Addis College
COTM 6301
Construction Economics and Financial Management
Nov 2019

COTM 6301

Construction Economics and Financial Management

Course Description:

- The aim of the course is to enable students to appreciate and make an intelligent contribution towards the managerial and financial aspects of construction companies in general and construction projects in particular.
- This includes developing awareness and understanding of the need for financial planning and monitoring and the cost control process

COTM 6301
Construction Economics and Financial Management
Course Description:

- The student will be able to:
  - Familiarize with principles concerning corporate strategies and financial management both at the construction company level and the construction project level
  - Develop the skills that will enable him or her to analyze and assess the performance of construction companies and understand their financial accounts
  - Learn a variety of techniques used to appraise investment schemes such as property and construction plant

COTM 6301

Construction Economics and Financial Management

Course Description:

- The course is intended
  - to provide the necessary knowledge on the monetary aspects of construction.
  - consider Construction economics and financial analysis methodologies and their applications in evaluating construction projects

COTM 6301
Construction Economics and Financial Management

- It will attempt to assist students to
  - Understand basic accounting and finance concepts
  - Understand the basic economic principles
  - Understand economic principles in relation to construction projects
  - Be able to identify the economic resources required to complete a typical construction project
  - Know how to plan and control construction costs
  - To understand economic feasibility assessment of construction projects

COTM 6301

Construction Economics and Financial Management

Course Outline

COTM 6301
Construction Economics and Financial Management
Course Outline

- Introduction to Construction Economics and Finance
- Construction project and their management
  - Project Life cycle
- Basic Accounting Concepts,
  - financial statements, Profit and loss statement / balance sheet, financial ratio analysis
  - construction accounting, and working capital management

Construction Economics and Financial Management Course Outline

- Basic economic principles in construction projects
  - Types of business:
    - Sole Proprietorships, Partnership, General Partnerships, Limited Partnerships, Share Companies, Private Limited Companies, and Joint Ventures.
  - Types of Resources in construction
    - Land
    - Finance
    - Human Resources

Construction Economics and Financial Management Course Outline

- Construction Finances and their Management
  - Cost Management in Construction
  - Cost planning:
  - Construction Cost Control
  - Cash flow forecasts
  - Cost control techniques:
    - valuations, financial statements and reports, s-curves, resource allocated bar charts, Earned Value Methodology

Construction Economics and Financial Management
Course Outline

- **Economic Evaluation of Construction Projects:**
- Introduction to Engineering Economics
  - Engineering, Science and Economics
  - Principles and processes of Decision making in engineering construction
  - Cash flows

Construction Economics and Financial Management Course Outline

- Economic Evaluation of Construction Projects
- Investment Appraisal Methods
  - Payback period
  - Present worth/ Net Present worth/ Net Present Value
  - Equivalent annual worth
  - Rate of Return
    - Internal rate of return
  - Benefit cost ratio and other methods
  - Mutually exclusive alternatives

Semester Project

- Types of Business in the Ethiopian legal Context
- Cost Benefit Analysis in Construction
- Risk Management in Construction
- Feasibility Study for a Highway Project
- Feasibility Study for an Airport
- Cost Planning and Management in Construction

Semester Project

- Financial Ratio Analysis for a construction Company: Case study
- Asset Management basic principles
- Tendering cost strategy and Analysis for a construction Company
- Challenges facing profitability in construction
- Labor and Equipment cost Management in a construction Company

Semester Project

- Depreciation analysis in Construction Financial Management
- Determination of Labor costs in Construction
- Determination and Analysis of Overhead costs in construction
- Monitoring cost and Profitability using Cost Loaded schedules
- Financing Construction Companies: alternative Methods

Semester Project

- Tax System in Ethiopia and its application to Construction
- A review of a feasibility study for a project: Case study

Introduction to
Construction Economics and Financial Management

Introduction to Construction Economics and Financial Management

- Introduction
  - The construction industry plays an important role in society. Construction forms our physical surroundings and creates the infrastructure we need to develop society
  - The Construction industry also consumes a substantial amount of resources as well as creating significant employment opportunities

Introduction to Construction Economics and Financial Management

- For any construction project to be successful, it must be technically sound and the resulting benefits must exceed the cost associated with the project.
- Construction economics and finance deals with the systematic evaluation of cost and benefit associated with construction projects.

Construction Economics and Financial Management

- Because Construction activities consume a substantial a amount of resources it is necessary to efficiently use these resources to contribute to the economic wealth of a country and of individuals,
- Economists, Engineers are therefore faced with making the right decisions concerning we there to develop a project and if so which one, where to develop the project, the suitability of a particular type of project, and when to commence the work

Construction Economics and Financial Management

- Finance and capital play a large part in every economy or business. Investment is often the key focus in the success of a construction business
- Finance and Construction managers are therefore faced with the task of making the right decisions

Construction Economics and Financial Management

- Construction managers therefore need fundamental principles to successfully manage the finances of construction companies and evaluate and decide the economic merits of projects
- This will require that managers be knowledgeable in the areas of business management, engineering economics, accounting, estimating, project management, and scheduling etc

Construction Economics and Financial Management

- Financial management
  - may be defined as the use of a company's financial resources and encompasses all decisions that affect a company's financial health.
  - Many everyday decisions affect a company's financial health. The difference between a marginally profitable and a very profitable company is good financial management (Peterson,2009)

Construction Economics and Financial Management

- Financial management is the use of a company's financial resources.
- This includes the use of cash and other assets—such as equipment.
- Many everyday decisions affect a company's financial future.
- For example, the decision to bid on a large project can have great impact on the finances of a company.

Construction Economics and Financial Management

- For instance When deciding whether to bid on a project, a manager may need to address the following questions:
  - Does the company have enough cash resources to perform this work or will the company need outside financing?
  - Can the company get bonded for this work? If not, what changes need to be made in the company’s financial structure so the company can get a bond for the project?
  - Should the company hire employees to perform the work or should the company subcontract out this labor?

Construction Economics and Financial Management

- Should the company lease or purchase the additional equipment needed for this project?
- If the company purchases the equipment, how should it be financed?
- Will this project require the company to increase its main office overhead? And,
- finally, what profit and overhead markup should be added to the bid?

• The answers to all of these questions will affect the company's finances.

Construction Economics and Financial Management

- The answer to one of the questions may change the available options to other questions.
  - For example, if the manager decides to hire employees to perform the work on the project, the project will require more financial resources than if the company had hired subcontractors to perform the labor and may leave the company with insufficient resources to purchase the additional equipment, leaving leasing the equipment as the only option.

Construction Economics and Financial Management

- On the other hand projects need to be assessed in terms of their economic worth ..

Introduction to Engineering Economics

Introduction to Engineering Economics

- As individuals we all make decisions in everyday life, for instance
  - –which things to buy,
  - –when to buy them
  - –with how much money,
  - –Whether we can afford it
  - –whether alternatives are available etc

Introduction to Engineering Economics

- Whilst as individuals we consider these decisions steps Companies as well as governments also carry out similar considerations in order to arrive at a decision

Introduction to Engineering Economics

- Companies and Governments consider decisions including
  - Which products/ projects to develop (Alternatives)
  - When to develop (time)
  - How long it will take to develop
  - What cost it will take (current)
  - Whether the available budget is sufficient
  - What profit it will generate (future)
  - Whether it is worth to invest in the scheme etc
  - Whether it will "return" money invested on it etc

Introduction to Engineering Economics

- This implies that before projects are implemented various decisions criteria's are considered including
  - Cost (economics, worth etc.)
  - Time
  - Technical (Buildability, etc)

Introduction to Engineering Economics

- These criteria's can be broadly classified into
  - Engineering/Technical and
  - Economic issues
  - If a project satisfies these criteria's then it can be considered to be "***feasible***…"

Introduction to Engineering Economics

- Feasibility: is the project worth it?
- Feasibility Study
  - A through evaluation of a proposed project to determine if it is
    - is technically **buildable**,
    - if it can be accomplished within the estimated cost, and
    - Is it economical?
    - Will cover its costs and be profitable.
    - Where can the finances be obtained?

Introduction to Engineering Economics

- During the planning stage of projects such concerns regarding the economic and technical "feasibility" are addressed
- But for a project to be "Feasible" or preferable it has to be compared with other "***alternatives***…."

Introduction to Engineering Economics

- Out of these alternatives the most suitable ***alternative*** is chosen
- By implication the other alternatives are ***excluded***…

Introduction to Engineering Economics

- But……When considering the viability of these alternatives a future time frame is usually considered
  - How long will the project take to complete?
  - How much will it cost? In how many years will it recover its cost? etc

Introduction to Engineering Economics

- But the future time frame carries with its an element of uncertainty
  - –This is because current costs of products or projects can only be estimated with reasonable accuracy in the "present" time
  - –While it is difficult to accurately (or close enough) estimate profits/benefits in the "Future" 'time scenario

Introduction to Engineering Economics

- Intuitively we also know that cost varies with time
  - And that money/cash invested in a project is injected at certain times…
  - Or cash flows into a project at certain times….
- Or that the value of money varies with time

The ***time value of money***

Introduction to Engineering Economics
Key terms

- Money
- Cost
- Time
  - Present
  - Future
- Cash
- Cash flow
- Alternatives
- Uncertainty
- Feasibility
- Engineering
- Economy
- Engineering Economy

Introduction to Engineering Economics

- Therefore in order to arrive at a meaningful decision in the choice of the best project alternative a systematic analysis of the above factors needs to be considered
- This is the domain of Engineering Economy

Introduction to Engineering Economics

- Engineering Economy uses a number of tools to arrive at a meaningful decision
- These include …

Introduction to Engineering Economics

Methods of analyzing a project or an investment

- –Pay back period (Initial Project Screening Method)
- –Present/future worth analysis
- –Equivalent annual worth analysis
- –Rate of return
- –Cost-benefit analysis
- –Breakeven Analysis

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Introduction to Construction Economics and Financial Management

- Introduction
  - Construction consumes a substantial a amount of resources in many countries
  - The efficient use of resources contribute to the wealth of a country and of individuals,
  - Economists, Engineers are therefore faced with making the right decisions concerning which project to develop, where to develop the project, the suitability of a particular type of project, and when to commence the work
  - Finance and capital play a large part in every economy or business. Investment is often the key focus in the success of a construction business

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Construction Financial Management

Construction Financial Management

- Construction companies are different from most other companies and are faced with many unique challenges and problems not faced by other companies in other industries. Although the construction industry is producing a product—as do manufacturing plants—the construction of buildings, roads, and other structures is different from manufacturing of most other products.
- Because of these unique characteristics the financial management principles applied to other product-producing industries often need to be modified before they are applied to the construction industry.

Construction Financial Management

- A construction company faces many risky ventures. These risky ventures expose construction companies to financial risks and may force them to go out of business
- Therefore for a construction company to be successful requires a specialized set of financial management skills
- Unlike other manufacturing industries construction industries are involved in unique ventures with their inherent challenges such as:
  - (1) constantly building unique, one-of-a-kind projects,
  - (2) building a project at a different location each time,
  - (3) dealing with retention and progress payments, and
  - (4) relying heavily on the use of subcontractors to complete the projects.

Construction Financial Management

- Therefore construction companies must manage their finances keep track of costs and profits etc. these includes
  - Monitoring and controlling project costs.
  - Monitoring project and company profitability.
  - Setting and monitoring labor markups.
  - Developing and tracking general overhead budgets.
  - Setting the minimum profit margin for use in bidding.
  - Analyzing the profitability of different parts of the company and making the necessary changes to improve profitability.

Construction Financial Management

- Managing Costs and Profits Financial managers are responsible for managing the company's costs and earning a profit for the company's owners. Financial managers rely heavily on the reports from the accounting system in their management of costs. Managing the company's costs and profits includes the following duties:

Introduction to Construction Economics and Financial Management

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Introduction to Construction Economics and Financial Management

- On the other hand projects have to be financially feasible before they are started
- This requires that Engineering projects be assessed economically

Engineering Economics

Engineering Economics

- Engineering Economy is the study of the feasibility and evaluation of the cost of possible solutions to engineering problems. When benefits outweigh costs the alternate becomes a acceptable one. The lowest cost among alternates can be selected by using different methods (Sharma, 2015)

Engineering Economics

- Engineering economics, then, can be defined as the science that deals with techniques of quantitative analysis useful for selecting a preferable alternative from several technically viable ones (Fraser et al. 2008)

Construction Projects and Their Management

Definition of Key Terms

- Definition of Key terms..
  - Project
  - Management
  - Project Management

What is a project?

- A project is a temporary endeavor involving a connected sequence of activities and a range of resources, which is designed to achieve a specific and unique outcome and which operates within time, cost and quality constraints and which is often used to introduce change

Definitions of “Project”

- A project is
  - ‘… A set of activities with a defined start point and a defined end state, which pursues a defined goal and uses a defined set of resources.’ (Slack et al)
  - “... A temporary endeavour undertaken to create a unique product or service”. (US PMI)
  - “... The process by which projects are defined, monitored, controlled & delivered.....desired outcome......bring about change” (APM)

Definitions of “Project”

- A project is a set of people and other resources temporarily assembled to reach a specific objective, normally with a fixed budget and with a fixed time period. Graham (1994)
- A project is a unique venture with a beginning and an end, conducted by people to meet established goals within parameters of cost, schedule and quality.
    - » Buchanan and Boody (1992)

What is a project?

- The simplest form of a project is a discrete undertaking with defined objectives often including time, cost and quality (performance) goals.
- All projects evolve through a similar 'life-cycle' sequence during which there should be recognised start and finish points.
- In addition, the project objectives may be defined in a number of ways, e.g. financial, social and economic, the important being that the goals are defined and the project is finite.

Association of project management (APM 1993)

Construction projects

- Following the above definitions one may observe that the temporary nature of construction activities places them in the category of "Projects" because construction
  - Is a temporary activity
  - Is a unique activity
  - Has a definite start and end point
  - Utilizes various resources
  - The key activities of Time, Cost, Quality, Scope etc must be managed

Project Scope

Project Scope definition

- Project scope definition
  - Provides sufficient information to identify the work to be performed,
  - allows the design to proceed without significant changes that may adversely affect the project budget and schedule.
  - assists the owner by providing a ***comprehensive check list*** of work items to be accomplished.

Management….

- Before Addressing issues related to Construction Projects one must understand the basic concept of "Management"
  - –So what is Management?

What is Management? (Adapted from Cirna 2015)

- Management is
- A set of activities which includes
  - planning and decision making, organizing, leading, and controlling

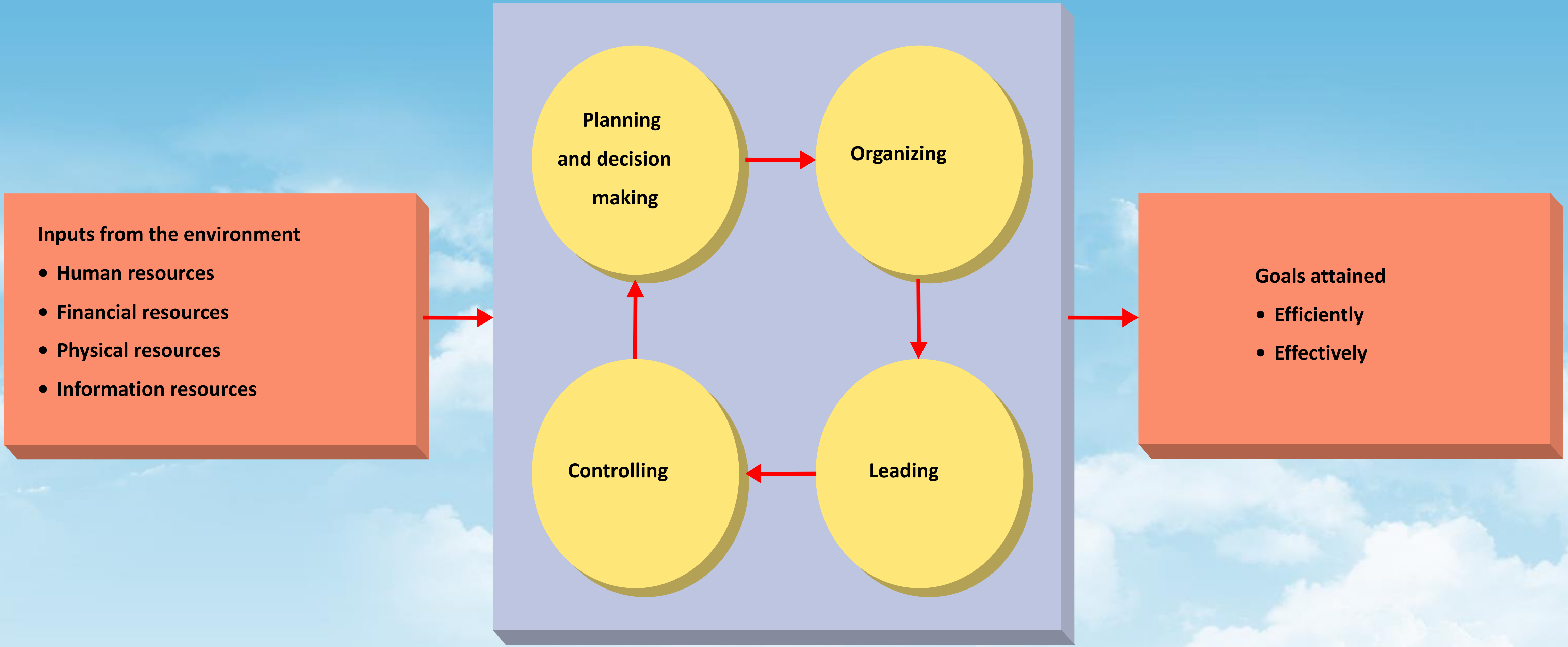
  directed at an organization's resources
  - human, financial, physical, and information

  with the aim of achieving organizational goals in an efficient and effective manner.

The Management Process

- Planning and Decision Making
  - Setting an organization’s goals and selecting a course of action from a set of alternatives to achieve them.
- Organizing
  - Determining how activities and resources are to be grouped.
- Leading
  - The set of processes used to get members of the organization to work together to advance the interests of the organization.
- Controlling
  - Monitoring the organization’s progress towards its goals.

Management in Organizations



Organizational Resources

- Human resources
  - Managerial talent and labor
- Financial resources
  - Capital investments to support ongoing and long-term operations
- Physical Assets
  - Raw materials; office and production facilities, and equipment
- Information
  - Usable data, information linkages

Project Management

Project Management

- Given the limited amount of resources assigned to a project, it becomes necessary to "***manage***" the project properly so that resources are not unnecessarily wasted.
- This leads to the concept of "*managing*" a project or "***Project Management***"

WHAT IS PROJECT MANAGEMENT?

- ***Project management*** is a set of principles, methods, and techniques that people use to effectively plan and control project work.
- Project Management establishes a sound basis for effective planning, scheduling, resourcing, decision-making, controlling, and re-planning.
- (Richman, 2002)

What is project management?

- The planning, co-ordination and control of a project from conception to completion (including commissioning) on behalf of a client requiring the identification of the client's objectives in terms of utility, function, quality, time and cost, and the establishment of relationships between resources, integrating monitoring and controlling the contributors to the project and their output, and evaluating and selecting alternatives in pursuit of the client's satisfaction with the project outcome.
  - » Walker (2002)

What is project management?

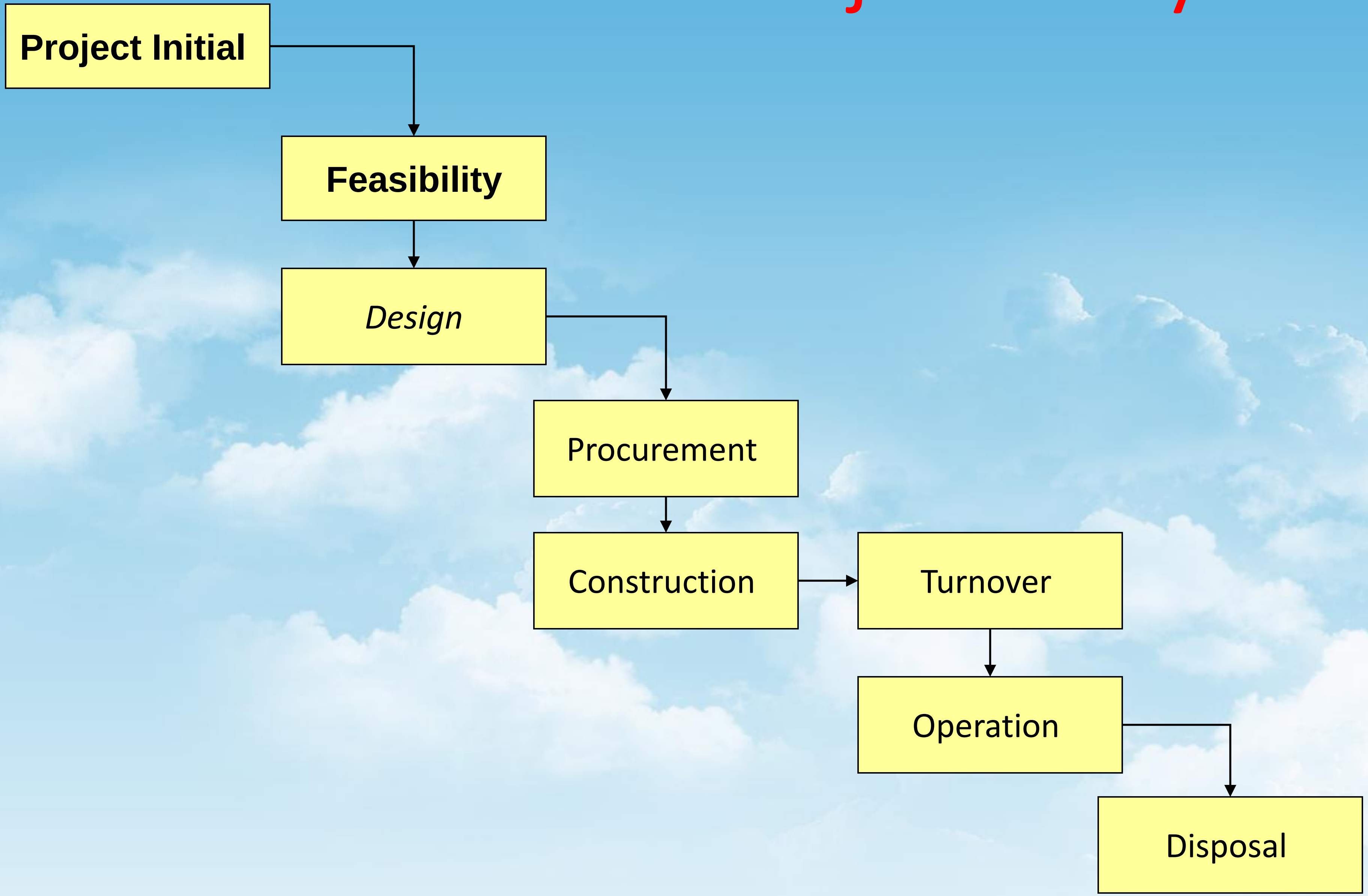
- Project management is the art of directing and coordinating human and material resources through the life of a project by using modern management techniques to achieve predetermined objectives of scope, cost, time, quality and participation satisfaction.

    » American Project Management Institute

WHAT IS PROJECT MANAGEMENT?

- Project management principles and techniques help complete projects on schedule, within budget, and in full accordance with project specifications. At the same time, they help achieve the other goals of an organization, such as productivity, quality, and cost effectiveness.
- The objective of project management is to optimize project cost, time, and quality. (Richman, 2002)
- This is acghieved through the relevant lifecycle phase of a project

Project Lifecycle



Elements of Construction Projects….

- ***The PMBOK classifies the elements of a project management to include the following***
  - ***Project Integration Management***
  - ***Project Scope Management***
  - ***Project Time Management***
  - ***Project Cost Management***
  - ***Project Quality Management***
  - ***Project Procurement Management***
  - ***Project Communications Management***
  - ***Project Risk Management***
  - ***Project Human Resource Management*** *(PMBOK, 2004)*

Engineering Economics

Engineering Economics

“The application of economic principles to engineering problems.”

Engineering Economics

Engineering Economics, is concerned with the use and "...application of **economic** principles" in the analysis of **engineering** decisions. ... Thus, it focuses on the ***decision making*** process,

Engineering Economics

- Traditionally referred to as " ***engineering economy***" this subject has also been called
  - –economic analysis,
  - –economic justification,
  - –capital investment analysis,

Engineering Economy

- The application of economic analysis techniques in the comparison of engineering design alternatives has been referred to as engineering economy.

Engineering Economics

- Engineering Economy is the study of the feasibility and evaluation of the cost of possible solutions to engineering problems. When benefits outweigh costs the alternate becomes a acceptable one. The lowest cost among alternates can be selected by using different methods (Sharma, 2015)

Engineering Economics

- Engineering economics, then, can be defined as the science that deals with techniques of quantitative analysis useful for selecting a preferable alternative from several technically viable ones (Fraser et al. 2008)

Introduction to Engineering Economics
Decision Making

Engineering Economics

Decision Making:

If two alternative solutions to an engineering problem are presented (ex. Should we choose a gravity or arch dam? Should we opt for a railway of high speed multi lane road?) one has to choose (decide) the better alternative….

Engineering Economics

- There are many factors that are considered in making decisions. These factors are combinations of economic and **non** economic ones.
- Engineers play a major role in investment by making decisions based on economic analysis and design considerations.
- This considers two time frames: the ***Present*** and ***Future*** ……

Engineering Economics

So engineering decisions have to made on the basis of economic considerations considering both present and future time frames

Engineering Economic Decisions

Engineering Economic Decisions

- The term Engineering Economic Decision refers to all investment decisions relating to an engineering project.
- The most relevant facet of an economic decision, from an engineer's point of view, is the evaluation of costs and benefits associated with making a capital investment.

Engineering Economic Decisions: Relevance

- There are many areas in which engineering-economic decisions are relevant

Introduction to Engineering Economics: Relevance

- Some issues considered in Engineering Economics include
  - Shall one build or acquire a new facility to meet the increased demand?
  - Should one maintain an old equipment or purchase a new one?
  - Is it worth spending money to market a new product?
    - Will the purchase of these equipment produce profit
    - In how many years can these equipment be paid for?

Engineering Economic Decisions

- Therefore Engineering economy attempts to answer the following questions
  - Which engineering projects are worthwhile? (project worthiness)
  - Which engineering projects should have a higher priority? (priority for available alternatives)
  - How should the engineering project be designed? (economic design)
  - How many units have to be sold before profit can be made? (Breakeven analysis)

Engineering Economy:
Problem-Solving Approach

Engineering Economy: Problem-Solving Approach

- In engineering economy problems must be approached systematically, this includes considering a structured approach that will result in choosing the best alternative among many.

Engineering Economy : Problem-Solving Approach

1. **Understand the Problem**
2. **Collect all relevant data/information**
3. **Define the feasible alternatives**
4. **Evaluate each alternative**
5. **Select the "best" alternative**
6. **Implement and monitor**

Major Role of Engineering Economy

Engineering Economy : Problem-Solving Approach

1. **Understand the Problem**
2. **Collect all relevant data/information**
3. **Define the feasible alternatives**
4. **Evaluate each alternative**
5. **Select the "best" alternative**
6. **Implement and monitor**

One of the more difficult tasks

Engineering Economy : Problem-Solving Approach

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Where the major tools of Engr. Economy are applied

Engineering Economy : Problem-Solving Approach

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2. **Collect all relevant data/information**
3. **Define the feasible alternatives**
4. **Evaluate each alternative**
5. **Select the "best" alternative**
6. **Implement and monitor**

Tools
Present Worth, Future Worth
Annual Worth, Rate of Return
Benefit/Cost, Payback, Capitalized Cost, Value Added

Basic Concepts of Engineering Economy

The Time Value of Money

Money-time relation and cash flow

Engineering Vs Economic Decisions

- Economic decisions involve future predictions, which may be different
- In considering economic decisions it is necessary to evaluate the attractiveness of an investment
- To do that information is required.
  - information required usually involving predicting, or forecasting, product sales, cost of items, future selling prices etc
- All this are set in a future time, for instance 5 , 10, 25 years from now
- Therefore there is an element of Forecast in the analysis process

Basic Concepts of Engineering Economy

- Engineering economy involves determining the worth of projects in a future setting
  - Cost of project at present
  - Profits and costs in the future (life time of Project)
  - Deciding whether they are worthwhile
  - This involves comparing costs within a given time frame, but as the value of money is dependent on time it is necessary to consider the issue of Time and Cost : the Time value of money

The Time Value of Money

- The change in the amount of money over a given time period is called the time value of money; by far, the most important concept in engineering economy

Interest

- Interest:
  - A fee paid for the use of another party's money. To the borrower it is the cost of renting money, to the lender the income from lending it. http://www.businessdictionary.com/definition/interest.html)
  - The earning power of money (Riggs et al, 1996).

Interest – Lending Example

- If you borrow 10,000 birr from a Bank for a year and you are required to pay back 10,700 birr in one years time
  - Borrowed amount 10,000 birr
  - Time you borrowed the money : for one year
  - Amount you pay back 10,700
  - Extra amount you have paid back 700 Birr
  - Interest you paid : 10700-10,000= 700 Birr per year
  - Interest rate (i) = 700/10,000 = 7%/Yr

Interest – lending Example

The previous example is form the borrower's point of view, which means that the 700 Birr is a cost to the borrower.

From the lenders point of view however the 700 Birr is a return to the lender for this use of his/her funds for one year

The Rate of Return is 7 %

Types of Interest

Types of Interest

- Money can be loaned and repaid in many ways, and. equally, money can earn interest in many different ways.
- Usually, however, at the end of each interest period, the interest earned on the principal amount is calculated according to a specified interest rate

Types of Interest

- There are many types of interest
  - –***Simple Interest***: *is* the *interest* earned or paid on a certain balance in one period. However, it does not take into account the effects of compounding, which is the process of earning *interest* on principal plus *interest* that was earned earlier
  - –***Compound Interest***: is the addition of **interest** to the principal sum of a loan or deposit, or in other words, **interest** on **interest**. It is the result of reinvesting **interest**, rather than paying it out, so that **interest** in the next period is then earned on the principal sum plus previously accumulated **interest**.

Types of Interest

– A ***nominal interest rate*** is the **interest rate** that does not take inflation into account. It is the **interest rate** that is quoted on bonds and loans. ... As opposed to the **nominal interest rate**, the **real interest rate** adjusts for the inflation and gives the **real rate** of a bond or a loan

– The ***effective*** annual *interest rate* is the *interest rate* that is actually earned or paid on an investment, loan or other financial product due to the result of compounding over a given time period. It is also called the *effective interest rate*, the *effective rate* or the annual equivalent *rate*

Types of Interest

- The two computational schemes for calculating this earned interest yield either simple interest or compound interest.

Methods of Calculating Interest

- Simple interest: the practice of charging an interest rate only to an initial sum (principal amount).
- Compound interest: the practice of charging an interest rate to an initial sum and to any previously accumulated interest that has not been withdrawn.

Interest

- *Engineering economic analysis uses the compound-interest scheme exclusively, as it is most frequently practiced in the real world*

Interest: Key Terms

- An initial amount of money in transactions involving debt or investments is called the ***principal***.
- The interest rate measures the cost or price of money and is expressed as a percentage per period of time.
- A period of time, called the interest period, determines how frequently interest is calculated. (Note that even though the length of time of an interest period can vary, interest rates are frequently quoted in terms of an annual percentage rate).

Interest: Key Terms

- A specified length of time marks the duration of the transaction and thereby establishes a certain number of interest periods.
- A plan for receipts or disbursements yields a particular cash flow pattern over a specified length of time. (For example, we might have a series of equal monthly payments that repay a loan.)
- A future amount of money results from the cumulative effects of the interest rate over a number of interest periods

Simple Interest

- *P* = Principal amount
- *i* = Interest rate
- *N* = Number of interest periods
- Example:
  - *P* = $1,000
  - *i* = 8%
  - *N* = 3 years
  - $I=(iP)N$

End of Year	Beginning Balance	Interest earned	Ending Balance
0			$1,000
1	$1,000	$80	$1,080
2	$1,080	$80	$1,160
3	$1,160	$80	$1,240

Compound Interest

- *P* = Principal amount
- *i* = Interest rate
- *N* = Number of interest periods
- Example:
  - *P* = $1,000
  - *i* = 8%
  - *N* = 3 years
  - *F=P(1+i)^N*

End of Year	Beginning Balance	Interest earned	Ending Balance
0			$1,000
1	$1,000	$80	$1,080
2	$1,080	$86.40	$1,166.40
3	$1,166.40	$93.31	$1,259.71

A_n = A discrete payment or receipt occurring at the end of some interest period.

i = The interest rate per interest period.

N = The total number of interest periods.

P = A sum of money at a time chosen as time zero for purposes of analysis; sometimes referred to as the **present value** or **present worth**.

F = A future sum of money at the end of the analysis period. This sum may be specified as F_N.

A = An end-of-period payment or receipt in a uniform series that continues for N periods. This is a special situation where $A_1 = A_2 = \cdots = A_N$.

V_n = An equivalent sum of money at the end of a specified period n that considers the effect of the time value of money. Note that $V_0 = P$ and $V_N = F$.

Simple Interest
Mathematical Expressions

Simple Interest Concepts and Mathematical Expressions

- The first scheme considers interest earned on only the principal amount during each interest period.
- In other words, under simple interest, the interest earned during each interest period does not earn additional interest in the remaining periods, *even though you do not withdraw it.*

Simple Interest
Mathematical Expressions

- Simple Interest is calculated on the principal amount only. It is easy (simple) to calculate
- Simple Interest is:

(principal)(interest rate)(time)

$$\$I = (P)(i)(n)$$

Simple Interest Concepts and Mathematical Expressions

- In general, for a deposit of *P dollars at a simple interest rate of i for N periods,* the total earned interest I would be

$$I = (iP)N.$$

- The total amount available at the end of *N periods, F. thus would be*

$$F = P + I$$

$$F = P + (iP)N$$

$$F = P(1 + iN).$$

Simple Interest Example

- Example
  - Borrow $1,000 for 3 years at 5% per year
  - Let "P" = the principal sum ($1,000)
  - i = the interest rate (5%/year)
  - Let N = number of years (3)
  - I = $1,000(0.05)(3) = $150.00

Simple Interest
Example

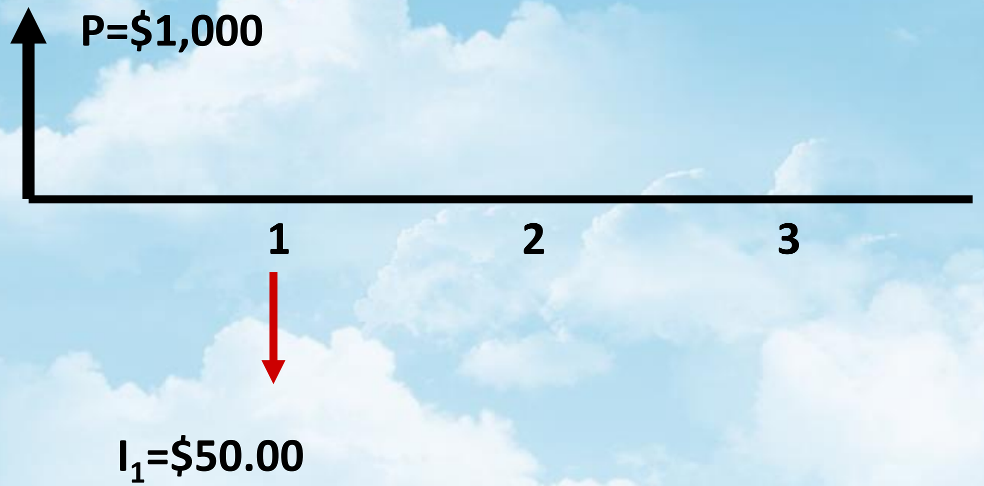
If you deposit 1000 birr for three years earning a simple interest of 5 % per year

- Year 1
  - I_1 = \$1,000(0.05) = \$50.00
- Year 2
  - I_2 = \$1,000(0.05) = \$50.00
- Year 3
  - I_3 = \$1,000(0.05) = \$50.00
  - Total earned interest at the end of three years is 50+50+50= 150
  - Total Amount will be 1000+150= 1150 Birr

Simple Interest: Graphical Representation

Accrued Interest: Year 1

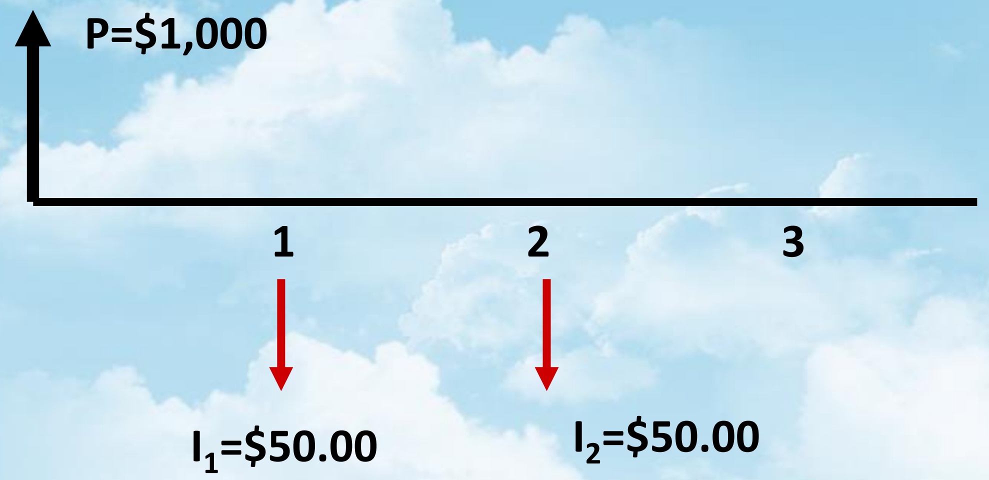
- "***Accrued***" **means "owed but not yet paid"**
- **First Year:**



$50.00 interest accrues but is not paid

Accrued Interest: Year 2

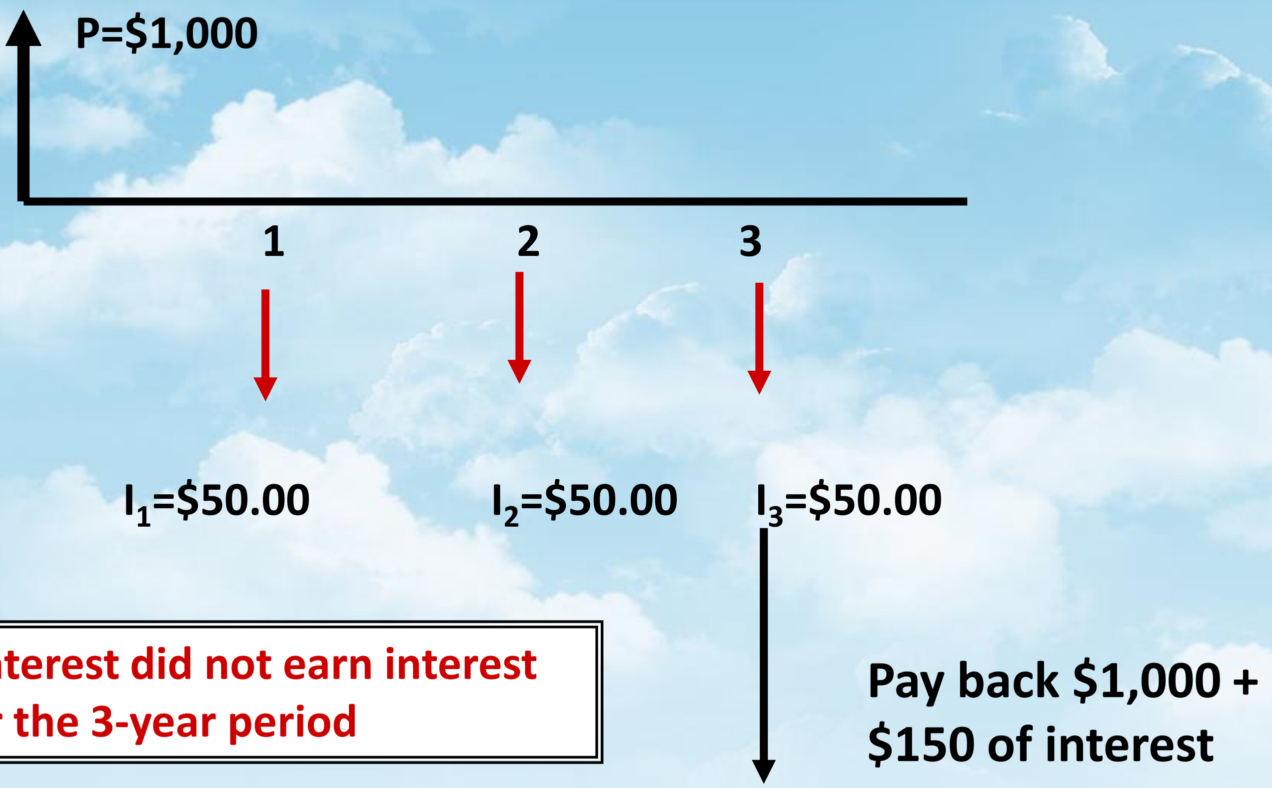
- **Year 2**



$50.00 interest accrues but is not paid

1.5 End of 3 Years

- **\$150 of interest has accrued**



The unpaid interest did not earn interest over the 3-year period

Simple Interest: Summary

- In a multi-period situation with simple interest:
  - The accrued interest does not earn interest during the succeeding time period.
  - Normally, the total sum borrowed (lent) is paid back at the end of the agreed time period PLUS the accrued (owed but not paid) interest.

Compound Interest Concepts and Mathematical Expressions

Compound Interest Concepts and Mathematical Expressions

- To "Compound" means to stop and compute. In this application, compounding means to compute the interest owed at the end of the period and then add it to the unpaid balance of the loan
- Interest then "earns interest"
- When interest is compounded, the interest that is accrued at the end of a given time period is added in to form a NEW principal balance.
- That new balance then earns or is charged interest in the succeeding time period

Compound Interest Concepts and Mathematical Expressions

- Under a compound-interest scheme, the interest earned in each period is calculated based on the total amount at the end of the previous period.
- This total amount includes the original principal plus the accumulated interest that has been left in the account. In this case, you are in effect increasing the deposit amount by the amount of interest earned.

Compound Interest Concepts and Mathematical Expressions

- In general, if you deposited (invested) P dollars at an interest rate *i, you would have and amount F at the end of year 1*

$$F_1 = P + iP = P(1 + i)$$

dollars at the end of one interest period.

Compound Interest Concepts and Mathematical Expressions

- If the entire amount (principal and interest) were reinvested at the same rate *i for another period, you would have at the end of the second period*

  $F_2 = P(1 + i) + i[P(1 + i)] = P(1 + i)(1 + i)$

  $F_2 = P(1+i)^2$

- Continuing. we see that the balance after period three is

  $F_3 = P(1 + i)^2 + i\,[P(1 + i)^2] = P(1 + i)^3.$

- This interest-earning process repeats, and after N *periods, the total accumulated* value (balance) F will grow to

$$F_N = P(1 + i)^N$$

Compound Interest Concepts and Mathematical Expressions

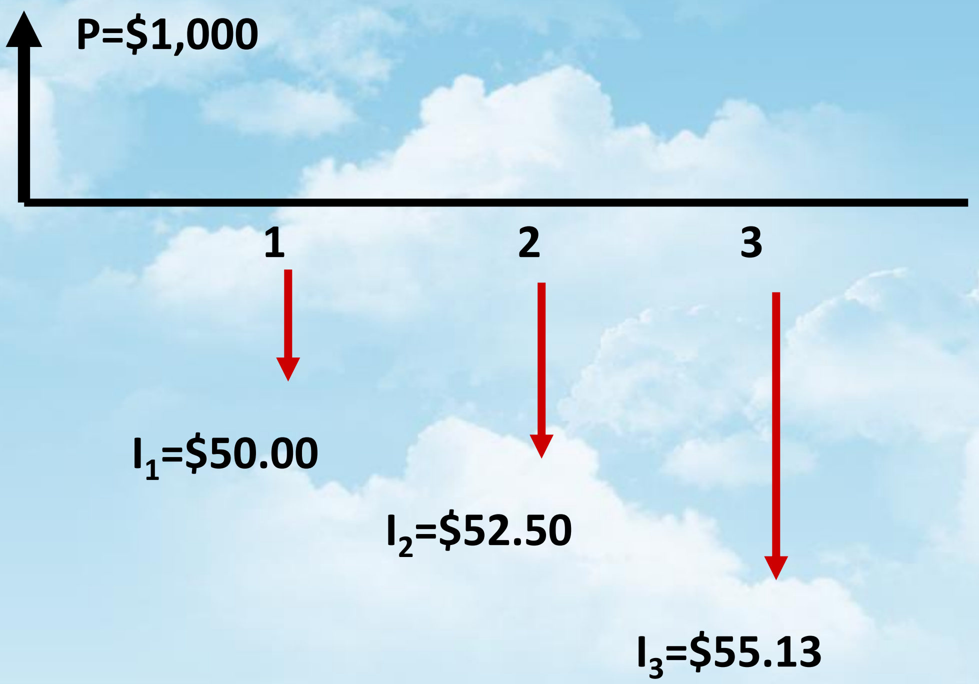
- Because of its origin in the compound-interest calculation, the factor $(1 + i)N$ is known as the compound-amount factor.
- Like the concept of equivalence, this factor is one of the foundations of engineering economic analysis. Given this factor, all other important interest formulas can be derived

Compound Interest: Example

- Assume:
  - P = $1,000
  - i = 5% per year compounded annually (C.A.)
  - N = 3 years

Compound Interest: Cash Flow

- **For compound interest, 3 years, we have:**



<u>Owe at t = 3 years:</u>

$1,000 + 50.00 + 52.50 + 55.13 = <u>$1,157.63</u>

Compound Interest: Calculated

- For the example:
  - P_0 = +$1,000
  - I_1 = $1,000(0.05) = $50.00
  - Owe P_1 = $1,000 + 50 = $1,050 (but we don't pay yet!)
  - New Principal sum at end of t = 1: = $1,050.00

Compound Interest: t = 2

- Principal and end of year 1: $1,050.00
- I_2 = $1,050(0.05) = $52.50 (owed but not paid)
- Add to the current unpaid balance yields:
  - $1,050 + 52.50 = $1,102.50
  - New unpaid balance or New Principal Amount
- Now, go to year 3…….

Compound Interest: $t = 3$

- New Principal sum: \$1,102.50
- I_3 = \$1102.50(0.05) = \$55.125 = \$55.13
- Add to the beginning of year principal yields:
    - \$1102.50 + 55.13 = \$1157.63
    - This is the loan payoff at the end of 3 years
- Note how the interest amounts were added to form a new principal sum with interest calculated on that new amount

Compound Interest: t = 3

- Using the formula
  - $F_N = P(1 + i)^N$
- Where P= 1000
- I = 5 %
- N= 3 years and substituting in the formula we obtain
- $F_3 = 1000(1+0.5)^3$

- $F_3 = 1000^* (1.0.5)^3$
- $F_3 = 1000^* (1.0.5)^3$
- $F_3 = 1000^*\ 1.157625 = 1157.625$

Interest Calculation: Basic Symbols

Terminology and Symbols

Specific symbols and their respective definitions have been developed for use in engineering economy.

Terminology and Symbols

- i = interest rate or rate of return per time period; percent per year, percent per month
- t = time, stated in periods; years, months, days, etc
- n = number of interest periods; years, months, days

Terminology and Symbols

P = value or amount of money at a time designated as the present or time 0.

- Also, P is referred to as
  - Present Worth (PW),
  - Present Value (PV),
  - Net Present Value (NPV),
  - Discounted Cash Flow (DCF), and
  - Capitalized Cost (CC); dollars

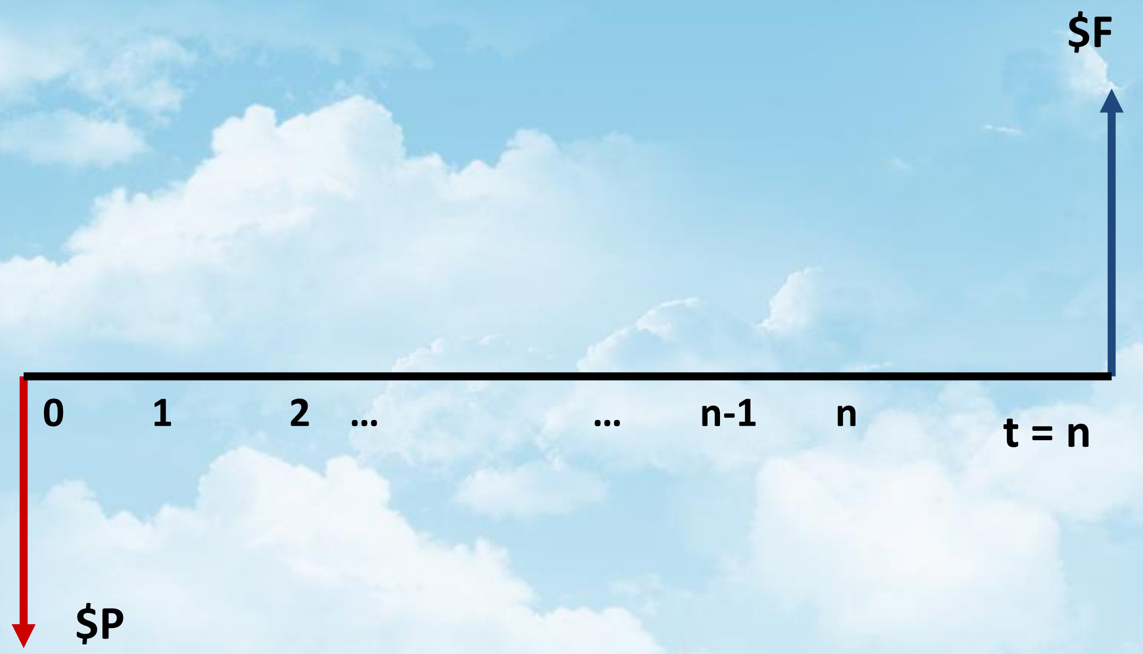
Terminology and Symbols

F = value or amount of money at some future time.

- Also, F is called
  - Future worth (FW) and
  - Future value (FV); dollars

P and F

- The symbols P and F represent one-time occurrences:
- Specifically:



P and F:

- It should be clear that a present value P represents a single sum of money at some time prior to a future value F
- This is an important basic point to remember

Terminology and Symbols

A = series of consecutive, equal, end-of-period amounts of money.

- Also, A is called the
  - Annual worth (AW) and
  - Equivalent uniform annual worth (EUAW); dollars per year, dollars per month

Annual Amounts

- It is important to note that the symbol A always represents a uniform amount (i.e., the same amount each period) that extends through consecutive interest periods.

Annual Amounts

Cash Flow diagram for annual amounts might look like the following:

A = equal, end of period cash flow amounts

Interest Rate – i% per period

- The interest rate *i* is assumed to be a compound rate, unless specifically stated as "simple interest"
- The rate *i* is expressed in percent per interest period; for example, 12% per year.

Terminology and Symbols

For many engineering economy problems:

- Involve the dimension of time
- At least 4 of the symbols { P, F, A, i% and n }
- At least 3 of 4 are either estimated or assumed to be known with certainty.

Representing Money Flows
The Cash Flow Diagram

Money-time relation and cash flow

- The time value of money is an important factor in economic consideration of projects. This is particularly crucial for long-term projects that are subject to changes in several cost parameters.
- Both the timing and quantity of cash flow are important for project management

Money-time relation and cash flow

- Many types of transactions involve interest-e.g., borrowing money, investing money, or purchasing machinery on credit-but certain elements are common to all of these types of transactions:
  - The initial amount of money invested or borrowed in transactions is called the principal (P).
  - The interest rate (i) measures the cost or price of money and is expressed as a percentage per period of time.

Money-time relation and cash flow

– A period of time called the interest period (n) determines how frequently interest is calculated.
  - (Note that, even though the length of time of an interest period can vary, interest rates are frequently quoted in terms of an annual percentage rate.

– A specified length of time marks the duration of the transaction and thereby establishes a certain number of interest periods (N).

Money-time relation and cash flow

- Problems involving the time value of money can be conveniently represented in graphic form with a cash flow diagram.
- Cash flow diagrams represent time by a horizontal line marked off with the number of interest periods specified.
- Arrows represent the cash flows over time at relevant periods:

Money-time relation and cash flow

- Upward arrows represent positive flows (receipts), and downward arrows represent negative flows (disbursements).
  - Note, too. that the arrows actually represent net cash flows: Two or more receipts or disbursements made at the same time are summed and shown as a single arrow (Net value)

Money-time relation and cash flow

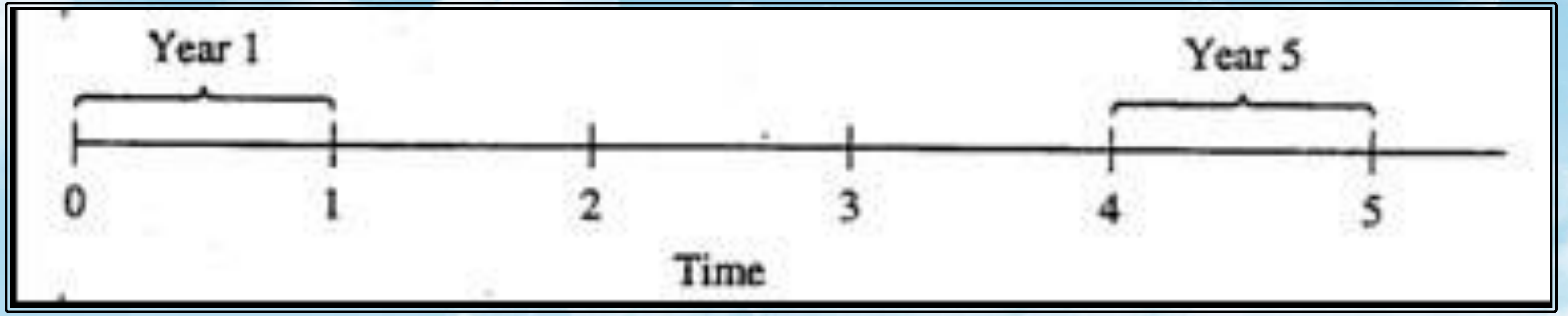
- Cash flow diagrams function in a manner similar to free-body diagrams, which most engineers frequently use.
- Cash flow diagrams give a convenient summary of all the important elements of a problem as well as serve as a reference point for determining whether the elements of a problem have been converted into their appropriate parameters

The Cash Flow Diagram: CFD

The Cash Flow Diagram is an extremely valuable analysis tool and is the first step in the solution process. It is a graphical Representation on a time scale. The cash flow diagram does not have to be drawn "to exact scale" but should be neat and properly labeled

Example Cash Flow diagrams

- Assume a 5-year problem
- The basic time line is shown below



- “Now” is denoted as t = 0

Displaying Cash Flows

A sign convention is applied

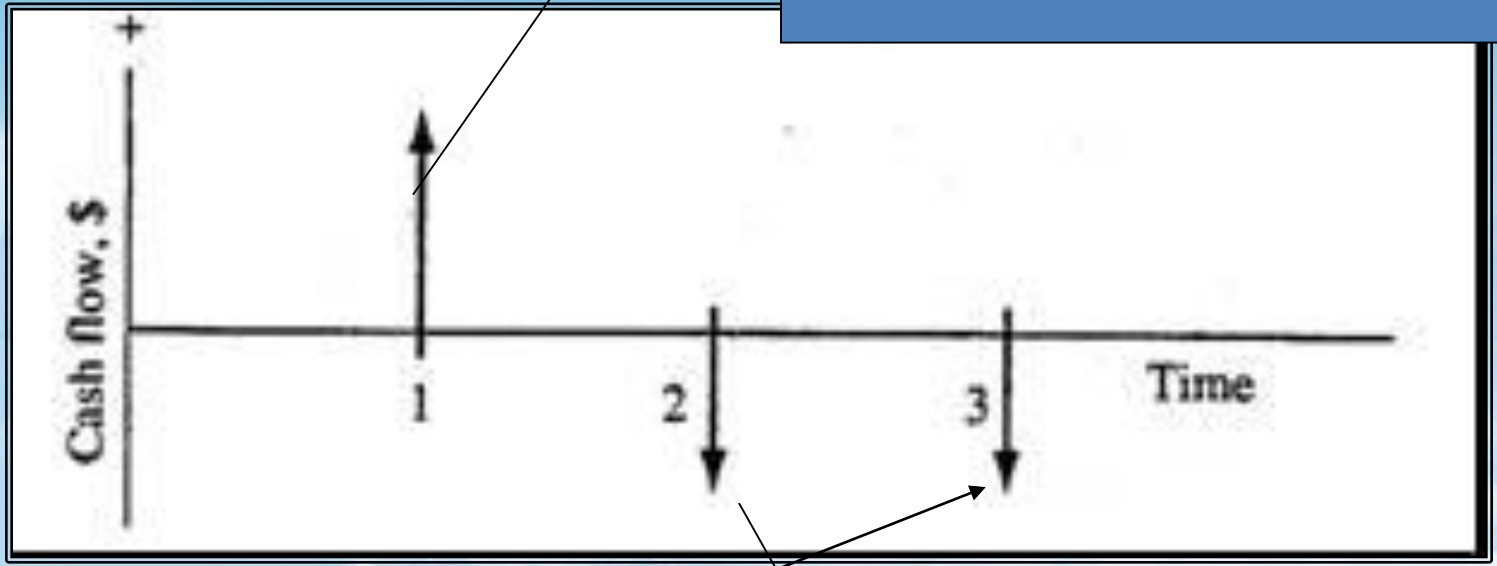
- Positive cash flows are normally drawn upward from the time line
- Negative cash flows are normally drawn downward from the time line

Displaying Cash Flows

The values (magnitude and timing) of estimated flows of money coming into the firm or going out are shown.

- –Revenues, Savings, salvage values, etc, positive cash flows
- –investment costs, operating costs, taxes paid, Disbursements, First costs of assets, labor salaries, taxes paid, utilities, rents, interest, etc – negative cash flows

Sample CF Diagram



Positive CF at t = 1

Negative CF’s at t = 2 & 3

Problem Perspectives

Before solving, one must decide upon the perspective of the problem

- Most problems will present two perspectives
- Assume a borrowing situation; for example:
  - Perspective 1: From the lender's view
  - Perspective 2: From the borrower's view
  - Impact upon the sing convention

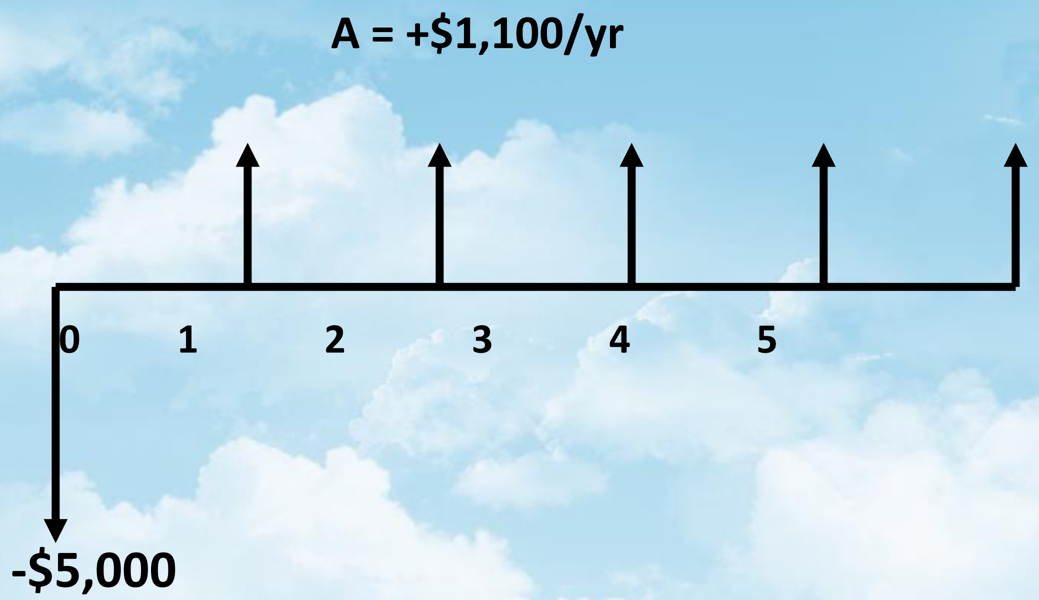
Lending – Borrowing Example

Assume \$5,000 is borrowed and payments are \$1,100 per year.

- Draw the cash flow diagram for this
  - First, whose perspective will be used?
  - Lender’s or the Borrower’s ? ? ?
  - Problem will “infer” or you must decide….

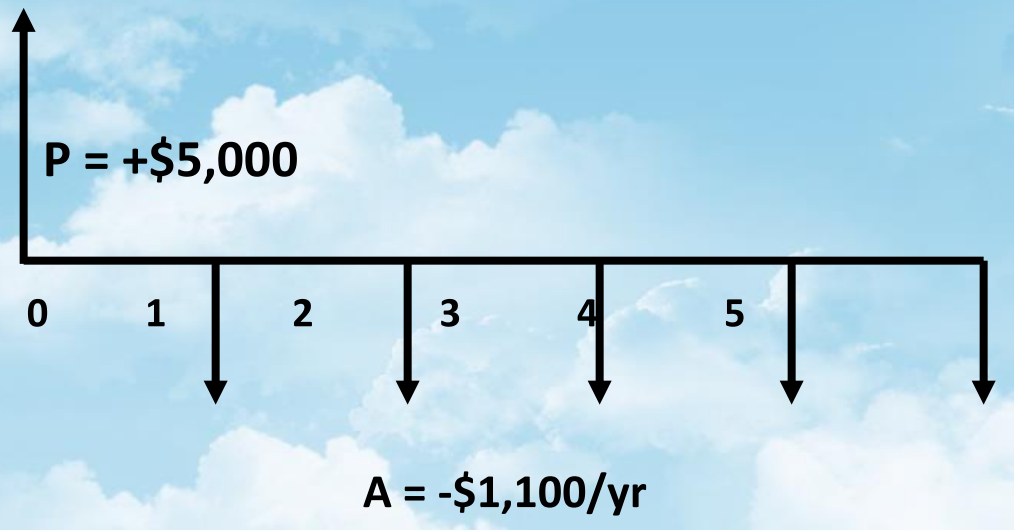
Lending – Borrowing

From the Lender's Perspective



Lending - Borrowing

From the Borrower's Perspective



Types of Cash Flows

Money-time relation and cash flow

- Cash flow can come as
  - Single payment
  - Uniform payment series
  - Linear and geometric gradient
  - Irregular payment series
- Over the life time of a project
- Since the cash flows are related to time the concept of interest becomes important

Cash Flows Diagram Assumptions

- All cash flows are assumed to occur at the END of a given time period (at the end of an interest period) :(End-of-Period Assumption)
  - All cash flows are assumed to occur at even if the money flows at times within the interest period.
- Cash flows are taken as NET CASH FLOW at a given period,: Cash Inflows – Cash Outflows

The Five Types of Cash Flows

(a) Single cash flow

1. single payment compound amount factor
2. single payment present worth factor

(a) Equal (uniform) payment series

1. compound amount factor
2. sinking - fund
3. present worth
4. capital recovery

(a) Linear gradient series

(b) Geometric gradient series

(c) Irregular payment series

Diagrammatic Representation of the Five Types of Cash Flows

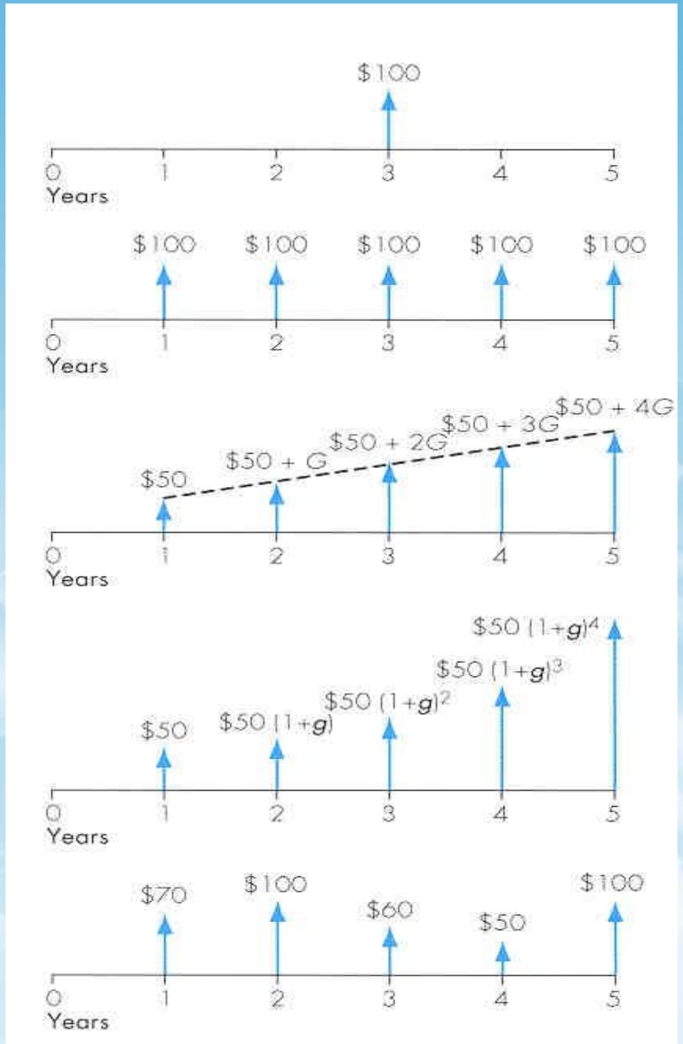
(a) Single cash flow

(b) Equal (uniform) payment series

(c) Linear gradient series

(d) Geometric gradient series

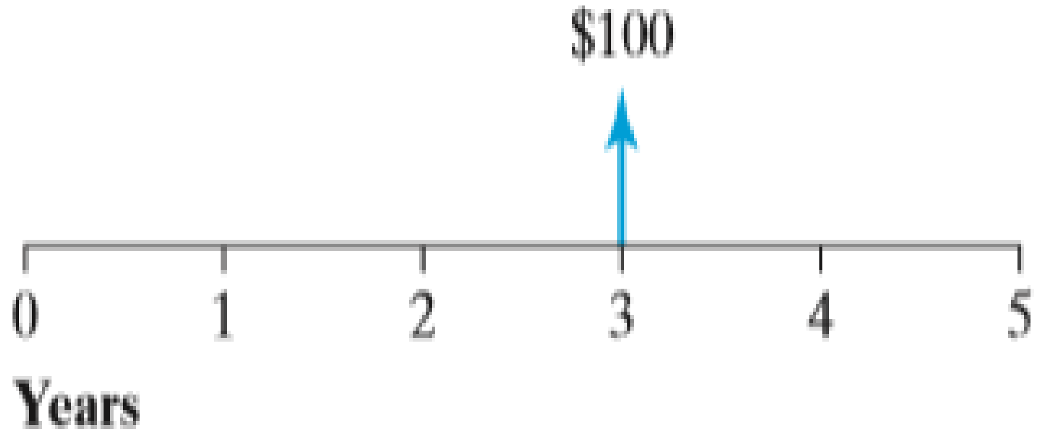
(e) Irregular payment series



Cash Flow Calculation Expressions

Single Cash Flow

- Single Cash Flow: The simplest case involves the equivalence of a single present amount and its future worth. Thus, the single-cash-flow formulas deal with only two amounts: a single present amount P and its future worth F



(a) Single cash flow

Single Cash Flow Formula
Given P find F

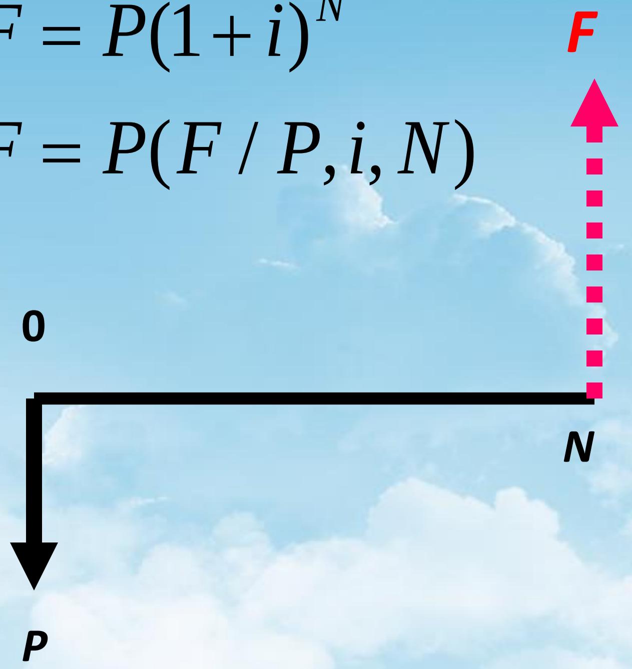
- Single payment -compound amount factor (growth factor)
- Given:

$$i = 10\%$$
$$N = 8 \text{ years}$$
$$P = \$2{,}000$$

- Find:

$$F = \$2{,}000(1 + 0.10)^8$$
$$= \$2{,}000(F / P, 10\%, 8)$$
$$= \$4{,}287.18$$

$$F = P(1+i)^N$$
$$F = P(F / P, i, N)$$

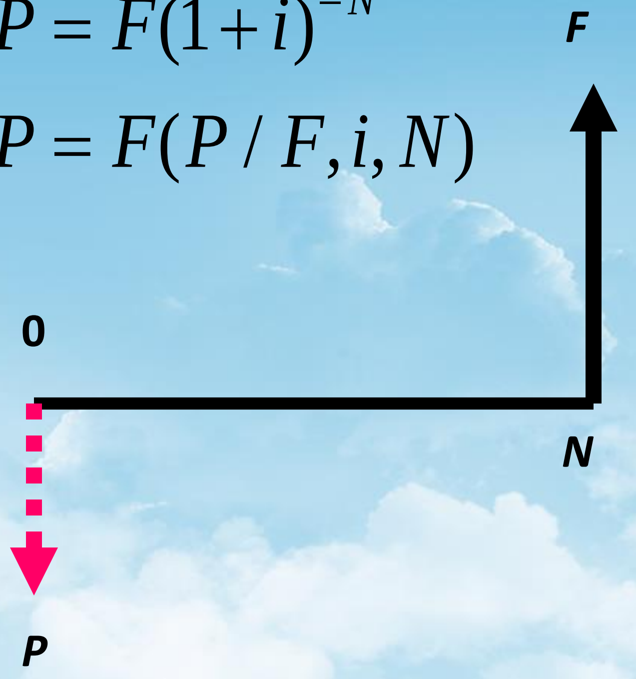


Single Cash Flow Formula
Given F find P

- Single payment present worth factor (discount factor)
- Given:
- Find:

$$P = F(1+i)^{-N}$$

$$P = F(P/F, i, N)$$

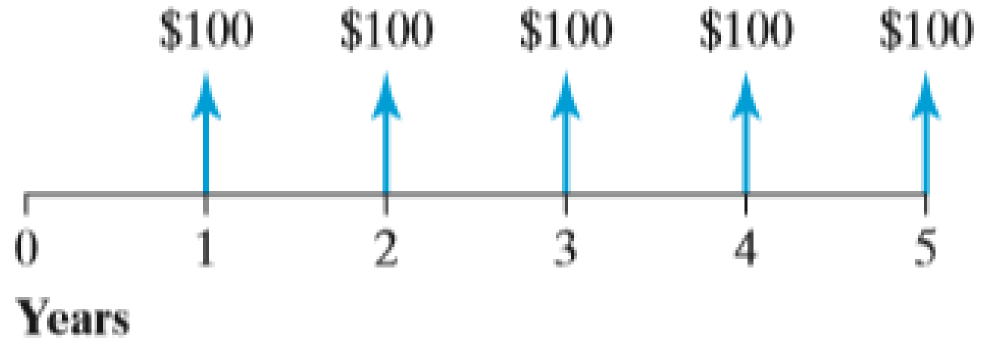


$$i = 12\%$$
$$N = 5 \text{ years}$$
$$F = \$1{,}000$$

$$\begin{aligned} P &= \$1{,}000(1+0.12)^{-5} \\ &= \$1{,}000(P/F, 12\%, 5) \\ &= \$567.40 \end{aligned}$$

Equal (Uniform) Series

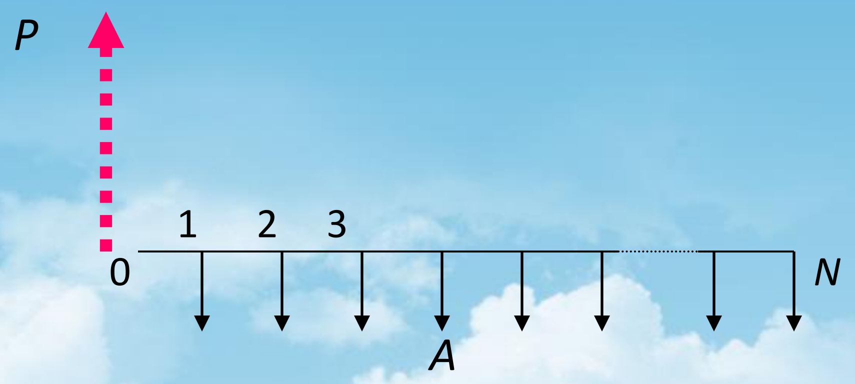
- Equal (Uniform) Series: Probably the most familiar category includes transactions arranged as a series of equal cash flows at regular intervals, known as an equal payment series (or uniform series)
  - For example, this category describes the cash flows of the common installment loan contract, which arranges the repayment of a loan in equal periodic installments. The equal-cash-flow formulas deal with the equivalence relations P, F, and A (the constant amount of the cash flows in the series).



(b) Equal (uniform) payment series at regular intervals

EQUAL PAYMENT SERIES PRESENT WORTH FACTOR

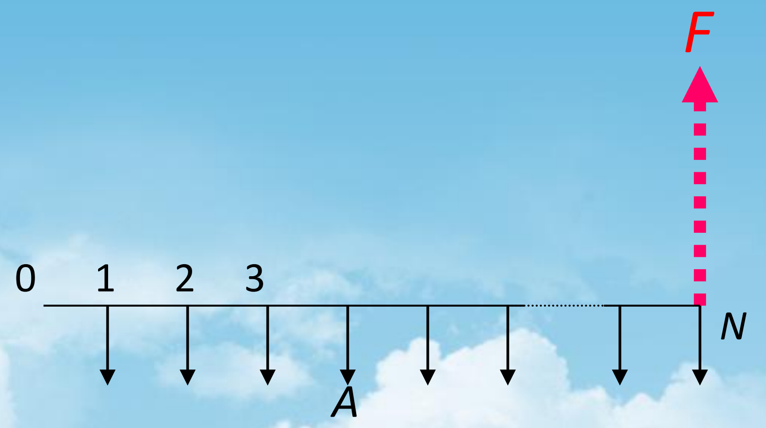
PRESENT WORTH: THE EQUIVALENT VALUE AT THE PRESENT, BASED ON *TIME VALUE OF MONEY*.



$$P = A\frac{(1+i)^N - 1}{i(1+i)^N}$$
$$= A(P/A, i, N)$$

- Given: A = \$32,639, N = 9 years, and i = 8%
- Find: P
- Solution: P = \$32,639(P/A,8%,9) = \$203,893

EQUAL PAYMENT SERIES COMPOUND AMOUNT FACTOR



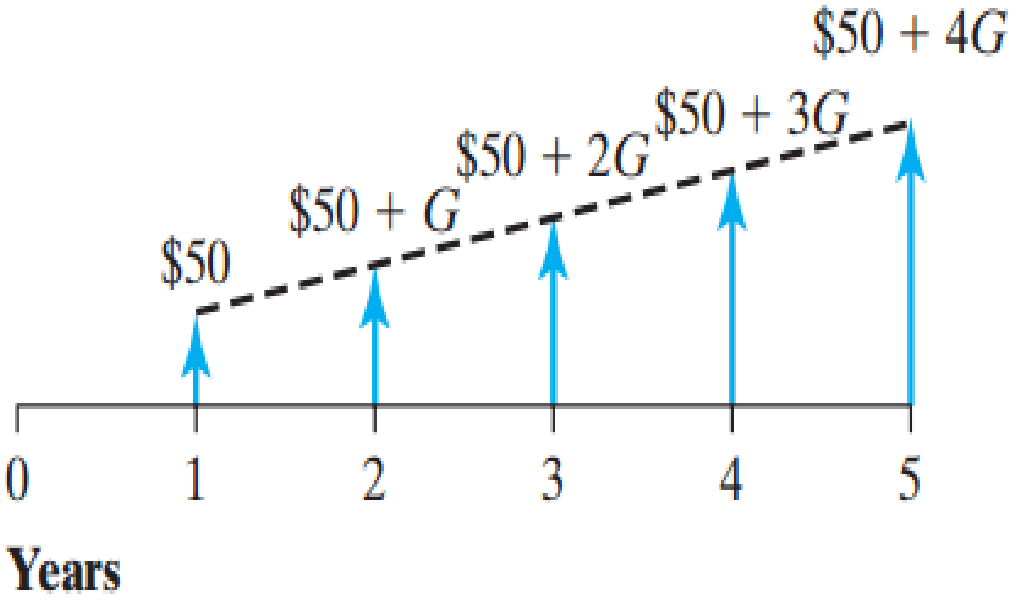
$$F = A\frac{(1+i)^N - 1}{i}$$
$$= A(F/A,i,N)$$

- Given: A = \$3,000, N = 10 years, and i = 7%
- Find: F
- Solution: F = \$3,000(F/A,7%,10) = \$41,449.20

Linear Gradient Series

Linear Gradient Series:

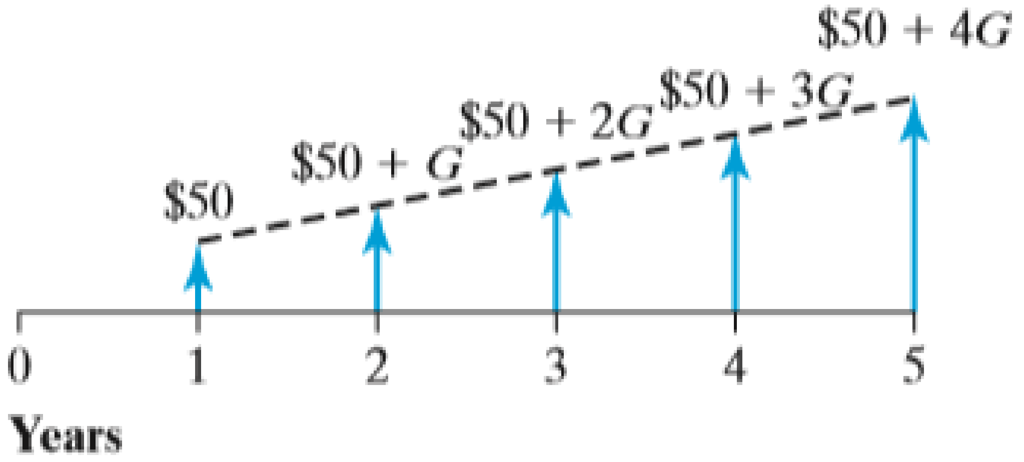
- While many transactions involve series of cash flows, the amounts are not always uniform; they may, however, vary in some regular way. One common pattern of variation occurs when each cash flow in a series increases (or decreases) by a fixed amount . A five-year loan repayment plan might specify, for example, a series of annual payments that increase by $500 each year. We call this type of cash flow pattern a ***linear gradient series*** because its cash flow diagram produces an ascending (or descending) straight line,
- In addition to using *P*, *F*, and *A*, the formulas employed in such problems involve a *constant amount G* of the change in each cash flow



(c) Linear gradient series, where each cash flow in the series increases or decreases by a fixed amount *G*

Linear Gradient Series

- Sometimes cash flows will vary linearly, that is, they increase or decrease by a set amount, G, the gradient amount.
- This type of series is known as a strict gradient series, as seen in the following .
  - Note that each payment is A, = *(n - 1)G.*
  - *Note* also that the series begins with a zero cash flow at the end of period zero. If G > 0.
- the series is referred to as an *increasing gradient series. If G < 0, it is referred to* as a *decreasing gradient series*



(c) Linear gradient series, where each cash flow in the series increases or decreases by a fixed amount *G*

Linear Gradient Series

- the form in which we find a typical cash flow can be separated into two components: a uniform series of N payments of amount *A, and a gradient series* of increments of a constant amount G.
- The need to view cash flows that involve linear gradient series as composites of two series is very important for the solution of problems, as we shall now see.

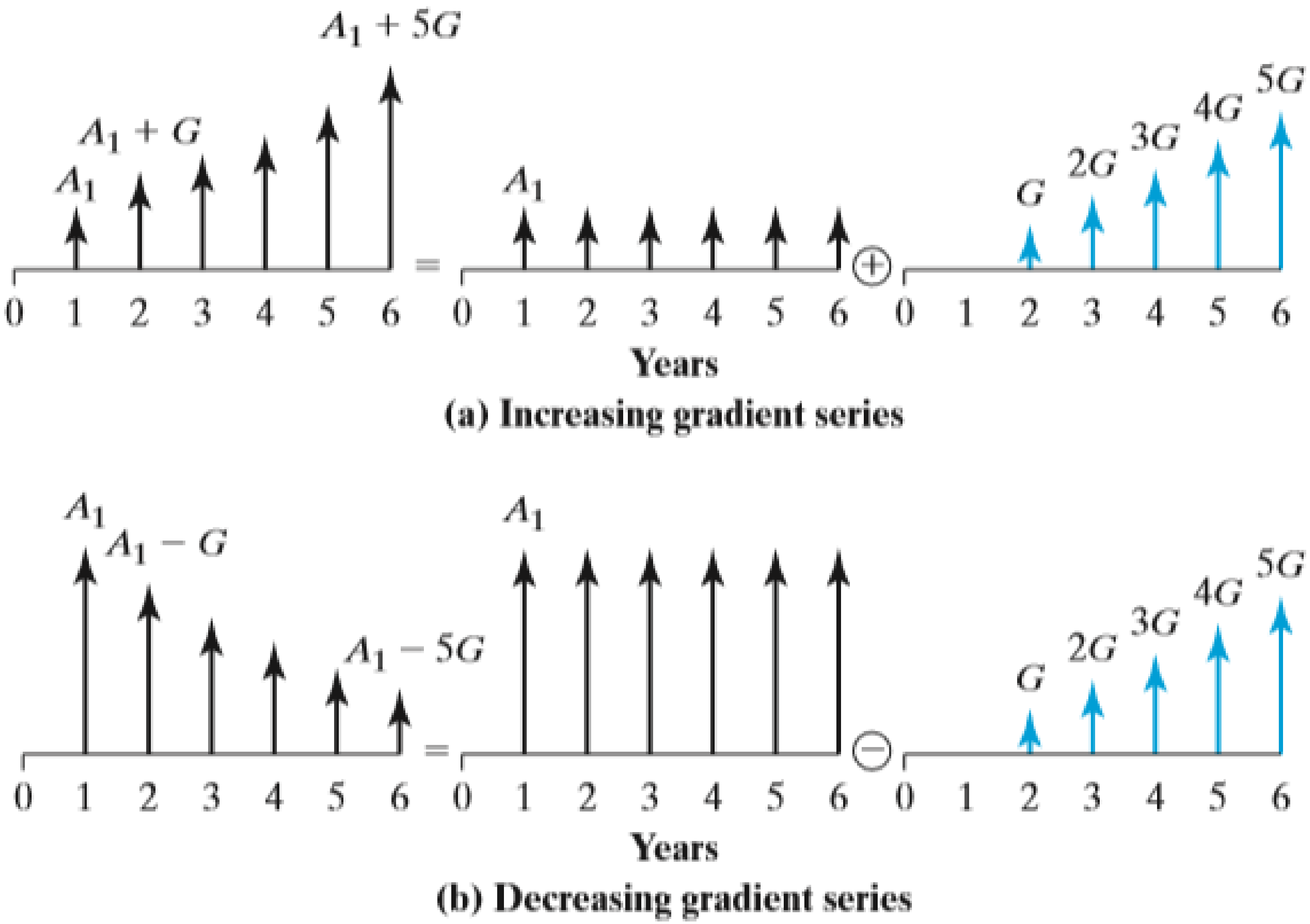
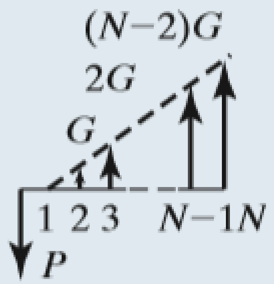


Figure 3.28 Two types of linear gradient series as composites of a uniform series of N payments of A_1 and the gradient series of increments of constant amount G.

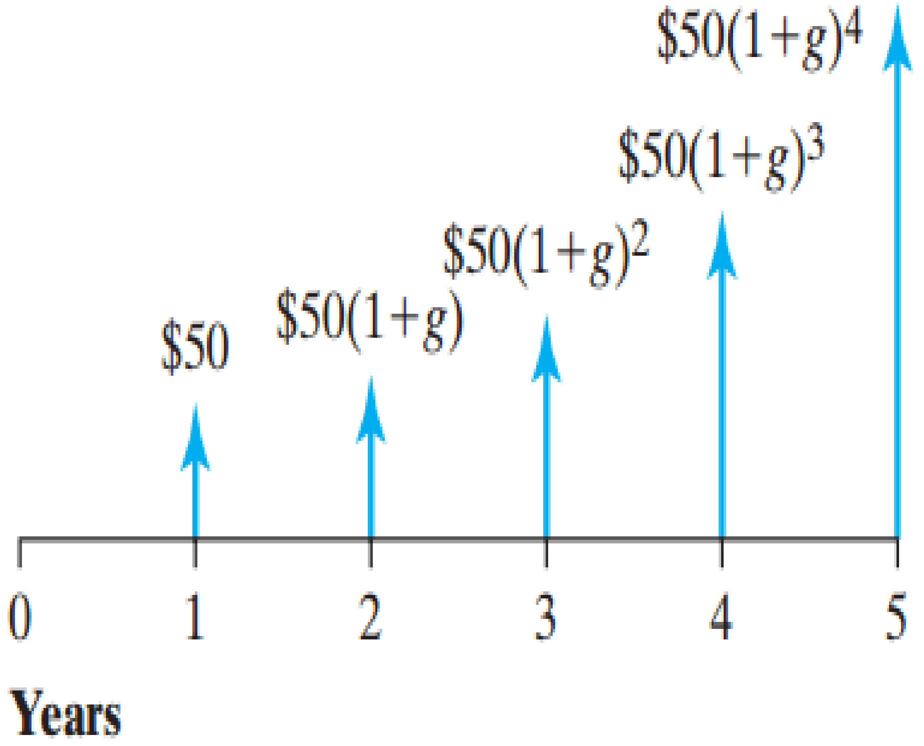
Linear Gradient Series

Linear gradient		
Present worth $(P/G, i, N)$	$P = G\left[\dfrac{(1+i)^N - iN - 1}{i^2(1+i)^N}\right]$	
Conversion factor $(A/G, i, N)$	$A = G\left[\dfrac{(1+i)^N - iN - 1}{i[(1+i)^N - 1]}\right]$	

Geometric Gradient Series

Geometric Gradient Series

- Another kind of gradient series is formed when the series in a cash flow is determined not by some fixed amount like $500, but by some fixed *rate*, expressed as a percentage. For example, in a five-year financial plan for a project, the cost of a particular raw material might be budgeted to increase at a rate of 4% per year. The curving gradient in the diagram of such a series suggests its name: a ***geometric gradient series***. In the formulas dealing with such series, the rate of change is represented by a lowercase *g*



(d) Geometric gradient series, where each cash flow in the series increases or decreases by a fixed rate (percentage) *g*

Geometric Gradient Series

- Another kind of gradient series is formed when the series in a cash flow is determined not by some fixed amount like *\$500, but by some fixed rate expressed as a* percentage.

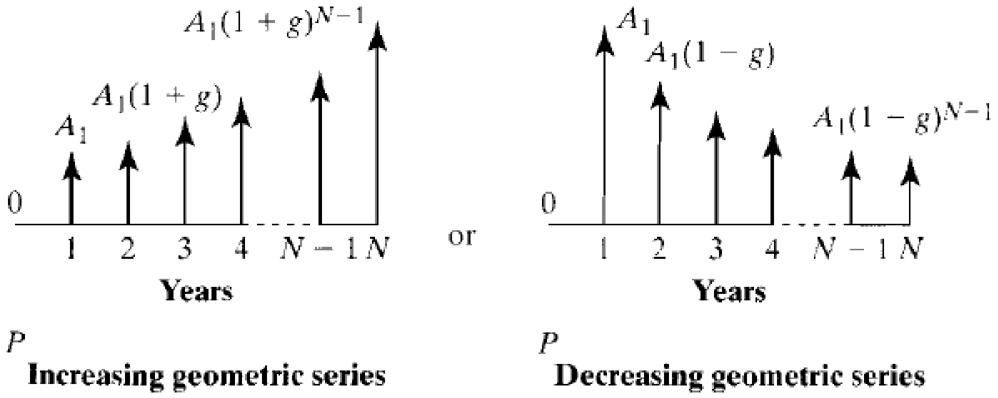
Geometric Gradient Series

- Many engineering economic problems, particularly those relating to construction costs or maintenance costs, involve cash flows that increase or decrease over time by a constant percentage (geometric), a process that is called compound growth.
  - *Price changes caused by inflation are a good example of such a geometric series.*
- If we use *g to designate the percentage change in a payment from one period* to the next, the magnitude of the nth payment. A_n *is related to the first payment* A_1 as follows:

Geometric Gradient Series

To find an expression for the present amount for the entire series, P, we apply the **single-payment present-worth factor** to each term of the series:

$$P = \sum_{n=1}^{N} A_1(1 + g)^{n-1}(1 + i)^{-n}. \tag{2.15}$$



$$P = \begin{cases} A_1 \dfrac{1-(1+g)^N(1+i)^{-N}}{i-g}, \text{if } i \neq g; \\ A_1 \dfrac{N}{(1+i)}, \text{if } i = g \end{cases}$$

A geometrically increasing or decreasing gradient series

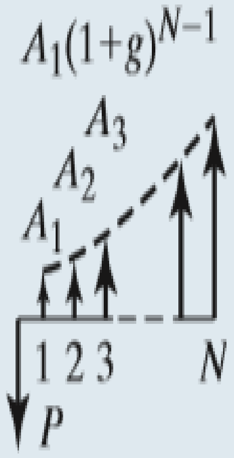
Geometric Gradient Series

Geometric gradient

Present worth

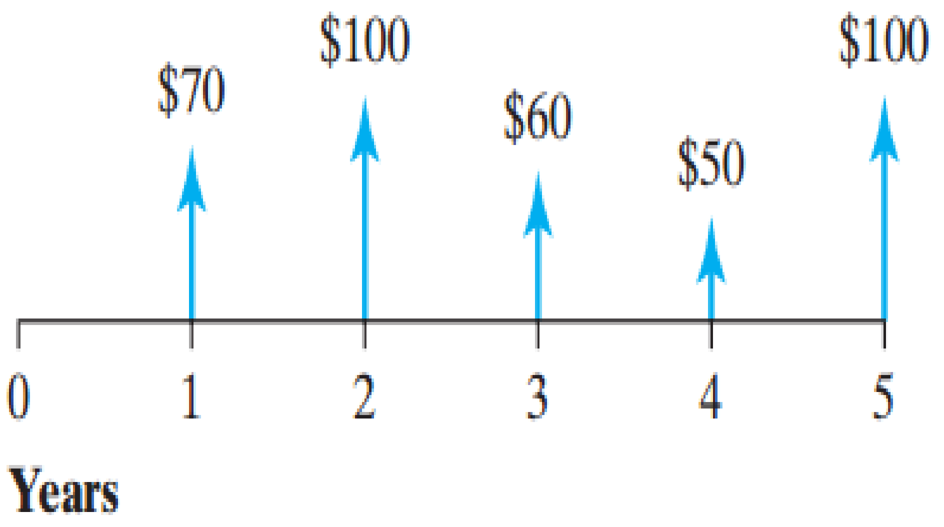
$(P/A_1, g, i, N)$

$$P = \begin{bmatrix} A_1\left[\dfrac{1-(1+g)^N(1+i)^{-N}}{i-g}\right] \\ A_1\left(\dfrac{N}{1+i}\right)(\text{if } i = g) \end{bmatrix}$$



Irregular (Mixed) Series:

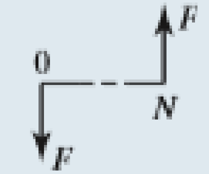
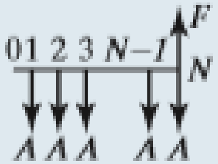
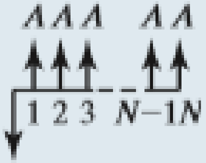
- Finally, a series of cash flows may be irregular, in that it does not exhibit a regular overall pattern. Even in such a series, however, one or more of the patterns already identified may appear over segments of time in the total length of the series.
- The cash flows may be equal, for example, for 5 consecutive periods in a 10-period series. When such patterns appear, the formulas for dealing with them may be applied and their results included in calculating an equivalent value for the entire series

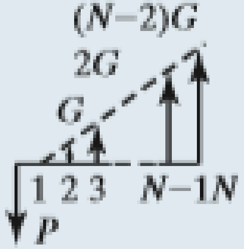


(e) Irregular payment series, which exhibits no regular overall pattern

Other Expressions

TABLE 3.4 Summary of Discrete Compounding Formulas with Discrete Payments

Flow Type	Factor Notation	Formula	Excel Command	Cash Flow Diagram
SINGLE	Compound amount $(F/P, i, N)$	$F = P(1+i)^N$	$=\text{FV}(i, N, P,, 0)$	
	Present worth $(P/F, i, N)$	$P = F(1+i)^{-N}$	$=\text{PV}(i, N, F,, 0)$	
EQUAL PAYMENT SERIES	Compound amount $(F/A, i, N)$	$F = A\left[\dfrac{(1+i)^N - 1}{i}\right]$	$=\text{PV}(i, N, A,, 0)$	
	Sinking fund $(A/F, i, N)$	$A = F\left[\dfrac{i}{(1+i)^N - 1}\right]$	$=\text{PMT}(i, N, P, F, 0)$	
	Present worth $(P/A, i, N)$	$P = A\left[\dfrac{(1+i)^N - 1}{i(1+i)^N}\right]$	$=\text{PV}(i, N, A,, 0)$	
	Capital recovery $(A/P, i, N)$	$A = P\left[\dfrac{i(1+i)^N}{(1+i)^N - 1}\right]$	$=\text{PMT}(i, N,, P)$	

G R A D I E N T	Linear gradient Present worth $(P/G, i, N)$ Conversion factor $(A/G, i, N)$	$P = G\left[\frac{(1+i)^N - iN - 1}{i^2(1+i)^N}\right]$ $A = G\left[\frac{(1+i)^N - iN - 1}{i[(1+i)^N - 1]}\right]$	
S E R I E S	Geometric gradient Present worth $(P/A_1, g, i, N)$	$P = \begin{bmatrix} A_1\left[\frac{1-(1+g)^N(1+i)^{-N}}{i-g}\right] \\ A_1\left(\frac{N}{1+i}\right)(\text{if } i = g) \end{bmatrix}$	

Summary

- Money has a time value because it can earn more money over time. A number of terms involving the time value of money were introduced in the above section
- Interest is the cost of money. More specifically, it is a cost to the borrower and an earning to the lender, above and beyond the initial sum borrowed or loaned.
- Interest rate is a percentage periodically applied to a sum of money to determine the amount of interest to be added to that sum.

Summary

- Simple interest is the practice of charging an interest rate only to an initial sum.
- Compound interest is the practice of charging an interest rate to an initial sum and to any previously accumulated interest that has not been withdrawn from the initial sum. Compound interest is by far the most commonly used system in the real world.
- Economic equivalence exists between individual cash flows and/or patterns of cash flows that have the same value. Even though the amounts and timing of the cash flows may differ, the appropriate interest rate makes them equal.

Summary

- The compound-interest formula, perhaps the single most important equation, is

$$F = P(1+i)^N$$

$$F = P(F/P, i, N)$$

- where P is a present sum, i is the interest rate, N is the number of periods for which interest is compounded, and F is the resulting future sum.
- All other important interest formulas are derived from this one.

Summary

- Cash flow diagrams are visual representations of cash inflows and outflows along a timeline. They are particularly useful for helping us detect which of the following five patterns of cash flow is represented by a particular problem:
  - 1. Single payment. A single present or future cash flow.
  - 2. Uniform series. A series of flows of equal amounts at regular intervals.
  - 3. Linear gradient series. A series of flows increasing or decreasing by a fixed amount at regular intervals.
  - 4. Geometric gradient series. A series of flows increasing or decreasing by a fixed percentage at regular intervals.
  - 5. Irregular series. A series of flows exhibiting no overall pattern. However, patterns might be detected for portions of the series.

Summary

- Cash flow patterns are significant because they allow us to develop interest formulas, which streamline the solution of equivalence problems. Table 3.4 summarizes the important interest formulas that form the foundation for all other analyses you will conduct in engineering economic analysis

Equivalence

Equivalence

Two things are said to be equivalent if they have the same effect.

- For Example if You travel at 68 miles per hour it is Equivalent to travelling at 110 kilometers per hour

Thus using two measuring scales, that is Miles and Kilometers, 68 mph is equivalent to 110 kph.

Equivalence

In this analysis, Is “68” equal to “110”?, not in terms of absolute numbers, but they are “equivalent” in terms of the two measuring scales

- Miles
- Kilometers

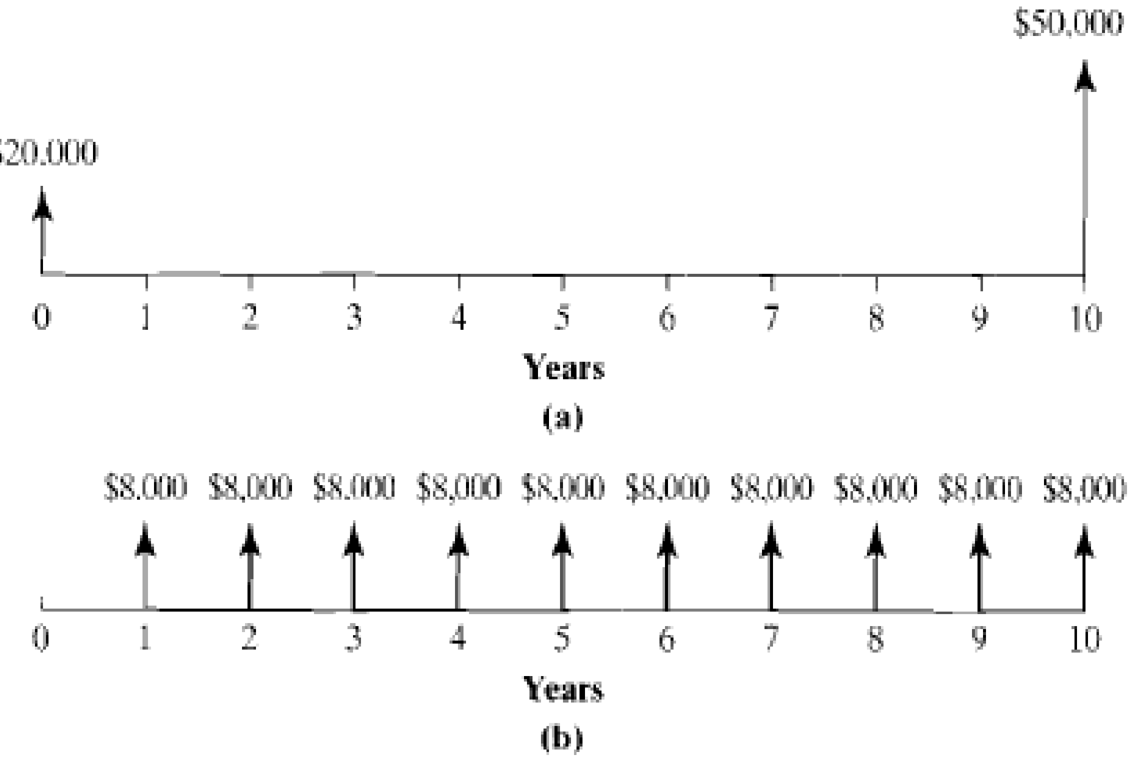
Economic Equivalence

ECONOMIC EQUIVALENCE

- The observation that money has a time value leads us to an important question: If receiving \$100 today is not the same as receiving \$100 at any future point, how do we measure and compare various cash flows'?
  - How do we know, for example, whether we should prefer to have \$20.000 today, and \$50,000 ten years from now or \$8,000 each year for the next 10 years?

Economic Equivalence

- Economic equivalence exists between cash flows that have the *same economic effect* and could therefore be traded for one another
- Even though the amounts and timing of the cash flows may differ, the appropriate interest rate makes them equal



Which option would you prefer? (a) Two payments ($20,000 now and $50,000 at the end of 10 years) or (b) 10 equal annual receipts in the amount of $8,000 each

Economic Equivalence

- The central question in deciding among alternative cash flows involves comparing their economic worth.
- This would be a simple matter if, in the comparison, we did not need to consider the time value of money: We could simply add the individual payments within a cash flow, treating receipts as positive cash flows and payments (disbursements) as negative cash flows.
- The fact that money has a time value, however, makes our calculations more complicated.

Economic Equivalence

- The central factor in deciding among alternative cash flows therefore involves comparing their economic worth.
- If time is not considered as a factor then all individual cash flows will be added (treating receipts as positive cash flows and payments (disbursements) as negative cash flows)
- This will be direct addition or subtraction

Economic Equivalence

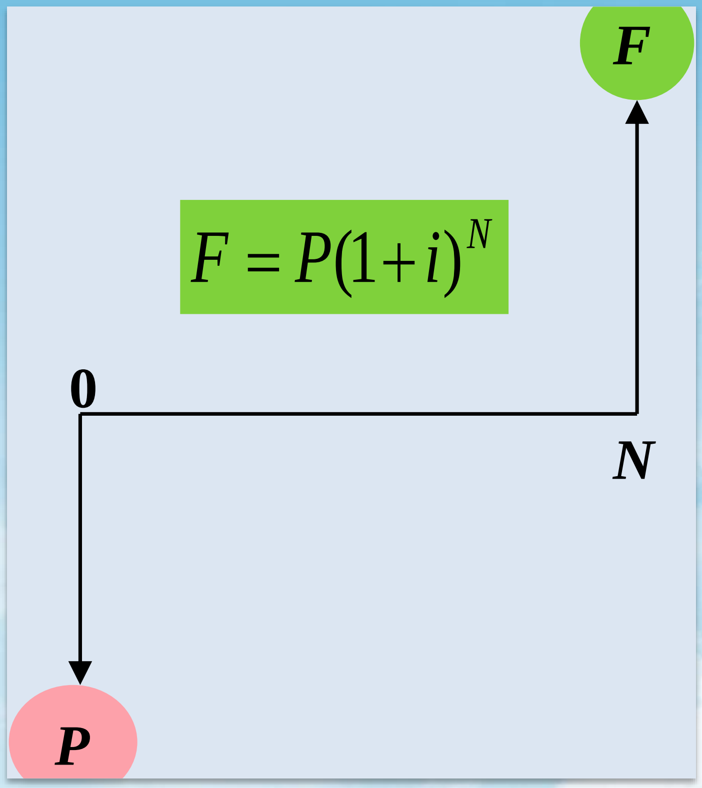
- However the fact that money has a time value makes the calculations more complicated.
- Calculations for determining the economic effects of one or more cash flows are based on the concept of economic equivalence.

Economic Equivalence

- Economic equivalence exists between cash flows that have the same economic effect and could therefore be traded for one another in the financial marketplace, which we assume to exist.
- Economic equivalence refers to the fact that a cash flow whether a single payment or a series of payments-can be converted to an *equivalent cash flow at any point in time.*
  - *The important fact to remember about the* present value of future cash flows is that the present sum is equivalent in value to the future cash flows.

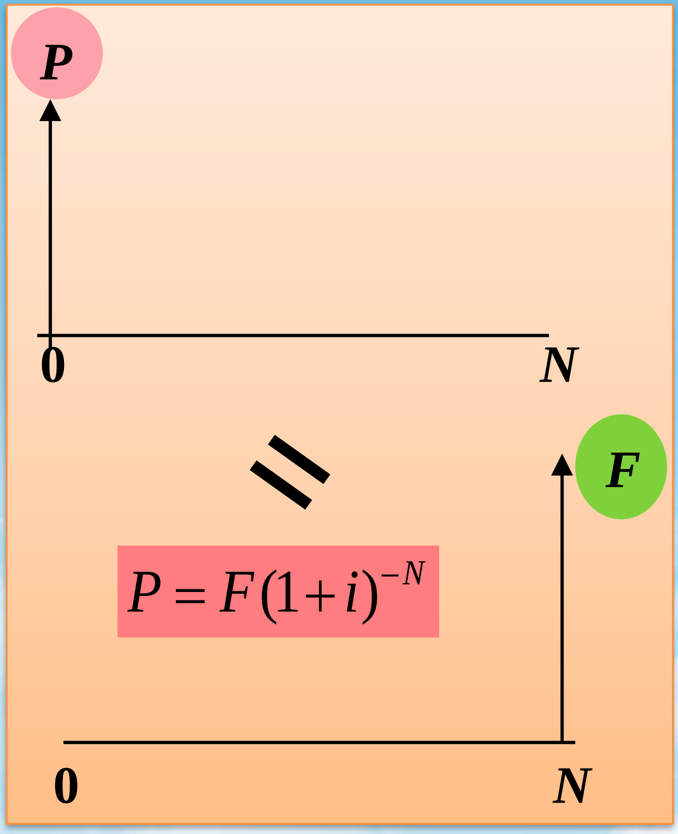
Equivalence Example: Compounding Concept

- If you deposit *P* dollars today for *N* periods at interest rate *i*, you will have *F* dollars at the end of period *N*.



Equivalence – Discounting Concept

- *F* dollars at the end of period *N* is equal to a single sum *P* dollars now, if your earning power is measured in terms of interest rate *i*.



$$P = F(1+i)^{-N}$$

Economic Equivalence

- Suppose you are offered the alternative of receiving either $3,000 at the end of five years or *P* dollars today. There is no question that the $3,000 will be paid in full (no risk). Because you have no current need for the money, you would deposit the *P* dollars in an account that pays 8% interest.
- What value of *P* would make you indifferent to your choice between *P* dollars today and the promise of $3,000 at the end of five years?

Economic Equivalence

- **STRATEGY:** Our job is to determine the present amount that is economically equivalent to $3,000 in five years, given the investment potential of 8% per year.
- Note that the statement of the problem assumes that you would exercise the option of using the earning power of your money by depositing it. The "indifference" ascribed to you refers to economic indifference; that is, in a marketplace where 8% is the applicable interest rate, you could trade one cash flow for the other

SOLUTION

Given: $F = \$3{,}000$, $N = 5$ years, and $i = 8\%$ per year.
Find: P.

Equation: Eq. (3.3), $F = P(1 + i)^N$.
Rearranging terms to solve for P gives

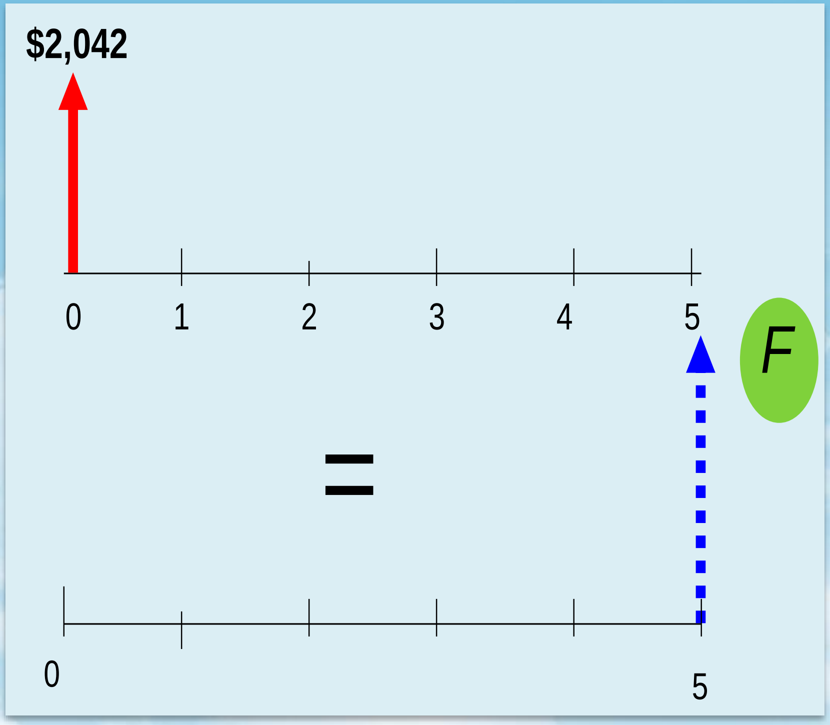
$$P = \frac{F}{(1 + i)^N}.$$

Substituting yields

$$P = \frac{\$3{,}000}{(1 + 0.08)^5} = \$2{,}042.$$

Equivalence Example 3.3

- **Given**: If you deposit $2,042 today in a savings account that pays an 8% interest annually, how much would you have at the end of 5 years?
- **Find**: At an 8% interest, what is the equivalent worth of $2,042 now in 5 years?

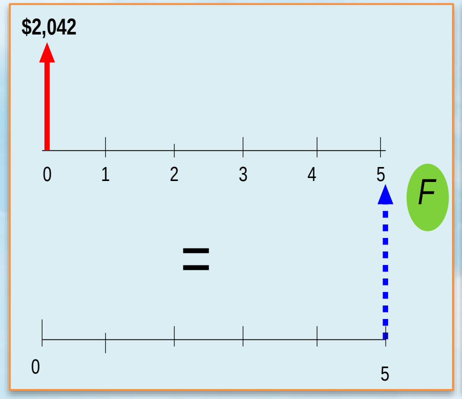


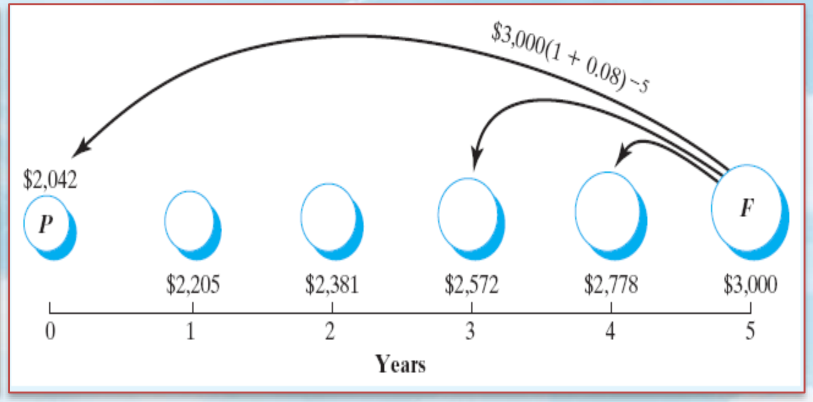
Solution

Various dollar amounts that will be economically equivalent to $3,000 in five years, at an interest rate of 8%

$$F = \$2,042(1 + 0.08)^5 = \$3,000$$

$$P = \frac{\$3,000}{(1 + 0.08)^5} = \$2,042$$

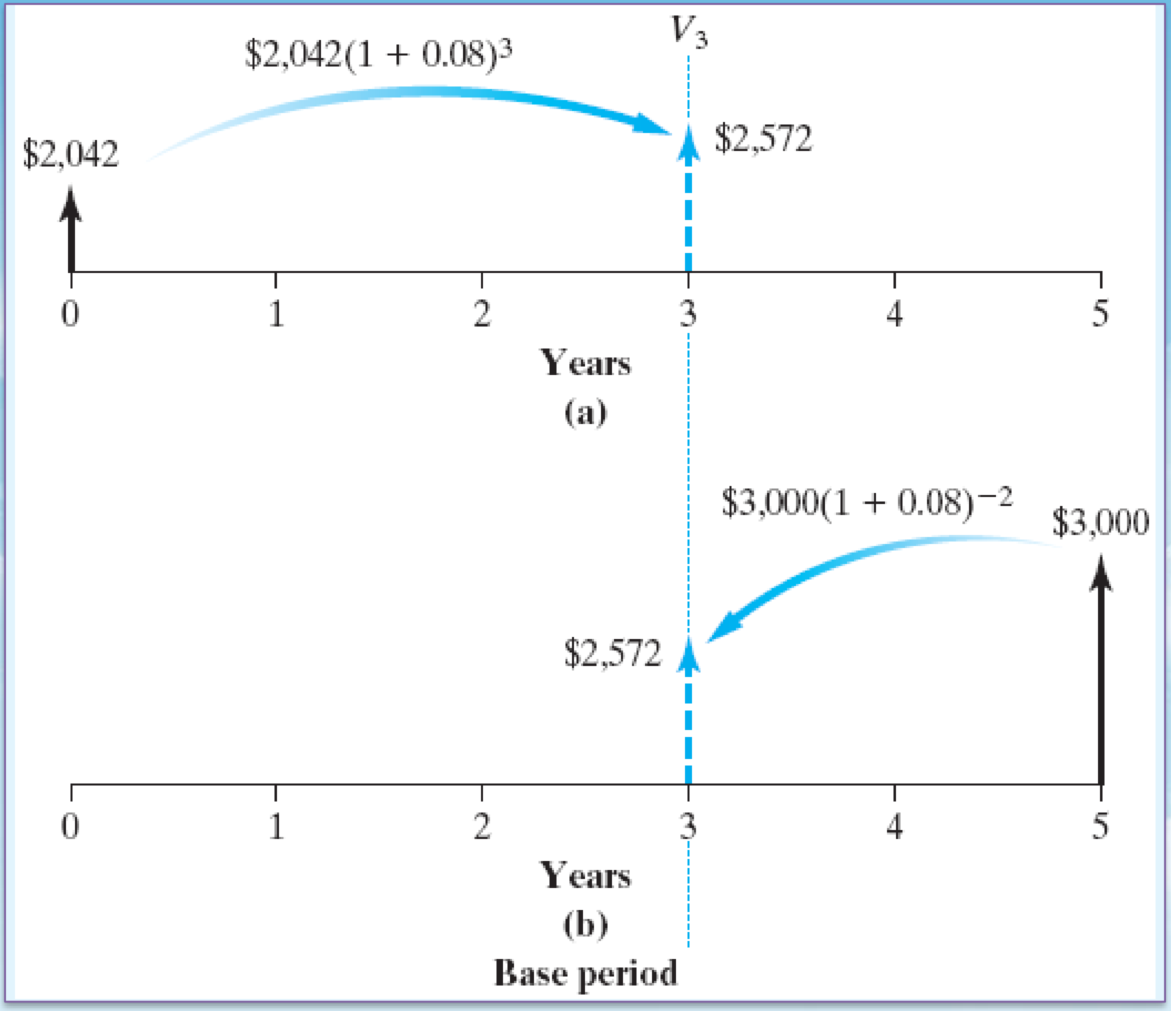




Equivalent Example 3.4: Cash Flows

- Given: \$2,042 today was equivalent to receiving \$3,000 in five years, at an interest rate of 8%.
- Find: Are these two cash flows are also equivalent at the end of year 3?
  - COMMENTS: In this example, it is clear that if *P* is anything less than \$2,042, you would prefer the promise of \$3,000 in five years to *P* dollars today; if *P* is greater than \$2,042, you would prefer *P.*
  - At a lower interest rate, *P* must be higher to be equivalent to the future amount. For example, at i = 4%, P = \$2,466

Solution



- Equivalent cash flows are equivalent at any common point in time, <u>as long as we use the same interest rate</u> (8%, in our example).

Economic Equivalence: Summary

Economic Equivalence

- Calculations for determining the economic effects of one or more cash flows are based on the concept of economic equivalence.
- **Economic equivalence** exists between cash flows that have the same economic effect and could therefore be traded for one another in the financial marketplace, which we assume to exist.
- Economic equivalence refers to the fact that a cash flow—whether a single payment or a series of payments—can be converted to an *equivalent* cash flow at any point in time.
  - For example, we could find the equivalent future value *F* of a present amount *P* at interest rate *I* at period *n*; or we could determine the equivalent present value *P* of *N* equal payments *A*

Economic Equivalence

- The preceding strict concept of equivalence, which limits us to converting a cash flow into another equivalent cash flow, may be extended to include the comparison of alternatives. For example, we could compare the value of two proposals by finding the equivalent value of each at any common point in time.
- If financial proposals that appear to be quite different turn out to have the same monetary value, then we can be *economically indifferent* to choosing between them: In terms of economic effect, one would be an even exchange for the other, so no reason exists to prefer one over the other in terms of their economic value

Economic Equivalence

- In order to completely determine the economic effect of a cash flow one needs to know more than just the size of a payment but also :
  - The magnitude of the payment.
  - The direction of the payment: Is it a receipt or a disbursement?
  - The timing of the payment: When is it made?
  - The interest rate in operation during the period under consideration.

  It follows that, to assess the economic impact of a series of payments, we must consider the impact of each payment individually

Equivalence Numerical Examples

Worked Example 2

- The ABC Company deposited $100 000 in a bank account on June 15 and withdrew a total of $115 000 exactly one year later. Compute:
  - (a) the *interest* which the ABC Company received from the $100 000 investment, and
  - (b) the annual *interest rate* which the ABC Company was paid

Worked Example 2

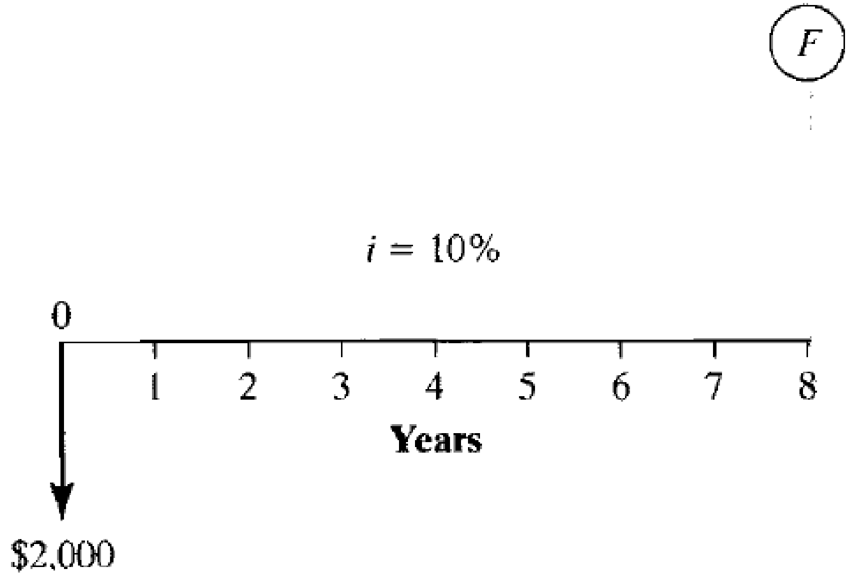
- Determine the principal that would have to be invested to provide $200 of simple interest income at the end of two years if the annual interest rate is 9%

Worked Example 2

- Solution
  - I=200
  - I= niP
  - 200= 0.09*2*P
  - =P= 200/90.09*2)
  - P=1111.11

Equivalence

If you had \$2,000 now and invested it at 10% interest compounded annually, how much would it be worth in eight years (Figure 2.8)?



Cash flow diagram

Equivalence

- Given:
  - –P = \$2,000,
  - –i = 10% per year, and
  - –N = 8 years.
- Find: F.
- We can solve this problem as follows :

$$F = \$2,000(1 + 0.10)^8$$

$$F = \$4,287.18.$$

Equivalence

- The compounding and discounting processes are reciprocals of one another and that we have been dealing with one equation in two forms:
  - Future-value form: $F = P(1 + i)^N$ and
  - Present-value form: $P = F(1 + i)^{-N}$
- There are four variables in these equations: P, F. N, and i. If the values of any three are known then the value of the fourth can be found.

Compound-Amount Factor:
Find F, Given A, *i, and W*

Compound-Amount Factor: Find F, Given A, *i, and W*

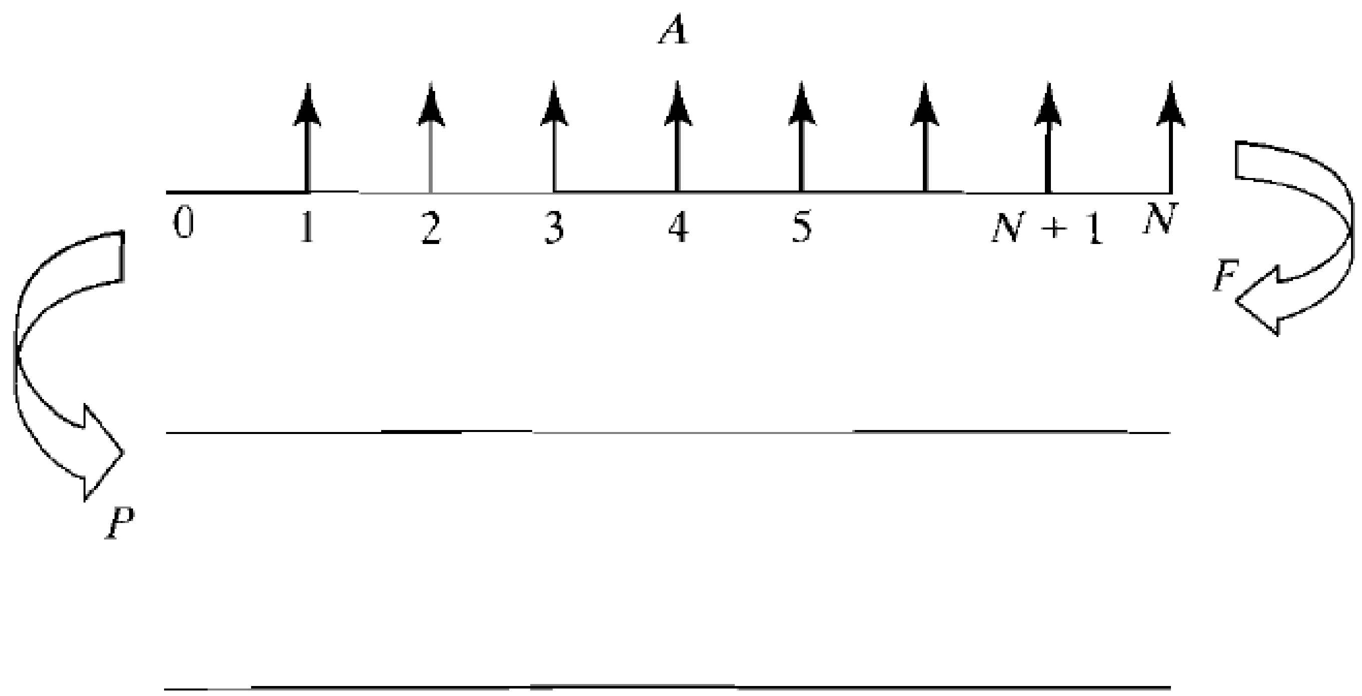
- Suppose we are interested in the future amount F of a fund to which we contribute A dollars each period and on which we earn interest at a rate of *i* per period.
- The contributions are made at the end of each of the N periods.

Compound-Amount Factor: Find F, Given A, *i, and W*

- These transactions are graphically illustrated in Figure 2.15. Looking at this diagram, we see that, if an amount A is invested at the end of each period for N periods, the total amount *F* that can be withdrawn at the end of *N periods will be the sum of the compound* amounts of the individual deposits

Compound-Amount Factor: Find F, Given A, *i, and N*

2-5 Equal-Payment Series



Equal payment series: Find equivalent *P* or *F*

Compound-Amount Factor: Find F, Given A, *i, and N*

As shown in Figure 2.15, the A dollars we put into the fund at the end of the first period will be worth $A(1+i)^{N-1}$ at the end of N periods. The A dollars we put into the fund at the end of the second period will be worth $A(1+i)^{N-2}$, and so forth. Finally, the last A dollars that we contribute at the end of the N^{th} period will be worth exactly A dollars at that time. This means we have a series in the form

$$F = A(1+i)^{N-1} + A(1+i)^{N-2} + \cdots + A(1+i) + A,$$

or, expressed alternatively,

$$F = A + A(1+i) + A(1+i)^2 + \cdots + A(1+i)^{N-1}. \tag{2.5}$$

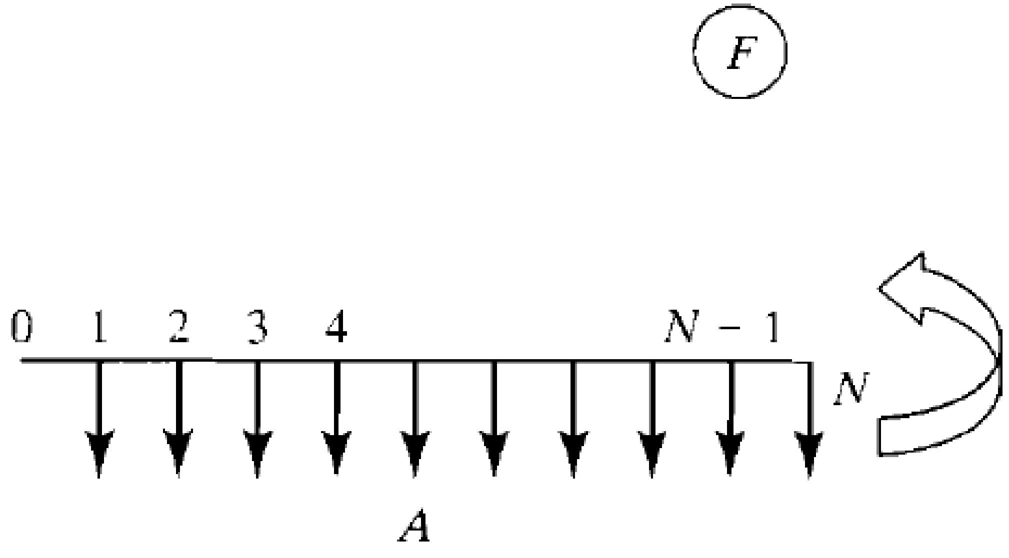
Multiplying Eq. (2.5) by $(1+i)$ results in

$$(1+i)F = A(1+i) + A(1+i)^2 + \cdots + A(1+i)^N. \tag{2.6}$$

Subtracting Eq. (2.5) from Eq. (2.6) to eliminate common terms gives us

$$F(1+i) - F = -A + A(1+i)^N.$$

Compound-Amount Factor: Find F, Given A, *i, and N*



$$F = A\,\frac{(1+i)^N - 1}{i}$$
$$= A(F/A, i, N)$$

Cash flow diagram of the relationship between *A* and *F*

Compound-Amount Factor: Find F, Given A, *i, and N*

Solving for F yields

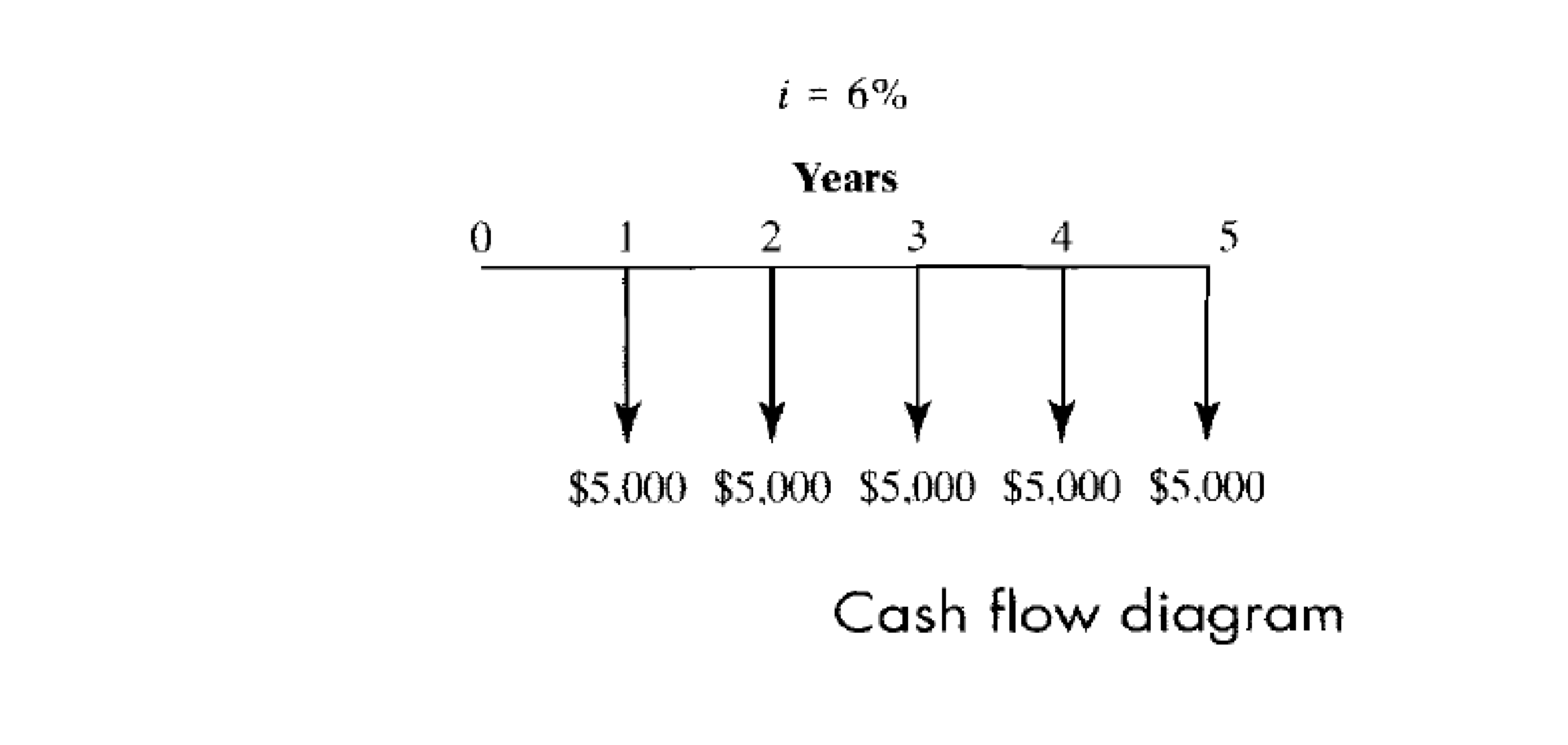
$$F = A\left[\frac{(1+i)^N - 1}{i}\right] = A(F/A, i, N). \tag{2.7}$$

The bracketed term in Eq. (2.7) is called the **equal-payment-series compound-amount factor**, or the **uniform-series compound-amount factor**; its factor notation is $(F/A, i, N)$. This interest factor has been calculated for various combinations of i and N in the tables in Appendix B.

Equal-Payment Series: Find *F, Given i, A, and N*

- Suppose you make an annual contribution of $5,000 to your savings account at the end of each year for five years.
- If your savings account earns 6% interest annually, how much can be withdrawn at the end of five years?

Equal-Payment Series:
Find *F, Given i, A, and N*



Equal-Payment Series: Find *F, Given i, A, and N*

- Given:
  - A = \$5.000,
  - N = 5 years. and
  - i = 6% per year.
- Find: F.
- Using the equal-payment-series compound-amount factor, we obtain
  - F = \$5,000(F/A, 6%. 5)
  - = \$5,000(5.6371)
  - = \$28,185.46.

Sinking-Fund Factor: Find A, Given F, *i, and N*

Sinking-Fund Factor: Find A, Given F, *i, and N*

If we solve Eq. (2.7) for A, we obtain

$$A = F\left[\frac{i}{(1+i)^N - 1}\right] = F(A/F, i, N). \tag{2.8}$$

The term within the brackets is called the **equal-payment-series sinking-fund factor**, or just **sinking-fund factor**, and is referred to with the notation $(A/F, i, N)$. A sinking fund is an interest-bearing account into which a fixed sum is deposited each interest period; it is commonly established for the purpose of replacing fixed assets.

Sinking-Fund Factor: Find A, Given F, *i, and N*

- How much do we need to save yearly at an interest rate of 7 % if we want to withdraw 100,000 Birr after 8 years?

Sinking-Fund Factor: Find A, Given F, *i, and N*

- Draw the Cash flow Diagram
- Given:
  - $i = 7\%$ per year,
  - $N = 8$ years.
  - $F = 100{,}000$
- Find: *A.*
  - Using the sinking-fund factors, we obtain
  - *A = $100,00O (A/F, 7%, 8)*
  - = $9,746.78.

Capital-Recovery Factor (Annuity Factor):
Find A, Given *P, i, and N*

Capital-Recovery Factor (Annuity Factor): Find A, Given *P, i, and N*

- We can determine the amount of a periodic payment, A, if we know P, i, and N.
- To relate P to A, recall the relationship between P and F in Eq. (2.3):

$$F = P(l + i)^N.$$

- *By replacing F in Eq. (2.8) by*

$P(1 + i)^N$, we get

Capital-Recovery Factor (Annuity Factor): Find A, Given *P, i, and N*

$$A = P(1 + i)^N \left[\frac{i}{(1 + i)^N - 1} \right],$$

or

$$A = P\left[\frac{i(1 + i)^N}{(1 + i)^N - 1} \right] = P(A/P, i, N).$$

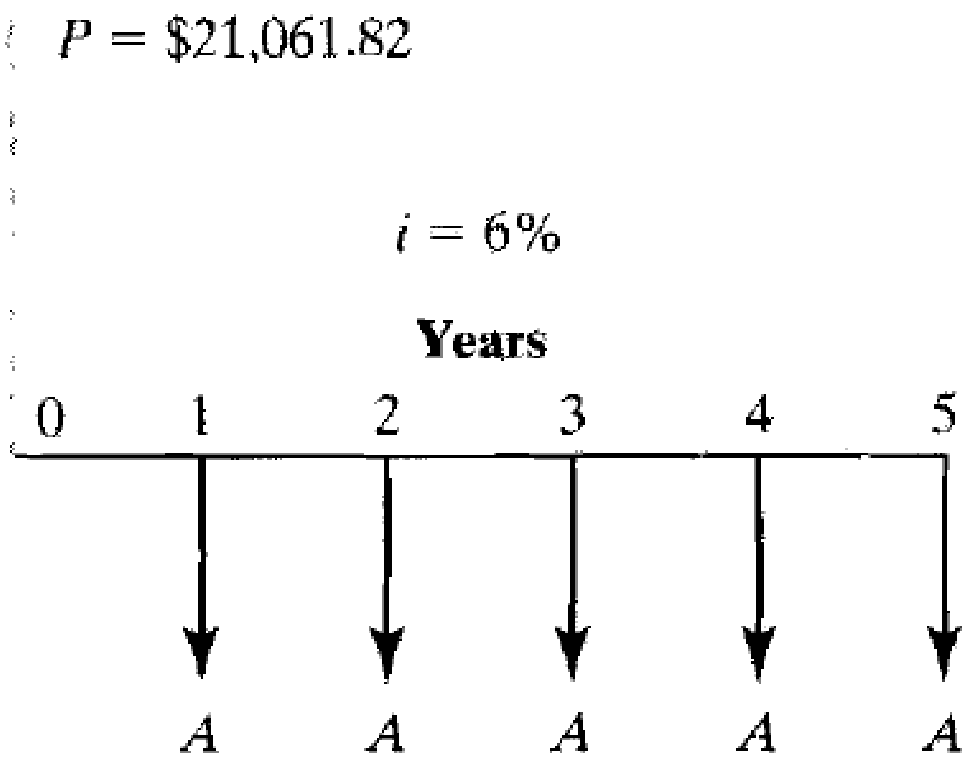
Capital-Recovery Factor (Annuity Factor): Find A, Given *P, i, and N*

- In this t*he portion within the brackets is* called the equal-payment-series capital-recovery factor, or simply capital-recovery factor, which is designated *(A/ P, i, N).*
- *In finance, this /I/P factor is referred to as the* annuity factor. The annuity factor indicates a series of payments of a fixed, or constant, amount for a specified number of periods.

Capital-Recovery Factor (Annuity Factor): Find A, Given *P, i, and N*

- You borrowed $21,061.82 to finance the educational expenses for your senior year of college.
- The loan will be paid off over five years.
- The loan carries an interest rate of 6% per year
- The loan is to be repaid in equal annual installments over the next five years.
  - Assume that the money was borrowed at the beginning of your senior year and that the first installment will be due a year later.
- Compute the amount of the annual installments (Figure 2.20).

Capital-Recovery Factor (Annuity Factor): Find A, Given *P, i, and N*



Cash flow diagram

Capital-Recovery Factor (Annuity Factor): Find A, Given *P, i, and N*

- Given:
  - –*P* = \$21,061.82,
  - –*i* = 6% per year, and
  - –*N* = 5 years.
- Find: A.
- Using the capital-recovery factor, we obtain
- *A* = \$21,061.82(*A*/*P*, 6%, 5)
  - –= \$21,061.82(0.2374)
  - –= \$5,000.

Capital-Recovery Factor (Annuity Factor): Find A, Given *P, i, and N*

The following table illustrates how the $5,000 annual repayment plan would retire the debt in five years:

End of Year	1	2	3	4	5
Beginning Balance	$21,061.82	$17,325.53	$13,365.06	$9,166.96	$4,716.98
Interest Charged (6%)	1,263.71	1,039.53	801.90	550.02	283.02
Payment Made	−5,000.00	−5,000.00	−5,000.00	−5,000.00	−5,000.00
Ending Balance	**$17,325.53**	**$13,365.06**	**$9,166.96**	**$4,716.98**	**$0.00**

Deferred Loan Repayment

- Suppose in Example 2.12 that you had wanted to negotiate with the bank to defer the first loan installment until the end of year two (but still desire to make five equal installments at 6% interest).
- If the bank wishes to earn the same profit as in Example 2.12, what should be the annual installment (Figure 2.21)?

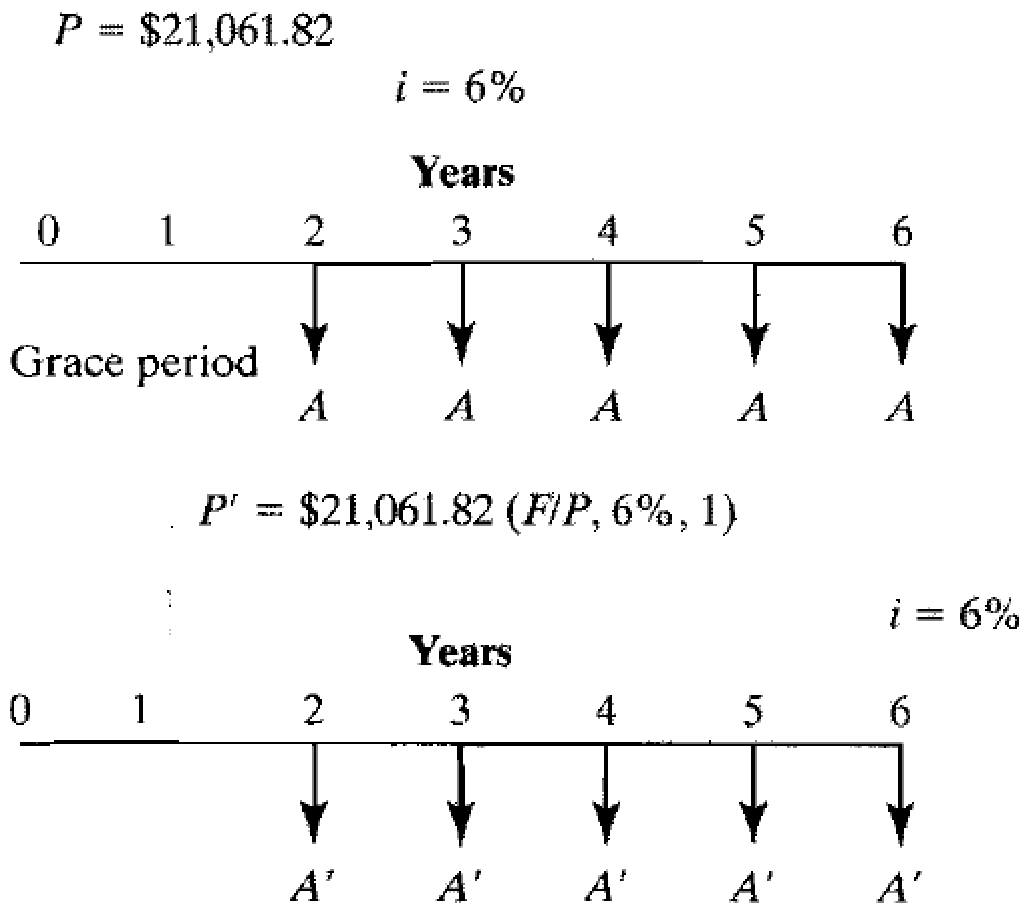
Deferred Loan Repayment

- Given:
  - P = \$21,061.82,
  - i = 6% per year, and
  - *N = 5 years,*
  - *but the first payment* occurs at the end of year two.
- Find: A.
- In deferring one year, the bank will add the interest accrued during the first year to the principal.
- In other words, we need to find the equivalent worth of \$21,061.82 at the end of year 1, P':

Deferred Loan Repayment

$$\begin{aligned} P' &= \$21{,}061.82(F/P, 6\%, 1) \\ &= \$22{,}325.53. \end{aligned}$$

Deferred Loan Repayment



A deferred-loan cash flow diagram

Deferred Loan Repayment

Thus, you are borrowing \$22,325.53 for five years. To retire the loan with five equal installments, the deferred equal annual payment, A', will be

$$\begin{aligned} A' &= \$22{,}325.53(A/P, 6\%, 5) \\ &= \$5{,}300. \end{aligned}$$

By deferring the first payment for one year, you need to make an additional \$300 in payments each year.

Present-Worth Factor: Find P, Given A, *i, and N*

Present-Worth Factor: Find P, Given A, *i, and N*

- What would you have to invest now in order to withdraw A dollars at the end of each of the next N periods?
- We now face just the opposite oi the equal-payment capital-recovery factor situation: *A is known, but P has to be determined. With the* capital-recovery factor given in Eq. (2.9), solving for P gives us

Present-Worth Factor: Find P, Given A, *i, and N*

$$P = A\left[\frac{(1+i)^N - 1}{i(1+i)^N}\right] = A(P/A, i, N). \tag{2.10}$$

The bracketed term is referred to as the **equal-payment-series present-worth factor** and is designated $(P/A, i, N)$.

Linear Gradient Series

Given: $A_1 = \$175{,}000$, $A_2 = \$189{,}000$, $G = \$7{,}000$ (from payment periods 3 to 26), $i = 4.5\%$ per year, and $N = 26$ years, as shown in Figure 2.28.

Find: P.

This problem is equivalent to asking what the equivalent present worth for this annual-payment series is at 4.5% interest. Since the linear gradient series starts at period 2 for this example (i.e., is delayed by one period), we can calculate the present value in two steps: First compute the value at $N = 1$ and then extend it to $N = 0$. This method yields the following:

$$\begin{aligned} P &= [\$175{,}000 + \$189{,}000(P/A, 4.5\%, 25) \\ &\quad + \$7{,}000(P/G, 4.5\%, 25)](P/F, 4.5\%, 1) \\ &= \$3{,}818{,}363. \end{aligned}$$

Inflation
Basic Concept

inflation

- Historically. the general economy has usually fluctuated in such a way as to experience inflation, a loss in the purchasing power of money over time.
- Inflation means that the cost of an item tends to increase over time, or, to put it another way, the same dollar amount buys less of an item over time.

Deflation

- Deflation is the opposite of inflation, in that prices decrease over time, and hence a specified dollar amount gains purchasing power.
- Inflation is far more common than deflation in the real world, so our consideration in this section will be restricted to accounting for inflation in economic analyses

Inflation: Consumer Price Index (CPI)

- Before one can introduce inflation into an equivalence calculation, we need a means of isolating and measuring its effect.
- Consumers usually have a relative, if not a precise. sense of how their purchasing power is declining. This sense is based on their experience of shopping for food, clothing, transportation, and housing over the years.
- Economists have developed a measure called the consumer price index (CPI), which is based on a typical market basket of goods and services required by the average consumer.

Inflation: Consumer Price Index (CPI)

- This market basket normally consists of items from eight major groups:
  - (1) food and alcoholic beverages,
  - (2) housing,
  - (3) apparel,
  - (4) transportation.
  - *(5) medical care,*
  - *(6) entertainment.*
  - *(7) personal care, and*
  - *(8) other goods and services*

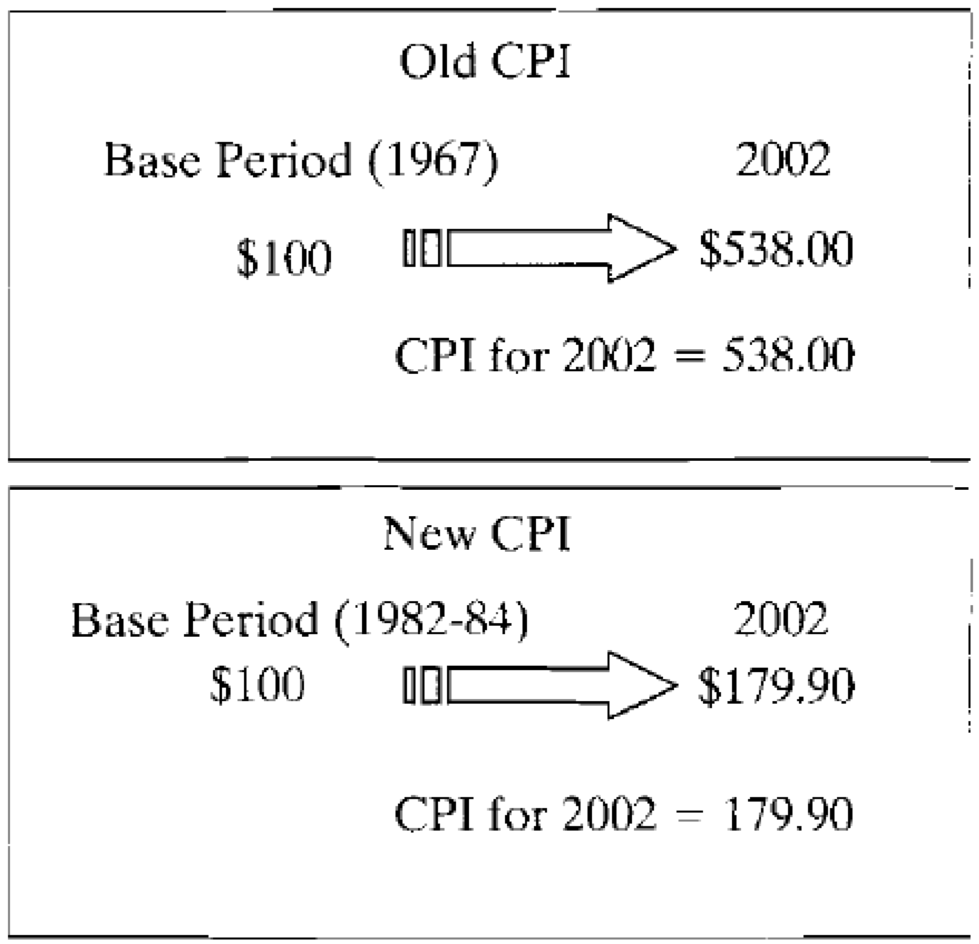
Consumer Price Index (CPI)

- The CPI compares the cost of the typical market basket of goods and services in a current month with its cost at a previous time, such as 1 month ago. 1 year ago or 10 years ago.
- The point in the past to which current prices are compared is called the base period. The index value for this base period is set at $100. The original base period used by the US Bureau of Labor Statistics (BLS) of the U.S. Department of Labor for the CPI index is 1967.

Inflation: Consumer Price Index (CPI)

- For example, let us say that, in 1967, the prescribed market basket could have been purchased for $100. Suppose the same combination of goods and services costs $538.80 in 2002.
- We can then compute the CPI for 2002 by multiplying the ratio of the current price to the base-period price by 100. In our example, the price index is ($538.80/$100)100 = 538.80, which means that the 2002 price of the contents of the market basket is 538.80% of its base-period price. (See Figure 4.1.)

Inflation: Consumer Price Index (CPI)



Measuring inflation based on CPI

Consumer Price Index (CPI)

Selected Price Indexes between 1993 and 2002

Year (Base Period)	New CPI (1982–84)	Old CPI (1967)	Gasoline (1982)	Steel (1982)	Passenger Car (1982)
1993	144.0	461.2	63.9	116.0	129.8
1994	147.4	441.4	61.7	122.0	133.3
1995	152.2	455.0	63.7	128.8	134.0
1996	156.6	468.2	72.8	125.8	135.2
1997	160.2	479.7	71.9	126.5	135.2
1998	162.5	487.1	53.4	122.5	132.2
1999	166.2	497.8	64.7	114.0	121.4
2000	171.2	512.9	94.6	116.0	133.4
2001	176.6	530.4	90.5	109.7	138.9
2002	178.9	535.8	126.6	117.4	128.8

Consumer Price Index (CPI)

Equivalence Calculations under Inflation

From Table 4.1, we can easily calculate the price index (or inflation rate) of gasoline from 2000 to 2001 as follows:

$$\frac{90.5 - 94.6}{94.6} = -0.04334 = -4.334\%.$$

Since the price index calculated is negative, the price of gasoline actually decreased at an annual rate of 4.334% over the year 2000, which was one of the better years for consumers who drive. However, in 2002, the price of gasoline increased at an annual rate of 39.88% over the price in 2001.

Average Inflation Rate (f)

- To account for the effect of varying yearly inflation rates over a period of several years. we can compute a single rate that represents an average inflation rate. Since each year's inflation rate is based 011 the previous year's rate, these rates have a compounding effect.
- As an example, suppose we want to calculate the average inflation rate for a two-year period. The first year's inflation rate is 4%, and the second year's rate is Soh, with a base price of $100. To calculate the average inflation rate for the two years, we employ the following procedure:

Average Inflation Rate (f)

Step 1: To find the price at the end of the second year, we use the process of compounding:

$$\underbrace{\overbrace{\$100(1 + 0.04)}^{\text{First year}}(1 + 0.08)}_{\text{Second year}} = \$112.32.$$

Step 2: To find the average inflation rate f, we establish the following equivalence equation:

$$\$100(1 + f)^2 = \$112.32, \text{ or } \$100(F/P, f, 2) = \$112.32.$$

Solving for f yields

$$f = 5.98\%.$$

Average Inflation Rate (f)

- Thus. we can say that the price increases in the last two years are equivalent to an average annual percentage rate of *5.98% per year.*
- *Note that the average is a geometric* average, not an *arithmetic* average over a several-year period.
- Using a single average rate such as this, rather than a different rate for each year's cash flows, simplifies our economic analysis.

Inflation

Category	2003 Price	2000 Price	Average Inflation Rate
Postage	$0.37	$0.33	3.89%
Homeowners insurance (per year)	$603.00	$500.00	6.44%
Auto insurance (per year)	$855.00	$687.00	7.56%
Private college tuition and fees	$18,273.00	$15,518.00	5.60%
Gasoline (per gallon)	$1.65	$1.56	1.89%
Haircut	$12.00	$10.50	4.55%
Car (Toyota Camry)	$22,000.00	$21,000.00	1.56%
Natural gas (per million BTUs)	$5.67	$3.17	21.38%
Baseball tickets (family of four)	$148.66	$132.44	3.92%
Cable TV (per month)	$47.97	$36.97	9.07%
Movies (average ticket)	$5.80	$5.39	2.47%
Movies (concessions)	$2.17	$1.98	3.10%
Health care (per year)	$2,088.00	$1,656.00	8.03%
Consumer price index (CPI) Base period: 1982 − 84 = 100	**184.20**	**171.20**	**2.47%**

Explain how the average inflation rates are calculated in the table.

Average Inflation

Let's take the fourth item, the cost of private college tuition, for a sample calculation. Since we know the prices during both 2000 and 2003, we can use the appropriate equivalence formula (single-payment compound amount factor or growth formula).

Given: $P = \$15{,}518$, $F = \$18{,}273$, and $N = 2003 - 2000 = 3$.

Find: f.

To solve this problem, we use the equation $F = P(1 + f)^N$:

$$\$18{,}273 = \$15{,}518(1 + f)^3.$$

Solving for f yields

$$\begin{aligned} f &= \sqrt[3]{1.1775} - 1 \\ &= 0.0560 = 5.60\%. \end{aligned}$$

In a similar fashion, we can obtain the average inflation rates for the remaining items as shown in the table. Clearly, the cost of natural gas increased the most among the items listed in the table.

Inflation

Page 118 General and Specific Inflation rate

Yearly and Average Inflation Rates

The accompanying table shows a utility company's cost to supply a fixed amount of power to a new housing development; the indices are specific to the utilities industry. Assume that year 0 is the base period.

Determine the inflation rate for each period, and calculate the average inflation rate over the three years.

Year	Cost
0	$504,000
1	$538,400
2	$577,000
3	$629,500

Given: History of utility cost.

Find: The yearly inflation rate (f_j) and the average inflation rate over the three-year time period (f).

The inflation rate during year 1 (f_1) is

$$(\$538{,}400 - \$504{,}000)/\$504{,}000 = 6.83\%.$$

The inflation rate during year 2 (f_2) is

$$(\$577{,}000 - \$538{,}400)/\$538{,}400 = 7.17\%.$$

The inflation rate during year 3 (f_3) is

$$(\$629{,}500 - \$577{,}000)/\$577{,}000 = 9.10\%.$$

The average inflation rate over the three years is

$$f = \left(\frac{\$629{,}500}{\$504{,}000}\right)^{1/3} - 1 = 0.0769 = 7.69\%.$$

Note that, although the average inflation rate is 7.69% for the period taken as a whole, none of the years within the period had this rate.[4]

Doubling of Investment

Doubling Time (Rule of 72)

- A common question most often asked by investors is:
  - How long will it take for my investment to double in value?
  - Must have a known or assumed compound interest rate in advance
  - Assume a rate of 13%/year to illustrate….

Doubling Time (Rule of 72)

- The Rule of 72 states:
  - The approximate time for an investment to double in value given the compound interest rate is:
  - Estimated time (n) = 72/i
  - For i = 13%: 72/13 = 5.54 years

Doubling Time (Rule of 72)

- Likewise, one can estimate the required interest rate for an investment to double in value over time as:
  - $i_{approximate} = 72/n$
  - Assume we want an investment to double in, say, 3 years.
  - Estimate i – rate would be: 72/3 = <u>24%</u>

EVALUATING BUSINESS AND ENGINEERING ASSETS

Performing an Engineering Economy Study

Performing an Engineering Economy Study

- What do all engineering economic decision problems have in common? The answer is that they all involve two dissimilar types of amounts. First, there is the investment, which is usually made in a lump sum at the beginning of the project.
- Although not literally made "today," the investment is made at a specific point in time that, for analytical purposes, is called today, or time 0. Second, there is a stream of cash benefits that are expected to result from the investment over some years in the future

Loan Versus Project Cash flows

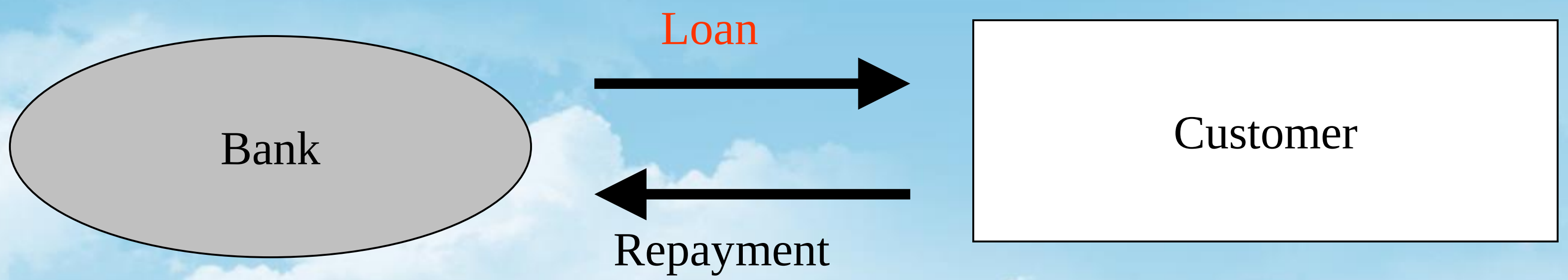
- An investment made in a fixed asset is similar to an investment made by a bank when it lends money. The essential characteristic of both transactions is that funds are committed today in the expectation of their earning a return in the future.
- In the case of the bank loan, the future return takes the form of interest plus repayment of the principal. This return is known as the loan cash flow.

Loan Versus Project Cash flows

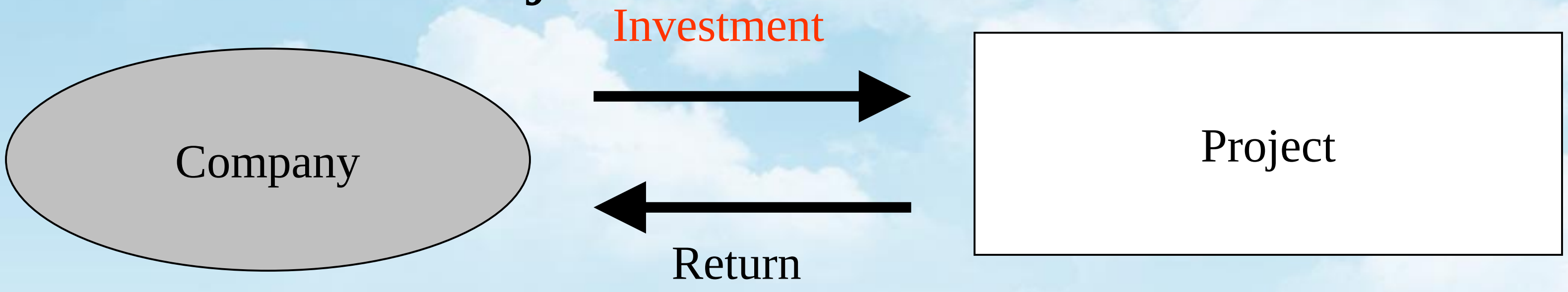
- In the case of the fixed asset, the future return takes the form of cash generated by productive use of the asset. The representation of these future earnings, along with the capital expenditures and annual expenses (such as wages. raw materials, operating costs, maintenance costs, and income taxes). is the project cash flow.
- This similarity between the loan cash flow and the project cash flow (see following) brings us to an important conclusion-that is, we can use the same equivalence techniques developed in earlier sections to measure economic worth

Bank Loan vs. Investment Project

Bank Loan



Investment Project



Performing an Engineering Economy Study

- In order to carry out an economic analysis of projects, the cost and the income that may be obtained as well as the timing of these incomes must be known and evaluated
- This is the main task in engineering economy exercise

Performing An Engineering Economy Study

- In order to apply economic analysis techniques, key terms and concepts need to be understood well.
  - Time value of money
  - Cash flows
  - Alternatives
  - Alternative selection
  - Evaluation criteria
  - Intangible factors

Performing An Engineering Economy Study Alternatives

In an engineering Economy analysis, alterative ways of solving a problem need to be identified first, then one must

- Estimate the cash flows for the alternatives (first cost, revenues and expenses and salvage values)
- Determine the interest rate
- Determine the time frame(Estimates of project life
- Analyze the cash flows for each alternative
- Select the best alternative

Performing An Engineering Economy Study:
Mutually Exclusive

Select One and only one from a set of feasible alternatives

Once an alternative is selected, the remaining alternatives are excluded at that point.

– In other words, the decision regarding any one project has no effect on the decision to accept or reject another project. Such projects are said to be independent.

Performing An Engineering Economy Study:
Mutually Exclusive

- Many engineering situations we are faced with selecting the most economically attractive project from a number of alternative projects, all of which solve the same problem or meet the same need. It is unnecessary to choose more than one project in this situation, and the acceptance of one automatically entails the rejection of all of the others. Such projects are said to be mutually exclusive

Performing An Engineering Economy Study: Do Nothing Alternative

If all of the proposed alternatives are not economically desirable then…

One usually defaults to the DO-NOTHING alternative

Performing An Engineering Economy Study: More Alternatives

- **Goal: Define, Evaluate, Select and Execute**

Do Nothing

Alt. 1

....

Alt. j

Which one do we accept?

3. Analysis of a project or an investment

Methods of analyzing a project or an investment

- –Pay back period (Initial Project Screening Method)
- –Present/future worth analysis
- –Equivalent annual worth analysis
- –Internal rate of return
- –Cost benefit ratio

Screening Projects: Payback Method

- Before studying the three measures of investment attractiveness, we will review a simple method that is commonly used to screen capital investments.
  - One of the primary concerns of most business people is whether, and when, the money invested in a project can be recovered.
- The payback method screens projects on the basis of how long it takes for net receipts to equal investment outlays

Screening Projects: Payback Method

- The payback period is determined by adding the expected cash flows for each year until the sum is equal to, or greater than, zero. The significance of this procedure can be easily explained.
- The cumulative cash flow equals zero at the point where cash inflows exactly match or pay back the cash outflows: thus, the project has reached the payback point. Once the cumulative cash flows exceed zero, cash inflows exceed cash outflows, and the project has begun to generate a profit, thus exceeding its payback point.

Screening Projects: Payback Method

- This calculation can take one of two forms by either ignoring time-value-of money considerations or including them.
- The former case is usually designated as the conventional-payback method. whereas the latter case is known as the discounted-payback method.
- A common standard used to determine whether to pursue a project is that a project does not merit consideration unless its payback period is shorter than some specified period of time.

Payback Period

- The payback period assesses the time for net revenue to “pay back” the initial investment: Example:
- Spend 10, 000 Birr on process to save 2,000 Birr/year
  - Payback period = 10,000/2000/year = 5 years
- This method was once a most common technique of assessing investment return (payback period)
- However because it doe not consider the Time value of money, it is now declining in use.

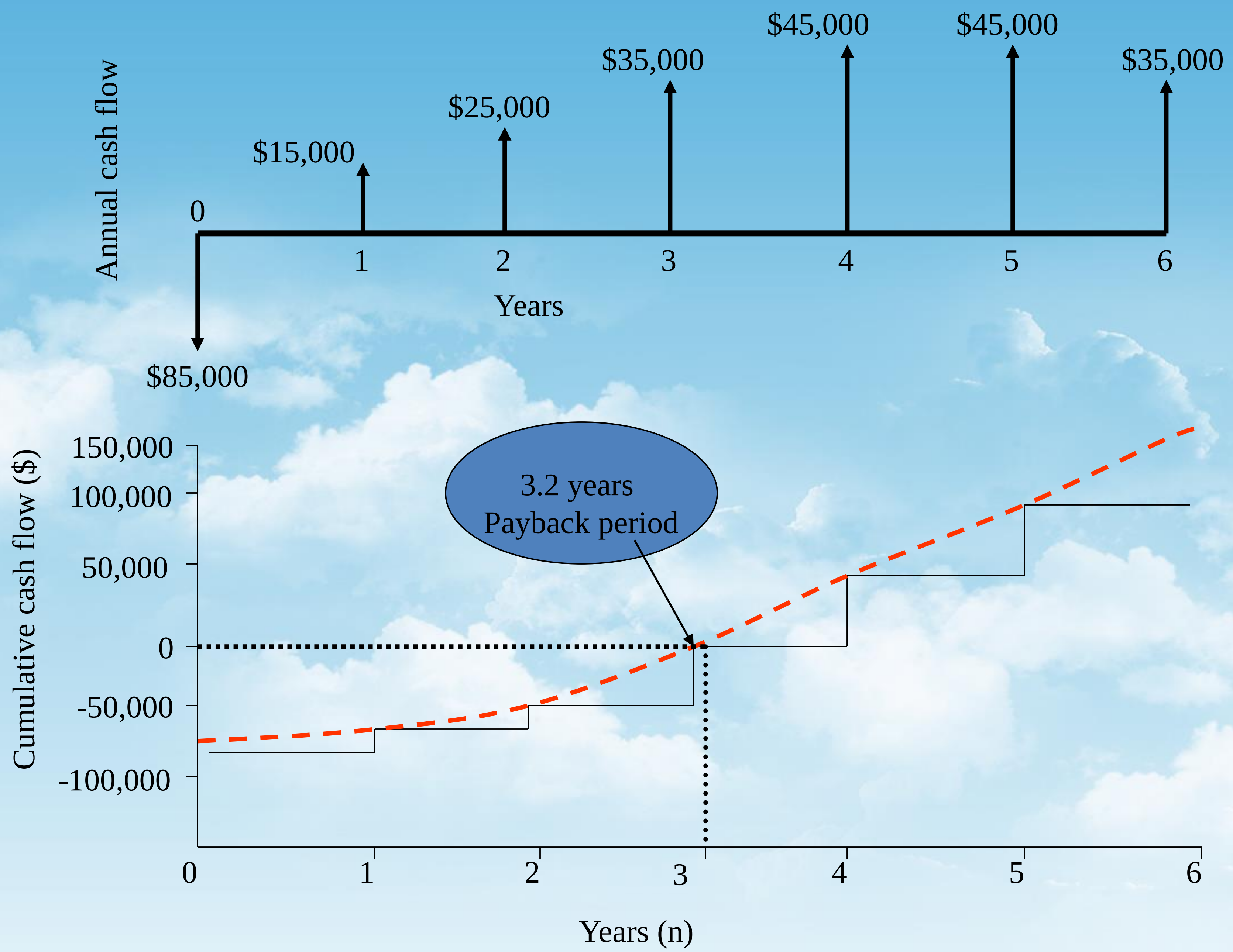
Payback Period

- Auto-numerics Company has just bought a new spindle machine at a cost of $105,000 to replace one that had a salvage value of $20,000.
- The projected annual after-tax savings via improved efficiency, which will exceed the investment cost, are as follows

Period	Cash Flow	Cumulative Cash Flow
0	−$105,000 + $20,000	−$85,000
1	15,000	−70,000
2	25,000	−45,000
3	35,000	−10,000
4	45,000	35,000
5	45,000	80,000
6	35,000	115,000

Screening Projects: Payback Method

- When used, the salvage value of the retired equipment is subtracted from the purchase price of the new equipment, revealing a closer true cost of the investment.
- The cumulative cash flow series in the following Figure shows that, the total investment is recovered at the end of year 4. If the firm's stated maximum payback period is three years, the project would not pass the initial screening stage.


Annual cash flow
$15,000
$25,000
$35,000
$45,000
$45,000
$35,000
0
1
2
3
4
5
6
Years
$85,000
Cumulative cash flow ($)
150,000
100,000
50,000
0
-50,000
-100,000
3.2 years
Payback period
0
1
2
3
4
5
6
Years (n)

Screening Projects: Payback Method

- In this example, we assumed that cash flows occur only in discrete lumps at the ends of years. If cash flows occur continuously throughout the year, our calculation of the payback period needs adjustment.
- A negative balance of $10,000 remains at the start of year 4.
- If the $45,000 is expected to be received as a more or less continuous flow during year 4, then the total investment will be recovered two-tenths ($10,000/$45.000) of the way through the fourth year. In this situation, the prorated payback period is thus 3.2 years.

Benefits and Flaws of Payback Screening

- The simplicity of the payback method is one of its most appealing qualities. Initial project screening by the payback method reduces the information search by focusing on that time at which the firm expects to recover the initial investment.
- The method may also eliminate some alternatives. thus reducing a firm's need to make further analysis efforts on those alternatives. But the much-used payback method of investment screening has a number of serious drawbacks as well:

Benefits and Flaws of Payback Screening

- The principal objection to the payback method is that it fails to measure profitability; that is, it assumes that no profit is made during the payback period.
- Simply measuring how long it will take to recover the initial investment outlay contributes little to gauging the earning power of a project

Payback method: Summary

- Advantages
  - Payback method is simple to use
  - Used for initial project screening method
- Disadvantages
  - Fails to measure profitability
  - Does not indicate interest expenses
  - Ignores all proceeds after the payback period
  - Therefore another alternative is necessary

Discounted-Payback Period

Discounted-Payback Period

- To remedy this shortcoming it is necessary to include the time value of money ex cost of funds (interest)used to support the project
- This modified method is called the "discounted payback period"
- In other words. we may define the discounted-payback period as the number of years required to recover the investment from *discounted cash flows.*

Benefits and Flaws of Payback Screening

- Because payback-period analysis ignores differences in the timing of cash flows, it fails to recognize the difference between the present and future value of money
  - (For instance, if you know that the money you borrowed is costing you 12% per year, the payback method will not be able to tell you how much your invested money is contributing toward your interest expense.)

Discounted payback period example

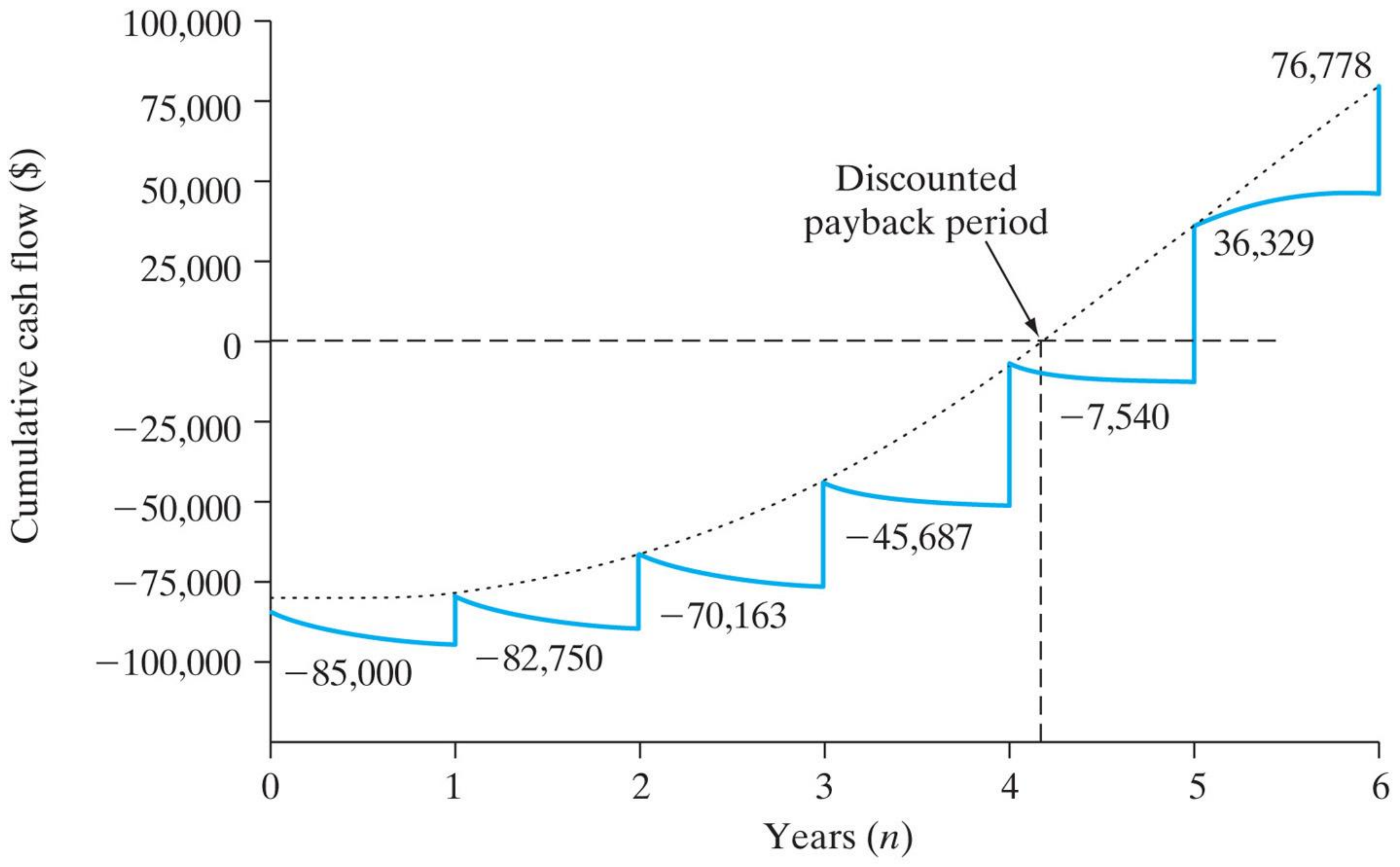
- A company bought a new machine at a cost of 105,000 to replace an old one that has a salvage value of $ 20,000.
- the company also requires a rate of return of 15 %. How long would it take to recover the funds?

Discounted Payback Period Calculation

Period	Cash Flow	Cost of Funds (15%)*	Cumulative Cash Flow
0	-$85,000	0	-$85,000
1	15,000	-$85,000(0.15) = -$12,750	-82,750
2	25,000	-$82,750(0.15) = -12,413	-70,163
3	35,000	-$70,163(0.15) = -10,524	-45,687
4	45,000	-$45,687(0.15) =-6,853	-7,540
5	45,000	-$7,540(0.15) = -1,131	36,329
6	35,000	$36,329(0.15) = 5,449	76,778

* Cost of funds = (Unrecovered beginning balance) X (interest rate)

Illustration of Discounted Payback Period



Net Present worth (NPW) or Net Present Value (NPV) method of project screening

Net Present Worth (Value)

- Net present value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows over a period of time.
- NPV is used in capital budgeting to analyze the profitability of a projected investment or project
  - Definition | Investopedia https://www.investopedia.com/terms/n/npv.asp#ixzz5CxQ0jmeW)

Net Present Worth (Value)

- A positive net present value indicates that the projected earnings generated by a project or investment (in present dollars) exceeds the anticipated costs (also in present dollars).
  - Generally, an investment with a positive NPV will be profitable, and an investment with a negative NPV will result in a net loss.
- This concept is the basis for the Net Present value, which dictates that the only investments that should be made are those with positive NPV values

    - Investopedia https://www.investopedia.com/terms/n/npv.asp#ixzz5CxQWz6ya

Net Present worth analysis

- The most convenient point at which to calculate the equivalent values is often at time zero or the present.
- Under the PW criterion, the present worth of all cash inflows associated with an investment project is compared with the present worth of all cash outflows associated with that project.

Net Present worth analysis

- The difference between the present worth of these cash flows Referred to as the net present worth (PW), determines whether the project is or is not an acceptable investment.
- When two or more projects are under consideration, PW analysis further allows us to select the best project by comparing their PW figures directly.

Net Present worth analysis Procedure

- Evaluation of a Single Project
  - Step 1: Determine the interest rate that the firm wishes to earn on its investments.
  - The interest rate you determine represents the rate at which the firm can always invest the money in its *investment pool. This interest rate is often* referred to as either a *required rate of return or a minimum attractive rate of return* (MARR). Usually this selection is a policy decision made by top management.

Note: Rate of Return (Wiki, 2019)

- In finance, **return** is a profit on an investment. It comprises any change in value of the investment, and/or cash flows which the investor receives from the investment, such as interest payment or dividends.
  - It may be measured either in absolute terms (e.g., dollars) or as a percentage of the amount invested.
- The **rate of return** is a profit on an investment over a period of time, expressed as a proportion of the original investment.[2] The time period is typically a year, in which case the rate of return is referred to as the *annual return*.
  - The return on investment (ROI) is return per dollar invested. It is a measure of investment performance, as opposed to size (c.f. return on equity, return on assets, return on capital employed).

Net Present worth analysis

- Step 2: Estimate the service life of the project.
- Step 3: Estimate the cash inflow for each period over the service life.
- Step 4: Estimate the cash outflow for each period over the service life.
- Step 5: Determine the net cash flows for each period (net cash flow = cash inflow - cash outflow).
- Step 6: Find the present worth of each net cash flow at the MARR. Add up these present-worth figures; their sum is defined as the project's PW.

Net Present worth analysis

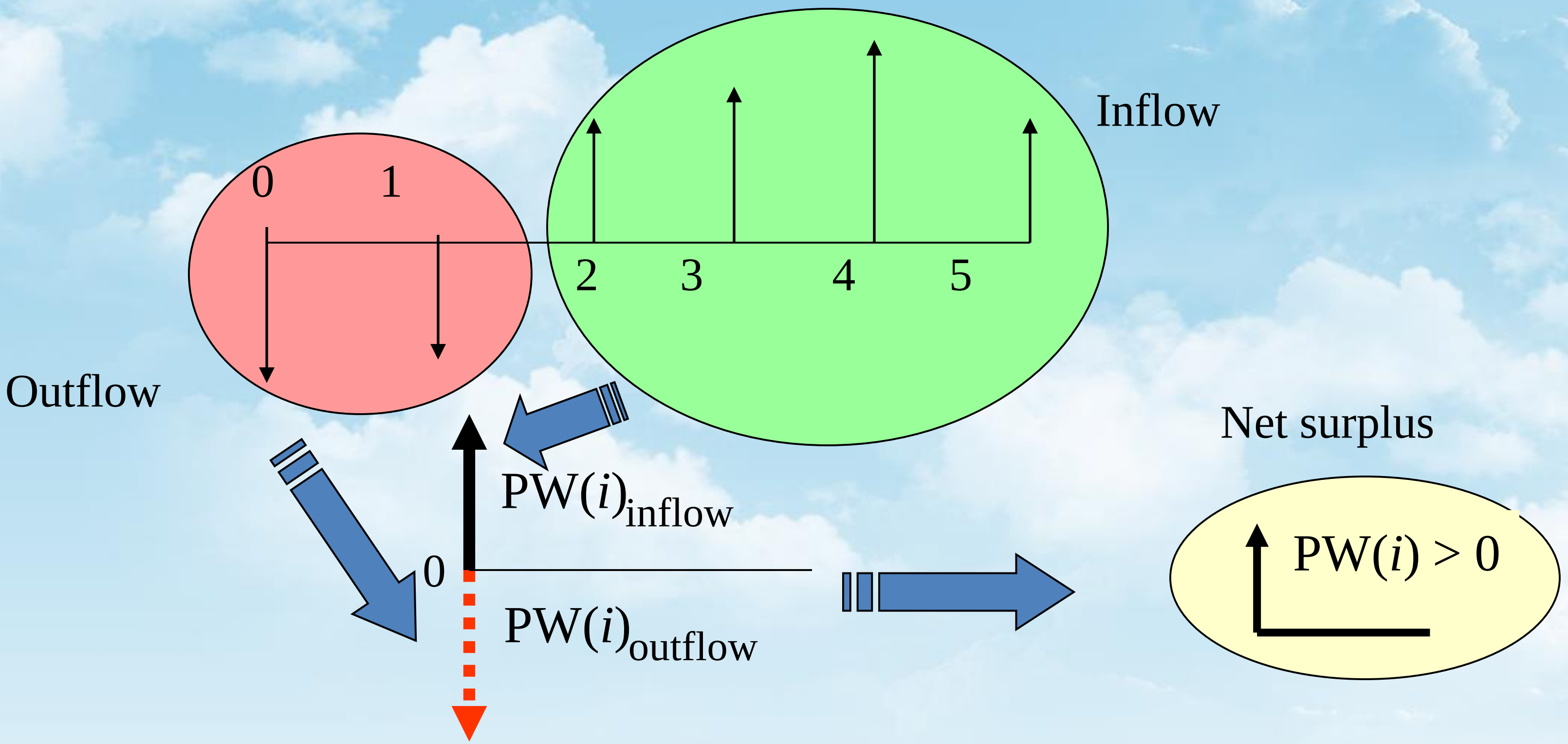
- Step 7: In this context, a positive PW means that the equivalent worth of the inflows is greater than the equivalent worth of the outflows, so the project makes a profit.
  - Therefore, if the PW(i) is positive for a single project, the project should be accepted; if it is negative, the project should be rejected.

Net Present worth analysis

- The process of applying the PW measure is shown in Figure 5.3 and is implemented with the following decision rule:
  - If PW(i) > 0, accept the investment.
  - If PW(i) = 0, remain indifferent.
  - If PW(i) < 0, reject the investment.

Net Present Worth Measure

- Principle: Compute the equivalent net surplus at $n = 0$ for a given interest rate of i.
- Decision Rule: Accept the project if the net surplus is positive.



Comparing More Than One Alternative

- The foregoing decision rule is for evaluation of a single project for which you can estimate the revenues as well as the costs.
- Evaluating and comparing more than one project involves the following steps :

Comparing More Than One Alternative

- If you need to select the best alternative, based on the net-present-worth criterion, select the one with the highest PW, as long as all the alternatives have the same service lives.
  - Comparison of alternatives with unequal service lives requires special assumptions,

Comparing More Than One Alternative

- As you will find in Section 5.4, comparison of mutually exclusive alternatives with the same revenues is performed on a *cost-only basis.*
  - *In this situation,* you should accept the project that results in the smallest PW of costs, or the least negative PW (because you are minimizing costs, rather than maximizing profits).

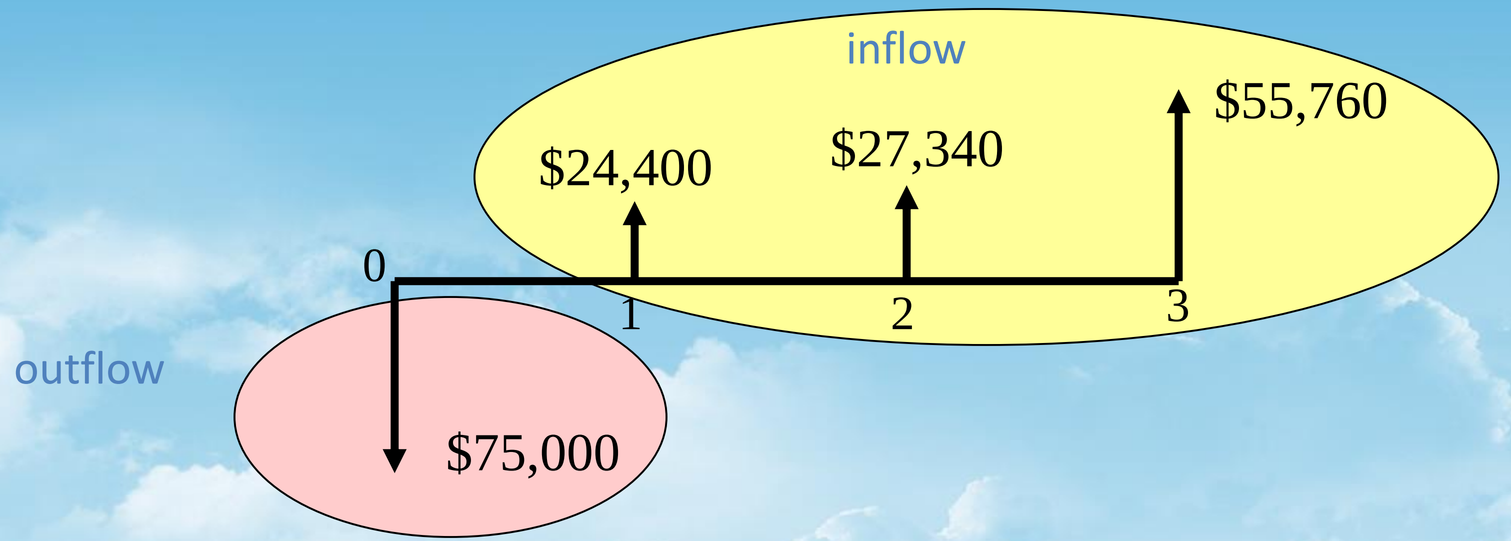
Net Present Worth: Example

- Tiger Machine Tool Company is considering the acquisition of a new metal cutting machine. The required initial investment of $75,000 and the projected cash benefits over a three-year project life are shown in the table in the next slide.
- You have been asked to evaluate the economic merits of the acquisition. The firms' MARR is known to be 15%

Net present worth example

End of year	Net cash flow
0	-$75,000
1	24,400
2	27,340
3	55,760

Example 7.5 - Tiger Machine Tool Company



$$PW(15\%)_{\text{inflow}} = \$24{,}400(P/F,15\%,1) + \$27{,}340(P/F,15\%,2) + \$55{,}760(P/F,15\%,3)$$

$$= \boxed{\$78{,}553}$$

$$PW(15\%)_{\text{outflow}} = \boxed{\$75{,}000}$$

$$PW(15\%) = \$78{,}553 - \$75{,}000$$

$$= \boxed{\$3{,}553 > 0, \text{ Accept}}$$

Present worth : Internal rate of Return

- In the above example, we computed the PW of the project at a fixed interest rate of 15%. If we compute the PW at varying interest rates, we obtain the data in the following Table.

Present Worth Amounts at Varying Interest Rates

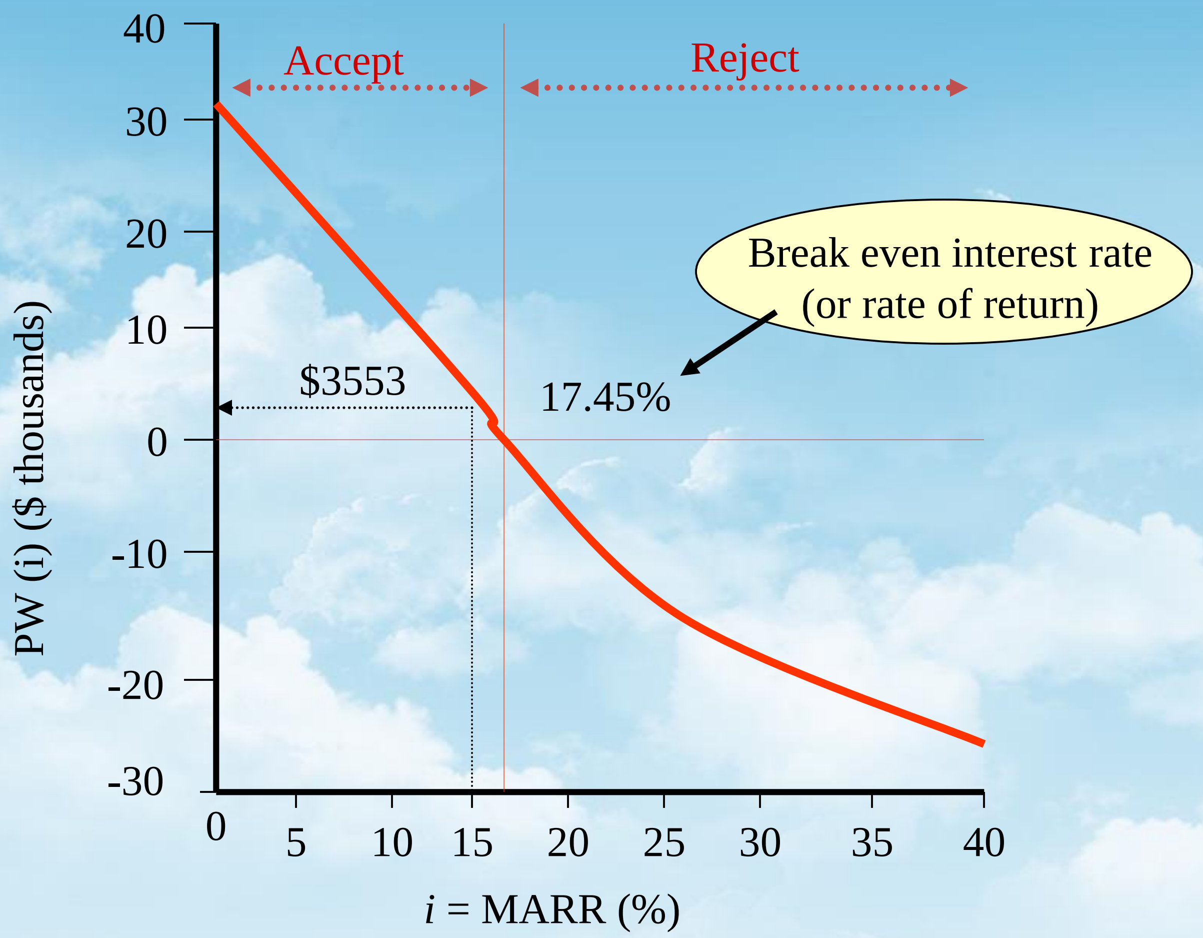
i (%)	PW(*i*)	*i*(%)	PW(*i*)
0	$32,500	20	-$3,412
2	27,743	22	-5,924
4	23,309	24	-8,296
6	19,169	26	-10,539
8	15,296	28	-12,662
10	11,670	30	-14,673
12	8,270	32	-16,580
14	5,077	34	-18,360
16	2,076	36	-20,110
17.45*	0	38	-21,745
18	-751	40	-23,302

*Break even interest rate

Present worth : Internal rate of Return

- Plotting the PW as a function of interest rate gives the graph in the following Figure the present-worth profile.

Present Worth Profile



Present worth : Internal rate of Return

- The above Figure indicates that the investment project has a positive PW if the interest rate is below 17.45% and a negative PW if the interest rate is above 17.45%.

Present worth : Internal rate of Return

The 17.45 % interest rate is known as the break-even interest rate (also known as the internal rate of return) is an interest rate in which costs equal benefits and the investment neither makes nor loses money.

Present worth : Internal rate of Return

- As can be seen If the firm's MARR is 15%, the project has a PW of $3.553 and so may be accepted. The figure of $3,553 measures the equivalent immediate gain in present worth to the firm following the acceptance of the project.
- On the other hand, at i = 20%. PW(20%) = -$3,412; the firm should reject the project in this case.
  - Note that the decision to accept or reject an investment is influenced by the choice of a MARR, so it is crucial to estimate the MARR correctly.

Variations of Present worth analysis
Future worth and Capitalized Equivalent Worth

Variations of Present worth analysis
Future Worth

- Future worth analysis and Capitalized equivalent worth analysis form variations of the present worth analysis
  - Future worth analysis: calculates the future worth of an investment undertaken
  - Capitalized equivalent worth analysis calculates the present worth of a project with perpetual life span

Variations of Present worth analysis
Future Worth

- Future worth (FW) or Net Future worth (NFW) measures surplus in an investment at a time period other than 0.
- Net future worth analysis is particularly useful when we want to compute the equivalent worth of a project at the end of its investment period rather than at its beginning.

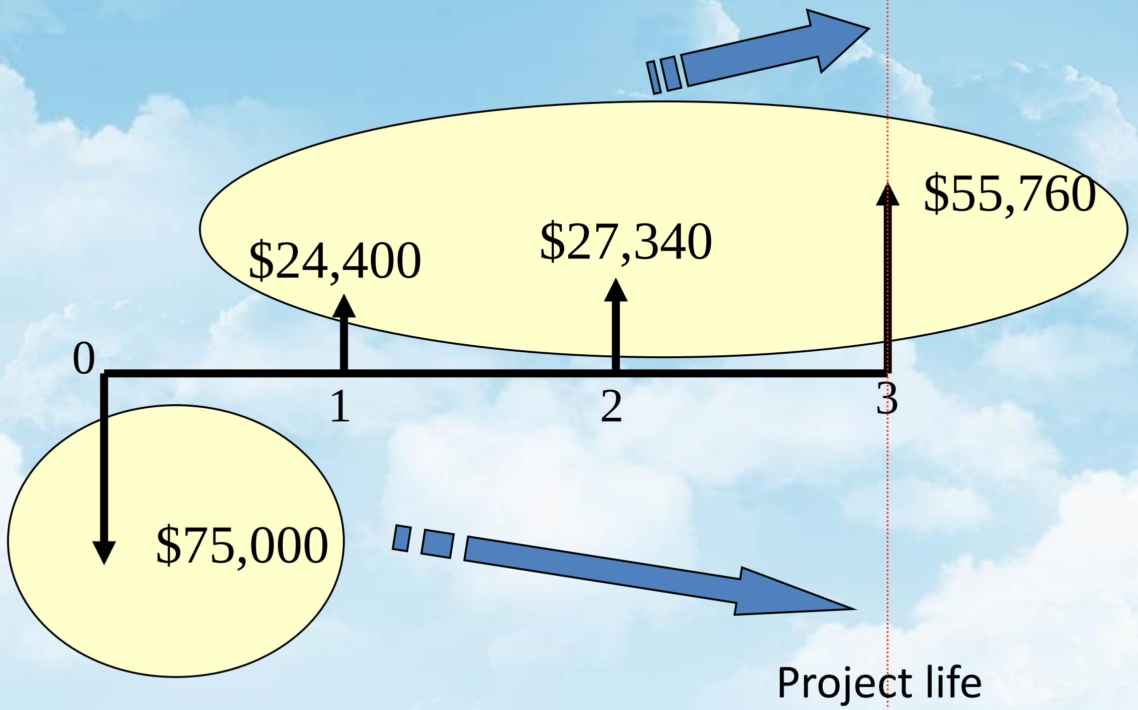
Variations of Present worth analysis
Future Worth

- **Future Worth** (FW) is the **value** of a sum of money at a **future** point in time for a given interest rate. It is given by the expression

$$F = P(1 + i)^N$$

Future Worth Criterion

- Given: the following Cash flows and MARR (i)=15 %
- Find: The net equivalent worth at the end of project life (3 years)



Future worth analysis

- Since the funds that return to the investment pool earn interest at a rate of 15 %, it would be of interest to see how much the firm would benefit from this investment. For this alternative, the returns after reinvestment are as follows:
  - $24.300(F/P. 15%,2) - $32,269
  - $27,34O(F/P. 15%, 1) = $31,441
  - $55,76O(F/P, 15%, 0) = $55,760
- Total $119,470
- These returns total $119,470. The additional cash accumulation at the end of three years from investing in the project is $119,470-$114,066=$5,404

Future Worth Criterion

$$FW(15\%)_{\text{inflow}} = \$24{,}400(F/P,15\%,2) + \$27{,}340(F/P,15\%,1)$$
$$+\$55{,}760(F/P,15\%,0)$$
$$= \boxed{\$119{,}470}$$
$$FW(15\%)_{\text{outflow}} = \$75{,}000(F/P,15\%,3)$$
$$= \boxed{\$114{,}066}$$
$$FW(15\%) = \$119{,}470 - \$114{,}066$$
$$= \$5{,}404 > 0,\ \text{Accept}$$

Future worth analysis

- This $5,404 is also known as *NFW, net future worth of the project at the project termination.*
- If we compute the equivalent present worth of this net cash surplus at time zero, we obtain $5,404(P/F, 15%. 3) = $3,553

Future worth analysis

- which is exactly the same as the PW of the project as computed by Eq. (5.1). Clearly, on the basis of its positive PW, the alternative of purchasing a new machine should be preferred to that of simply leaving the funds in the investment pool at the MARR.
- Thus, in PW analysis, any investment is assumed to be returned at the MARR. If a surplus exists at the end of the project life, then we know that PW (MARR) > 0. Figure 5.7 summarizes the reinvestment concept as it relates to the firm's investment pool

Future worth analysis

- Net Future worth measures surplus in an investment at a time period other than 0. net future worth analysis is particularly useful when we want to compute the equivalent worth of a project at the end of its investment period rather than at its beginning.
  - If FW(i) > 0, accept the investment.
  - If FW(i) = 0, remain indifferent.
  - If FW(i) < 0, reject the investment.

Future worth analysis
Project Balance Scenario

- Suppose that the firm does not have $75,000 at the outset. In fact. the firm doesn't have to maintain an investment pool at all. Let's further assume that the firm borrows all its capital from a bank at an interest rate of 15%, invests in the project, and uses the proceeds from the investment to pay off the principal and interest on the bank loan. How much is left over for the firm at the end of the project period?

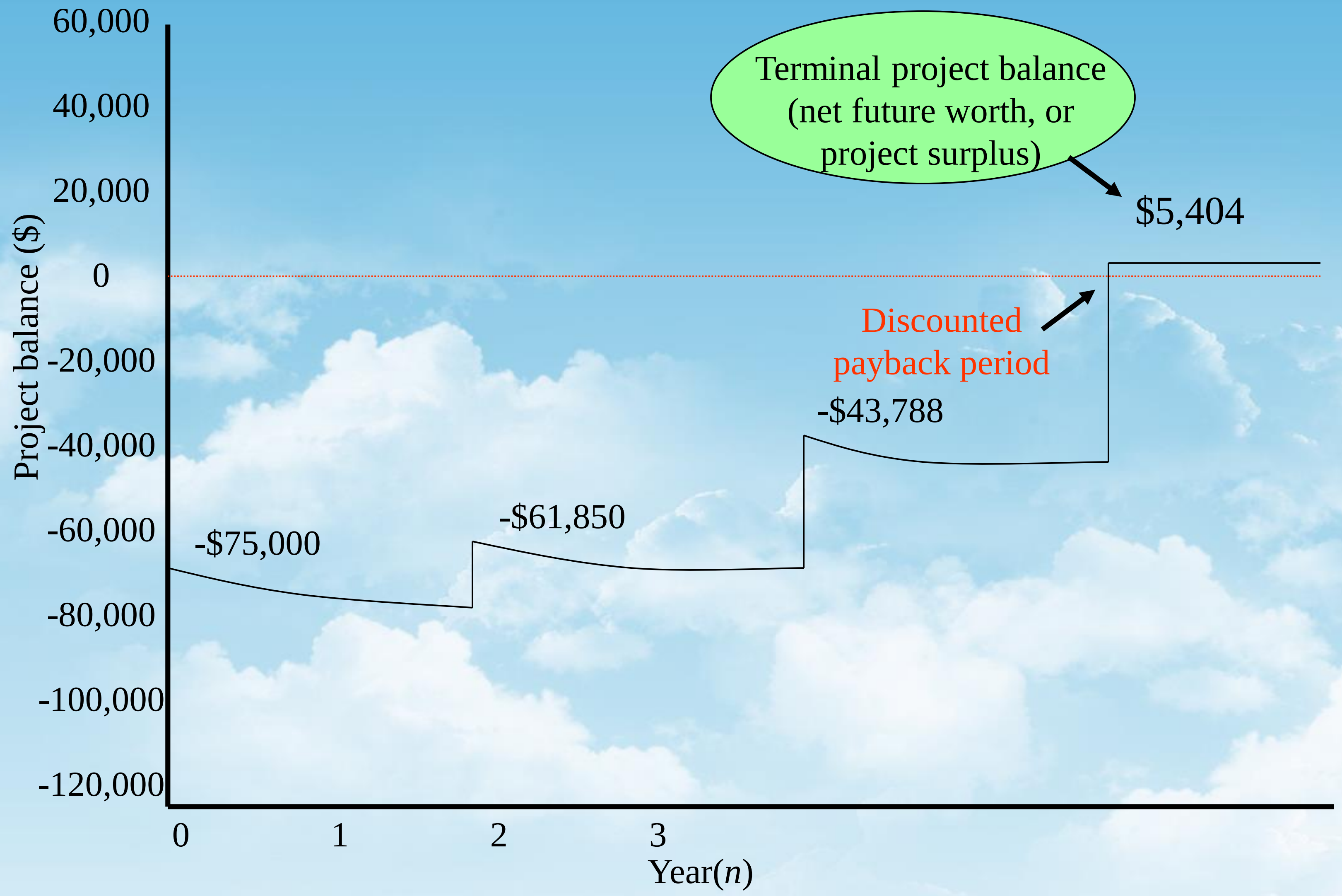
Project Balance Concept

N	0	1	2	3
Beginning Balance		-$75,000	-$61,850	-$43,788
Interest		-$11,250	-$9,278	-$6,568
Payment	-$75,000	+$24,400	+$27,340	+$55,760
Project Balance	-$75,000	-$61,850	-$43,788	+$5,404

Net future worth, FW(15%)

PW(15%) = $5,404 (*P*/*F*, 15%, 3) = $3,553

Project Balance Diagram



Net Future Worth Analysis
Capitalized-Equivalent Method

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Capitalized-Equivalent Method

- A special case of the PW criterion is useful when the life of a proposed project is perpetual or the planning horizon is extremely long (say, 40 years or more).
- Many public projects such as bridges. waterway constructions, irrigation systems, and hydroelectric dams are expected to generate benefits over an extended period of time (or forever).
- In this section. we examine the capitalized-equivalent [CE(i)] method for evaluating such projects.

Capitalized-Equivalent Method

- Consider the cash flow series shown in Figure 5.9. How do we determine the PW for an infinite (or almost infinite) uniform series of cash flows or a repeated cycle of cash flows?
- The process of computing the PW for this infinite series is referred to as the capitalization of project cost.

Capitalized-Equivalent Method

- **Capitalized** cost is **defined** as the present worth of a constant annual cost over an infinite analysis period. It can be shown that the factor (P/A,i%, n = infinity) is equal to (1 / i), with the interest rate i in decimal form

Capitalized-Equivalent Method

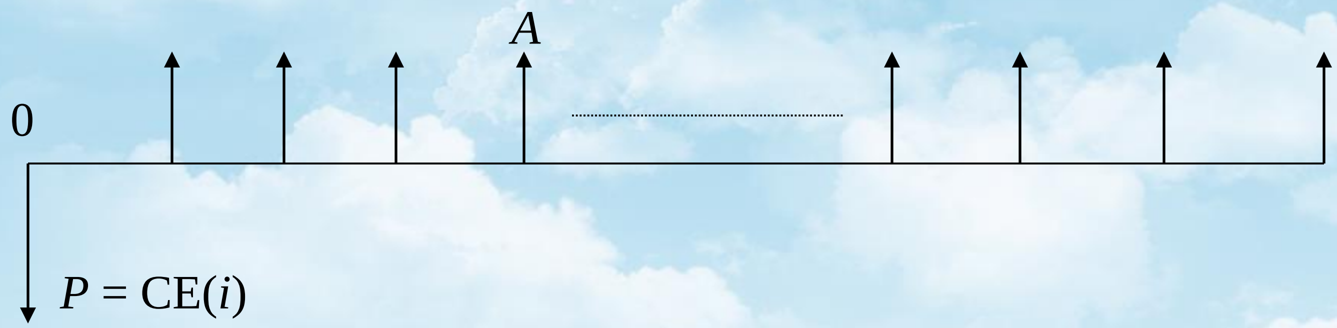
- The cost is known as the capitalized cost. The capitalized cost represents the amount of money that must be invested today in order to yield a certain return *A at the end of each and every* period forever. assuming an interest rate of i.

Capitalized Equivalent Worth

- **Principle**: **PW for a project with an annual receipt of *A* over infinite service life**

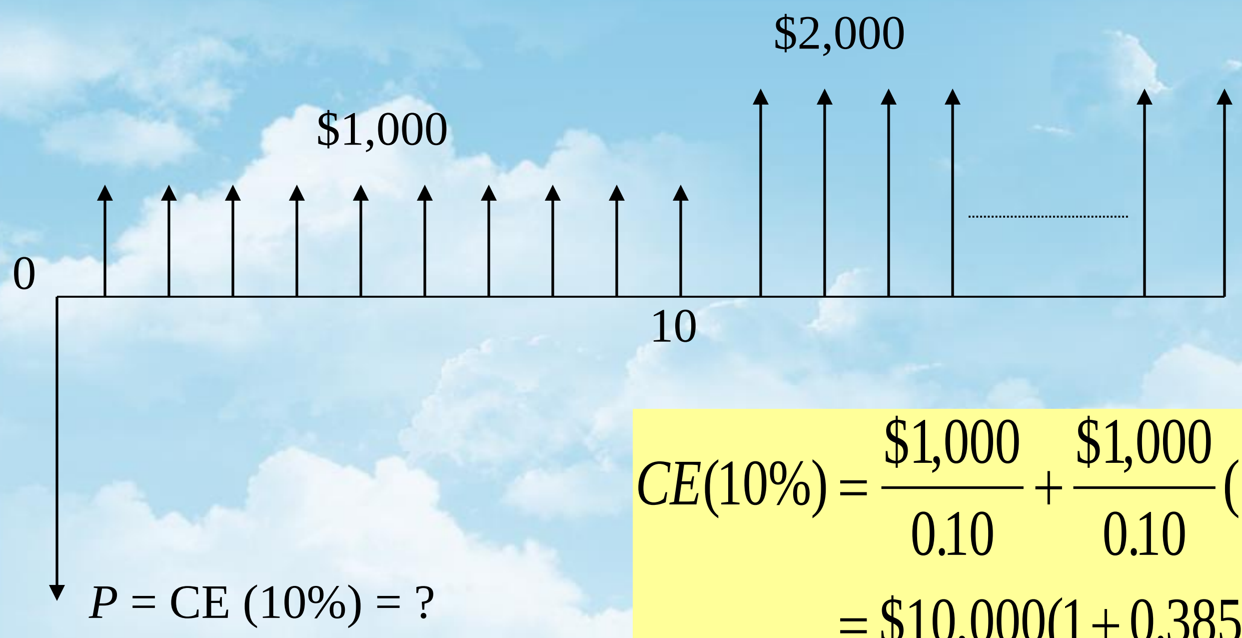
- **Equation**:

$$\mathbf{CE}(i) = A(P/A, i, \infty) = A/i$$



Given: $i = 10\%, N = \infty$

Find: P or CE (10%)



$$CE(10\%) = \frac{\$1{,}000}{0.10} + \frac{\$1{,}000}{0.10}(P/F,10\%,10)$$
$$= \$10{,}000(1 + 0.3855)$$
$$= \$13{,}855$$

Capitalized-Equivalent Cost: Example

- An engineering school has just completed a new engineering complex worth \$50 million. A campaign targeting alumni is planned to raise funds for future maintenance costs, which are estimated at \$2 million per year.
- Any unforeseen costs above \$2 million per year would be obtained by raising tuition. Assuming that the school can create a trust fund that earns 8% interest annually, how much has to be raised now to cover the perpetual string of \$2 million annual costs?

Capitalized-Equivalent Cost

Given: $A = \$2$ million, $i = 8\%$ per year, and $N = \infty$.

Find: CE(8%).

The capitalized-cost equation is

$$\text{CE}(i) = \frac{A}{i}.$$

Substituting in our given values, we obtain

$$\begin{aligned} CE(8\%) &= \$2{,}000{,}000/0.08 \\ &= \$25{,}000{,}000. \end{aligned}$$

Capitalized-Equivalent Cost

- It is easy to see that this lump-sum amount should be sufficient to pay maintenance expenses for the school forever. Suppose the school deposited $25 million at a bank that paid 8% interest annually.
- At the end of the first year, the $25 million would earn 8%($25 million) = $2 million interest. If this interest were withdrawn, the $25 million would remain in the account.
- At the end of the second year. the $25 million balance would again earn 8%($25 million) = $2 million. The annual withdrawal could be continued forever, and the endowment (gift funds) would always remain at $25 million.

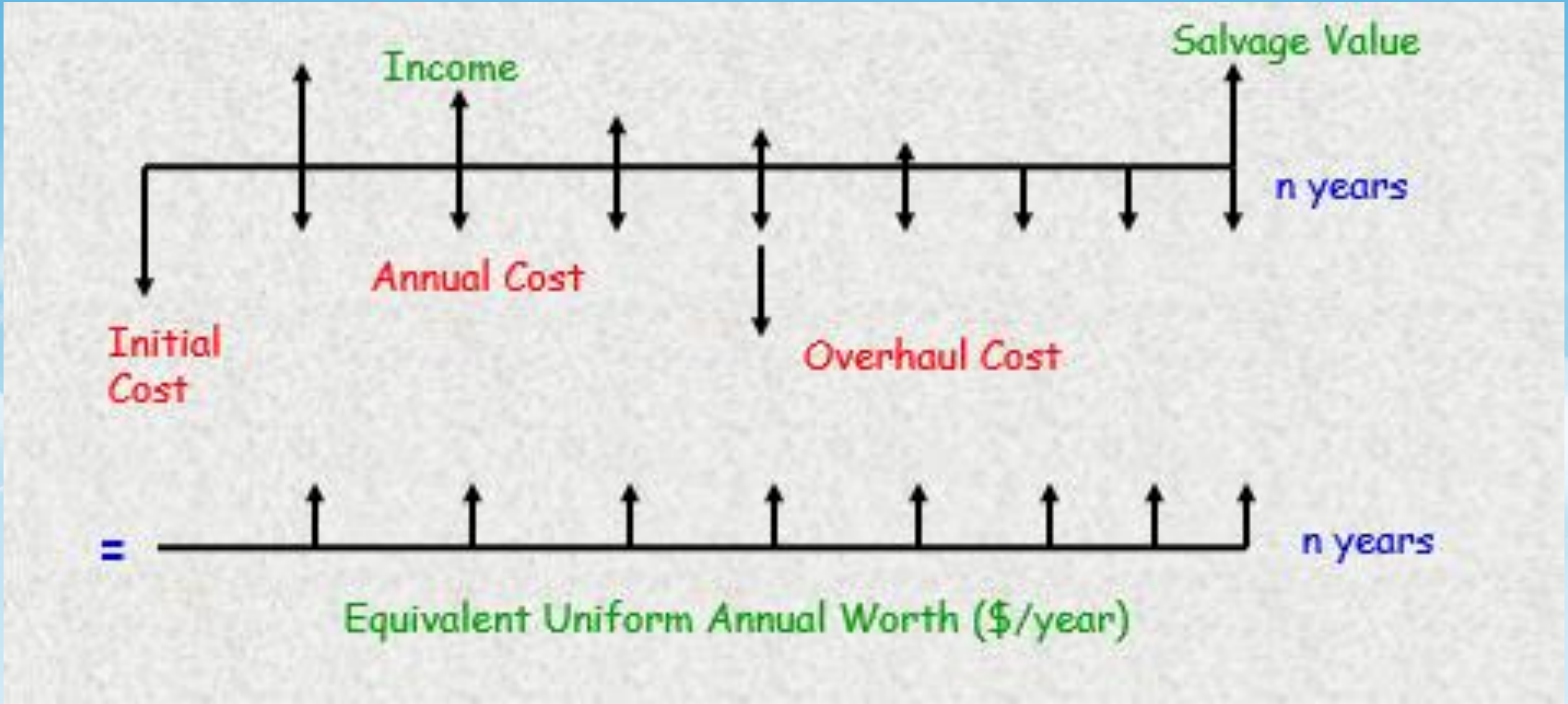
Annual Equivalent Worth Analysis

Annual Equivalent worth

- Annual-equivalence analysis, along with present-worth analysis, is the second major equivalence technique for translating alternatives into a common basis of comparison.

Annual Equivalent worth

- Annual Worth (AW) Analysis is defined as the equivalent uniform annual worth of all estimated receipts (income) and disbursements (costs) during the life cycle of a project.


Salvage Value
Income
n years
Annual Cost
Initial
Cost
Overhaul Cost
=
n years
Equivalent Uniform Annual Worth ($/year)

Annual Equivalent worth

Capital recovery
$(A/P, i, N)$

$$A = P\left[\frac{i(1+i)^N}{(1+i)^N - 1}\right]$$

Annual Equivalent worth

- The annual equivalent worth (AE) criterion provides a basis for measuring investment worth by determining equal payments on an annual basis.
- Knowing that any lump-sum cash amount can be converted into a series of equal annual payments, we may first find the net present worth of the original series and then multiply this amount by the capital-recovery factor:
  - $AE(i) = PW(i)(A/P, i, N)$.

Annual Equivalent worth

- We use this formula to evaluate the investment worth of projects as follows:
- Evaluating a Single Project: The accept-reject decision rule for a single *revenue* project is as follows:
  - If AE(i) > 0, accept the investment.
  - If AE(i) = 0. remain indifferent to the investment.
  - If AE(i) < 0, reject the investment

Annual Equivalent worth

- Notice that the factor *(A/P, i, N) in the above equation is positive for* $-1 < i < \infty$, which indicates that the AE(i) value will be positive if and only if PW(i) is positive.
- In other words, accepting a project that has a positive AE(i) value is equivalent to accepting a project that has a positive PW(i) value. Therefore. the AE criterion provides a basis for evaluating a project that is consistent with the PW criterion.

Annual Equivalent Cost Method

Annual Equivalent Cost Method

- When only costs are involved, the AE method is sometimes called the *annual equivalent cost method*. In this case, revenues must cover two kinds of costs: operating costs and capital costs.

Annual Equivalent Cost Method

- **Capital costs** are fixed, one-time **expenses** incurred on the purchase of land, buildings, construction, and equipment used in the production of goods or in the rendering of services.
- In other words, it is the total **cost** needed to bring a project to a commercially operable status.

Annual Equivalent Cost Method

- *Operating costs are incurred by the operation of physical plants or equipment* needed to provide service; examples include the costs of items such as labor and raw materials.

Capital Recovery Cost

- *Capital recovery costs (or ownership costs) are incurred by purchasing assets to* be used in production and service.
    - Capital **recovery** is the earning back of the initial funds put into an investment. **Capital recovery** must occur before a company can earn a profit on its investment
- Normally, capital costs are nonrecurring (i.e.. one-time costs), whereas operating costs recur for as long as an asset is owned.

Capital Recovery Cost

- *Capital recovery* represents the return of an invested capital over an investment's life span. one cannot determine a true return on an investment until the amount of the initial investment is returned.
- The term "capital recovery" is used with both long-term assets and with companies, For example, if your company purchases a concrete mixer for $300,000, the company cannot determine any profits on the printing press until it recovers the $300,000 it spent.

Annual Equivalent worth

- Because operating costs recur over the life of a project, they tend to be estimated on an annual basis, so for the purposes of annual equivalent cost analysis, no special calculation is required.
- However. because capital costs tend to be one-time costs. In conducting an annual equivalent cost analysis we must translate these one-time costs into its annual equivalent over the life of the project.

Annual Equivalent worth:
capital-recovery cost. CR(i).

- The annual equivalent of a capital cost is given a special name: capital-recovery cost designated CR(i).
- Two general monetary transactions are associated with the purchase and eventual retirement of a capital asset:
  - the asset's initial cost (I) and its
  - salvage value *(S)*

Annual Equivalent worth: Example

- Consider a machine that costs *$20,000 and has a five-year useful life. At the end* of the five years, it can be sold for *$4,000 after all tax adjustments have been factored* in.
- If the firm could earn an after-tax revenue of *$4.400 per year with this* machine, should it be purchased at an interest rate of *10%? (All benefits and* costs associated with the machine are accounted for in these figures.)

Annual Equivalent worth: Example

- Given:
  - *I = \$20,000,*
  - *S = \$4,000.*
  - *A = \$4,400,*
  - *N = 5 years, and*
  - *i = 10% per* year.
- Find: *AE, and determine whether the firm should or should not purchase the* machine.

Annual Equivalent worth: Example

- We will compute the capital costs in two different ways:
- *Method 1:*
  - –*First compute the PW of the cash flows:*

Annual Equivalent worth: Example

Capital recovery $(A/P, i, N)$

$$A = P\left[\frac{i(1+i)^N}{(1+i)^N - 1}\right]$$

Annual Equivalent Worth: Capital Recovery Cost

Method 1: First compute the PW of the cash flows:

$$
\begin{aligned}
PW(10\%) &= -\$20{,}000 \\
&\quad + \$4{,}400(P/A, 10\%, 5) + \$4{,}000\,(P/F, 10\%, 5) \\
&= -\$20{,}000 + \$4{,}400(3.7908) + \$4{,}000(0.6209) \\
&= -\$836.88.
\end{aligned}
$$

Then compute the AE from the calculated PW:

$$AE(10\%) = -\$836.88(A/P, 10\%, 5) = -\$220.76.$$

This negative AE value indicates that the machine does not generate sufficient revenue to recover the original investment, so we may reject the project. In fact, there will be an equivalent loss of \$220.76 per year over the machine's life.

Annual Equivalent worth

- PW (10%) = -$ 20,000 + $4,400 (P/A, 10%, 5) + $4000 (P/A, 10%, 5)
- = -$ 20,000 + $4,400 (3.7908) + $4000 (0.6209)
- =-$ 836.88
- Then compute the AE from the calculated PW:
- AE(10%) = - $836.88 (A/P, 10 %, 5)= -$220.76

Annual Equivalent worth

- This negative *AE value indicates that the machine does not generate sufficient* revenue to recover the original investment, so we may reject the project. In fact, there will be an equivalent loss of *$220.76 per year over the machine's life.*
- However, the annual operating benefits actually amount to only $4,400, resulting in a loss of $220.76 per year. Therefore, the project is not worth undertaking

Annual Equivalent Worth: Capital Recovery Cost

- *Method 2: The second method is to separate cash flows associated with the asset* acquisition and disposal from the normal operating cash flows.
  - Since the operating cash flows-the *$4.400 yearly income-are already given in equivalent annual* flows *($AE(i)_2$) we need only to convert the cash flows associated with asset* acquisition and disposal into equivalent annual flows *(AE(i),).*

Annual Equivalent Worth: Capital Recovery Cost

- *According to Equation (6.3)*
  - CR(i) = *(I - S)(A/P, i, N) + iS.*
  - In this case,
  - *AE(i), = -CR(i)*
  - *= -[($20,000 - $4,000)(A/P, 10%, 5) + (0.10)$4,000]*
  - *= -$4,620.76.*

Annual Equivalent Worth: Capital Recovery Cost

Knowing that

$$AE(i)_2 = \$4{,}400,$$

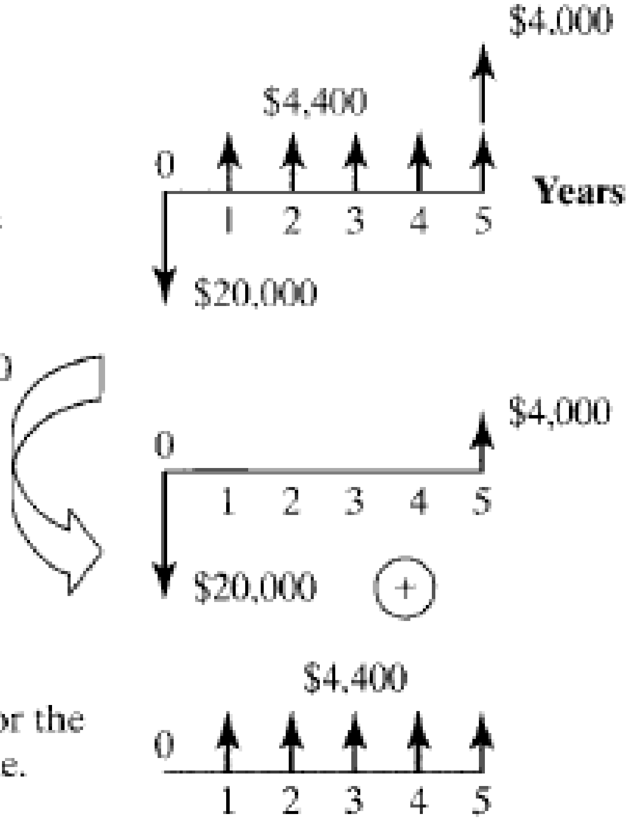
we can calculate the total AE as follows:

$$\begin{aligned} AE(10\%) &= AE(i)_1 + AE(i)_2 \\ &= -\$4{,}620.76 + \$4{,}400 \\ &= -\$220.76. \end{aligned}$$

Obviously, Method 2 saves a calculation step, so we may prefer it over Method 1. We may interpret Method 2 as determining that the annual operating benefits must be at least \$4,620.76 in order to recover the asset cost. However, the annual operating benefits actually amount to only \$4,400, resulting in a loss of \$220.76 per year. Therefore, the project is not worth undertaking. (See Figure 6.3.)

Annual Equivalent Worth: Capital Recovery Cost

- **Given:** I = \$20,000, S = \$4,000, N = 5 years, and i = 10%.
- **Find:** Determine whether an annual revenue of \$4,400 is enough to cover the capital costs.
- **Solution:** CR(10%) = \$4,620.76.
- **Conclusion:** Need an additional annual revenue in the amount of \$220.76 for the investment to be worthwhile.



Justifying an investment, based on the AE method

Annual Equivalent Worked Example

Finding Annual Equivalent Worth by Conversion from Present Worth

- Singapore Airlines is planning to equip some of its Boeing 747 aircrafts with inflight e-mail and Internet service on transoceanic flights. Passengers on these flights will be able to send and receive e-mail no matter where they are in the skies. As e-mail has become a communications staple, airlines have been under increasing pressure to offer access to it. But the rollout has been slow. Because airlines are hesitant to invest in systems that could quickly become outdated. Hoping to provide added value to its passengers, Singapore Airlines has decided to offer the service through telephone modems for 10 Boeing 747s in 2010.

Finding Annual Equivalent Worth by Conversion from Present Worth

- If the project turns out to be a financial success, Singapore Airlines will introduce the service to the remaining 56 Boeing 747s in its fleet. The service will be free during the first year. After the promotional period, a nominal charge of about $10 will be instituted for each e-mail message sent or received. Singapore Airlines has estimated the projected cash flows (in millions of dollars) for the systems in the first 10 aircraft as follows:

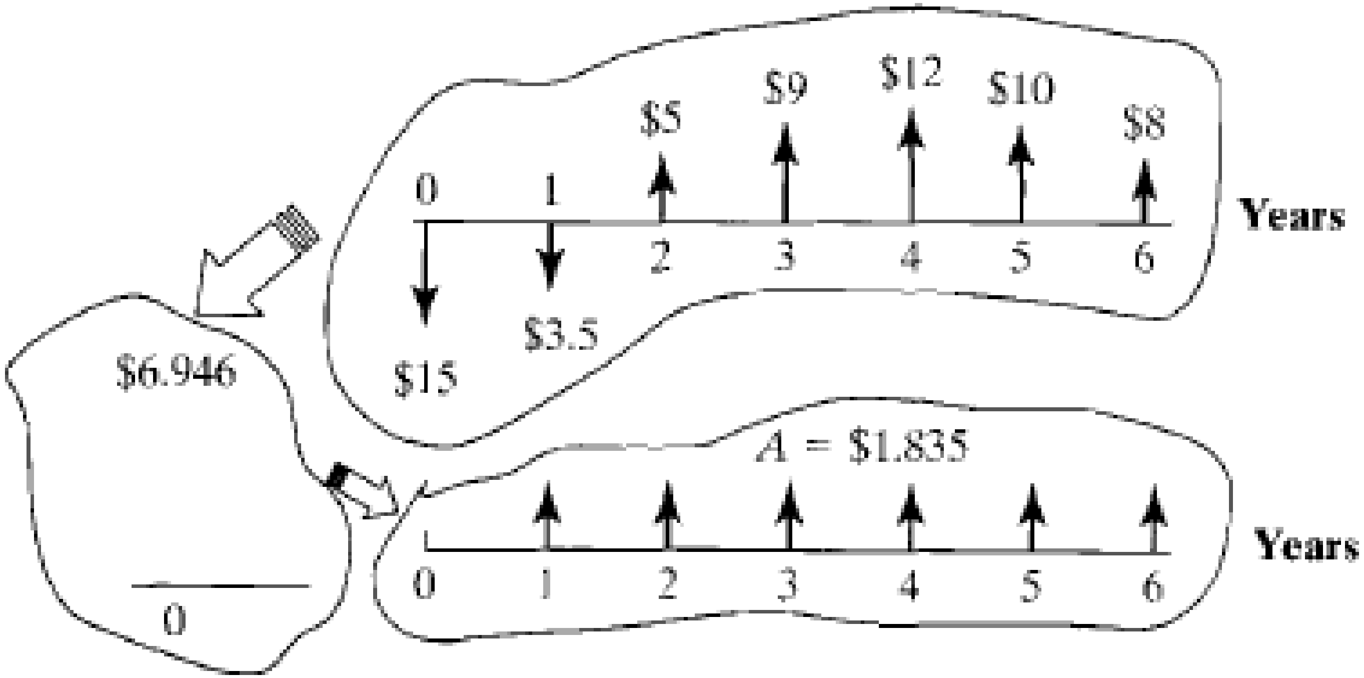
Determine whether the project can be justified at MARR of 15 % and calculate the annual befits or loss that would be generated after the installation of the system

N, Year	An (in Millions of Dollars)
2010	-15
2011	-3.5
2012	5
2013	9
2014	12
2015	10
2016	8

Finding Annual Equivalent Worth by Conversion from Present Worth

- When a cash flow has no special pattern, it is easiest to find the AE in two steps:
  - (1) find the PW of the flow and
  - (2) find the AE of the PW.
- Given: The cash flow diagram in the following Figure
  - *i = 15 5%.*
- Find: The AE.

Finding Annual Equivalent Worth by Conversion from Present Worth



PW(15%) = $6.946   AE(15%) = $6.946(A/P, 15%, 6)
= $1.835

Note: All dollar values are in millions of dollars.

Computing equivalent annual worth

Finding Annual Equivalent Worth by Conversion from Present Worth

- We first compute the PW at i = 15%:
- PW(15%) = -$I5 - $3.5(P/F, 15%, 1) + $5(P/F, 15%,2) + ...+ $10(P/F, IS%, 5) + $8(P/F, 15%, 6)
- = $6.946 million.
- Since PW(15%) > 0, the project would be acceptable under the PW analysis.

Finding Annual Equivalent Worth by Conversion from Present Worth

- Now, spreading the PW over the project life gives
- AE(15%) = \$6.916(A/P, 15%, 6) = \$1.835 million.
- Since AE(15%) > 0, the project is worth undertaking. The positive AE value indicates that the project is expected to bring in a net annual benefit of \$1.835 million over the life of the project.

Rate of Return

Rate Of Return

- Along with the PW and AE criteria. the third primary measure of investment worth is rate of return. As shown earlier*, the PW measure is easy to* calculate and apply.
- Nevertheless, many engineers and financial managers prefer rate-of-return analysis to the PW method, because they find it intuitively more appealing to analyze investments in terms of percentage rates of return rather than in dollars of PW

Rate Of Return

- Consider the following statements regarding an investment's profitability:
  - This project will bring in a 15% rate of return on the investment.
  - This project will result in a net surplus of $10.000 in terms of PW.
- Neither statement describes the nature of an investment project in any complete sense. However, the rate-of-return figure is somewhat easier to understand, because many of us are so familiar with savings and loan interest rates, which are in fact rates of return.

Rate Of Return

- In this section, we will examine four aspects of rate-of-return analysis:
  - (1) Return on investment;
  - (2) Rate of return;
  - (3) Internal rate-of-return and
  - (4) comparison of mutually exclusive alternatives, based on rate of return

Rate of Return

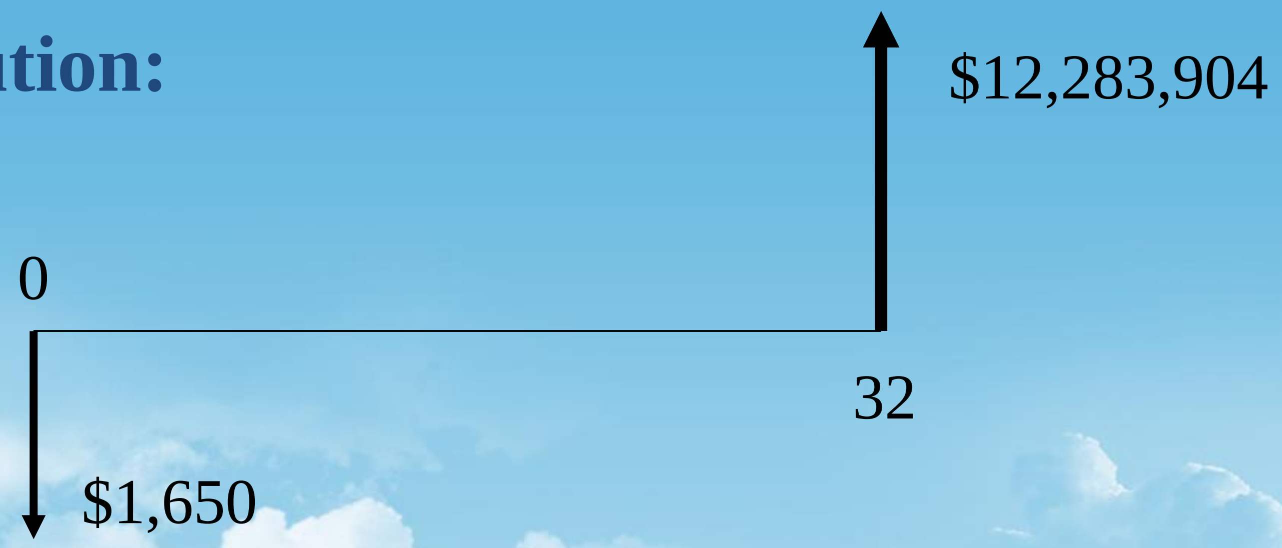
- Definition: A relative percentage method which measures the yield as a percentage of investment over the life of a project

Example: Meaning of Rate of Return

In 1970, when Wal-Mart Stores, Inc. went public, an investment of 100 shares cost $1,650. That investment would have been worth $12,283,904 on January 31, 2002.

What is the <u>rate of return</u> on that investment?

Solution:



Given: P = $1,650

F = $12,283,904

N = 32

Find i:

$$F = P(1+i)^N$$

$$\$12{,}283{,}904 = \$1{,}650\,(1 + i\,)^{32}$$

i = 32.13% → Rate of Return

Suppose that you invested that amount ($1,650) in a savings account at 6% per year. Then, you could have only $10,648 on January, 2002.

What is the meaning of this 6% interest here?

This is your opportunity cost if putting money in savings account was the best you can do at that time!

So, in 1970, as long as you earn more than 6% interest in another investment, you will take that investment.

Therefore, that 6% is viewed as a minimum attractive rate of return (or required rate of return).

So, you can apply the following decision rule, to see if the proposed investment is a good one.

ROR (32.13%) > MARR(6%)

Internal Rate of Return

- several ways to determine its rate of return are available. Some of the most practical methods are as follows:
  – • Direct solution method,
  – •Trial-and-error method, and
  – • Computer solution method.

Summary

- Mathematically, we can determine the rate of return for a given project cash flow series by locating an interest rate that equates the net present worth of the project's cash flows to zero.
- This break-even interest rate is denoted by the symbol i^*.
- The internal rate of return (IRR) is another term for ROR which stresses the fact that we are concerned with the interest earned on the portion of the project that is internally invested, not those portions released by (borrowed from) the project.

Benefit-Cost ratio and other methods

Benefit Cost Ratio

- One of the most important aspects of a public project is to quantify the benefits of the project in money terms
- For instance in an airport expansion work it is necessary to quantify the cost of airport delays in dollar terms. In other words, planners ask, "What is the economic benefit of reducing airport delays?"
  - From the airline's point of view, taxiing and arrival delays mean added fuel costs. For the airport, delays mean lost revenues in landing and departure fees.
  - From the public's point of view, delays mean lost earnings, as people then have to spend more time on transportation. Comparing the investment costs with the potential benefits, an approach known as benefit–cost analysis, is an important feature of economic analysis.

Benefit cost ratio

- *Benefit-cost* analysis is a decision-making tool used to systematically develop useful information about the desirable and undesirable effects of public projects.
- In a sense, we may view benefit-cost analysis in the public sector as profitability analysis in the private sector.
- In other words, benefit-cost analysis attempts to determine whether the social benefits of a proposed public activity outweigh the social costs.

Benefit Cost Ratio

- Usually, public investment decisions involve a great deal of expenditure, and their benefits are expected to occur over an extended period of time.
- Examples of *benefit-cost* analyses include studies of public transportation systems, environmental regulations on noise and pollution, public safety programs, education and training programs, public health programs, flood control systems, water resource development projects, and national defense program

Benefit cost ratio

- The three types of benefit-cost analysis problems are as follows:
  - (1) problems for which the goal is to *maximize* the *benefits* for any given set of costs (or budgets).
  - (2) problems for which the goal is to maximize the net benefits when both benefits and costs vary, and
  - (3) problems for which the goal is to minimize costs in order to achieve any given level of benefits (often called cost-effectiveness analysis)

Benefit cost ratio

- To evaluate public projects designed to accomplish widely differing tasks. we need to measure the benefits or costs in the same units in all projects so that we have a common perspective by which to judge them.
- In practice, this requirement means expressing both benefits and costs in monetary units, a process that often must be performed without accurate data. In performing benefit-cost analysis, we define users as the public and sponsors as the government

Benefit cost ratio

- The general framework for benefit-cost analysis can be summarized as follows:
  - 1. Identify all users' benefits (favorable outcomes) and dis-benefits (unfavorable outcomes) expected to arise from the project.
  - 2. Quantify, as much as possible. these benefits and dis-benefits in dollar terms so that different benefits and the respective costs of attaining them may be compared.
  - 3. Identify the sponsor's costs and quantify them.
  - 4. Determine the equivalent net benefits and net costs at the base period: use a discount rate appropriate for the project.
  - 5. Accept the project if the equivalent users' net benefits exceed the equivalent sponsor's net costs.

Cost Benefit Analysis

Decision making is about choices

- For an individual
  - They might rely on intuition, a “gut feel” for the right choice. They decide to do an analysis of the choices or it may be a combination of both of these.
- For a company
  - Being concerned with the profit earning capacity and income flow, they may undertake a cashflow analysis or a full financial appraisal of the project.
- For the Government
  - Decision making for governments is much harder. Not only are they expected to consider the profitability (or at least neutrality) of the costing but must also include consideration of the social cost and benefits of their choices. They are also expected to act within the political environment to satisfy the political agenda set by the government of the day and finally, must also comply with environmental considerations.

Cost Benefit Analysis

What is Cost Benefit Analysis?

- CBA has been established primarily as a tool for use by governments in making their social and economic decisions.
- CBA measures costs and benefits to the community of adopting a particular course of action e.g. Constructing a dam, by-pass etc.
- CBA is a decision making device for evaluating activities that are not priced by the market.
- CBA attempts to simulate a market result in areas where the market does not operate to establish prices OR attempts to quantify and include in estimates of cost and benefits to client but also to rest of community.

Cost Benefit Analysis

- To begin a benefit-cost analysis, we identify all project benefits and disbenefits to the users, bearing in mind the indirect consequences resulting from the project the so-called secondary effects.
- For example. construction of a new highway will create new businesses such as gas stations. restaurants. and motels (benefits), but it will also divert some traffic from the old roads. and. as a consequence, some businesses may be lost (disbenefits).
- Once the benefits and disbenefits are quantified. we define the overall user's benefit B as follows:
  - ***B = benefits - disbenefits***

Cost Benefit Analysis

Other issues

- Is the project worthwhile financially?
- Is it the best option?
- Should it be undertaken at all?

Project Risk and Uncertainty

Project Risk and Uncertainty

- Risk: is the potential for loss
- Risk: describes an investment project whose cash flow is not known in advance with absolute certainty, but for which an array of alternative outcomes and their probabilities (odds)are known.
- Project Risk : refers to variability in a projects NPW

Project Risk and Uncertainty

- When deciding whether or not to make a major capital investment, such as introducing a new product, a number of issues must be considered and estimated.
- The factors to be estimated include the total market for the product: the market share that the firm can attain: the growth in the market; the cost of producing the product; the selling price of the product; the life of the product: the cost and life of the equipment needed; and the effective tax rates.
- Many of these factors are subject to substantial uncertainty. A common approach is to make single-number "best estimates" for each of the uncertain factors and then to calculate measures of profitability, such as PW or rate of return for the project.

Project Risk and Uncertainty

- This approach has two drawback
  - No guarantee can ever ensure that the best estimates will ever match actual values.
  - 2. No provision is made to measure the risk associated with the investment or the project risk. In particular. managers have no way of determining either the probability that a project will lose money or the probability that it will generate large profits.

Project Risk and Uncertainty

- Because cash flows can be so difficult to estimate accurately. project managers frequently consider a range of possible values for cash flow elements.
- If a range of values for individual cash flows is possible, it follows that a range of values for the PW of a given project is also possible.
- Clearly, the analyst will want to try to gauge the probability and reliability of individual cash flows occurring and, consequently, the level of certainty about overall project worth.

Project Risk and Uncertainty

- Quantitative statements about risk are given as numerical probabilities or as values for likelihood (odds) of occurrence. Probabilities are given as decimal fractions in the interval 0.0 to 1.0. An event or outcome that is certain to occur has a probability of 1.0.
- As the probability of an event approaches 0, the event becomes increasingly less likely to occur. The assignment of probabilities to the various outcomes of an investment project is generally called risk analysis

Project Risk and Uncertainty

- We may begin analyzing project risk by first determining the uncertainty inherent in a project's cash flows. We can do this analysis in a number of ways, which range from making informal judgments to performing complex economic and statistical analyses.
- In this section, we will introduce three methods of describing project risk:
  - (1) sensitivity analysis,
  - (2) break-even analysis, and
  - (3) scenario analysis.
- Each method will be explained with reference to a single example (Boston Metal Company). We also introduce the method for conducting sensitivity analysis for mutually exclusive alternatives

Sensitivity Analysis

Sensitivity Analysis

- One way to glean a sense of the possible outcomes of an investment is to perform a sensitivity analysis.
- Sensitivity analysis determines the effect on the PW of variations in the input variables (such as revenues. operating cost. and salvage value) used to estimate after-tax cash flows.

Sensitivity Analysis

- In calculating cash flows, some items have a greater influence on the final result than others. In some problems, the most significant item is easily identified. For example, the estimate of sales volume can have a major impact in a project's PW, especially in new product introductions.
- We may want to identify the items that have an important influence on the final results so that they can be subjected to special scrutiny

Sensitivity Analysis

- Sensitivity analysis is sometimes called "what-if analysis," because it answers questions such as what if incremental sales are only 1,000 units, rather than 2,000 units? Then what will the PW be?
- Sensitivity analysis begins with a base-case situation, which is developed using the most likely value for each input.
- We then change the specific variable of interest by several specified percentages above and below the most likely value, while holding other variables constant.

Sensitivity Analysis

- Next we calculate a new PW for each of these values. A convenient and useful way to present the results of a sensitivity analysis is to plot sensitivity graphs.
- The slopes of the lines show how sensitive the PW is to changes in each of the inputs:
- The steeper the slope, the more sensitive the PW is to a change in a particular variable.
- Sensitivity graphs identify the crucial variables that affect the final outcome the most. We will use Example 10.1 to illustrate the concept of sensitivity analysis

Risk and Uncertainty

- Because cash flows can be so difficult to estimate accurately. project managers frequently consider a range of possible values for cash flow elements.
- If a range of values for individual cash flows is possible, it follows that a range of values for the PW of a given project is also possible.
- Clearly, the analyst will want to try to gauge the probability and reliability of individual cash flows occurring and, consequently, the level of certainty about overall project worth

Risk and Uncertainty

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- The assignment of probabilities to the various outcomes of an investment project is generally called risk analysis

Risk and Uncertainty

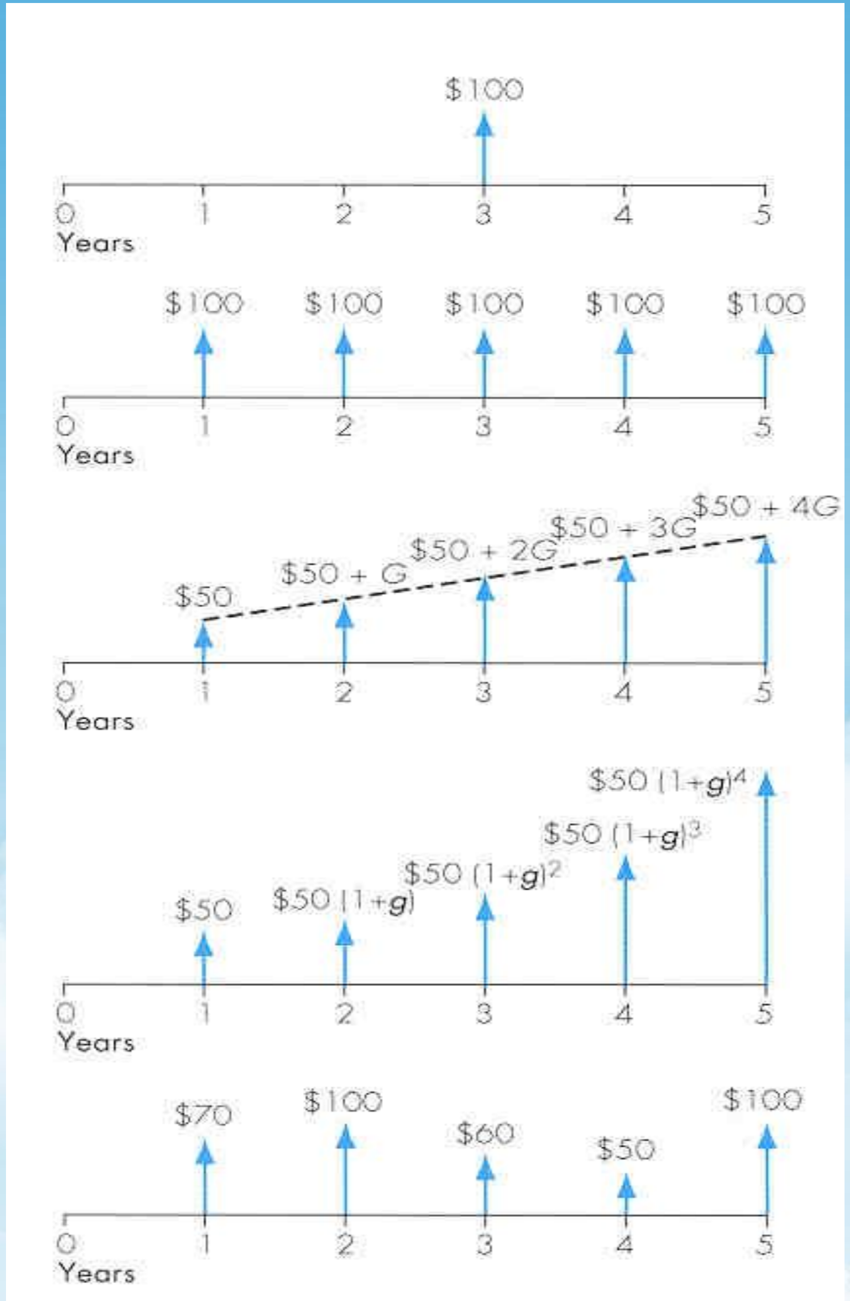
- We may begin analyzing project risk by first determining the uncertainty inherent in a project's cash flows.
- We can do this analysis in a number of ways, which range from making informal judgments to performing complex economic and statistical analyses.
- In this section, we will introduce three methods of describing project risk:
  - (1) sensitivity analysis,
  - (2) break-even analysis, and
  - (3) scenario analysis

- In Engineering economics we ***predict*** *cash flows*

- *How do you know for sure that what you are claiming for interest rate, costs, revenues remain true???*

- *Well for some situations you can be close enough to consider your "single point" analysis to be worthwhile.*

- For other you need to consider what is called **RISK**



Risk and Uncertainty

- We use the term **risk** to describe an investment project where cash flows are not ***known in advanced with certainty***.

- What to do: **Instead of single point analysis**, an **array of outcomes and their probabilities** or odds are to considered.

Methods of Describing Project Risk

- Sensitivity Analysis: a means of **identifying the project variables** which, *when varied, have the greatest effect on project acceptability*.

- Break-Even Analysis: a means of identifying the *value of a particular project variable that causes the project to exactly break even*.

- Scenario Analysis: a means of comparing a "**base case**" to one or more additional scenarios, such as best and worst case, to identify the extreme and most likely project outcomes.

Sensitivity analysis

- One way to glean a sense of the possible outcomes of an investment is to perform a sensitivity analysis. Sensitivity analysis determines the effect on the PW of variations in the input variables (such as revenues. operating cost. and salvage value) used to estimate after-tax cash flows.

Sensitivity analysis

- In calculating cash flows, some items have a greater influence on the final result than others.
- In some problems, the most significant item is easily identified.
  - For example, the estimate of sales volume can have a major impact in a project's PW, especially in new product introductions. We may want to identify the items that have an important influence on the final results so that they can be subjected to special scrutiny

Sensitivity Analysis

- Boston Metal Company (BMC), a small manufacturer of fabricated metal parts, must decide whether to enter the competition to become the supplier of transmission housings for Gulf Electric, a company that produces the housings in its own in-house manufacturing facility, but that has almost reached its maximum production capacity.
- Therefore, Gulf is looking for an outside supplier. To compete, BMC must design a new fixture for

Sensitivity Analysis

- the production process and purchase a new forge. The available details for this purchase are as follows:
- •The new forge would cost $125,000. This total includes retooling costs for the transmission housings.
- If BMC gets the order, it may be able to sell as many as 2,000 units per year to Gulf Electric for $50 each, in which case variable production costs,2 such as direct labor and direct material costs, will be $15 per unit.
- The increase in fixed costs,3 other than depreciation, will amount to $10,000 per year.
- The firm expects that the proposed transmission-housings project will have about a five-year product life.

Sensitivity Analysis

- The firm also estimates that the amount ordered by Gulf Electric in the first year will be ordered in each of the subsequent four years. (Due to the nature of contracted production, the annual demand and unit price would remain the same over the project after the contract is signed.)
- •The initial investment can be depreciated on a MACRS basis over a seven-year period, and the marginal income tax rate is expected to remain at 40%.
- At the end of five years, the forge is expected to retain a market value of about 32% of the original investment

Sensitivity Analysis

- On the basis of this information, the engineering and marketing staffs of BMC have prepared the cash flow forecasts shown in Table 12.1.
- Since the NPW is positive ($40,168) at the 15% opportunity cost of capital (MARR), the project appears to be worth undertaking.

Sensitivity analysis

- Refer to Page 361-363 of Text book

Sensitivity Analysis – Example 10.1

- Transmission-Housing Project by Boston Metal Company
  - New investment = $125,000
  - Number of units = 2,000 units
  - Unit Price = $50 per unit
- Unit variable cost= $15 per unit (direct labor and direct-material costs)
  - Fixed cost = $10,000/Yr
  - Project Life = 5 years
  - Salvage value = $40,000
  - Income tax rate = 40%
  - MARR = 15%

Example 10.1 - After-tax Cash Flow for BMC's Transmission-Housings Project – "Base Case"

	0	1	2	3	4	5
Revenues:						
Unit Price		50	50	50	50	50
Demand (units)		2,000	2,000	2,000	2,000	2,000
Sales revenue		$100,000	$100,000	$100,000	$100,000	$100,000
Expenses:						
Unit variable cost		$15	$15	$15	$15	$15
Variable cost		30,000	30,000	30,000	30,000	30,000
Fixed cost		10,000	10,000	10,000	10,000	10,000
Depreciation		17,863	30,613	21,863	15,613	5,575
Taxable Income		$42,137	$29,387	$38,137	$44,387	$54,425
Income taxes (40%)		16,855	11,755	15,255	17,755	21,770
Net Income		$25,282	$17,632	$22,882	$26,632	$32,655

(Example 10.1, Continued)

Cash Flow Statement	0	1	2	3	4	5
Operating activities						
Net income		25,282	17,632	22,882	26,632	32,655
Depreciation		17,863	30,613	21,863	15,613	5,575
Investment activities						
Investment	(125,000)					
Salvage						40,000
Gains tax						(2,611)
Net cash flow	($125,500)	$43,145	$48,245	$44,745	$42,245	$75,619

	A	B	C	D	E	F	G
1	Example 10.1 BMC's Transmission-Housings Project						
2							
13	**Income Statement**						
14		0	1	2	3	4	5
15	Revenues:						
16	Unit Price		$ 50	$ 50	$ 50	$ 50	$ 50
17	Demand (units)		2000	2000	2000	2000	2000
18	Sales Revenue		$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000
19	Expenses:						
20	Unit Variable Cost		$ 15	$ 15	$ 15	$ 15	$ 15
21	Variable Cost		30,000	30,000	30,000	30,000	30,000
22	Fixed Cost		10,000	10,000	10,000	10,000	10,000
23	Depreciation		17,863	30,613	21,863	15,613	5,581
25	Taxable Income		$ 42,137	$ 29,387	$ 38,137	$ 44,387	$ 54,419
26	Income Taxes (40%)		16,855	11,755	15,255	17,755	21,768
28	Net Income		$ 25,282	$ 17,632	$ 22,882	$ 26,632	$ 32,651
29							
30	**Cash Flow Statement**						
31	Operating Activities:						
32	Net Income		25,282	17,632	22,882	26,632	32,651
33	Depreciation		17,863	30,613	21,863	15,613	5,581
34	Investment Activities:						
35	Investment	(125,000)					
36	Salvage						40,000
37	Gains Tax						(2,613)
39	Net Cash Flow	$ (125,000)	$ 43,145	$ 48,245	$ 44,745	$ 42,245	$ 75,619
40							

Sensitivity Analysis

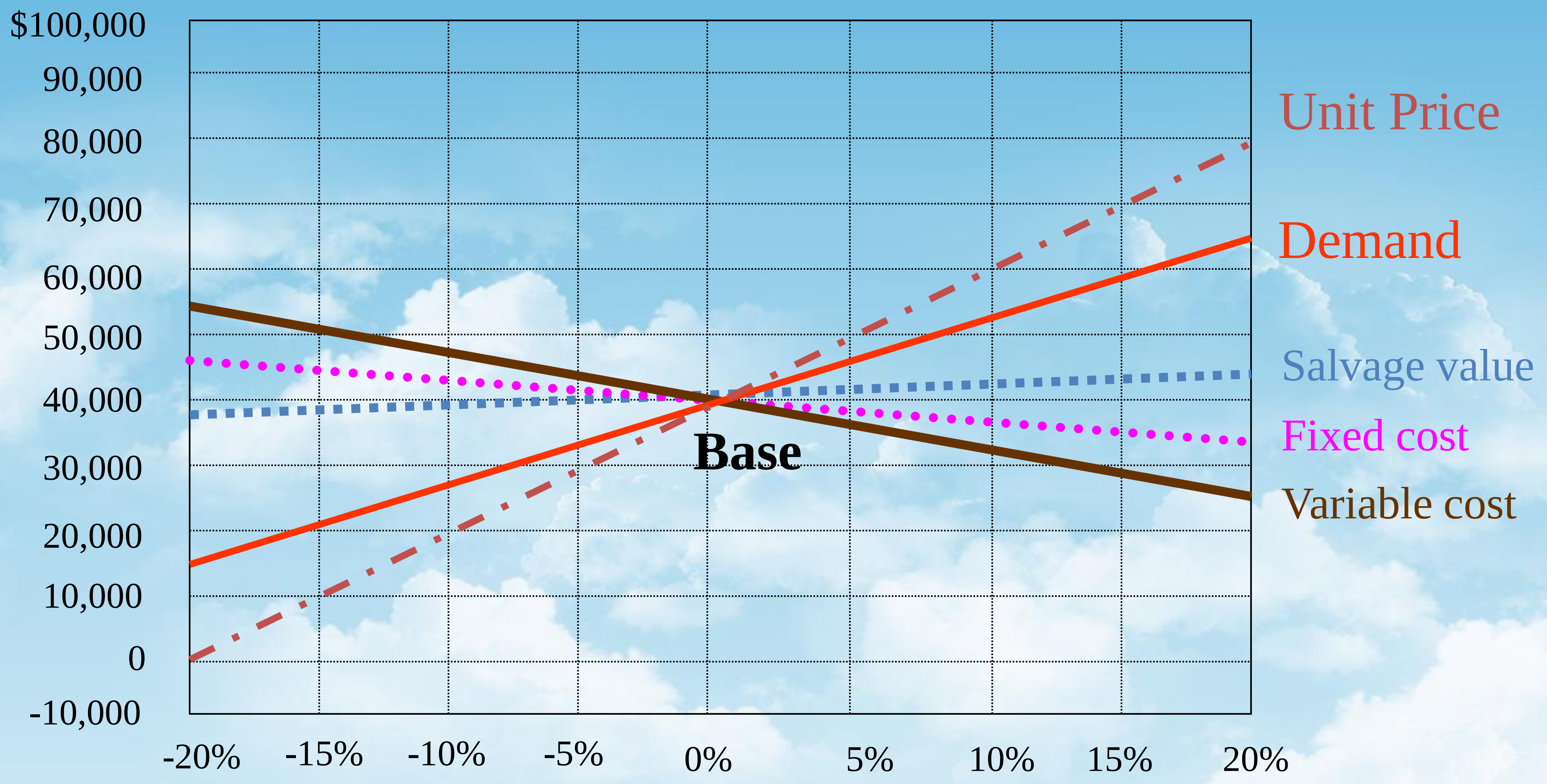
- After defining the unit sales, unit price. unit variable cost, fixed cost, and salvage value, we conduct a sensitivity analysis with respect to these key input variables.
- This is done by varying each of the estimates by a given percentage and determining what effect the variation in that item will have on the final results. If the effect is large, the result is sensitive to that item. Our objective is to locate the most sensitive item(s).

Example 10.1 - Sensitivity Analysis for Five Key Input Variables

Deviation	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
Unit price	$57	$9,999	$20,055	$30,111	$40,169	$50,225	$60,281	$70,337	$80,393
Demand	12,010	19,049	26,088	33,130	40,169	47,208	54,247	61,286	68,325
Variable cost	52,236	49,219	46,202	43,186	40,169	37,152	34,135	31,118	28,101
Fixed cost	44,191	43,185	42,179	41,175	40,169	39,163	38,157	37,151	36,145
Salvage value	37,782	38,378	38,974	39,573	40,169	40,765	41,361	41,957	42,553

Base

Sensitivity graph – BMC's transmission-housings project (Example 10.1)



Sensitivity Analysis

- In the above Figure, we see that the project's PW is
  - (1) very sensitive to changes in product demand and unit price,
  - (2) fairly sensitive to changes in the variable costs, and
  - (3) relatively insensitive to changes in the fixed cost and the salvage value.

Sensitivity Analysis

- Graphic displays such as the one above provide a useful means to communicate the relative sensitivities of the different variables on the corresponding PW value.
- However, sensitivity graphs do not explain any interactions among the variables or the likelihood of realizing any specific deviation from the base case. Certainly, it is conceivable that a project might not be very sensitive to changes in either of two items, but very sensitive to combined changes in them

Sensitivity Analysis for Mutually Exclusive Alternatives

Sensitivity Analysis for Mutually Exclusive Alternatives

- A local U.S. Postal Service office is considering purchasing a 4,000 Ib forklift truck. which will be used primarily for processing incoming as well as outgoing postal packages.
- Forklift trucks traditionally have been fueled by either gasoline, liquid propane gas (LPG), or diesel fuel. Battery-powered electric forklifts, however, are increasingly popular in many industrial sectors, because of their economic and environmental benefits.
- Therefore, the postal service is interested in comparing the four different types of forklifts. Purchase costs as well as annual operating and maintenance costs for each type of forklift are provided by a local utility company and the Lead Industries Association.
- Annual fuel and maintenance costs are measured the discount of number of shifts per year, where one shift is equivalent to eight hours of operation

Sensitivity Analysis for Mutually Exclusive Alternatives

- The postal service is unsure of the number of shifts per year, but it expects it should be somewhere between 200 and 260 shifts. Since the U.S. Postal Service does not pay income taxes, no depreciation or tax information is required.
- The U.S. government uses 10% as the discount rate for any project evaluation of this nature. Develop a sensitivity graph that shows how the best choice out of alternatives changes as a function of number of shifts per year.

Sensitivity Analysis for Mutually Exclusive Alternatives

- Two annual cost components are pertinent to this problem:
  - (1) ownership cost (capital cost) and
  - (2) operating cost (fuel and maintenance cost).
- Since the operating cost is already given on an annual basis, we only need to determine the equivalent annual ownership cost for each alternative.
- A comparison of the variables of the four forklift types is given in the following table:

Example 10.2 - Sensitivity Analysis for Mutually Exclusive Alternatives

	Electrical Power	LPG	Gasoline	Diesel Fuel
Life expectancy	7 year	7 years	7 years	7 years
Initial cost	$30,000	$21,000	$20,000	$25,000
Salvage value	$3,000	$2,000	$2,000	$2,200
Maximum shifts per year	260	260	260	260
Fuel consumption/shift	32 kWh	12 gal	11 gal	7 gal
Fuel cost/unit	$0.05/kWh	$1.00/gal	$1.20/gal	$1.10/gal
Fuel cost/shift	$1.60	$12	$13.20	$7.7
Annual maintenance cost:				
Fixed cost	$500	$1,000	$1,200	$1,500
Variable cost/shift	$5	$6	$7	$9

Capital Costs versus Operating Costs

- When only costs are involved, the AE method is sometimes called the annual equivalent cost method. In this case. revenues must cover two kinds of costs: operating costs and capital costs.
  – *Operating costs are incurred by the operation of physical plants or equipment* needed to provide service; examples include the costs of items such as labor and raw materials.
  – *Capital Recovery costs (or ownership costs) are incurred by purchasing assets to* be used in production and service. Normally, capital costs are nonrecurring (i.e..one-time costs), whereas operating costs recur for as long as an asset is owned

Capital Costs versus Operating Costs

- Refer page 191 of text book

Capital Costs versus Operating Costs

- Because operating costs recur over the life of a project, they tend to be estimated on an annual basis, so for the purposes of annual equivalent cost analysis, no special calculation is required.
- However. because capital costs tend to be one-time costs. In conducting an annual equivalent cost analysis we must translate these one-time costs into its annual equivalent over the life of the project.

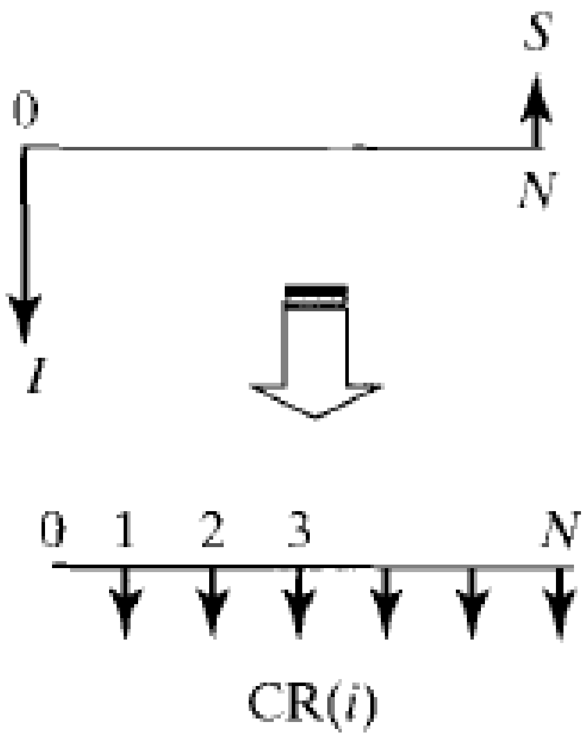
Capital Costs versus Operating Costs

- The annual equivalent of a capital cost is given a special name: capital-recovery cost. designated CR(i).
- Two general monetary transactions are associated with the purchase and eventual retirement of a capital asset:
  - –the asset's initial cost (I) and
  - –its salvage value *(S).*
- *Taking these amounts into account, we calculate the* capital-recovery cost as follows:
- $CR(i) = I(A/P, i. N) - S(A/F. i. N)$.

Capital Costs versus Operating Costs

- Definition: The cost of owning a piece of equipment is associated with two amounts: (1) the equipment's initial cost (I) and (2) its salvage value (S).
- Capital costs: Taking these amounts into account, we calculate the capital costs as follows:

$$\begin{aligned} CR(i) &= I(A/P, i, N) - S(A/F, i, N) \\ &= (I - S)(A/P, i, N) + iS \end{aligned}$$



Calculation of capital recovery cost (with return)

Capital Costs versus Operating Costs

- AE(i)=-(I(A/P, I, N)-S(A/F, I, N))= -CR(i)

- CR(i)= -(I-S)(A/P,i,N) +iS

Capital (Ownership) Cost

- Electrical power:

  CR(10%) = ($30,000 - $3,000)(*A*/*P*, 10%, 7) ⍰+ (0.10)$3,000
  = $5,845

- LPG:

  CR(10%) = ($21,000- $2,000)(*A*/*P*, 10%, 7) +⍰ (0.10)$2,000
  = $4,103

- Gasoline:

  CR(10%) = ($20,000-$2,000)(*A*/*P*, 10%, 7) ⍰+ (0.10) $2,000
  = $3,897

- Diesel fuel:

  CR(10%) = ($25,000 -$2,200)(*A*/*P*, 10%, 7) ⍰+(0.10) $2,200
  = $4,903

Annual O&M Cost

- Electrical power:

  $\$500 + (1.60 + 5)M = \$500 + 6.6M$

- LPG:

  $\$1{,}000 + (12 + 6)M = \$1{,}000 + 18M$

- Gasoline:

  $\$800 + (13.2 + 7)M = \$800 + 20.20M$

- Diesel fuel:

  $\$1{,}500 + (7.7 + 9)M = \$1{,}500 + 16.7M$

Annual Equivalent Cost

- Electrical power:

  $$AE(10\%) = 6,345 \; \square + 6.6M$$

- LPG:

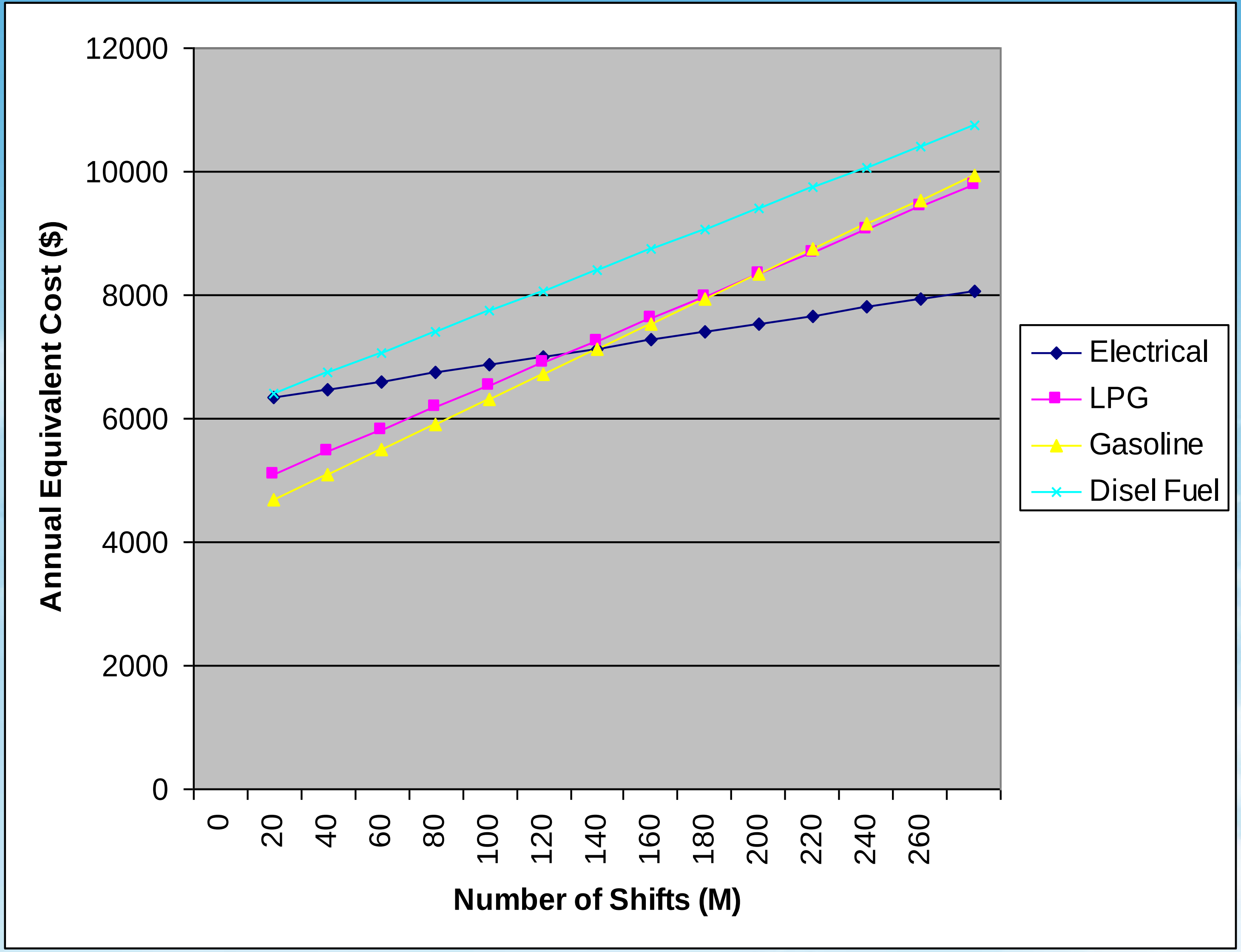
  $$AE(10\%) = 5,103 \; \square + 18M$$

- Gasoline:

  $$AE(10\%) = 4,697 \; \square + 20.20M$$

- Diesel fuel:

  $$AE(10\%) = 6,403 \; \square + 16.7M$$



Annual Equivalent Cost ($)
12000
10000
8000
6000
4000
2000
0
0
20
40
60
80
100
120
140
160
180
200
220
240
260
Number of Shifts (M)
Electrical
LPG
Gasoline
Disel Fuel

Sensitivity Analysis for Mutually Exclusive Alternatives

- In the above Figure*, these four annual-equivalence costs are plotted as a function* of the number of shifts, *M.*
- *It appears that the economics of the electric* forklift truck can be justified as long as the number of annual shifts exceeds approximately *121.*
- *If the number of shifts is less than 121, the gasoline truck becomes* the most economically viable option. The diesel option is not a viable alternative for any range of *M.*

Break Even analysis

Break-Even Analysis

- When we perform a sensitivity analysis for a project. we are asking how serious the effect of lower revenues or higher costs will be on the project's profitability. Managers sometimes prefer to ask how much sales can decrease below forecasts before the project begins to lose money. This type of analysis is known as break-even analysis.
- Note that this break-even value calculation is similar to the calculation used for the internal rate of return when we want to find the interest rate that makes the PW equal zero. as well as many other "cutoff values" where a choice changes.

Break-Even Analysis

- From the sensitivity analysis in Example 10.1, BMC's managers are convinced that the PW is most sensitive to changes in annual sales volume. Determine the required annual sales volume (units) to break even.
- The after-tax cash flows shown in Table 10.3 are basically the same as in Table 10.1

	A	B	C	D	E	F	G
1	Example 10.1 BMC's Transmission-Housings Project						
2							
13	**Income Statement**						
14		0	1	2	3	4	5
15	Revenues:						
16	Unit Price		$ 50	$ 50	$ 50	$ 50	$ 50
17	Demand (units)		2000	2000	2000	2000	2000
18	Sales Revenue		$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000
19	Expenses:						
20	Unit Variable Cost		$ 15	$ 15	$ 15	$ 15	$ 15
21	Variable Cost		30,000	30,000	30,000	30,000	30,000
22	Fixed Cost		10,000	10,000	10,000	10,000	10,000
23	Depreciation		17,863	30,613	21,863	15,613	5,581
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35	Investment	(125,000)					
36	Salvage						40,000
37	Gains Tax						(2,613)
39	Net Cash Flow	$ (125,000)	$ 43,145	$ 48,245	$ 44,745	$ 42,245	$ 75,619
40							

Analytical Approach

Unknown Sales Units (*X*)

	0	1	2	3	4	5
Cash Inflows:						
Net salvage						37,389
***X*(1-0.4)($50)**		30*X*	30*X*	30*X*	30*X*	30*X*
0.4 (dep)		7,145	12,245	8,745	6,245	2,230
Cash outflows:						
Investment	-125,000					
-*X*(1-0.4)($15)		-9*X*	-9*X*	-9*X*	-9*X*	-9*X*
-(0.6)($10,000)		-6,000	-6,000	-6,000	-6,000	-6,000
Net Cash Flow	-125,000	21*X* + 1,145	21*X* + 6,245	21*X* + 2,745	21*X* + 245	21*X* + 33,617

- PW of cash inflows

$PW(15\%)_{\text{Inflow}}$ = (PW of after-tax net revenue)

+ (PW of net salvage value)

+ (PW of tax savings from depreciation

$= 30X(P/A, 15\%, 5) + \$37{,}389(P/F, 15\%, 5) + \$7{,}145(P/F, 15\%,1) + \$12{,}245(P/F, 15\%, 2)$

$+ \$8{,}745(P/F, 15\%, 3) + \$6{,}245(P/F, 15\%, 4)$

$+ \$2{,}230(P/F, 15\%,5)$

$= 30X(P/A, 15\%, 5) + \$44{,}490$

$= 100.5650X + \$44{,}490$

- PW of cash outflows:

$$PW(15\%)_{\text{Outflow}} = (\text{PW of capital expenditure\_}$$
$$+ (\text{PW}) \text{ of after-tax expenses}$$
$$= \$125{,}000 + (9X+\$6{,}000)(P/A, 15\%, 5)$$
$$= 30.1694X + \$145{,}113$$

- The NPW:

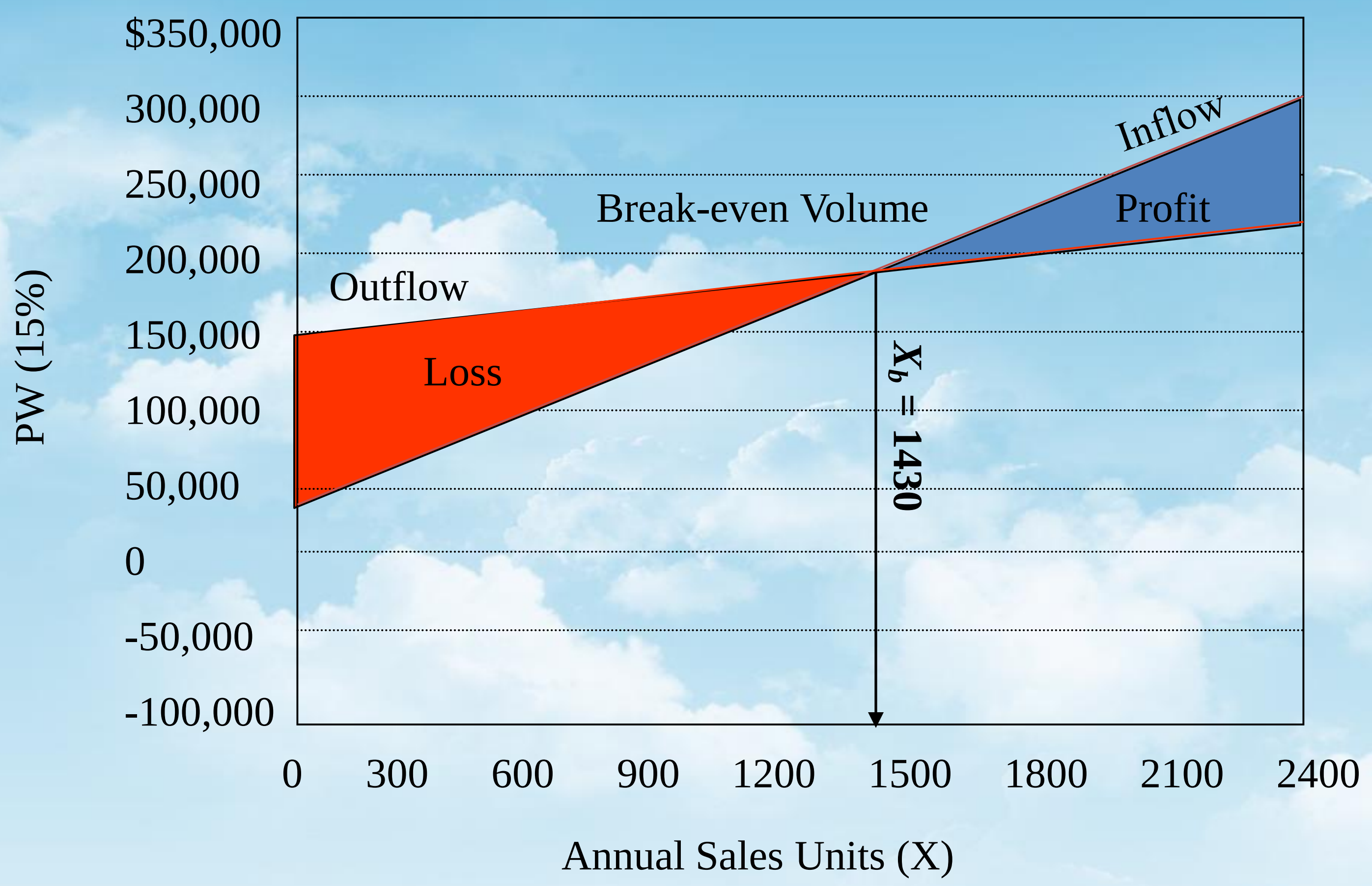
$$\text{PW } (15\%) = 100.5650X + \$44{,}490$$
$$- (30.1694X + \$145{,}113)$$
$$= 70.3956X - \$100{,}623.$$

- Breakeven volume:

$$\text{PW } (15\%) = 70.3956X - \$100{,}623 = 0$$
$$X_b = 1{,}430 \text{ units.}$$

Demand	PW of inflow	PW of Outflow	NPW
X	**100.5650*X* - $44,490**	**30.1694*X* + $145,113**	**70.3956*X* -$100,623**
0	$44,490	$145,113	100,623
500	94,773	160,198	65,425
1000	145,055	175,282	30,227
1429	188,197	188,225	28
1430	188,298	188,255	43
1500	195,338	190,367	4,970
2000	245,620	205,452	40,168
2500	295,903	220,537	75,366

Break-Even Analysis Chart



Scenario Analysis

Scenario Analysis

- Although both sensitivity and break-even analyses are useful, they have limitations. Often, it is difficult to specify precisely the relationship between a particular variable and the PW.
- The relationship is further complicated by interdependencies among the variables. Holding operating costs constant while varying unit sales may ease the analysis, but in reality operating costs do not behave in this manner. Yet it may complicate the analysis too much to permit movement in more than one variable at a time.

Scenario Analysis

- A scenario analysis is a technique that considers the sensitivity of the PW to changes in both key variables and the range of likely variable values. For example the decision maker may consider two extreme cases: a worst-case scenario (low unit sales, low unit price, high variable cost per unit, high fixed cost, and so on) and a best-case scenario.
- The PWs under the worst and the best conditions are then calculated and compared with the expected. or base-case, PW. Example 10.4 illustrates a plausible scenario analysis for BMC's transmission-housings project

Scenario Analysis

Variable Considered	Worst-Case Scenario	Most-Likely-Case Scenario	Best-Case Scenario
Unit demand	1,600	2,000	2,400
Unit price ($)	48	50	53
Variable cost ($)	17	15	12
Fixed Cost ($)	11,000	10,000	8,000
Salvage value ($)	30,000	40,000	50,000
PW (15%)	-$5,856	$40,169	$104,295

Capital Budgeting Decisions

Capital Budgeting Decisions

- We have until now dealt with situations where, at some interest rate, we choose each project's best mutually exclusive alternative. Thus, we were assuming that there is an ample amount of money to make all desired capital investments in these projects.
- But the concept of scarcity of resources is fundamental to a economic choice of projects. It is through this mechanism that more economically attractive activities are encouraged at the expense of less desirable activities.

Capital Budgeting Decisions

- For industrial firms, there are often more ways of spending money than there is money that is available. The result is that we must select from available alternatives the more attractive projects and reject-or, at least, delay-the less attractive projects

Capital Budgeting Decisions

- This problem of rationing capital among competing projects is one part of a two-part problem called capital budgeting. In planning its capital expenditures, an industrial firm is faced with two questions:
  - "Where will money for capital expenditures-come from?“ and,
  - "How shall we allocate available money among the various competing projects?"

Capital Budgeting Decisions

- For the sake of simplicity, we have looked at projects in an isolated setting-almost as if a firm had just one project it was considering. In the business world, we know that this is rarely the case.
- A firm will find that there are a great many projects that are economically attractive. This situation raises two problems not previously considered:
  - 1. How do you rank projects to show their order of economic attractiveness?.
  - 2. What do you do if there is not enough money to pay the costs of all economically attractive projects?

Capital Budgeting Decisions

- First we screen all alternatives to find those that merit further consideration. Then we will select the best alternative from each project, assuming that there is no shortage of money. The next step will be the addition of a budget constraint.
- If we find that there is not enough money to fund the best alternative from each project, we will have to do what we can with the limited amount of money available.
- It will become important that we have a technique for accurately ranking the various competing projects in order of economic attractiveness. All this is designed to answer the question, How shall we allocate available money among the various competing projects?

Mutually Exclusive Alternatives and Single Project Proposals

- Until now we have dealt with mutually exclusive alternatives, that is, selecting one alternative results in rejecting the other alternatives being considered.
- Even in the simplest problems encountered, the question was one of selection *between alternatives. Should, for example,* Machine *A or Machine B be purchased to perform the necessary task?*
- *Clearly, the purchase* of one of the machines meant that the other one would not be purchased. Since either machine would perform the task, the selection of one precludes the possibility of selecting the other one as well.

Capital Budgeting Decisions

TABLE 17-1 Criteria for Rejecting Unattractive Alternatives

For Each Alternative Compute	Reject Alternative When	Do Not Reject Alternative When
Rate of return, i	i < MARR	$i \geq$ MARR
Present worth, PW	PW of benefits < PW of costs	PW of benefits $\geq$ PW of costs
Annual cost, EUAC	EUAC > EUAB	EUAC $\leq$ EUAB
Annual benefit, EUAB		
Benefit–cost ratio, B/C	B/C < 1	B/C $\geq$ 1
Net present worth, NPW	NPW < 0	NPW $\geq$ 0

Capital Budgeting Decisions

TABLE 17-2 Criteria for Choosing the Best Alternative from Among Mutually Exclusive Alternatives

	Situations		
Analysis Method	**Fixed Input** (The cost of each alternative is the same.)	**Fixed Output** (The benefits from each alternative are the same.)	**Neither Input Nor Output Fixed** (Neither the costs nor the benefits for the alternatives given are the same.)
Present worth	Maximize present worth of benefits	Minimize present worth of cost	Maximize net present worth
Annual cash flow	Maximize equivalent uniform annual benefits	Minimize equivalent uniform annual cost	Maximize EAUB − EAUC
Benefit–cost ratio	Maximize benefit–cost ratio	Maximize benefit–cost ratio	Incremental benefit–cost ratio analysis is required
Rate of return	Incremental rate of return analysis is required		

RATIONING CAPITAL BY RATE OF RETURN

- One way of looking at the capital rationing problem is through the use of rate of return. The technique for selecting from among independent projects is illustrated by Example 17-2 shown in the next slide
- These projects are independent, so their only interdependence is the budget constraint on the total accepted set of projects.

RATIONING CAPITAL BY RATE OF RETURN

EXAMPLE 17-2

Nine independent projects are being considered. Figure 17-1 may be prepared from the following data.

Project	Cost (thousands)	Uniform Annual Benefit (thousands)	Useful Life (years)	Salvage Value (thousands)	Computed Rate of Return
1	$100	$23.85	10	$ 0	20%
2	200	39.85	10	0	15
3	50	34.72	2	0	25
4	100	20.00	6	100	20
5	100	20.00	10	100	20
6	100	18.00	10	100	18
7	300	94.64	4	0	10
8	300	47.40	10	100	12
9	50	7.00	10	50	14

If a capital budget of $650,000 is available, which projects should be selected?

RATIONING CAPITAL BY RATE OF RETURN

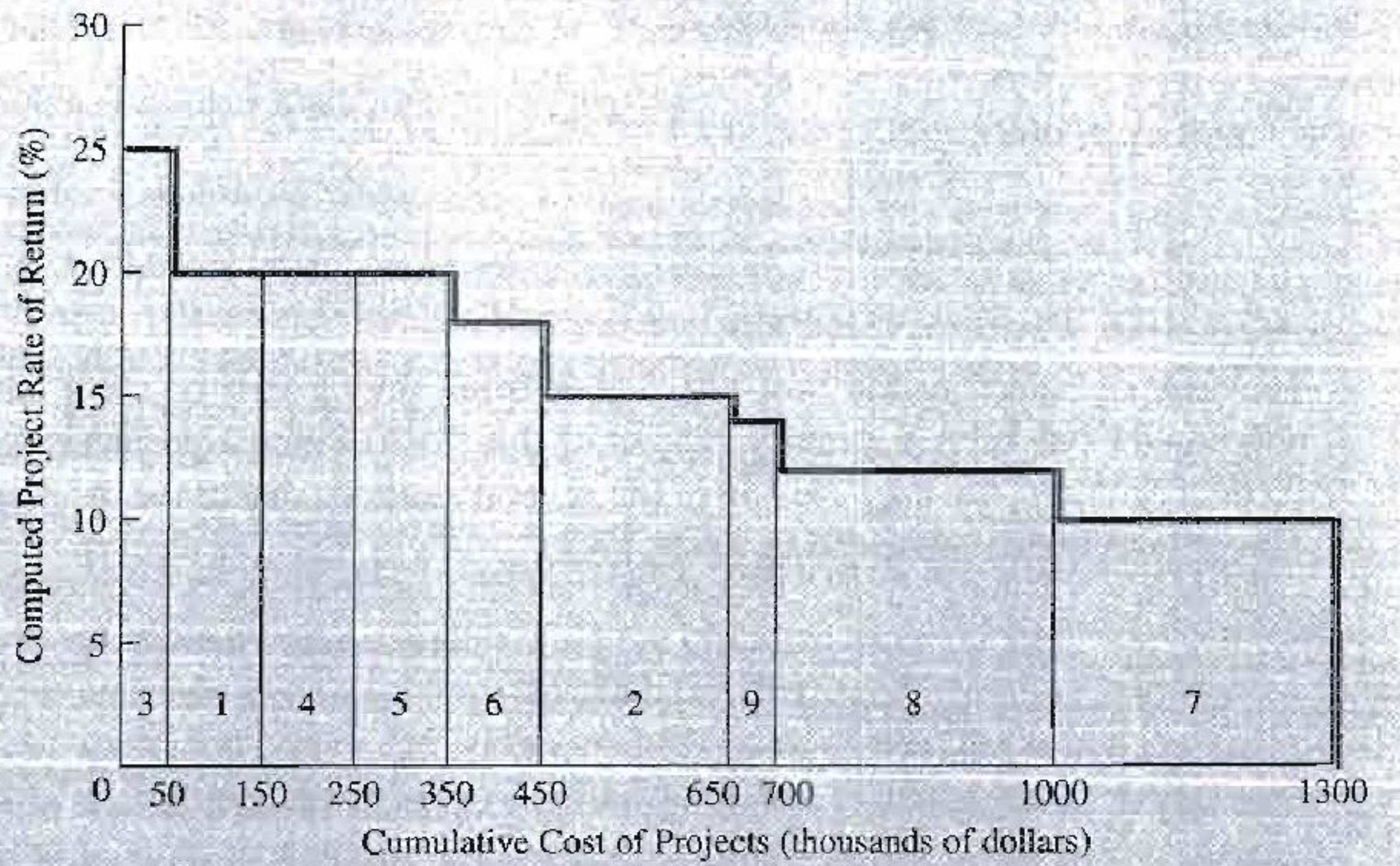


FIGURE 17-1 Cumulative cost of projects versus rate of return.

RATIONING CAPITAL BY RATE OF RETURN

- In Example 17-2, the rate of return was computed for each project and then the projects were arranged in order of decreasing rate of return. For a fixed amount of money in the capital budget, the projects are selected by going down the list until the money is exhausted. Thus when we use this procedure, we cut off approving projects at the point where the money runs out. This point is called the cutoff rate of return. Figure 17-2 illustrates the general situation.

RATIONING CAPITAL BY RATE OF RETURN

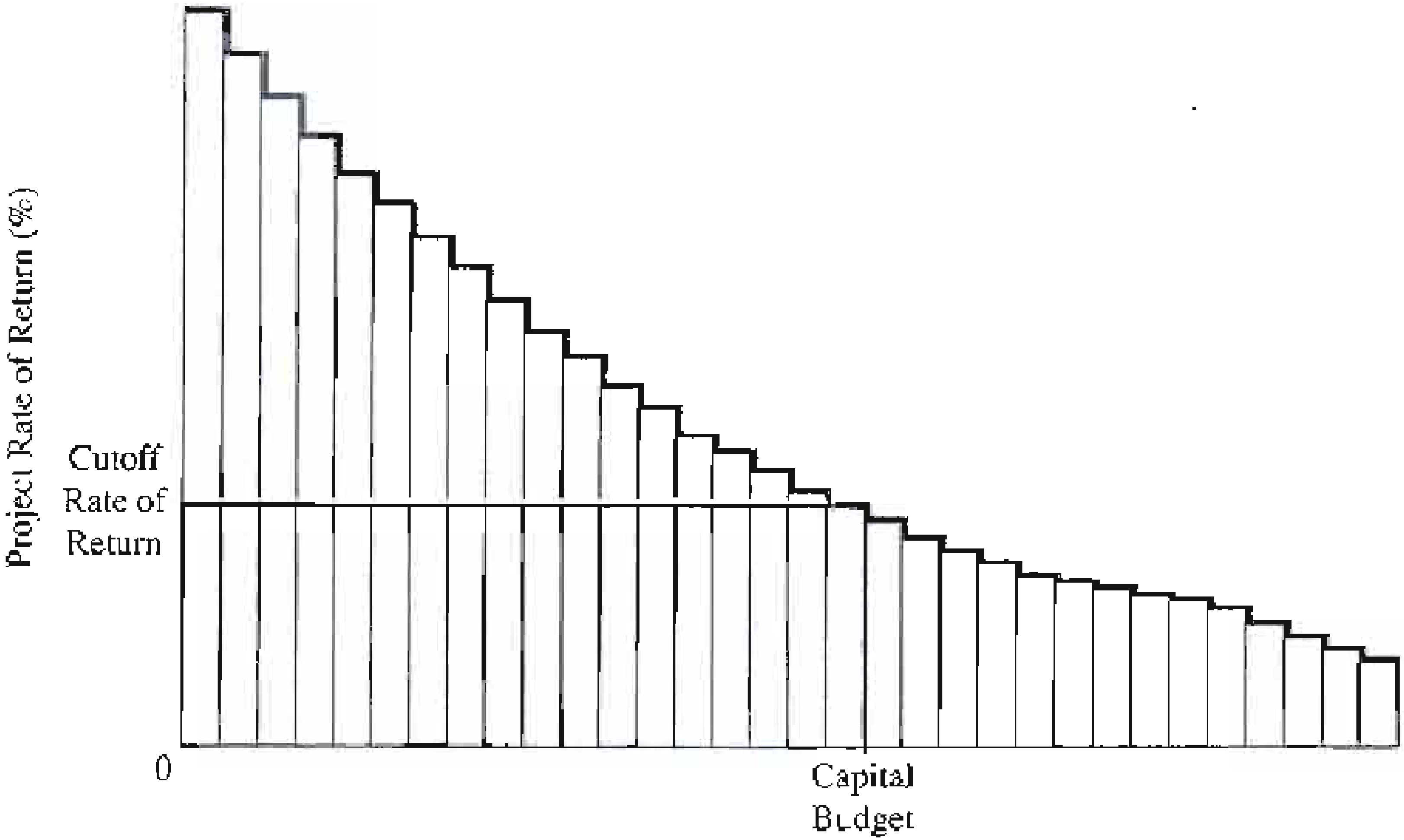


FIGURE 17-2 Location of the cutoff rate of return.

RATIONING CAPITAL BY RATE OF RETURN

- For any set of ranked projects and any capital budget, the rate of return at which the budget is exhausted is the cutoff rate of return. In Figure 17-2 the cost of each individual project is small in comparison to the capital budget. The cumulative cost curve is a relatively smooth curve producing a specific cut off rate of return. Looking back at Figure 17-1, we see the curve is actually a step function. For Example 17-2, the cutoff rate of return is between 14 and 15% for a capital budget of $650,000.

Significance of the Cutoff Rate of Return

- Cutoff rate of return is determined by comparison of an established capital budget and the available projects. One must examine all the projects and all the money for some period of time (like one year) to compute the cutoff rate of return.
- It is a computation relating known projects to a known money supply. For this period of time, the cutoff rate of return is the opportunity cost (rate of return on the opportunity or project forgone) and also the minimum attractive rate of return. In other words, the minimum attractive rate of return to get a project accomplished *is the cutoff rate of return.*
- MARR =Cutoff rate of return =Opportunity cost

RATIONING CAPITAL BY PRESENT WORTH METHODS

- Previously we have chosen from among project alternatives to maximize net present worth. If we can do the same thing for a group of projects, and we do not exceed the available money supply then the capital budgeting problem is solved.
- But more frequently in capital budgeting problem we will be unable to accept all desirable projects. We, therefore, have a task not previously encountered. We must choose the best from the larger group of acceptable projects.

RATIONING CAPITAL BY PRESENT WORTH METHODS

- But more frequently in capital budgeting problem we will be unable to accept all desirable projects. We, therefore, have a task not previously encountered. We must choose the best from the larger group of acceptable projects

RATIONING CAPITAL BY PRESENT WORTH METHODS

ratior

EXAMPLE 17-3

Use the present worth method to determine which of the nine independent projects of Example 17-2 should be included in a capital budget of $650,000. The minimum attractive rate of return has been set at 8%.

Project	Cost (thousands)	Uniform Annual Benefit (thousands)	Useful Life (years)	Salvage Value (thousands)	Computed NPW (thousands)
1	$100	$23.85	10	$ 0	$60.04
2	200	39.85	10	0	67.40
3	50	34.72	2	0	11.91
4	100	20.00	6	100	55.48
5	100	20.00	10	100	80.52
6	100	18.00	10	100	67.10
7	300	94.64	4	0	13.46
8	300	47.40	10	100	64.38
9	50	7.00	10	50	20.13

[1] Lorie, J. and L. Savage, "Three Problems in Rationing Capital," *Journal of Business*, October 1955, pp. 229–239.

RATIONING CAPITAL BY PRESENT WORTH METHODS

SOLUTION

Locating a value of p in [NPW − p(PW of cost)] by trial and error, we use the following table, where all amounts are in thousands of dollars.

			Trial $p = 0.20$		Trial $p = 0.25$	
·roject	Cost	Computed NPW	[NPW − p(PW of cost)]	Cost	[NPW − p(PW of cost)]	Cost
1	$ 100	$60.04	$40.04	$ 100	$35.04	$100
2	200	67.40	27.40	200	17.40	200
3	50	11.91	1.91	50	−0.59	
4	100	55.48	35.48	100	30.48	100
5	100	80.52	60.52	100	55.52	100
6	100	67.10	47.10	100	42.10	100
7	300	13.46	−46.54		−61.54	
8	300	64.38	4.38	300	−10.62	
9	50	20.13	10.13	50	7.63	50
	$1300			$1000		$650

For a value of p equal to 0.25, the best selection order is computed to be Projects 1, 2, 4, 5, 6, and 9. (*Note:* the smallest value for p is 0.239.)

Alternate Formation of Example 17-3

- The preceding answer does not agree with the solution obtained in Example 17-2. The difficulty is that the interest rate used in the present worth calculations is not equal to the computed cutoff rate of return. In Example 17-2 the cutoff rate of return was between 14 and 15%, say 14.5%. We will re compute the present worth solution using MARR = 14.5%, again with amounts in thousands of dollars.

Alternate Formation of Example 17-3

Project	Cost	Computed NPW at 14.5%	Cost of Projects with Positive NPW
1	$100	$22.01	$100
2	200	3.87	200
3	50	6.81	50
4	100	21.10	100
5	100	28.14	100
6	100	17.91	100
7	300	−27.05	
8	300	−31.69	
9	50	−1.28	
			$650

Alternate Formation of Example 17-3

- Solution
- At a MARR of 14.5% the best set of projects is the same as computed in Example 17-2, namely, Projects 1,2,3,4,5, and 6, and their cost equals the capital budget. One can see that only projects
- with a rate of return greater than MARR can have a positive NPW at this interest rate. With MARR equal to the cutoff rate of return, we *must obtain the same solution by either the rate of return or* present worth method.

Financial Management

Introduction to Financial Management

Introduction to Financial Management

- Financial management is management principles and practices applied to finance.
- Financial decision making includes decisions as to size of investment, sources of capital, extent of use of different sources of capital and extent of retention of profit or dividend payout ratio.
  - *Financial management*, is therefore, planning, execution and control of investment of money resources, raising of such resources and retention of profit/payment of dividend.

Introduction to Financial Management

- **Financial Management** is
  - planning, organizing, directing and controlling the **financial** activities such as procurement and utilization of funds of a company.
  - It means applying general **management** principles to **financial** resources of the enterprise.
- Financial management is concerned mainly with raising funds in the most economic and suitable manner, using these funds as profitably as possible

Introduction to Financial Management

- Financial management is the use of a company's financial resources. This includes the use of cash and other assets— such as equipment

Introduction to Financial Management

- Financial *planning* and *control* defines as a combination of strategies it supports the entire **financial management** process for an organization.
- The process begins at *financial planning*, many times in the form of cash flow and forecasting balance sheet

Introduction to Financial Management

- **The financial planning process is a logical, six-step procedure:**
  - (1) determining your current financial situation.
  - (2) developing financial goals.
  - (3) identifying alternative courses of action.
  - (4) evaluating alternatives.
  - (5) creating and implementing a financial action plan, and.
  - (6) reevaluating and revising the plan.

Introduction to Financial Management

- Financial **controls** include procedures (which are part of company policy) that are implemented to manage a company's financial resources
- Financial control may be carried out internally or externally
  - **Internal control**, as defined by accounting and auditing, is a process for assuring of an organization's objectives in operational effectiveness and efficiency, reliable financial reporting, and compliance with laws, regulations and policies.
- A broad concept, internal control involves everything that controls risks to an organization.

Construction Financial management

(Adapted from CONSTRUCTION ACCOUNTING AND FINANCIAL MANAGEMEN, Peterson ,2009)

Construction Financial management

- Construction companies are different from most other companies and are faced with many unique challenges and problems not faced by other companies in other industries. For instance construction companies are involved in projects that are
  - Unique, one time activity
  - Project oriented
  - Risky venture
  - Decentralized production
  - Differing payment modes (advance, Interim, Retention etc)
  - Involvement of subcontractors

Construction Financial management

- For instance when deciding whether to bid on a project, a manager may need to address the following questions:
  - Does the company have enough cash resources to perform this work or will the company need outside financing?
  - Can the company get bonds for this work? If not, what changes need to be made in the company’s financial structure so the company can get a bond for the project?
  - Should the company hire employees to perform the work or should the company subcontract out this labor?

Construction Financial management

- Should the company lease or purchase the additional equipment needed for this project?
- If the company purchases the equipment, how should it be financed?
- Will this project require the company to increase its main office overhead?
- And, finally, what profit and overhead markup should be added to the bid? The answers to all of these questions will affect the company’s finances

Construction Financial management

- In construction companies Financial managers are responsible for accounting or tracking how the company’s financial resources are used, including the following:
  - Setting up a working accounting system
  - Keeping track of costs and Profits
  - tracking project overhead costs
  - Preparing and reviewing financial statements etc.
  - Making decisions on purchases

Construction Financial management

- Managing the company’s costs and profits includes the following duties:
  - Controlling project costs.
  - Monitoring project and company profitability.
  - Setting labor burden markups.
  - Developing and tracking general overhead budgets.
  - Setting the minimum profit margin for use in bidding.
  - Analyzing the profitability of different parts of the company and making the necessary changes to improve profitability.
  - Monitoring the profitability of different customers and making the necessary marketing changes to improve profitability.

Construction Financial management

- The above issues are followed up by a company's financial manager, to assesses a company's financial performance.
- Accounting records and analyses a company's performance and predict its future performance
- *Accounting*

Accounting Basics

Accounting Basics

- ac·count·ing [ə kównting] *noun*

- bookkeeping: the activity, practice, or profession of maintaining the business records of a person or organization and preparing forms and reports for tax or other financial purposes
  -

Accounting Basics

- **Accounting** is defined as the collection, compilation and systematic recording of business transactions in terms of money, the preparation of financial reports, the analysis and interpretation of these reports for the information and guidance of management."

Accounting Basics

- Accounting focuses on the day-to-day flow of money in and out of a company or institution, prepares reports for management use whereas
- Finance is a broader term for the management of assets and liabilities and the planning of future growth

Figure 16.2 The Accounting Cycle

Basic Data

Transactions
Receipts, invoices, and other source documents related to each transaction are assembled to justify making an entry in the firm's accounting records.

Processing

Record
Transactions are recorded, usually electronically, in chronological order in books called journals, along with a brief explanation for each entry.

Classify
Journal entries are transferred, or posted, usually electronically, to individual accounts kept in a ledger. All entries involving cash are brought together in the ledger's cash account; all entries involving sales are recorded in the ledger's sales account.

Summarize
All accounts in the ledger are summarized at the end of the accounting period, and financial statements are prepared from these account summaries.

Financial Statements

- Balance Sheet
- Income Statement
- Statement of Owners' Equity
- Statement of Cash Flows

Accounting Basics

- **Financial accounting**
  - preparation and communication of financial information mainly for those outside the organization
- **Management Accounting**
  - preparation and communication of financial and other information for the internal use of management
- **Cost Accounting**
  - collation of data for inventory valuation

Accounting vs. Engineering Economy

Evaluating past performance

Accounting

Evaluating and predicting future events

Engineering Economy

Past

Present

Future

Accounting Basics

(Adapted from Introduction to Management accounting, Horngren et al, 2014)

- The accounting process begins with a transaction.
  - A transaction is any event that affects the financial position of an organization and requires recording
- Financial statements are used to summarize the recorded accounting transactions.

Accounting Key Terms Definition

Key Terms

- *Balance sheet*
- *Assets*
  - *Current assets*
  - *Fixed assets*
  - *Other assets*
- *Equity*
- *Liability*
- *Revenue*
- *Income*
- *Expenses*
- *Cost*
- *Profit and loss*
- *Cash flow*
- *Inventory*
- *Depreciation*
- *Breakeven*
- *Income Statement*

Balance Sheet

balance sheet

The balance sheet (also called statement of financial position or statement of financial condition) is a *snapshot* of the financial status of an organization at a *point in time*.

- The balance sheet states what the firm owns and how it is financed.

balance sheet

The balance sheet (also called statement of financial position or statement of financial condition) is a snapshot of the financial status of an organization at a point in time.

The balance sheet has two sections

– assets and

– liabilities plus owners’ (stockholders’) equity

Balance Sheet

- A balance sheet shows what a company owns (*assets*) and what it owes (*liabilities*) and where the money came from to acquire those assets (source of funds)

Assets

Assets

- *Assets* are resources owned by a company and which have future economic value that can be measured and can be expressed in Birr/dollars.
  - Examples include cash, investments, accounts receivable, inventory, supplies, land, buildings, equipment, and vehicles.

Assets

Resources owned or controlled by a company

- Cash
- Accounts Receivable
- Notes Receivable
- Vehicles
- Land
- Store Supplies
- Equipment
- Buildings

Assets

- Assets are listed in the order of their "*liquidity*" –how much time it takes to convert them to cash

Assets

- An asset is anything of monetary value owned by a person or business.
- Assets are classed as
  - current,
  - capital/fixed,
  - tangible or
  - intangible and
- expressed in terms of their cash value on financial statements

Basic Accounting

- ***Current assets*** can be *converted to cash* or its equivalent in less than *one year*. Current assets generally include three major accounts:
  - **1.** The first is *cash*. A firm typically has a cash account at a bank to provide for the funds needed to conduct day-to-day business. Although assets are always stated in terms of dollars, only cash represents actual money.
  - **2.** The second account is *accounts receivable* —money that is owed the firm, but that has not yet been received.
  - **3.** The third account is *inventories*, which show the dollar amount invested in raw materials, work in process, and finished goods available for sale.

Basic Accounting

- ***Fixed/Capital assets*** are relatively permanent and take time to convert into cash. The most common fixed asset is the *physical investment* in the business, such as land, buildings, factory machinery, office equipment, and automobiles.
  - With the exception of land, most fixed assets have a limited useful life. For example, buildings and equipment are used up over a period of years. Each year, a portion of the usefulness of these assets expires, and a portion of their total cost should be recognized as a depreciation expense.
  - The term *depreciation* denotes the accounting process for this gradual conversion of fixed assets into expenses.

Capital Assets

- Fixed/Capital assets are important for businesses in that they can be sold if the business is in financial difficulty or used as *collateral* for business *loans*.
- Given that most capital assets decline in value over time, in financial records capital assets are usually expressed as the cost of the asset minus *depreciation*.
- Capital assets depreciate at different rates depending on the asset class (as defined by the tax authorities).
  – For example in Ethiopia ……

Basic Accounting

- Finally, *other assets* include *investments made in other companies* and intangible assets such as goodwill, copyrights, franchises, and so forth. Goodwill appears on the balance sheet only when an operating business is purchased in its entirety.
- *Goodwill* indicates any additional amount paid for the business above the fair market value of the business. (Here, the fair market value is defined as the price that a buyer is willing to pay when the business is offered for sale.)

Equity

Equity

- Equity represents the amount of money that would be returned to a company’s shareholders if all of the assets were liquidated and all of the company's debt was paid off.

Equity

- In accounting, equity (or owner's equity) is the difference between the value of the assets and the value of the liabilities of something owned. ...
  - For example, if someone owns a car worth $15,000 (an asset), but owes $5,000 on a loan against that car (a liability), the car represents $10,000 of **equity**.
  - It is the difference between what your **business** is worth (your assets) minus what you owe on it (your debts and liabilities)

Equity

- Equity is found on a company's balance sheet and is one of the most common financial metrics employed by analysts to assess the financial health of a company. Shareholder equity can also represent the book value of a company. Equity can sometimes be offered as Payment in Kind

Liability

Liability

- A **liability** is defined as the *future sacrifices* of economic benefits that the entity is *obliged* to make to other entities as a result of past transactions or other *past* events, the settlement of which may result in the transfer or use of assets, provision of services or other yielding of economic benefits in the future.

Liability

- A liability is defined by the following characteristics:
  - –Any type of *borrowing* from persons or banks for improving a business or personal income that is payable during short or long time;
  - –A duty or responsibility to others that entails settlement by future transfer or use of assets, provision of services, or other transaction yielding an economic benefit, at a specified or determinable date, on occurrence of a specified event, or on demand;

Liability

- *Liability* **includes**
  - *Current liabilities* are bills that are due to creditors and suppliers within a short period of time (normally, within one year).
  - The major current liabilities include accounts and notes payable within a year. Also included are accrued expenses (wages, salaries, interest, rent, taxes, etc., owed, but not yet due for payment), and advance payments and deposits from customers.

Assets = *Liabilities* + Owners' equity

Revenue

Revenue

- A *revenue* is the income that a business has from its normal business activities, usually from the sale of good and services to customers. Revenue is also referred to as *sales* or turnover.
- Revenue may refer to *business income in general*, or it may refer to the amount, in a monetary unit, earned during a period of time, as in "Last year, Company X had revenue of $42 million".

Revenue

- **Total Revenue** – also known as turnover, sales revenue or ‘sales’ = Price x Quantity Sold

TR = P x Q

Income

Income

- *Income* (also called net income, profits, or earnings), is the excess of revenues over expenses.
- It increases stockholders’ equity

Income

- The income statement measures performance over a specific period of time, say, a year.

- The accounting definition of income is:

  Income = Revenue – Expenses

Expenses

Expenses

- An expense is an outflow of cash or other valuable assets from a person or company to another person or company
- An *Expense* is s the money spent, or costs incurred, by a business in their effort to generate revenues.
- Expens***es*** represent the cost of doing business; they are the sum of all the activities that result in a profit.

There are two types of expenses:

- –FIXED COSTS and
- –VARIABLE COSTS

Cost

Cost

- *cost* is defined as the cash amount (or the cash equivalent) given up for an asset.
- **Cost** includes all **costs** necessary to get an asset in place and ready for use.
  - For example, the **cost** of an item in inventory also includes the item's freight **cost**.

Costs

- **Fixed (Indirect/Overheads)** – are not influenced by the amount produced but can change in the long run e.g., insurance costs, administration, rent, some types of labour costs (salaries), some types of energy costs, equipment and machinery, buildings, advertising and promotion costs
- **Variable (Direct)** – vary directly with the amount produced, e.g., raw material costs, some direct labour costs, some direct energy costs

Expenses: Fixed Costs

- Fixed costs include
  - Rent
  - Salary
  - Capital Investments and maintenance
  - Utilities (phone, water, electric, etc)
  - Insurance
  - Taxes (on property, plant, and equipment)
  - Advertising
  - Others things that do not depend on number of units produced.

Expenses: Variable Costs

- Variable Costs include
  - Materials Cost
  - Supplies
  - Production Wages
  - Outside / Contracted labor
  - Advertising
  - Sales Commissions / Distribution Costs
  - Equipment Maintenance
  - Other things that depend on the number of units produced (e.g. royalties paid)

Costs

- **Total Costs (TC)** = Fixed Costs (FC)+ Variable Costs (VC)
- **Average Costs** = TC/Output (Q)
  - AC (unit costs) show the amount it costs to produce one unit of output on average
- **Marginal Costs (MC)** – the cost of producing one extra or one fewer units of production
  - $MC = TC_n - TC_{n-1}$

Profit

Profit

- *Profit* describes the *financial benefit* realized when revenue generated from a business activity exceeds the expenses, costs, and taxes involved in sustaining the activity in question.

Cashflow

Cashflow

- *Cash flow* is the difference in amount of cash available at the beginning of a period (opening balance) and the amount at the end of that period (closing balance).
- Cash flow is called positive if the closing balance is higher than the opening balance, otherwise called negative.
- www.businessdictionary.com/definition/cash-flow.html

Cashflow

- Cash flow is increased by
  - (1) selling more goods or services,
  - (2) selling an asset,
  - (3) reducing costs,
  - (4) increasing the selling price,
  - (5) collecting faster,
  - (6) paying slower,
  - (7) bringing in more equity, or
  - (8) taking a loan.

Cash Flow Statements

- A *cash flow statement* is a report of all a firm's transactions that involve cash
- The key elements are revenues (money flowing in) and expenses (money flowing out).
- Cash flow statements compare the sum of the revenues to the sum of the expenses on a regular time basis – usually monthly.
- The difference between cash inflow(sources) and cash use (out flow) represents the net cash flow

Inventory

Inventory

- *Inventory* accounting is the body of accounting that deals with valuing and accounting for changes in inventoried assets.
- A company's inventory typically involves goods in three stages of production:
  - raw goods,
  - in-progress goods, and
  - finished goods that are ready for sale.

Inventory

- Inventory accounting will assign values to the items in each of these three processes and record them as company assets.
- Assets are goods that will likely be of future value to the company. Assets need to be accurately valued so the company can be accurately valued.

Inventory

- Inventory items at any of the three production stages can *change in value*. Changes in value can occur for a number of reasons including *depreciation*, *deterioration*, *obsolescence*, change in customer taste, increased demand, decreased market supply, and so on.
- An accurate inventory accounting system will keep track of these changes to inventory goods at all three production stages and adjust company asset values and the costs associated with the inventory accordingly.

Depreciation

Depreciation

- *Depreciation* is an accounting method of allocating the cost of a tangible or physical asset over its useful life or life expectancy.
- Depreciation represents how much of an asset's value has been used up.
- Depreciating assets helps companies earn revenue from an asset while expensing a portion of its cost each year the asset is in use. If not taken into account, it can greatly affect profits

Depreciation

- *Depreciation* shows that an asset such as equipment or a building is wearing out and being used up.
- Depreciation expense is computed by dividing the estimated useful life of the asset into the asset's historical cost less any salvage value estimated by the business.

Depreciation

- If a machine cost $5,000 and has a salvage value of $500, with a useful life of five years, then the depreciation expense per year will be $900.

$$(\$5{,}000 - \$500) \big/ 5\text{years} = \$900$$

Breakeven

Breakeven

- The *break even* point is the production level where *total revenues equals total expenses*. In other words, the break-even point is where a company produces the same amount of revenues as expenses either during a manufacturing process or an accounting period. Since revenues equal expenses, the net income for the period will be zero.
- The company didn't lose any money during the period, but it also didn't gain any money either. It simply broke even

Income Statement

The Income Statement

- The income statement summarizes a firm's revenues and expenses for a period of time.
  - The date on the income statement will be a phrase such as, "For the month ended July 31," or "For the year ended December 31."
    - If revenues exceed expenses, then the result is net income.
    - If expenses exceed revenues, then the result is a net loss.

The Income Statement

- The *income statement* reports the revenues, gains, expenses, losses, net **income** and other totals for the period of time shown in the heading of the **statement**.

Basic Accounting

- The *income statement* indicates whether the company is making or losing money during a stated *period*, usually a year.
- Most businesses prepare quarterly and monthly income statements as well.
- The company’s accounting period refers to the period covered by an income statement

Basic Income Statement Equation

Revenue

−

Expenses

Net Income (Loss)

The Income Statement

- One of the three important financial Statements used for reporting a company's financial performance over a specific accounting period include
  - income statement with
  - Balance Sheet and
  - Cash flows
- The income statement primarily focuses on the company's revenues and expenses during a particular period.

Balance Sheet Vs Income statement

Basic Accounting

The Balance Sheet:

- What is the company's financial position at the end of the reporting period? We find the answer to this question in the company's **balance sheet statement**. A company's balance sheet, sometimes called its **statement of financial position**, reports three main categories of items:
  - assets,
  - liabilities, and
  - stockholders' equity.
- Assets are arranged in order of liquidity. The most liquid assets appear at the top of the page, the least liquid assets at the bottom of the page.
- Because cash is the most liquid of all assets, it is always listed first.
- Current assets are so critical that they are separately broken out and totaled.
- They are what will hold the business afloat for the next year

Balance Sheet Vs Income statement

- The *balance sheet* reveals the status of an organization's financial situation as of a *specific point in time*, while an income statement reveals the results of the firm *for a period of time*.
  - For example, financial statement issued for the month of December will contain a balance sheet as of December 31 and an income statement for the month of December
- The balance sheet reports assets, liabilities, and equity while the income statement reports revenues and expenses that net to a profit or loss

Accounting Reporting Standards

Accounting Reporting Standards

- *Convergence of Accounting Standards*: Aims to narrow or remove differences so that investors can better understand financial statements prepared under different accounting frameworks
  - *IASB* – International Accounting Standards Board has the responsibility of IFRS
  - *IFRS* – International Financial Reporting Standards (EU countries adopted)
  - *US GAAP* – US Generally Accepted Accounting Principles determined by FASB
  - *FASB* – Financial Accounting Standards Board determines accounting standards for financial statements

Financial statements

Financial statements

(Adapted from Introduction to Management accounting, Horngren et al, 2014)

- The accounting process begins with a transaction.
  - A transaction is any event that affects the financial position of an organization and requires recording
- Financial statements are used to summarize the recorded accounting transactions.

Financial statements

Financial Status for Businesses:

- All businesses prepare their financial status. Of the various reports corporations issue to their stockholders, the ***annual report*** is by far the most important, containing basic financial statements as well as management's opinion of the past year's operations and the firm's future prospects. The report includes:
  - What is the company's financial position at the end of the fiscal period?
  - How well did the company operate during the fiscal period?
  - On what did the company decide to use its profits?
  - How much cash did the company generate and spend during the fiscal period?

Financial statements

- *Financial statement* record and assist in answering
  - –How well the company is performing now and
  - –How well it might perform in the future

Financial statements

A financial statement is a quantitative way of showing how a company is doing.

Three different ways of representing the financial state of a company:

1. Cash Management (can the company meet its obligations?)
2. Profitability (Is it making money?) - the income statement
3. Assets versus Liabilities (what is the value of the company? Who owns what?) - the balance sheet

Each one of these questions is answered by the Financial Statements.

Financial statements

- Cash Flow Statements
  - These answer the important managerial question “do I have enough cash to run my business”
- Income Statements
  - This is the financial sheet that tells you if your company is profitable or not.
- Balance Sheets
  - How much debt do I have? How large are my assets? This sheet tells you the answer to these questions.

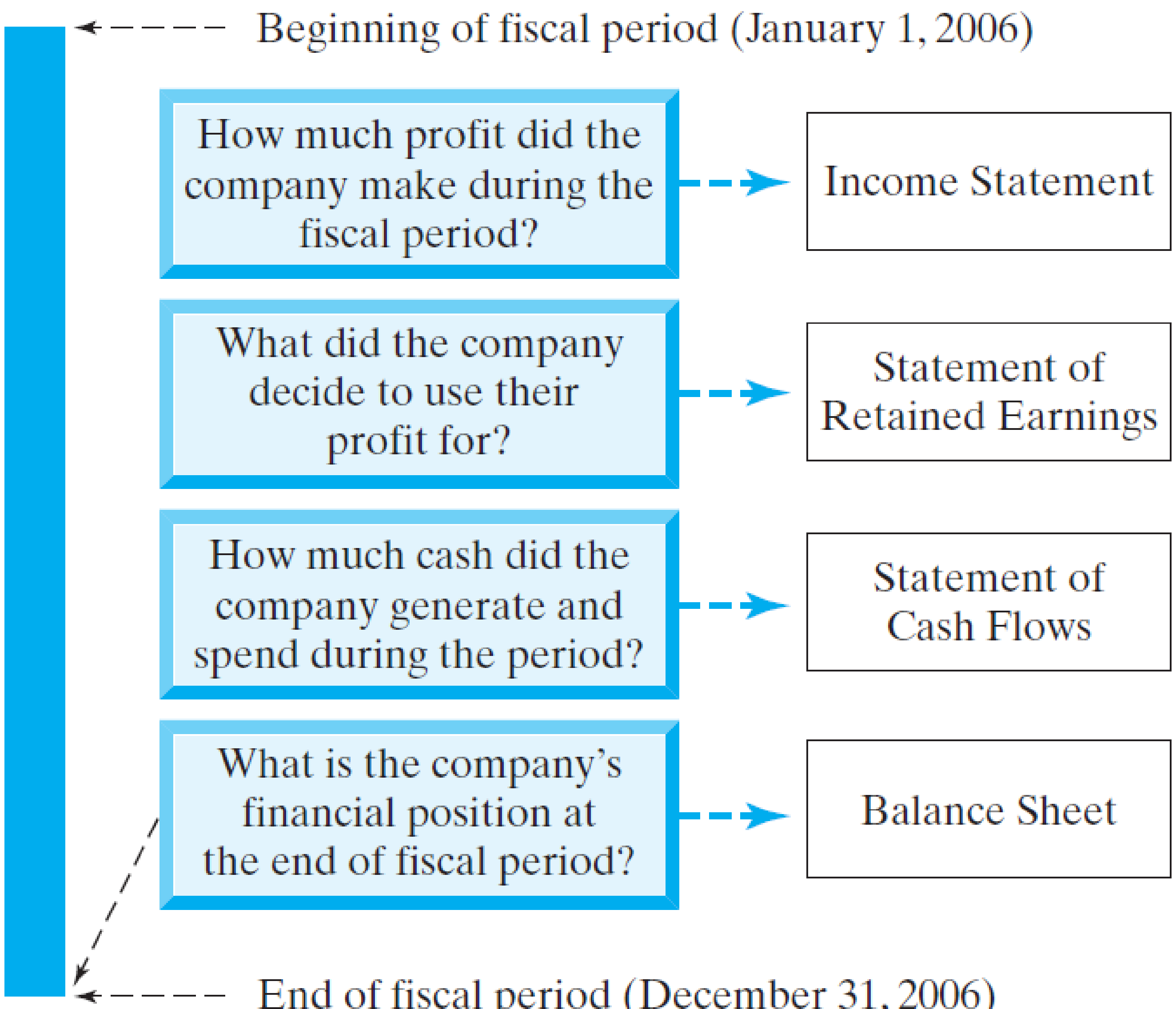


Figure 2.2 Information reported on the financial statements.

Basic Accounting

An organizations financial manger (Accountant) answers these questions using the company's financial statement:

The financial statement contains three major elements

- –Balance sheet
- –Income statement
- –statement of cash flows

Financial Ratios And Business Decisions

Financial Ratios And Business Decisions

- *Ratio analysis* is a quantitative method of gaining insight into a company's liquidity, operational efficiency, and profitability by comparing information contained in its financial statements.

Financial Ratios And Business Decisions

- The data retrieved from financial statements is used to compare a company's performance over time to assess whether the company is improving or deteriorating, to compare a company's financial standing with the industry average, or to compare a company to one or more other companies operating in its sector to see how the company stacks up.

Financial Ratios And Business Decisions

- A **financial ratio** or **accounting ratio** is a relative magnitude of two selected numerical values taken from an enterprise's financial statements.
- There are many standard ratios used to try to evaluate the overall financial condition of a corporation or other organization.

GLOBAL CONGLOMERATE CORPORATION

Consolidated Balance Sheet
Year Ended December 31 (in $ million)

Assets	2012	2011
Current Assets		
Cash	21.2	19.5
Accounts receivable	18.5	13.2
Inventories	15.3	14.3
Other current assets	2.0	1.0
Total current assets	57.0	48.0
Long-Term Assets		
Land	22.2	20.7
Buildings	36.5	30.5
Equipment	39.7	33.2
Less accumulated depreciation	(18.7)	(17.5)
Net property, plant, and equipment	79.7	66.9
Goodwill and intangible assets	20.0	20.0
Other long-term assets	21.0	14.0
Total long-term assets	120.7	100.9
Total Assets	**177.7**	**148.9**

Liabilities and Stockholders' Equity	2012	2011
Current Liabilities		
Accounts payable	29.2	24.5
Notes payable/short-term debt	3.5	3.2
Current maturities of long-term debt	13.3	12.3
Other current liabilities	2.0	4.0
Total current liabilities	48.0	44.0
Long-Term Liabilities		
Long-term debt	99.9	76.3
Capital lease obligations	—	—
Total debt	99.9	76.3
Deferred taxes	7.6	7.4
Other long-term liabilities	—	—
Total long-term liabilities	107.5	83.7
Total Liabilities	**155.5**	**127.7**
Stockholders' Equity	**22.2**	**21.2**
Total Liabilities and Stockholders' Equity	**177.7**	**148.9**

Financial Ratios And Business Decisions

- Financial ratios are relationships determined from a company's financial information and used for comparison purposes. Examples include such often referred to measures as return on investment (ROI), return on assets (ROA), and debt-to-equity, etc
- These ratios are the result of dividing one account balance or financial measurement with another.
- Usually these measurements or account balances are found on one of the company's financial statements—balance sheet, income statement, cashflow statement, and/or statement of changes in owner's equity.

Financial Ratios And Business Decisions

- **Ratio analysis** - tool for measuring a firm's liquidity, profitability, and reliance on debt financing, as well as the effectiveness of management's resource utilization.

Financial Ratios And Business Decisions

- Financial ratios provide businesses with a valuable tool with which to measure their progress against predetermined internal goals, a certain competitor, or the overall industry.
- In addition, tracking various ratios over time is a powerful means of identifying trends in their early stages.
- Ratios are also used by bankers, investors, and business analysts to assess a company's financial status.

Financial Ratios And Business Decisions

- Financial ratios are grouped into the following categories:
  - –Liquidity ratios
  - –Leverage ratios
  - –Efficiency ratios
  - –Profitability ratios
  - –Market value ratios

Table 16.1 Major Categories of Financial Ratios

Category	Ratio	Description
Liquidity ratios	Current ratio	Current assets divided by current liabilities
	Quick (acid-test) ratio	Current assets (minus inventory) divided by current liabilities
Efficiency ratios	Inventory turnover	Cost of goods sold divided by average inventory
	Receivables turnover	Credit sales divided by average accounts receivable
	Total asset turnover	Revenue or sales divided by average total assets
Leverage ratios	Debt ratio	Total liabilities divided by total assets
	Long term debt to equity	Long-term debt divided by owners' equity
Profitability ratios	Gross profit margin	Gross profit divided by revenue or sales
	Net profit margin	Net profit divided by revenue or sales
	Return on equity	Net profit divided by average owners' equity

Financial Ratios And Business Decisions

- Profitability Ratios
  - –Reveals a company's ability to generate profits
- Turnover Ratios
  - –Reveals the company's efficiency with regard to the use of its assets
- Debt-Related Ratios –Reveals a company's ability to re-pay its obligations

Profitability Ratios

- Earnings Per Share (EPS)
  - –Measures the earnings per each share of common stock outstanding
- Price-Earnings Ratio (PE)
  - –Measures an investor’s expectations of future profitability
- Gross Margin Percentage
  - –Estimates the incremental profit generated by each dollar of sales
- Return on Total Assets
  - –Measures the net income generated for each dollar invested in assets
- Return on Common Stockholders’ Equity
  - –Measures the net income generated for each dollar invested by the shareholders

Profitability Ratios: Formulas

Earnings per share	(Net income − Preferred dividends) ÷ Number of common shares outstanding
Price–earnings ratio	Market price per share ÷ Earnings per share
Gross margin percentage	Gross margin ÷ Net sales
Return on total assets	[Net income + (Interest expense × (1 − Tax rate))] ÷ Total assets
Return on common stockholders' equity	(Net income − Preferred dividends) ÷ Common stockholders' equity

Turnover Ratios

- Asset Turnover
  - –Measures how efficiently assets are utilized
- Accounts Receivable Turnover
  - –Measures the number of times each year receivables are collected
- Days' Sales in Receivables
  - –Measures the average number of days necessary to collect credit sales
- Inventory Turnover
  - –Measures the number of times each year inventory is sold
- Days' Sales in Inventory
  - –Measures the average number of days necessary to sell all inventory

Turnover Ratios: Formulas

Asset turnover	Net sales ÷ Total assets
Accounts receivable turnover	Net credit sales ÷ Accounts receivable
Days' sales in receivables	365 ÷ Accounts receivable turnover
Inventory turnover	Cost of goods sold ÷ Inventory
Days' sales in inventory	365 ÷ Inventory turnover

Debt-Related Ratios

- Current Ratio
  - –Measures a company’s ability to meet short-term obligations
- Acid-Test Ratio (Quick Ratio)
  - –More stringent measure of the current ratio
- Debt-to-Equity Ratio
  - ––Assesses the company’s debt position
- Times Interest Earned
  - – Measures a company’s ability to re-pay long-term debt

Debt-Related Ratios

Current ratio	Current assets ÷ Current liabilities
Acid test (Quick ratio)	[(Cash + Marketable securities) + Short-term receivables] ÷ Current liabilities
Debt-to-equity ratio	Total liabilities ÷ Stockholders' equity
Times interest earned	Operating income ÷ Interest expense

Summary of Ratio Formulas

Profitability Ratios	
Earnings per share	(Net income − Preferred dividends) ÷ Number of common shares outstanding
Price–earnings ratio	Market price per share ÷ Earnings per share
Gross margin percentage	Gross margin ÷ Net sales
Return on total assets	[Net income + (Interest expense × (1 − Tax rate))] ÷ Total assets
Return on common stockholders' equity	(Net income − Preferred dividends) ÷ Common stockholders' equity
Turnover Ratios	
Asset turnover	Net sales ÷ Total assets
Accounts receivable turnover	Net credit sales ÷ Accounts receivable
Days' sales in receivables	365 ÷ Accounts receivable turnover
Inventory turnover	Cost of goods sold ÷ Inventory
Days' sales in inventory	365 ÷ Inventory turnover
Debt Related Ratios	
Current ratio	Current assets ÷ Current liabilities
Acid test (Quick ratio)	[(Cash + Marketable securities) + Short-term receivables] ÷ Current liabilities
Debt-to-equity ratio	Total liabilities ÷ Stockholders' equity
Times interest earned	Operating income ÷ Interest expense

Financial Ratios And Business Decisions

- ***Liquidity Ratios***
  - Liquidity ratios demonstrate a company's ability to pay its current obligations. In other words, they relate to the *availability of cash* and other assets to cover accounts payable, short-term debt, and other liabilities
  - Liquidity ratios are financial ratios that measure a company’s ability to repay both short- and long-term obligations. Common liquidity ratios include the following:

Financial Ratios And Business Decisions

- The *current ratio* measures a company's ability to pay off short-term liabilities with current assets:
  - **Current ratio = Current assets / Current liabilities**

Financial Ratios And Business Decisions

- *Current ratio:* Current Assets/Current Liabilities—measures the ability of an entity to pay its near-term obligations. "Current" usually is defined as within one year. Though the ideal current ratio depends to some extent on the type of business, a general rule of thumb is that it should be at least 2:1.
- A lower current ratio means that the company may not be able to pay its bills on time, while a higher ratio means that the company has money in cash or safe investments that could be put to better use in the business.

Financial Ratios And Business Decisions

- Using the information below calculate and analyze current ratios for two construction companies X and Y

		2017	2018	2019
• Company X	Current Assets	33, 350	32,256	31,390
	Current Liabilities	33,000	28,950	27,564
• Company Y	Current Assets	23, 350	25,660	18672
	Current Liabilities	21,000	17,645	15,564

NB. All costs in Millions

Financial Ratios And Business Decisions

- Current Ration for Company X = 33,350/ 33,000= 1.01

Financial Ratios And Business Decisions

- *Quick ratio (or "acid test"):* Quick Assets (cash, marketable securities, and receivables)/Current Liabilities—provides a stricter definition of the company's ability to make payments on current obligations. Ideally, this ratio should be 1:1. If it is higher, the company may keep too much cash on hand or have a poor collection program for accounts receivable. If it is lower, it may indicate that the company relies too heavily on inventory to meet its obligations.

Financial Ratios And Business Decisions

- The *acid test ratio* measures a company's ability to pay off short-term liabilities with quick assets:
- **Acid-test ratio = Current assets – Inventories / Current liabilities**

Current assets:	
Cash and cash equivalents	$ 76,000
Marketable securities	110,000
Trade and other receivables	230,000
Inventories	167,000
Prepayments	42,000
Total current assets	$ 625,000
Non-current assets:	
Long-term investments	$ 450,000
Fixed assets	900,000
Total current assets	$ 1,350,000
TOTAL ASSETS	**$ 1,975,000**
Current liabilities	$ 350,000
Non-current liabilities	900,000
Stockholders' equity	725,000
TOTAL LIABILITIES & EQUITY	**$ 1,975,000**

Quick ratio	= Quick assets ÷ Current liabilities
	= ($76,000 + $110,000 + $230,000) ÷ $350,000
Quick ratio	= **1.19**

Quick Ratio Example

- A quick ratio that is greater than 1 means that the company has enough quick assets to pay for its current liabilities. Quick assets (cash and cash equivalents, marketable securities, and short-term receivables) are current assets that can be converted very easily into cash. Hence, companies with good quick ratios are favored by creditors.
- In the example above, the quick ratio of 1.19 shows that the above Company has enough current assets to cover its current liabilities. For every $1 of current liability, the company has $1.19 of quick assets to pay for it.

Financial Ratios And Business Decisions

- The *cash ratio* measures a company's ability to pay off short-term liabilities with cash and cash equivalents:
- **Cash ratio = Cash and Cash equivalents / Current Liabilities**

Current assets:	
Cash and cash equivalents	$ 110,000
Marketable securities	180,000
Trade and other receivables	220,000
Inventories	450,000
Prepayments	90,000
Total current assets	$ 1,050,000
Non-current assets:	
Long-term investments	$ 400,000
Fixed assets	1,300,000
Total current assets	$ 1,700,000
TOTAL ASSETS	**$ 2,750,000**
Current liabilities	$ 460,000
Non-current liabilities	1,000,000
Stockholders' equity	1,290,000
TOTAL LIABILITIES & EQUITY	**$ 2,750,000**

$$\text{Cash ratio} = (C\&CE + MS) \div CL$$

$$= (\$110{,}000 + \$180{,}000) \div \$460{,}000$$

$$\text{Cash ratio} = 0.63$$

Cash Ratio

- If the company has enough cash & cash equivalents and marketable securities to cover for current liabilities, the cash ratio will result in an amount greater than 1; otherwise, less than 1.
  - In the above example, the total cash & cash equivalents and marketable securities of the above company is not enough to cover for all current liabilities. For every dollar of current liability, the company only has $0.63 of cash and marketable securities to pay for it. Nonetheless, the company has other current assets that it can liquidate to be able to settle its current obligations.

Financial Ratios And Business Decisions

- The operating cash flow ratio is a measure of the number of times a company can pay off current liabilities with the cash generated in a given period:
- **Operating cash flow ratio = Operating cash flow / Current liabilities**

Financial Ratios And Business Decisions

- *Leverage ratios* look at the extent to which a company has depended upon borrowing to finance its operations. As a result, these ratios are reviewed closely by bankers and investors. Most leverage ratios compare assets or net worth with liabilities. A high leverage ratio may increase a company's exposure to risk and business downturns, but along with this higher risk also comes the potential for higher returns

Financial Ratios And Business Decisions

- **Leverage Financial Ratios**

Leverage ration measures the amount of capital that comes from debt.

In other words, leverage financial ratios are used to evaluate a company’s debt levels. Common leverage ratios include the *Debt ratio* and *Debt to Equity ratio*:

Financial Ratios And Business Decisions

- *Debt ratio:* Debt/Total Assets—measures the portion of a company's capital that is provided by borrowing. A debt ratio greater than 1.0 means the company has negative net worth, and is technically bankrupt. This ratio is similar, and can easily be converted to, the debt to equity ratio.

Financial Ratios And Business Decisions

- The *debt ratio* measures the relative amount of a company's assets that are provided from debt:
- **Debt ratio = Total liabilities / Total assets**

Debt Ratio

- A company has a total assets of $100,000 and total liabilities of $25,000. the Debt ratio can be calculated as

DR= Total Liabilities/ Total Assets

= 25,000/100,000= 0.25

The Company has has 4 times as many assets as it has liabilities

Financial Ratios And Business Decisions

- *Debt to equity ratio:* Debt/Owners' Equity—indicates the relative mix of the company's investor-supplied capital. A company is generally considered safer if it has a low debt to equity ratio—that is, a higher proportion of owner-supplied capital—though a very low ratio can indicate excessive caution. In general, debt should be between 50 and 80 percent of equity.

Financial Ratios And Business Decisions

- The debt to equity ratio calculates the weight of total debt and financial liabilities against shareholders equity:
- **Debt to equity ratio = Total liabilities / Shareholder's equity**

Debt to Equity ratio

- Assume a company has $100,000 of bank lines of credit and a $500,000 mortgage on its property. The shareholders of the company have invested $1.2 million.
- Calculate the Debt to Equity Ratio

Debt to Equity ratio

DER= 100000+500,000/1.2million= 0.5

A debt ratio of .5 means that there are half as many liabilities than there is equity. In other words, the assets of the company are funded 2-to-1 by investors to creditors.

- This means that investors own 66.6 cents of every dollar of company assets while creditors only own 33.3 cents on the dollar.

Financial Ratios And Business Decisions

- *Interest coverage:* Earnings before Interest and Taxes/Interest Expense—indicates how comfortably the company can handle its interest payments. In general, a higher interest coverage ratio means that the small business is able to take on additional debt. This ratio is closely examined by bankers and other creditors.

Financial Ratios And Business Decisions

- The *interest coverage ratio* determines how easily a company can pay its interest expenses:
- **Interest coverage ratio = Operating income / Interest expenses**

Financial Ratios And Business Decisions

- The *debt service coverage* ratio determines how easily a company can pay its debt obligations:
- **Debt service coverage ratio = Operating income / Total debt service**

Financial Ratios And Business Decisions

- **Efficiency Ratios**
- *Efficiency ratios*, also known as activity financial ratios, are used to measure how well a company is utilizing its assets and resources. Common efficiency ratios include:
- Asset turnover ratio and Inventory Turnover Ratio

Financial Ratios And Business Decisions

The Asset Turnover Ratio measures a company's ability to generate sales from assets:

– ***Asset turnover ratio = Net sales / Total assets***

Financial Ratios And Business Decisions

The Inventory Turnover Ratio measures how many times a company's inventory is sold and replaced over a given period:

- **Inventory turnover ratio = Cost of goods sold / Average inventory**

Financial Ratios And Business Decisions

- The accounts receivable turnover ratio measures how many times a company can turn receivables into cash over a given period:
  - **Receivables turnover ratio = Net credit sales / Average accounts receivable**
- The days sales in inventory ratio measures the average number of days that a company holds onto its inventory before selling it to customers:
  - **Days sales in inventory ratio = 365 days / Inventory turnover ratio**

Financial Ratios And Business Decisions

- **Profitability Ratios:** measure a company's ability to generate income relative to revenue, balance sheet assets, operating costs, and equity. Common profitability financial ratios include the following: the gross margin ratio and the operating margin ratio

Financial Ratios And Business Decisions

- The gross margin ratio compares the gross profit of a company to its net sales to show how much profit a company makes after paying off its cost of goods sold:

Gross margin ratio = Gross profit / Net sales

Financial Ratios And Business Decisions

- The operating Margin ratio compares the operating income of a company to its net sales to determine operating efficiency:

Operating margin ratio = Operating income / Net sales

Financial Ratios And Business Decisions

- The return on assets ratio measures how efficiently a company is using its assets to generate profit:

Return on assets ratio = Net income / Total assets

Financial Ratios And Business Decisions

- The return on equity ratio measures how efficiently a company is using its equity to generate profit:

Return on equity ratio = Net income / Shareholder's equity

Debt Management

- All businesses need assets in order to operate. To acquire assets, a firm must raise capital. When the firm finances its long-term needs externally, it may obtain funds from the capital markets. Capital comes in two forms, debt and equity. Debt capital refers to borrowed capital from financial institutions and bond market. Equity capital refers to capital obtained from the owners of the company.

Debt Management

- Since a company must pay its creditors on time and in full to remain solvent and out of bankruptcy, one primary concern of financial analysis is to determine how able a firm is to cover its required debt payments.
- To do so, we first examine the extent to which a company uses debt financing (or financial leverage) in business operation as follows:
  - check the balance sheet to determine the extent to which borrowed funds have been used to finance assets, and
  - review the income statement to see the extent to which fixed charges (interests) are covered by operating profits.
- Two essential indicators of a business' ability to pay its long-term liabilities are the *debt ratio and the times-interest-earned ratio.*

Debt Management

- The relationship between total liabilities and total assets, generally called the *debt ratio,* tells us the proportion of the company's assets that it has financed with debt:
- Debt ratio = Total debt /Total assets

Project Monitoring: Cost Control

Cost Management In Construction

- The project money plan is the financial forecast for the project, and it sets the basis for the control of project costs and cash flow.
- Developing the money plan involves the functions of cost estimating, budgeting, Cash flow, cost control, and project profitability. Taken together, these functions make up the field of cost engineering
  - (Ritz 1994)

Cost Management In Construction

- Issues to consider in Project costing….
  - Mobilization Cost
  - Cost of materials
  - Cost of labor (Site safety and security costs)
  - Field staff salaries and expenses
  - office equipment and supplies
  - Vehicles and construction equipment
  - Temporary site facilities
  - Variations in works
  - Retainage..(payment for subcontractors)

Project Cash Flow

- An estimate of all income and expenditures and their anticipated dates based on the expected actual transfer of funds and billings is used to forecast cash flow

Cost planning

- ***Cost planning:*** A development budget study is undertaken to determine the total costs and returns expected from the project.
- A cost plan is prepared to include all construction costs, and all other items of project cost including professional fees and contingency.
- All costs included in the cost plan will also be included in the development budget in addition to the developer's returns and other extraneous items such as project insurance, surveys and his or her agent's or other specialist advisers' fees.

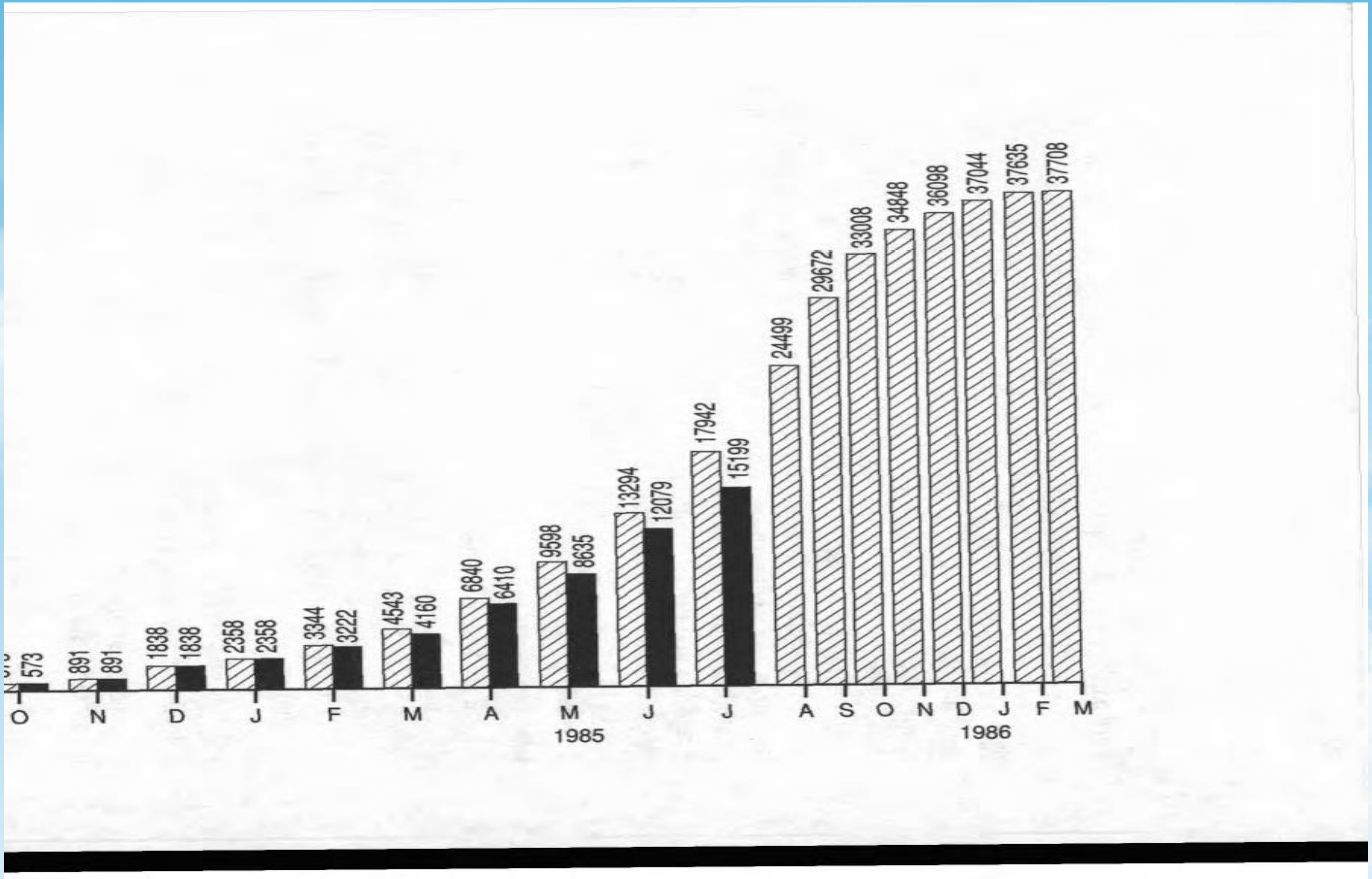
Cost planning

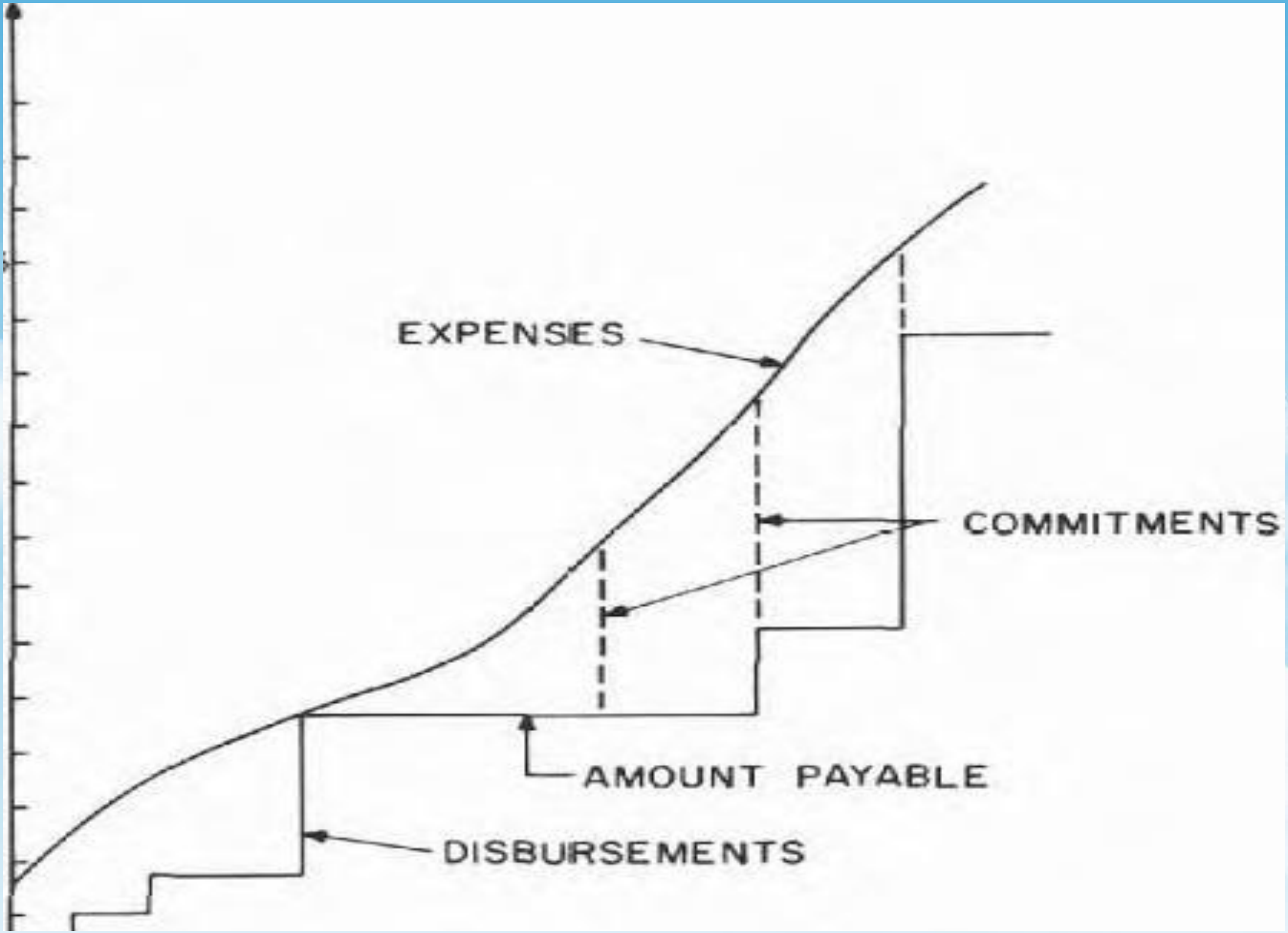
- The objective of the cost plan is to allocate the budget to the main elements of the project to provide a basis for cost control.
- The cost plan should, therefore, include the best possible estimate of the cash flow for the project and should also set targets for the future running costs of the facility. The cost plan should cover all stages of the project and will be the essential reference against which the project costs are managed.

Cost planning

- The cost plan provides the basis for a cash flow plan, based upon the master schedule, allocating expenditure and income to each period of the client's financial year.
- The expenditures should be given at a stated base-date level and at out-turn levels based on a stated forecast of inflation. A cash flow histogram and cumulative expenditure. graph are shown in the Figure.
- When the cost plan is in place it serves as the reference point for the monitoring and control of costs throughout a project.

Project Cash Flow




EXPENSES
COMMITMENTS
AMOUNT PAYABLE
DISBURSEMENTS

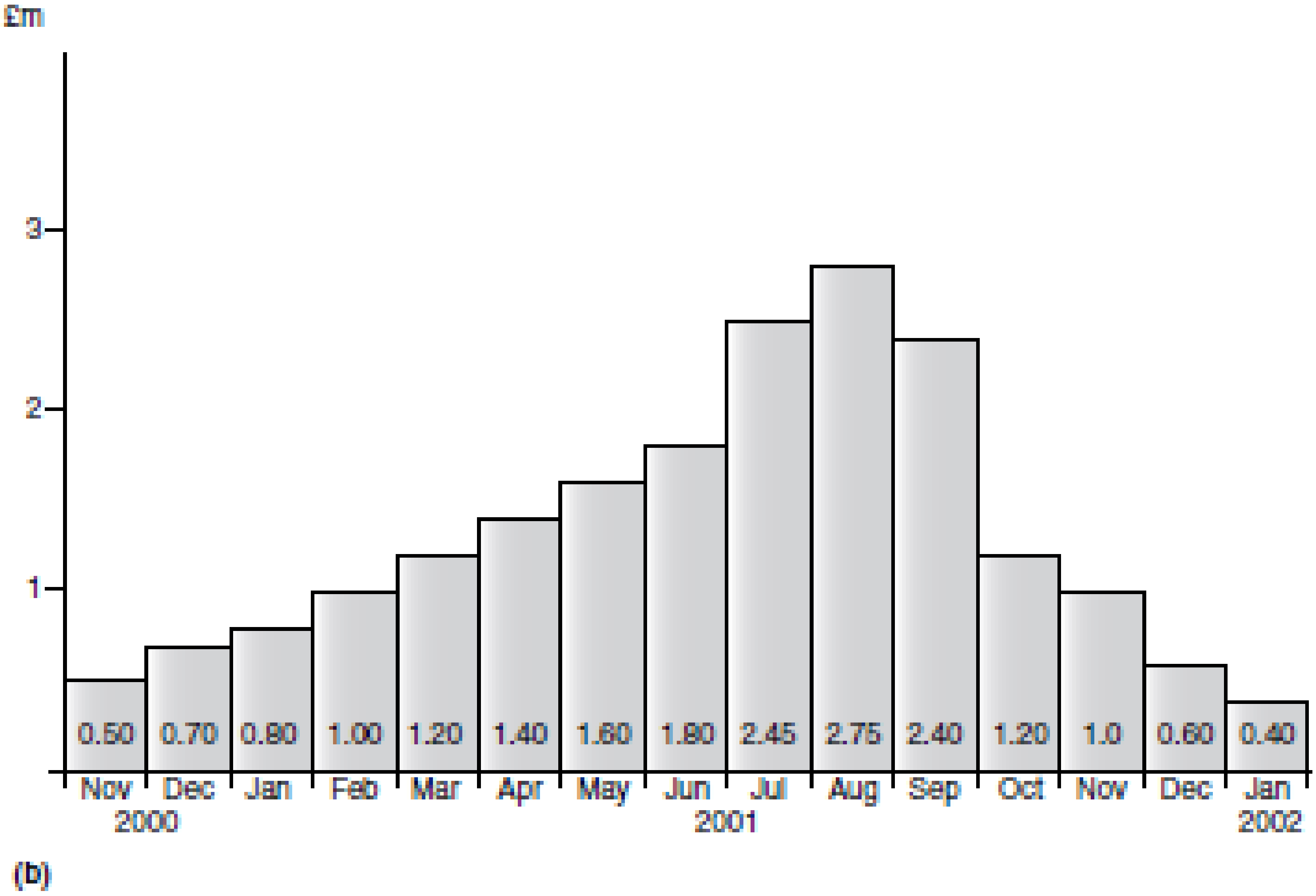
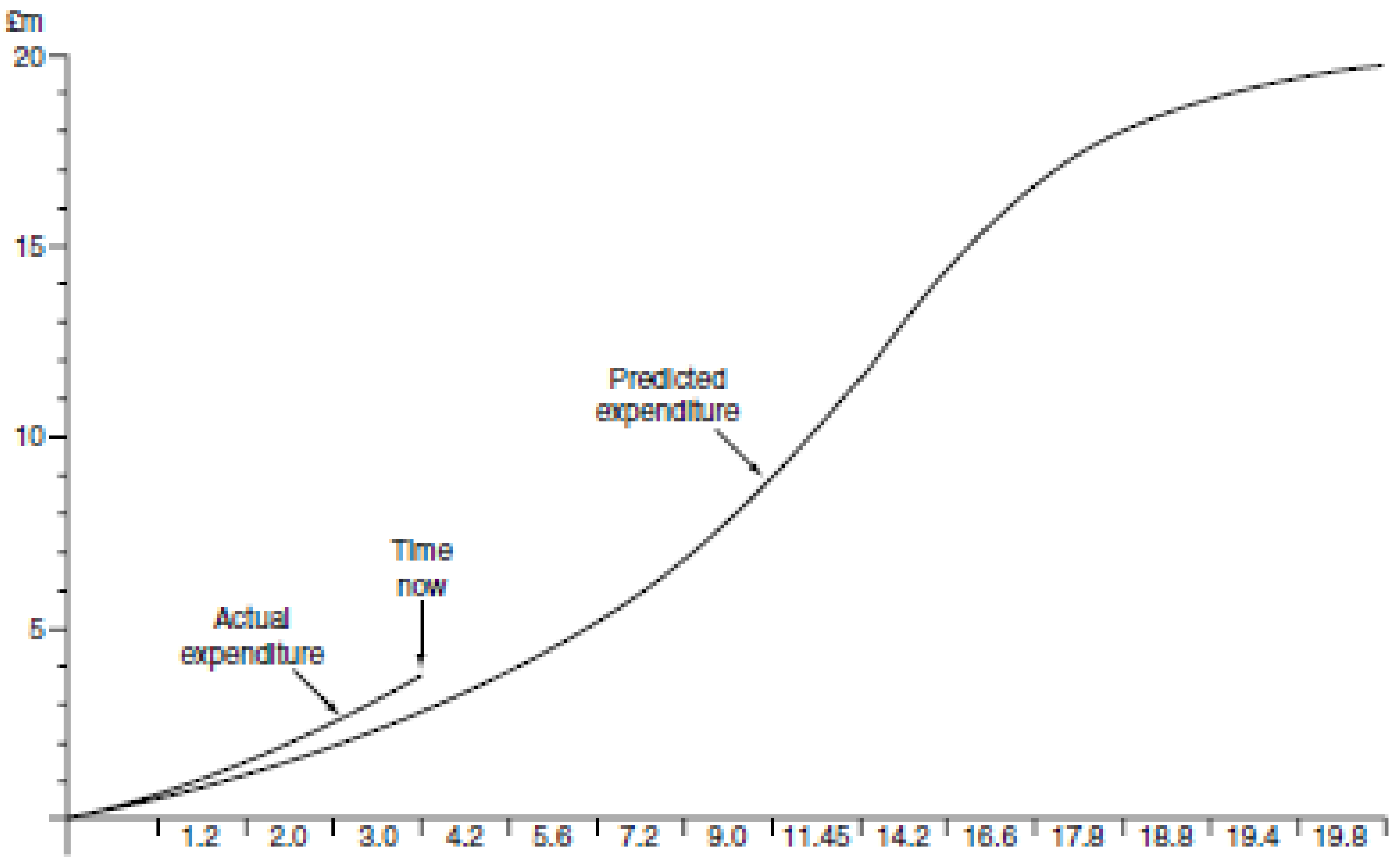


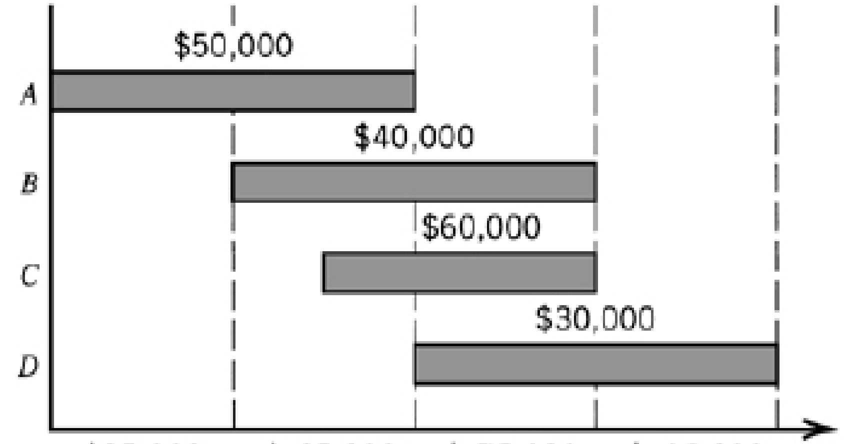
Figure 3.4 Examples of: (a) construction expenditure graph; (b) cash flow histogram



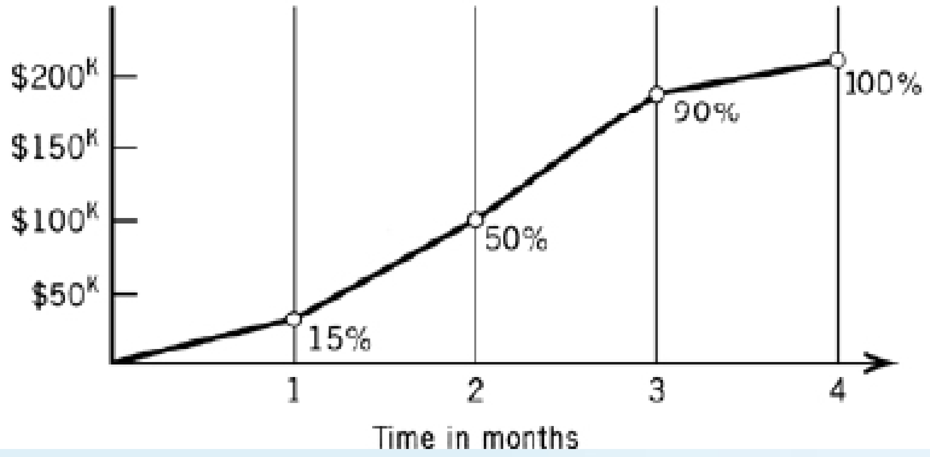
£m
20
15
10
5
Predicted expenditure
Time now
Actual expenditure
1.2
2.0
3.0
4.2
5.6
7.2
9.0
11.45
14.2
16.6
17.8
18.8
19.4
19.8

(a)

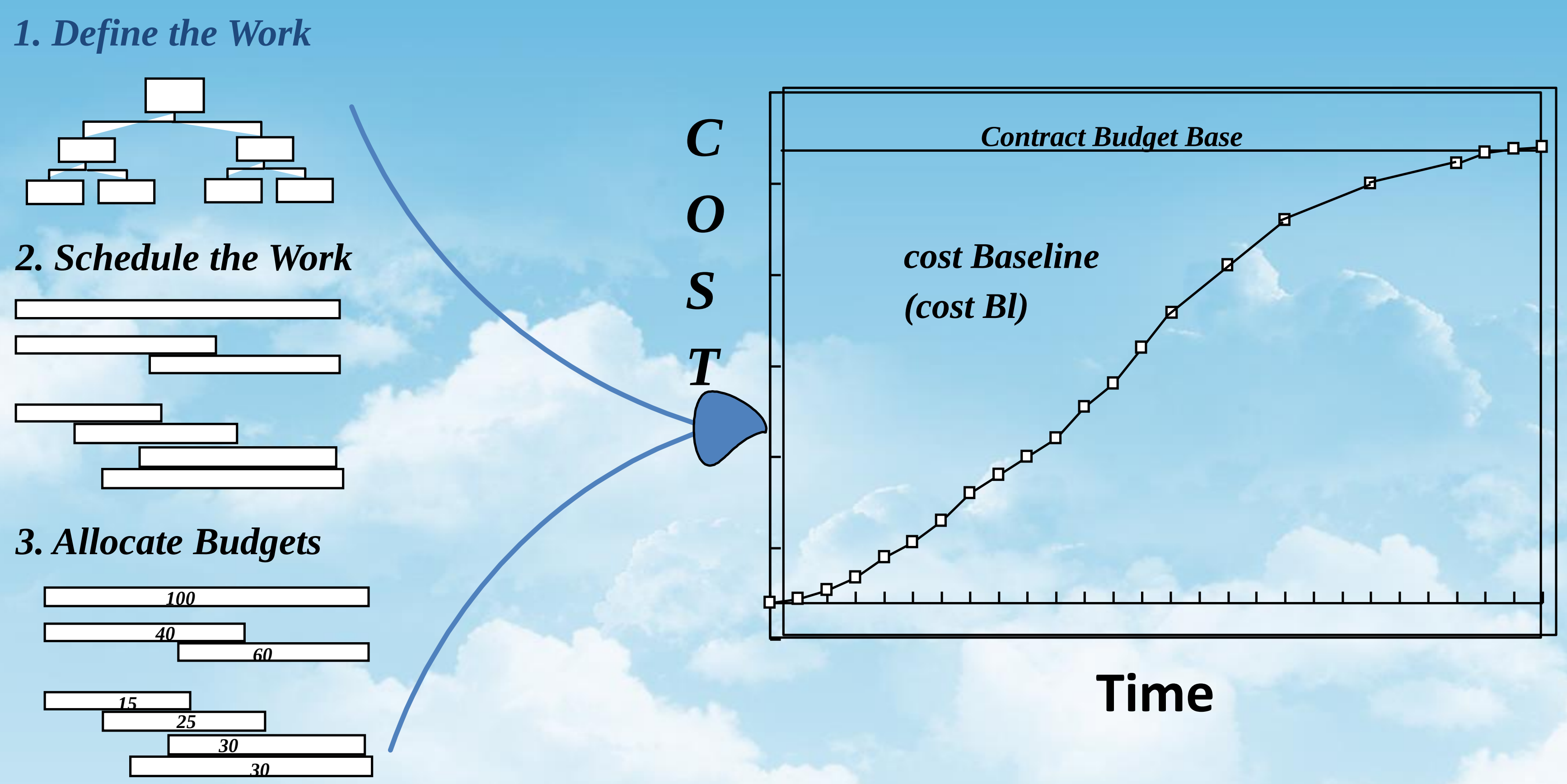
Development cost loaded schedule of S- curve



Monthly direct costs	$25,000	$ 65,000	$ 75,000	$ 15,000
Monthly indirect costs	$ 5,000	$ 5,000	$ 5,000	$ 5,000
Total monthly costs	$30,000	$ 70,000	$ 80,000	$ 20,000
Cumulative monthly costs	$30,000	$100,000	$180,000	$200,000



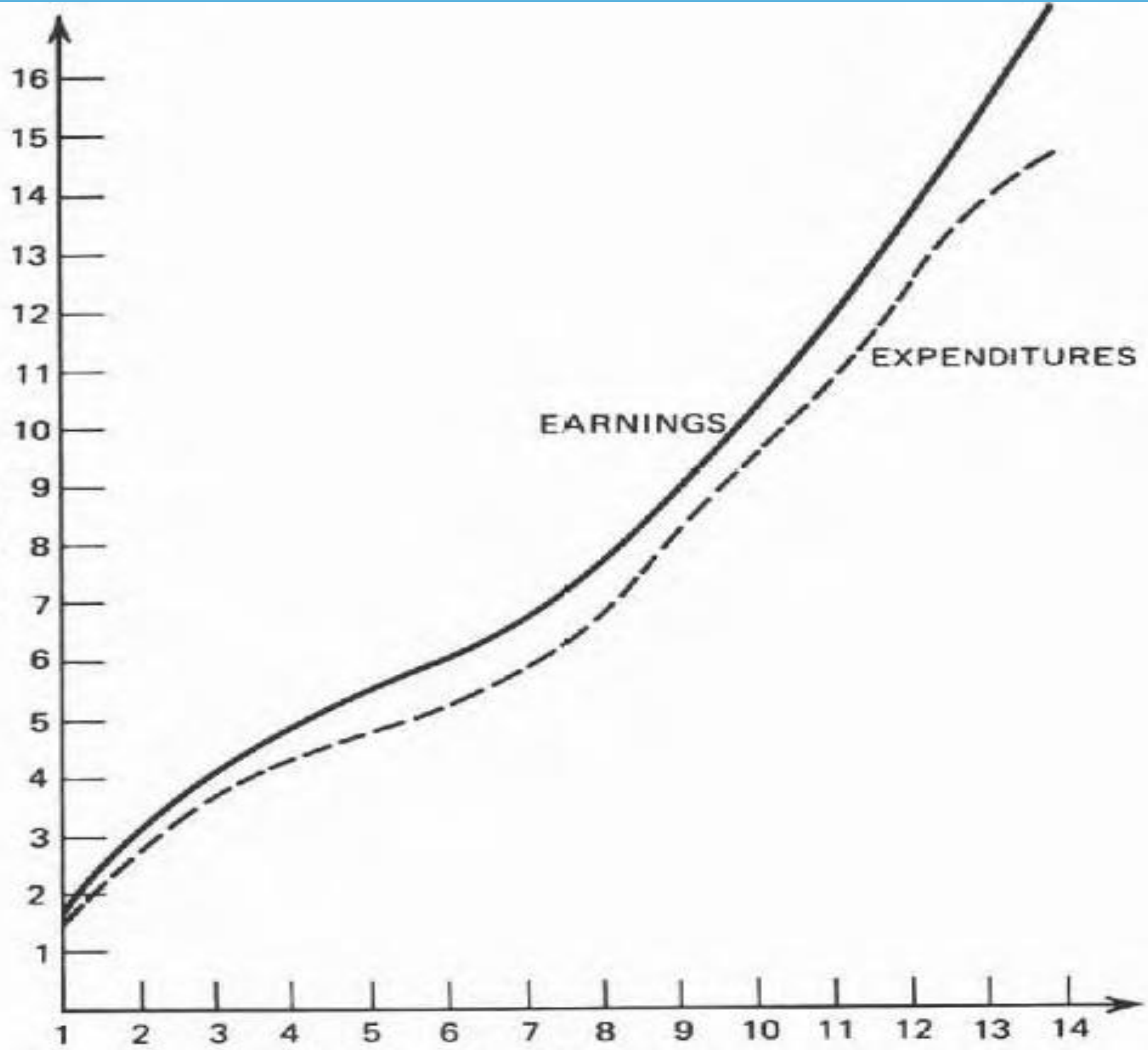
Establishing the Performance Measurement Baseline
An Iterative 3-Step Process



Pm (Performance measurement)

Cost Control

- Ensuring that the project costs are always reported back against the original approved budget. Any subsequent variations to the budget must be clearly indicated in the cost reports.
- Plotting actual expenditure against predicted to give an indication of the project's progress



16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
EARNINGS
EXPENDITURES
1
2
3
4
5
6
7
8
9
10
11
12
13
14

Project Cash Flow

- Project cash flow plan is the projected rate at which the project's cash resources will be spent
- cash flow plan is developed from the cost estimate and the project schedule.
- The overall shape of the cash flow curve will follow that of the project life-cycle bell curve
  - Payments start slowly at the front, rise to a peak near the midpoint, and taper off at the end. Plotting money spent versus time will result in a classic **S** curve

Earned Value Methodology in Construction

Earned Value Analysis

- Project cost control is concerned with ensuring that projects stay within their budgets, while getting the work done on time and at the correct quality.
- One system for doing this, called *earned value analysis*, was developed in the 1960s The method is considered the correct way to monitor and control almost any project. The method is also called simply *variance analysis*.

Earned Value Analysis

- Variance analysis allows the project manager to determine trouble spots in the project and to take corrective action. The following definitions are useful in understanding the analysis:
  - *Cost variance*: Compares deviations and performed work.
  - *Schedule variance*: Compares planned and actual work completed.

Earned Value Analysis; Key terms

- *BCWS* (budgeted cost of work scheduled):
  - The budgeted cost of work scheduled to be done in a given time period or the level of effort that is supposed to be performed in that period.
- *BCWP* (budgeted cost of work performed):
  - The budgeted cost of work actually performed in a given period or the budgeted level of effort actually expended. BCWP is also called *earned value* and is a measure of the Birr(Dollar) value of the work actually accomplished in the period being monitored.

Earned Value Analysis

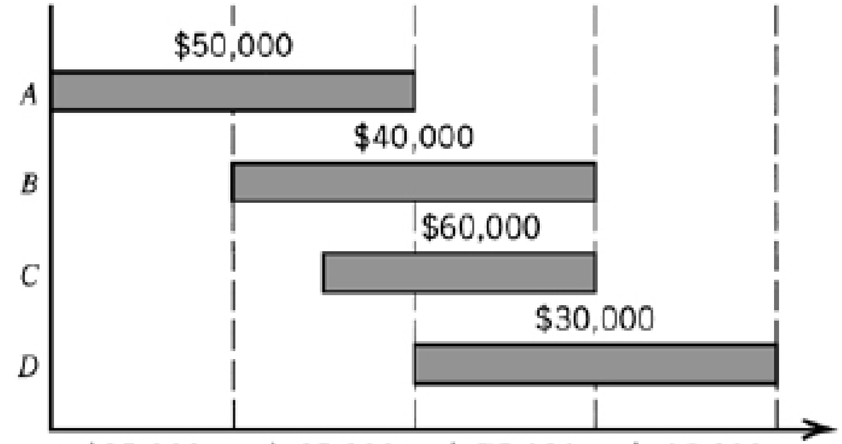
- *ACWP* (actual cost of work performed):
  - The amount of money (or effort) actually spent in completing work in a given period.
- Cost Variance = BCWP – ACWP
- Schedule Variance = BCWP – BCWS
- Variance: Any deviation from plan By combining cost and schedule variances, an integrated cost/schedule reporting system can be developed.

Earned Value Analysis: Baseline Plan

Cost loaded schedule; is a schedule that shows not only the time frame when a task is to be completed but also the cost of the work so that the cost of the work completed each week or month can be estimated.

The costs for each task are spread out over duration of the task uniformly, resulting in daily, weekly or monthly cost for each of the tasks.

Development cost loaded schedule of S- curve



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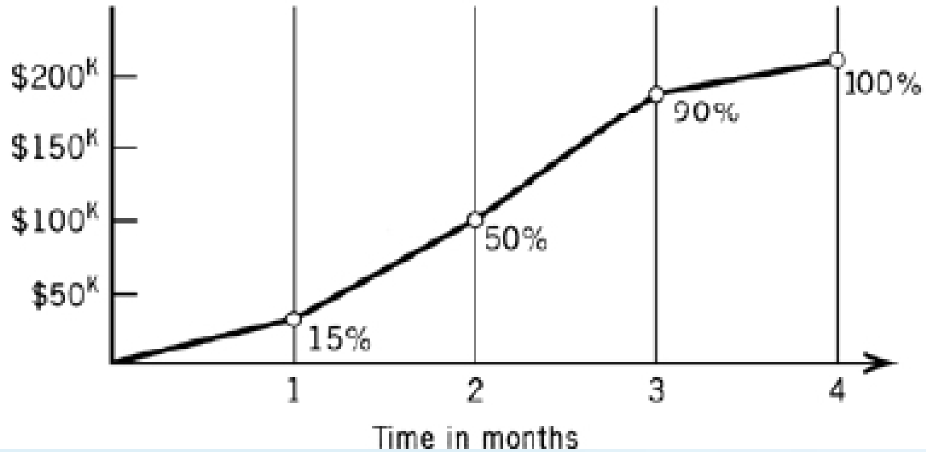
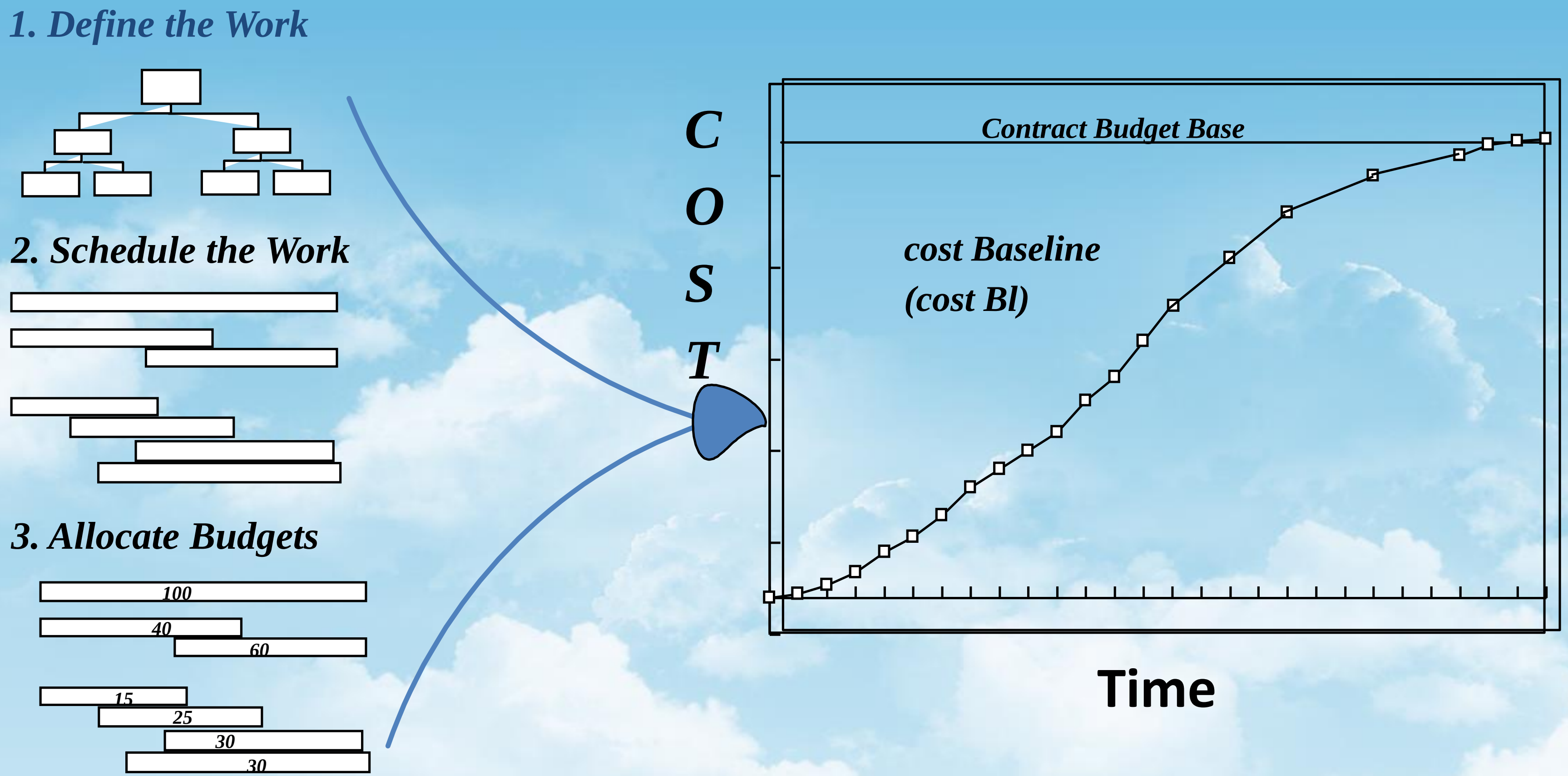
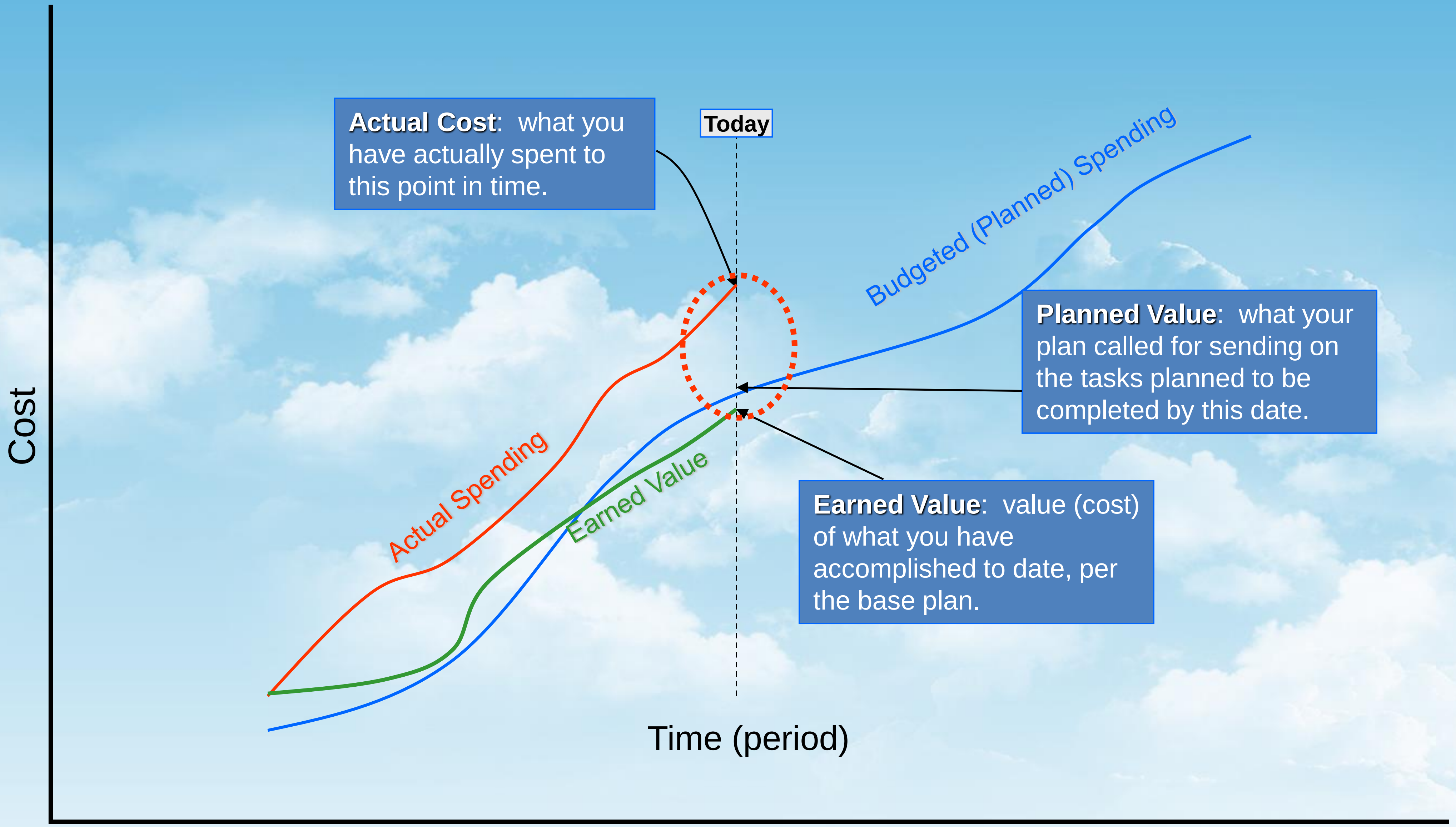


Establishing the Performance Measurement Baseline
An Iterative 3-Step Process

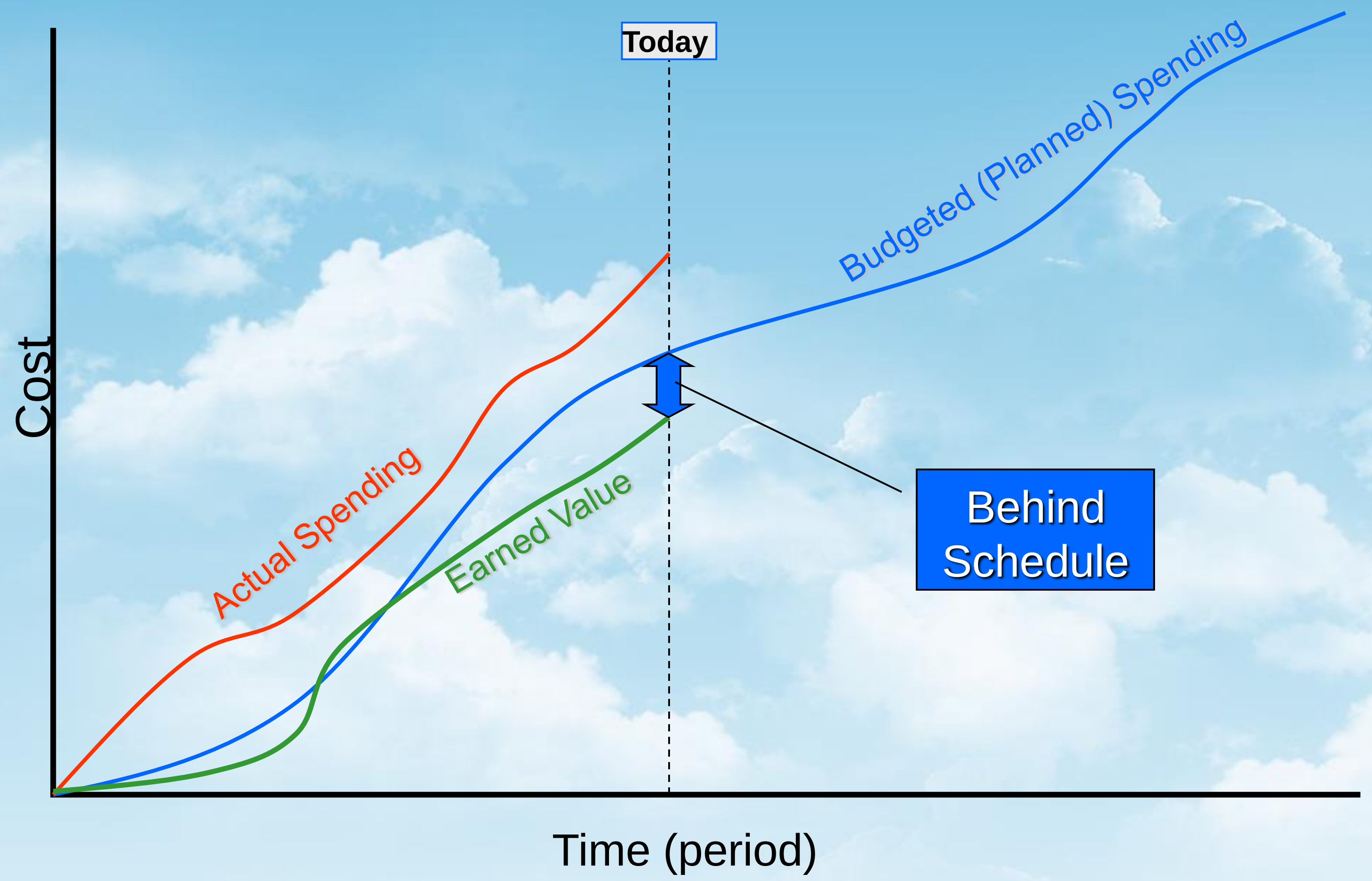


Pm (Performance measurement)

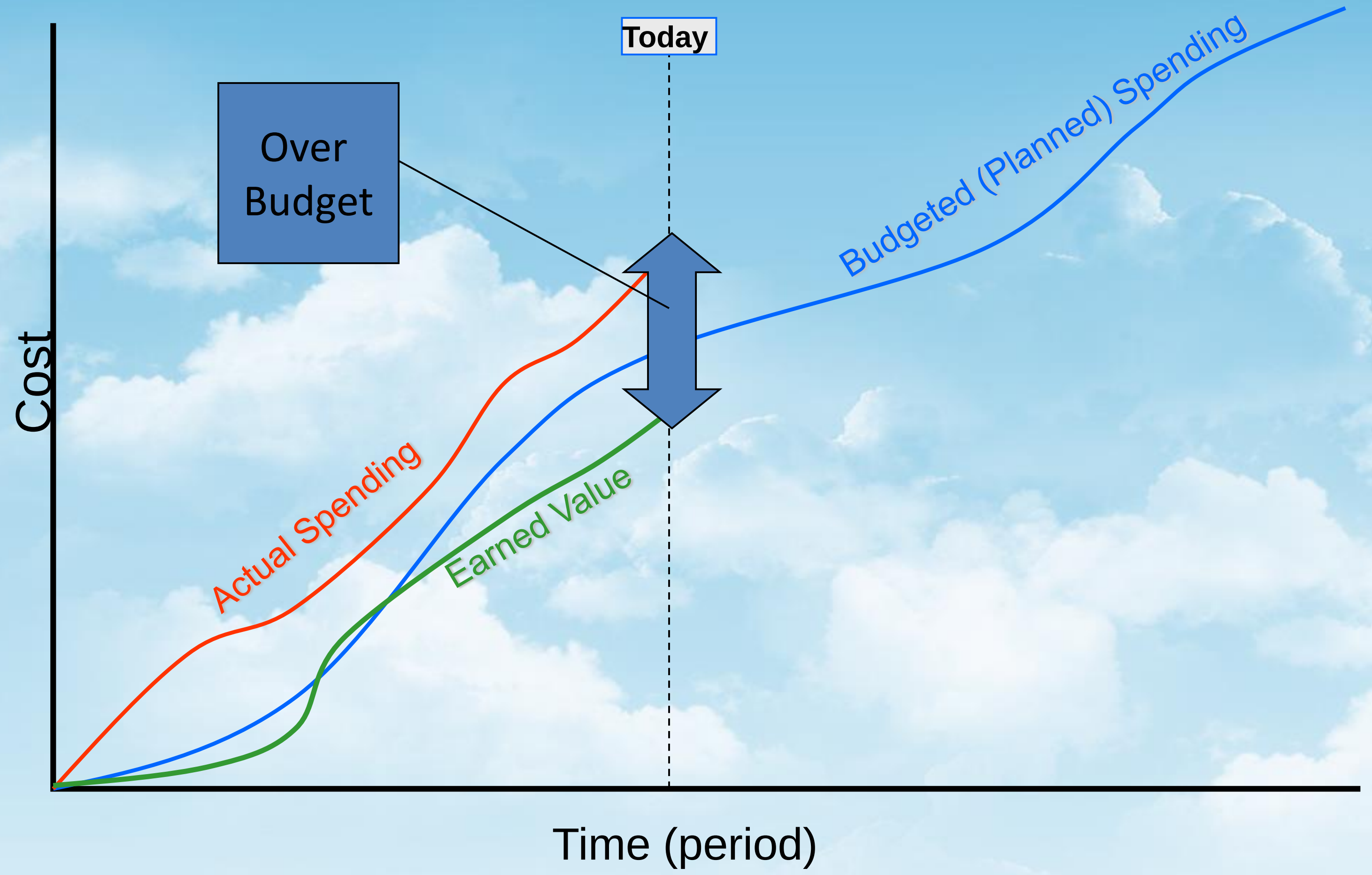
Earned Value: Example



Earned Value: Example



Earned Value: Example



Cost/Schedule Graph

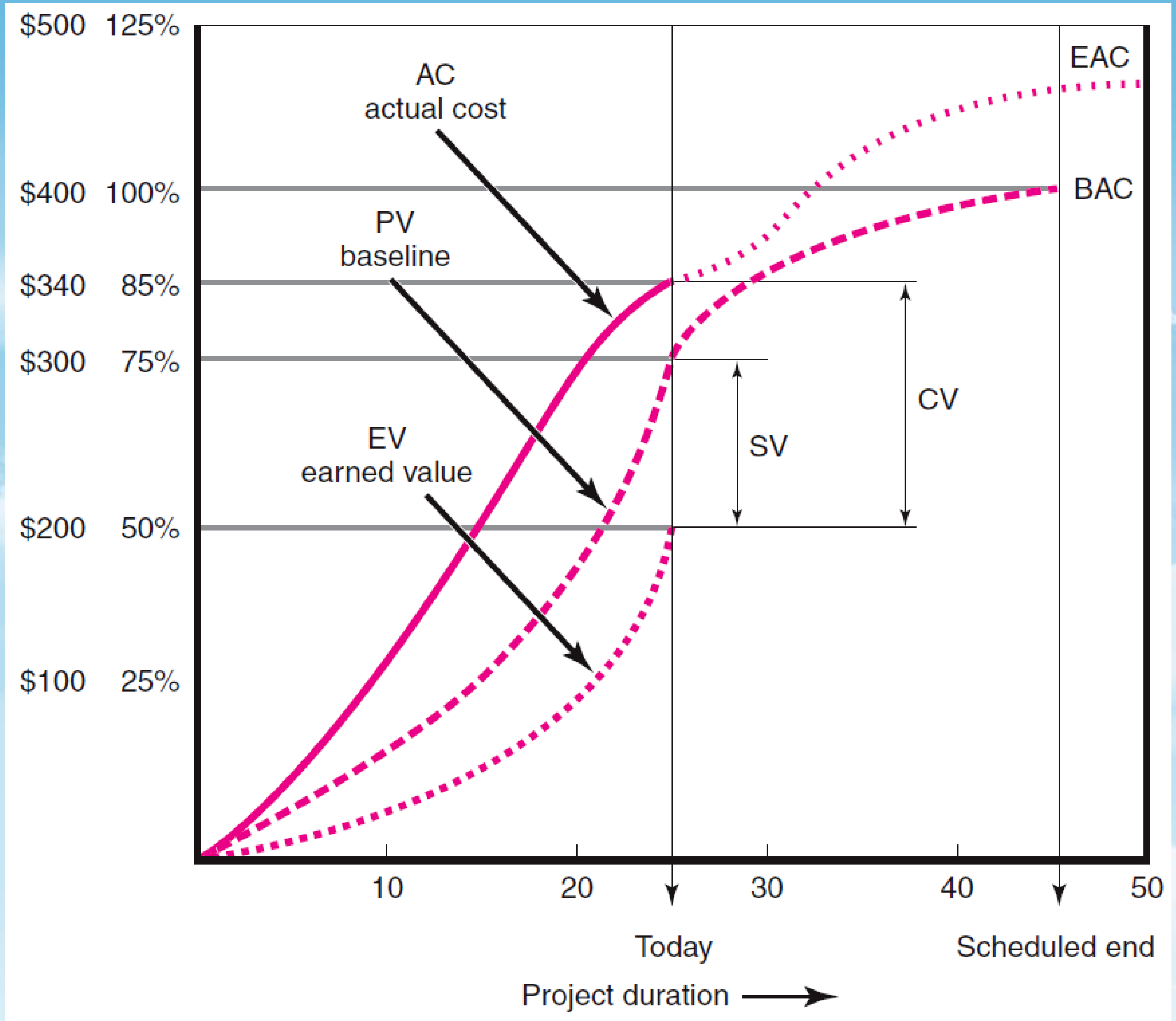


FIGURE 13.4

Earned-Value Review Exercise

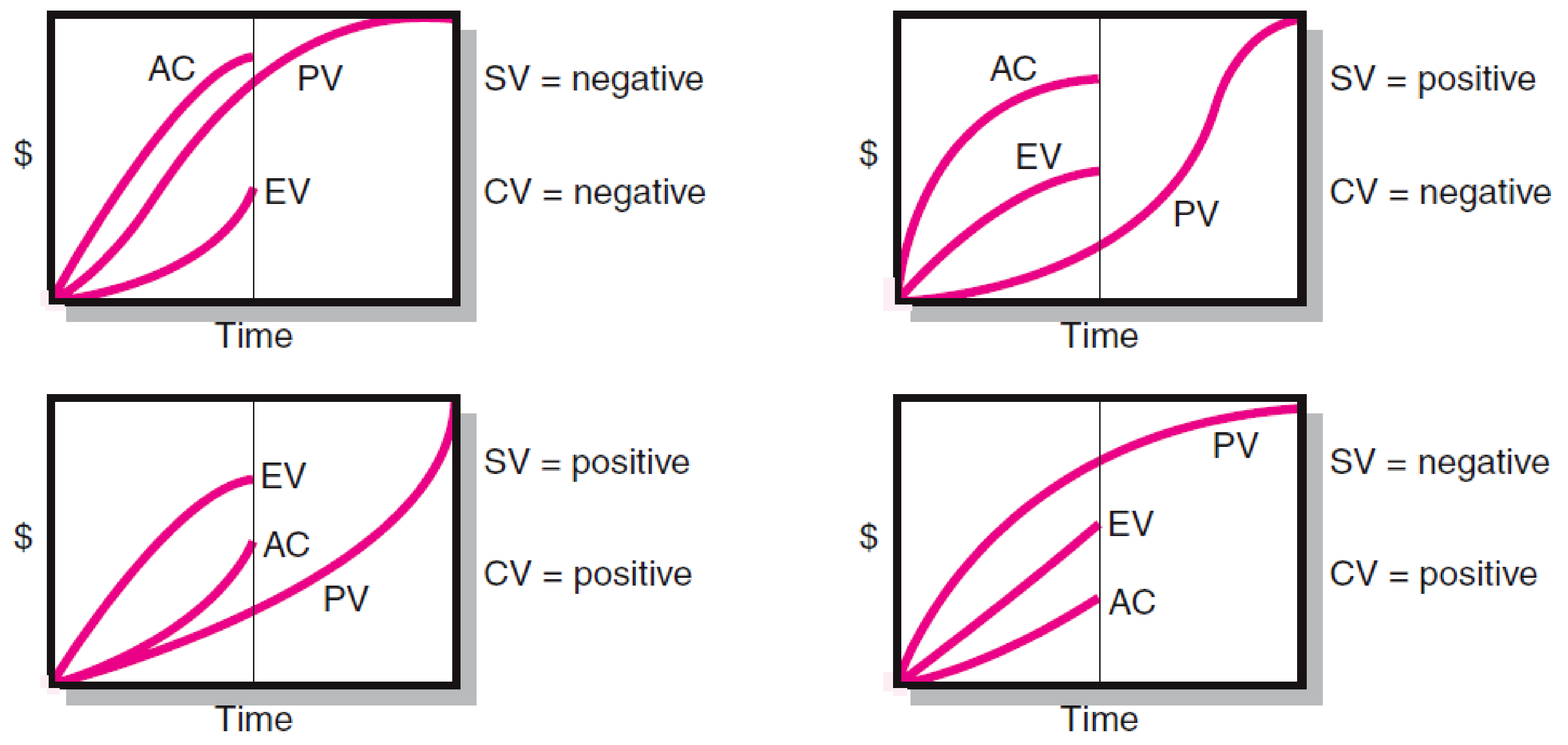


FIGURE 13.5

Indexes to Monitor Progress

- Performance Indexes
  - Cost Performance Index (CPI)
    - Measures the cost efficiency of work accomplished to date.
    - CPI = EV/AC
  - Scheduling Performance Index (SPI)
    - Measures scheduling efficiency
    - SPI = EV/PV
  - Percent Complete Indexes
    - Indicates how much of the work accomplished represents of the total budgeted (BAC) and actual (AC) dollars to date.
    - PCIB = EV/BAC
    - PCIC = AC/EAC

Interpretation of Indexes

Index	Cost (CPI)	Schedule (SPI)
>1.00	Under cost	Ahead of schedule
=1.00	On cost	On schedule
<1.00	Over cost	Behind schedule

TABLE 13.3

Forecasting Model: EAC_f

The equation for this forecasting model:

$$EAC_f = ETC + AC$$

$$EAC = \frac{\text{Work remaining}}{CPI} = \frac{BAC - EV}{EV/AC}$$

where EAC_f = estimated total cost at completion.

ETC = estimated cost to complete remaining work.

AC = cumulative actual cost of work completed to date.

CPI = cumulative cost index to date.

BAC = total budget of the baseline.

EV = cumulative budgeted cost of work completed to date.

Key Terms

Baseline budget
Control chart
Cost performance index (CPI)
Cost variance (CV)
Earned value (EV)
Estimated Cost at Completion—Forecasted (EAC_f)
Estimated Cost at Completion—Revised Estimates (EAC_{re})
Percent complete index—budget costs (PCIB)
Percent complete index—actual costs (PCIC)
Schedule performance index (SPI)
Schedule variance (SV)
Scope creep
To complete performance index (TCPI)
Tracking Gantt chart
Variance at completion (VAC)

Earned Value Concepts

- Planned Value (PV) – planned cost of doing the scheduled work (formerly BCWS)
- Earned Value (EV) – *planned* cost of the work completed (formerly BCWP)
- Actual Cost (AC) – actual cost of the work completed (formerly ACWP)
- Performance Measurement Baseline (PMB) – the time-phased budget plan against which performance is measured

Earned Value Concepts (cont.)

- Schedule Variance (SV) – measures how project is doing relative to the schedule

$$SV = EV - PV$$

Positive → Ahead of Sched., Negative → Behind Sched.

- Cost Variance (CV) – measures how project is performing; productivity measure

$$CV = EV - AC$$

Positive → Efficient, Negative → Inefficient

Earned Value Concepts (cont.)

- Budget Variance (BV) – measures how project is doing against the budget

$$BV = PV - AC$$

Positive → Under Budget, Negative → Over Budget

- Budget At Completion (BAC) – sum of the planned value plus the Undistributed Budget

Earned Value Concepts (cont.)

- Schedule Performance Index (SPI) – measure of schedule compliance: is work being done at the planned rate?

$$SPI = EV/PV$$

<1 ➔ Slower than planned, >1 ➔ Faster than planned

- Cost Performance Index (CPI) – productivity measure: is the work costing what was expected?

$$CPI = EV/AC$$

< 1 ➔Inefficient, > 1 ➔ Efficient

Earned Value Concepts (cont.)

- Estimate To Complete (ETC) – estimate of the effort required to complete the project from the current date

$$ETC = (BAC - EV)/CPI$$

- Estimate At Completion (EAC) – the estimated total cost of the project

$$EAC = AC + ETC$$

Earned Value Concept Summary

Acronym	Definition	Equation	Interpretation
PV	Budgeted cost of task	(none)	
EV	Earned value for task	(none)	
AC	Actual cost of task	(none)	
SV	Schedule Variance	SV=EV - PV	>0 = Ahead, <0 = Behind
BV	Budget Variance	BV=PV - AC	>0 = Under, <0 = Over
CV	Cost Variance	CV=EV - AC	>0 = Productive, <0 = Unproductive
BAC	Budget At Completion	BAC= UB + Σ PV	"UB"=Undistributed Budget
SPI	Schedule Perf. Index	SPI=EV/PV	>1 = Faster, <1 = Slower
CPI	Cost Perf. Index	CPI=EV/AC	>1 = Efficient, < 1 = Inefficient
ETC	Estimate to Complete	ETC=(BAC-EV) /CPI	
EAC	Estimate At Completion	EAC=AC+ETC	
VAC	Variance at Completion	VAC = BAC - EAC	>0 = Under, <0 = Over

Benefits of Earned Value

- *It is a single management control system that provides reliable data. It integrates work, schedule, and cost using a work breakdown structure.*
- The associated database of completed projects is useful for comparative analysis.
- The cumulative cost performance index (CPI) provides an early warning signal.
- *The schedule performance index provides an early warning signal.*

(Christensen, David S., "The Costs and Benefits of the Earned Value Management Process," Acquisition review Quarterly, Fall, 1998, p. 373.)

Benefits of Earned Value

- The CPI is a predictor for the final cost of the project.
- It uses an index-based method to forecast the final cost of the project.
- The "to-complete" performance index allows evaluation of the forecasted final cost.
- The periodic (e.g., weekly or monthly) CPI is a benchmark.

(Christensen, David S., "The Costs and Benefits of the Earned Value Management Process," Acquisition Review Quarterly, Fall, 1998, p. 373.)