

# 2

UNIT

## Project Organization and Scheduling

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- Project Elements
- Work Breakdown Structure
- Types of WBS
- Functions
- Activities and Tasks
- Project Life Cycle
- Product Life Cycle

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### PART-1

*Project Elements, Work Breakdown Structure, Types of WBS, Functions, Activities and Tasks, Project Life Cycle and Product Life Cycle.*

#### CONCEPT OUTLINE : PART-1

- The purpose of work breakdown structure (WBS) is to divide the program/project into manageable pieces of work to facilitate planning and control of cost, schedule and technical content.
- **Types of WBS :**
  - a. Product breakdown
  - b. Service project breakdown
  - c. Result project breakdown
  - d. Cross cutting element
  - e. Project management
- Task is a generic term for work, that is, not included in the WBS but that potentially could be a further decomposition of work by the individual responsible for that work.
- Various phases of project life cycle are :
  - a. Initiation
  - b. Planning
  - c. Executing
  - d. Controlling
  - e. Closing
- Various types of product life cycle model are :
  - a. SDLC model
  - b. Waterfall model
  - c. Prototyping model
  - d. V-process model
  - e. Spiral model
  - f. Iterative enhancement model
  - g. Rapid application development (RAD) model

#### Questions-Answers

#### Long Answer Type and Medium Answer Type Questions

**Que 2.1.** What are the elements of project ?

**Answer**

In order to ensure that all our projects reach the required level of success, here are the 5 essential elements that need to be included :

**1. Strategic planning :**

- a. The first stage of any project is to understand the need for the project and what it is trying to achieve. SMART (Specific, Measurable, Attainable, Relevant, Timely) objectives need to be established along with measures of success and key milestones where progress can be reviewed.
- b. Working as an internal project manager will require close liaison with key internal stakeholders and departments to establish their specific requirements and set commonly agreed objectives.

**2. Product development :**

- a. The variety of activities that are deemed to be projects are wide-ranging and varied, and can include new products, processes and services. The development of any of these needs to be closely linked to meeting defined business objectives and adding value to the organization.
- b. The benefits of a project should be well articulated at the beginning so there is a clear link to the success of the project and the impact on overall business aims.

**3. Communication :**

- a. It is vital to sell the benefits of any project to those who will be affected during the project or by the project's final outcome. Implementing a new process requires that end users understand why the project is beneficial and potential buyers need to be convinced by the advantages of new products and services.
- b. In essence, communicating the message of why new or different is good will help counteract the typical human reluctance to change.

**4. Resources :**

- a. It is vital to ensure that adequate resources in terms of people, time, finances and equipment are in place. Internally, this could involve the IT department providing the appropriate hardware/software, Human Resources recruiting the necessary people or the Facilities department providing offices or other relevant support.
- b. There also needs to be allocated budgets and finance as well as appropriate timelines for project completion.

**5. People :** No project manager works in isolation. There are many stakeholders involved in a project who all have a specific role to play and who all have a vested interest in the project's success. The key stakeholders who drive projects and help make them a success include:

- a. **Sponsor :** The project sponsor is the person who defines the business objectives that drive the project. The sponsor can be a member of the senior management team or someone from outside of the organization.

- b. **Project manager :** A professional project manager creates the project plan and ensures that it meets the budget, schedule and scope determined by the sponsors. The project manager is also responsible for risk assessment and management.
- c. **Project team members :** These can include subject area experts, members of departments, external professionals and new recruits. Anyone who can offer a positive contribution to the project in terms of their knowledge and capabilities makes a good team member.

**Que 2.2.** Write short note on work breakdown structures.

**UPTU 2012-13, Marks 05**

**OR**

**What do you mean by Work Breakdown Structure (WBS) in context to software project and product ? Discuss with examples.**

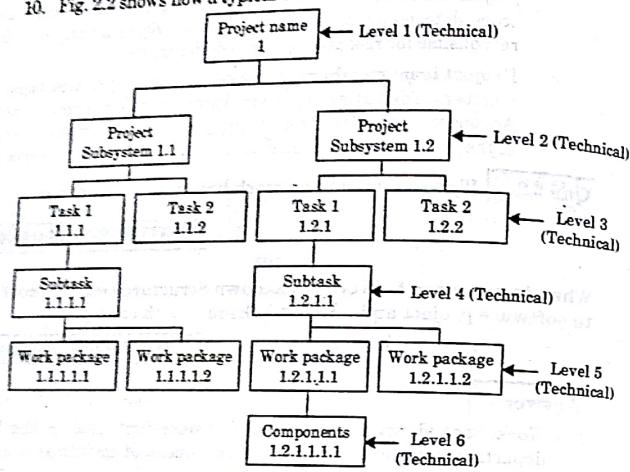
**UPTU 2014-15, Marks 05**

**Answer**

1. Work Breakdown Structures (WBS) were first used by the U.S. department of defense for the development of missile systems in mid-1960..
2. The purpose of a work breakdown structure (WBS) is to divide the program/project into manageable pieces of work to facilitate planning and control of cost, schedule and technical content.
3. It identifies the total work to be performed and divides the work into manageable elements, with increasing levels of detail.
4. Work breakdown structure (WBS) is a chart in which the critical work elements, called tasks, of a project are illustrated to describe their relationships to each other and to the project as a whole.
5. 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.
6. A well-organized, detailed WBS can assist key personnel in the effective allocation of resources, project budgeting, procurement management, scheduling, quality assurance, quality control, risk management, product delivery and service oriented management.
7. When creating a WBS, the project manager defines the key objectives first and then identifies the tasks required to reach those goals.
8. A WBS takes the form of a tree diagram with the "trunk" at the top and the "branches" at the bottom.
9. The primary requirement or objective is shown at the top, with increasingly specific details shown as the observer reads down.

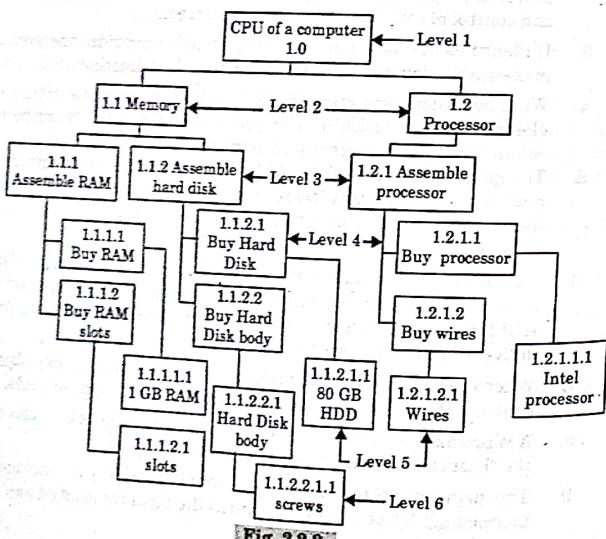
### Project Organization and Scheduling

10. Fig. 2.2 shows how a typical WBS looks like.



**Fig. 2.2.1.**

11. There are six levels till where we can drill down and breakdown the job structure :



**Fig. 2.2.2.**

- Level 1 :** The first level is the project name or the name of the assignment.
  - Level 2 :** Level 2 represents the subsystem which will make up the project.
  - Level 3 :** Level 3 shows the task to be performed to complete the subsystem from managerial aspect.
  - Level 4 :** The main task is further broken down into sub tasks from a technical aspect.
  - Level 5 :** This is the final deliverable also termed as work package.
  - Level 6 :** These are components needed to form the work package.
- Example :** The following figure shows 'WBS for CPU' for assembling a CPU of a computer.

**Que 2.3.** Write short note on work breakdown structure with its type.

**UPTU 2013-14, Marks 05**

**Answer**

**Work breakdown structure :** Refer Q. 2.2, Page 45C, Unit-2.

**Types of WBS :**

There are different types of projects and, therefore, different types of WBSs, each with unique elements. All WBSs have two or more of the five types of level 2 elements as shown in Fig. 2.3.1.

These five types of elements are as follows :

**1. Product breakdown :**

- The subdivision based on the physical structure of the product(s) being delivered (as the capital asset) is the most common basis for a WBS and the easiest WBS to develop.
- These projects have a tangible output product : software, a building, a dam, an airplane, a user's manual, etc., all have a natural structure.
- Alternatively, there may be multiple products delivered such as an airport ground surveillance system, an IT system for a centralized clearing house, an integrated deep water system, or an orbiting space laboratory system.

**2. Service project breakdown :**

- Service projects do not have a tangible, structured deliverable. The output is a defined body of work done for others : conference, party, wedding, vacation trip, etc.
- The work breakdown is a logical collection of related work areas.

**3. Results project breakdown :**

- Results projects do not have a tangible, structured deliverable. The output is the consequence of a process that results in a product or a conclusion : cancer research, new drug development, culture change, etc.
- The work breakdown is a series of accepted steps.

- 4. Cross-cutting element :**
- This is a breakdown of items that cut across the product, such as architectural design, assembly or system test.
  - These usually are technical and supportive in nature. There may be more than one element of this characteristic at level 2.
  - While there is no restriction, these types of cross-cutting elements are rare in service or results projects.
- 5. Project management :**
- This is a breakdown of the managerial responsibilities and managerial activities of the project.
  - It includes items such as reports, project reviews, and other activities of the project manager or his or her staff (Conceptually, these are the overhead of the project).
  - Normally, there is only one of these types of WBS element, but it exists on all projects as a level 2 element.

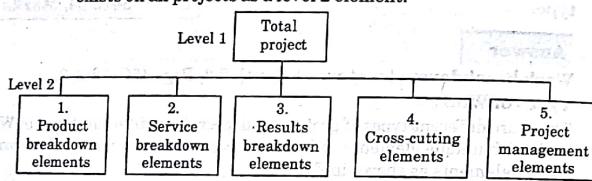


Fig. 2.3.11 A model of a WBS

**Que 2.4.** What are the principles of WBS ? Discuss in detail.

**Answer**

WBS principles are as follows :

- The WBS covers the total scope of the project. Work not involved in the WBS, is not in the project.
- All deliverables or output products are represented in the WBS.
- The sum of the elements at each level represents 100 percent of the work of the next higher level (The sum of the level 2 items is 100 percent of the project work or cost).
- Work in each element is equivalent to the sum of the work in the subordinate elements.
- The subdivisions should be logical and reflect the nature of the product, service, or result.
- Each WBS element should represent a discrete element of work that can be described in the WBS dictionary.
- Each WBS element should have a unique identifier.
- WBS element descriptors preferably should be nouns, with adjective modifiers if necessary. For clarity or for cultural reasons, WBS descriptors may include verbs and modifiers. However, they should not be considered

- activities since activities are the action elements that occur below the WBS.
- The work in each WBS element may be described in detail in a WBS dictionary, which may become the basis for statements of work or work-authorizing documents.
  - Project management is a level 2 element in all WBSs.
  - Stakeholders should participate in the development of the WBS.
  - The WBS should be baselined after approval by the stakeholders.
  - A formal change process should exist for baselined WBSs.
  - The WBS should focus on project output or deliverables; it is not an organization chart, a schedule, or a resource list.
  - The lowest level should be the level above the activities—the work package level.
  - The lowest level should permit adequate control and visibility for project management.
  - The lowest level need not be the same for all branches of the WBS.
  - The lowest level should not be so detailed as to create an administrative burden.
  - The WBS does not reflect time relationships or horizontal relationships between elements; all structural relationships are vertical.

**Que 2.5.** What are the recommended steps to develop a project WBS ?

**Answer**

The recommended steps to develop a project WBS are as follows :

- Step 1:** Identify the project objectives (this will assist in steps 2 and 3).
- Step 2:** Determine the general type of project by identifying specifically whether the primary output is a product, service, or result.
- Step 3:**
  - If the project output is a product, level 2 will include the product name, secondary product names, and cross-cutting elements. Make sure all project outputs can be related to a level 2 element (proceed to step 4).
  - If the project output is a service, level 2 will include the top-level groupings of the various types of work and the project management element. Consider identifying as many activities as possible and grouping them by logical categories related to areas of work (**bottom-up synthesis**) (proceed to step 5).
  - If the project output is a result, level 2 will consist of the major steps in the **acknowledged** process necessary to achieve the result plus the project management element (proceed to step 6).

- Step 4:** For product WBSs, subdivide the product element into the logical physical breakdown of the product. Subdivide the cross-cutting elements into the supporting work (proceed to step 7).
- Step 5:** For service WBSs, subdivide the level 2 WBS elements into functional work areas (proceed to step 7).
- Step 6:** For results WBSs, subdivide each level 2 WBS elements into the standard processes specified to achieve the objective or output of the element (proceed to step 7).
- Step 7:** Review the work at each level to make sure 100 percent of the work is identified; add elements as necessary. In a product WBS, make sure integrative elements are added as necessary.
- Step 8:** Continue to subdivide the elements to the work package level. Further subdivision would violate the principles outlined above. Stop when the next level would be activities or is unknown until further analysis or planning is performed.
- Step 9:** Review the WBS with stakeholders and adjust as necessary to make sure that all the project work is covered.

**Que 2.6** What are the main features and uses of WBS ?

**Answer**

Features of WBS :

1. **Structure :** WBS diagram is drawn like the organization chart. Different desktop applications offer functionalities to easily create this kind of diagrams.
2. **Description :** Each WBS element should be described with a title. The meaning of each title should be clear.
3. **Coding :** One of the main features of WBS is the ability to uniquely code the different elements of the work. The coding system can be alphabetic, numeric or alphanumeric.
4. **Depth :**
  - a. The recommended depth of a WBS diagram is three to four levels. If deeper hierarchies are required, the division into subprojects can be used and one element would then present one subproject.
  - b. The downside adding of too many levels is firstly the readability of the diagram and secondly, the fact that the larger the diagram, the more troublesome it is to update when major changes occur in the project.
5. **Level of detail :** A rule of thumb is creating a WBS diagram is to make the lowest level element (often called work package) small enough to be considered a separate work element when estimating the amount of work in a project. This allows the work package later to be divided into a list of work activities and tasks.

#### Uses of WBS :

1. For dividing the project into phases.
2. For dividing the project into responsibility areas within the organization.
3. For dividing the schedule of the project into sub-schedules whose interrelations are known.
4. For giving grounds to following the cost of the project by defining clear targets to it.
5. For giving hierarchical outlining and coding for the work to be done.
6. For enabling integrating planning and managing of the project from both financial and scheduling perspective.

**Que 2.7** What do you mean by activity ? Explain different characteristics of activity.

**Answer**

1. Before we try to identify the activities that make up a project, it is worth reviewing what we mean by a project and its activities and adding some assumptions that will be relevant when we start to produce an activity plan.
  - a. A project is composed of a number of interrelated activities.
  - b. A project may start when at least one of its activities is ready to start.
  - c. A project will be completed when all of the activities it encompasses have been completed.
  - d. An activity must have a clearly defined start and a clearly defined endpoint, normally marked by the production of a tangible deliverable.
  - e. If an activity requires a resource, then that resource requirement must be forecastable and is assumed to be required at a constant level throughout the duration of the activity.
  - f. The duration of an activity must be foreseeable assuming normal circumstances, and the reasonable availability of resources.
  - g. Some activities might require that others are completed before they can begin (these are known as precedence requirements).
2. The activity-based approach consists of creating a list of all the activities that the project is thought to involve.
3. This might involve a brainstorming session involving the whole project team or it might stem from an analysis of similar past projects.
4. When listing activities, particularly for a large project, it might be helpful to subdivide the project into the main lifestyle stages and consider each of these separately.

5. Rather than doing this in an adhoc manner, with the obvious risks of omitting or double-counting tasks, a much favoured way of generating a task list is to create a Work Breakdown Structure (WBS).
6. This involves identifying the main (or high-level) tasks required to complete a project and then breaking each of these into a set of lower level tasks. Fig. 2.7.1 shows a fragment of a WBS where the design task has been broken down into three tasks and one of these has been further decomposed into two tasks.

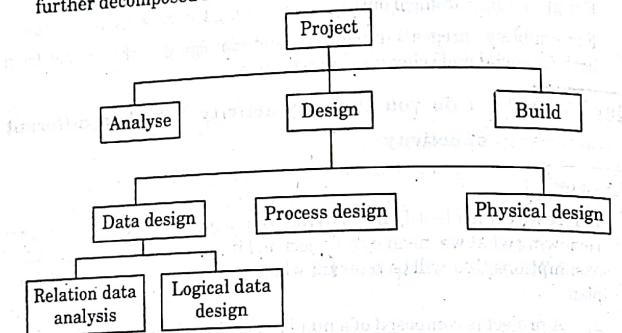


Fig. 2.7.1.

7. Activities are added to a branch in the structure if they directly contribute to the task immediately above if they do not contribute to the parent task, then they should not be added to that branch.
8. The tasks at each level in any branch should include everything, that is, required to complete the task at the higher level if they are not a comprehensive definition of the parent task, then something is missing.
9. When preparing a WBS, consideration must be given to the final level of detail or depth of the structure.
10. Each branch should, however, be broken down at least to a level where each leaf may be assigned to an individual or responsible section within the organization.
11. Advantages claimed for the WBS approach include the belief that it is much more likely to result in a task catalogue that is complete and is composed of non-overlapping activities.
12. Note that, it is only the leaves of the structure that comprise the list of activities in the project, higher level nodes merely represent collections of activities.

The characteristics of activities are as follows :

1. Work is performed and described in terms of a verb, adjective, and noun.

2. A single person or organization is responsible for the work — more than one resource may be assigned to an activity, but one person is in charge of delivering the output.
3. It has defined start and finish points — there is either a specific predecessor activity or event that must be completed first or a specific date on which the activity is scheduled to start; the scheduled end date is based on the estimated duration, baseline duration, or scheduled duration of the activity.
4. Usually, there is a tangible output or product at completion — projects occasionally have level-of-effort activities or support activities without clearly defined outputs.
5. It fits logically under an existing WBS element — if it does not, the activity is not part of the project, the WBS needs modification, or the activity is ambiguous and needs redefinition.
6. Actual schedule status data can be collected for the activity — for schedule control, the start and end points must be sufficiently defined so that the start and finish of the activity can be reported.
7. Actual cost (person-hour) data can be collected for the activity or work package that contains the activity — for cost or resource control, actual cost data or the actual expenditure of resources can be collected.
8. The labour and costs necessary to perform the activity can be estimated — the resource requirements must be able to be determined in the planning phase.
9. The output of the activity is known or can be identified — outputs are frequent pieces of paper or other tangible proof of the activity being completed.
10. The activity represents a significant effort in support of project objectives — trivial or incidental activities need not be included.
11. Zero duration activities are milestones or events and represent the start or completion of another activity or set of activities — they should be included at the start and finish of the project and included to identify completion of key activities or groups of activities.

**Que 2.8. What are different product identification techniques ?**

**Answer**

1. For identifying tasks and activities, product development technique needed is an awareness of the processes of software development using different life cycles.
2. Life cycles must be evaluated and tailored to the individual needs of each project.
3. A general understanding of software development activities (software engineering) and how to define the software product are competencies needed for task and activity identification.

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54 (CS/IT-7) C

4. The project management skills needed here are a continuation of those needed for building the WBS, such as documenting plans in an arranged structure and finding tasks and activities that can be used to create a schedule.
5. Activity ID requires the people skills of leadership, interface, and communication, and the ability to present ideas effectively throughout the identification process.
6. The product development techniques are as follows :
  - a. Assessing processes : Defining criteria for reviews.
  - b. Defining the product : Identifying customer environment and product requirements.
  - c. Evaluating alternative processes : Evaluating various approaches.
  - d. Tailoring processes : Modifying standard processes to suit a project.
  - e. Understanding development activities : Learning the software development cycle.

**Que 2.9.** Diagrammatically represent the product life cycle model.

**UPTU 2012-13, Marks 05**

**OR**

Write short note on product life cycle.

**OR**

Write short note on project life cycle and product life cycle.

**UPTU 2013-14, Marks 05**

**OR**

What do you mean by project life cycle and product life cycle ?

**UPTU 2014-15, Marks 05**

**Answer**

The product life cycle is discussed as follows :

#### 1. Product life cycle :

- a. The product life cycle describes the sales pattern of a product over time. Generally, the time span begins with product introduction and ends with its obsolescence and replacement.
- b. While the form of life cycle is fairly standard, it is subjected to variations.
- c. The concept underlying the premise of product life cycle is that all products pass through the stages outlined below.

### Software Project Management

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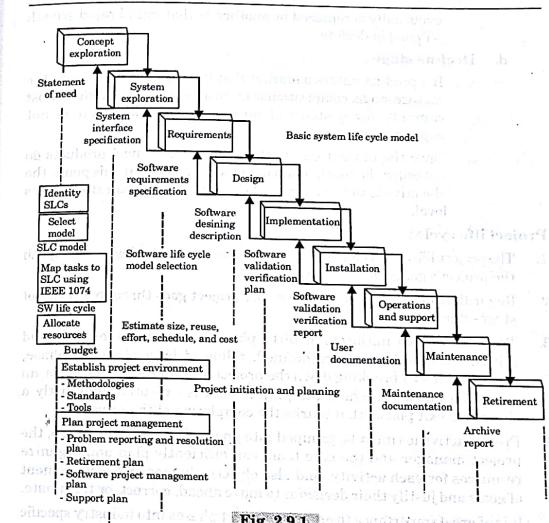


Fig. 2.9.1.

**2. Basic stages in the product life cycle :** There are basic four stages of PLC :

- a. **Development stage :** It is the first stage and represents a slow growth period. It is assumed that newly released products require some time to gain market acceptance, so sales in the initial period are slow. Sales rise but at a slow rate.
- b. **Growth stage :** It is the second stage of PLC. Once the product introduction proved successful, rapid growth stages are reached and sales increase according to the market value.
- c. **Mature stage :**
  - i. It is the third stage of PLC. According to the concept of life cycle, the market for any product is limited, and sales will generally fall short of their potential.
  - ii. When this point is reached, the market enters the maturation stage. The life cycle goes further to assume that each product reaches a point where no further growth is possible.

eventually is replaced by another or that initial rapid growth will end in decline.

**d. Decline stage :**

- i. If a product enters a market that has already moved into the mature stage, competition is intense because the product must compete for a share of an existing market that is not experiencing growth.
- ii. Once the market enters the decline stage, new products do not enter the market and demand level falls. At this point, the objective is to increase market share to maintain stable sales level.

**Project life cycle :**

1. The project life cycle refers to a logical sequence of activities to accomplish the project's goals and objectives.
2. Regardless of scope or complexity, any project goes through a series of stages during its life.
3. There is first an initiation or birth phase, in which the outputs and critical success factors are defined, followed by a planning phase, characterized by breaking down the project into smaller parts/tasks, an execution phase, in which the project plan is executed, and lastly a closure or exit phase, that marks the completion of the project.
4. Project activities must be grouped into phases because by doing so, the project manager and the core team can efficiently plan and organize resources for each activity, and also objectively measure achievement of goals and justify their decisions to move ahead, correct, or terminate.
5. It is of great importance to organize project phases into industry specific project cycles.
6. Not only because each industry sector involves specific requirements, tasks, and procedures when it comes to project, but also because different industry sectors have different needs for life cycle management methodology. And paying close attention to such details is the difference between doing things well and excelling as project managers.
7. Diverse project management tools and methodologies prevail in the different project cycle phases.

Following are the stages of project life cycle :

**1. Initiation :**

- a. In this stage, the scope of the project is defined along with the approach to be taken to deliver the desired outputs.
- b. The project manager is appointed and in turn, he selects the team members based on their skills and experiences.
- c. The most common tools or methodologies used in the initiation stage are project charter, business plan, project framework (or overview), business case justification and milestone reviews.

**2. Planning :**

- a. The second phase should include a detailed identification and assignment of each task until the end of the project.
- b. It should also include a risk analysis and a definition of criteria for the successful completion of each deliverable.
- c. The governance process is defined, stakeholders identified and reporting frequency and channels agreed.
- d. The most common tools or methodologies used in the planning stage are business plan and milestones reviews.

**3. Execution and controlling :**

- a. The most important issue in this phase is to ensure project activities properly executed and controlled.
- b. During the execution phase, the planned solution is implemented to solve the problem specified in the project's requirements.
- c. In product and system development, a design resulting in a specific set of product requirements is created. This convergence is measured by prototypes, testing, and reviews.
- d. As the execution phase progresses, groups across the organization become more deeply involved in planning for final testing, production, and support.
- e. The most common tools or methodologies used in the execution phase are an update of risk analysis and score cards, in addition to business plan and milestone reviews.

**4. Closure :**

- a. In this last stage, the project manager must ensure that the project is brought to its proper completion.
- b. The closure phase is characterized by a written formal project review report containing the following components :
  - i. a formal acceptance of the final product by the client,
  - ii. weighted critical measurements (matching the initial requirements specified by the client with the final delivered product),
  - iii. rewarding the team, a list of lessons learned,
  - iv. releasing project resources and
  - v. a formal project closure notification to higher management.
- c. No special tool or methodology is needed during the closure phase.

**Que 2.10.** Discuss SDLC model in brief.

**Answer**

Software Development Life Cycle (SDLC) :

1. Software development life cycle represents number of identifiable stages under which software goes during its life.
2. It is a diagrammatic representation which also provides description of various phases and their sequence in life cycle of software product.
3. Software undergoes some basic stages during its life cycle i.e., requirement analysis and specification, design, coding, testing and maintenance.
4. There are many software models which are used as per requirement of software product.
5. All models undergo these basic stages while their mapping of the stages may be different as per model requirement.
6. We have different life cycle models, each one has its own advantages and disadvantages. We can choose any one of them on the basis of :
  - a. Development speed
  - b. Product quality
  - c. Project visibility
  - d. Administrative overhead
  - e. Risk exposure

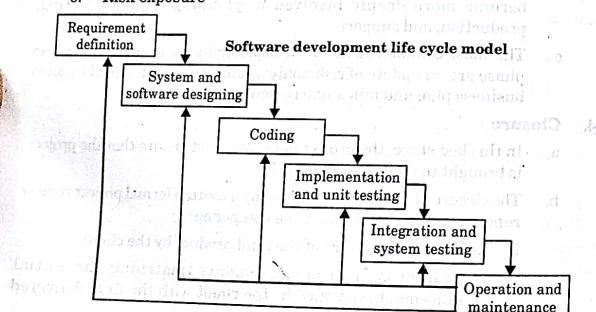


Fig. 2.10.1

**Phases of software development life cycle models :**

1. Requirement definition (system analysis and system specification)
2. System and component (software) design
3. Coding
4. Implementation and unit testing
5. Integration and system testing
6. Operation and maintenance

**Que 2.11. Explain waterfall model and its limitations.****UPTU 2014-15, Marks 05****Answer****Waterfall model :**

1. Waterfall model is a theoretical software development model which was used in 70's.
2. It is also known as classical, traditional, conventional or linear segment model.
3. "There are different stages to the development and the output of first stage flow to the next (second) stage and output of second flows to third stage and so on."
4. It force on sequential phase development in which no phase can overlap another phase and so the developer must complete each phase before starting next phase.
5. Each phase of this model has a well defined starting and ending criteria which is to be documented by which the standard outputs (deliverables) to be produced by each phase can formulate.
6. This model does not allow to go back to the previous stage from one stage "one way street with no turning back" like waterfall that's why it is called waterfall model.
7. The different phases of this model are :

**a. Feasibility study :**

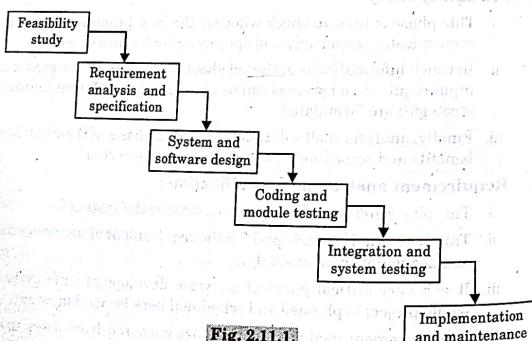
- i. This phase is used to check whether the new proposed system is economically, technically and operationally feasible or not.
- ii. In which information is gathered about what output to be produce, input required and process can be used and then different solution strategies are formulated.
- iii. Finally, analysis of all solutions done on the basis of their cost and benefits and accordingly the best solution is selected.

**b. Requirement analysis and specification :**

- i. This phase give specification about what is the system for.
- ii. This phase analyze and specifies the requirement of user/customer and document them properly.
- iii. It is a very critical phase of software development life cycle as whole project is planned and scheduled here for development.
- iv. In requirement analysis, the data are gathered from users using different methods such as interviews, questionnaires, on site observation and through written document of the organization.

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- v. And, then it is to be assured that the requirements are understood properly and no inconsistency, incompleteness and ambiguity are left.
- vi. Finally, the requirements are organized systematically in the form of document called software requirement specification (SRS) document.
- c. **System and software designing phase :** In design phase, overall structure or architecture is developed which is transformation of requirement specified in SRS.
- d. **Coding and module testing :**
  - i. In this phase, system design is translated into source code also called program code.
  - ii. Here, programming for different module is done in selected programming language. End product of coding phase is module testing, in which each module is tested individually whether they are working properly or not, this is also called unit testing.
  - iii. The output of this phase is programmed module.
- e. **Integration and system testing :**
  - i. According to plan, individually tested module are integrated to develop the system.
  - ii. Generally, in this integration all the module are not joined together to form the system rather than it is done in various steps and during these steps the partially integrated system is tested and then the next module added to it and again the testing is done.



- iii. This help to find out whether the developed system conforms the requirement or not.

**iv. The output of this phase is testing and integration report.****f. Implementation/Installation and maintenance :**

- i. In this phase, system is installed at the user end and it is checked. If there is any up gradation required in hardware or software element at user end that is made available.
- ii. Training is given to user staff for using the system.
- iii. Once the software is properly installed there is need of maintaining the software.
- iv. This ensures that software is working properly at user site.
- v. The maintenance requires much more efforts than software development.

**Advantages of waterfall model :**

1. Easy to understand.
2. Each stage has well defined input and output.
3. Helps in project planning.
4. It provides a template into which models for analysis, design, code, test and support can be placed.
5. It provides structure to a technically weak or inexperienced staff.

**Disadvantages of waterfall model :**

1. Iteration not possible as it is one way street.
2. Requirements freezing at starting stage.
3. Sequencing, no stage can start until the previous stage is completed.
4. A rigid model.
5. Difficulty in accommodating changes after project development.
6. Customer gets opportunity very late to review the project so less user involvement during development process.

**Que 2.12. What is prototyping model ? When it is used ?****Answer****Prototype model :**

1. There are certain drawbacks in waterfall model.
2. This model developed to overcome from main two drawbacks of waterfall model.
3. They are :
  - a. Difficult to predict how the new system will be.
  - b. Difficulty in predicting the entire requirements at very beginning of project, because even end user don't know all requirements initially.

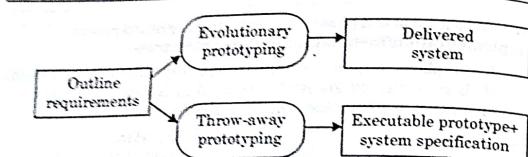
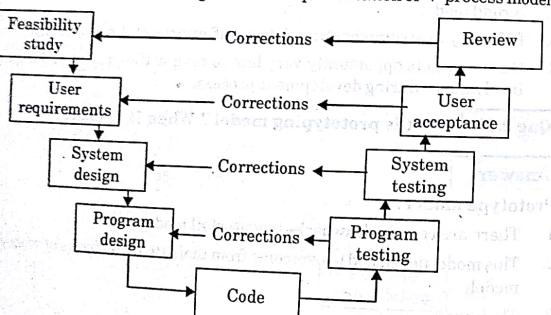


Fig. 2.12.1.

4. In prototype model, firstly a working prototype is developed instead of developing actual software.
5. This is developed according to available requirements which basically have limited functions, low reliability while it passes through all stages of development i.e., design, coding, testing but is done formally.
6. Now, this model is used by developer and given to user for review which helps the user to better understand his need and requirement and then feedback from user is collected and given to developer that helps to remove uncertainties in the requirements of the software.
7. Prototype modeling is of two types :
  - a. Evolutionary/Exploratory prototyping
  - b. Throw-away prototyping

**Que 2.13. Explain V-process model.****Answer**

1. Figure 2.13.1 shows a diagrammatic representation of V-process model.



2. This is an elaboration of the waterfall model and stresses the necessity for validation activities that match the activities that create the products of the project.

Fig. 2.13.1.

3. The V-process model can be seen as expanding the activity testing in the waterfall model.
4. Each step has a matching validation process which on finding the defects causes a loop back to the corresponding development stage and a reworking of the following steps.
5. Ideally, this feedback should only occur where a discrepancy has been found between what was specified by a particular activity and what was actually implemented in the next lower activity on the descent of the V loop.
6. For example, the system designer might have written that a calculation be carried out in a certain way.
7. A second developer building code to meet this design might have misunderstood what was required.
8. At system testing stage, the original designer would be responsible for checking that the software is doing what was specified and this would discover the coder's misreading of that document.

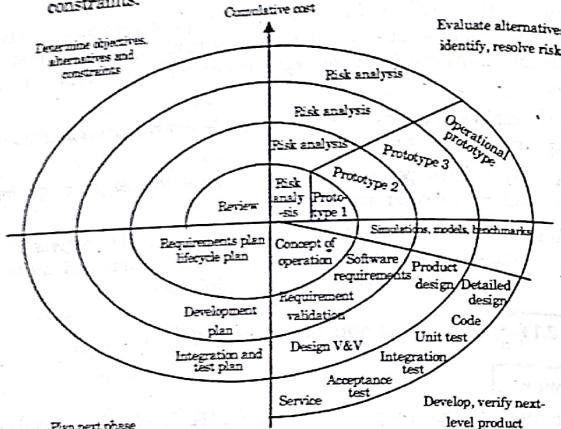
**Que 2.14. Write short note on spiral model.****Answer**

1. In 1987, Boehm proposed a model for the development of software known as Boehm spiral life cycle model.
2. According to name, the activities of this model are organized like a spiral that has many circles whose number depends on software requirement.
3. The radial dimension of this model, the cumulative cost for accomplishing different stages (phases) and angular dimension show the progress in completing each cycle of the spiral.
4. The main objective of this model is to minimize the risk through the use of prototype. This model is mainly used for large projects.
5. The spiral model can said to be made up of waterfall model in which each stage is preceded by risk analysis.
6. Its main feature is risk avoidance rather than documentation or coding.
7. This model is more flexible than any other model as number of phases through which the product will be developed is not fixed, it depends on software requirement.
8. The two basic step of this model are :
  - a. Identify the sub-problem which is having highest risk.
  - b. Find solution for that particular problem (risk).
9. Generally, there are four spirals in Boehm spiral life cycle model.
10. The inner (first) spiral is concept development cycle, the second spiral indicates new product development cycle; the third spiral represents product enhancement cycle and fourth spiral is known as product maintenance cycle.

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11. Each phase of this model is split into four quadrant (sections) having specific functions:

- a. In the first quadrant, we do identification of objectives; find out different alternative for achieving the objective and present constraints.

**Fig. 2.14.1.**

- b. In the second quadrant, we evaluate these alternatives on the basis of objective and constraints. The main focus in this step is given on evolution of alternative on the basis of risk as risk causes the chances of unmet objectives.
- c. In the third quadrant, project development and validation is carry out.
- d. In the fourth quadrant, the project is reviewed and decision is made up whether to continue with a further loop of spiral or not. If it is decided to continue, the project plan is drawn up for the next phase of project.

**Que 2.15.** Discuss incremental life cycle model in brief.**Answer**

1. The incremental life cycle model is similar to the waterfall in many respects, but it differs in that it produces some tangible results to the customer sooner.
2. The initial processes of system requirements and feasibility, software requirements and general design are done in sequence, once for the overall project.
3. A partitioning into increments then occurs, where a number of different development efforts, beginning with detailed design are identified.

4. These increments can be planned as sequential or parallel efforts, depending upon the project characteristics and project constraints.
5. For the same reason as the waterfall model, incremental life cycle model is suitable for large projects with requirements that are known, stable and understood.
6. Due to above characteristics, incremental life cycle model is the best choice when early release of some parts of the software is beneficial or when earlier release of the entire system can be accomplished through multiple teams working in parallel on different increments.
7. When requirements are known and understood but may not be stable, the incremental model is a logical choice because later releases can incorporate changes in that surface during the earlier development efforts.
8. Use of this model requires careful partitioning of the system/product and well defined interfaces between the increments, especially if they will be developed in parallel.
9. Project managers using the incremental model must be aware of the need for additional attention to the coordination of multiple efforts.
10. This includes additional effort that will likely be needed in the test process, where integration is addressed.

**Que 2.16.** Discuss evolutionary life cycle model in brief.**Answer**

1. The evolutionary life cycle model applies in sequential aspects of the waterfall model, and partitioning of the project borrowed from the incremental model, but adds the evolution or the discovery of requirements.
2. Even though incremental development is planned when using the evolutionary model, the increments are not likely to be developed in parallel.
3. This is because the purpose of each increment is to deliver a portion of the system with known requirements for subsequent increments.
4. Unlike the waterfall and incremental models, the system requirements and feasibility and software requirements processes are not done once for the entire project, but these are revised at the start of each evolutionary development cycle to incorporate the latest requirements.
5. Evolutionary life cycle model is preferable life cycle model when requirements are not fully known, but a subset of the requirements is known, stable and understood.
6. Benefits include the early delivery of some functions and the early testing of some assumptions before the entire system is built around them.

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7. The major weakness of this model is related to the inability to plan in detail at the outset of the project.
8. Because the requirements are not fully known, problems with the scope creep, inaccurate estimating and less than optimal architecture are possible.
9. The predominantly sequential nature of this life cycle makes it not particularly rapid or cost efficient for complex systems.
10. Project managers using the evolutionary model must plan to revise the overall architecture as the system evolves.
11. Flexibility must also be built-in at the individual software module level.
12. Time that appears to be gained on the front end of a project because of the early release of the first increment may be spent on later increments on modification and integration efforts.

**Que 2.17.** Explain iterative enhancement model in brief.

**Answer**

1. The classical waterfall model work on the concept that once the requirements specified, no further change will require in any phase of life cycle of product.
2. Iterative model is developed to overcome this drawback of waterfall model.
3. It is a combination of benefits of waterfall and prototype model. It is very popular model used by industries.
4. In this model, software is developed in increments, each increment adds some functional capability to the system until full system is developed.
5. It provide better testing result as testing after each increment is easy as compare to entire model testing of waterfall model.
6. Prototyping used in this model help in identifying the system requirements.
7. In this model, a partial product is developed on few easily understandable requirements of overall requirements, and then a project control list is developed which contain the entire task which have to be performed in final implementation.
8. This helps in finding out how far the product is from final product.
9. This product is given to the user to work and slowly enhancement is done in this product which increases its functionality. That's why it is called incremental model.
10. The model prioritizes the system requirement and implements them in group.
11. With each step, next task is removed from control list. Designing, coding and implementation of selected task is done and analysis of partial

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- product is done for checking the performance after this increment and the list is updated.
12. The process is iterated until the control list is empty and final implementation of system is done.
  13. In this model, developer themselves provide specification, so they have good control over system development.

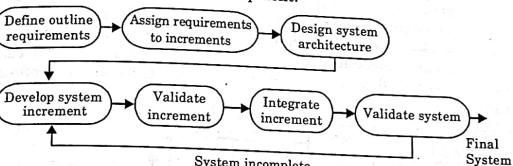


Fig. 2.17.1. Iterative enhancement model.

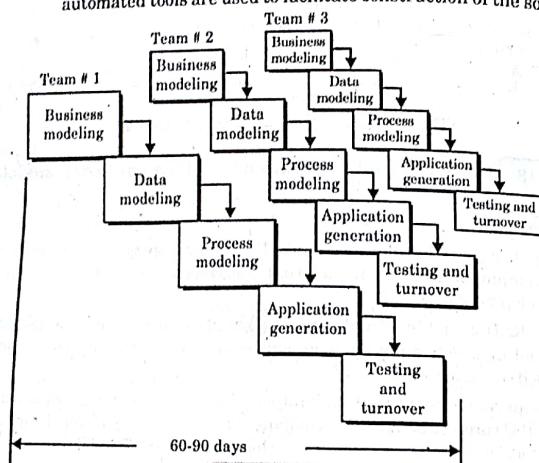
**Que 2.18.** Discuss Rapid Application Development (RAD) model.

**Answer**

1. Rapid application development (RAD) is an incremental software development process model that emphasizes an extremely short development cycle.
2. The RAD model is a "high-speed" adaptation of the linear sequential model in which rapid development is achieved by using component-based construction.
3. If requirements are well understood and project scope is constrained, the RAD process enables a development team to create a "fully functional system" within very short time periods (example, 60 to 90 days).
4. Used primarily for information systems applications, the RAD approach encompasses the following phases :
  - a. **Business modeling :** The information flow among business functions is modeled in a way that answers the following questions :
    - i. What information drives the business process ?
    - ii. What information is generated ?
    - iii. Who generates it ?
    - iv. Where does the information go ?
    - v. Who processes it ?
  - b. **Data modeling :** The information flow defined as part of the business modeling phase is refined into a set of data objects that are needed to support the business. The characteristics (called attributes) of each object identified and the relationships between these objects are defined.

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- c. **Process modeling :** The data objects defined in the data modeling phase are transformed to achieve the information flow necessary to implement a business function. Processing descriptions are created for adding, modifying, deleting, or retrieving a data object.
- d. **Application generation :** RAD assumes the use of fourth generation techniques rather than creating software using conventional third generation programming languages. The RAD works to reuse existing program components (when possible) or create reusable components (when necessary). In all cases, automated tools are used to facilitate construction of the software.

**Fig. 2.18.1.**

- e. **Testing and turnover :** Since the RAD process emphasizes reuse, many of the program components have already been tested. This reduces overall testing time. However, new components must be tested and all interfaces must be fully exercised.

**Que 2.19.** What do you mean by project feasibility ? Discuss the project feasibility report and its format.

**Answer:**

**Project feasibility :**

- When we are developing a system (software), we must know whether proposed system will be feasible or not i.e., practically implemented or not ?
- It may be possible that the proposed (candidate) system may not be implemented due to many reasons like, it may take long time in

- development than the specified time limit, cost may increase than proposed one etc. Therefore we must analyze feasibility of system.
- Feasibility is the analysis of risks, costs and benefits relating to economics, technology and user operations.
  - The output of feasibility study is a document known as feasibility study report.
  - The report must be answering the following key questions :
    - Will the new system provide a better way to do jobs ?
    - What the proposed system will do ?
    - What will be estimated cost of proposed system ?
    - What will be benefits from proposed system ?
  - There are several types of feasibility depending on the aspect they covers. All the feasibilities are equally important. These are described below :
    - Technical feasibility :** The technical feasibility study basically centers on alternatives for hardware, software and design approach to determine the functional aspect of system. The technical issues raised during the feasibility study are :
      - Does the necessary technology exists (can it be acquired) to do suggested ?
      - Does the proposed equipment have technical capacity to hold the data required to use the new system ?
      - Will the proposed system and components provide adequate response to enquiries regardless of number or location of users ?
      - Can the system be expanded, if developed ?
      - Are there technical guarantee of accuracy, reliability and security of data ?
    - Operational feasibility :** Operational feasibility is a measure of how people are able to work with system. This type of feasibility demands if the system will work when developed and installed. The following question may help to test the operational feasibility of a project :
      - Is there a sufficient support for the project from management and user ?
      - Have the users been involved in the planning and development of project.
      - Are current business methods acceptable to user ?
    - Economical feasibility :**
      - Economic analysis is most frequently used for evaluating the effectiveness of proposed (candidate) system, more commonly known as cost benefit analysis.

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- ii. The cost benefit analysis is used to determine benefits and savings that are expected from candidate system and compare them with cost.
- iii. If the benefits are more than the cost then decision is made to design and implement the system.
- iv. The cost and benefits may be direct or indirect and tangible or intangible.

### Project feasibility report and its format :

1. The report is a formal document for management use, brief enough and sufficiently non-technical to be understandable, yet detailed enough to provide basis for system design.
2. There is no standard format for preparing feasibility reports. Analysts usually decide on format that suits the particular user and system. Generally a feasibility report contains following sections :
  - a. The cover letter, which represent report formally and brief introduction to management nature, general finding and recommendation.
  - b. Table of contents specifies the location of various parts of the reports. Management can quickly refer to the section that concerns them.
  - c. Explanation of purpose and scope of project, reason for doing feasibility study, and name of departments involved in feasibility study.
  - d. Methods used for detail finding of present system, checking of system efficiency and effectiveness of system, description of objectives of the system. A discussion of output, reports, costs, and benefits gives management a feel for the pros and cons for the candidate system.
  - e. Economic justification details point-by-point cost comparison and preliminary cost estimated for the development and the operation of the candidate system. A return on investment analysis of the project is also included.
  - f. Recommendation and suggestion suggest to management the most beneficial and cost effective system.
  - g. Appendixes document all memos and data compiled during the investigation. They are presented at the end of the report for the reference.

**Que 2.20.** Discuss the economic feasibility on the basis of direct cost, indirect cost, tangible cost, and intangible cost.

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### Answer

1. The cost benefit analysis is necessary to determine the economic feasibility.
2. The basic objective of cost benefit analysis is to find out whether it is economically worthwhile to invest in the project.
3. If the return on the investment is good then the project is considered economically worthwhile.
4. Cost benefits analysis is performed by first listing all costs associated with the project.
- i. **Cost :** The cost consists of direct cost/tangible cost and indirect costs/intangible cost.
  - a. **The direct cost/tangible cost :** The direct cost is directly associated with the project such as cost of buying the equipments (Hardware like printer, computers, disk drive etc., software, salary to staff, cost involved in preparation of physical location such as air conditioner, lights, wiring etc., operating cost such as use of paper, CD's etc.
  - b. **The indirect cost/intangible cost :** The indirect cost is not directly associated with project, it is a result of operations that directly associated with a system (a given system/project). It often referred as over head. Indirect cost involves time spent by user in discussing problems with system analyst, gathering the data about the problems etc.
- ii. **Benefits :** The benefits can also be broadly classified as tangible benefits and intangible benefits.
  - a. **Tangible benefits :** The tangible benefits are directly measurable. They are :
    1. Decreasing salary cost by automating manual procedure.
    2. Preventing costly but frequent errors.
    3. Sending bills early in the month.
    4. Increasing control over inventory level.
    5. Increase in production.
  - b. **Intangible benefits :** Intangible benefits are :
    1. Better service to customer.
    2. Superior quality of product.
    3. Upgrading or creating new customer services.
    4. Developing a new image in market.
    5. Reducing repetitive or monotonous work for employees.

**PART-2**

*Ways to Organize Personnel, Project Schedule, Scheduling Objectives, Building the Project Schedule, Scheduling Terminology and Techniques.*

**CONCEPT OUTLINE : PART-2**

- Project scheduling is an inexact process in that it tries to predict the future.
- Some of the project scheduling are :
  - a. It provides visibility.
  - b. It provides basic structure for reporting information.
  - c. It aids in scheduling risk analysis.
- Some of terminology and techniques are activity, level of effort, project network diagram etc.

**Questions-Answers****Long Answer Type and Medium Answer Type Questions**

**Que 2.21.** Write a short note on software project team organization.

**Answer**

1. Project management is not a one-person operation.
2. It requires a group of individuals dedicated to the achievement of a specific goal.
3. Project management includes :
  - a. A project manager
  - b. An assistant project manager
  - c. A project (home) office
  - d. A project team
4. Generally, project office personnel are assigned full-time to the project and work out of the project office, whereas the project team members work out of the functional units and may spend only a small percentage of their time on the project.
5. Normally, project office personnel report directly to the project manager.

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6. A project office usually is not required on small projects, and sometimes the project can be accomplished by just one person who may fill all of the project office positions.
7. Before the staffing function begins, five basic questions are usually considered :
  - i. What are the requirements for an individual to become a successful project manager?
  - ii. Who should be a member of the project team?
  - iii. Who should be a member of the project office?
  - iv. What problems can occur during recruiting activities?
  - v. What can happen downstream to cause the loss of key team members?

**Que 2.22.** What consistency, respect, inclusion, and honesty are factors that contribute to effective people management? Discuss.

**UPTU 2012-13, Marks 10**

**Answer**

1. The people working in a software organization are its greatest assets.
2. In successful companies and economies, this is achieved when people are respected by organization and are assigned responsibilities that reflect their skills and experience.
3. Team members should pay some attention to consistency, respect, inclusion and honesty.
4. These are the key factors contributed towards effective people management :
  - a. **Consistency :** People in a project team should all be treated in a comparable way. No one expects all rewards to be identical but people should not feel that their contribution to the organization is undervalued.
  - b. **Respect :**
    - i. Respect is right evaluation or showing an appropriate behaviour to the object of respect.
    - ii. It is a feeling of admiration to someone because of their qualities and achievements.
    - iii. It is a key human value which is a genuine expression of regard to a person. It helps to succeed in life.
    - iv. Different people have different skills and managers should respect these differences.

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- v. In some cases, people do not fit into a team and they cannot continue, it is important not to jump to conclusions about this at an early stage in the project.
- c. **Inclusion :** People contribute effectively when they feel that others listen to them and take account of their proposals. It is important to develop a working environment where all views, even though of junior staff, are considered.
- d. **Honesty :**
  - i. A manager should always be honest about what is going well and what is going bad in the team.
  - ii. Also should be honest about level of technical knowledge and willing to refer to staff with more knowledge when necessary.
  - iii. If try to cover up ignorance or problems, we will eventually be found out and will lose the respect of the group.

**Que 2.23.** What do you mean by project schedule? Write down steps in building the project schedule.

OR

Discuss various steps for building a project schedule with an example.

**Answer**
**Project schedule :**

1. Scheduling is an inexact process in that it tries to predict the future.
2. While it is not possible to know with certainty how long a project will take, there are techniques that can increase the likelihood of being close.
3. If we are close in our planning and estimating, we can manage the project to achieve the schedule by accelerating some efforts or modifying approaches to meet required deadlines.
4. Building the project schedule is a complex activity.
5. Basically there are five key processes for developing a project schedule.
6. They are as follows :
  - a. **Define activities :**
    - i. The goal of the activity definition step is to identify all the tasks required to accomplish the product.
    - ii. This frequently results in identifying all the work products and deliverables that comprise the project.
    - iii. These deliverables are found as the components of a Work Breakdown structure (WBS).
    - iv. The project schedule further decomposes these deliverables into the actual activities required to complete the work.

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- b. **Sequence activities :**
  - i. In this step, design the sequence of activities with dependencies required to complete the project.
  - ii. During this step, one will identify any dependencies of related tasks and document them in the project schedule.
  - iii. One will need to analyze each of the tasks to understand which task has a dependency on additional tasks.
  - iv. Dependencies relationships must include finish-to-start and start-to-finish dependencies.
- c. **Estimate activity resources :**
  - i. The next step is to identify the resources and their availability to our project.
  - ii. Remember that not all team members will be 100% available to our project as some team members will be working on multiple projects.
  - iii. In this step, one will also assign resources to each of the tasks.
- d. **Estimate activity durations :**
  - i. With resources assigned, the next step is to estimate each task's duration.
  - ii. The activity's duration is the number of working periods required to complete the task.
  - iii. Selecting the correct duration type impacts the resource availability and the forecasted task end date.
- e. **Develop schedule :**
  - i. The last step is to analyze the project schedule and examine the sequences, durations, resources and inevitable scheduling constraints.
  - ii. The goal of this step is to validate the project schedule which correctly models the planned work.
  - iii. In this step one will not only validate the duration estimates are accurate, but validate the resource allocations are correct.

**Que 2.24.** What are the basic objectives of scheduling?

**Answer**

The basic objectives of scheduling are as follows :

1. It is the basis for all planning and predicting and help management decide how to use its resources to achieve time and cost goals.
2. It provides visibility and enables management to control "one-of-a-kind" programs.
3. It helps management to evaluate alternatives by answering such questions as how time delays will influence project completion, where slack exists between elements, and what elements are crucial to meet the completion date.

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4. It provides a basis for obtaining facts for decision-making.
  5. It utilizes a so-called time network analysis as the basic method to determine manpower, material, and capital requirements, as well as to provide a means for checking progress.
  6. It provides the basic structure for reporting information.
  7. It reveals interdependencies of activities.
  8. It facilitates "what if" exercises.
  9. It identifies the longest path or critical paths.
  10. It aids in scheduling risk analysis.

**Ques 2.25:** Discuss the various terms used in scheduling and techniques.

**Answer**

Terminology used in scheduling and techniques are discussed as follows :

1. **Activity :** An element of work performed during the course of a project. (Normally have duration, cost, and resource requirements).
2. **Baseline :** The original plan plus or minus approved changes.
3. **Arrow Diagram Method (ADM) :**
  - a. A network diagramming technique in which activities are represented by arrows.
  - b. The tail of the arrow represents the start and the head of the arrow represents the end of the activity.
  - c. Activities are connected at points called nodes to illustrate the sequence in which activities are expected to be performed.
  - d. Also called Activity-On-Arrow (AOA).
4. **Backward pass :** The calculation of late finish and start dates for the uncompleted portions of all network activities determined by working backwards through the network logic from the project's end date.
5. **Critical activity :** An activity on a critical path.
6. **Critical path :** The series of activities which determines the earliest completion of the project. The critical path is usually defined as those activities with float less than or equal to a specified value (usually zero).
7. **Critical Path Method (CPM) :** A network analysis technique used to predict project duration by analyzing which path has the least amount of scheduling flexibility. Early dates are calculated using a forward pass; late dates are calculated using a backwards pass.
8. **Dummy activity :**
  - a. An activity of zero duration used to show a logical relationship in the arrow diagramming method.

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- b. Dummy activities are used when logical relationships cannot be completely or correctly described with regular activity arrows.
- c. Dummies are shown graphically as a dashed line headed by an arrow.
9. **Duration (DU) :** The number of work periods (not including holidays and other non-working periods) required to complete an activity or other project element.
10. **Early finish date (EF) :** In the critical path method, the earliest possible date in which the uncompleted portions of an activity or project can complete and can change as the project progresses.
11. **Early start date (ES) :** In the critical path method, the earliest possible date in which the uncompleted portions of an activity or project can start, can change as the project progresses.
12. **Effort :** The number of labour units required to complete an activity or other project element should not be confused with duration.
13. **Event-on-node :** A network diagramming technique in which events are represented by boxes (or nodes) connected by arrows to show the sequence in which the events are to occur.
14. **Float :** The amount of time that an activity may be delayed from its early start without delaying the project finish date. (Also called slack, total float, and path float).
15. **Forward pass :** The calculation of the early start and early finish dates for the uncompleted portions of all network activities.
16. **Free Float (FF) :** The amount of time an activity can be delayed without delaying the early start of any immediately succeeding activities.
17. **Gantt chart :** A graphic display of schedule-related information using bars.
18. **Hammock :** An aggregate or summary activity.
19. **Hanger :** An unintended break in a network path. Hangers are usually caused by missing activities or missing logical relationships.
20. **Lag :** A modification of a logical relationship which directs a delay in the successor task.
21. **Late finish date (LF) :** In the critical path method, the latest possible date that an activity may be completed without delaying a specified milestone (usually the project finish date).
22. **Late start date (SF) :** In the critical path method, the latest possible date that an activity may begin without delaying a specified milestone (usually the project finish date).
23. **Lead :** A modification of a logical relationship which allows an acceleration of the successor task. For example, in a FS relationship with a 10 day lead, the successor can start 10 days prior to the completion of the predecessor.

24. **Level of effort (LOE)**: Support type activity (e.g., vendor or customer liaison) that does not readily lend itself to measurement of discrete accomplishment. Generally characterized by a uniform rate of activity over a specific period of time.
25. **Logical relationship**: A dependency between two project activities or between an activity and a milestone. Four possible types : FS, FF, SS, and SF.
26. **Master schedule** : A summary level schedule which identifies the major activities and milestones.
27. **Milestone** : A significant event in the project, usually completion of a major deliverable.
28. **Milestone schedule** : A summary level schedule which identifies the major milestones.
29. **Path convergence** : In mathematical analysis, the tendency of parallel paths of approximately equal duration to delay the completion of the milestone where they meet.
30. **Precedence Diagram Method (PDM)** : A network diagramming technique in which activities are represented by nodes. Activities are linked by precedence relationships to show the sequence in which the activities are to be performed.
31. **Program Evaluation and Review Technique (PERT)** : An event-oriented network analysis technique used to estimate project duration when there is a high degree of uncertainty with the individual activity duration estimates.
32. **Project network diagram** : Any schematic display of the logical relationships of project activities.
33. **Remaining Duration (RDU)** : The time needed to complete an activity.
34. **Resource leveling** : Any form of network analysis in which start and finish dates are driven by resource management concerns.
35. **Resource-Limited schedule** : It is a project schedule whose start and finish dates reflect expected resource availability. The final project schedule should always be resource limited.
36. **Scheduled Finish date (SF)** : The point in time work was scheduled to finish on an activity. The scheduled finish date is normally within the range of dates delimited by the early finish date and the late finish date.
37. **Scheduled Start date (SS)** : The point in time work was scheduled to start on an activity. The scheduled start date is normally within the range of dates delimited by the early start and late start dates.
38. **Time-Scaled network diagram** : Any project network diagram drawn in such a way that the positioning and length of the activity represents its duration. Essentially, it is a bar chart that includes network logic.

**Que 2.26.]** Describe project schedule with :

- a. **Scheduling objectives**
- b. **Scheduling terminology**

c. **Scheduling techniques**

**UPTU 2013-14, Marks 10**

**Answer**

- a. **Scheduling objectives** : Refer Q. 2.24, Page 75C, Unit-2.
- b. **Scheduling terminology** : Refer Q. 2.25, Page 76C, Unit-2.
- c. **Scheduling techniques** : Refer Q. 2.25, Page 76C, Unit-2.

**PART-3**

**Network Diagrams : PERT, CPM, Bar Charts : Milestone Charts and Gantt Charts,**

**CONCEPT OUTLINE : PART-3**

- PERT chart is a project management tool used to schedule, organize and coordinate tasks within a project.
- CPM is similar to PERT chart and act as both for preparation of schedule and resource planning.
- A milestone chart shows a group of milestones in an organized way.
- Gantt charts are useful for monitoring the progress of a project which is underway.

**Questions-Answers**

**Long Answer Type and Medium Answer Type Questions**

**Que 2.27.]** What do you mean by activity networks ?

**Answer**

1. The foundation of this approach originated from the Special Projects Office of the US Navy in 1958.
2. They developed this technique for evaluating the performance of large development projects.
3. The technique can be broken down into three stages :
  - a. **Planning** : It identifies tasks and estimate duration of times.
  - b. **Scheduling** : Establish time table of start and finish times.
  - c. **Analysis** : Establish the float and evaluate and revise as necessary.
4. The activity network of tasks, needed to complete project, showing the order in which the tasks need to be completed and the dependencies between them.

5. This is represented graphically, which is shown in Fig. 2.27.1.

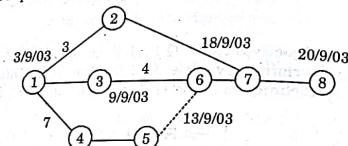


Fig. 2.27.1.

6. The diagram consists of a number of circles, representing events within the development life cycle, such as the start or completion of a task, and lines, which represent the task themselves.
7. Each task is additionally labeled by its time duration.
8. Thus the task between events 4 and 5 is planned to take 3 time units.
9. The primary benefit is the identification of the critical path.
10. In critical path, total time for activities on this path is greater than any other path through the network (delay in any task on the critical path leads to a delay in the project).
11. The degree of difficulty in developing a plan is usually a function of the number of activities or tasks, their sequence, their timing, and the complexity.
12. For small projects, the plan may consist of only a simple flow diagram, bar charts, or computer spreadsheets.
13. For larger projects, there are a number of tools that are used to develop plans.
14. There are two types of activity networks diagram. They are :
  - a. Program Evaluation and Review Techniques (PERT)
  - b. Critical Path Method (CPM)

**Que 2.28.** An activity network for a software project consisting of 8 events, 12 activities, and 1 dummy activity is shown in the Fig. 2.28.1.

UPTU 2012-13, Marks 10

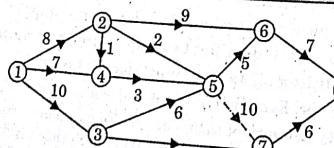


Fig. 2.28.1.

- a. Find the critical path for the above.
- b. Calculate slack for each activity.
- c. Find earliest and latest start time.
- d. Find the earliest and latest finish time.

**Answer****Forward calculations :**

$$\begin{aligned} E_1 &= 0 \\ E_2 &= 8 \\ E_3 &= 10 \\ E_4 &= \max(8+1, 0+7) = 9 \\ E_5 &= \max(8+2, 9+3, 10+6) = 16 \\ E_6 &= \max(16+5, 8+9) = 21 \\ E_7 &= \max(10+16, 10+4) = 26 \\ E_8 &= \max(6+26, 7+21) = 32 \end{aligned}$$

**Backward calculations :**

$$\begin{aligned} L_8 &= 32 \\ L_7 &= 32 - 6 = 26 \\ L_6 &= 32 - 7 = 25 \\ L_5 &= \min(25 - 5, 26 - 10) = 16 \\ L_4 &= 16 - 3 = 13 \\ L_3 &= \min(16 - 6, 26 - 4) = 10 \\ L_2 &= \min(13 - 1, 16 - 2, 25 - 9) = 12 \\ L_1 &= \min(12 - 8, 13 - 7, 10 - 10) = 0 \end{aligned}$$

Task	Normal Time	Earliest Time		Latest Time		Slack
		Start ( $E_i$ )	Finish ( $E_f$ )	Start ( $L_i$ )	Finish ( $L_f$ )	
(1,2)	8	0	8	4	12	4
(1,4)	7	0	7	6	13	6
(1,3)	10	0	10	0	10	0
(2,4)	1	8	9	12	13	4
(2,5)	2	8	10	14	16	6
(2,6)	9	8	17	16	25	8
(3,5)	6	10	16	10	16	0
(3,7)	4	10	14	22	26	12
(4,5)	3	9	12	13	16	4
(5,6)	5	16	21	20	25	4
(5,7)	10	16	26	16	26	0
(6,8)	7	21	28	25	32	4
(7,8)	6	26	32	26	32	0

**Critical Path :**

$$(1,3) \Rightarrow (3,5) \Rightarrow (5,7) \Rightarrow (7,8)$$

**Que 2.29.** Write a short note on PERT.

**Answer**

1. A Project (or program) Evaluation and Review Technique (PERT) chart is a project management tool used to schedule, organize, and coordinate tasks within a project.
2. PERT can be both a cost and a time management systems.
3. PERT is organized by events and activities or tasks.
4. PERT charts depict task, duration, and dependency information.
5. Each chart starts with an initiation node from which the first task, or tasks, originates.
6. If multiple tasks begin at the same time, they are all started from the node or branch, or fork out from the starting point.
7. Each task is represented by a line, which states its name or other identifier, its duration, the number of people assigned to it, and in some cases the initials of the personnel assigned.
8. The other end of the task line is terminated by another node, which identifies the start of another task, or the beginning of any slack time, that is, waiting time between tasks.

**Steps in drawing a PERT chart :**

1. Make a list of the project tasks.
  2. Assign a task identification letter to each task.
  3. Determine the time duration for each task.
  4. Draw the PERT network, number each node, label each task with its task identification letter, connect each node from start to finish, and put each task's duration on the network.
  5. Determine the need for any dummy tasks.
  6. Determine the earliest completion time for each task node.
  7. Determine the latest completion time for each task node and verify the PERT network for correctness.
- The benefits of PERT are as follows :**
1. The PERT network is continuously useful to project managers prior to and during a project.
  2. The PERT network is straightforward in its concept and is supported by software.
  3. The PERT network's graphical representation of the project's tasks help to show the task interrelationships.
  4. The use of the PERT network is applicable in a wide variety of projects.
  5. PERT is a scheduling tool that also shows graphically which tasks must be completed before other tasks begins.

6. By displaying the various task paths, PERT enables the calculation of a critical path.
7. PERT controls time and costs during the project and also facilitates finding the right balance between completing a project on time and completing it within the budget.
8. It exposes all possible parallelism in the activities and thus helps in allocating resources.
9. It allows scheduling and simulation of alternative schedules.

**Limitations of PERT :**

1. In order of the PERT network to be useful, projects tasks have to be clearly defined as well as their relationships to each other.
2. The PERT network does not deal very well with task overlap. PERT assumes the following tasks begin after their preceding tasks end.
3. The PERT network is only as good as the time estimates that entered by the project manager.
4. PERT does not help in deciding which activities are necessary or how long each will take.

**Que 2.30. Write a short note on CPM.****OR****Discuss the concept of PERT / CPM schedule along with example.****UPTU 2014-15, Marks 05****Answer**

**PERT :** Refer Q. 2.29, Page 81C, Unit-2.  
**CPM:**

1. Critical Path Method (CPM) charts are similar to PERT charts and are sometimes known as PERT/CPM. CPM acts as the basis both for preparation of a schedule, and of resource planning.
2. They were developed in the 1950s to control large defense projects, and have been used routinely since then.
3. During management of a project, it allows to monitor the achievements of project goals. It also helps to see where remedial action needs to be taken to get a project back on course.
4. In a CPM chart, the critical path is indicated. Critical path is the path of longest duration as determined on a project network diagram.
5. The critical path determines the total duration of the project. If a task on the critical path is delayed, the final completion of the project will likely to be delayed.
6. The critical path is "critical" because tasks that follow a critical task cannot be started until all of the previous tasks on the critical path are completed.

7. Thus, if a task on the critical path is delayed, all tasks following the delayed critical task will be pushed out in time.
8. The critical tasks will have starting and finishing times, that is, fixed relative to the start of the project.
9. Tasks not on the critical path will usually have some flexibility relative to when they can start and finish.
10. This flexibility is called "float", or sometimes "slack". Float is the difference between the time available for performing a task and time required to complete a task.

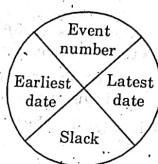


Fig. 2.30.1

11. The most important aspect of it is the ability to identify those activities that can be done at the same time.
12. Critical path analysis is an effective and powerful method of assessing:
  - a. What tasks must be carried out?
  - b. Where parallel activity can be performed?
  - c. The shortest time in which you can complete a project.
  - d. Resources needed to execute a project.
  - e. The sequence of activities, scheduling and timings involved.
  - f. Task priorities.
  - g. The most efficient way of shortening time on urgent projects.

**Benefits of CPM :**

- a. It identifies the task that must be completed on time for the whole project to be completed on time.
- b. It also identifies which tasks can be delayed for a while if resource needs to be reallocated to catch up on missed tasks.
- c. CPM helps to minimize cost.

**Limitations of CPM :**

- a. The relation of tasks to time is not as immediately obvious as with Gantt charts.
- b. These are more difficult to understand.

**Que 2.31.** Write a note on milestone chart.

**Answer**

1. A milestone is used to represent groups of activities or significant events or commitments in the project.
2. A milestone chart shows a group of milestones in an organized way similar to a gantt chart with one milestone per line vertically with a description on the left and the milestone located horizontally along a time scale showing when it occurs.
3. Milestones differ from the bars in a gantt chart in that they show only a single date and are usually depicted as a triangle instead of a bar.
4. Milestones can be shown in various colors depicting the status of the milestone.
5. Milestones can also appear on gantt charts; project management software supports the placement of milestones on gantt charts and other project reports and displays generated by the software.
6. The milestone chart was devised to save space on the project manager supervisor's walls. Each project manager collected related groups of activities in the project and assigned a milestone to each group.
7. A milestone was placed on the project schedule representing the group. Another milestone was placed on the project manager supervisor's milestone chart as well.
8. If there were changes in the schedule that affected the completion date of the milestone, the project manager had to visit the supervisor's office and move the milestone.
9. Milestone schedules can be produced using today's project management software.
10. They are created simply by listing the milestones as activities and giving them duration of zero.
11. Since, they are being created on a gantt chart, the length of the gantt schedule bar for the milestone would have a zero length and could not be seen.
12. A triangle or another symbol is put on the chart instead. The symbol can be coloured to show various statuses and conditions as needed.

**Advantages of milestone chart :**

1. Controlling can be easily done and inter relationships between other similar activities can be easily established.
2. These points are those that can be easily identified over the main bar.
3. Milestones are key events of a main activity represented by a bar.
4. These specific points in time that mark the completion of certain portions of the main activity.

5. If the activity is broken or sub divided into a number of sub-activities, each one of which can be easily recognized during the progress of the project.
6. The beginning and end of these sub-divided activities or tasks are termed as milestones.

#### Disadvantages of milestone chart :

The milestone chart's disadvantages include the following :

1. When used separately from a detailed schedule with activity dependencies, it is difficult to understand how to reach a milestone. This is especially true when the chart includes many milestones.
2. As the number of milestones grows, the chart loses its appeal. By being overcrowded, it may become ineffective in managing the work, thereby defeating its own purpose.
3. Coupling it with a schedule with activity dependencies may be the best option to mitigate risks associated with detailed milestone charts.

#### Que 2.32. Explain Gantt chart.

##### Answer

1. A Gantt chart is a horizontal bar chart developed as a production control tool in 1917 by Henry L. Gantt, an American engineer and social scientist.
2. Frequently used in project management, a Gantt chart provides a graphical.
3. Gantt charts are useful tools for planning and scheduling projects.
4. They allow to assess how long a project should take, determine the resources needed, and lay out the order in which tasks need to be carried out.
5. They are useful in managing the dependencies between tasks.
6. When a project is under way, Gantt charts are useful for monitoring its progress.
7. We can immediately see what should have been achieved at a point in time, and can therefore take remedial action to bring the project back on course.
8. This can be essential for the successful and profitable implementation of the project.
9. To draw up a Gantt chart, it must follow these steps :

**Step 1:** List all activities in the plan. For each task, show the earliest start date, estimated length of time it will take, and whether it is parallel or sequential. If tasks are sequential, show which stages they depend on.

**Step 2:** Head up graph paper with the days or weeks through to task completion.

**Step 3 :** Plot the tasks onto the graph paper. Next draw up a rough draft of the Gantt chart. Plot each task on the graph paper, showing it starting on the earliest possible date. Draw it as a bar, with the length of the bar being the length of the task. Above the task bars, mark the time taken to complete them.

**Step 4 :** Schedule activities. Now take the draft Gantt chart, and use it to schedule actions. Schedule them in such a way that sequential actions are carried out in the required sequence. Ensure that dependent activities do not start until the activities they depend on have been completed. While scheduling, ensure that we make best use of the resources we have available, and do not over-commit resource.

**Step 5 :** Presenting the analysis. The final stage in this process is to prepare a final version of the Gantt chart. This should combine the draft analysis with our scheduling and analysis of resources. This chart will show when we anticipate that jobs should start and finish.

#### Advantages of gantt chart :

1. This is a simple and very inexpensive method and can be developed even by supervisory staff with some amount of training.
2. These charts clearly show the decided time and work schedules for every job.
3. Monitoring and control are easier and can be done within a minimum time frame and at the lowest cost.
4. These charts can be changed and updated quickly at a lower cost.
5. There is no need to develop the customized Gantt chart boards as the standard chart boards are available in the market.

#### Disadvantages of gantt chart :

In spite of the above-mentioned advantages, there are certain disadvantages.

1. They do not show job interrelationships and interdependence.
2. Cost implications cannot be shown.
3. With these charts, it is not possible to depict other alternatives for project completion.
4. The shape and form of Gantt charts can differ according to the nature of the requirement.

#### Que 2.33. Differentiate between :

a. PERT and CPM

b. Gantt chart and Milestone chart

**UPTU 2013-14, Marks 10**

**Answer****a. PERT and CPM:**

S.No.	PERT	CPM
1.	PERT uses event oriented network.	CPM uses activity oriented network.
2.	Estimate of time for activities is not so accurate and definite.	Durations of activity may be estimated with a fair degree of accuracy.
3.	It is used mostly in research and development projects, particularly projects of non-repetitive nature.	It is used extensively in construction projects.
4.	Probabilistic model concept is used.	Deterministic concept is used.
5.	PERT is basically a tool for planning.	CPM can control both time and cost when planning.
6.	In PERT, it is assumed that cost varies directly with time. Attention is therefore given to minimize the time so that minimum cost results. Thus in PERT, time is the controlling factor.	In CPM, cost optimization is given prime importance. The time for the completion of the project depends upon cost optimization. The cost is not directly proportional to time. Thus, cost is the controlling factor.

**b. Gantt chart and milestone chart :**

S.No.	Gantt chart	Milestone
1.	It is used to depict key events along a timescale graphically.	It is used to represent the timing of various tasks that are required to complete a project.
2.	It focuses mainly on the end-dates by which something needs to be complete or by which certain objectives need to be achieved.	It focuses more on the activities to be carried out to complete the project.

**Que 2.34.** Explain various advantages of Milestone charts and Gantt charts.

**UPTU 2014-15, Marks 05**

**Answer**

Advantages of milestone charts : Refer Q. 2.31, Page 85C, Unit-2.  
Advantages of gantt charts : Refer Q. 2.32, Page 86C, Unit-2.

**VERY IMPORTANT QUESTIONS**

*Following questions are very important. These questions may be asked in your SESSIONALS as well as UNIVERSITY EXAMINATION.*

**Q. 1.** What do you mean by work breakdown structure ? Also, discuss its types and features.

**Ans:** Refer Q. 2.2, Q. 2.3, and Q. 2.6.

**Q. 2.** Write short note on :

- i. Project life cycle
- ii. Product life cycle

**Ans:** Refer Q. 2.9.

**Q. 3.** Explain the following terms :

- i. Project schedule
- ii. Scheduling objectives
- iii. Scheduling terminology and techniques.

**Ans:**

- i. Refer Q. 2.23.
- ii. Refer Q. 2.24.
- iii. Refer Q. 2.25.

**Q. 4.** Discuss the activity network, PERT and CPM.

**Ans:** Refer Q. 2.27, Q. 2.29, and Q. 2.30.

**Q. 5.** Write short note on Gantt and Milestone charts.

**Ans:** Refer Q. 2.31 and Q. 2.32.

