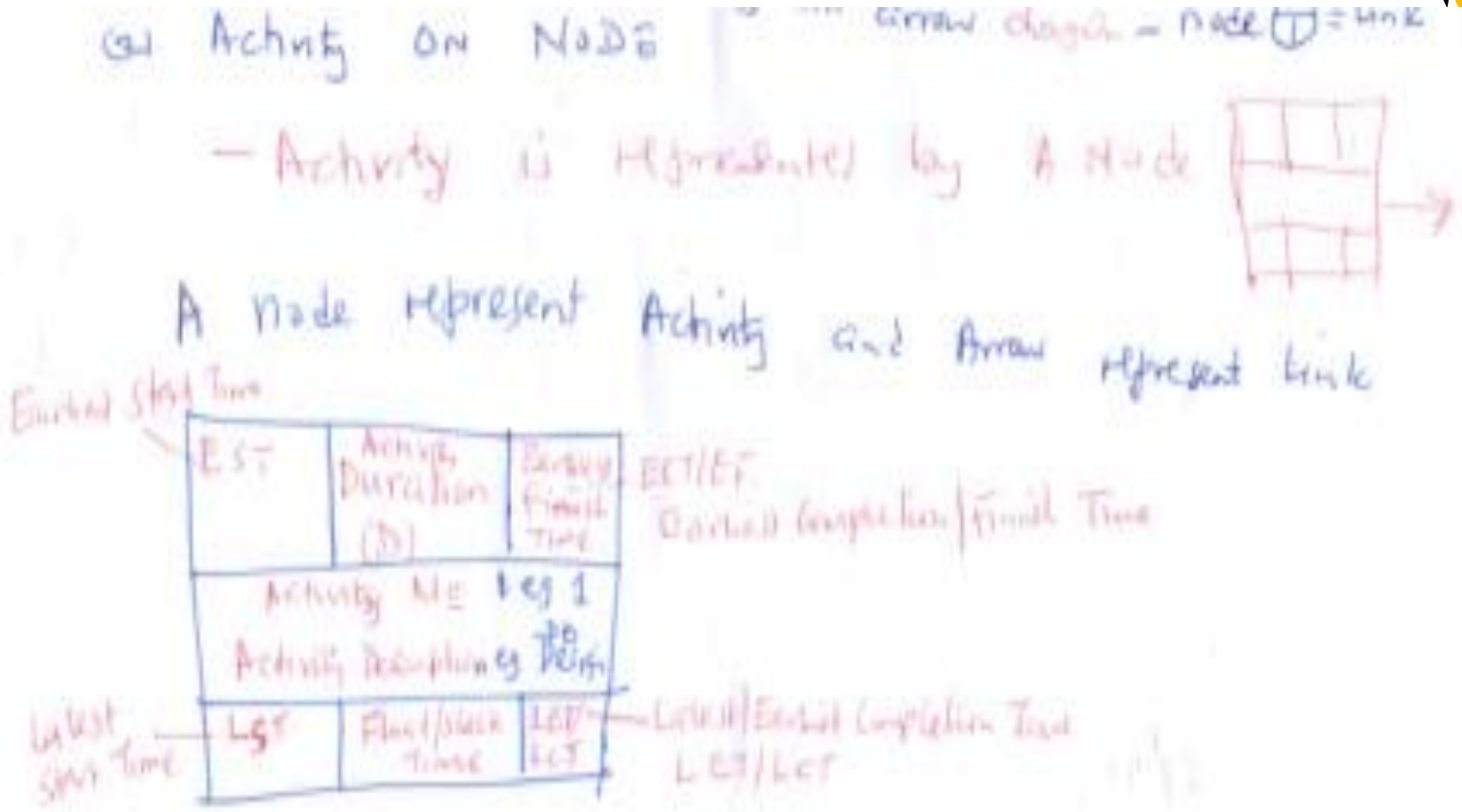
AOA EXAMPLE 3

- Example 3



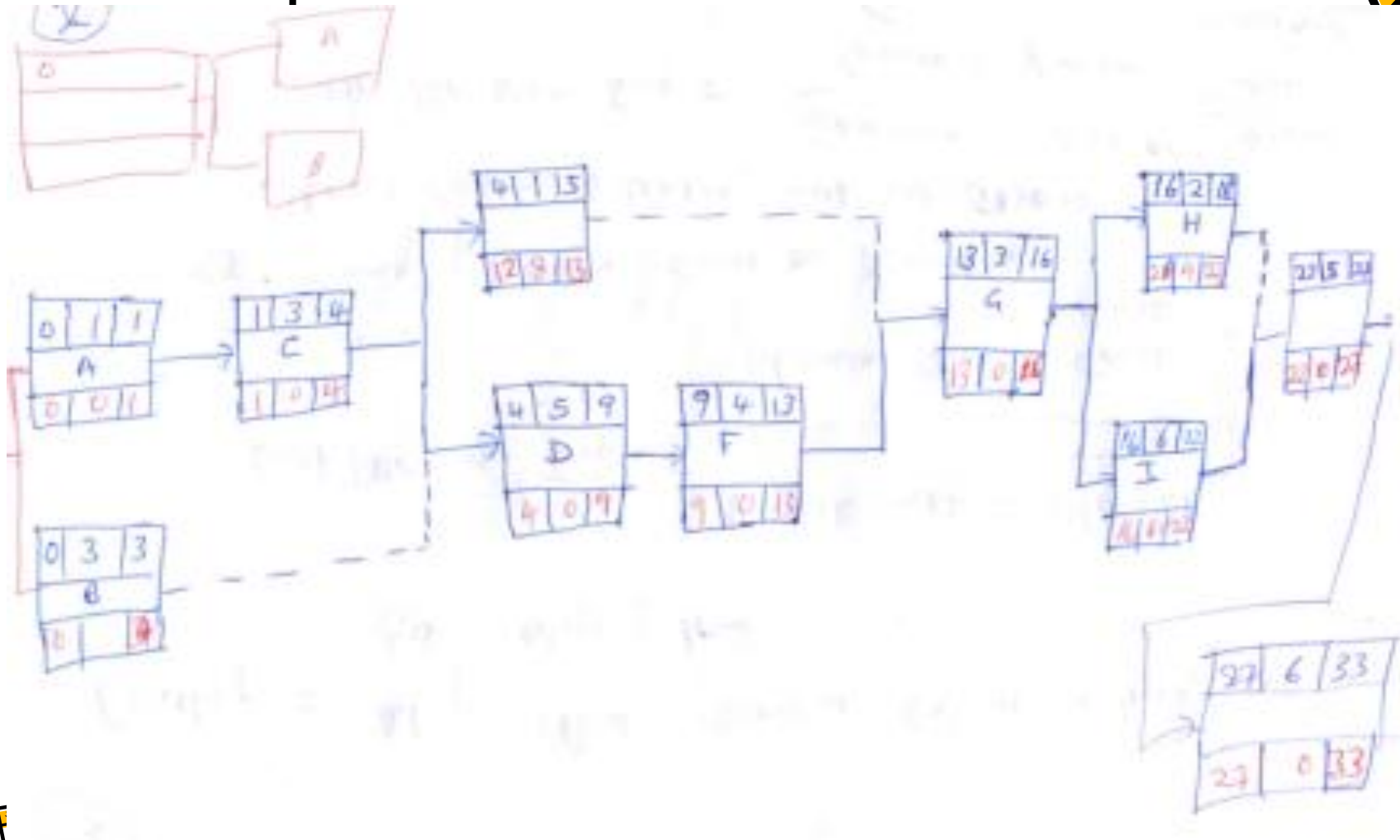
Activity on Node(AoN)

- Activity on Node(AoN)



Activity on Node(AoN)

- Example



NETWORK ANALYSIS Cont…

Analysing network

- EST = (Earliest start time) **at an event is the earliest time activities ahead of that event can start, keeping in mind that ALL activities before the event must be complete**. It is calculated in the *forward pass*. We add up activity durations in each path leading to that event, then take the largest. The first event has EST value 0. The EST in the last event gives us the project duration. In the above figure the project duration is therefore 12 weeks.
- LCT = **(Latest Completion time) at an event is the latest that preceding activities can complete without delaying any of the succeeding activities.** *It is calculated in the backward pass, starting from the last event, whose LCT is set to the project duration* (in the above case, 12). We subtract activity durations in each path leading backwards to that event, then take the smallest.
- The critical path is the sequence of activities that have the same EST and LCT values.

Network Analysis Cont…

Critical Path Analysis

- The objective of critical path analysis is to determine times for the following:
- **ES = Earliest Start Time**. This is the earliest time an activity can be started, allowing for the fact that all preceding activities have been completed.
- **LS = Latest Start Time**. This is the latest time an activity can be started without delaying the start of following activities which would put the entire project behind schedule.
- **EF = Earliest Finish Time**. The earliest time an activity can be finished.
- **LF = Latest Finish Time**. The latest time that an activity can finish for the project to remain on schedule.
- **S = Activity Slack Time**. The amount of slippage in activity start or duration time which can be tolerated without delaying the project as a whole.

NETWORK ANALYSIS Cont…

If ES and LS for any activity is known, then one can calculate values for the other three times as follows:

- EF = ES + t
- LF = LS + t
- S = LS - ES or S = LF - EF

- Analysis of the project normally involves:

  i) Determining the Critical Path.

  - The critical path is the group of activities in the project that have a slack time of zero. This path of activities is critical because a delay in any activity along it would delay the project as a whole.

  ii) Calculating the total project completion time, T.

  - This is done by adding the activity times of those activities on the critical path.

  - The steps in critical path analysis are as follows:

    a) Determine ES and EF values for all activities in the project: the Forward Pass through the network.

    b) Calculate LS and LF values for all activities by conducting a backward pass through the network

NETWORK ANALYSIS Cont…

c) Identify the critical path which will be those activities with zero slack (i.e. ES=LS and EF=LF).

d) Calculate total project completion time.

PERT and Activity Time Estimation

- The major distinguishing difference between PERT and CPM is the use of three time estimates for each activity in the PERT technique, with CPM using only one time for each activity using CPM.The three time estimates specified for each activity in PERT are:
  - the optimistic time;
  - the most probable time; and
  - the pessimistic time.

The optimistic, most likely and pessimistic time estimates are used to calculate an expected activity completion time which, because of the skewed nature of the beta distribution, is marginally grater than the most likely time estimate.

Where:

Network Analysis Cont…

- In addition, the three time estimates can be used to calculate the variance for each activity. The formulae used are as follows:

$$t = \frac{o+4m+p}{6}$$

$$v = \left(\frac{p-o}{6}\right)^2$$

Where;

- o, m, p - optimistic, most likely, and pessimistic times
- t - expected completion time for task
- v - variance of task completion time

- Knowing the details of a project, its network and values for its activity times (t) and their variances (v) a complete PERT analysis can be carried out. This includes the determination of the ES, EF, LS, LF and S for each activity as well as identifying the critical path, the project completion time (T) and the variance (V) for the entire project.

- Expected time

Expected Time (T_e)

$$T_e = \frac{1}{6}(\text{Optimistic Time} + 4 \times \text{Most Likely Time} + \text{Pessimistic Time})$$

$$= \frac{1}{6}(O + 4M + P) = \frac{O + 4M + P}{6}$$

Activity A	Optimistic T_e	Most Likely Time	Pessimistic Time	$T_e = \frac{1}{6}(O + 4M + P)$
A	3	4	5	$\frac{3+4\times4+5}{6} = \frac{24}{6} = 4$
B	5	10	15	$\frac{5+4\times10+15}{6} = \frac{60}{6}$ 10
C	3	6	9	$\frac{3+4\times6+9}{6} = \frac{36}{6} = 6$ 6
D	4	8	12	$\frac{4+4\times8+12}{6} = \frac{48}{6} = 8$
E				

Work breakdown structure

Activity	Immediate Predecessors	Optimistic Time (Days)	Most Likely Time (Days)	Pessimistic Time (Days)
A	-	5	6	7
B	-	10	13	28
C	A	1	2	15
D	B	8	9	16
E	B,C	25	36	41
F	D	6	9	18

Activity crashing

Crashing = Adding More Resources to an activity to reduce time

$$\text{Cost per Unit Time} = \frac{\text{Crash Cost} - \text{Normal Cost}}{\text{Normal Time} - \text{Crash Time}}$$

eg Normal 5 weeks Crash = 3 weeks

Normal Cost = 200 000, Crash cost = 600 000

$$\text{Cost per Unit Time} = \frac{600\,000 - 200\,000}{5 \text{ week} - 3 \text{ week}} = \frac{400\,000}{2 \text{ week}}$$

$= 200\,000$/week

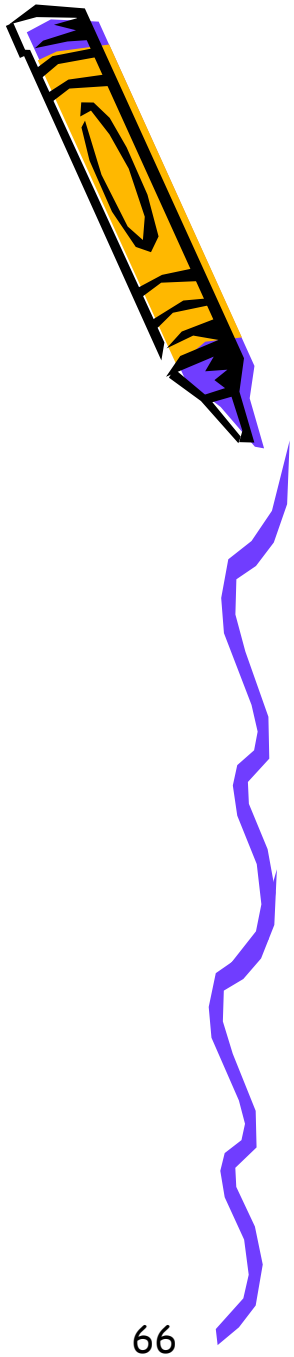
Worked Examples on Networks

- A project has the following activities, precedence relationships, and activity durations:

Activity	Immediate Predecessors	Activity Duration (weeks)
A	-	3
B	-	4
C	-	3
D	C	12
E	B	5
F	A	7
G	E, F	3

  - Draw a Gantt chart for the project.
  - Construct a CPM network for the project.
  - Identify those activities comprising the critical path.
  - What is the project's estimated duration?
  - Construct a table showing for each activity, its activity duration, earliest start time, latest start time, earliest finish time, latest finish time, and the activity slack.
  - Answers:
    - » C, D
    - » 15 weeks

Project planning - Scheduling



THE END

- QUE &ANS
- COMMENTS