Module 3
Project Planning & Scheduling

Points to be Covered…

1. Work Breakdown Structure (WBS)
2. Linear Responsibility Chart
3. Interface Coordination
4. Concurrent Engineering
5. Project Cost Estimation and Budgeting
6. Top down and Bottom up Budgeting
7. Networking and Scheduling Techniques
8. PERT
9. CPM
10. GANTT Chart
11. Introduction to Project Management Information System (PMIS)

1. Work Breakdown Structure

o Work Breakdown Structure is a hierarchical tree structure that outlines project and breaks it down into a smaller and more manageable units.

❖ **Characteristics**

- o Definable
- o Manageable
- o Estimated
- o Independent
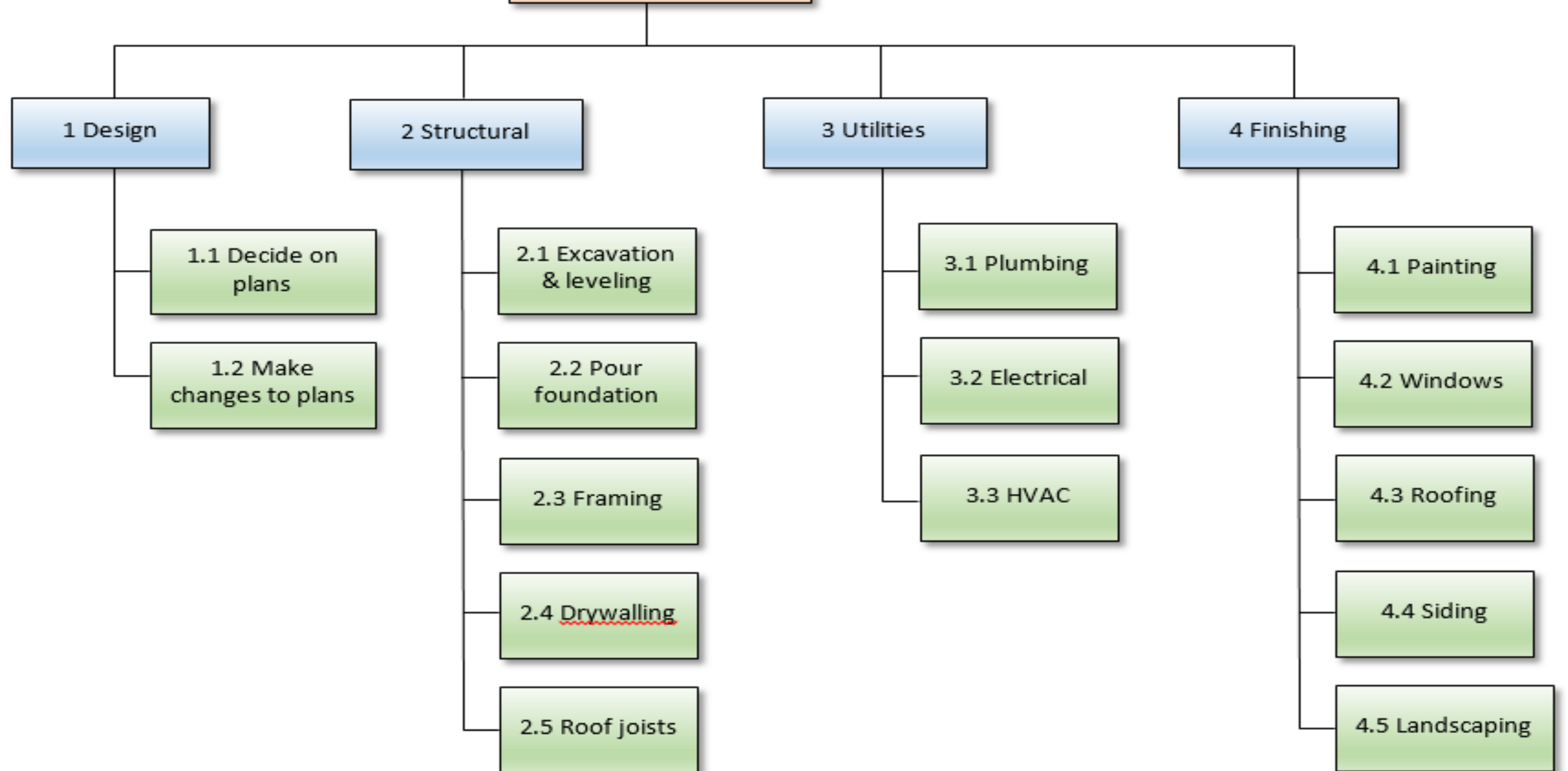- o Integration
- o Measurable
- o Adaptable

❖ **Rules**

- o The 100% Rule
- o Mutually Exclusive
- o Focus on Outcomes
- o The 8/80 Rule

Work Breakdown Structure

- 100 % rule : **the sum of the work at the "child" level must equal 100% of the work represented by the "parent"**

- "8 – 80" rule - **the lowest level of work should be not less than 8 hours and not more than 80 hours**.

Build a House

1 Design
- 1.1 Decide on plans
- 1.2 Make changes to plans

2 Structural
- 2.1 Excavation & leveling
- 2.2 Pour foundation
- 2.3 Framing
- 2.4 Drywalling
- 2.5 Roof joists

3 Utilities
- 3.1 Plumbing
- 3.2 Electrical
- 3.3 HVAC

4 Finishing
- 4.1 Painting
- 4.2 Windows
- 4.3 Roofing
- 4.4 Siding
- 4.5 Landscaping

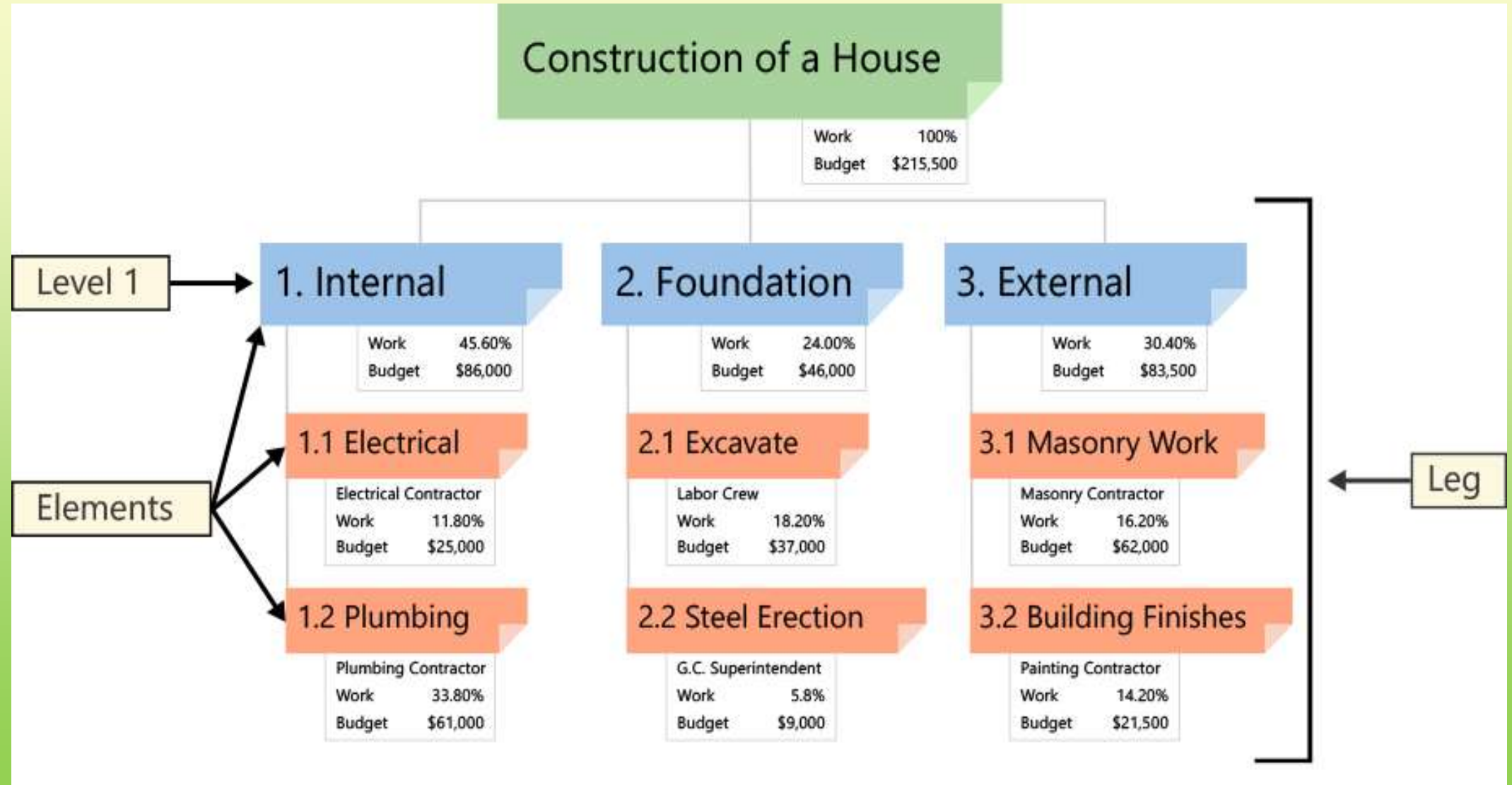# 1. Work Breakdown Structure

❖ **Different Forms of WBS**

- o Phase-based Structure
- o Deliverable-based Structure
- o Responsibility-based Structure
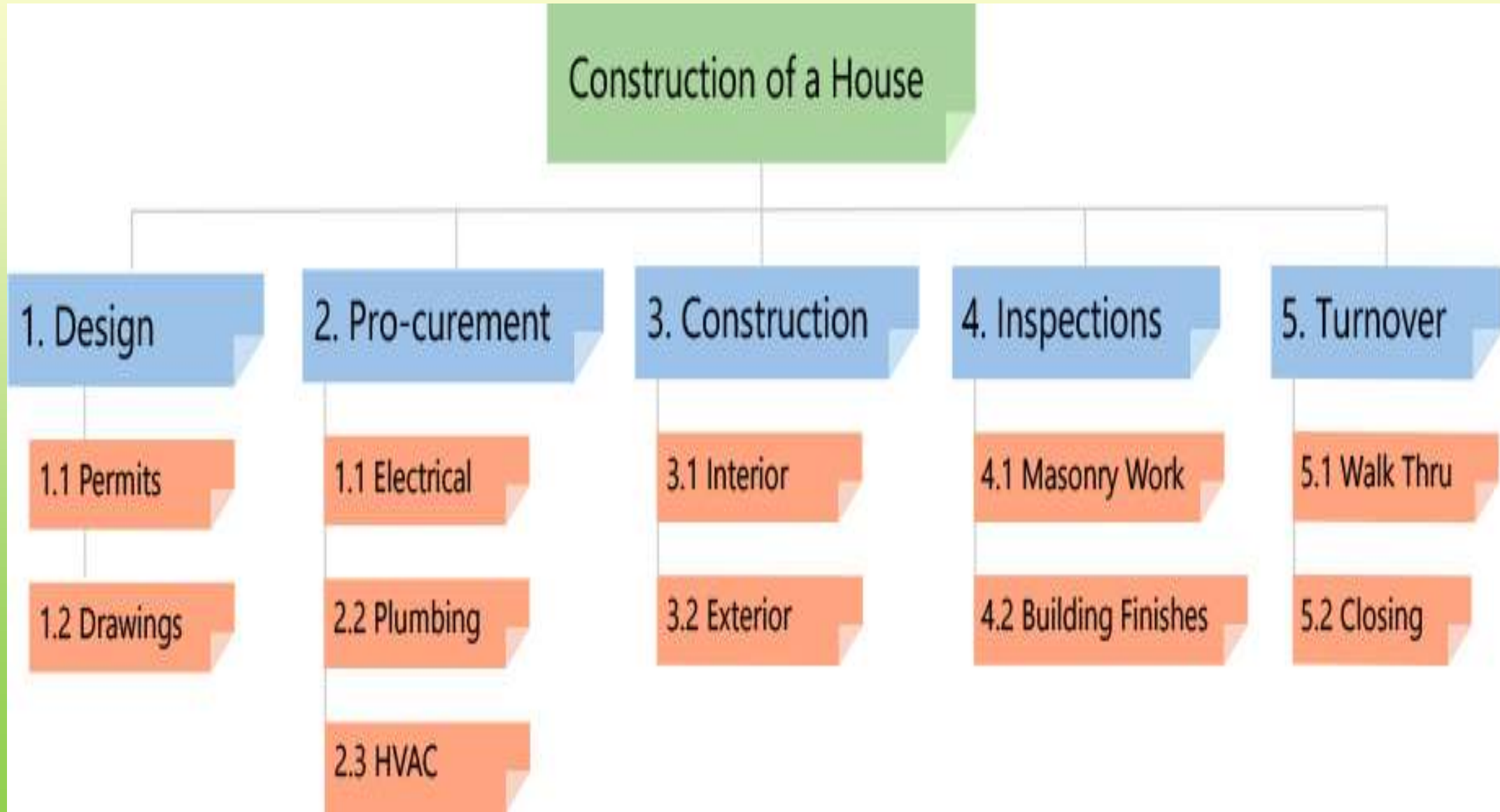- o Resource Breakdown Structure

❖ **Process to create WBS**

- o Step 1: List high-level deliverables
- o Step 2: Think about tasks
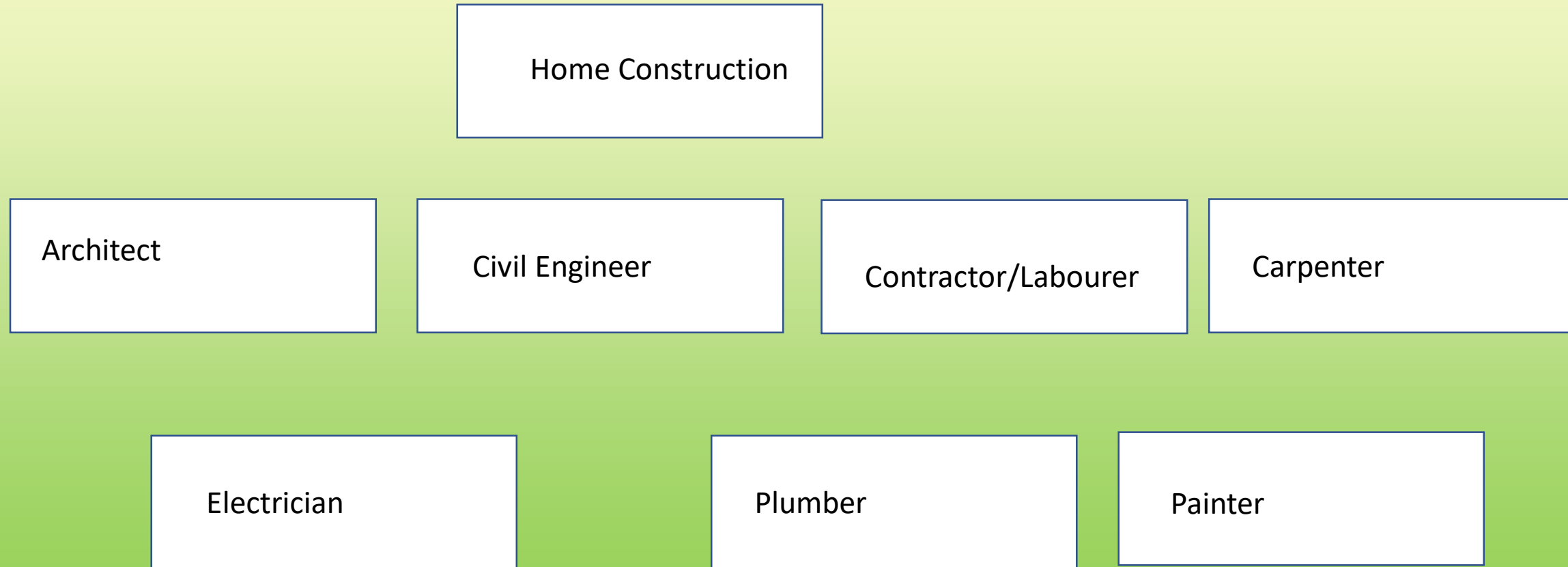- o Step 3: Prepare Minute Details
- o Step 4: Format and Estimate

Deliverable based WBS

Construction of a House

Work	100%
Budget	$215,500

Level 1 →

1. Internal

Work	45.60%
Budget	$86,000

2. Foundation

Work	24.00%
Budget	$46,000

3. External

Work	30.40%
Budget	$83,500

Elements

1.1 Electrical

Electrical Contractor
Work	11.80%
Budget	$25,000

2.1 Excavate

Labor Crew
Work	18.20%
Budget	$37,000

3.1 Masonry Work

Masonry Contractor
Work	16.20%
Budget	$62,000

Leg

1.2 Plumbing

Plumbing Contractor
Work	33.80%
Budget	$61,000

2.2 Steel Erection

G.C. Superintendent
Work	5.8%
Budget	$9,000

3.2 Building Finishes

Painting Contractor
Work	14.20%
Budget	$21,500

Phase based WBS

Construction of a House

1. Design
- 1.1 Permits
- 1.2 Drawings

2. Pro-curement
- 1.1 Electrical
- 2.2 Plumbing
- 2.3 HVAC

3. Construction
- 3.1 Interior
- 3.2 Exterior

4. Inspections
- 4.1 Masonry Work
- 4.2 Building Finishes

5. Turnover
- 5.1 Walk Thru
- 5.2 Closing

Responsibility based WBS

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                    ┌─────────────────────┐
                    │                     │
                    │  Home Construction  │
                    │                     │
                    └─────────────────────┘

┌──────────────┐  ┌──────────────┐  ┌─────────────────────┐  ┌──────────────┐
│              │  │              │  │                     │  │              │
│  Architect   │  │ Civil Engineer│  │ Contractor/Labourer │  │  Carpenter   │
│              │  │              │  │                     │  │              │
└──────────────┘  └──────────────┘  └─────────────────────┘  └──────────────┘

      ┌──────────────┐          ┌──────────────┐    ┌──────────────┐
      │              │          │              │    │              │
      │  Electrician │          │    Plumber   │    │    Painter   │
      │              │          │              │    │              │
      └──────────────┘          └──────────────┘    └──────────────┘
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Resource based WBS

1. Work Breakdown Structure…

1. Phase-based work breakdown structure

The first level of a phase-based work breakdown structure will be elements that are typical phases of a project.

The second phase will usually be elements that are distinctive deliverables in each of the phases highlighted.

The lower level of both phase-based and deliverable-based work breakdown structures are elements that are deliverables.

For a phase-based work breakdown structure, work associated with different elements will be divided into work unique to the element in the first level of your work breakdown structure.

2. Deliverable-based work breakdown structure

A work breakdown structure based on the deliverables identifies connections between the project's deliverables and the scope.

1. Work Breakdown Structure…

3. Responsibility-based work breakdown structure

The responsibility-based work breakdown structure defines the project's elements by the organizational units that will work on the project.

The first level of the structure in a responsibility-based work breakdown structure will be the organization units, the rest of the levels will often follow the same format as the other two work breakdown structures.

4. Resource Breakdown Structure

Resource Breakdown Structure (RBS) is a project management tool that provides a hierarchical decomposition of resources, either structured by resource category, types or by IT/business function that has resource needs.

Example of Resource Breakdown Structure
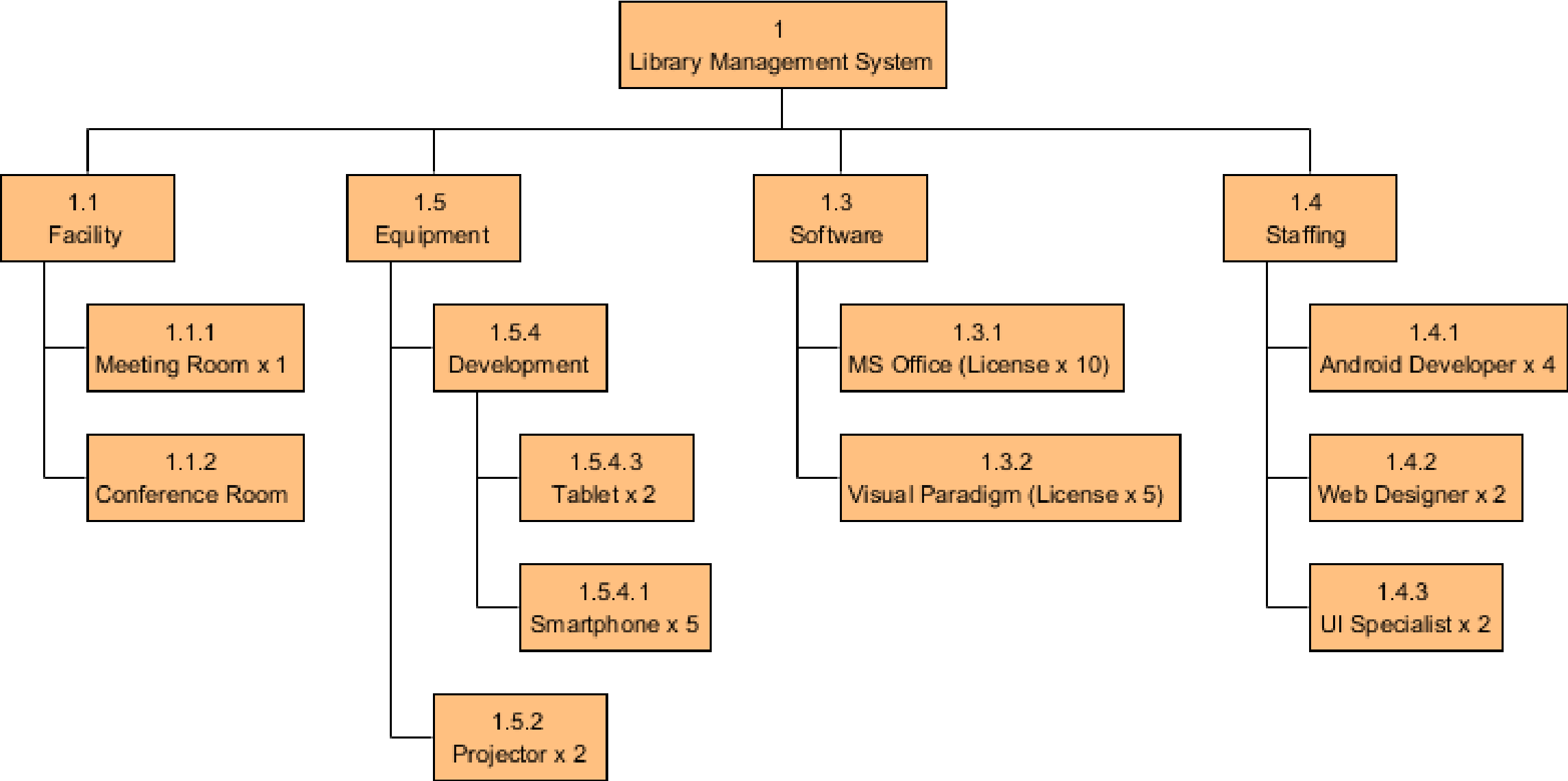
2. Linear Responsibility Chart

o Linear Responsibility Chart is the chart of responsibility which defines the project participants and shows authority and responsibility relationships among them.

o It is also called as Linear Chart, Matrix Responsibility Chart (MRC), Responsibility Interface Matrix (RIM), Responsibility and Accountability (RAM).

3. Interface Coordination

o Interface Coordination is a process that facilitates agreements with other stakeholders regarding roles and responsibilities, timing for providing interface information and identification of critical interfaces early in the project through a structured process.

o Interface is defined as a point of connect between entities working on a common project.

❖ **Interfaces are**
   o Physical
   o Functional
   o Contractual
   o Organizational
   o Knowledge
   o Resource

3. Interface Coordination…

❖ **Objectives**

o Identify the appropriate personnel who will be responsible for each interface request and for the resolution of interface request.

o Provide a system that will facilitate the identification of interfaces and address the specific interface request requirements.

o Establish a procedure that promotes efficient management of interface issues from initiation to close out.

o Define methods for communication and coordination of interface requests between various parties.

o Facilitate clear and frequent communications amongst parties.

o Facilitate the agreement of a schedule for interface request resolution and close-out.

o Define a means for the control, expediting, and reporting of progress on the transfer of interface requests.

o Define processes of assurance that interface requests are effectively identified and managed.

3. Interface Coordination…

❖ **Process**

- o Identification and recording an interface.
- o Creating an interface agreeing.
- o Agreeing/ Resolving Conflict.
- o Monitoring the Status.
- o Reporting the Status.
- o Closing the Interface Agreement.

3. Interface Coordination…

❖ **Roles and Responsibility of Interface Coordinators**

o Participants in interface meetings with involved parties are required to manage interfaces.

o Review outgoing interface requests and serve as interface requests.

o Ensure resolution of inbound interface requests.

o Actively monitor interface request register to expediting requests and open/update/close requests on behalf of their team.

o Provide collaborate interface resolution support.

o Serve as PMT liaison between contractor and operating plant point of contract. Project liaisons communicate effectively between multiple team members and stakeholders. The job will require persuasiveness, approachability, likeability, adaptability, and skills in project management.

o Inform Interface Manager of potential impacts due to unsatisfactory resolution response.

4. Concurrent Engineering

o Concurrent Engineering is a method of designing and developing products, in which the different stages run simultaneously.

o It is a systematic approach to integrated product development that emphasizes the response to customer expectations.

❖ **Methods to implement Concurrent Engineering**

 o Project Methods

 o Problem Solving Methods

4. Concurrent Engineering…

❖ **Advantages**

- Encourage multi-disciplinary collaboration.
- Reduces product cycle time.
- Reduces cost.
- Increase quality by supporting the entire project cycle – enhanced quality.
- Increases productivity by stopping the mistakes in their trends.
- Gives the competitive edge advantage.

❖ **Disadvantages**

- Complex to manage.
- Relies on everyone working together hence communication is critical.
- Room for mistakes are small as it impacts all the electrical, mechanical, software departments or disciplines.

5. Project Cost Estimation and Budgeting

o Project Cost Estimation is the process of determining the total expenditure of the project.

❖ **Project Cost Management**
   o Plan Cost Management
   o Estimate Costs
   o Determine Budget
   o Control Costs

5. Project Cost Estimation and Budgeting…

❖ **Plan Cost Management**

   o   Plan Cost Management is the process that establishes the policies, procedures, and documentation for planning, managing, expending, and controlling project costs.

❑ **Inputs**

1. Project management plan
2. Project charter
3. Enterprise environmental factors
4. Organizational process assets

❑ **Tools and Techniques**

1. Expert judgment
2. Analytical techniques
3. Meetings

❑ **Outputs**

1. Cost management plan

5. Project Cost Estimation and Budgeting…

❖ **Estimate Cost**

o Estimate Costs is the process of developing an approximation of the monetary resources needed to complete project activities.

❑ **Inputs**

1. Cost management plan
2. Human resource management plan
3. Scope baseline
4. Project schedule
5. Risk register
6. Enterprise environmental factors
7. Organizational process assets

❑ **Tools and Techniques**

1. Expert judgment
2. Analogous estimating
3. Parametric estimating
4. Bottom-up estimating
5. Three-point estimating
6. Reserve analysis
7. Cost of quality
8. Project management software
9. Vendor bid analysis
10. Group decision-making techniques

❑ **Outputs**

1. Activity cost estimates
2. Basis of estimates
3. Project documents updates

Tools and technique for cost estimation

- **Expert Judgement**

While estimating the project cost, the first step is to take the comments from the experts. The experts are the people who have prior knowledge on similar kind of projects. So they can suggest valuable insight based on their experience. You can also take their advice on various tools and techniques that can be used to estimate similar kind of project.

- **Analogous Estimation**

Normally, at the early stages of your project, you do not have much detail, so taking into account of similar projects previously completed by your organization, the cost of the project can be estimated. Analogous estimation technique uses the parameters such as scope, budget, duration, size, weight and complexity of previous projects having similar nature of works. It measures the current project on that basis and does the estimation.

Tools and technique for cost estimation

- **Analogous Estimation Continues**
- The technique is less costly and less time-consuming. But the accuracy of this estimation is lower than the other estimation techniques as it is purely based on historical data. It can be applied to the whole project or some part of the project in combination with other techniques.
- For example, if the budget of a particular activity in the previous project has X amount, and by measuring the same activity in your current project looks identical, then the same X amount can be applied to that.

- **Parametric Estimation**
- This technique uses an algorithm to calculate the cost of the activity considering the historical data and other project variables. A statistical relationship needs to be evaluated between the historical data and other variables. This technique can be used for the complete project or for some of the activities in conjunction with other estimation techniques.

Tools and technique for cost estimation

- Parametric estimation continues

For example, in an industrial project, one of the activities is to make 10 valves in the first phase. So as part of historical data gathering, you got the information that construction of each valve requires $150.

Based on that information you can calculate as:

Total cost of making 10 valves = cost per valves * no. of valves

Total cost = 150*10 = 1500

- **Bottom-Up Estimation**

- Bottom-up estimation technique starts with the estimation from the lower level i.e. the work package level created as per WBS and then rolled up to higher-level. The accuracy of this estimation technique is high as you are doing the estimation from granular level

Tools and technique for cost estimation

- **Bottom-Up Estimation**
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- **Three-Point Estimation**
- To deal with uncertainties and risk, you need to take the help of three-point estimation which is also referred as PERT- Program Evaluation and Review Technique.
- The Program Evaluation and Review Technique use three types of estimations:
- M – Most Likely: The realistic or ideal situation, all the required resources will be assigned and can achieve the expected productivity
- O – Optimistic: Estimation based on best case scenario
- P – Pessimistic: Estimation based on worst case scenario
- Based on the above assumptions, the expected duration can be calculated using two basic formulas.
- Triangular Distribution – (O+M+P)/3
- Beta distribution – (O+4M+P)/6

Tools and technique for cost estimation

- **Reserve Analysis**
- To deal with uncertainty, you need to allocate some funds called as the contingency reserve. That is the part of the cost baseline to mitigate the identified and accepted risks. Also for unknown risks, an amount needs to be estimated which is called management reserve. This is not included in the cost baseline but part of the overall project budget. It is important to keep the reserve budget to deal with uncertain events. The contingency reserve is under the project manager authority, while to use the management reserve the project manager need to take approval from the sponsors.

- **Cost of Quality**
- Basically, two types of costs are there to ensure the quality, one is called the cost of conformance which is the budget required for prevention and appraisals, and another one is cost of non-conformance that may be used up due to internal and external failures. Cost of quality means estimating the cost of both conformance and non-conformance expenses.

Tools and technique for cost estimation

- **Project Management Software**
- There are some tools which can be used to perform the project cost estimation, such as cost estimating software application, spreadsheets, simulation and statistical tools.

- **Vendor Analysis**
- This is another technique to estimate the cost by comparing the various bids proposed by the vendors. There may be differences in their bids but you can get an idea considering the average bid values.

Tools and technique for cost estimation

- **Group Decision Making Techniques**
- This technique emphasizes the involvement of a group of people who are going to perform the technical work. By involving those you will gain more details on the work and thus helpful to estimate more accurately. Also, it develops a commitment from the people who are involved in the discussion to complete the work as estimated.

- Depending upon the nature of your project, either you can apply these techniques together or in combinations of few techniques to estimate the project cost. Also, keep in mind that the estimations are never drawn to an exact figure; it is always in the probable ranges. In the initial phases, the preliminary estimate ranges between -15% to +50%, while the rough order of magnitude estimates in between -25% to +75%. And the budget estimate falls in -10% to +25% ranges.

5. Project Cost Estimation and Budgeting…

❖ **Determine Budget**

o Determine Budget is the process of aggregating the estimated costs of individual activities or work packages to establish an authorized cost baseline.

❑ **Inputs**
1. Cost management plan
2. Scope baseline
3. Activity cost estimates
4. Basis of estimates
5. Project schedule
6. Resource calendars
7. Risk register
8. Agreements
9. Organizational process assets

❑ **Tools and Techniques**
1. Cost aggregation
2. Reserve analysis
3. Expert judgment
4. Historical relationships
5. Funding limit reconciliation

❑ **Outputs**
1. Cost baseline
2. Project funding requirements
3. Project documents updates

5. Project Cost Estimation and Budgeting…

❖ **Control Cost**

   o   Control Costs is the process of monitoring the status of the project to update the project costs and managing changes to the cost baseline.

❑ **Inputs**

1. Project management plan
2. Project funding requirements
3. Work performance data
4. Organizational process assets

❑ **Tools and Techniques**

1. Earned value management
2. Forecasting
3. To-complete performance index (TCPI)
4. Performance reviews
5. Project management software
6. Reserve analysis

❑ **Outputs**

1. Work performance information
2. Cost forecasts
3. Change requests
4. Project management plan updates
5. Project documents updates
6. Organizational process assets updates

6. Top Down and Bottom Up Budgeting

o Top Down estimating is a project estimating technique in which the overall project is estimated first and then individual task are apportioned from it.

o Bottom Up estimating is a project estimating technique in which the individual task are estimated first and rolled up into overall project estimate.

7. Networking and Scheduling Techniques

o Network Planning is a technique used to plan, schedule and control the interrelated activities of the project.

o Network Diagram is a graphical representation of all the tasks, responsibilities and workflow for a project.

❖ **Types of Network Diagrams**
  o Arrow Diagram Method
  o Precedence Diagram Method

7. Networking and Scheduling Techniques…

❖ **Concepts of Network Analysis**

- o Activity
  - o Predecessor Activity
  - o Successor Activity
  - o Concurrent Activity
  - o Dummy Activity
- o Event
  - o Merge Event
  - o Burst Event
  - o Merge and Burst Event

❖ **Techniques of Network Analysis**

- o Critical Path Method (CPM)
- o Programme Evaluation and Review Technique (PERT)

8. PERT

o PERT is a management technique used with responsibility accounting and to attain well defined objectives.

o It is designed for scheduling complex interrelated tasks of the projects.

❖ **PERT System of Three Time Estimate**

    o Optimistic Time

    o Most likely Time (t_m)

    o Pessimistic Time (t_p)

8. PERT…

❖ **PERT Algorithm**

1. Develop a list of activities that made up the project including immediate predecessors.

2. For each activity, a rough PERT network is drawn on the basis of which activity precedes, which activity follows which one, which activity are concurrent with which one.

3. The network is sketched to conform to rules and conventions.

4. Events are numbered in ascending order from left to right.

5. Time estimates (Optimistic Estimate, Most Likely Estimate, Pessimistic Estimate)for each activity are obtained.

6. Then upon the assumption of beta distribution for the activity duration, the expected time t_e for each activity is computed using $t_e = 1(1+4m+b)/6$.

8. PERT…

❖ **PERT Algorithm…(continued)**

7. Using the expected activity time estimates, determine the earliest start time and the earliest finish time for each activity, the earliest finish time for the complete project corresponds to the earliest finish time for the last activity.

8. After determining the latest start time and the latest finish time for each activity, compute the float associated with each activity, the critical path activities are the activities with zero float. Determine now the critical path through the given network.

9. Using the values for b and a, which were determined in step 5. calculate the variance (σ^2) of each activities time estimated by $\sigma^2 = [1(b-a)/6]^2$.

10. Use the variability in the activity times to estimate the variability of the project completion date, then using this estimate compute the probability of meeting a specified completion date by using the standard normal equation

    $$Z = \frac{\text{Due date} - \text{Expected date of completion}}{\sqrt{\text{Project Variance}}}$$

    where Z = no of standard deviations the due date or target date lies from the mean or expected date

9. CPM

o CPM method is developed by E. I. du Pont de Nemours Company (USA) in 1958.

o It is used to schedule and control the project.

o It is used to estimate the total project duration and to assign starting and finishing times to all activities involved in the project.

❖ **CPM Systems**
  o Activity-On-Arrow (AOA) Network
  o Activity-On-Node (AON) Network

9. CPM…

❖ **Steps**

1. Break down the project into various activities systematically. Label all activities. Arrange all the activities in logical sequence. Construct the network diagram.

2. Number all the nodes (events) and activities. Find the time for each activity considering it to be deterministic. Indicate the activity times on the arrow diagram.

3. Calculate earliest start time, earliest finish time, latest start time and latest finish time. Tabulate activity normal times, earliest times and latest times.

4. Determine the total float for each activity by taking difference between the earliest time and latest time for each node.

5. Identify the critical activities and connect them with the beginning node and the ending node in the network diagram by double line arrow. This gives the critical path.

6. Calculates the total project duration.

7. Reduce the total project duration, crash the critical activities of the network.

8. Optimize the cost.

9. Update the network and smooth the network resource.

10. GANTT Chart

o   Gantt bar Chart is a horizontal bar chart that visually represents a project plan over time.

o   It shows the status of each task and who's responsible for each task in the project.

❖ **Key Parts of Gantt Chart**
   o   Task List
   o   Timeline
   o   Dateline
   o   Bars
   o   Milestones
   o   Dependencies
   o   Progress
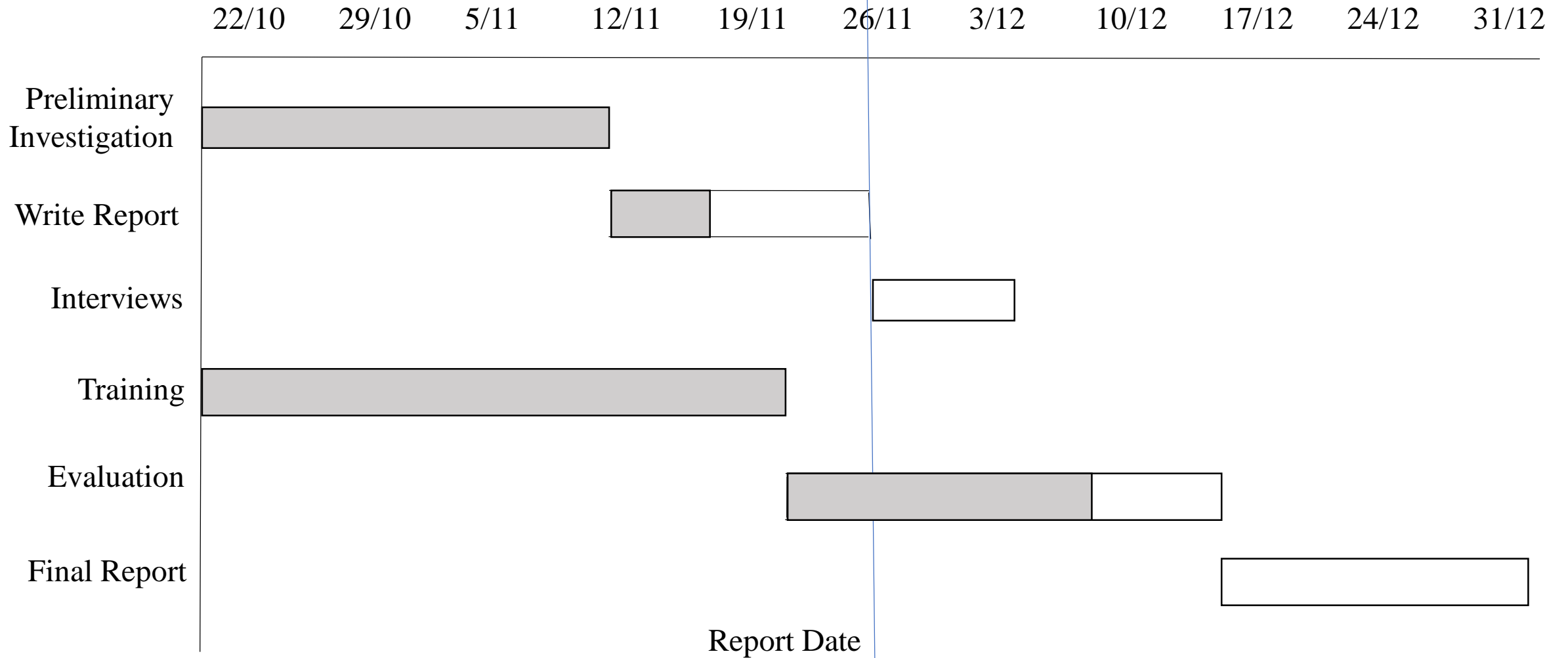   o   Resource assigned

10. GANTT Chart…

Fig: Gantt Chart of Project Schedule

10. GANTT Chart…

❖ **Functions of Gantt Chart**

   o   Plan, schedule, manage and monitor the tasks involved in the projects.

   o   Define the tasks that require completion.

   o   The chart is displayed as a horizontal bar chart.

   o   Horizontal bars of different length represent the project timeline.

   o   This includes task sequence, task duration, task start date and task end dates.

10. GANTT Chart…

❖ **Benefits of Gantt Chart**

o It identifies all the task, task which are executing in parallel and dependent tasks.

o It organizes high level tasks and resource allocation.

o It detects potential bottlenecks and identify tasks that may have been excluded from the project timeline.

o The bars represents which tasks are completed.

o It depicts the task slack time

11. Introduction to Project Management Information System (PMIS)

o PMIS is a computer based information system that efficiently stores and organized information needed to run a project.

o Project Management Book of Knowledge (PMBOK) is an information system consisting of the tools and techniques used to gather, integrate and disseminate the outputs of project management processes.

❖ **Objective:**
  o To reduce project duration
  o Minimize the cost of crashing

11. Introduction to Project Management Information System (PMIS)…

❖ **Tools used by PMIS**
- o Schedule and Planning
- o Resource Management
- o Budget
- o Control and Performance
- o Reporting and Communication
- o Integration and Ease of Use

11. Introduction to Project Management Information System (PMIS)…

❖ **Functions**

o During initiation phase, Project Manager uses PMIS to prepare preliminary budget including cost estimate and resource.

o It schedules the project.

o It define the scope of work, assists with preparing the bid and can be used when presenting the data to decision-makers.

o It supports cost management planning including WBS analysis and integration of control processes.

o It proves beneficial to the Project Manager when resource planning in terms of availability and level.

o It establishes a baseline for project scope, schedule and cost.

o Once the project has been executed, PMIS starts collecting, organizing and storing data as it comes in from the project team, which is then compared to the baseline projections.

o It uses cost and schedule forecasts to help if changes are required mid-project.

o It supports materials management, cost collect, performance measurement and reporting.

o During closing, it review requirements to make sure that project has met all its goals and objectives.

o It organizes all the collected information for performance review, productivity analysis, final reports and then keeps an archive with the historical data for future projects.

Thank you