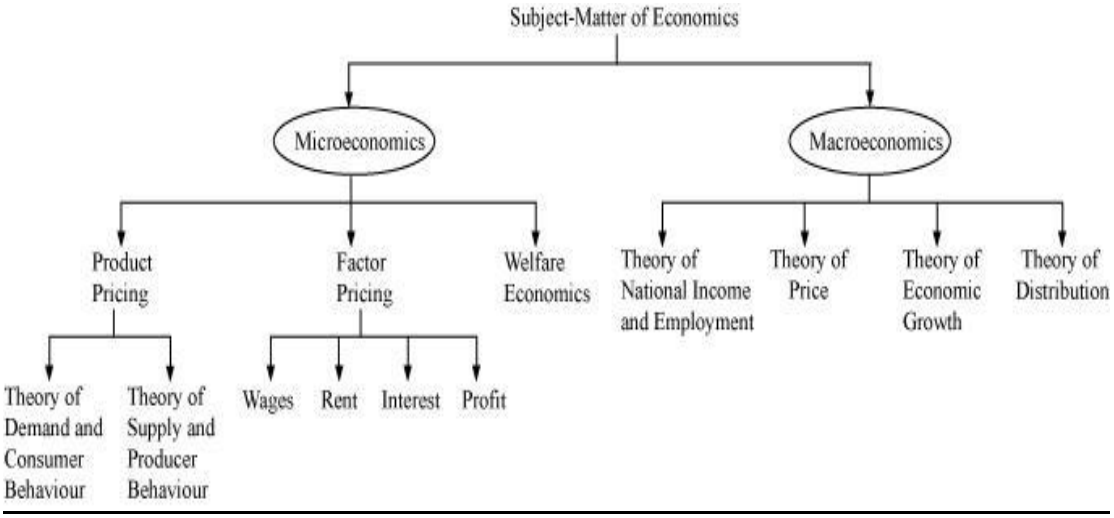
Economics for Engineers
UNIT 1 PART 1

1. **Microeconomics and Macroeconomics**
2. **Utility**
3. **Budget Line**
4. **Indifference Curve**
5. **Engineering Economics**



1. Microeconomics and Macroeconomics

The **micro economics** is the study of an economic behaviour of a particular individual, firm, or household, i.e. it studies a particular unit. In other words, Microeconomics is the branch of economics that concentrates on the behavior and performance of the individual units, i.e. consumers, family, industry, firms. Here, the demand plays a key role in determining the quantity and the price of a product along with the price and quantity of related goods (complementary goods) and substitute products, so as to make a judicious decision regarding the allocation of scarce resources, concerning their alternative uses. **Examples**: Individual Demand, Price of a product, etc.

Microeconomics is also useful for studying the effects of your own decisions. One of the most common principles in microeconomics is **opportunity cost**.

Opportunity cost is the value of making one decision over another. A decision that involves economy cost is the choice of one meal instead of another: by choosing a certain food, you miss out on the benefits offered by another. It is the value of the benefit that is sacrificed by choosing an alternative.

Choices involving opportunity cost could relate to your career. By choosing one job over another, you may gain opportunities but lose others. In addition to factors like supply and demand, opportunity cost is one of the principles of microeconomics.

On the other hand, **macroeconomics** is the study of the economy as a whole i.e., not a single unit but the combination of all, firms, households, nation, etc. Macroeconomics is the branch of economics that concentrates on the behaviour and performance of aggregate variables and those issues which affect the whole economy. It includes regional, national and international economies and covers the major areas of the economy like unemployment, poverty, general price level, GDP (Gross Domestic Product), imports and exports, economic growth, globalization, monetary/ fiscal policy, etc. It helps in resolving the various problems of the economy, thereby enabling it to function efficiently.

Examples: Aggregate Demand, National Income, etc.

For example, while a micro economist might study the effects of low interest rates on individual borrowers, a macroeconomist would observe the effects that low interest rates have on the national housing market or the unemployment rate.

Another common focus of macroeconomics is the way taxes affect the economics of a nation. A macroeconomist would look at the effects of a decrease in income taxes using measures like GDP and national income, rather than individual factors.

2. **<u>UTILITY</u>** is the want satisfying power of a commodity. It refers to the amount of satisfaction a consumer receives from consumption of a good or service. It is a subjective concept but economist has been trying to objectify it in the following approaches.

<u>THERE ARE TWO APPROACHES TO MEASURE UTILITY</u>:

1. **Cardinal utility analysis:** This is given by Marshall which measures utility in quantitative by assigning units called utils which is measured in numbers.
2. **Ordinal utility analysis:** This is also known as indifference curve analysis. This is given by Hicks and Allen. It measures utility in qualitative order like first preference, second preference, third preference etc. It is measured in ranks.

Utility is not useful as drugs may give utility to a drug addict but are not useful otherwise.

<u>CONCEPTS OF UTILITY: TWO TYPES</u>

1. **Total utility (TU):** It is defined as total psychological satisfaction which a consumer derives from consumption of a certain amount of a commodity. Mathematically, it is an aggregate of marginal utility (MU) derived from consumption of different units of the commodity.

$$TU = \sum MU$$

2.**Marginal utility (MU):**It is an addition made to TU by consuming an additional unit of the commodity or it is the additional utility derived from consumption of one more unit of the given commodity.

$$MU_X = \frac{\Delta TU \text{ of good X}}{\Delta Quantity \text{ of good X}}$$

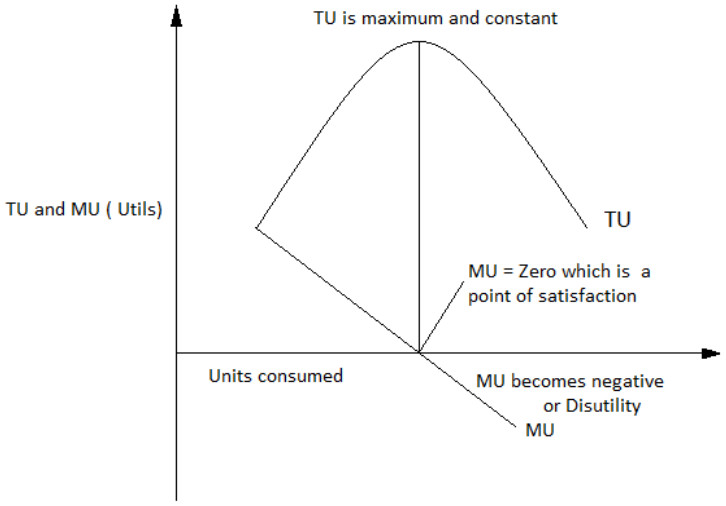
$$MU_n = TU_n - TU_{n-1}$$

LAW OF DIMINISHING MARGINAL UTILITY (DMU*<u>:</u>*) Also called Gossen's first law of consumption. This law states that as a consumer consumes more and more units of a commodity, marginal utility derived from additional units goes on falling.

<u>Assumption of Law of DMU</u>:

1. **Cardinal measurement of utility**: It is assumed that utility can be measured in utils.
2. **Standard unit of measurement:** Unit of measurement should not be very large or very small.
3. **Continuous consumption:** There should not be time gap between consumption of successive units of the commodity.
4. **MU of rupee remains constant:** e.g. if MU of 1 rupee is 3 utils it means that by spending 1 rupee, consumer gets satisfaction equal to 3 utils.
5. **Fixed income of the consumer and price of the commodity**.

Diagrammatically, the TU and MU drawn below:



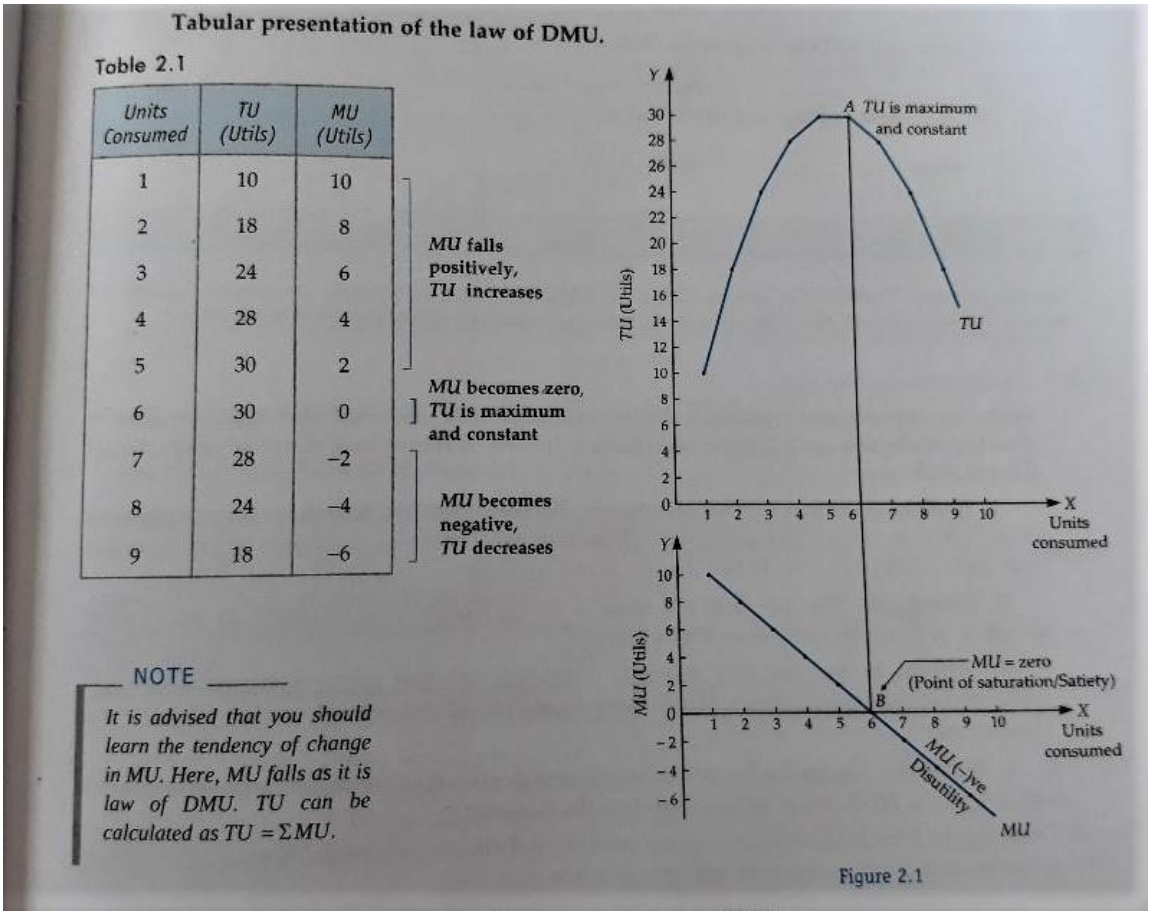


Figure 2.1

In the above figure, total utility and marginal utility are measured along the Y axis and quantity of goods consumed by an individual is measured along the X axis. According to Law of diminishing marginal utility, as a consumer consumes more and more units of a commodity, marginal utility derived from additional units goes on falling. In the initial period of consumption, total utility derived by an individual increases. After reaching a certain level of consumption, total utility becomes maximum and thereafter falls e.g. when we are thirsty, the first glass of water gives us satisfaction and satisfaction increases as we drink more and more water but the satisfaction will fall after reaching certain level of consumption of water.

RELATIONSHIP BETWEEN TU AND MU:

1. As long as MU is positive, TU increases.
2. MU=0, TU is maximum and constant.
3. When MU is negative, TU decreases.
4. TU is the summation of MU.
5. MU curve is the slope of TU curve.

Exceptions to the Law of DMU:

1. Hobbies: hobbies like collection of old coins, MU increases with every additional unit of old coin. Thus, law of DMU does not apply.
2. Drunkards: the law does not apply to a drunkard.
3. Misers: greed of money increases with every additional acquisition of money to a miser so law does not apply here.
4. Music and poetry: hearing gives better satisfaction than the first time hearing so MU rises and thus law cannot apply here too.
5. Reading: a person who loves reading would get more and more satisfaction with every additional book.

CONDITIONS OF CONSUMER EQUILIBRIUM USING CARDINAL UTILITY ANALYSIS:

CASE I: consumer equilibrium in case of one or a single commodity:

1. MU of X = price of X commodity
2. TU decreases with additional purchase after equilibrium.

2.4 CONDITIONS OF CONSUMER EQUILIBRIUM (Using Cardinal Utility Analysis)

2.4.1 Consumer Equilibrium in Case of a Single Commodity

Consumer equilibrium refers to a situation in which a consumer spends his income on purchase of a commodity in such a way that gives him maximum satisfaction. Consumer equilibrium is determined when the following conditions are satisfied :

1. Marginal utility (MU_x) = Price (P_x)
2. Total gain decreases with additional purchase after equilibrium

Condition 1. $MU_X = Price_X$

- *MU* implies satisfaction.
- Price implies sacrifice.

Why MU_X = Price$_x$?

Why not $MU_X > P_X$ or $MU_X < P_X$

- When $MU_X > P_X$, a consumer gains more satisfaction as compared to sacrifice he makes in terms of price paid by him. Hence, he gets prepared to buy more. Law of DMU operates. *MU* falls as he buys more and becomes equal to price of the commodity.
- When $MU_X < P_X$, a consumer suffers losses as he is paying more than what he actually gains. He reduces consumption of the commodity. Law of DMU operates (in opposite direction). *MU* begins to rise and becomes equal to the price of the commodity

So a consumer is at equilibrium when $MU_X = P_X$

Condition 2. Total gain falls after equilibrium

It is because marginal utility is falling (Law of DMU) and after equilibrium it becomes smaller than the price paid for the additional units of the commodity.

Explanation of Consumer Equilibrium

So far we have learnt that *MU* is measured in utils, but to make *MU* comparable to price, we need to convert *MU* (utils) into *MU* (in money terms)

$$MU \text{ in money terms/Rupees} = \frac{MU \text{ (utils)}}{(MU \text{ of a rupee})^*}$$

* "*MU* of a rupee is the utility obtained when an additional rupee is spent on other goods."

In simple words, *MU* of a rupee is purchasing power of a rupee in terms of utils. It refers to worth of a rupee defined by a consumer in terms of utility that he obtains from a given basket of goods with a rupee. *For example*, refer to Box 2.3.

Box 2.3

If *MU of a rupee is 3 utils*, it means that by spending one rupee, a consumer gets satisfaction equal to 3 utils.

In the same example, **if *MU* (utils) is 12**, then *MU* in money terms will be $= \frac{12 \text{ utils}}{3 \text{ utils}} = ₹4$

It means that he will have to spend **₹4** to get satisfaction equal to **12 utils** as **one rupee** can buy him **3 utils of satisfaction**.

The following schedule (Table 2.2) is based upon *three* assumptions :

(*i*) *MU* falls as law of DMU operates
(*ii*) *MU* of a rupee is 2 utils
(*iii*) Price of the commodity is ₹3 per unit

Table 2.2

Units Consumed	MU (Utils)	MU (₹) or in Money Terms		Price (₹)	Gain MU (₹) − Price (₹)
1	10	5	>	3	2
2	8	4	>	3	1
3	6	3	=	3	0
4	4	2	<	3	−1
5	2	1	<	3	−2
6	0	0	<	3	−3
7	−2	−1	<	3	−4
8	−4	−2	<	3	−5
9	−6	−3	<	3	−6

It is clear from the above table 2.2 that consumer equilibrium is determined at 3 units of the commodity. It implies that the consumer should buy 3 units of the commodity, as at this level marginal utility (MU_x) in Rupees = Price (P_x) in Rupees. In other words, **satisfaction** (MU_x) received from 3 units of the commodity is **equal** to **sacrifice** (P_x)

Condition 1. Satisfaction (MU_x) = Sacrifice (P_x) at 3 units. Also

Condition 2. Total gain (2 + 1 + 0) falls after this level as $MU_X < P_X$

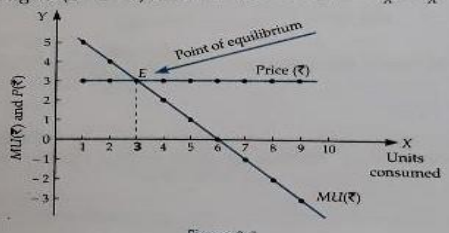


Figure 2.2

Consumer equilibrium is determined at point *E* as here *MU* (₹) = Price (₹) that is ₹3, which means that his satisfaction (*MU*) is equal to sacrifice (price) paid for it. Accordingly, he should buy 3 units of the commodity. In Fig. 2.2,

- Before point *E*, *MU* > Price, so he should buy more till he reaches equilibrium.
- After point *E*, Price > *MU*, so he should not go beyond point *E* as he suffers losses. (Refer to explanation of condition 1 of section 2.4.1)

CASE II: consumer equilibrium in case of two goods: in real, consumer consumes more than one commodity. In such case, law Of DMU is extended to many goods. Law of Equi-marginal utility helps in determining consumer equilibrium in case of 2 or more goods and it is written as

1. $\frac{\text{MU of good X}}{\text{MU of good Y}} = \frac{\text{Price of good X}}{\text{Price of good Y}}$ =Marginal Utility of money income

2. Law of diminishing marginal utility operates.

Box 2.4

To summarise : **condition of consumer equilibrium is**

MU (₹) = Price (₹)

or $\frac{MU \text{ (utils)}}{MU \text{ of a rupee}}$ = Price (₹)

NOTE

MU (₹) is MU in money terms

$\left[\frac{6 \text{ utils}}{2 \text{ utils}} = ₹\ 3\right]$ → in the above example

or $\frac{MU \text{ (utils)}}{\text{Price (₹)}} = MU$ of a rupee

$\left[\frac{6 \text{ utils}}{₹\ 3} = 2 \text{ utils}\right]$ → in the above example

2.4.2 Consumer Equilibrium in Case of two Commodities

In actual life, a consumer consumes more than one commodity. In such a case, law of DMU is extended to many goods which the consumer purchases. *Law of Equi-marginal utility* helps in determining consumer equilibrium in case of two commodities.

According to this law, a consumer gets maximum satisfaction when ratios of *MU* of two commodities to their respective prices are equal. In other words, a consumer will spend his income in such a way that utility gained from the last rupee spent on each commodity is equal.

There are *two* ways in which consumer equilibrium can be determined in case of two commodities :

(*i*) When price of each commodity is the same

(*ii*) When prices of two commodities are different

(i) When Price of each Commodity is the Same

In case of 2 commodities, a consumer attains equilibrium when marginal utilities of both the goods are equal *i.e.*,

MU of good $X = MU$ of good Y

or $\frac{MU_X}{P_X} = \frac{MU_Y}{P_Y} = MU_m$ (*MU* of last rupee spent or *MU* of a rupee)

The *conditions* of equilibrium are

1. $MU_x = MU_y$
2. Law of diminishing marginal utility **(DMU) operates.**
3. Exp. on commodity$_x$ + Exp. on commodity$_y$ = Money income (*Implied condition*)

Let us illustrate it by assuming that :

1. Price of one unit of each good is ₹ 1.
2. Money income of a consumer is ₹ 5.

Table 2.3

Units consumed	MU_X (utils)/ MU of a rupee*		MU_Y (utils) / MU of a rupee*	
1	12	I	10	II
2	10	III	8	IV
3	8	V	6	
4	6		4	
5	4		2	

* Since Price of good X and Price of good Y is same therefore MU (utils) is same as MU of a rupee.

Box 2.5

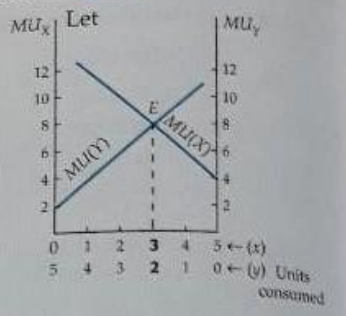


Figure 2.3

Being a rational consumer he will try to maximise his total satisfaction. He spends first rupee on 'X', second on 'Y', third on 'X', fourth on 'Y' and fifth on 'X'. He gets maximum satisfaction equal to 48 utils. If he spends his money on any other combination, total utility would be less than 48 utils. Thus he buys 3 units of good x and 2 units of good y.

Hence the consumer's equilibrium is determined when marginal utilities of both the goods are equal *i.e.*,

$$MU \text{ of good } X = MU \text{ of good } Y \quad \text{or} \quad \frac{MU_X}{P_X} = \frac{MU_Y}{P_Y} = MU_m$$

(ii) When Prices of Two Commodities are Different

If the prices of two goods are different, then the conditions of consumer equilibrium are :

1. $\frac{MU_X}{P_X} = \frac{MU_Y}{P_Y} = MU$ of last rupee spent/MU of a rupee

What happens if $\frac{MU_X}{P_X}$ is not equal to $\frac{MU_Y}{P_Y}$?

(*a*) If $\frac{MU_X}{P_X} > \frac{MU_Y}{P_Y}$, the consumer gets more marginal utility from the last rupee spent on X as compared to Y. Thus he would prefer to buy more of X and less of Y. Law of DMU operates. It will cause fall in MU_X and rise in MU_Y. The consumer would continue to buy more of X till $\frac{MU_X}{P_X}$ is equal to $\frac{MU_Y}{P_Y}$.

(*b*) If $\frac{MU_X}{P_X} < \frac{MU_Y}{P_Y}$, the consumer gets more marginal utility from the last rupee spent on Y as compared to X. Thus he prefers to buy more of Y and less of X. Law of DMU operates. It will cause fall in MU_Y and rise in MU_X. The consumer would continue to buy more of Y till $\frac{MU_X}{P_X} = \frac{MU_Y}{P_Y}$.

LIMITATIONS OF CARDINAL UTILITY:

1. Consumer are irrational: this theory assumes that consumers act rational which mean consumer try to maximize satisfaction by consuming goods but there are many circumstances in which consumer behave irrational.
2. Utility measureable: this theory assumes that utility can be measured but in reality it is difficult to measure the psychological behavior of a consumer.
3. The assumption of constant utility of money is also unrealistic as income increases the marginal utility of money changes.
4. It fails to discuss behavior of an inferior goods and giffen goods.

3. BUDGET LINE OR PRICE LINE: It represents the different bundles that the consumer can purchase spending his entire money income at given price.

Price line, M = (Price of X good) X (units of quantity of X) + (Price of Y good) X (Quantity of Y)

Slope of budget line = Price of good X divided by Price of good Y

$= P_X / P_y$

For example, if $P_1 = ₹4$, $P_2 = ₹2$ and $M = ₹20$, then the following bundles *do not form a part* of budget set *i.e.*, these are consumer budget constraint (0, 14), (1, 20), (2, 34), (3, 14) and (5, 4) etc. because here $P_1x_1 + P_2x_2 > M$.

2.5.4 Budget Line or Price Line and Features of Budget Line

A budget line represents the different bundles that the consumer can purchase spending his entire money income at given prices.

Here $P_1x_1 + P_2x_2 = M$.

It is a graphic presentation of all those bundles which cost the amount just equal to income of the consumer. The following table is based upon *three* assumptions :

- Price of good 1 is ₹4 per unit
- Price of good 2 is ₹2 per unit
- Money income of the consumer is ₹20

Table 2.5

Combinations	Quantity of good 1	Quantity of good 2	Expenditure* = Income (₹)
A	0	10	$4\times0+2\times10=20$
B	1	8	$4\times1+2\times8=20$
C	2	6	$4\times2+2\times6=20$
D	3	4	$4\times3+2\times4=20$
E	4	2	$4\times4+2\times2=20$
F	5	0	$4\times5+2\times0=20$

* Expenditure = $P_1x_1 + P_2x_2$

Observations :

(*a*) Budget line is AF (Fig. 2.5), which shows that entire income is spent on good 1 and good 2.

(*b*) Attainable combinations (Budget set) are shown by :

- All points on *AF* where

$$P_1x_1 + P_2x_2 = M$$

For example, *A, B, C, D, E, F* and

- All points inside (to the left of) *AF* where

$$P_1x_1 + P_2x_2 < M,$$

For example, points *N, P* & *Q* etc.

(*c*) Non attainable combinations (consumer budget constraint) are shown by :

- All points to the right of *AF* where

$$P_1x_1 + P_2x_2 > M$$

For example, points *S, T, U, V* etc.

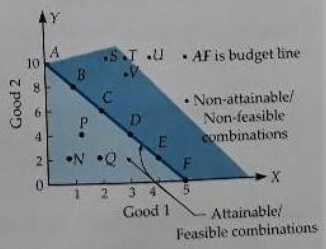


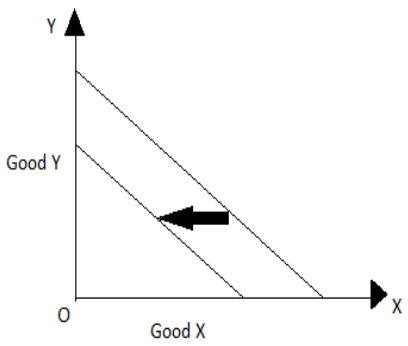
Figure 2.5

SHIFT AND ROTATION OF BUDGET LINE:

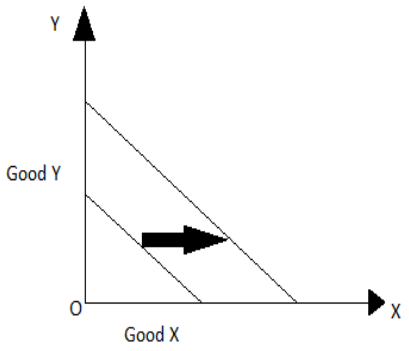
Budget line depends on three factors namely:

1. Income 2. Price of Good X 3.Price of Good Y

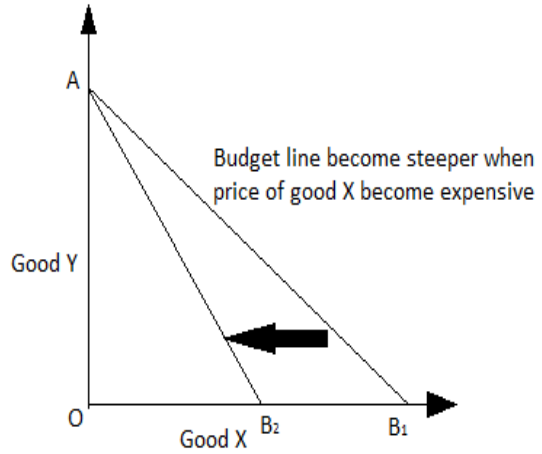
A decrease or increase in income other things remaining constant, budget line will shift a parallel leftward or rightward and it is shown below:



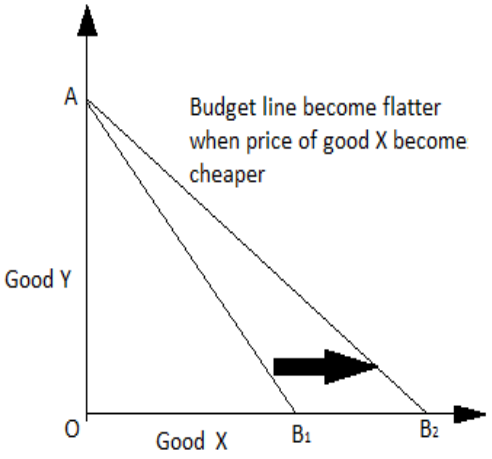
Leftward shift of budget line due to decrease in income



Rightward shift of budget line due to increase in income

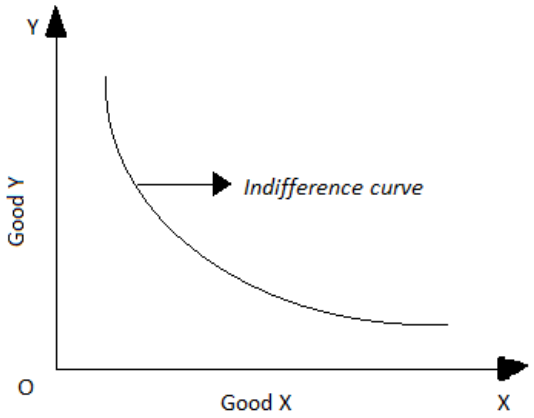


An increase in price of good X will make budget line to rotate left from AB_1 to AB_2



A decrease in price of good X will make budget line to rotate right from AB_1 to AB_2

4.INDIFFERNECE CURVE or Iso-utility or Equal utility curves: An indifference curve is a locus of points each representing a different combination of two goods yielding the same utility or level of satisfaction.



ASSUMPTION OF ORDINAL UTILITY THEORY OR ASSUMPTION OF INDIFFERENCE CURVE(IC)

1. Rationality: it means consumer aims at maximizing his total satisfaction.
2. Ordinal utility: ordinal utility approach assumes that utility is only ordinally measureable by consumers' subjective evaluation.
3. Transitivity: Consumers' choices are transitive means if a consumer prefers good A than good B and B to C then he must prefer A to C.
4. Consistency of choice: Consistency of choice means that if a consumer prefers A to B in one period, he must not B to A in another period or treat them as equal, everything remaining the same.

MARGINAL RATE OF SUBSTITUTION (MRS) OR slope of indifference curve: Marginal rate of substitution is a tool of indifference curve analysis. MRS means the rate at which a consumer will sacrifice the successive units of one good for a marginal increase of another good.

Slope of Indifference curve = MRS = $\frac{\Delta Y}{\Delta X}$

PROPERTIES OF INDIFFERNECE CURVE (IC):

1. An indifference curve slopes downwards: it means that an IC has a negative slope. Negative slope implies that the two goods are substitutes for one another. Therefore, if quantity of one commodity decreases, quantity of the other commodity must increase if the consumer has to stay at the same level of satisfaction.
2. IC is convex to the origin. It is due to diminishing MRS and the goods are imperfect substitutes of each other.
3. ICs do not intersect nor are tangent to each other. If two ICs intersect or be tangent to each other, it would imply that an IC indicates two different levels of satisfaction and violates consistency and transitivity assumption.
4. Higher lC represents a higher level of satisfaction than the lower IC.

2.6.3 Marginal Rate of Substitution (MRS) OR Slope of Indifference Curve

Marginal rate of substitution is a tool of indifference curve analysis. MRS means the rate at which a consumer will forgo (sacrifice) the successive units of one good for a marginal increase of another good.

MRS of good 1 for good 2 is the number of units of good 2 that the consumer is willing to give up for an additional unit of good 1, so as to maintain the same level of satisfaction.

Table 2.7

Bundles	Good 1 (x_1) (Units)	Good 2 (x_2) (Units)	$MRS \rightarrow \frac{Loss}{Gain} \rightarrow \frac{\Delta x_2}{\Delta x_1}$ (Units)
A	1	12	–
B	2	8	4 : 1 or 4
C	3	5	3 : 1 or 3
D	4	3	2 : 1 or 2
E	5	2	1 : 1 or 1

$$MRS = \frac{\text{Change in the quantity of good the consumer is willing to sacrifice}}{\text{Change in the quantity of good the consumer is willing to gain}}$$

For example, when consumer shifts from bundle *A* to *B i.e.*, when he wants to consume 1 more unit of good 1, he has to sacrifice 4 units of good 2.

Numerically :

$$MRS_{x_1x_2} = \frac{\Delta x_2}{\Delta x_1} \frac{(\text{Loss})}{(\text{Gain})} = \frac{4}{1} = 4$$

MRS = Slope of indifference curve

$$MRS_{x_1x_2} = \frac{\Delta x_2}{\Delta x_1}$$

For example, shifting from *A* to *B*

Loss = 4 units

Gain = 1 unit

$$MRS = \frac{\Delta x_2}{\Delta x_1}$$

$$\therefore \quad MRS = \frac{4}{1} \frac{(\text{Loss})}{(\text{Gain})} = 4 \text{ units}$$

Here $\frac{PP_1}{RR_1} > \frac{P_1P_2}{R_1R_2}$

As a consumer increases consumption of 1 good, *MRS decreases*. It is because in order to get every successive unit of good 1, the consumer is *prepared to give up less and less* units of good 2. That is why the indifference curve is convex to the origin (Fig. 2.16).

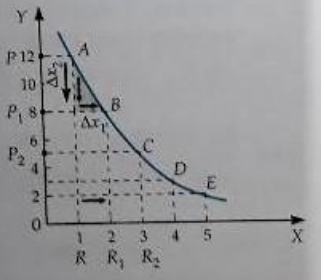


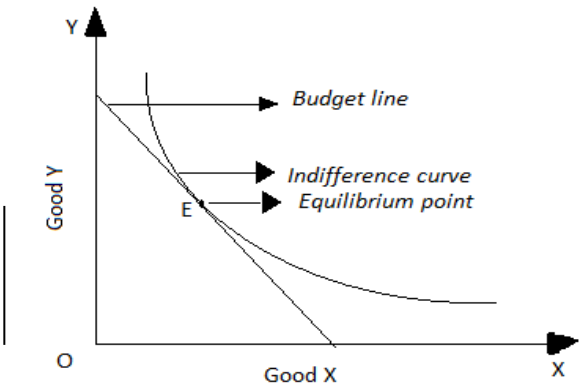
Figure 2.16

CONSUMER EQUILIBRIUM (ORDINAL UTILITY OR INDIFFERENCE CURVE APPROACH):

Consumer is in equilibrium when he maximizes his total utility, given his income and prices of goods and services he consumes. Two conditions must be satisfied for the consumer to be in equilibrium and they are

1. $MRS_{XY} = P_X/P_Y$

2. IC must be convex to the origin.



SLOPE OF IC:

SLOPE of IC is MRS = SLOPE of BUDGET LINE i.e. P_X/P_Y

Important topic:

1. Role of Engineers in the economic development of a country.
2. Microeconomics vs macroeconomics with e.g.
3. Explanation of Law diminishing Utility with diagrams.
4. Consumer's equilibrium conditions using Marginal Utility approach in case of one commodity as well as in case of two commodities.
5. Consumer's equilibrium by using Indifference curve and budget line along with diagram and conditions.
6. Engineering vs Technical vs Economic efficiency

Engineering economy; Engineering Economic Decisions; Engineering efficiency; Relation between science, engineering, technology and economic development.

ECONOMICS

- Prof. Lionel Robbins defines economics as "Science which studies human behaviour as a relationship between ends and scarce means which have alternative means"
- Alfred Marshall defined economics as "A study of mankind in the ordinary business life, it examines that part of individual and social actions which is most closely connected with the attainment and with the use of material requisites' of well-being.
- A study of how limited resources are used to satisfy unlimited human wants.

OBJECTIVES OF ECONOMICS

•A high level of employment •Price stability •Efficiency
•An equitable distribution of income •Growth

FLOW IN AN ECONOMY

1. The flow of goods, services, resources and money payments results in a simple economy
2. Households and business firms are the two major entities in a simple economy.
3. Business organizations use various economic resources such as land, labour and capital which are provided by households to produce consumer goods and services which will be used by them.
4. Business firms make payment to the money to the households for receiving various resources
5. The households in turn make payments to the business organizations

Accreditation Board for Engineering and Technology has adopted the following definition:

Engineering is the profession in which knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize economically the materials and forces of nature for the benefit of mankind.

The role of scientists is to add to humankind's accumulated body of systematic knowledge and to discover universal laws of behaviour. Engineering is an application of science. It is an art composed of skill and ingenuity in adapting knowledge to the uses of humanity. The role of engineer is to apply this knowledge to particular situations to produce products and services.

Modern civilization depends to a large degree upon engineering. Most products and services used to facilitate work, communication, transportation, and national defence and to furnish sustenance, shelter, and health are directly or indirectly a result of engineering activity.

Thus, Engineering activities of analysis and design are not an end in themselves. They are means for satisfying human wants. It has two concerns: materials and forces of nature, and the needs of people. Engineering must be closely associated with economics because of resource constraints. Engineering proposals are evaluated in terms of worth and cost before they are undertaken.

Economics and Engineering

Economics is a big part of an engineer's job. The engineer must translate scientific ideas in products and systems that better mankind. Ideas need to make sense economically and the engineer must be able to convince others that this is so. That is true of any organization that you might join upon graduation.

Why Engineers Study Engineering Economics

Engineering is the profession in which knowledge of the mathematical and natural sciences gained by study experience and practice is applied with judgment to develop ways to utilise economically the material and forces of nature for the benefit of mankind.

Engineers students should prepare themselves with economic empowerment so that they could manage their wealth, help them in starting their own business or during managerial period. It is because money is one of important factor in completing a project. Furthermore, fresh graduates also need to manage their wealth well since a lot of graduates facing problem because lack of information about the loans that they have made. It is necessary to balance the unlimited desire versus the resource-constrained world; to maximize output (worth) given input (cost) and to take the necessary for maximizing efficiency (output/ input or worth cost)"

In the beginning of the 20th century, engineers were mainly concerned with the design, construction, operation of machines structures and processes. Engineers are planners and builders. They are also problem solvers, managers and decision makers.

Engineering Economics is a subject of vital importance to Engineers. This subject helps one understand the need for the knowledge of Economics for being an effective manager and decision maker. It is the application of engineering or mathematical analysis and synthesis to decision making in economics. It is the knowledge and techniques concerned with evaluating the worth of commodities and services relative to their cost. It analyses of the economics of engineering alternatives.

The Economics theories are used to take decisions related to uncertain and changing business environment. Economics theories deal with the principles of demand, pricing, cost, production, competition, trade cycles, and national income and so on.

As a discipline, it is focused on the branch of economics known as microeconomics in that it studies the behaviour of individuals and firms in making decisions regarding the allocation of limited resources. Thus, it focuses on the decision making process, its context and environment

Principles of Engineering Economics:

1. Time value of money: A nearby penny is worth a distant dollar.
2. All that counts are the differences among alternatives.
3. Marginal revenue must exceed marginal cost.
4. Additional risk is not taken without the expected additional return.

ENGINEERING PROCESS

1. Determination of objectives: It involves the search for new objectives for engineering application- to find out what people need and want that can be supplied by engineering.

2. Identification of strategic factors for obtaining the objectives. e.g. developing a device to lift a heavy box.

3. Determination of means: Strategic factors may be achieved in many ways.

4. Evaluation of Engineering Proposals: if the means devised to overcome strategic factors come within the field of engineering, they may be termed engineering proposals. The most desirable of the several proposals is the one that can be performed at the least cost.

5. Assistance in decision making: An important facet of the engineering process is to improve the certainty of decision with respect to the want-satisfying objective of engineering application. Correct decisions can offset many operating handicaps.

SCOPE OF ENGINEERING ECONOMICS

1. Engineering economics plays a very major role in all engineering decisions.
2. It is concerned with the monetary consequences, financial analysis of the projects, products and processes that engineers design.
3. Engineering economics helps an engineer to assess and compare the overall cost of available alternatives for engineering projects.
4. According to the analysis an engineer can take decision from the alternative which is more economic.
5. Engineering economics concepts are used in the fields for improving productivity, reducing human efforts, controlling and reducing cost.

6. Engineering economics helps to understand the market conditions general economic environment in which the firm is working.
7. It helps in allocating the resources.
8. Engineering economics helps to deal with the identification of economic choices, and is concerned with the decision making of engineering problems of economic nature.

Business Decisions are not Simple

- Product design
- Process design (inspection, operations, raw materials)
- Machine selection
- Facility design

All decisions are interrelated. You can't make one without affecting many others. This is especially true when multiple products, periods, stages are involved.

The Question is:

- How do you operate in this environment?
- How does the organization you work for operate?

Engineering economics is entirely involved with evaluating the comparison of alternatives that involve spending money in hopes of earning more.

Engineering Economic Decisions:

In manufacturing, engineering is involved in every detail of a product's production, from conceptual design to shipping. Engineers must consider the effective use of capital assets such as buildings and machinery. One of the primary tasks of engineer is to plan for the acquisition of equipment that will enable the firm to design and produce products economically. Prediction of the performance of an investment into the future is very important.

The term **'engineering economic decision'** defined as any investment decision associated with an engineering project. The aspect of an economic decision that is of most interest from an engineer's perception is the evaluation of benefits and costs associated with making a capital investment. These decisions are to be made by the Engineers considering all the factors such as cash flows, time of occurrence, interest. The decision affects what will be done and the numbers used in this analysis are the best estimates of what is expected to occur in the future.

The five main types of engineering economic decisions are

(1) Equipment or process selection.
(2) Replacement of equipment
(3) New product or product expansion
(4) Reduction of cost
(5) Improvement in quality or service.

Steps for decision-making process:

Understand the problem and define the objectives.
Collect relevant information.
Define the viable alternative solutions and make realistic assessments.
Identify the criteria for decision making using one or more features.
Evaluate each and every alternative using sensitivity analysis to enhance the estimate.
Select the best and reliable alternative.
Implement the best solution and regularly monitor the results.

ENGINEERING EFFICIENCY, TECHNICAL EFFICIENCY & ECONOMIC EFFICIENCY:

- **ENGINEERING EFFICIENCY:** It is defined as the ratio of output to the input of a physical system. The physical system may be a diesel engine, shop floor, machine working etc. It is the physical amount of some single key input used in production and is measured by the ratio of that input to output.

Engineering efficiency is the ratio between the energy needed to power an engine or process and the energy the engine or process creates. The greater the engineering efficiency ratio, the more efficient the process. In manufacturing, production line designers and managers use engineering efficiency calculations to save energy and money.

One simple example is a steam boiler. If the boiler's efficiency is 55 percent, 55 percent of the energy that runs the boiler converts to work, and the remaining 45 percent of energy used is lost. In a boiler, the lost energy could be heat, friction or other factors.

Maximizing engineering efficiency in a process or machine generally takes time, tweaking and experimentation. Boeing took years to design its Dreamliner 787, but the end result was a plane that has fewer

parts than typical commercial jetliners, which simplifies maintenance, and that burns 20 percent less fuel than comparable airplanes. Boeing engineers faced a considerable amount of criticism due to how long it took before the airplane starting hitting the assembly line. However, the success of the 787 demonstrates the merit of investing in efficiency.

More efficient designs save money for manufacturers over entire manufacturing process. Some processes can reduce the amount of raw materials needed to create a finished product, which lets companies save money that would otherwise be sent to suppliers. Using prototype and testing shops can lead to improvements throughout the production line, and more efficient machines can add or remove steps from the production line to make the process more efficient.

Engineering efficiency (%) = (Output/Key Input) x 100

Engineering efficiency does not take financial considerations. It is purely about physical relationships.

Ex. engineering efficiency of an engine: Let a steam engine is 40 percent efficient means that 40 percent of the energy in the fuel is converted into work done, while the other 60 percent is lost in friction, heat loss, and other unavoidable sources of waste.

Let's suppose we have a system which receives a power as input and outputs another power. The efficiency is the ratio between the output and input power.

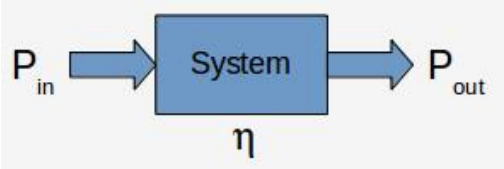


Image: Efficiency of a system

The symbol used to define efficiency is the Greek letter eta (η):

$$\eta = P_{out} \text{ divided by } P_{in}$$

If we want to express the efficiency as percentage the mathematical expression becomes:

$$\eta = P_{out} / P_{in} \, x100[\%]$$

For example if we take an electric motor which receives a 1000 W power from a battery and outputs 900 W at the rotor, what is the efficiency of the motor?

$$\eta = 900/1000x100=90\%$$

Where are the remaining 100 W gone? Why aren't they available at the motor output (rotor)?

The answer is simple. Since the rotor is mounted on some bearings, there is an amount of friction in the bearings. The friction absorbs a part of the input power and transforms it into heat. Also there are some winding losses in the motor itself. The friction losses together with the winding losses reduces the output power of the motor.

$$P_{out} = P_{in} - P_{loss}$$

- **Technical Efficiency:** is related to physical amount of all resources used in producing a product.

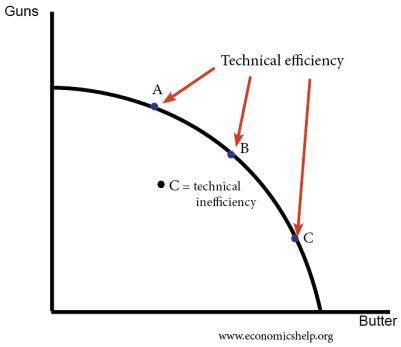
Technical efficiency (%) = (Output produced / All Input resources) x 100

Thus technical efficiency is about getting the most output from any given set of inputs; or, equivalently, about producing a given level of output using the least amount of physical inputs. Ex. Technical efficiency of a diesel engine Technical efficiency (%) = (Heat equivalent of mechanical energy produced/ Heat equivalent of fuel used) x 100

EX., Let a firm is using 100 units of labour and 50 units of capital to produce a level of output. If the firm could maintain its output level by using only 90 units of labour without using more capital, then it is being technically inefficient in current methods as it is "wasting" 10 labour units.

Technical efficiency is the effectiveness with which a given set of inputs is used to produce an output. A firm is said to be technically efficient if a firm is producing the maximum output from the minimum quantity of inputs, such as labour, capital, and technology.

Technical efficiency requires no unemployment of resources.



many different ways and thereby achieving different combinations of all goods and services. The collection of all such combinations of goods and services is called the *production possibility set of an economy*.

1.8.1 Meaning of Production Possibility Curve (PPC)

Production Possibility Curve shows graphical presentation (or is the locus) of various combinations of two goods that can be produced with available technologies and given resources assuming that the resources are fully and efficiently employed (utilised).

1.8.2 Assumptions to Draw Production Possibility Curve (PPC)

1. The resources available are fixed.
2. The technology remains unchanged.
3. The resources are fully employed.
4. The resources are efficiently employed.
5. The resources are not equally efficient in production of all products. Thus if resources are transferred from production of one good to another, the cost increases. In other words, marginal opportunity cost increases.

The last assumption needs explanation because it determines the shape of the PPC. If this assumption changes, the shape changes.

Efficiency in production means productivity *i.e.*, output per unit of an input. Let the input be worker. Suppose an economy produces only two goods X and Y. Suppose a worker is employed in production of X because he is best suited for it. The economy decides to reduce production of X and increase that of Y. The worker is transferred to Y. He is not that efficient in production of Y as he was in X. His productivity in Y will be low, and so cost of production high.

The implication is clear. If the resources are transferred from one use to another, the less and less efficient resources will be transferred leading to rise in the **marginal opportunity cost** which is technically termed as **marginal rate of transformation** (MRT).

For example, let us assume that the economy has decided to produce wheat and cloth. Different combinations of wheat and cloth can be represented through the following schedule and diagram.

Table 1.2

Combinations or Possibilities	Production of Wheat (Units)	Production of Cloth (Units)	MOC/MRT $\frac{\text{Loss}}{\text{Gain}}$
A	0	10	–
B	1	9	1
C	2	7	2
D	3	4	3
E	4	0	4

Table 1.2 shows hypothetical possibilities of production of wheat and cloth. If economy uses all its resources to produce cloth then maximum 10 units of cloth can be produced and if entire resources are used to produce wheat, then maximum 4 units of wheat are produced, there exist various other combinations between A and E (the extreme possibilities) *e.g.*, 1 unit of wheat and 9 units of cloth etc.

When the above data is plotted on a graph, we get PPC (Production possibility curve) as given in Fig. 1.3.

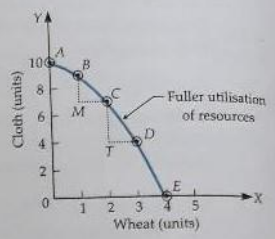


Figure 1.3

AE is PPC which shows various combinations of two goods wheat and cloth. Point *A* shows maximum produc- tion of cloth *i.e.*, ten units with zero amount of wheat and point *E* shows maximum amount of wheat *i.e.*, 4 units with no amount of cloth. In between *A* and *E* there are various possibilities (*B, C, D*) of production of wheat and cloth. When points *A, B, C, D, E* are joined, we get a curve *AE*. This curve is called *production possibility curve/ transformation curve* as we transform from production of one good to the other. We can measure **MRT on PPC**.

For example, MRT between the possibilities *B* and *C* is equal to $\frac{BM}{MC}$ and between *C* and *D* is $\frac{CT}{TD}$.

Since *MRT* is rising, PPC is concave in shape.

1.8.3 Characteristics/Properties of Production Possibility Curve (PPC)

1. PPC slopes downwards

In a situation of fuller utilisation of resources, production of both the commodities cannot be increased *i.e.*, more production of one good is associated with less production of the other, because resources are scarce. In the above example, when production of wheat rises, production of cloth falls *i.e.*, ↑ wheat and ↓ cloth (–ve relation) as resources are withdrawn from production of cloth to produce more of wheat.

2. PPC is concave to the point of origin

A typical PP curve is taken to be concave curve because it is based on a more realistic assumption that no resource is equally efficient in production of all the goods. So when resources are transferred from *Y* to *X* more and more units of *Y* are to be transferred to produce one more unit of *X*.

PPC is concave because in order to produce an additional unit of wheat, more and more units of cloth are sacrificed. In other words, MOC/MRT rises. It means that opportunity cost of every additional unit of wheat tends to increase in terms of loss of production of cloth. Economic reason of increasing MOC is that as more and more of one good is produced, factors producing it become less and less productive. Hence more units of other good (cloth) are sacrificed to ensure a unit increase of former good (wheat). This is because of application of *Law of diminishing returns* or law of *increasing opportunity costs*. However PPC may be straight or convex also as explained in Section 1.8.3A.

1.8.3A Marginal Opportunity Cost (MOC) Determines Shape/Slope of PPC

Production Possibility Curve (PPC) can have *three* shapes :

1. Convex 2. Straight 3. Concave.

Hence, there are *three* possibilities.

- **Economic Efficiency** is related to the value or cost (rather than the physical amounts) of all inputs used in producing a given output. It is defined as the ratio of output to the input of a business system. Worth is the annual revenue generated by the way of operating business and cost is the total annual expenses incurred in carrying out the business.

Economic efficiency (%) = (Output/ Input) x 100 = (Worth/ Cost) × 100

The production of a given output is economically efficient if there are no other ways of producing the output that use a smaller total value of inputs.

Ex. a firm has three alternative production methods. First require a lot of labour but only a little capital, second requires a lot of capital and only a little labour, while third production method may require a lot of land but relatively little of both labour and capital. In order to be economically efficient (maximize its profits) the firm should choose the production method that costs the least.

Economic efficiency is also called 'productivity'.