AAiT

School of Civil and Environmental Engineering

Engineering Economics (CEng 5211)

Chapter 1: Basic Concepts of Engineering Economics

Content

Basic Concepts of Engineering Economics

- Introduction
- Engineering economics decisions
- Understanding financial statements

Basic Concepts of Engineering Economics

- The process of producing goods and services requires the use of resources such as labor, raw materials, capital, equipment, machines, etc.
- Making choices is necessary because everything we want might not be available.
- Economics deal with a certain problem faced by all societies i.e., the problem of Scarcity.

*"**Scarcity**: the excess of human needs over what can actually be produced."*

- Economics is the study of choices in the face of scarcity of resources.

Why is scarcity a problem?

- If we know that we have limited resources we could just behave accordingly. The problem arises because human wants and needs are virtually unlimited but **resources available to satisfy them are not**.
- Scarcity implies that we face some sort of constraints every time we take an economic decision.
- The presence of constraints has the main implication of creating **trade-offs** among different alternatives. The concept of trade-off is one of the core principles in economics.
- Economics is the study of choices under conditions of scarcity, or the study of choice with constraints.

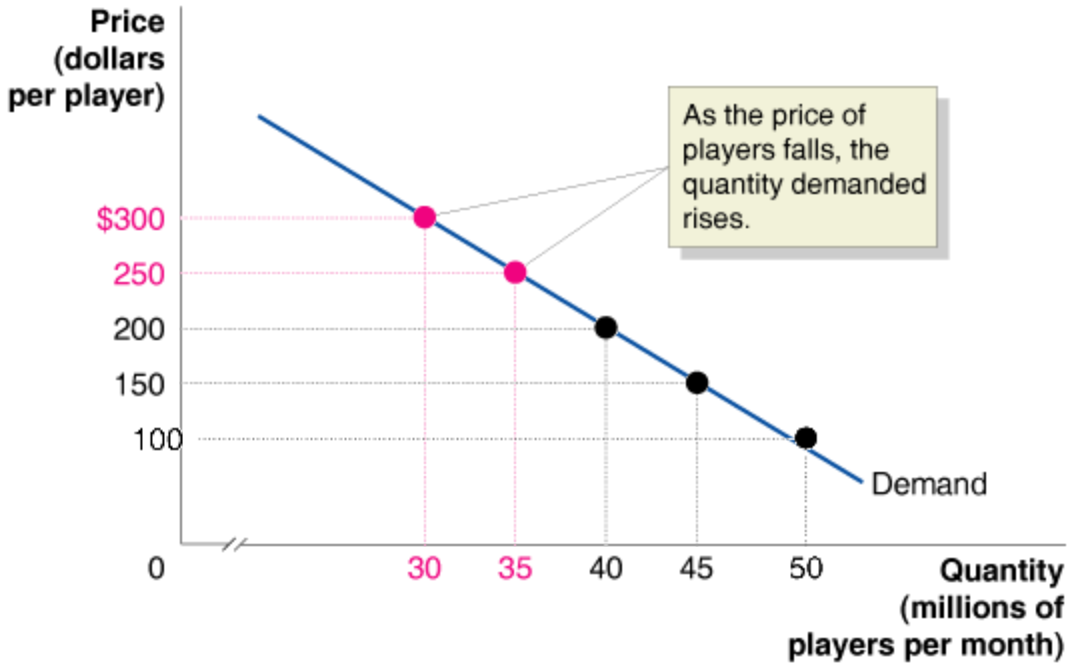
- Trade-off: The idea that because of scarcity, producing more of one good or service means producing less of another good or service.

  Trade-offs force society to make choices.

- Trade-offs forces engineers to make choices, particularly when answering the following fundamental questions:
  - Which engineering projects are worthwhile?
  - Which engineering projects should have a higher priority?
  - How should the engineering project be designed?
- As summarized by the concept of trade-off, any choice, made when resources are scarce, involves some sacrifice.
- The opportunity cost expresses "the basic relationship between scarcity and choice".

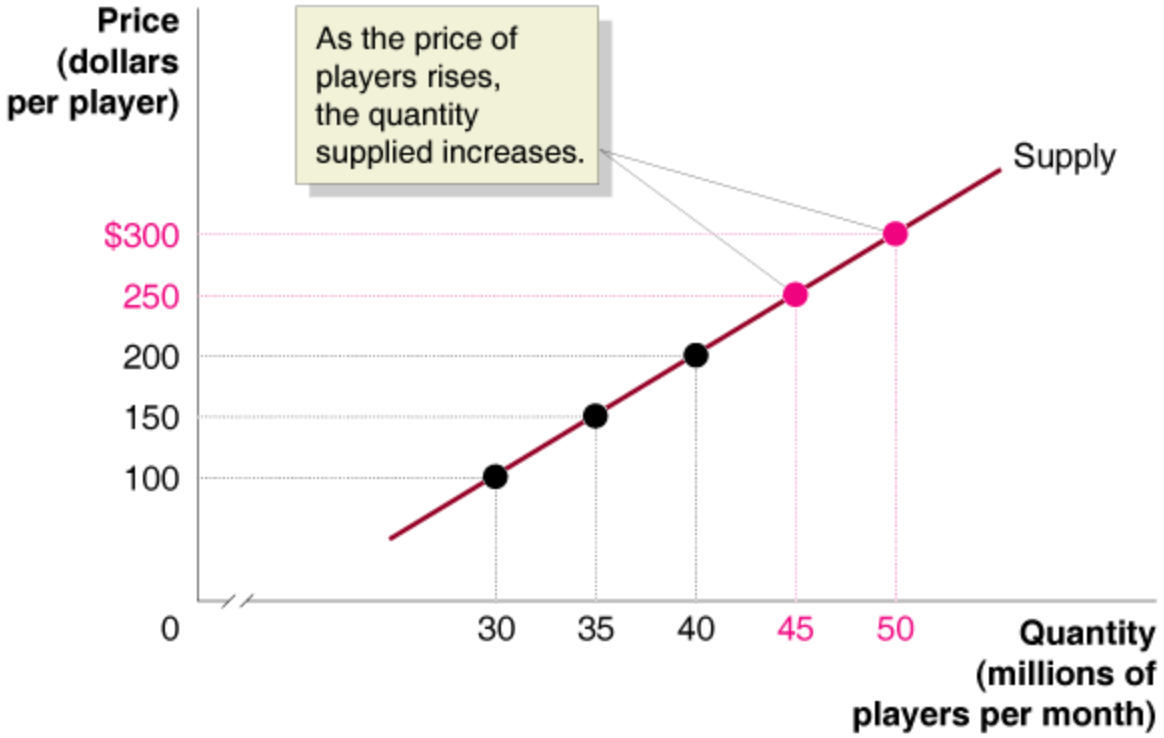
- **Law of demand**: The rule that, holding everything else constant, when the price of a product falls, the quantity demanded of the product will increase, and when the price of a product rises, the quantity demanded of the product will decrease.

Demand Schedule	
Price (dollars per player)	Quantity (millions of players per month)
$300	30
250	35
200	40
150	45
100	50

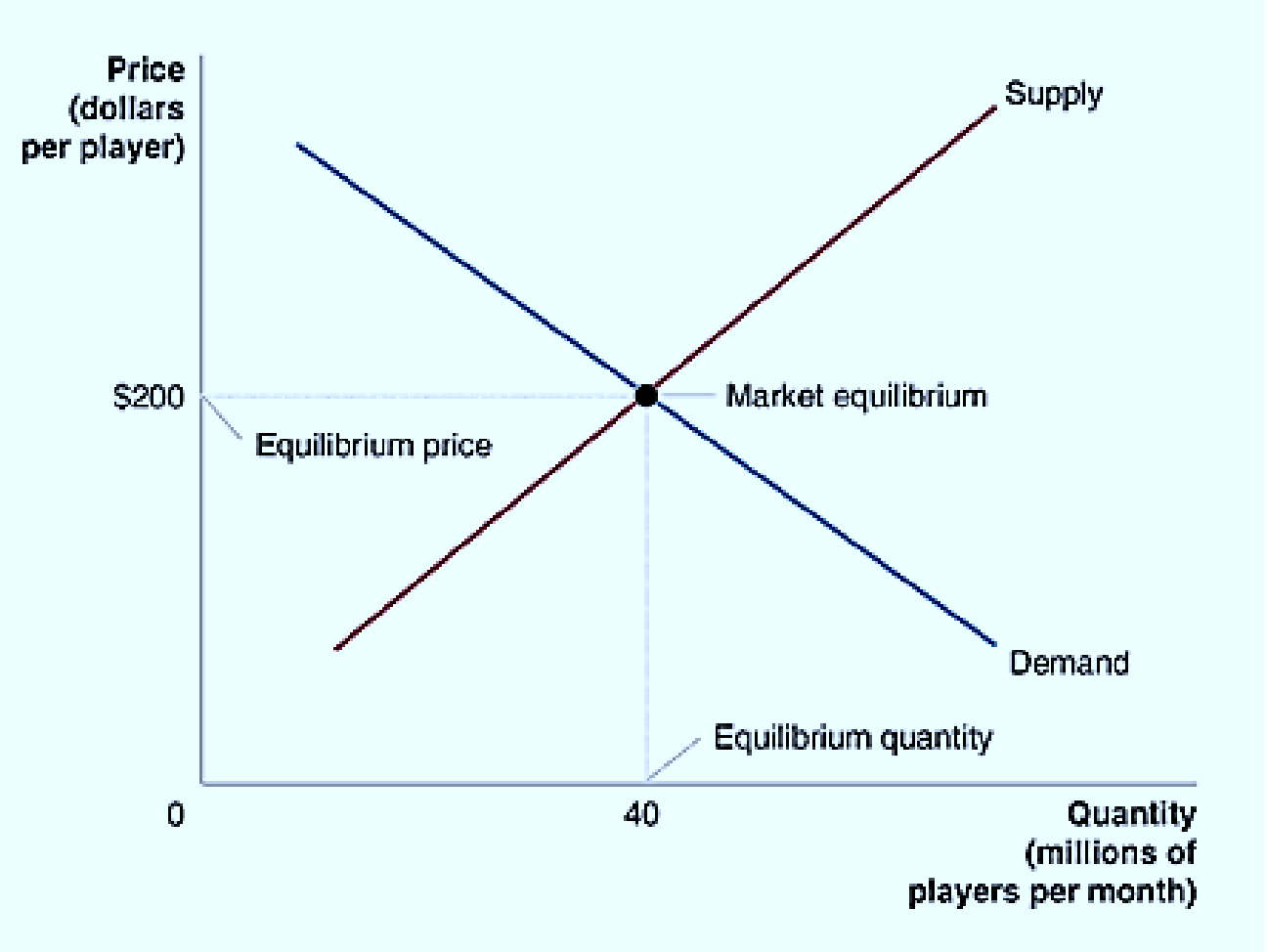


- **Law of supply**: The rule that, holding everything else constant, increases in price cause increases in the quantity supplied, and decreases in price cause decreases in the quantity supplied.

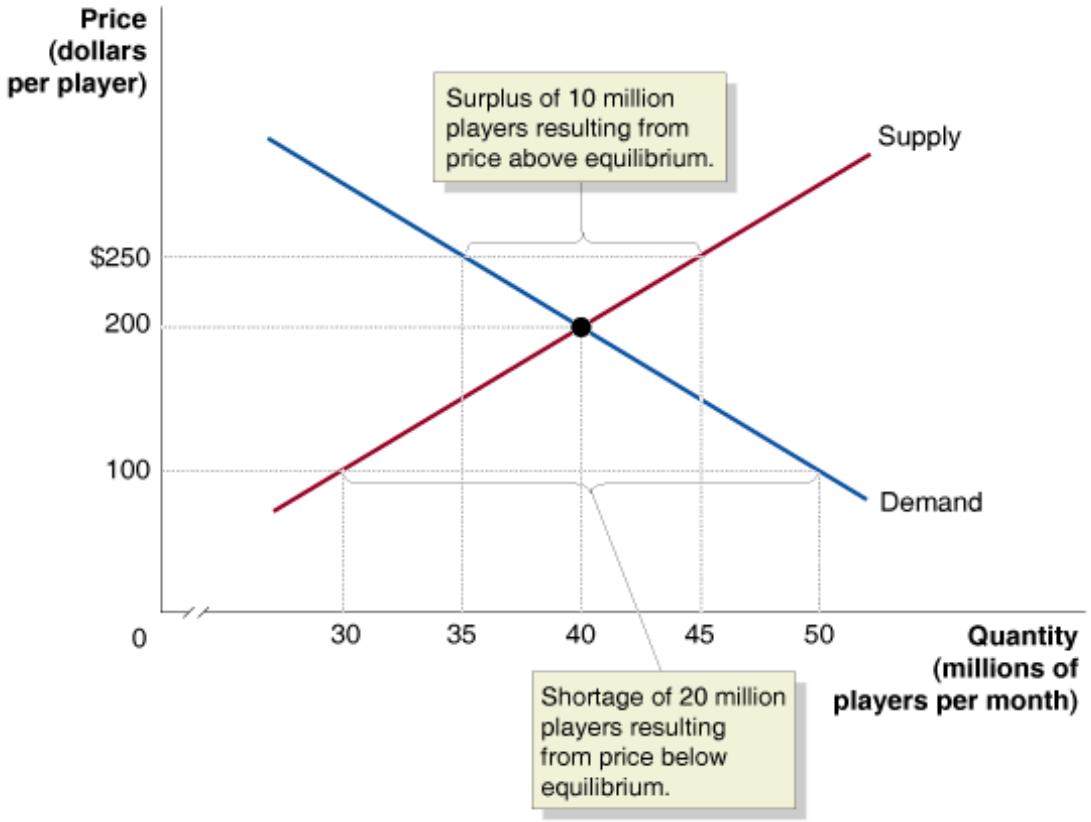
Supply Schedule	
Price (dollars per player)	Quantity (millions of players per month)
$300	50
250	45
200	40
150	35
100	30



- **Market equilibrium**: A situation in which quantity demanded equals quantity supplied.



- **Surplus:** A situation in which the quantity supplied is greater than the quantity demanded.
- **Shortage:** A situation in which the quantity demanded is greater than the quantity supplied.



- Economic decision making for engineering systems is called **engineering economy**.
- Engineering economy is a collection of techniques that simplify comparisons of alternatives on an economic basis.
- The purpose of engineering economy is to expose us to the methods which are widely used for evaluation of alternative projects.
- The principles and methodology of engineering economy are utilized to analyze alternative uses of financial resources, particularly in relation to the physical assets and the operation of an organization.
- **Alternatives**: Options or uses of resources.

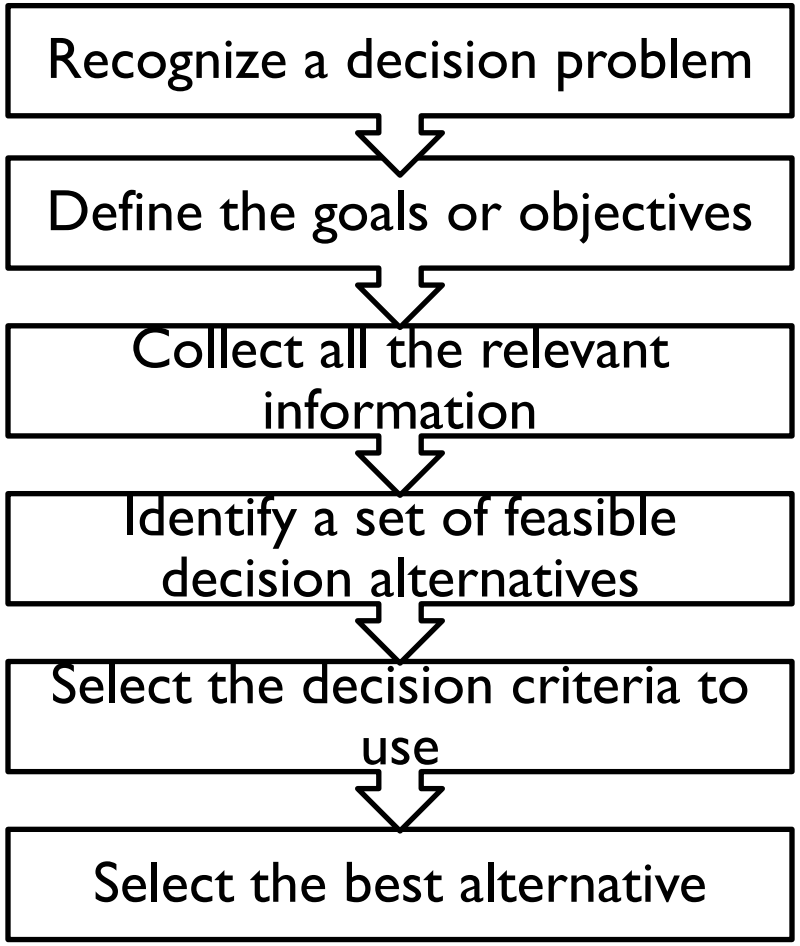
Economics

- The study of how limited resources are used to satisfy unlimited human wants.
- The study of how people, institutions, and society make economic choices under conditions of scarcity.

Engineering Economics

- It is a subset of economics that deals with the analysis and evaluation of the factors that will affect the economic success of engineering projects to the end that a recommendation can be made which will ensure the best use of capital.
- It is the application of economic techniques to the evaluation of design and engineering alternatives.
- It deals with the concepts and techniques of analysis useful in evaluating the worth of systems, products, and services in relation to their costs.

Rational Decision-Making Process



- Need a car
- Want mechanical security
- Gather technical as well as financial data
- Choose between Saturn and Honda
- Want minimum total cash outlay
- Select Honda

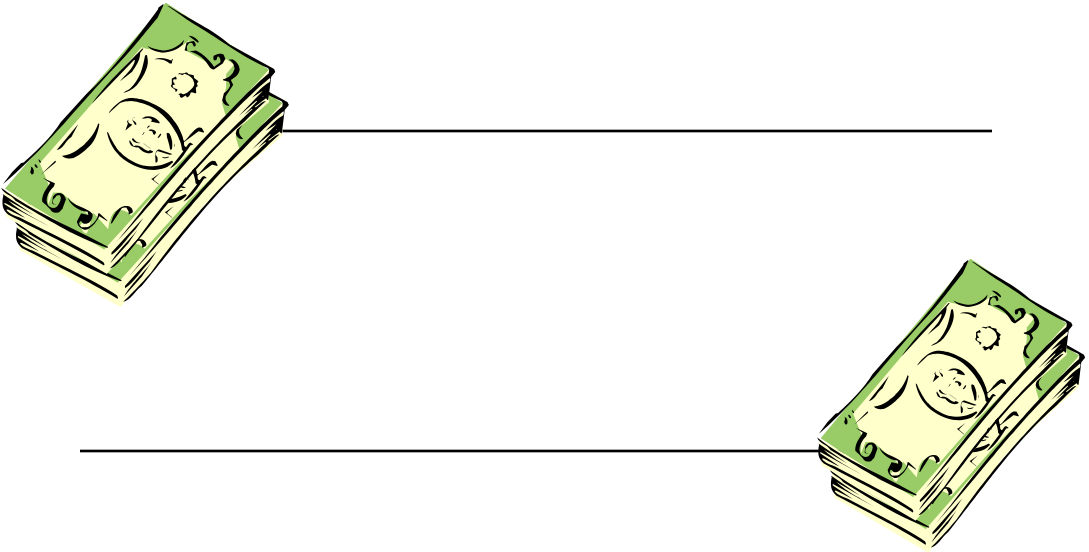
FUNDAMENTAL PRINCIPLES OF ENGINEERING ECONOMICS

- **Principle 1**: A nearby dollar is worth more than a distant dollar
- **Principle 2**: All it counts is the differences among alternatives
- **Principle 3**: Marginal revenue must exceed marginal cost
- **Principle 4**: Additional risk is not taken without the expected additional return

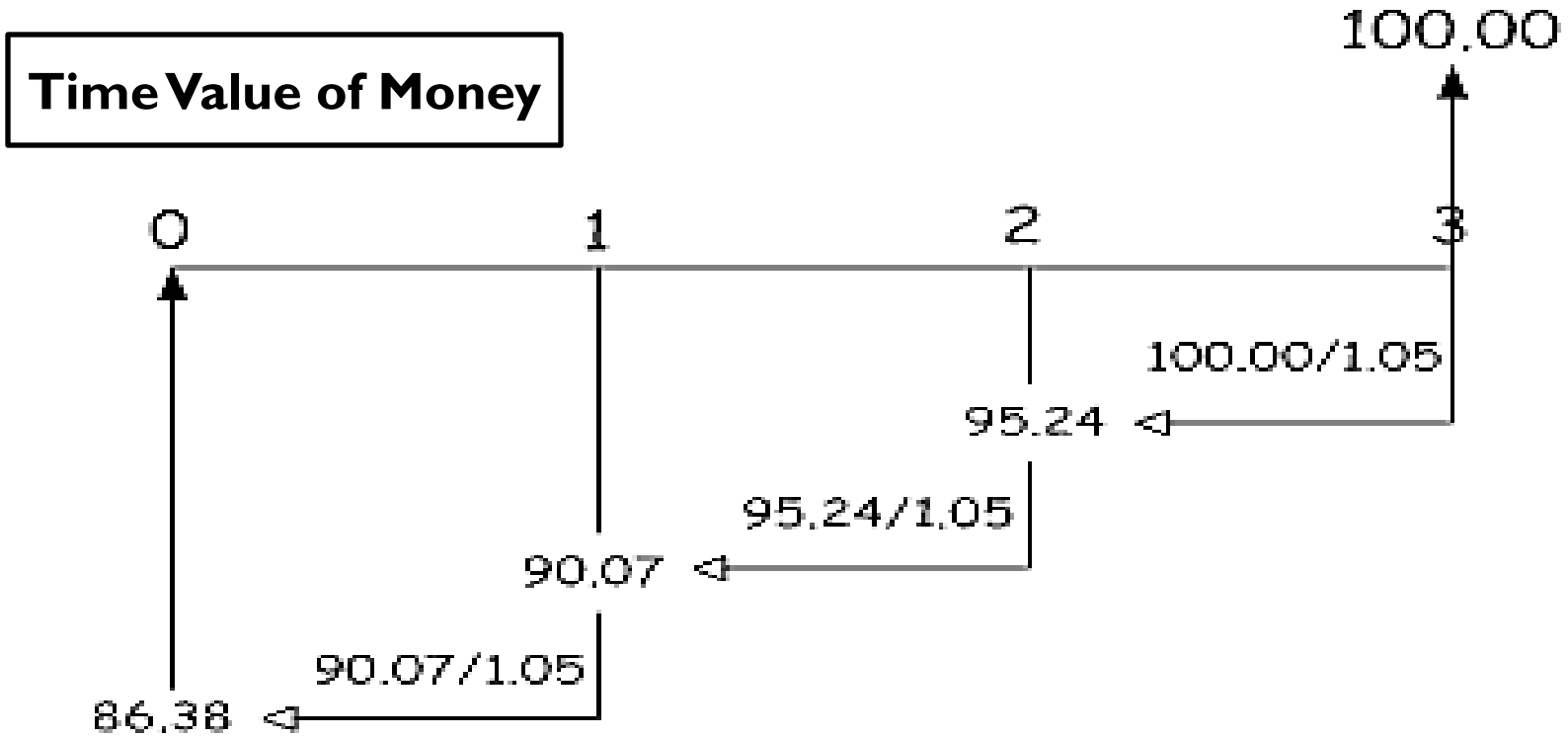
PRINCIPLE 1:

A nearby penny is worth a distant dollar

- A fundamental concept in engineering economics is that money has a time value associated with it.
- **Money has a time value?---Reading Assignment**
- It is better to receive money earlier than later.



- If you receive 100 ETB now, you can invest it and have more money available six months from now.
- This concept will be the basic foundation for all engineering project evaluation.


Time Value of Money
100.00
0
1
2
3
100.00/1.05
95.24
95.24/1.05
90.07
90.07/1.05
86.38

PRINCIPLE 2:

All that counts are the differences among alternatives.

- An economic decision should be based on the differences among the alternatives considered.
- All that is common is irrelevant to the decision.

Option	Monthly Fuel Cost	Monthly Maintenance	Cash Outlay at Signing	Monthly Payment	Salvage Value at the End of Year 3
Buy	$960	$550	$6,500	$350	$9,000
Lease	$960	$550	$2,400	$550	0

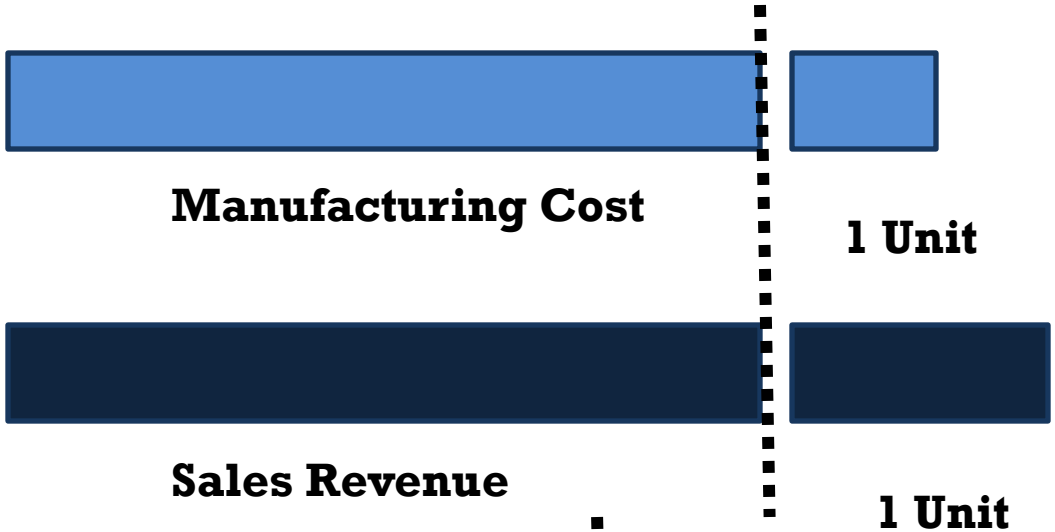
Irrelevant items in decision making

Differential (Incremental) Analysis: **difference in total cost that results from selecting one alternative instead of the other.**

PRINCIPLE 3:

Marginal Revenue must exceed Marginal Cost.

- Each decision alternative must be justified on its own economic merits before being compared with other alternatives.
- **Marginal revenue** means the **additional revenue made possible by increasing the activity by one unit.**
- **Marginal cost** means that productive resources like natural resources, human resources, capital goods available to make goods and services are *limited*. Therefore, people can not have all the goods and services they want.
- As a result, they must choose some things and give up others.



Marginal Cost

Marginal Revenue

Cost of Goods Sold	$2 per unit
Gross Revenue	$4 per unit

Marginal Analysis: ensures that Marginal Revenue>Marginal Cost

PRINCIPLE 4:

Additional Risk is not taken without the Expected Additional Return.

- Investors demand a minimum return that must be greater than the anticipated rate of inflation or any perceived risk.
- Expected returns from bonds and stocks are normally higher than the expected return from a savings account.

Investment Class	Potential Risk	Expected Return
Savings account (Cash)	Low/None	1.5%
Bond (Debt)	Moderate	4.8%
Stock (Equity)	High	11.5%

Risk and Return Trade Off

Types of Strategic Engineering Economic Decisions

1. Equipment & process selection	• Selecting the best course of action from various alternatives to get best returns
2. Equipment replacement	• Decision involves considering the expenditure necessary to replace worn-out or obsolete equipments

3. New product & product expansion	• To increase the revenue
	• Two common types:
	  • Through existing production/ distribution,
	  • Through new product or expand to a new geographical area

Types of Strategic Engineering Economic Decisions

4. Cost Reduction

- Attempts to lower operating costs of the company
- Whether a company should buy equipment to perform an operation currently done manually or spend money now in order to save more money later

5. Service improvement

- To improve of the quality of products/ services

- **Accounting Vs Engineering Economics**

Evaluating past performance

Accounting

Evaluating and predicting future events

Engineering Economy

Past | *Future*

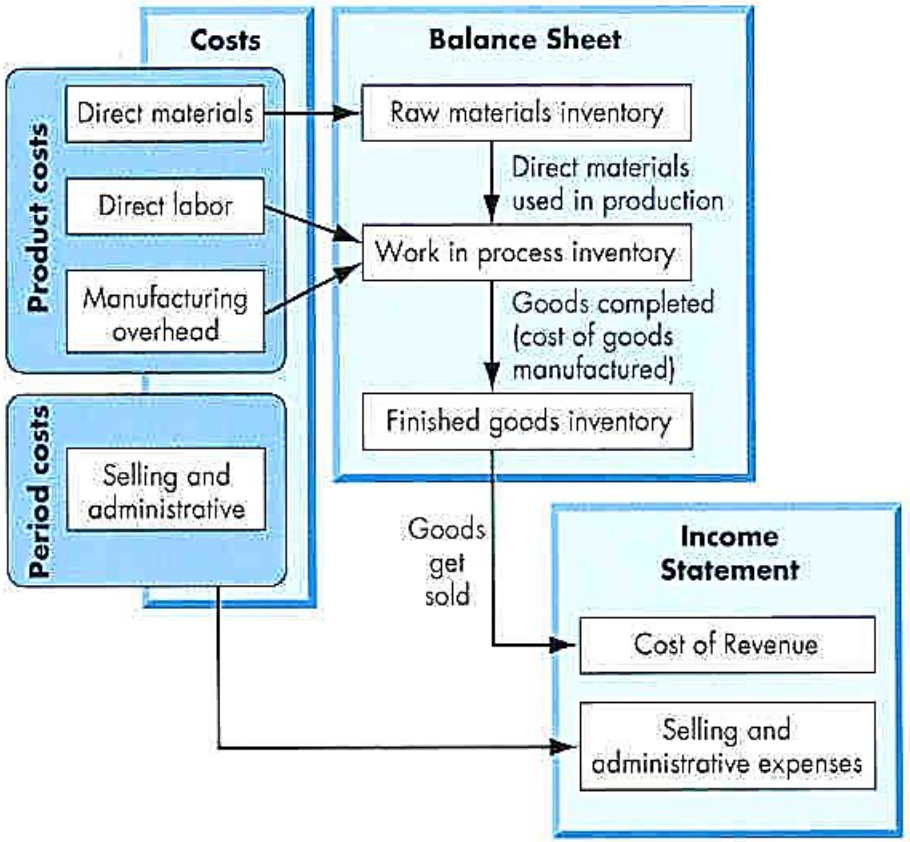
Present

General Cost Terms

Cost of revenue = Cost of goods sold

- Raw materials inventory
- Work-in-process inventory
- Finished goods inventory

- **Construction Costs**
  - **Direct Cost**
  - **Indirect labor**
  - **Overhead**



Cost Classification of Cost Relevant to Decision-Making

- **Classification of cost:**

RELEVANT TO DECISION-MAKING	FINANCIAL STATEMENTS	PREDICTING COST BEHAVIOR
- Differential costs - Marginal costs - Sunk costs - Opportunity costs	- Balance statement - Income statement - Cash flow statement	- Fixed cost - Variable cost

Cost Classification of Cost Relevant to Decision-Making

- **Differential cost:** difference in costs between any two alternatives.
- **Differential revenue:** difference in revenues between any two alternatives.

Current/Adopting: new production method	Current Dies	Better Dies	Differential Cost
Variable costs:			
Materials	$150,000	$170,000	$20,000
Machining labor	85,000	64,000	-21,000
Electricity	73,000	66,000	-7,000
Fixed costs:			
Supervision	25,000	25,000	0
Taxes	16,000	16,000	0
Depreciation	40,000	43,000	3,000
Total	$392,000	$387,000	-$5,000

Make or Buy Decision	Make Option	Buy Option	Differential Cost
Variable cost			
Direct materials	$100,000		-$100,000
Direct labor	190,000		-190,000
Power and water	35,000		-35,000
Gas filter		340,000	340,000
Fixed costs			
Heating light	20,000	20,000	0
Depreciation	100,000	100,000	0
Rental income		-35,000	-35,000
Total cost	$445,000	$425,000	-$20,000
Unit cost	$22.25	$21.25	-$1.00

Cost Classification of Cost Relevant to Decision-Making

- **Marginal costs:** is the variable for one more unit.
- **Sunk costs:** is the money already spent as a result of past decision. Disregarded in economic analysis because current decisions cannot change the past (Not relevant for future decisions.)

Example: money spent to buy a new machine last year.

Cost Classification of Cost Relevant to Decision-Making

- **Opportunity costs:** The potential benefit that is given up as an alternative course of action is chosen.
- The benefit that is forgone by engaging a resource in a chosen activity instead of engaging that same resource in the forgone activity. Is the best or next highest ranked alternative foregone because of choosing the given action.
- Could also be considered as a **forgone opportunity cost**: because we are giving up the benefit that could have been realized.

  Example: Choosing to use a resource for one activity we are giving up the opportunity of using the same resource at that time in some other activity.
- Economists use the term opportunity cost to highlight the fact that making choices in the face of scarcity implies a cost (exactly related to the concept of trade-off).

Classification for Predicating Cost Behaviors

- **Fixed Cost:** The costs of providing a company's basic operating capacity.
- company's fixed cost does not vary with the volume of production. It remains the same even if no goods or services are produced, and therefore, cannot be avoided.

  Cost behavior: Remain constant over the time though volume may change.

  Is constant or unchanging regardless of the level of output or activity.

  Example: Annual insurance premium, property tax, and license fee, building rents, depreciation of buildings, salaries of administrative and production personnel.

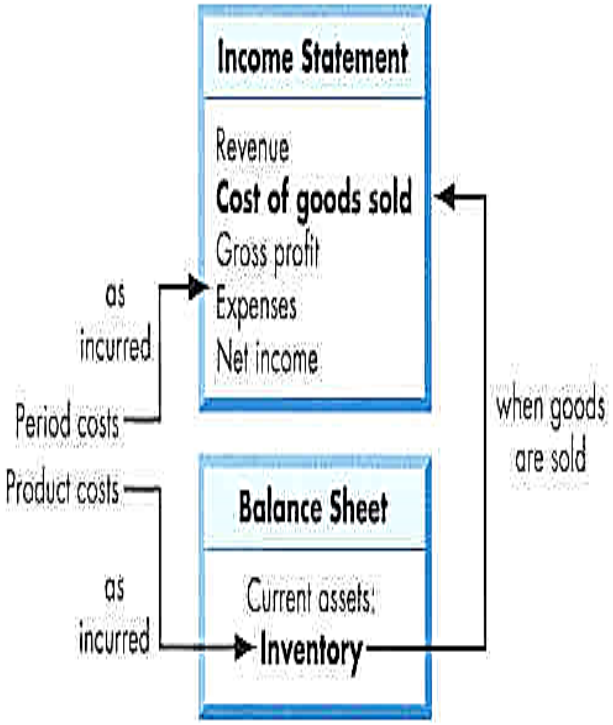
- **Variable Cost:** is a company's cost that is associated with the amount of goods or services it produces. A company's variable cost increases and decreases with its production volume.

  Cost behavior: Increase or decrease according to the level of production.

  Example: Production of ceramic tiles.

Classification for Financial Statement

- **Matching Concept:** states that the **costs incurred** to generate **particular revenue** should be **recognized as expenses** in the same period that the revenue is recognized.
- **Period costs**: Those costs that are charged to expenses in the time period basis (advertising, executive salaries, sales commissions, public relations, other non manufacturing costs).
- **Product costs**: Those costs that are involved in the purchase or manufacturing of goods. Since product costs are assigned to inventories, known as inventory costs. (all costs related to manufacturing process).



How the period costs and product costs flow through financial statement

Financial Statement

Net Worth: is a statement that "shows where one stands financially at a give point in time." At time of asking financial support from financial institutions: Determine how credit worthy you are by examining the net worth.

- It is used:
  - Financial planning and Report Financial Health of a corporation: an information presented to investors
  - By lender: to see borrower's ability to meet scheduled payments.
- Includes future projection and revenue: based on accounting information.

Net worth= Asset + Liabilities

Cash Investment Stocks	Debts

- NW means what you would be left with if you sold everything and paid off what you owe.

Financial Statement or Report

- Annual report is the most important report issued by organizations and contains financial statement and future prospects.
- What would one want to know about the company at the end of the fiscal year?

- **What is the company's financial position at the end of the reporting period?**	**Balance sheet statement**
- **How much profit was made during the reporting period?**	**Income statement**
- **How much cash was generated & spent?**	**Statement of cash flow**
- **Where was decided to use the profit?**	**Statement of retained earning**

- **Note:** Fiscal year/Operation cycle: can be any 12 month term, but usually from Jan 1-Decem 31 of a calendar year.

Balance Sheet

"….where one stands financially…"

- It lists the assets, liabilities, and equity of a business entity on a specified date. Makes use of the "Accounting Equation"- The equality between the assets and the claims against the assets is always maintained.

Asset = Liability + Equity

- Resources are **balanced** by the source of funding, hence the name 'Balanced Sheet'.
- **Liabilities and equity are understood as claim against assets and indicate sources of fund to acquire assets and operate the business.**
- These three balance sheet segments give investors an idea as to what the company owns and owes, as well as the amount invested by shareholders.

Balance Sheet Statement

1. Asset: how much the company owns at the time of reporting. Based on liquidity and the time required to convert into cash asset is divided into current assets and long term asset .

a. Current Asset: can be converted into cash in less than one year.

- Cash and its equivalent: short-term certificates of deposit, as well as hard currency.
- Account receivable: money which customers owe the company (Owned but not received yet)
- Inventories: investment on raw material, work-in-progress, goods available for sale.
- Prepaid expenses: representing value that has already been paid for, such as insurance, rent…

b. Long Term Asset: relatively permanent and take time to converted into cash.

- Fixed assets: these include land, machinery, equipment, buildings and other durable, generally capital-intensive assets

Balance Sheet Statement

b. Long Term Asset: relatively permanent and take time to converted into cash.

- Long-term investments: securities that will not or cannot be liquidated in the next year
- Intangible assets: these include non-physical, but still valuable, assets such as goodwill. Are only listed on the balance sheet if they are acquired.

2. Liability: money that a company owes to outside parties, from bills it has to pay to suppliers to utilities and salaries.

a. Current liability: that is due within one year and are listed in order of their due date.

- Short term debt
- Interest payable
- Wages payable
- Dividends payable and other

Balance Sheet Statement

b. Long-term liability: money the company owes and is due at any point after one year.

- Long-term debt

3. Owners'/ Shareholders'/ Stockholder Equity: portion of the assets of a company which are provided by the investors (owners). It is the liabilities of the company to the owner.

- Retained earnings: are the net earnings a company either reinvests in the business or uses to pay off debt; the rest is distributed to shareholders in the form of dividends.

Balance Sheet Statement

EXHIBIT A.2 Balance sheet for Engineered Buildings, Inc., December 31, 20xx (all amounts in $1000)

Assets		**Liabilities**	
Current assets		Current liabilities	
Cash (money market)	850	Accounts payable	765
Accounts receivable	2380	Notes payable	850
(*minus*) Bad debt provision	−95	Accrued expense	425
Inventories	1105	Total current liabilities	2040
Total current assets	4240		
		Long-term debt	2380
Fixed assets			
Land	340	**Total Liabilities**	**4420**
Plant and equipment	2805		
(*minus*) Accumulated depr.	−1700	**Equity**	
Total fixed assets	1445		
		Common stock	1200
Other assets		Capital surplus	420
Prepays/deferred charges	510	Retained earnings	410
Intangibles	255	Total equity	2030
Total other assets	765		
Total Assets	**6450**	**Total Liabilities and Equity**	**6450**

Balance Sheet Statement

PRUFROCK CORPORATION 2008 and 2009 Balance Sheets ($ in millions)	
	2008
Assets	
Current assets	
Cash	$ 84
Accounts receivable	165
Inventory	393
Total	$ 642
Fixed assets	
Net plant and equipment	$2,731
Total assets	$3,373
Liabilities and Owners' Equity	
Current liabilities	
Accounts payable	$ 312
Notes payable	231
Total	$ 543
Long-term debt	$ 531
Owners' equity	
Common stock and paid-in surplus	$ 500
Retained earnings	1,799
Total	$2,299
Total liabilities and owners' equity	$3,373

Income Statement/ Profit and Loss Statement

- It is a financial statement that reports a company's financial performance over a specific accounting period.
- Summarizes the revenue and expenses over the month, quarter, or year.
- It is possible to evaluate revenues, and expenses that occur in the interval between consecutive balance sheet statement.
- Unlike the balance sheet, which covers one moment in time, the income statement provides performance information about a time period.

  Net Profit (Loss) = Revenue-Expense

Income Statement/ Profit and Loss Statement

Example

PRUFROCK CORPORATION 2009 Income Statement ($ in millions)		
Sales		$2,311
Cost of goods sold		1,344
Depreciation		276
Earnings before interest and taxes		$ 691
Interest paid		141
Taxable income		$ 550
Taxes (34%)		187
Net income		$ 363
Dividends	$121	
Addition to retained earnings	242	

Income statement for Engineered Buildings, Inc.
December 31, 20xx (all amounts in $1000)

Operating Revenues		
Sales		8075
(*minus*) Returns and allowances		−85
Total Operating Revenues		**7990**
Operating Expenses		
Cost of goods and services sold		4760
Gross profit		3230
Marketing, general, and addminstrative		2040
Depreciation		340
Total operating expense		**7140**
Total operating income		**850**
Nonoperating Revenues and Expenses		
Interest receipts		51
Interest payments		−258
Total nonoperating income		**−207**
Net Income Before Taxes		**643**
Income Taxes		−225
Net Profit (Loss) for Year 20xx		**418**

Cash Flow Statement

- It is a financial report that provides aggregate data regarding all cash inflows a company receives as well as all cash outflows during a given quarter. (cash inflows: ongoing operations and external investment sources; cash outflows: payment for business activities and investments during a given quarter.)
- It includes cash flows from operations, investment, and financing.
- Cash flows from operations starts with net income and then reconciles all noncash items to cash items within business operations. Includes accounts payable, depreciation.
- Cash flows from investing activities includes cash spent on property, plant and equipment.
- Cash flows from financing is the section that provides an overview of cash used in business financing.

Income Statement/ Profit and Loss Statement

Example

PRUFROCK CORPORATION 2009 Statement of Cash Flows ($ in millions)	
Cash, beginning of year	$ 84
Operating activity	
Net income	$363
Plus:	
Depreciation	276
Increase in accounts payable	32
Less:	
Increase in accounts receivable	– 23
Increase in inventory	– 29
Net cash from operating activity	$619
Investment activity	
Fixed asset acquisitions	–$425
Net cash from investment activity	–$425
Financing activity	
Decrease in notes payable	–$ 35
Decrease in long-term debt	– 74
Dividends paid	– 121
Increase in common stock	50
Net cash from financing activity	–$180
Net increase in cash	$ 14
Cash, end of year	$ 98

Summarizing Remark

- Engineers design and create
- Designing involves economic decisions
- Engineers must be able to incorporate economic analysis into their creative efforts
- Often engineers must select and implement from multiple alternatives
- Understanding and applying time value of money, economic equivalence, and cost estimation are vital for engineers
- A proper economic analysis for selection and execution is a fundamental task of engineering


THE BIRTH OF FREE MARKET ECONOMICS
I WISH I HAD A ROCK.
I WISH I HAD A STICK.

Questions ?