



University of Engineering and  
Technology, Peshawar

# Engineering Economics

CSE-305

(Chapter 02)



## Costs Concepts And The Economic Environment

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# Agenda

- Understanding Different Cost Terminologies
- The General Economic Environment
  - Consumer and Producer Goods and Services
  - Necessities, Luxuries and Price Demand
  - Cost, Volume and Breakeven Point
  - Total Revenue Function
  - Measures of Economic Worth
  - Competition, Monopoly and Oligopoly
  - Average Unit Cost Function
- Present Economy Studies and Applications





# Cost Terminology

- When accomplishing Engineering Economy studies and communicating results, it is important to use consistent definitions for cost terms
- Otherwise, common understanding is jeopardized
- The definitions for selected terms will help achieve the goal
- Such as:
  - **Fixed Costs/ Variable Costs,**
  - **Recurring/ Non-Recurring Costs,**
  - **Incremental/ Non-Incremental Costs,**
  - **Direct/ Indirect Costs etc**





# Cost Terminology

## Fixed Costs:

- **Fixed costs** are costs that are independent of output. These remain constant throughout the relevant range and are usually considered sunk for the relevant range (not relevant to output decisions). **Fixed costs** often include rent, buildings, machinery, salaries or monthly rental fees.



## Variable Costs:

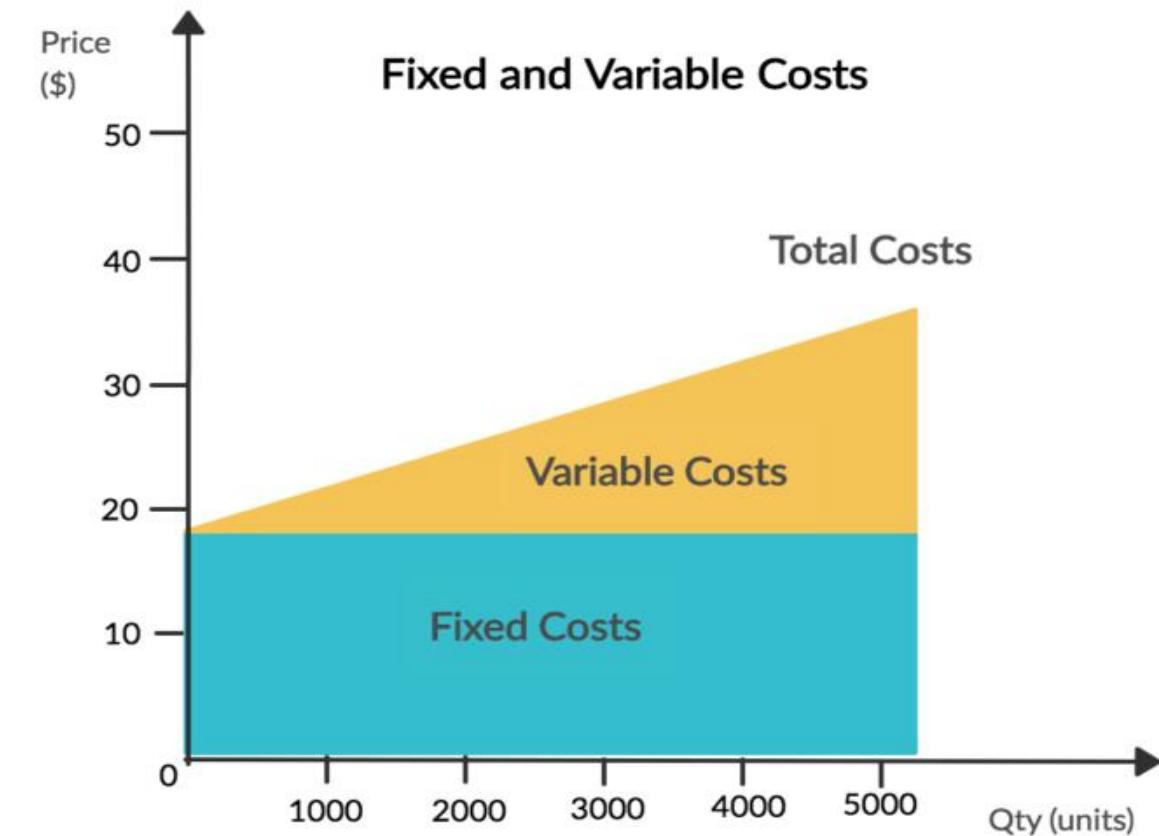
- **Variable costs** are costs that vary with output. Generally **variable costs** increase at a constant rate relative to labor and capital. **Variable costs** may include wages, utilities, materials used in production, etc.
- In accounting they also often refer to mixed costs. These are simply costs that are part fixed and part variable. An example could be electricity, since electricity usage may increase with production but if nothing is produced a factory still may require a certain amount of power just to maintain itself.



# Fixed VS Variable Costs

Vary as changes in the production are implemented

Include expenses with equipments and materials, performance bonuses, freight and sales commissions, for example



Can or cannot be proportional to these production changes

If there's no production, there's no variable cost



# Cost Terminology

## Incremental/Additional/ Revenue Costs:

- **Incremental Costs** are related to the system outputs and variable costs. Increasing the system outputs by one or more units increments the total costs.

$$\text{Incremental Cost Per Unit} = \frac{\text{Variable Cost}}{\text{Units Produced}}$$

- Incremental Cost for an automobile may be \$0.24, but this depends on several considerations, such as total mileage driven during the year (normal operating range), the mileage expected for the next major trip, and the age of the automobile.





# Cost Terminology: Example

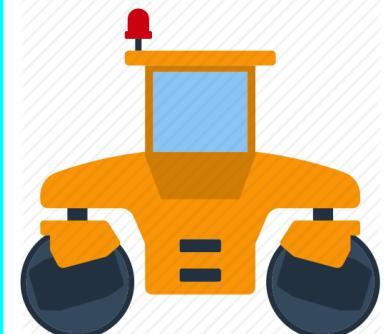
- In connection with surfacing a new highway the contractor has a choice of two sites on which to set up the asphalt mixing plant equipment. The contractor estimates that it will cost **\$1.15 per** cubic yard per mile to haul the asphalt paving material from the mixing plant to the job site. Factors relating to the two site alternatives are as follows

<u>Cost Factor</u>	Site A	Site B
Average hauling distance	6 Miles	4.3 Miles
Monthly Rental of Site	\$1000	\$5000
Cost to set up and remove equipment	\$15000	\$25000
Hauling cost	\$1.15	\$1.15

If site B is to be selected there will be an added charge **of \$96 per day for a flagman.**

The job involves 50000 cubic yards of mixed asphalt paving material. It is estimated that 4 months i.e. **17 weeks of 5 working days per week** will be required for the job. Compare the two sites in terms of their fixed , variable and total costs. Which one is better site.

For the selected site how many cubic yards of paving material does the contractor have to deliver before starting to make a profit if paid \$8.05 per cubic yard delivered to the job site.???????



## Cost Terminology: Example

- Rent , Setup Removal and Flagman are all **Fixed costs**
- Calculate them for each site
- Hauling is a **Variable Cost** find out for both site A and Site B
- Add them you will find the solution to the best Site
- In order to calculate profit first calculate all the fixed costs
- Then find the variable cost per yard delivered.
  - Total cost= Total Revenue
  - $\$53,160 + \$ 4.95x = \$8.05x$
- Find x and that is your profit on the job
- After delivering x cubic yards of material

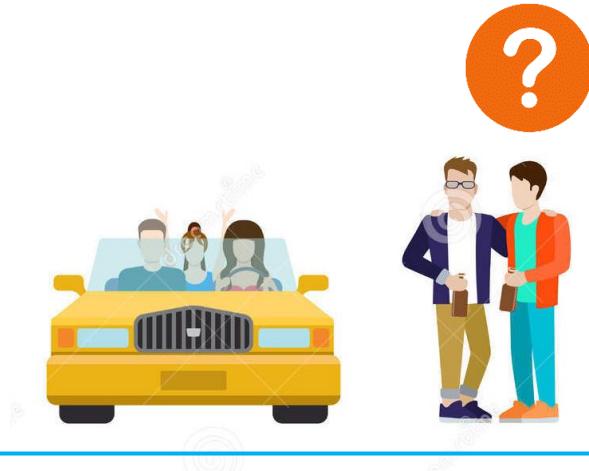




## Cost Terminology: Example

Four college students who live in the same geographical area intend to go for Christmas vacation 400 miles each way. One of the student has an automobile and agrees to take the other three if they will pay the cost of operating the automobile for the trip. When they return from the trip the owner presents each of them with a bill for **\$102.40**, stating that she has kept a careful record of the costs of operating the car and that is based on an annual average of **15000 miles** the cost per mile is **\$0.384**. The three others feel the charge is too high and ask to see the cost figures on which it is based. The owner shows them the following list.

<u>Cost element</u>	<u>Cost per mile</u>
Gasoline	\$0.120
Oil and lubrication	\$0.021
Tires	\$0.027
Depreciation	\$0.150
Insurance and taxes	\$0.024
Repairs	\$0.030
Garage	\$0.012
<b>Total</b>	<b>\$0.384</b>



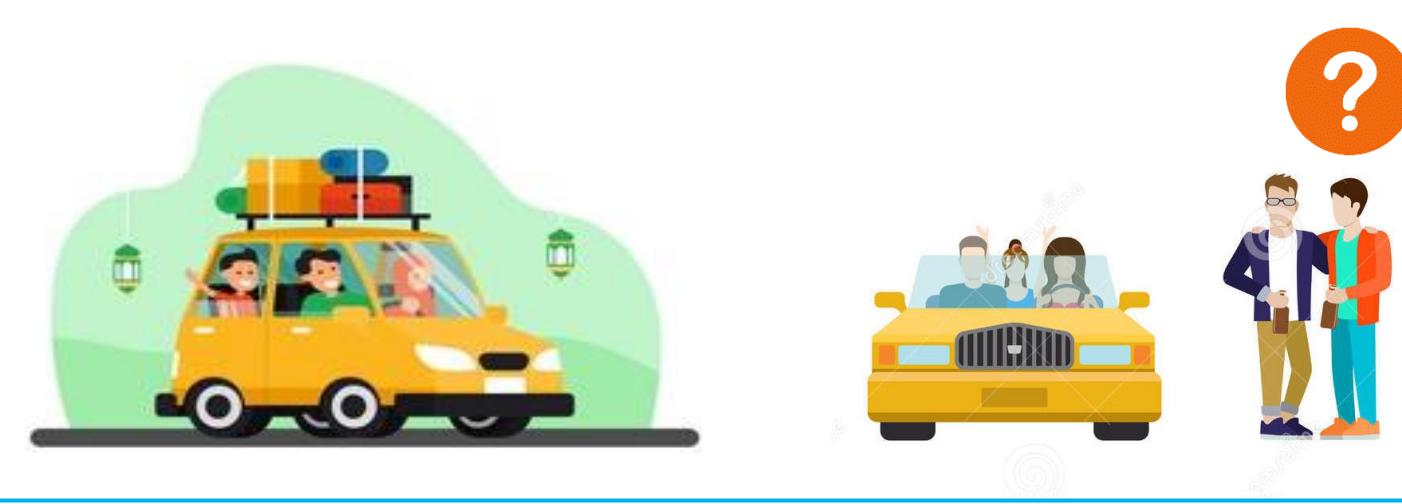


## Cost Terminology: Example

The three riders after reflecting on the situation form the opinion that only the costs for gasoline, oil and lubrication, tires and repairs are a function of mileage driven (variable costs) and thus could be caused by the trip.

Since these four costs total only **\$0.198 per mile** and thus **\$158.40** for the **800 miles** trip the share for each student would be  **$\$158.40/3= \$52.80$**

Obviously, the opposing views are substantially different. Which of either is correct? What are the consequences of the two different viewpoints in this matter and what should be the decision-making criterion?

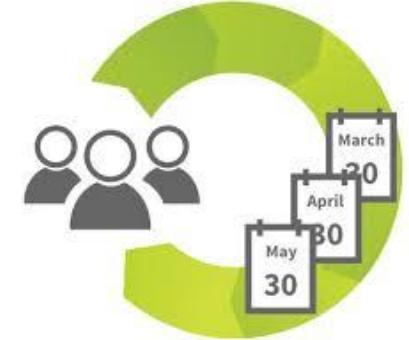




# Cost Terminology

## Recurring Costs:

- Repetitive costs that occur when an organization produces similar goods or services on a continuing basis
- A Fixed Cost that is paid on regular basis e.g., daily, monthly etc.
- Example: office space rental, architectural and engineering services



## Non-Recurring Costs:

- Non repetitive costs that are paid as cumulative amount over a short or long period of time only once
- Example: The purchase cost of a real estate upon which a plant is to be built





# Recurring VS Non-Recurring Cost

## Recurring

On-going costs to run and operate shared services for the given functions. Typical costs can include:

- ◆ End-state staff costs for the function or shared services operation
- ◆ Technology maintenance costs
- ◆ Monthly lease costs for the site



- ◆ Identification of per-transaction costs permits business unit comparison of current and future costs
- ◆ Separation of one-time implementation costs provides clarity to future, end-state costs (often much lower than one-time costs)

## Non-Recurring

One-time costs incurred to build and set-up shared services for the given functions. Typical costs can include:

- ◆ Severance for terminated staff
- ◆ Relocation for retained staff
- ◆ Redundant staff costs during overlap
- ◆ Technology implementation costs
- ◆ Site refurbishment costs



- ◆ Establishment of non-recurring costs facilitates cost allocation discussion between parent group and business units
- ◆ Clear inclusion of cost elements into non-recurring costs ensures the organization is consciously working to identify all possible cost elements in implementation





# Cost Terminology

## Direct Costs:

- Can be reasonably measured and allocated to a specific output or work activity
- Example: The labor material costs associated with a product, service or construction activity

## Indirect/ Burden/ Overhead Costs:

- Difficult to attribute or allocate to particular service or activity
- Interchangeably used with **Overhead Costs** and **Burden Costs**
- Example: Costs of common tools, general supplies and equipment maintenance



# Direct VS Indirect Cost

## DIRECT COSTS

Expenses that directly go into producing goods or providing services



Direct Labor



Direct Materials



Manufacturing Supplies

## The Iceberg Impact

Direct vs. Indirect Costs of Injuries



### Direct Costs

Paid by Worker's Comp Insurance

- Medical (doctor visits, physical therapy, etc.)
- Claim mitigation
- Time loss from work

### Indirect Costs

Paid by Businesses

- Reduced or lost productivity
- Lost contracts
- Increased administrative costs
- Lost time at the supervising level
- Costs of training replacements
- Overtime costs
- Potential legal fees
- Equipment repair
- Negative publicity
- Damage to customer relationships
- OSHA investigations or fines
- Increased insurance costs
- More...

## INDIRECT COSTS

General business expenses that keep you operating



Rent



Utilities



General office expenses



# Direct VS Indirect Cost

Cost	Product A	Product B
<b><u>Direct costs:</u></b>		
Raw materials	20,000	15,000
Packing materials	2,000	1,800
Factory labour wages	9,000	6,000
<b><u>Indirect costs:</u></b>		
Rent	20,000	10,000
General maintenance expenses	2,666.67	1,333.33
Electricity	5,333.33	2,666.67
Staff welfare expenses	7,500	4,500
Sales and marketing	4,666.67	2,333.33
Office staff salary	6,875	4,125
<b>Total costs</b>	<b>78,042</b>	<b>47,758</b>
<b>No of units produced</b>	<b>2000</b>	<b>1000</b>
<b>Cost per unit</b>	<b>39.02</b>	<b>47.76</b>





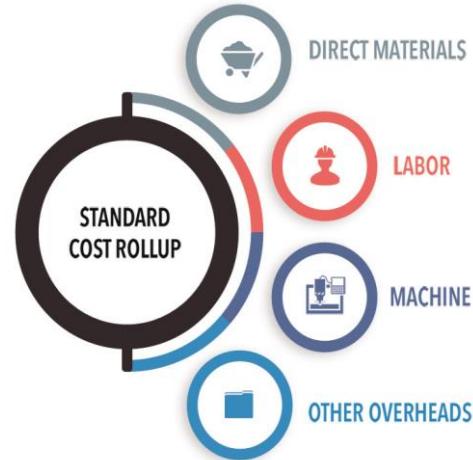
# Cost Terminology

## Standard Costs:

- Representative costs per unit of output that are established in advance of actual production or service delivery
- Plays an important role in cost control and other management purposes
- Example: A standard cost for manufacturing one unit of an automotive part: Direct Labor, Direct material, Factory overhead costs

## Sunk Costs:

- Costs that results from the past decisions and has no relevance to analyzing future alternatives, costs and revenues
- Example: Sunk costs occurs in replacement of assets



# Sunk Cost Confusion

## Which one is sunk cost?

- Suppose your firm is considering the replacement of a piece of equipment. It originally cost **\$50000**, is presently shown on the company records with a value of **\$20000** and can be sold for an estimated **\$5000**.



# Cost Terminology

## Opportunity Costs:

- **Opportunity Cost** is the cost of best rejected opportunity
- Example: Best use of a vacant warehouse in terms of income or saving



## Sunk Costs:

- Suppose your firm is considering the replacement of a piece of equipment. It originally cost \$50000, is presently shown on the company records with a value of \$20000 and can be sold for an estimated \$5000.  
What is opportunity cost here?





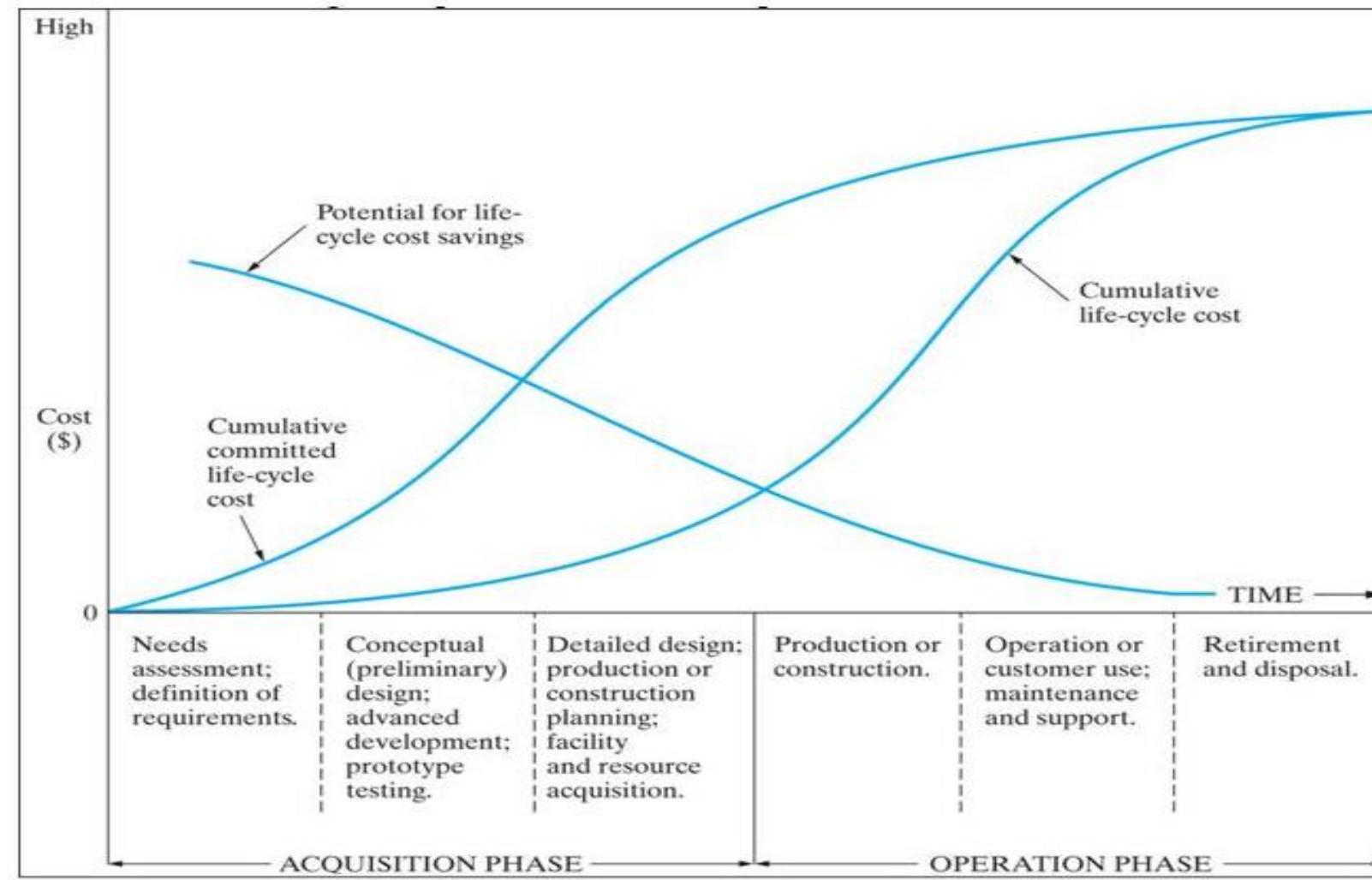
# Phases of Life-Cycle and their Costs

## The Four Primary Stages of an Engineering Project





# Phases of Life-Cycle and their Costs





# INTERMISSION



# Consumers, Producers, Goods and Services

## Consumer Goods and Services:

- **Products or Services** that are directly used by the people to satisfy their wants.
- Example: Food, clothing, homes, cars, television sets, haircuts opera and medical services are examples.



## Producer Goods and Services:

- **Products or Services** that are used to produce consumer goods and services or other producer goods.
- Machine tools, factory buildings, buses and farm machinery are examples.
- Thus, the amount of the producer goods needed is indirectly related to the amount of consumer goods or services that are demanded by the people.





# Measures of Economic Worth

## Utility:

- Goods and services are produced and desired because directly or indirectly they have utility
- Utility is the power to satisfy human wants and needs
- Utility is measured in terms of value expressed in some medium of exchange as the price that must be paid to obtain the item
- Much of our business activity including engineering focuses on increasing the utility of materials and products by changing their form or location



# Necessities and Luxuries

## Necessities:

- Goods and services may be divided into two types necessities and luxuries.
- **Necessities** are the basic human requirements under given circumstances
- Obviously, these terms are relative because for most goods and services, what one person may consider to be necessity may be considered by another to be a luxury.
- Example: A person living in one community may find that an automobile is a necessity to get to and from work.

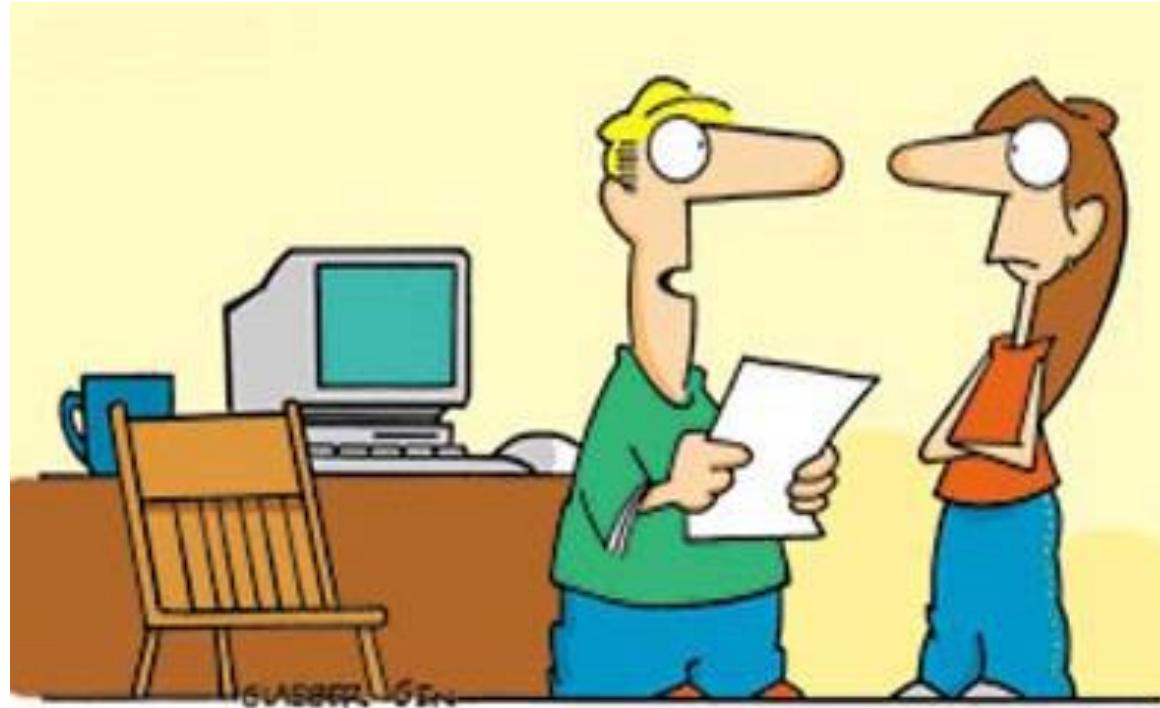
## Luxuries

- **Luxuries** are goods and services which are not basic requirements under given situation and circumstances.
- Example: If same person lived and worked in a different city adequate public transportation might be available and an automobile may be considered a luxury.



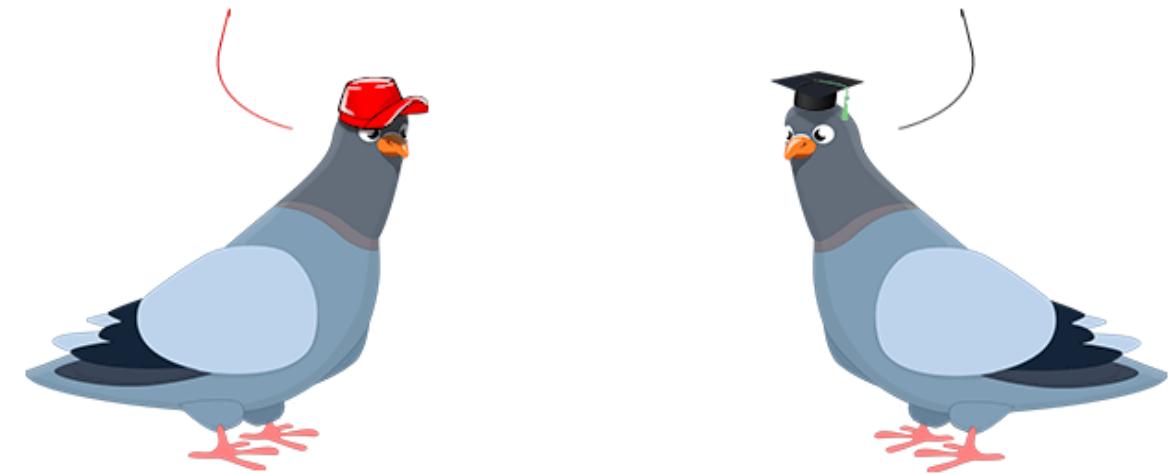


# Necessities and Luxuries



\*IF WE SACRIFICE A FEW LUXURIES LIKE FOOD, CLOTHING, AND SHELTER, WE CAN AFFORD NECESSITIES LIKE A FASTER COMPUTER AND BIGGER MONITOR.\*

what's the  
opposite of  
luxuries?



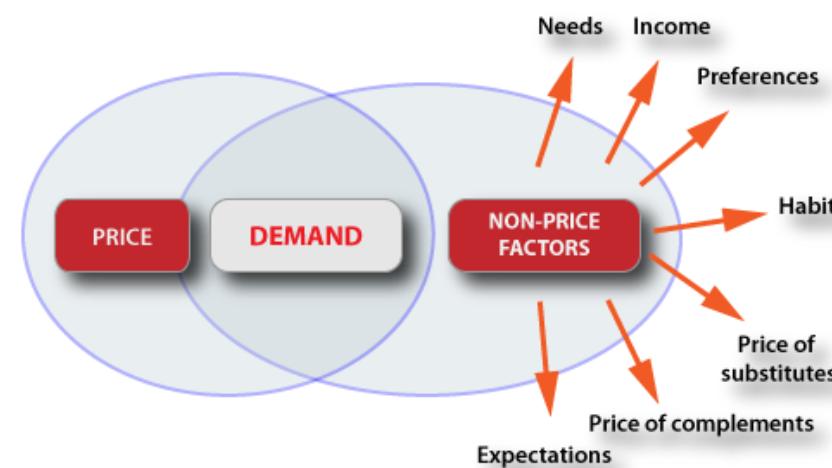
Luxury is a necessity that begins where necessity ends

— Coco Chanel —



# Price and Demand

- The classification of goods and services into luxuries and necessities is less easy for producer goods than for consumer goods.
- However, for all goods and services there is a relationship between the price that must be paid and the quantity that will be demanded or purchased



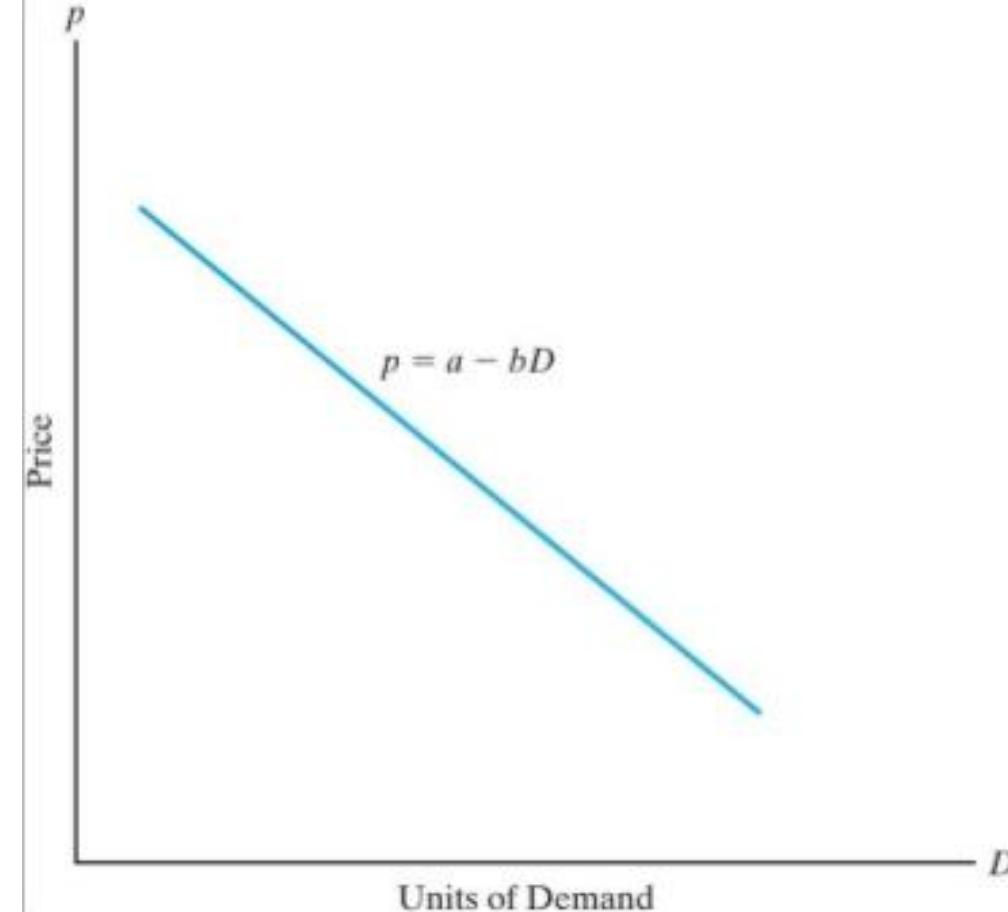
## Price and Demand



*"We need to track availability of our products through the supply chain to respond to real-time demand and ensure supplies are adequate in markets where demand is increasing due to current events or happenings."*



# Price and Demand Relationship



This general relationship between price and demand is shown in the following:

$$p = a - b D \quad \text{for } 0 < D < a / b$$

Where,

**a** is the intercept on the price axis

**-b** is the slope

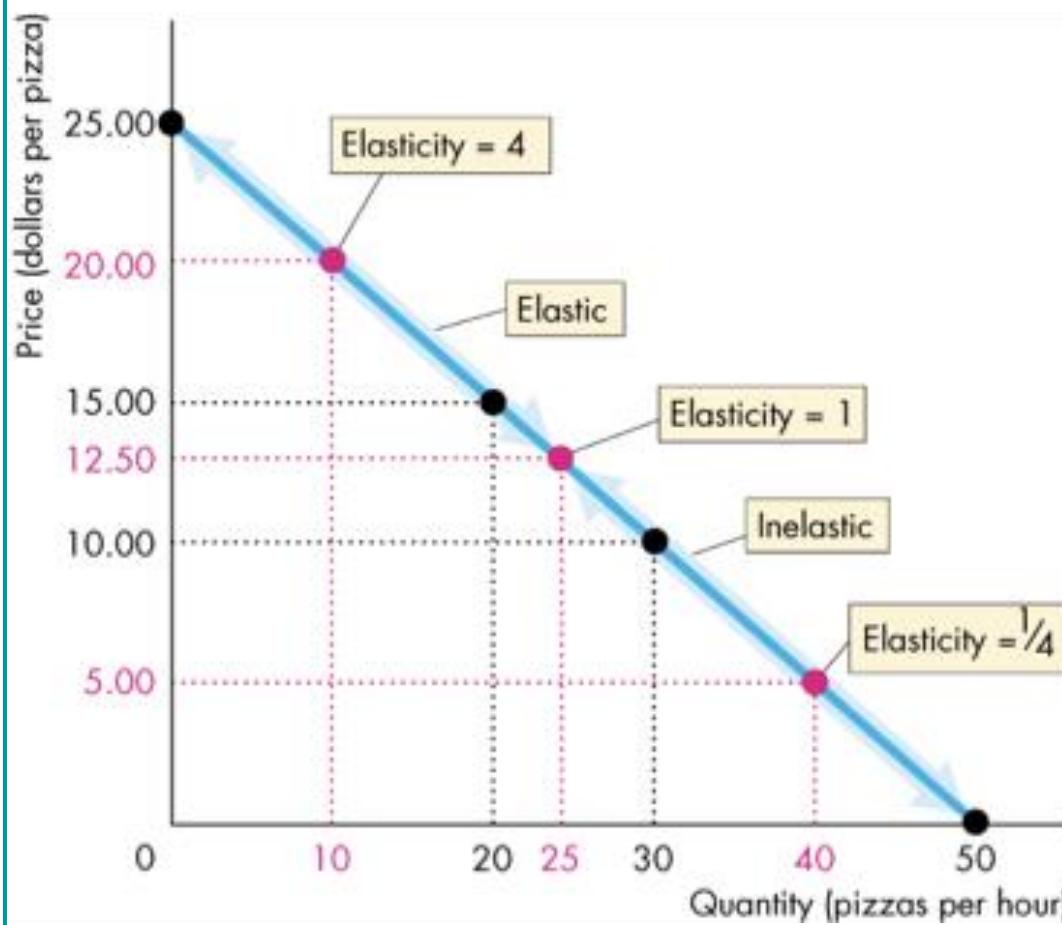
**D** is the Demand

Thus, **b** is the amount by which the demand increases for each unit/increase in **p**

Both **a** and **b** are constants and follows:

$$D = (a - p) / b$$

# Elasticity in Price and Demand

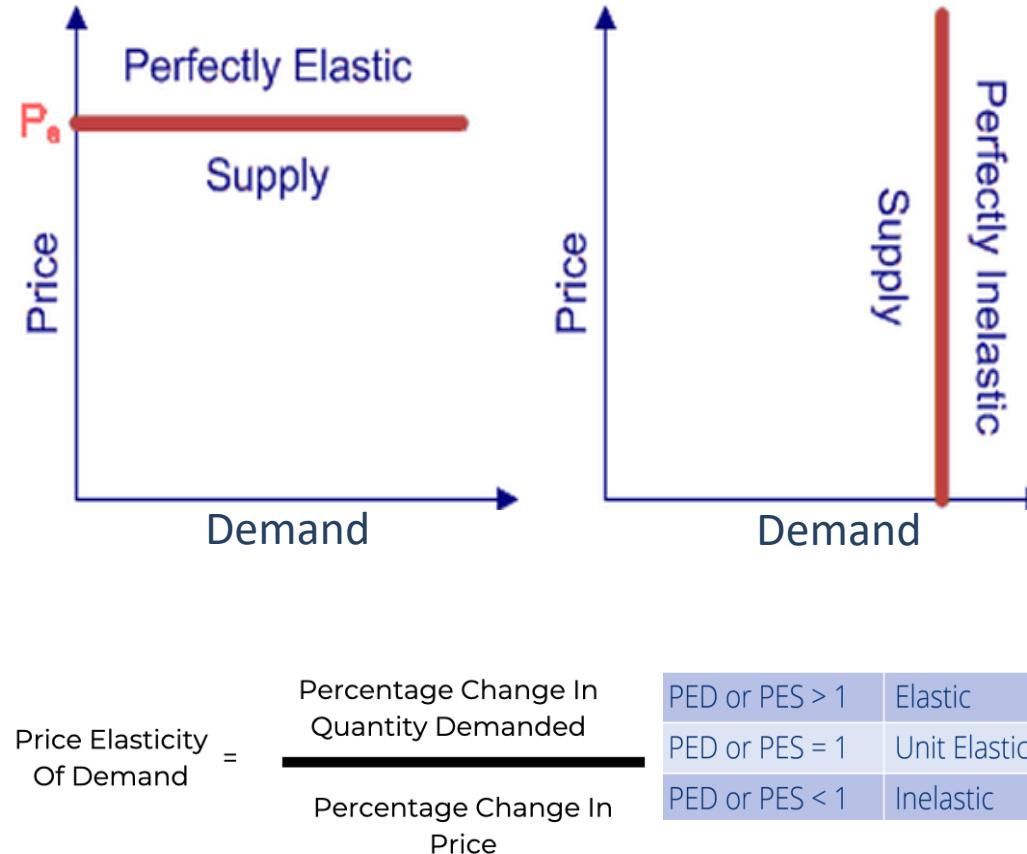


- The extent to which price changes influence demand varies according to the **Elasticity of the demand**
- The demand for products is said to be **Elastic** when a decrease in the selling price results in considerable increase in sales.
- If a change in selling price produces little or no effect on demand the demand is said to be **Inelastic**





# Elasticity in Price and Demand



## Calculating Elasticity

- What does this equation mean?
  - How do you calculate a percentage change?
- PRICE ELASTICITY OF DEMAND**
- $$\frac{\% \Delta Q}{\% \Delta P}$$
- Numerator  
——————  
Denominator
- “the % change in quantity demanded ( $Q_d$ ), divided by the % change in price”
  - Another important thing to remember is that percentage changes can be positive or negative, but **elasticity is always an absolute value (positive)**.

$$\text{Price Elasticity of Demand} = \frac{\% \text{ Change in the Quantity Demanded } (\Delta Q)}{\% \text{ Change in the Price } (\Delta P)}$$

$$\text{Price Elasticity of Supply} = \frac{\% \text{ Change in the Quantity Supplied } (\Delta Q)}{\% \text{ Change in the Price } (\Delta P)}$$



# Competition, Monopoly and Oligopoly



**How easy would it be for a company to launch a new subscribers service? OR**

**Launch a new operating system? OR**

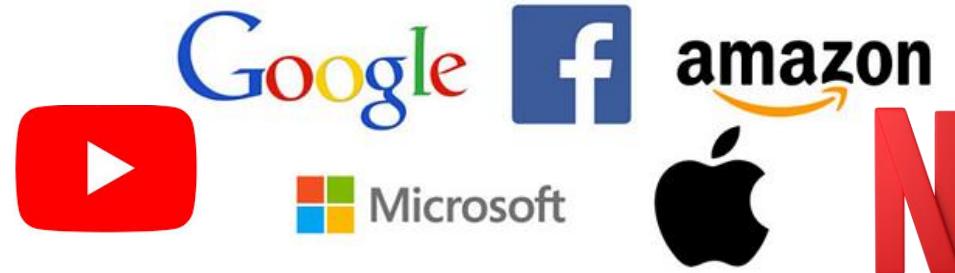
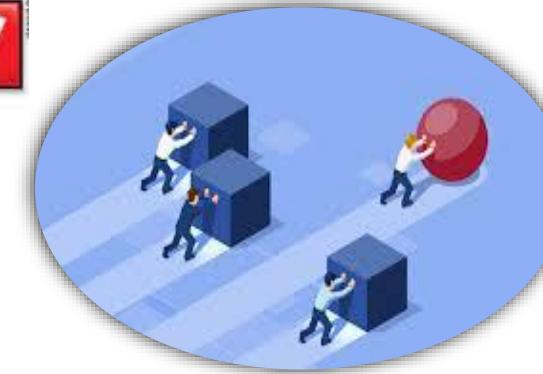
**What do you think of when comes to a cell phone brand? OR**

**Why is it difficult? What should be the strategy here?**





# Competition, Monopoly and Oligopoly



**How easy would it be for a company to launch a new Social Platform? OR**

**Launch a new Search Engine? OR**

**What do you think of when comes to Launching a new online video sharing platform?**

**Why is it difficult? What should be the strategy here?**





# Competition, Monopoly and Oligopoly



## An example of oligopoly:



The global market for pharmaceuticals is dominated by a few very large companies.

The pharmaceutical industry continues to operate as an oligopoly due to the nature of the industry and the barriers of entry which exist.

Developing a new drug is an extremely complex and expensive task which requires a huge amount of resources. In addition, most drugs have patents which mean that they cannot be replicated and produced by other firms.

## Oligopoly:

Oligopoly is defined as a market situation in which there are a few sellers or producers dealing in either the homogenous or heterogenous products

What do you think of when comes to a vehicle brand? OR Crockery OR Diamonds OR Stationery OR Eatery?

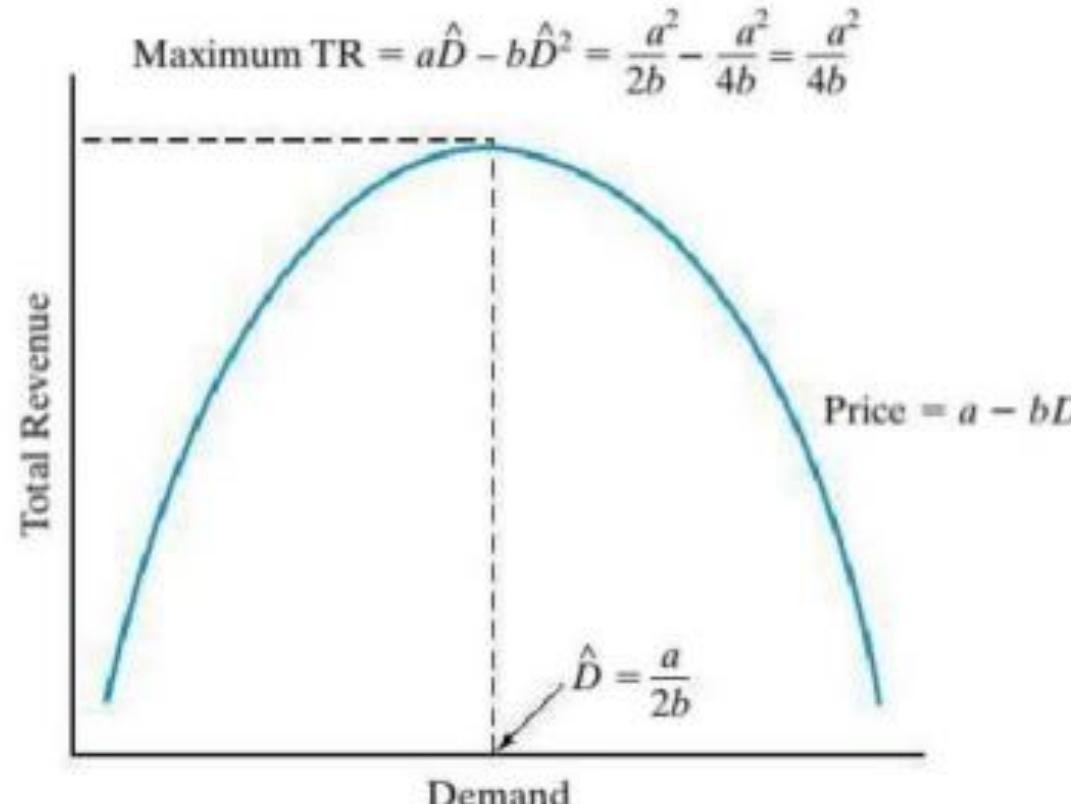
How much the brand matter in these scenarios?

What should be the strategy here?





# Price and Demand Relationship



The **Total Revenue (TR)**, that results from a business venture during a given period is the product of the **selling price per unit (p)**, and the number of the **units sold (D)**. Thus:

$$TR = \text{price} * \text{Demand} = p * D$$

Where, the relationship between the price and demand is given as:

$$TR = (a - bD) * D$$

$$TR = aD - bD^2 \quad \text{for } 0 < D < a/b$$

From Calculus, the **demand D (Marginal/ Incremental Revenue)** will produce **maximum Total Revenue** at:

$$\frac{d TR}{d D} = a - 2bD = 0$$

$$D = a / 2b$$



# Cost, Volume and Breakeven Point Relationship

Fixed costs remain constant over a wide range of activities if the business does not permanently discontinue operations, but variable cost vary in total with the volume of output.

Thus, at any demand D total cost is:

$$C_T = C_V + C_F$$

Where,

**$C_T$  = Total Costs**

**$C_V$  = Total Variable Costs**

**$C_F$  = Total Fixed Costs**

For Linear Relationship mentioned here:

$$C_V = c_v (D)$$

Where,  $c_v$  is the variable cost per unit item aka Standard cost.

At breakeven point  $D^*$ , the Total Revenue is equal to the Total Costs and an increase in demand will result in a profit for the operation. Then at the optimal demand profit is maximized.

Here, at breakeven point both total revenue and total cost are equal, and the Profit/Loss is given as:

$$TR = C_T$$

$$\text{Profit / Loss} = TR - C_T$$

$$(a D - b D^2) = (C_F + c_v D)$$

$$-C_F + (a - c_v) D - bD^2 = 0 \text{ for } 0 < D < a/b$$

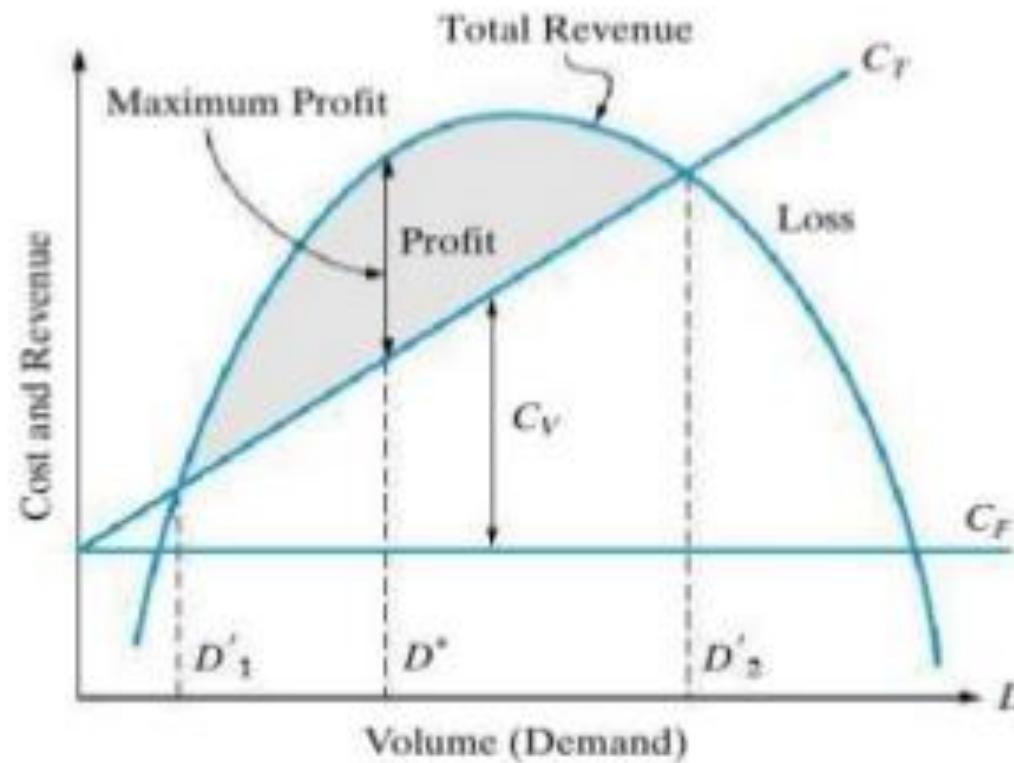
From Calculus, the optimum demand  $D$  will produce maximum Profit at:

$$d (\text{Profit}) / d D = -C_F + (a - c_v) D - bD^2 = 0$$

$$D = a - c_v / 2 b$$



# Cost, Volume and Breakeven Point Relationship



**Combined Costs and Revenue Functions, and Breakeven Points, as functions of Volume and Costs**

**Conditions:** For profit to occur two conditions must be met.

- 1)  $(a - c_v) > 0$  that is the price per unit that will result in no demand has to be greater than the variable cost per unit.
- 2) **Total Revenue (TR)** must exceed **Total Cost (C\_T)** for the period involved.

From the Quadratic Equation with one unknown  $D^*$ , we can solve for both  $D_1$  and  $D_2$ :

$$-C_F + (a - c_v) D - bD^2 = 0$$

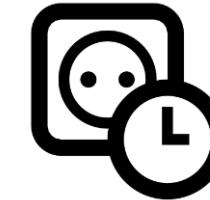
$$D = \frac{-(a - c_v) \pm \sqrt{(a - c_v)^2 - 4(-b)(-C_F)}}{2(-b)}$$



# Cost, Volume and Breakeven Point Relationship

**Example 2.6:** A company produces an electric timing switch that is used in consumer and commercial products made by several other manufacturing firms. The **fixed cost ( $C_F$ )** is **\$73000 per month**, and the **variable cost ( $c_v$ )** is **\$83** per unit. The **selling price per unit** is  **$p=180-0.02D$**  based on previous equations. For this situation find the following:

- Determine the **optimal volume** for this product and confirm that a **profit** occurs at this demand.
- Determine the **volumes** at which **breakeven** occurs that is what is the **range of profitable demand?**



**Example 2.7:** An engineering consulting firm measures its output in a standard service hour unit, which is a function of the personnel grade levels in the professional staff. The **variable cost ( $c_v$ )** is **\$62 per standard service hour**. The charge out rate i.e., **selling price ( $p$ )** is  **$1.38c_v = \$85.56$**  per hour. The maximum **output** of the firm is **160,000** hours per year, and its **fixed cost ( $C_F$ )** is **\$2024000** per year, for this firm.

- What is the **breakeven point** in standard service hours and in percentage of total capacity.
- What is the **percentage reduction** in the **breakeven point** if **fixed costs** are reduced by **10%**; if **variable cost per hour** is reduced **10%**; if both costs are reduced by **10%**; and if the **selling price per unit** is increased by **10%**.



# Cost, Volume and Breakeven Point Relationship

**Example 2.8:** A plant has a capacity of **4100** hydraulic pumps per month. The **fixed cost ( $C_F$ )** is **\$504000** per month. The **variable cost ( $c_v$ )** is **\$166** per pump, and **sales price (p)** is **\$328** per pump (assume that sales equal output volume).

- What is the **breakeven point** in number of pumps per month?
- What **percentage reduction** will occur in the breakeven point if fixed costs were reduced by **18%** and unit variable costs by **6%**?



**Example 2.9:** The annual **fixed costs ( $C_F$ )** for a plant are **\$100,000**, and the **variable costs ( $C_v$ )** are **\$140,000** at **70%** utilization of available capacity, with **net sales** of **\$280,000**. What is the **breakeven point** in units of production if the **selling price** per unit is **\$40**?

**Example 2.10:** A company produces circuit boards used to update outdated computer equipment. The **fixed cost ( $C_F$ )** is **\$42,000** per month, and the **variable cost ( $c_v$ )** is **\$53** per circuit board. The **selling price** per unit is  $p = \$150 - 0.02D$ . Maximum **output** of the plant is **4,000 units** per month.

- Determine **optimum demand** for this product.
- What is the **maximum profit** per month?
- At what **volumes** do **breakeven** occur?
- What is the company's range of **profitable demand**?





# Summary

- **Understanding Different Cost Terminologies**
- **The General Economic Environment**
  - Consumer and Producer Goods and Services
  - Necessities, Luxuries and Price Demand
  - Cost, Volume and Breakeven Point
  - Total Revenue Function
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- **Present Economy Studies and Applications**