



# **COST MANAGEMENT OF ENGINEERING PROJECTS**

**by**

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# Outline

**The concept of strategic cost management, Strategic Cost Analysis .**

**The meaning and different types of project management and project execution.**

**Human Resources and Project contracts, cost behavior and profit planning types and contents, Project execution.**

**profit planning and cost behavior, types of contracts, Project execution.& Innovation.**

# UNIT-I

## INTRODUCTION

# INTRODUCTION



But it is not sufficient to simply reduce cost In the contemporary business environment, cost management has become a critical survival skill for many, costs must be managed strategically .

Many authors stressed organizations, instead that the strategic importance of cost management has drastically increased in the recent years due to intense competition.

According to Cooper and Slag Mulder customers in highly competitive markets expect that each generation of products presents improvements. These improvements may include: improved quality, improved functionality or reduced prices. Any of these improvements alone or any combination of them urge a firm to manage its costs to stay profitable.

# Concept of strategic cost management

- Strategic cost management is understood in different ways in literature. Cooper and Slag Mulder argued that strategic cost management is “the application of cost management techniques so that they simultaneously improve the strategic position of a firm and reduce costs”.
- A hospital redesigns its patient admission procedure so it becomes more efficient and easier for patients. The hospital will become known for its easy admission procedure so more people will come to that hospital if the patient has a choice.

- second example of a cost management. Initiative that will weaken the organization's competitive position is illustrated as follows. A large airline company only has two desks for administering and selling tickets.
- This set-up induces long lines for the airline customer which can ultimately result in high dissatisfaction and a bad reputation for the airline.
- As a general rule, an organization should never undertake any practices that are predicted to weaken the position of the organization.

# Strategic Cost Management

Strategic Cost Management and Control flexibility with any cost reduction efforts contributing to an improved strategic position. A sophisticated understanding of an organization's cost structure can go a long way in the search for Sustainable competitive advantage, this point is emphasized by Shank and Govindarajan who define strategic cost management as “the managerial use of cost information explicitly directed at one or more of the four stages of strategic management

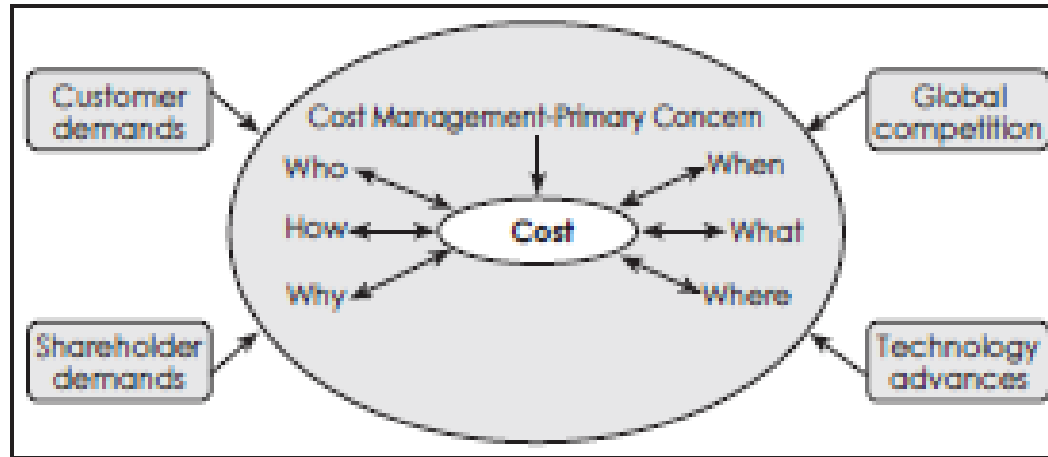
- (1) formulating strategies,
- (2) communicating those strategies throughout the organization,
- (3) developing and carrying out tactics to implement the strategies,
- (4) developing and implementing controls to monitor the success of objectives”.



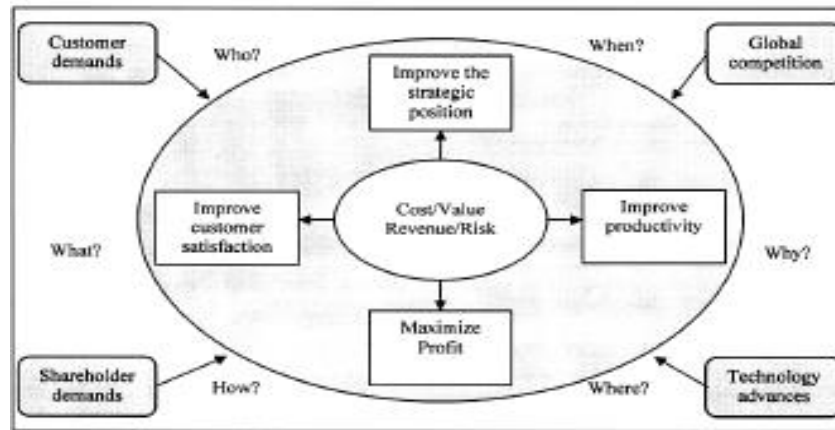
# Objectives of strategic cost management



Change is an imprint of contemporary business environment that cannot be avoided. In the 21st century, strategic cost management is facing just such a challenge. Strategic cost management has both the opportunity and difficult task of defining and shaping its own future as well as the future of companies. Trends and changes in the business environment such as: increase of global competition, increasingly demanding customers and shareholders, and rapid advances in information and manufacturing technology - traditional cost management may be not adaptable to these events.



Cost and revenue management is the present role of strategic cost management in the 21st century, strategic cost management primary concern will not only be cost management but also increase revenues, improve productivity and customer satisfaction, and the same time improve the strategic position of the company.



Strategic Cost Management must bridge the gap between cost and value as well as between the language of the market and the language of the business. Traditional Cost Management during the 20th Century faced many criticism, however, Strategic Cost Management during 21st Century faces a future that will be unique and rewarding compared to its current realities.

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# The difference between traditional cost management : strategic cost management

	Traditional Cost Management	Strategic Cost Management
Focus	Internal	External
Perspective	Value-added	Value chain
Cost analysis-way	In term of: product, customer, and function  With a strongly internal focus Value added is a key concept	In terms of the various stages of the overall value chain of which the firm is a part  With a strongly external focus Value-added is seen as a dangerously narrow concept
Cost analysis-objective	Three objectives will apply, without regard to the strategic context: Score keeping, attention directing, and problem solving.	Although the three objectives are always present, the design of cost management system changes dramatically depending on the basic strategic positioning of the firm: either under a cost leadership strategy, or under a product differentiation strategy.
Cost driver concept	A single fundamental cost driver pervades literature - cost is a function of volume. Applied too often only at the overall firm level.	Multiple cost drivers such as: Structural drivers (e.g. scale, scope, experience, technology, complexity) Executional drivers (e.g. participative management, total quality management) Each value activity has a set of unique cost drivers.

Cost containment philosophy	Cost reduction approached via responsibility centers or product cost issues	Cost containment is a function of the cost driver(s) regulating each value activity.
Primary concern	Cost impact	Cost/Value/Revenue relationship
Key disciplines	Finance/Accounting	Marketing/Economics
Primary role	Scorekeeper	Analyst and consultant
Management responsibility	Follower/reactive Risk-averse	Leader/proactive Comfortable with ambiguity

The emergence of SCM results from a blending of three underlying themes, each taken from the strategic management literature:

1. Value chain analysis
2. Strategic positioning analysis
3. Cost driver analysis

# Value chain analysis

The first theme that underlies the work in strategic cost management concerns the focus of cost management efforts. Stated in question form: How do we organize our thinking about cost management? In the SCM framework, managing costs effectively requires a broad focus, external to the firm. Porter has called this focus the value chain. The value chain for any firm in any business is the linked set of value-creating activities all the way from basic raw material sources for component suppliers through to the ultimate end-use product delivered into the final consumers' hands.

But the value chain concept is fundamentally different from the value-added concept. From a strategic perspective, the value-added concept has two big problems; it starts too late and it stops too soon. Starting cost analysis with purchases misses all the opportunities for exploiting linkages with the firm's suppliers.

This focus is external to the firm, seeing each firm in the context of the overall chain of value-creating activities of which it is only a part, from basic raw material components to end-use consumers. In contrast, management accounting today often adopts a focus that is largely internal to the firm its purchases, its processes, its functions, its products, and its customers. Another way of saying this is that management accounting takes a value-added perspective, starting with payments to suppliers (purchases), and stopping with charges to customers (sales). The key theme is to maximize the difference (the value added) between purchases and sales.



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Starting cost analysis with purchases misses all the opportunities for exploiting linkages with the firm's suppliers. Such opportunities can be dramatically important to a firm.

The second major theme underlying the work in strategic cost management concerns the perceived uses of management accounting information, stated, again, in question form: What role does cost management play in the firm? The theme of SCM can be stated very succinctly. Following Porter's (1980) delineation of basic strategic choices, a business can compete either by having lower costs (cost leadership) or by offering superior products (product differentiation).

That these two approaches demand very different conceptual frameworks has been widely accepted in the strategy literature and, although strategic positioning does not involve simple either/or choices in practice, the implications for strategic management have been frequently amplified.! but the implications of strategic positioning for management accounting are not as well explored.

Since differentiation and cost leadership involve different managerial mindsets, they also involve different cost analysis perspectives. As one example of how strategic positioning can significantly influence the role of cost analysis, consider the decision to invest in more carefully engineered product costs.

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# The strategic positioning concept

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# The Cost Driver concept

In SCM it is acknowledged that cost is caused, or driven, by many factors that are interrelated in complex ways. Understanding means understanding the complex interplay of the set of cost drivers at work in any given situation. At this level of generality, the idea is almost tautological. It is hardly contentious or counterintuitive until one contrasts it with the prevailing theme in traditional management accounting today. In management accounting, cost is a function, primarily, of only one cost driver, output volume.

Cost concepts related to output volume permeate the thinking and the writing about cost: fixed versus variable cost, average cost versus marginal cost, cost-volume-profit analysis, break even analysis, flexible budgets, and contribution margin, to name a few. In SCM, output volume as such is seen to capture very little of the richness of cost behavior.

Reference to the learning curve also appears in much managerial accounting text. However, rather than seeing experience as one of many cost drivers, the accounting literature sees it more narrowly as an explanation of how the relationship between cost and output volume changes over time as cumulative output increases for one particular product of process. That is, even in the learning curve literature in accounting, output volume is still the preeminent cost driver. Experience is seen as a phenomenon that can help explain the changing relationship between output volume and costs over time.



If output volume is a poor way to explain cost behavior, what is a better way? Porter (1985a) presents one attempt to create a comprehensive list of cost drivers, but his attempt is more important than his particular list. In the strategic management literature, better lists exist (Riley, 1987). Following Riley, the following list of cost drivers is broken into two categories. The first category comprises “structural” cost drivers, drawing upon the industrial organization literature (Scherer, 1980). From this perspective there are at least five strategic choices by the firm regarding its underlying economic structure that drive cost position for any given product group:

- (i) Scale: How big an investment to make in manufacturing, in R&D, and in marketing resources.
- (ii) Scope: Degree of vertical integration. Horizontal integration is more related to scale.
- (iii) Experience: How many times in the past the firm has already done what it is doing again.
- (iv) Technology: What process technologies are used at each step of the firm's value chain.
- (v) Complexity: How wide a line or products or services to offer to customers.

Each structural driver involves choices by the firm that drive product cost. Given certain assumptions, the cost calculus of each structural driver can be specified. Of the structural drivers, scale, scope, and experience have received a large amount of attention from economists and strategists over the years.

Of these three, only experience has drawn much interest from management accountants, as noted previously. Complexity, as a structural variable, has received the most attention among accountants recently. Some examples of the potential importance of complexity as a cost determinant are in the work on activity based costing by Kaplan (1987), Cooper (1986), or Shank and Govindarajan (1988d). We consider this work as a useful strategic analysis tool, but not as the primary tool. The second category of cost drivers, executional drivers (Riley, 1987), are those determinants of a firm's cost position that hinge on its ability to execute successfully. Whereas structural cost drivers are not monotonically scaled with performance, executional drivers are. That is for each of the structural drivers, more is not always better. There are diseconomies of scale, or scope, as well as economics.

Technological leadership versus followership is a legitimate choice for most firms. In contrast, for each of the executional drivers, more is always better. The list of basic executional drivers includes at least the following: Work force involvement (participation) - the concept of work force commitment to continual improvement. Total quality management (beliefs and achievement regarding product and process quality). Capacity utilization (given the scale choices on plant construction). Plant layout efficiency. (How efficient, against current norms, is the layout) Product configuration. (Is the design or formulation effective?) Exploiting linkages with suppliers and/or customers, per the firm's value chain. While it may not always be true that a higher level of these executional factors improves cost position, examples of diseconomies are much less frequent.

# Key ideas of cost drivers

Whatever cost drivers are on the list, the key ideas are as follows:

- For strategic analysis, volume is usually not the most useful way to explain cost behavior.
- In a strategic sense, it is more useful to explain cost position in terms of the structural choices and executional skills that shape the firm's competitive position.
- Not all the strategic drivers are equally important all the time, but some (more than one) of them are very probably very important in every case.
- For each cost driver there is a particular cost analysis framework that is critical to understanding the positioning of a firm. Being a well-trained cost analyst requires knowledge of these various frameworks.

# Strategic Cost Analysis – Target Costing, Life Cycle Costing and Kaizen Costing



In every business, the owners and managers need to know what their product or service costs to deliver and what they can sell it for. They want to make strategic decisions that maximize their profits, and they require information to do this. Even not-for-profit businesses have a service or product that they wish to offer but are constrained by the funding they receive from grants, donations and bequests. The simple truth is that you can not decide what to do unless you know the cost. This link between cost information and strategy has always been present, possible in an unsophisticated and informal manner. Increasing competitiveness and the contributions made by academics, consultants, and practicing business people have made that link explicit.

# Business process re-engineering



**Business process re-engineering (BPR)** is a business management strategy, originally pioneered in the early 1990s, focusing on the analysis and design of workflows and processes within an organization. BPR aimed to help organizations fundamentally rethink how they do their work in order to dramatically improve customer service, cut operational costs, and become world-class competitors. In the mid-1990s, as many as 60% of the Fortune 500 companies claimed to either have initiated reengineering efforts, or to have plans to do so. seeks to help companies radically restructure their organizations by focusing on the BPR ground-up design of their business processes. According to Davenport (1990) a business process is a set of logically

Related tasks performed to achieve a defined business outcome. Re-engineering emphasized a holistic focus on business objectives and how processes related to them, encouraging full-scale recreation of processes rather than iterative optimization of sub processes. Business process re-engineering is also known as business process redesign, business transformation, or business process change management.

The globalization of the economy and the liberalization of the trade markets have formulated new conditions in the market place which are characterized by instability and intensive competition in the business environment. Competition is continuously increasing with respect to price, quality and selection, service and promptness of delivery.



The conclusion is that strategic decisions cannot be successfully made unless you understand cost information. Strategic Cost Analysis explains the tools that managers need. It examines the different methods of calculating cost, techniques for controlling and monitoring costs, and ways to integrate cost data and strategy into every aspect of the organization. It helps companies identify, analyze and use strategically important resources for continuing success.

Strategic Cost Analysis (SCA) focuses on an organization's various activities, identifies the reasons for their costs, and financially evaluates strategies for creating a sustainable competitive advantage. The technique provides organizations with the total costs and revenues of strategic decisions.

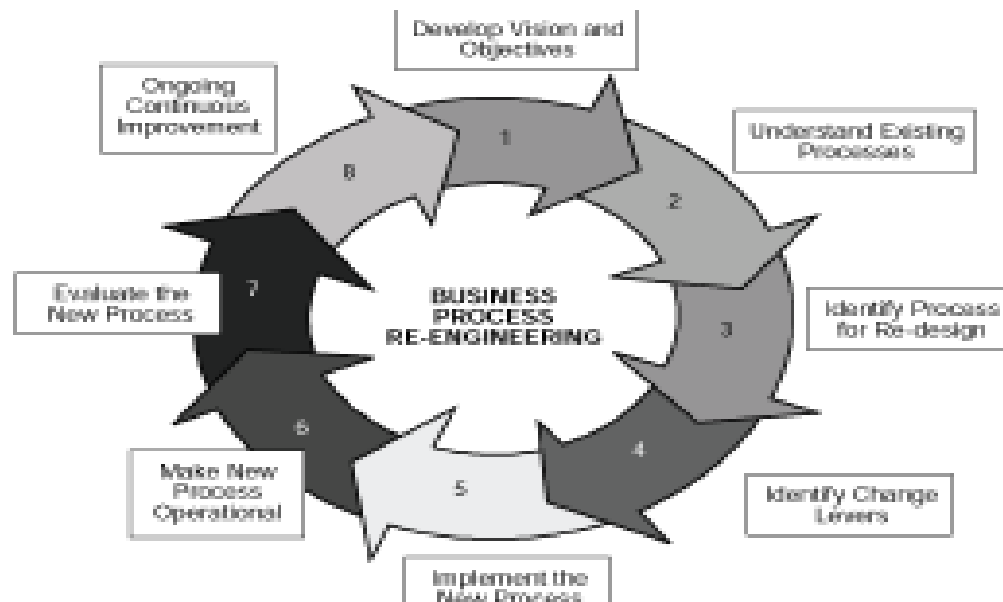
Removal of barriers, international cooperation, technological innovations cause competition to intensify. All these changes impose the need for organizational transformation, where the entire processes, organization climate and organization structure are changed.

Cost concepts in decision-making; relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision Making.

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## UNIT – II

### COST CONCEPTS

# Cost management in project management



Cost management is the process of estimating, allocating , and controlling the costs in a project. It allows a business to predict coming expenses in order to reduce the chances of it going over budget. Projected costs are calculated during the planning phase of a project and must be approved before work begins. As the project plan is executed, expenses are documented and tracked so things stay within the cost management plan. Once the project is completed, predicted costs vs. actual costs are compared, providing benchmarks for future cost management plans and project budgets.

# Cost concepts in decision making , Fixed, variable, and mixed costs



## Cost concepts in decision making

Many business decisions require a firm knowledge of several cost concepts. Different types of costs have differing characteristics. Consequently, when reviewing a business case to determine which path to take, it is useful to understand the following cost concepts:

### ***Fixed, variable, and mixed costs***

A fixed cost, such as rent, does not change in lock step with the level of activity. Conversely, a variable cost, such as direct cost, will change as the level of activity changes. Those few costs that change somewhat with activity are considered mixed cost. It is important to understand the distinction, since a decision to alter an activity may or may not alter costs. For example, shuttering a facility may not terminate the associated building lease payments, which are fixed for the duration of the lease.



## ***By-product costs***

A product may be an incidental by-product of a production process (such as sawdust at a lumber mill). If so, it does not really have any cost, since its cost would have been incurred anyways as a result of the production of the main product. Thus, selling a by-product at any price is profitable; no price is too low.

## ***Allocated costs***

By-product costs are allocated to manufactured goods only because it is required by the accounting standards (for the production of accounting standards). There is no cause-and-effect between the creation of one additional unit of production and the incurrence of additional overhead. Thus, there is no reason to include allocated overhead in the decision to set a price for one additional unit.

## **Discretionary costs**

Only a few costs can actually be dropped without causing any short-term harm to an organization. Examples are employee training and maintenance. Over the long-term, delaying these expenditures will eventually have a negative effect. Thus, managers need to understand the impact of their decisions over a period of time when determining which costs to cut back.

## **Steps costs**

Though some costs are essentially fixed, it may be necessary to make a large investment in them when the activity level increases past a certain point. Adding a production shift is an example of a step cost. Management should understand the activity volumes at which step costs can be incurred, so that it can manage around them - perhaps delaying sales or outsourcing work, rather than incurring step costs.

# Classification

Costs may be classified as **differential cost**, **opportunity cost** and **sunk cost**. This classification is made for decision making purposes. Explanation and examples of differential, opportunity and sunk costs are given below:

## **Differential cost:**

The work of managers includes comparison of costs and revenues of different alternatives. **Differential cost** (also known as **incremental cost**) is the difference in cost of two alternatives. For example, if the cost of alternative A is Rs10,000 per year and the cost of alternative B is Rs8,000 per year. The difference of Rs2,000 would be differential cost. The differential cost can be a fixed cost or variable cost.

Unlike other types of cost, opportunity cost does not require the payment of cash or its equivalent. It is a potential benefit or income that is given up as a result of selecting an alternative over another. For example, You have a job in a company that pays you Rs25,000 per year. For a better future, you want to get a Master's degree but cannot continue your job while studying. If you decide to give up your job and return to school to earn a Master's degree, you would not receive Rs25,000. Your opportunity cost would be Rs25,000.

Almost every alternative has an opportunity cost. It is not entered in the accounting records but must be considered while making decisions

# Opportunity cost



## **Opportunity cost:**

Unlike other types of cost, opportunity cost does not require the payment of cash or its equivalent. It is a potential benefit or income that is given up as a result of selecting an alternative over another. For example, You have a job in a company that pays you Rs.25,000 per year. For a better future, you want to get a Master's degree but cannot continue your job while studying. If you decide to give up your job and return to school to earn a Master's degree, you would not receive Rs.25,000. Your opportunity cost would be Rs.25,000.

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# Sunk cost and costing system

## **Sunk cost:**

The costs that have already been incurred and cannot be changed by any decision are known as **sunk costs**. For example, a company purchased a machine several years ago. Due to change in fashion in several years, the products produced by the machine cannot be sold to customers. Therefore the machine is now useless or obsolete. The price originally paid to purchase the machine cannot be recovered by any action and is therefore a sunk cost. These costs should not be taken into account while making any decision because no action can reverse them.

## **costing system:**

A costing system is designed to monitor the costs incurred by a business. The system is comprised of a set of forms, processes, controls, and reports that are designed to aggregate and report to management about revenues costs, and profitability. The areas reported upon can be any part of a company.

# Objectives of a Costing System

1. To ascertain the cost per unit of the different products manufactured by a business concern;
2. To provide a correct analysis of cost both by process or operations and by different elements of cost;
3. To disclose sources of wastage whether of material, time or expense or in the use of machinery, equipment and tools and to prepare such reports which may be necessary to control such wastage;
4. To provide requisite data and serve as a guide for fixing prices of products manufactured or services rendered;
5. To ascertain the profitability of each of the products and advise management as to how these profits can be maximized.
6. To exercise effective control if stocks of raw materials, work-in-progress, consumable stores and finished goods in order to minimize the capital locked up in these stocks;

7. To reveal sources of economy by installing and implementing a system of cost control for materials, labour and overheads;

8. To advise management on future expansion policies and proposed capital projects;

9. To present and interpret data for management planning, evaluation of performance and control;

10. To help in the preparation of budgets and implementation of budgetary control;

11. To organize an effective information system so that different levels of management may get the required information at the right time in right form for carrying out their individual responsibilities in an efficient manner;

12. To guide management in the formulation and implementation of incentive bonus plans based on productivity and cost savings;

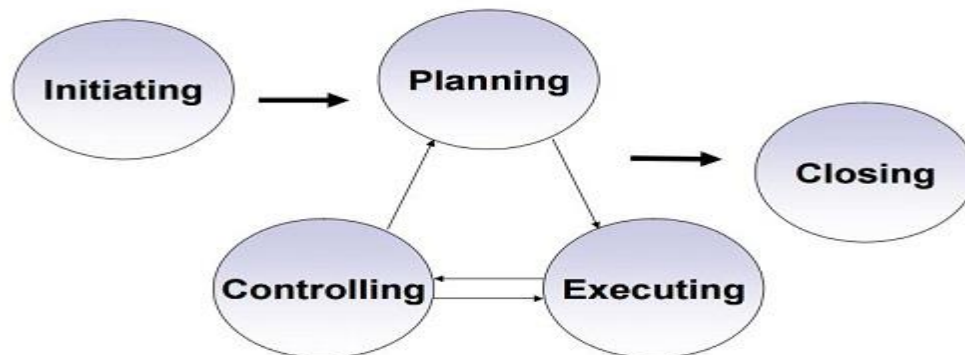


# Phases of Project Management

Project management is using specific knowledge, skills, tools and techniques to ensure project activities meet the project goals. Deciding you need to understand more about project management before this contract gets off the ground, you decide to do a little research on basic project management concepts, including the skills a project manager should have

## Five Phases of Project Management

You find that project management is broken into 5 basic phases.



# Definition and Planning

The concept and initiation phase is very broad, leaving many details unplanned. To further define it, the definition and planning phase digs into project specifics. A project team defines the tasks, calculates a budget and schedule, determines what resources are necessary, and defines acceptance and testing criteria. All of this information is put into a project plan, which is reviewed and approved by the customer. The definition and planning stage ensures everybody has the same expectations, preventing unexpected and often costly mistakes.

For your software project, you realize that the definition and planning phase is where project management will add true value to the success of the contract because the overall concept in the contract is refined into a working plan that lays out, in detail, project expectations. Any concerns can be worked through at this stage before any tasks have been started.

# Basic Principle of Inventory Valuation



One basic principle for inventory valuation. Generally, the inventory of a firm should be valued at the lower of cost or net realizable value. This principle comes from the conservative system of accounting.

So the principle basically states that we must value the inventory either at the cost of the inventory or at its net realizable value. We will record it at the lower amount amongst the two in accordance with the conservative cost approach. Now let us understand the terms cost and net realizable value.

# Provision of data for Decision Making



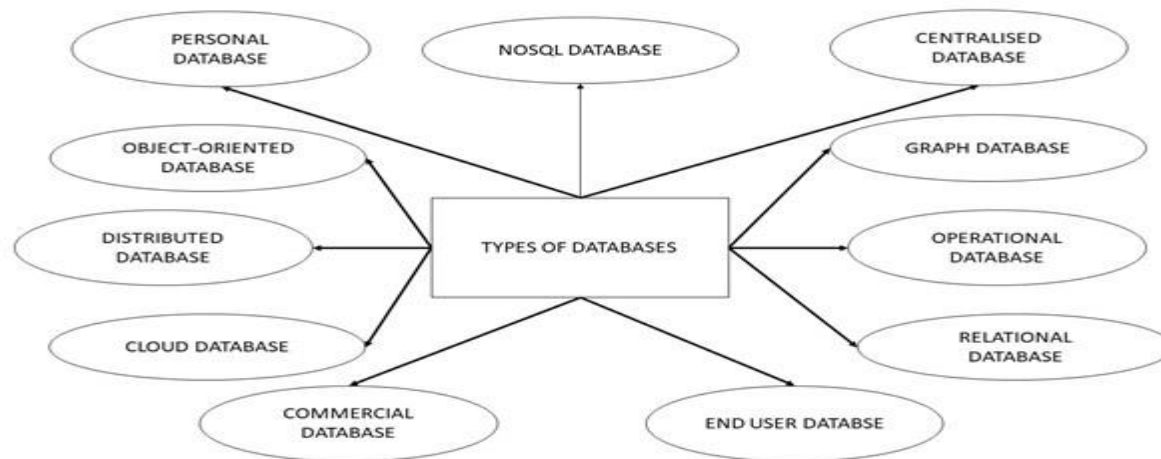
Provision of data for Decision Making Project: meaning, Different types, why to manage, cost overruns centers, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities. Detailed Engineering activities. Pre project execution main clearances and documents. Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process.

Data is increasingly under the spotlight as regulators and clients demand more from financial institutions. In order to address this issue, this paper puts forward a framework for improving the accuracy and overall quality of data that is used to inform decision-making. Drivers for adopting a more systematic approach to improving data quality are explained in terms of the current regulatory and business context.

# Types of Databases

Depending upon the usage requirements, there are following types of databases available in the market:

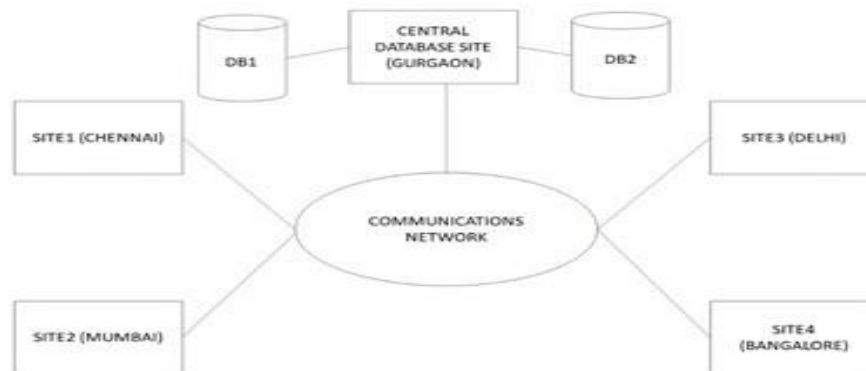
1. Centralized database.
2. Distributed database.
3. Personal database.
4. End-user database.
5. Commercial database.
6. NoSQL database.
7. Operational database.
8. Relational database.
9. Cloud database.
10. Object-oriented database.
11. Graph database.



# Centralized Database

The information(data) is stored at a centralized location and the users from different locations can access this data. This type of database contains application procedures that help the users to access the data even from a remote location.

Various kinds of authentication procedures are applied for the verification and validation of end users, likewise, a registration number is provided by the application procedures which keeps a track and record of data usage. The local area office handles this thing.



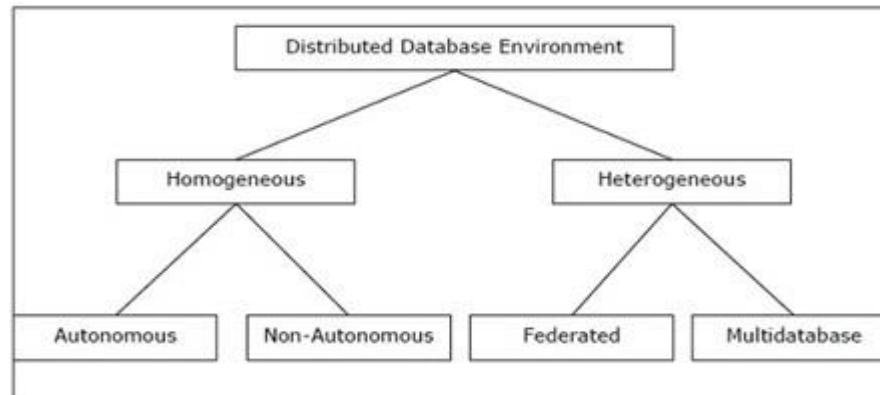
## ***2. Distributed Database***

Just opposite of the centralized database concept, the distributed database has contributions from the common database as well as the information captured by local computers also. The data is not at one place and is distributed at various sites of an organization. These sites are connected to each other with the help of communication links which helps them to access the distributed data easily. You can imagine a distributed database as a one in which various portions of a database are stored in multiple different locations(physical) along with the application procedures which are replicated and distributed among various points in a network.

There are two kinds of distributed database, viz. homogenous and heterogeneous. The databases which have same underlying hardware and run over same operating systems and application procedures are known as homogeneous DDB, for eg.

# Personal Database

All physical locations in a DDB. Whereas, the operating systems, underlying hardware as well as application procedures can be different at various sites of a DDB which is known as heterogeneous DDB.



## ***3. Personal Database***

Data is collected and stored on personal computers which is small and easily manageable. The data is generally used by the same department of an organization and is accessed by a small group of people.



## **4.End User Database**

The end user is usually not concerned about the transaction or operations done at various levels and is only aware of the product which may be a software or an application. Therefore, this is a shared database which is specifically designed for the end user, just like different levels' managers. Summary of whole information is collected in this database.

## **5.Commercial Database**

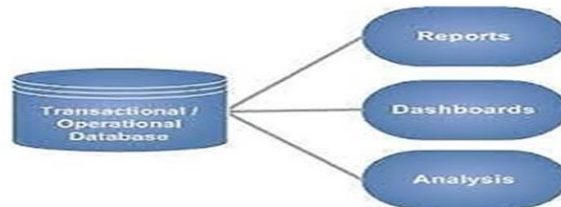
These are the paid versions of the huge databases designed uniquely for the users who want to access the information for help. These databases are subject specific, and one cannot afford to maintain such a huge information. Access to such databases is provided through commercial links.

## 6.NoSQL Database, Operational Database

These are used for large sets of distributed data. There are some big data performance issues which are effectively handled by relational databases, such kind of issues are easily managed by NoSQL databases. There are very efficient in analyzing large size unstructured data that may be stored at multiple virtual servers of the cloud.

## 7.Operational Database

Information related to operations of an enterprise is stored inside this database. Functional lines like marketing, employee relations, customer service etc. require such kind of databases.



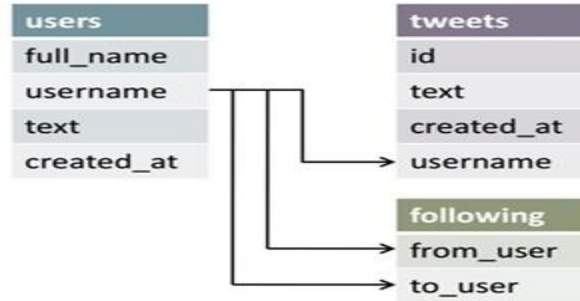
# Relational Databases

## 8.Relational Databases

These databases are categorized by a set of tables where data gets fit into a pre-defined category. The table consists of rows and columns where the column has an entry for data for a specific category and rows contains instance for that data defined according to the category. The Structured Query Language (SQL) is the standard user and application program interface for a relational database.

There are various simple operations that can be applied over the table which makes these databases easier to extend, join two databases with a common relation and modify all existing applications.

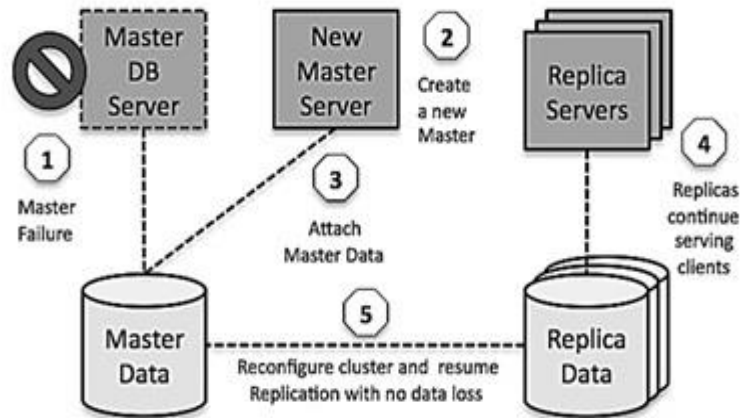
# Cloud Databases



## 9.Cloud Databases

Now a day, data has been specifically getting stored over clouds also known as a virtual environment, either in a hybrid cloud, public or private cloud. A cloud database is a database that has been optimized or built for such a virtualized environment. There are various benefits of a cloud database, some of which are the ability to pay for storage capacity and bandwidth on a per-user basis, and they provide scalability on demand, along with high availability.

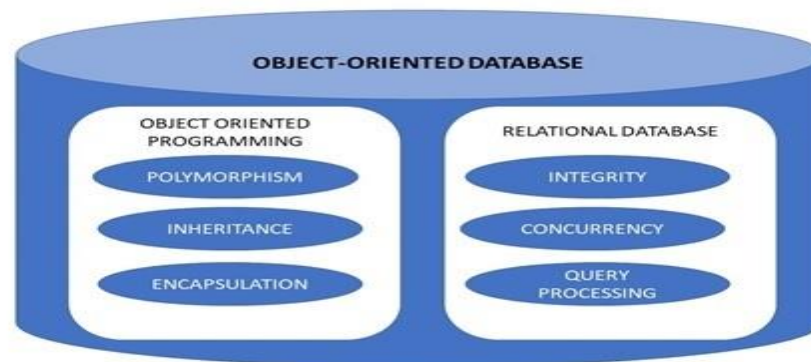
A cloud database also gives enterprises the opportunity to support business applications in a software-as-a-service deployment.



## 10. Object-Oriented Databases

An object-oriented database is a collection of object-oriented programming and relational database. There are various items which are created using object-oriented programming languages like C++, Java which can be stored in relational databases, but object-oriented databases are well-suited for those items.

An object-oriented database is organized around objects rather than actions, and data rather than logic. For example, a multimedia record in a relational database can be a definable data object

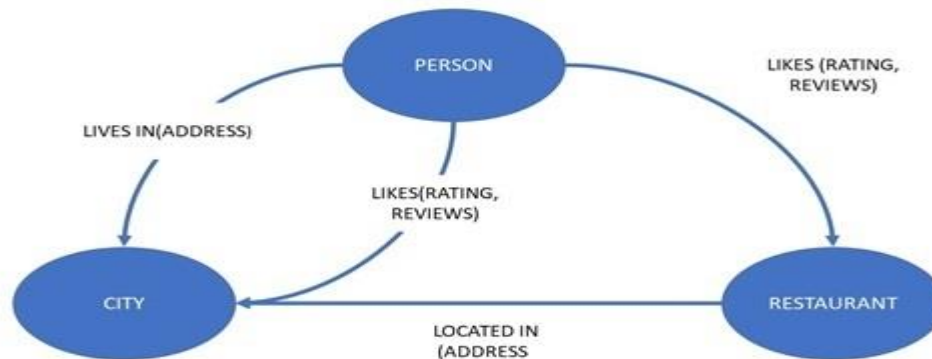


# Graph Databases

## 11. Graph Databases

The graph is a collection of nodes and edges where each node is used to represent an entity and each edge describes the relationship between entities. A graph-oriented database, or graph database, is a type of NoSQL database that uses graph theory to store, map and query relationships.

Graph databases are basically used for analyzing interconnections. For example, companies might use a graph database to mine data about customers from social media.



The object of project management is to produce a complete project which complies with the client's objectives. In many cases the object of project management is also to shape or reform the client's brief in order to feasibly be able to address the client's objectives. Once the client's objectives are clearly established they should influence all decisions made by other people involved in the project – for example project managers, designers, contractors and sub-contractors. Ill-defined or too tightly prescribed project management objectives are detrimental to decision making.



A project is a temporary endeavor designed to produce a unique product, service or result with a defined beginning and end (usually time-constrained, and often constrained by funding or staffing) undertaken to meet unique goals and objectives, typically to bring about beneficial change or added value.<sup>[3][4]</sup> The temporary nature of projects stands in contrast with business as usual (or operations),<sup>[5]</sup> which are repetitive, permanent, or semi-permanent functional activities to produce products or services. In practice, the management of such distinct production approaches requires the development of distinct technical skills and management strategies

A project is **temporary** in that it has a defined beginning and end in time, and therefore defined scope and resources.

# Critical chain project management



Critical chain project management (CCPM) is an application of the [theory of constraints](#) (TOC) to planning and managing projects, and is designed to deal with the uncertainties inherent in managing projects, while taking into consideration limited availability of [resources](#) (physical, human skills, as well as management & support capacity) needed to execute projects.

The goal is to increase the flow of projects in an organization ([throughput](#)). Applying the first three of the [five focusing steps](#) of TOC, the system constraint for all projects, as well as the resources, are identified. To exploit the constraint, tasks on the critical chain are given priority over all other activities. Finally, projects are planned and managed to ensure that the resources are ready when the critical chain tasks must start, subordinating all other resources to the critical chain.

3)Time

4)Cost

5)Quality

6)Procurement

7)Human resources

8)Communications

9)Risk management

10)Stakeholder management

All management is concerned with these, of course. But project management brings a unique focus shaped by the goals, resources and schedule of each project. The value of that focus is proved by the rapid, worldwide growth of project management:

- [as a recognized and strategic organizational competence](#)
- [as a subject for training and education](#)
- [as a career path](#)

# Lean project management

Lean project management uses the principles from [lean manufacturing](#) to focus on delivering value with less waste and reduced time

## Phased approach

The phased (or staged) approach breaks down and manages the work through a series of distinct steps to be completed, and is often referred to as "traditional"<sup>[28]</sup> or "[waterfall](#)". Although it can vary, it typically consists of five process areas, four phases plus control:



You will continue in this manner moving along each path filling in LF and LS for activities that don't have it already filled in.

## Manage Your Schedule with the Critical Path Method

The *Critical Path Method* is an important tool for managing your project's schedule. As you can see, it's not very difficult to determine its key elements. However, once your project has more than a few activities, [critical path scheduling](#) can become tedious.

Luckily, today's project management software provides this information for you. So take a few minutes and learn how to access this information from your software and you'll soon be on top of your schedule and performing *critical path analysis* like a seasoned pro.

# Process-based management Project production management



**Process-based management:** The incorporation of process-based management has been driven by the use of maturity models such as the [OPM3](#) and the [CMMI](#) (capability maturity model integration; see [this example](#) of a predecessor) and [ISO/IEC 15504](#) (SPICE – software process improvement and capability estimation). Unlike SEI's CMM, the OPM3 maturity model describes how to make project management processes capable of performing successfully, consistently, and predictably in order to enact the strategies of an organization.

**Project production management:** Project production management is the application of operations management to the delivery of capital projects. The Project production management framework is based on a project as a production system view, in which a project transforms inputs (raw materials, information, labor, plant & machinery) into outputs (goods and services)

# Major process groups

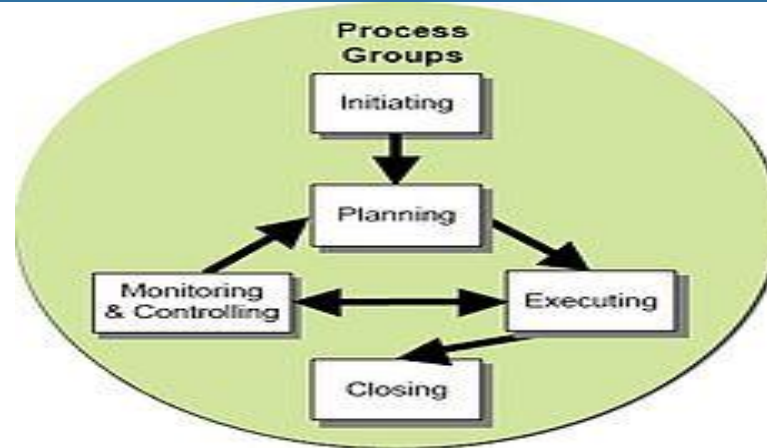
Traditionally (depending on what project management methodology is being used), project management includes a number of elements: four to five project management process groups, and a control system. Regardless of the methodology or terminology used, the same basic project management processes or stages of development will be used.

Major process groups generally include:

- |                               |             |                            |
|-------------------------------|-------------|----------------------------|
| 1) Initiation                 | 2) Planning | 3) Production or execution |
| 4) Monitoring and controlling | 4) Closing  |                            |

In project environments with a significant exploratory element (e.g., [research and development](#)), these stages may be supplemented with decision points (go/no go decisions) at which the project's continuation is debated and decided. An example is the [Phase–gate model](#).

# Initiating process



## Initiating process



The initiating processes determine the nature and scope of the project. If this stage is not performed well, it is unlikely that the project will be successful in meeting the business' needs.



# Initiating process

The key project controls needed here are an understanding of the business environment and making sure that all necessary controls are incorporated into the project. Any deficiencies should be reported and a recommendation should be made to fix them.

The initiating stage should include a plan that encompasses the following areas. These areas can be recorded in a series of documents called Project Initiation documents.

## **Planning**

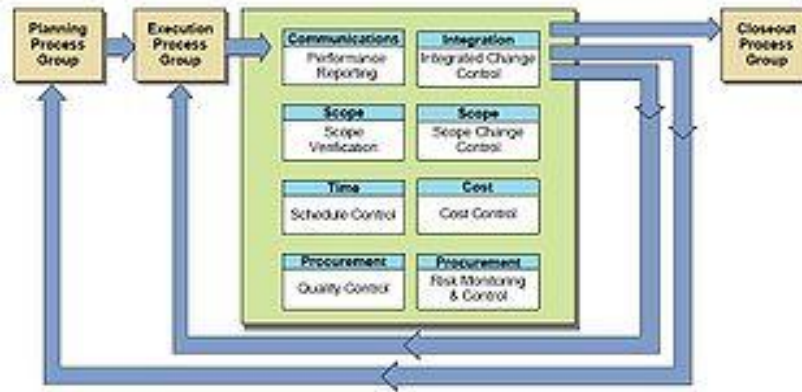
After the initiation stage, the project is planned to an appropriate level of detail (see [example of a flow-chart](#)).<sup>[34]</sup> The main purpose is to plan time, cost and resources adequately to estimate the work needed and to effectively manage risk during project execution. As with the Initiation process group, a failure to adequately plan greatly reduces the project's chances of successfully accomplishing its goals.

# Project Documentation

Documenting everything within a project is key to being successful. In order to maintain budget, scope, effectiveness and pace a project must have physical documents pertaining to each specific task. With correct documentation, it is easy to see whether or not a project's requirement has been met. To go along with that, documentation provides information regarding what has already been completed for that project. Documentation throughout a project provides a paper trail for anyone who needs to go back and reference the work in the past. In most cases, documentation is the most successful way to monitor and control the specific phases of a project. With the correct documentation, a project's success can be tracked and observed as the project goes on. If performed correctly documentation can be the backbone to a project's success.

# Monitoring and controlling

## Monitoring and controlling



### Monitoring and controlling process group processes

Monitoring and controlling consists of those processes performed to observe project execution so that potential problems can be identified in a timely manner and corrective action can be taken, when necessary, to control the execution of the project. The key benefit is that project performance is observed and measured regularly to identify variances from the project management plan.

# Project Complexity

Complexity and its nature plays an important role in the area of project management. Despite having number of debates on this subject matter, studies suggest lack of definition and reasonable understanding of complexity in relation to management of complex projects. As it is considered that project complexity and project performance are closely related, it is important to define and measure complexity of the project for project management to be effective.

By applying the discovery in measuring work complexity described in Requisite Organization and Stratified Systems Theory.

# Work breakdown structure

The [work breakdown structure](#) (WBS) is a [tree structure](#) that shows a subdivision of the activities required to achieve an objective – for example a program, project, and contract. The WBS may be hardware-, product-, service-, or [process](#)-oriented (see an example in a [NASA reporting structure \(2001\)](#)).

A WBS can be developed by starting with the end objective and successively subdividing it into manageable components in terms of size, [duration](#), and responsibility (e.g., systems, subsystems, components, tasks, sub-tasks, and work packages), which include all steps necessary to achieve the objective.

The work breakdown structure provides a common framework for the natural development of the overall planning and control of a contract and is the basis for dividing work into definable increments from which the statement of work can be developed and technical, schedule, cost, and labor hour reporting can be established.

# Reasons for project time overruns across project lifecycle

Stages	External issues	Internal issues
Pre-planning	<ul style="list-style-type: none"> <li>• Delay in regulatory approvals</li> <li>• Unavailability/delayed availability of funds</li> <li>• Land/site handover</li> </ul>	<ul style="list-style-type: none"> <li>• Lack of project managers/commercial managers with adequate planning skills</li> <li>• Lack of Liaison Officer /Planning engineer</li> <li>• Lack of cost managers</li> <li>• Lack of safety officers/ environmental practitioners</li> </ul>
Planning and design	<ul style="list-style-type: none"> <li>• Lack of strong policies</li> <li>• Ineffective procurement planning</li> <li>• Design/scope change</li> <li>• Delay in regulatory approvals</li> <li>• Delay in decision making</li> </ul>	<ul style="list-style-type: none"> <li>• Lack Of planning engineer/commercial managers</li> <li>• Lack of liaison officer or planning engineer</li> <li>• Lack of .&amp;P engineers</li> </ul>
Execution and monitoring	<ul style="list-style-type: none"> <li>• Weak/ineffective project planning &amp; monitoring</li> <li>• Contractual disputes</li> <li>• Unavailability/delayed availability of funds</li> <li>• Lack of strong R&amp;R policies</li> <li>• Delay land/site handover</li> </ul>	<ul style="list-style-type: none"> <li>• Lack of project managers/site managers/planning engineers/quantity supervisors</li> <li>• Lack of awareness modern equipment &amp; technology</li> <li>• Lack of liaison officer and commercial officers</li> </ul>
Closure and handover	<ul style="list-style-type: none"> <li>• Pre-commissioning teething troubles y</li> <li>• Contractual disputes</li> </ul>	<ul style="list-style-type: none"> <li>• Lack of commissioning project and site managers audit and total quality management professionals</li> </ul>

# various stages of project execution



At the start of a project, the amount of planning and work required can seem overwhelming. There may be dozens, or even hundreds of tasks that need to be completed at just the right time and in just the right sequence.

Seasoned project managers know it is often easier to handle the details of a project and take steps in the right order when you break the project down into phases. Dividing your project management efforts into these five phases can help give your efforts structure and simplify them into a series of logical and manageable steps.

# Project Initiation

Initiation is the first phase of the project lifecycle. This is where the project's value and feasibility are measured. Project managers typically use two evaluation tools to decide whether or not to pursue a project:

**Business Case Document** – This document justifies the need for the project, and it includes an estimate of potential financial benefits.

**Feasibility Study** – This is an evaluation of the project's goals, timeline and costs to determine if the project should be executed. It balances the requirements of the project with available resources to see if pursuing the project makes sense.

Teams abandon proposed projects that are labeled unprofitable and/or unfeasible. However, projects that pass these two tests can be assigned to a project team or designated project office.



## 2. Project Planning

Once the project receives the green light, it needs a solid plan to guide the team, as well as keep them on time and on budget. A well-written project plan gives guidance for obtaining resources, acquiring financing and procuring required materials. The project plan gives the team direction for producing quality outputs, handling risk, creating acceptance, communicating benefits to stakeholders and managing suppliers.

## 3. Project Execution

This is the phase that is most commonly associated with project management. Execution is all about building deliverables that satisfy the customer. Team leaders make this happen by allocating resources and keeping team members focused on their assigned task. Execution relies heavily on the planning phase. The work and efforts of the team during the execution phase are derived from the project plan.

#### **4. Project Monitoring and Control**

Monitoring and control are sometimes combined with execution because they often occur at the same time. As teams execute their project plan, they must constantly monitor their own progress. To guarantee delivery of what was promised, teams must monitor tasks to prevent scope creep, calculate key performance indicators and track variations from allotted cost and time.

#### **5. Project Closure**

Teams close a project when they deliver the finished project to the customer, communicating completion to stakeholders and releasing resources to other projects. This vital step in the project lifecycle allows the team to evaluate and document the project and move on the next one, using previous project mistakes and successes to build stronger processes and more successful teams.

# Net Profit Important

How much profit your business generates depends upon the efficiency of its operations. Such levels of profit are determined after considering both long-term and short-term goals of your business. In the short-run, the level of profitability showcases your business' capability to sustain its operations. Whereas, in the long-run, the pattern of profitability helps in taking managerial decisions such as expansion of business.

Apart from this, even the stakeholders of your business analyze profits generated by your business over a period of time. Each stakeholder examines the level of profitability from a different perspective. For an internal stakeholder like the top management, it is important to analyze profits as it helps them to measure the efficiency of the business. Such information helps the financial expert in guiding the management on its operational aspects.

# Net Profit

Net Profit is a measure of profitability of a company usually referred to as ‘the bottom line’ of the [income statement](#). It refers to the profit that remains after deducting expenses from gross profit. These expenses include all operating expenses, non-operating expenses, taxes and preferred stock dividends of a business.

Therefore, net profit is an important component of trading and profit and loss account of a business. The trading account represents the results from the manufacturing activities of a business. That is, the activities that involve manufacturing, purchasing and the ones that help in bringing goods to the point of sale. Thus, purchases is one of the constituents of such activities. The other constituents of the activities directly related to the production are direct expenses.

These expenses include carriage inwards, freight inwards, wages, factory lighting, coal, water and fuel, royalty on production, etc . On the other hand, the profit and loss account represents the Gross Profit on the credit side. Furthermore, the expenses related to normal operations of a business are represented on the debit side. These expenses include operating, non-operating and indirect expenses.

# Accounting ratios and Net Profit Ratio



## Accounting ratios

The **accounting ratios** are an important tool in analyzing the financial statement of a business. The profitable ratio, also known as performance ratios, help in determining the earning capacity of your business. These ratios let you know the efficiency with which the resources of your business are utilized.

The important ratios based on Net Profit are Net Profit Ratio and Net Profit Margin.

## Net Profit Ratio

Net profit ratio is based on all inclusive concept of profit. This ratio showcases relationship between revenue from business operations and net profit after operational as well as non-operational expenses and incomes. The Net Profit ratio is calculated as under:

Net Profit Ratio = Net profit/Revenue from Operations × 100

# Marginal cost

**Marginal cost** is the **cost** of one additional unit of output. The concept is used to determine the optimum production quantity for a company, where it **costs** the least amount to produce additional units. If a company operates within this "sweet spot," it can maximize its profits.

The term **marginal cost** implies the **additional cost involved in producing an extra unit of output**, which can be reckoned by total variable cost assigned to one unit. It can be calculated as:

**Marginal Cost = Direct Material + Direct Labor + Direct Expenses + Variable Overheads**

Characteristics of Marginal Costing



# Margin of Safety

Margin of Safety (MOS) is defined as the excess of actual or projected sales over break-even sales, that can be expressed in monetary terms or units, or as a percentage of total sales.

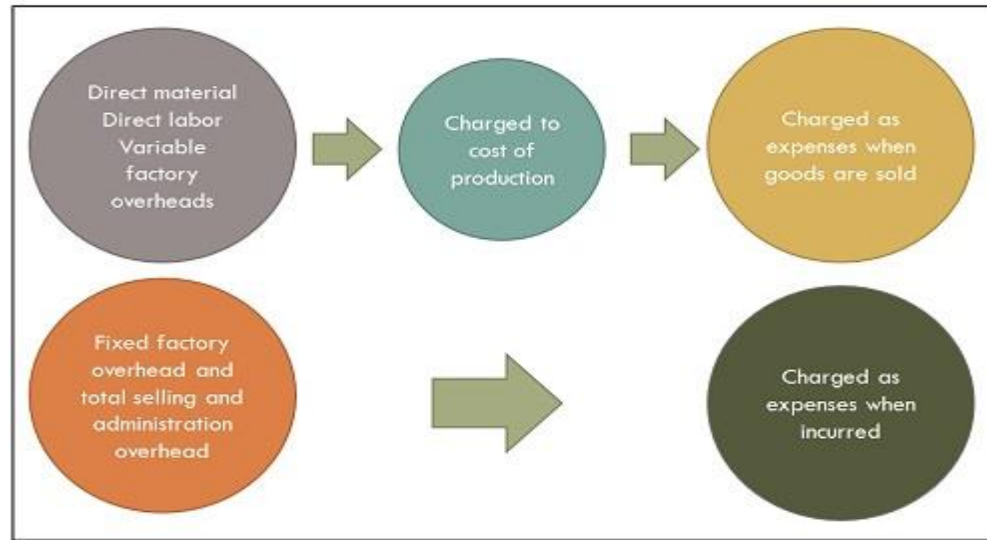
The margin of Safety implies the sales point over and above the break-even point, that results in profit. Break-even point (BEP), is the point wherein total cost and total revenue are at equilibrium and profit is zero. It can be calculated as:

Another way to calculate the margin of safety is to find out the difference between budgeted and break-even sales (in units) and then multiply the result by the contribution per unit. This is because, at BEP, fixed overheads are absorbed and any further contribution, will amount to profit. It can be computed as:

The Margin of Safety is vital to the company, as a reduced activity level, will lead to losses.



# Marginal Costing Approach



The difference between product costs and period costs forms a basis for marginal costing technique, wherein only **variable cost is considered as the product cost while the fixed cost is deemed as a period cost**, which incurs during the period, irrespective of the level of activity.

# Average Cost

The Average Cost is the per unit cost of production obtained by dividing the total cost (TC) by the total output (Q). By per unit cost of production, we mean that all the fixed and variable cost is taken into the consideration for calculating the average cost. Thus, it is also called as Per Unit Total Cost.

Symbolically, the average cost is expressed as:

$$AC = TC/Q$$

Also,

$$AC = \text{Average Variable cost (AVC)} + \text{Average Fixed cost (AFC)}$$

Where,

$$\text{Average variable cost} = \text{Total Variable Cost (TVC)} / \text{Total output (Q)}$$

$$\text{Average fixed cost} = \text{Total Fixed Cost (TFC)} / \text{Total output (Q)}$$

# Opening Stock and Purchases less returns

## Opening Stock

It is the stock of goods or inventory that is in hand at the beginning of the year. Such a stock is carried forward from the previous year and does not change during the accounting period. This item appears on the debit side of the trading account as it forms part of the cost of goods sold during the year.

## Opening Stock and Purchases less returns

Goods bought for reselling after adding value are considered purchases. These appear on the debit side of the trading account of your business. Further, these include both cash and credit purchases. On the other hand, goods returned are the goods that are sent back to the supplier. These goods are deducted from the purchases and appear as net purchases in the trading account.

# Wages and Carriage Inwards/Freight Inwards

## Wages

Wages refer to the earnings of the workers who worked directly on the cost project. It is a remuneration given to the employees engaged in factory for loading, unloading and production of goods. These appear on the debit side of the trading account.

## Carriage Inwards/Freight Inwards

These are the transport expenses incurred while bringing raw materials or goods purchased to the place of business. These expenses are borne with regards to the purchases made during the year. Furthermore, these expenses appear on the debit side of the trading account.

# Packaging Material and Packaging Charges



## **Fuel/Water/Power/Gas**

These expenses are incurred during the manufacturing process and are hence considered direct.

## **Packaging Material and Packaging Charges**

Packaging charges refer to the cost of the packaging material used in the product. It is a direct expense for your business. This expense is considered direct as the containers or any other packaging material used to contain the goods form a part of the goods to be sold. However, the packing material refers to the containers that are used for transporting the goods. It is regarded as an indirect expense. Such an expense is debited to the profit and loss account of your business.

# Indirect Expenses

These are the expenses associated with two or more cost projects jointly. The indirect expenses cannot be traced directly to each of the cost projects. That is, it is not possible to figure out how much of the cost is attributable to a single cost project.

Thus, indirect expenses are the expenses not directly attributable to a particular cost object. These expenses include: Selling and Distribution overheads, Administrative Overheads and other expenses such as finance expenses. And Selling and Distribution Overheads and Distribution Overheads combined together are referred to as Marketing Overheads.

# Distribution Overheads

Distribution Overheads are the costs incurred in handling a product or service from the time it is ready for delivery until it reaches the ultimate consumer. For instance, cost of packing, repacking, labeling, etc. is a part of the distribution cost. Following expenses come under distribution cost:

1. Packing, repacking or labeling.
2. Transportation cost
3. Cost of warehousing

## **Cost of Sales or Cost of Goods Sold**

Cost of goods sold refers to the direct costs incurred to produce goods or render services with the purpose of selling them. These costs include the cost of materials and direct labor costs incurred in producing goods. However, cost of goods sold does not include indirect expenses, like selling and distribution costs. Hence we can say:  $\text{Cost of Goods Sold} = \text{Opening Stock} + \text{Purchases} + \text{Direct Expenses} - \text{Closing Stock}$

# Cost of Sales and Operating Profit

**Cost of Sales or Cost of Goods Sold:** Cost of goods sold refers to the direct costs incurred to produce goods or render services with the purpose of selling them. These costs include the cost of materials and direct labor costs incurred in producing goods. However, cost of goods sold does not include indirect expenses, like selling and distribution costs. Hence we can say:

Cost of Goods Sold = Opening Stock + Purchases + Direct Expenses  
– Closing Stock

**Operating Profit:** Operating Profit refers to the profit earned through the normal operations and activities of your business. It is the excess of operating revenue over operating expenses. Thus, the Operating Income for the year ended March 31, 2018 stood at Rs 84,294 million. This figure is calculated after considering operating expenses and revenues but before accounting financial incomes and expenses.



Hence, we can say that operating profit is profit before interest and tax (EBIT). Similarly, abnormal items such as loss by fire, etc. are also not taken into account while calculating Operating Profit.

Operating Profit of a company is calculated as follows:

Operating profit = Net Profit + Non Operating xpenses –

Non Operating Incomes (Or)

Operating Profit = Gross Profit – Operating Expenses +  
Operating Incomes

Let's try to understand how Net Profit is calculated after having a fair idea about various components of Net Profit, . Generally, the formula for Net Profit stands at:

Net Profit = Gross Profit + Other Incomes – Indirect Expenses

So let's consider the consolidated Income Statement of Wipro Limited as of March 31, 2018 to understand how Net Profit is calculated.

## UNIT – V

# QUANTITATIVE TECHNIQUES

## Quantitative Analysis

Quantitative analysis is the process of collecting and evaluating measurable and verifiable data such as revenues, market share, and wages in order to understand the behavior and performance of a business. In the past, business owners and company directors relied heavily on their experience and instinct when making decisions.

## Critical path

The critical path for any network is the longest path through the entire network. Since all activities must be completed to complete the entire project, the length of the critical path is also the shortest time allowable for completion of the project. Thus if the project is to be completed in that shortest time, all activities on the critical path must be started as soon as possible. A quantitative analyst's main task is to present a given hypothetical situation in terms of numerical values. Quantitative analysis helps in evaluating performance, assessing financial instruments, and making predictions.

# 1. Regression Analysis

## 1. Regression Analysis

Regression analysis is a common technique that is not only employed by business owners but also by statisticians and economists. It involves using statistical equations to predict or estimate the impact of one variable on another. For instance, regression analysis can be used to determine how interest rates affect consumers' behavior regarding asset investment. One other core application of regression analysis is establishing the effect of education and work experience on employees' annual earnings. In the business sector, owners can use regression analysis to determine the impact of advertising expenses on business profits. By using this approach, a business owner can establish whether there's a positive or negative correlation between two variables.

## 2. Linear Programming

Most companies occasionally encounter a shortage of resources such as facility space, production machinery, and labor. Linear programming is a quantitative method that determines how to achieve such an optimal solution. It is also used to determine how a company can make optimal profits and reduce its operating costs, subject to a given set of constraints, such as labor.

## 3. Data Mining

Data mining is a combination of computer programming skills and statistical methods. The popularity of data mining continues to grow in parallel to the increase in the quantity and size of available data sets. Data mining techniques are used in evaluating very large sets of data, with the aim of finding patterns or correlations concealed within them.

# Applications of Quantitative Analysis in the Business Sector and Project Management



Business owners are often forced to make decisions under conditions of uncertainty. Luckily, quantitative techniques enable them to make the best estimates and thus minimize the risks associated with a particular decision. Ideally, quantitative models provide company owners with a better understanding of information, to enable them to make the best possible decisions.

## **Project Management**

One area where quantitative analysis is considered an indispensable tool is in project management. As mentioned earlier, quantitative methods are used to find the best ways of allocating resources, especially if these resources are scarce. Projects are then scheduled based on the availability of certain resources.

## Production Planning

Quantitative analysis also helps individuals to make informed product-planning decisions. Let's say a company is finding it challenging to estimate the size and location of a new production facility. Quantitative analysis can be employed to assess different proposals for costs, timing, and location. With effective product planning and scheduling, companies will be more able to meet their customers' needs while also maximizing their profits.

## Marketing

Every business needs a proper marketing strategy. However, setting a budget for the marketing department can be tricky, especially if its objectives are not set. With the right quantitative method, marketers can find an easy way of setting the required budget and allocating media purchases. The decisions can be based on data obtained from marketing campaigns.

## **Finance**

The accounting department of a business also relies heavily on quantitative analysis. Accounting personnel use different quantitative data and methods such as the discounted cash flow model to estimate the value of an investment. Products can also be evaluated, based on the costs of producing them and the profits they generate.

## **Purchase and Inventory**

One of the greatest challenges that businesses face is being able to predict the demand for a product or service. However, with quantitative techniques, companies can be guided on just how many materials they need to purchase, the level of inventory to maintain, and the costs they're likely to incur when shipping and storing finished goods.



# The Bottom Line

Quantitative analysis is the use of mathematical and statistical techniques to assess the performance of a business. Before the advent of quantitative analysis, many company directors based their decisions on experience and gut. Business owners can now use quantitative methods to predict trends, determine the allocation of resources, and manage projects.

Quantitative techniques are also used to evaluate investments. In such a way, organizations can determine the best assets to invest in and the best time to do so. Some of the quantitative analysis methods include regression analysis, linear programming, and data mining.

# Advantages of Network models over linear programming

**Network models have three main advantages over linear programming:**

1.They can be solved very quickly. Problems whose linear program would have 1000 rows and 30,000 columns can be solved in a matter of seconds. This allows network models to be used in many applications (such as real-time decision making) for which linear programming would be inappropriate.

2. They have naturally integer solutions. By recognizing that a problem can be formulated as a network program, it is possible to solve special types of integer programs without resorting to the ineffective and time consuming integer programming algorithms.

3.They are intuitive. Network models provide a language for talking about problems that is much more intuitive than the "variables, objective, and constraints" language of linear and integer programming.

# Production Planning



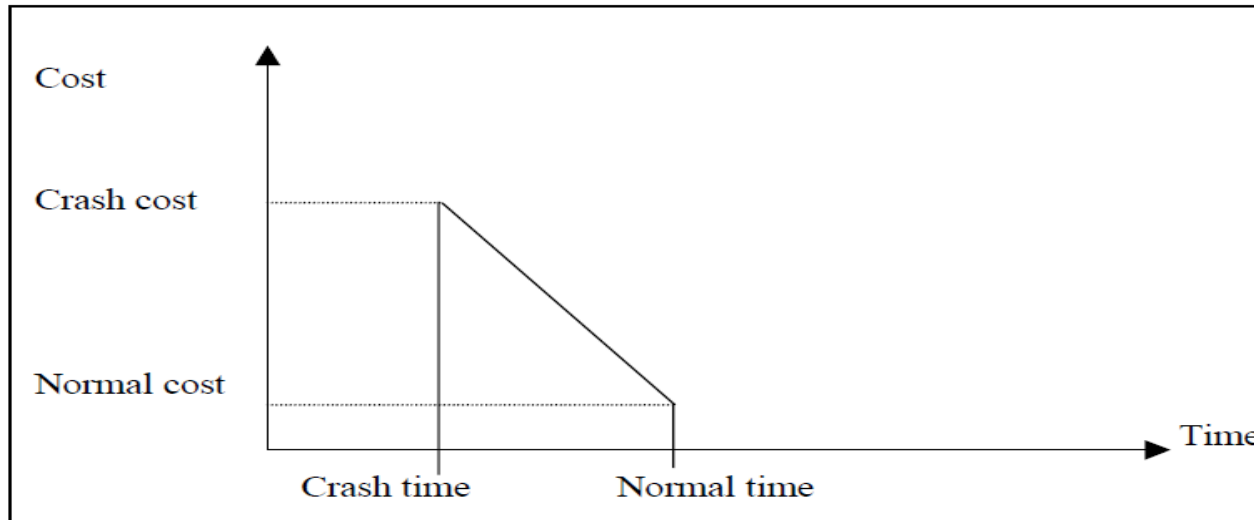
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# Cost Slope in network analysis

## Cost Slope

Cost slope is the increase in cost per unit of time saved by crashing. A linear cost curve is shown in Figure.

## Linear Cost Curve



$$\text{Cost slope} = \frac{\text{Crash cost } C_c - \text{Normal cost } N_c}{\text{Normal time } N_{tt} - \text{Crash time } C_{tt}}$$

## Example:

The following Table gives the activities of a construction project and other data.

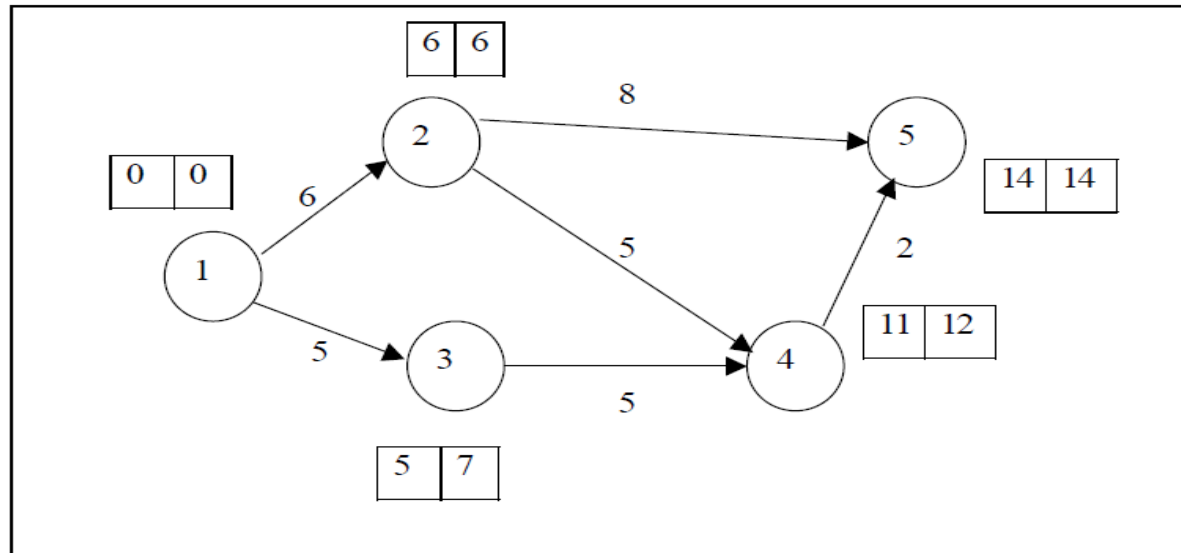
### ***Construction Project Data***

Activity	Normal		Crash	
	Time (days)	Cost (Rs)	Time (days)	Cost (Rs)
1-2	6	50	4	80
1-3	5	80	3	150
2-4	5	60	2	90
2-5	8	100	6	300
3-4	5	140	2	200
4-5	2	60	1	80

If the indirect cost is Rs. 20 per day, crash the activities to find the minimum duration of the project and the project cost associated.

**Solution:** From the data provided in the table, draw the network diagram and find the critical path.

### Network Diagram



From the diagram, we observe that the critical path is 1-2-5 with project duration of 14 days. The cost slope for all activities and their rank is calculated as shown in table below

Cost slope =  $\frac{\text{Crash cost } C_c - \text{Normal cost } N_c}{\text{Normal time } N_{tt}}$

Cost Slope for activity 1-2 =  $\frac{80 - 50}{6 - 4} = \frac{30}{2} = 15$ .

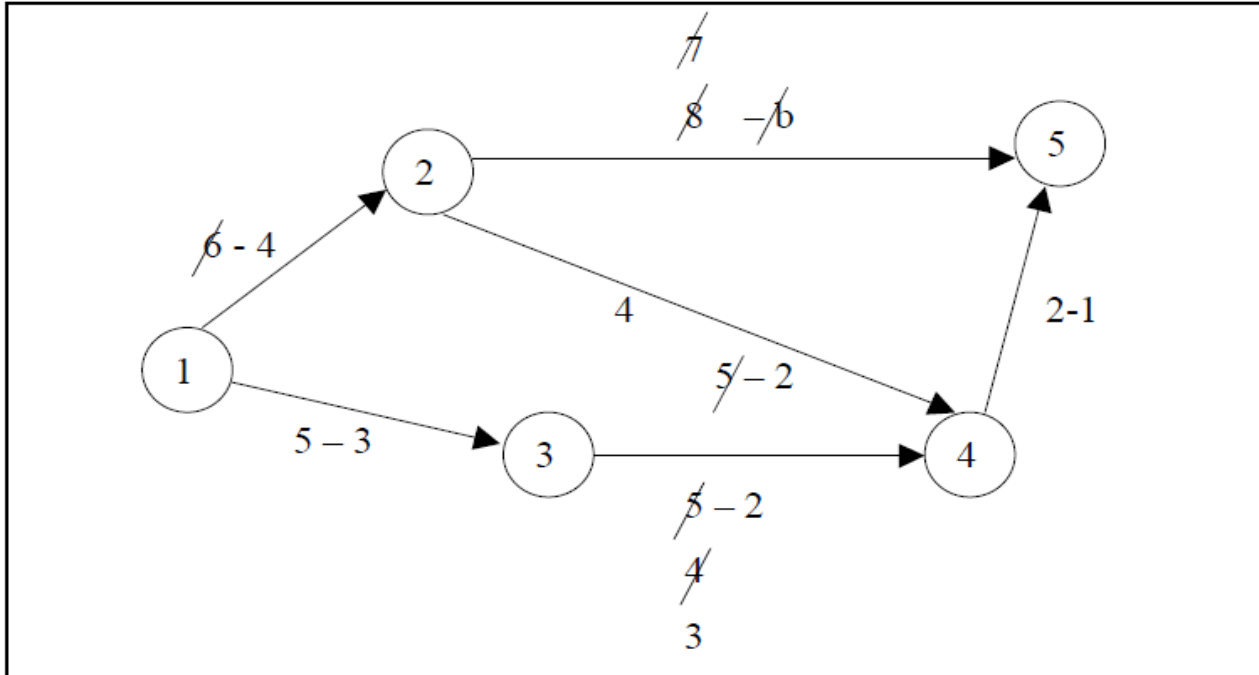
# Cost Slope and Rank Calculated

Activity	Cost Slope	Rank
1-2	15	2
1-3	35	4
2-4	10	1
2-5	100	5
3-4	20	3
4-5	20	3

The available paths of the network are listed down in Table indicating the sequence of crashing.

## *Sequence of Crashing*

Path	Number of days crashed
1-2-5	<del>14</del> <del>12</del> <del>11</del> 10
1-2-4-5	<del>13</del> <del>11</del> <del>11</del> 10
1-3-4-5	<del>12</del> <del>12</del> <del>11</del> 10



The sequence of crashing and the total cost involved is given in the following table

Initial direct cost = sum of all normal costs given = Rs. 490.00



# Sequence of Crashing & Total Cost

Activity Crashed	Project Duration	Critical Path	Direct Cost in (Rs.)	Indirect Cost (in Rs.)	Total Cost (in Rs)
–	14	1 – 2 – 5	490	$14 \times 20 = 280$	770
1 – 2(2)	12	1 – 2 – 5	$490 + (2 \times 15) = 520$	$12 \times 20 = 240$	760
2 – 5 (1)	11	1 – 2 – 5	$520 + (1 \times 100) + (1 \times 20) = 640$	$11 \times 20 = 220$	860
3 – 4 (1)		1 – 3 – 4 – 5 1 – 2 – 4 – 5			
2 – 5 (1)	10	1 – 2 – 5	$640 + (1 \times 100) + (1 \times 10) + (1 \times 20) = 770$	$10 \times 20 = 200$	970
2 – 4 (1)		1 – 3 – 4 – 5			
3 – 4 (1)		1 – 2 – 4 – 5			

it is not possible to crash more than 10 days, as all the activities in the critical path are fully crashed. hence the project review techniques

## The project review techniques are

In the critical path method, the time estimates are assumed to be known with certainty. In certain projects like research and development, new product introductions, it is difficult to estimate the time of various activities. Hence PERT is used in such projects with a probabilistic method using three time estimates for an activity, rather than a single estimate, as shown in Figure. Minimum project duration is 10 days with the total cost of Rs. 970.00.

**Example :** A project schedule has the following characteristics as shown in the table

***Project Schedule***

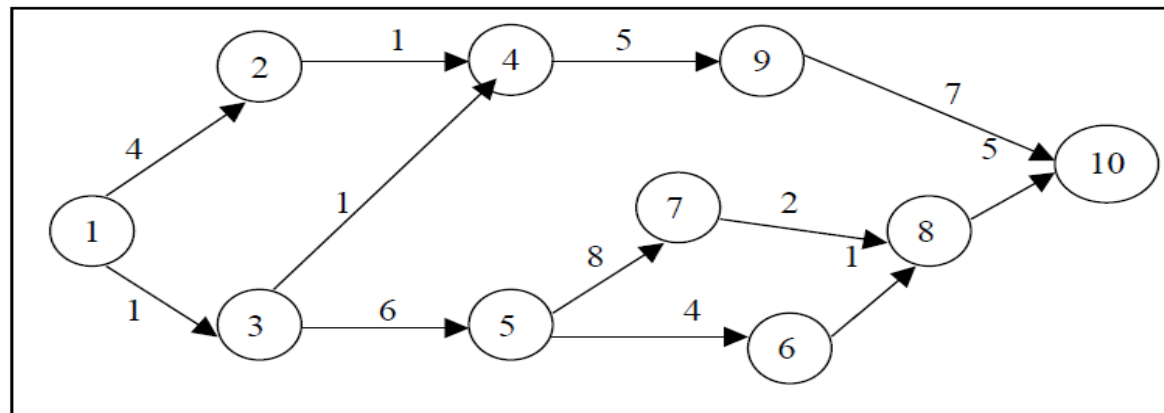
Activity	Name	Time	Activity	Name	Time (days)
1-2	A	4	5-6	G	4
1-3	B	1	5-7	H	8
2-4	C	1	6-8	I	1
3-4	D	1	7-8	J	2
3-5	E	6	8-10	K	5
4-9	F	5	9-10	L	7

- i. Construct PERT network.
- ii. Compute  $T_E$  and  $T_L$  for each activity.
- iii. Find the critical path.

# Solution

(i) From the data given in the problem, the activity network is constructed as shown in the following figure.

*Activity Network Diagram*



(ii) To determine the critical path, compute the earliest, time  $T_E$  and latest time  $T_L$  for each of the activity of the project. The calculations of  $T_E$  and  $T_L$  are as follows:

To calculate  $T_E$  for all activities,

$$T_{E1} = 0$$

$$T_{E2} = T_{E1} + t_1, 2 = 0 + 4 = 4$$

$$T_{E3} = T_{E1} + t_1, 3 = 0 + 1 = 1$$

$$\begin{aligned} T_{E4} &= \max (T_{E2} + t_2, 4 \text{ and } T_{E3} + t_3, 4) \\ &= \max (4 + 1 \text{ and } 1 + 1) = \max (5, 2) \\ &= 5 \text{ days} \end{aligned}$$

$$T_{E5} = T_{E3} + t_3, 6 = 1 + 6 = 7$$

$$T_{E6} = T_{E5} + t_5, 6 = 7 + 4 = 11$$

$$T_{E7} = T_{E5} + t_5, 7 = 7 + 8 = 15$$

$$\begin{aligned} T_{E8} &= \max (T_{E6} + t_6, 8 \text{ and } T_{E7} + t_7, 8) \\ &= \max (11 + 1 \text{ and } 15 + 2) = \max (12, 17) \\ &= 17 \text{ days} \end{aligned}$$

$$T_{E9} = T_{E4} + t_4, 9 = 5 + 5 = 10$$

$$\begin{aligned} T_{E10} &= \max (T_{E9} + t_9, 10 \text{ and } T_{E8} + t_8, 10) \\ &= \max (10 + 7 \text{ and } 17 + 5) = \max (17, 22) \\ &= 22 \text{ days} \end{aligned}$$

# To calculate $T_L$ for all activities

$$T_{L10} = T_{E10} = 22$$

$$T_{L9} = T_{E10} - t_{9,10} = 22 - 7 = 15$$

$$T_{L8} = T_{E10} - t_{8,10} = 22 - 5 = 17$$

$$T_{L7} = T_{E8} - t_{7,8} = 17 - 2 = 15$$

$$T_{L6} = T_{E8} - t_{6,8} = 17 - 1 = 16$$

$$\begin{aligned} T_{L5} &= \min (T_{E6} - t_{5,6} \text{ and } T_{E7} - t_{5,7}) \\ &= \min (16 - 4 \text{ and } 15 - 8) = \min (12, 7) \\ &= 7 \text{ days} \end{aligned}$$

$$T_{L4} = T_{L9} - t_{4,9} = 15 - 5 = 10$$

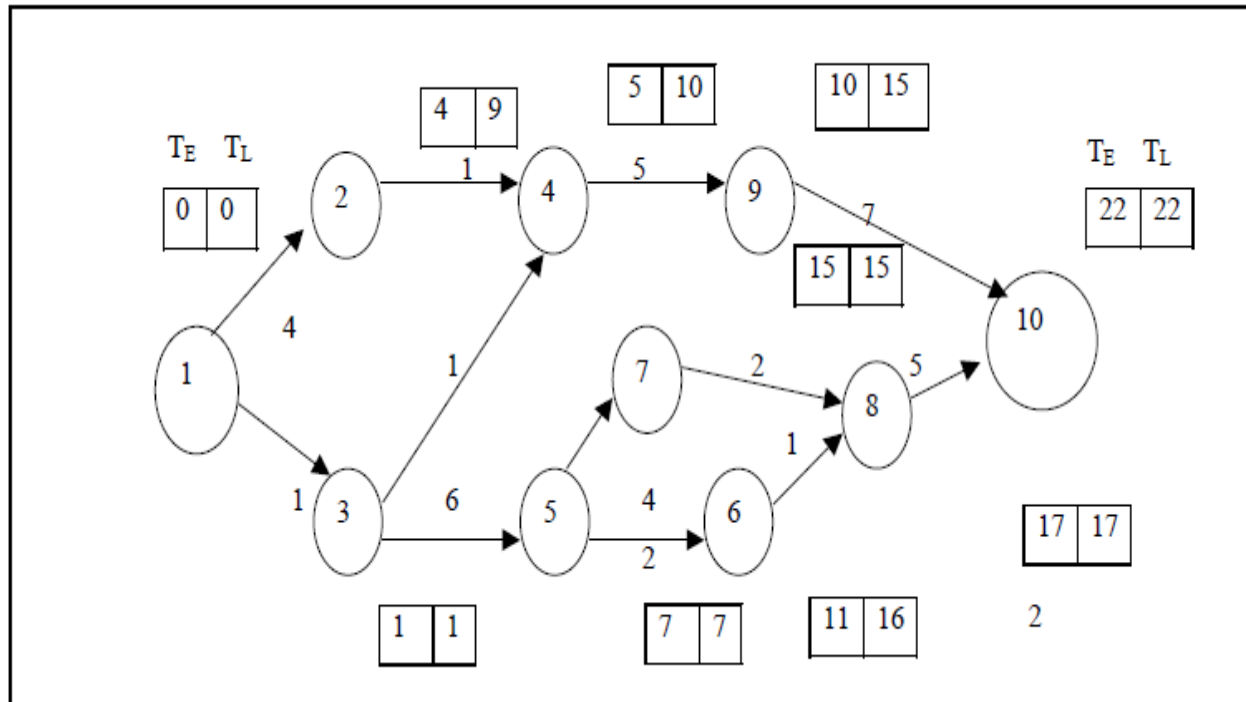
$$\begin{aligned} T_{L3} &= \min (T_{L4} - t_{3,4} \text{ and } T_{L5} - t_{3,5}) \\ &= \min (10 - 1 \text{ and } 7 - 6) = \min (9, 1) \\ &= 1 \text{ day} \end{aligned}$$

$$T_{L2} = T_{L4} - t_{2,4} = 10 - 1 = 9$$

$$\begin{aligned} T_{L1} &= \min (T_{L2} - t_{1,2} \text{ and } T_{L3} - t_{1,3}) \\ &= \min (9 - 4 \text{ and } 1 - 1) = 0 \end{aligned}$$

Activity	Activity Name	Normal Time	Earliest Time		Latest Time		Total Float
			Start	Finish	Start	Finish	
1-2	A	4	0	4	5	9	5
1-3	B	1	0	1	0	1	0
2-4	C	1	4	5	9	10	5
3-4	D	1	1	2	9	10	8
3-5	E	6	1	7	1	7	0
4-9	F	5	5	10	10	15	5
5-6	G	4	7	11	12	16	5
5-7	H	8	7	15	7	15	0
6-8	I	1	11	12	16	17	5
7-8	J	2	15	17	15	17	0
8-10	K	5	17	22	19	22	0
9-10	L	7	10	17	15	22	5

(iii) From the table, we observe that the activities 1 – 3, 3 – 5, 5 – 7, 7 – 8 and 8 – 10 are critical activities as their floats are zero.



The critical path is 1-3-5-7-8-10 (shown in double line in the above figure) with the project duration of 22 days.



# Pert

PERT is an acronym for Program (Project) Evaluation and Review Technique, in which planning, scheduling, organizing, coordinating and controlling uncertain activities take place. The technique studies and represents the tasks undertaken to complete a project, to identify the least time for completing a task and the minimum time required to complete the whole project. It was developed in the late 1950s. It is aimed to reduce the time and cost of the project.

PERT uses time as a variable which represents the planned resource application along with performance specification. In this technique, first of all, the project is divided into activities and events. After that proper sequence is ascertained, and a network is constructed. After that time needed in each activity is calculated and the critical path (longest path connecting all the events) is determined.

Developed in the late 1950s, Critical Path Method or CPM is an algorithm used for planning, scheduling, coordination and control of activities in a project. Here, it is assumed that the activity duration is fixed and certain. CPM is used to compute the earliest and latest possible start time for each activity.

The process differentiates the critical and non-critical activities to reduce the time and avoid the queue generation in the process. The reason for the identification of critical activities is that, if any activity is delayed, it will cause the whole process to suffer. That is why it is named as Critical Path Method.

# Differences between PERT and CPM

1.The most important differences between PERT and CPM are provided below:

2.PERT is a project management technique, whereby planning, scheduling, organizing, coordinating and controlling uncertain activities are done. CPM is a statistical technique of project management in which planning, scheduling, organizing, coordination and control of well-defined activities take place.

3.While PERT is evolved as a research and development project, CPM evolved as a construction project.

4.PERT is set according to events while CPM is aligned towards activities.

5.A deterministic model is used in CPM. Conversely, PERT uses a probabilistic model.

6. There are three time estimates in PERT, i.e. optimistic time ( $t_o$ ), most likely time ( $t_m$ ), pessimistic time ( $t_p$ ). On the other hand, there is only one estimate in CPM.

7. PERT technique is best suited for a high precision time estimate, whereas CPM is appropriate for a reasonable time estimate.

8. PERT deals with unpredictable activities, but CPM deals with predictable activities.

10. There is a demarcation between critical and non-critical activities in CPM, which is not in the case of PERT.

11. PERT is best for research and development projects, but CPM is for non-research projects like construction projects.

12. Crashing is a compression technique applied to CPM, to shorten the project duration, along with the least additional cost. The crashing concept is not applicable to PERT.



*Thank you*