The Production Possibility Curve

CHAPTER 6

INTRODUCTION

The production function is purely a technical relation which connects factor inputs and outputs. This function represents the technology of a firm or an industry of the economy as a whole. It also includes all the technical efficient methods of production of one unit of output. Usually, a commodity may be produced by various methods of production.

OBJECTIVES

At the end of this chapter, students should be able to:

◆ Define a production possibility curve;
◆ Construct the production possibility schedule and draw its curve;
◆ Explain the concept of productivity through total physical product, average and marginal physical products;
◆ Construct the hypothetical table of total, average and marginal physical products and draw their curves;
◆ Explain through the use of a graph the relationship existing among total, average and marginal products;
◆ State the law of variable proportions.

6.1 Definition of Production Possibility Curve

A Production Possibility Curve (PCC) is a graphical presentation which shows that locus of points of levels of two quantities of X and Y which use up all the variable resources of the fi rm.

Considering the importance of production as a major solution to the economic problem of “what to produce” and the endless number of “ends” to satisfy in an economy (e.g. better roads, more houses and better education for the younger ones). The firm must choose what they can produce given their limited resources of men, land and machines which can be used in a number of ways.

6.2 Production Possibility Schedule and Curve

Let us take a look at what is often called a Production Possibility Curve. For example, if there were a fixed number of workers, machines, money and land, the amount could be devoted to the production of either tractors or tanks. Let us consider a hypothetical table of possible levels of output.

TABLE 6.1 Tractor and Tank Units

	Tractor Units	Tank Units
a	30	–
b	28	6
c	24	12
d	16	18
e	–	24

The tractor units may be in hundreds and the tanks in fifties. These levels of output may be plotted on a graph as shown below.

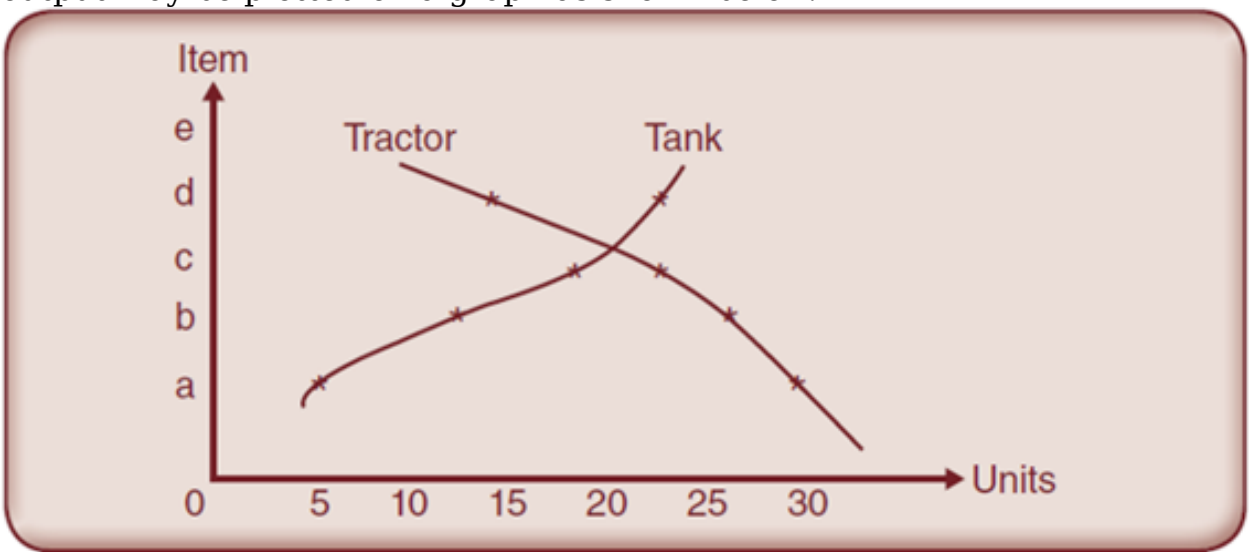

FIG. 6.1 Production possibility curve for tractors and tanks

It can be seen that in moving from point (a) to point (b) with a production of 2 tractor units, resources can increase the output of tanks by 6 units. Moving up a further 4 tractor units, that is moving from point (b) to (c), increases the output of further 6 units of tanks and so on. The opportunity cost of increasing tank production from 6 to 12 units is 4 units of tractors and the opportunity cost of increasing tractor production from 16 to 24 units is 6 tanks. A common tendency of this Production Possibility Curve should be noted here. Assuming that the community has chosen the position (a) and wishes to move to (b), it will give up 2 units of tractors to produce 6 units of tanks.

However, to move from position (b) to (c), that is for a further 6 units of tanks, 4 units of tractors will now have to be given up. To produce a further 6 units (moving to (d) from (c)) involves the given up of not 4 but 8 units of tractors. The more the effort devoted to the stepping up of production of one article, the greater the sacrifice of the other, thereby increasing opportunity cost.

6.3 Concepts of Productivity

There are three different concepts of productivity, namely total physical

product, average physical product and marginal physical product.

6.3.1 Total Physical Product

This concept refers to the total output of a commodity produced by the combination of fixed and variable factors. As the number of variable inputs increase, the fixed factor remaining constant, the total output will increase but in a disproportionate manner. As an example, let us take to production of cotton on a plot of 10 acres, by combining a lot of labour.

Table 6.2 is a hypothetical table, showing the different quantities of outputs of land with different units of labour employed. This table is illustrated in Fig. 6.2. It may be observed from the table and the figure that the total product increases first at an increasing rate from 10 to 22 (i.e. by 2 tonnes) later the total output increases but at a diminishing rate – from 52 to 66 (i.e. by 14 tonnes) from 66 or 76

TABLE 6.2 Output of Cotton on a 10 Acre of Land

Number of Workers	Total Output of Cotton (in tonnes)
1	10
2	22
3	36
4	52
5	66
6	78
7	82
8	85
9	85
10	83

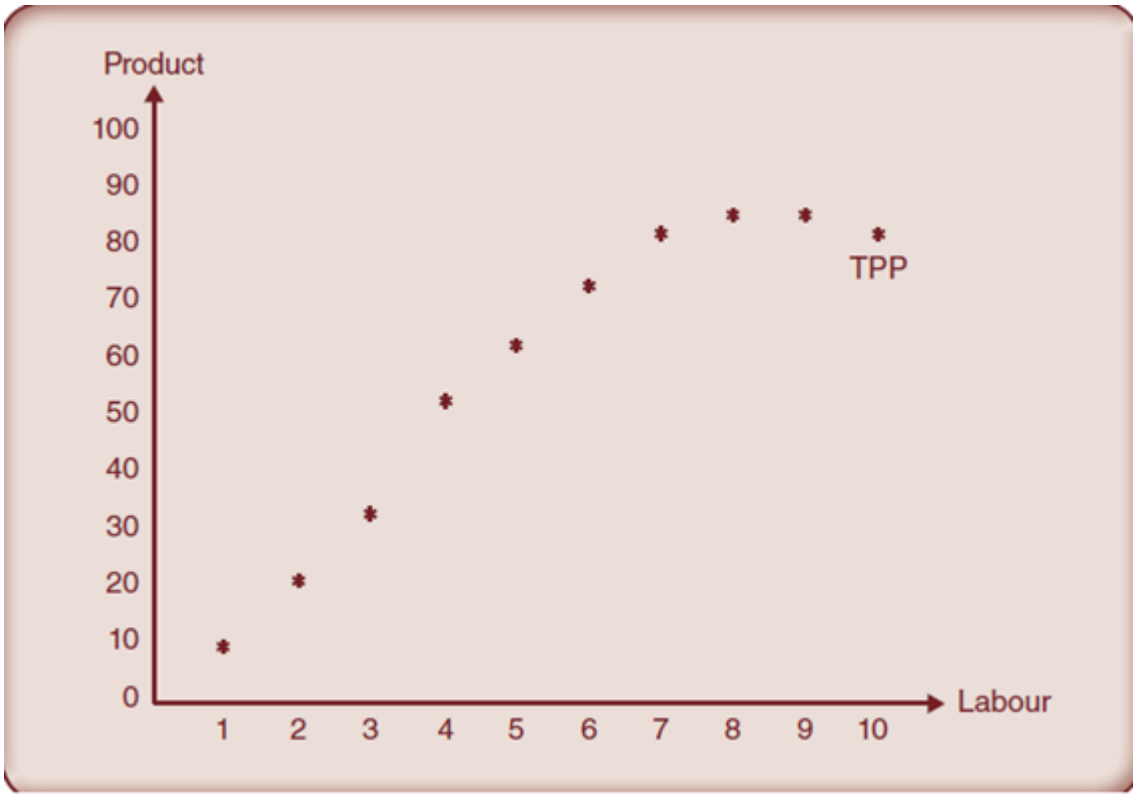

FIG. 6.2 Production of cotton

(i.e. by 10 tonnes) and so on. The total product curve first rises more rapidly, then slowly until it reaches the maximum and then finally begins to decrease. In fig.6.2 we have taken a plot of 10 acres combined with more units of labour. This is what the economist refers to as the intensive application of land. On the other hand, we can take different plots of land each of 10 acres, and then combine each plot with different units of labour. For example the first plot is combined with one worker to produce 10 tonnes of cotton, the second plot is combined with three workers to produce 36 tonnes, and so on. This is the extensive application of land, however, the principle of returns to scale will be the same in both cases.

6.3.2 Average and Marginal Physical Products

Average product refers to the output of one variable unit. It is calculated by dividing the total product by the number of variable inputs. If three workers produce 36 tonnes of cotton, the average output of product of one worker is 12 tonnes; whereas if four workers produce 52 tonnes of cotton, the average output per worker will be 13 tonnes. Marginal product, on the other hand, refers to the additional output, i.e. addition to the total output for an additional input. For instance, if two workers produce 22 tonnes and three workers produce 36 tonnes, the marginal worker is the third worker and the marginal product of output is 36 – 22 tonnes = 14 tonnes. The marginal worker
is the additional worker and marginal output is the addition to the total output because of the use of the additional worker. Table 6.3 below hypothetically illustrates average and marginal products.
Table 6.3 and Fig 6.3 illustrate total, average and marginal products of a typical production with a fixed factor. Both average and marginal products first rise, reach maximum and then decline. However, the marginal product rises at a fast rate and then declines at a faster rate. In other words, marginal product exceeds average product when the latter is rising, it equals average product when the latter is at maximum, and it lies below average product when the latter is falling. This relationship between them can be easily understood from the definitions of average and marginal outputs.

TABLE 6.3 Average and Marginal Products of Cotton on a 10-acre Plot of Land

Number of Workers	Total Output (in tonnes)	Average Output of Labour (in tonnes)	Marginal Output of Labour (in tonnes)
1	10	10	10
2	22	11	12
3	36	12	14
4	52	12	16
5	66	13.2	14
6	76	12.7	10
7	82	11.7	6
8	85	10.6	3
9	85	9.5	0
10	83	8.3	–2

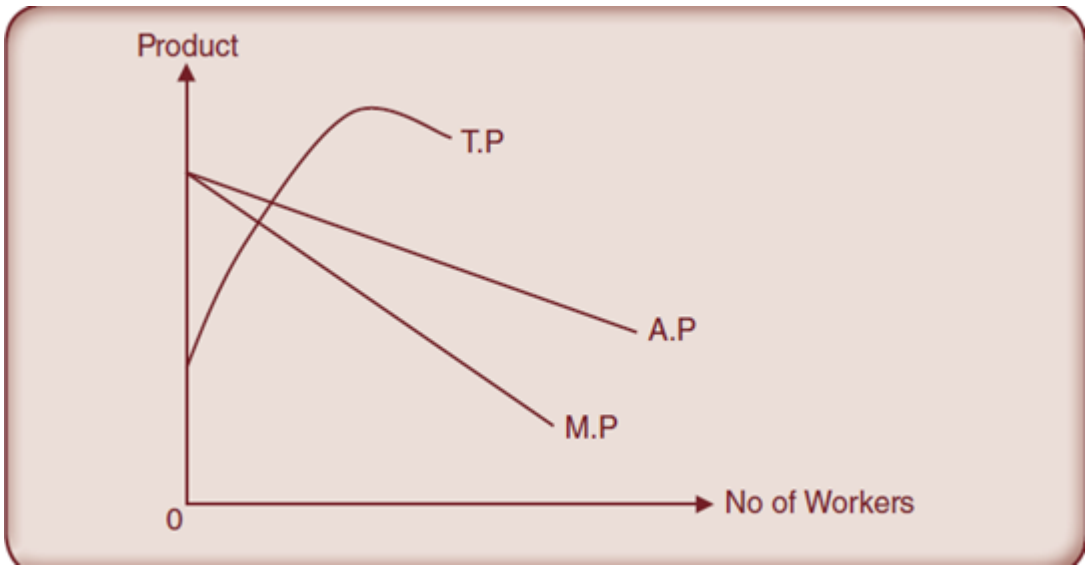

FIG. 6.3 Average and marginal products

From these discussions, it follows that marginal output is the additional output while the average output is the output for one unit of a variable factor. As long as the addition to the total is greater than the previous average, the average must increase. If the addition to the total is less than the previous average, the newly computed average must be less. Therefore, since the additional output (marginal output) first rises and then declines, so also must the average output, making the two curves intersect at the point where the average curve reaches its maximum.

Another notable feature of average and marginal products is that, after a stage, both average and marginal outputs decline. It is possible for the average product to decline to zero. Marginal product, on the other hand, may fall to zero and can actually become negative as shown in fig 6.4.

6.3.3 Total, Average and Marginal Product

The relationships as described so far, between total, average and marginal

products, can be illustrated with the help of fig 6.4. The total product curve shall be considered first. As more units of the variable factor (labour) are combined with the fixed factor (land), the total output rises gradually and then rapidly, reaching a maximum rate of increase (i.e. maximum slope) at point A. So far the slope of the total product curve is equal to the marginal product, the maximum slope of the total product curve (point A) corresponds to the maximum point of the marginal product curve (point B lies directly below A).

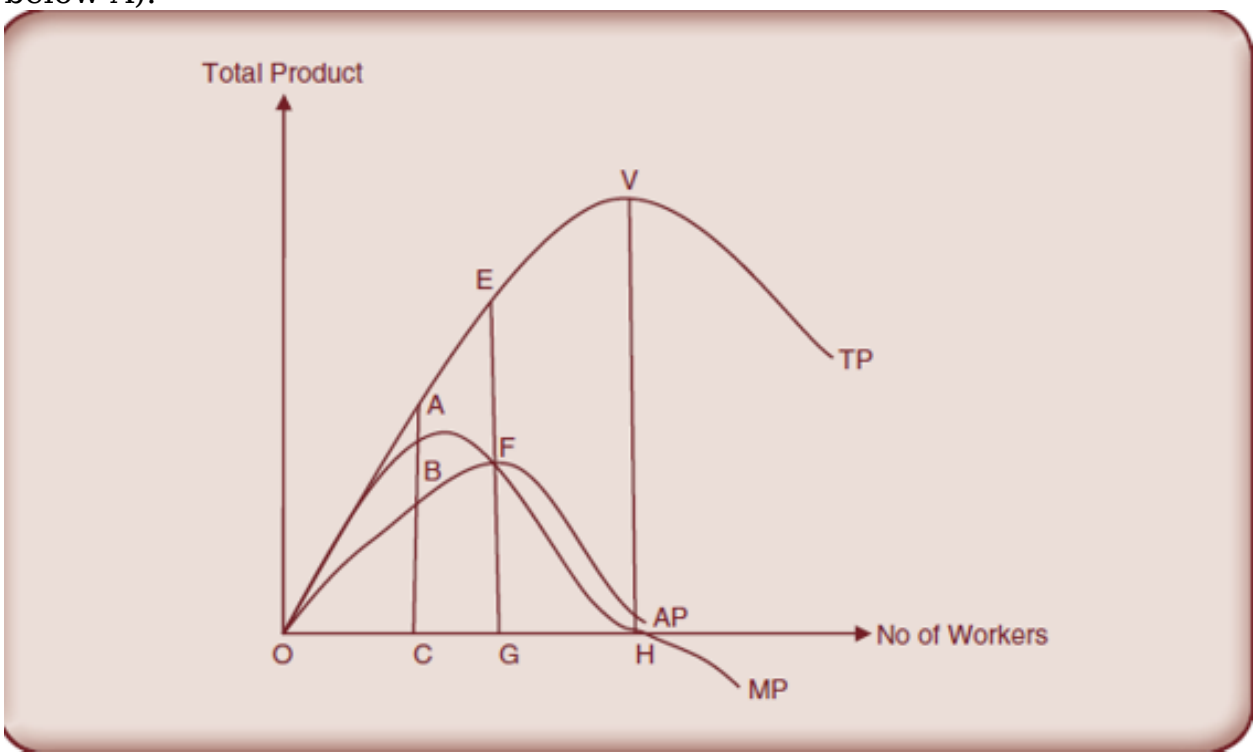

FIG. 6.4 Total, Average and Marginal product curves

Even after point A, the total product curve continues to rise but the rate of increase decreases and so its slope is less steep. The marginal product curve, therefore declines after point B. At point E, the line from the origin is tangential to the total product curve and, therefore, it corresponds to the maximum average product (point F). At this point, the marginal product is equal to the average product. It will be observed that point F is directly below point E.

At point E, the total product curve continues to rise but the rate of increase is progressively slow until the total product reaches the maximum at point V. At this point, the slope of the total product is zero, while the corresponding marginal product is zero. Beyond OH units of the variable inputs, total output will decline and the marginal product will be negative.

Both the average and marginal product curve are rising but the marginal product curve rises at a faster rate than the average product.

After point B, the marginal product starts declining, though the average product continues to rise. At the maximum point of average product curve, the marginal product becomes equal to the former.

During the downward phase, both the average product and marginal product decline but the latter declines at a faster rate. Finally, the marginal product becomes zero and even negative. As long as the marginal product is rising, the average product lies below it; but when the marginal product is declining the average product lies above it.

6.4 The Law of Variable Proportions

When two factor units are combined, there is one combination which may be regarded as the optimum combination or the best proportion between the factors. As our variable factor is increased from this point, the proportions get worse all the time. This will lead to a diminishing return which is called

the law of variable proportion.
The law states that if increasing quantities of variable factors of production are used in conjunction with a fixed quantity of another factor of product, after a certain point each successive unit of the variable bring about a decreasing marginal product.
The three stages of production and least cost combination of factors are analysed below:

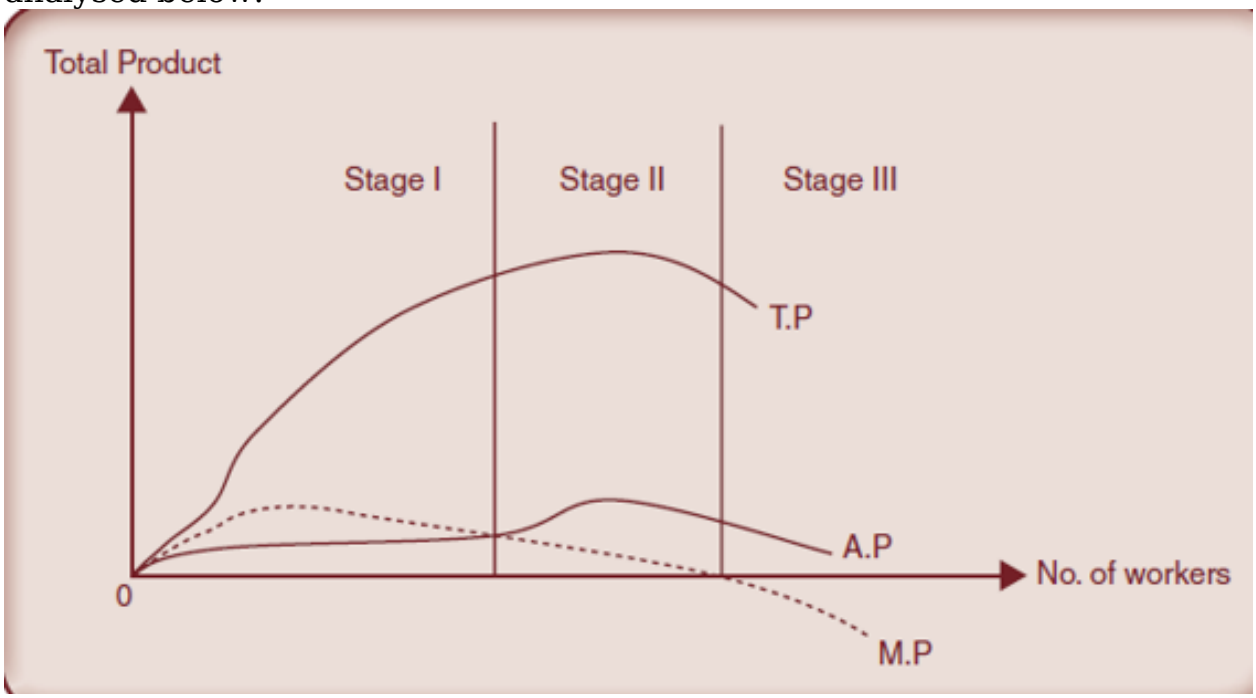

FIG. 6.5 Three stages of production and least cost combination of factors

■ The first stage of production is characterized by an increase in (a) the average product of labour and (b) the total product per unit of land. At the bounding of the first and second stages, the efficiency of labour is maximum, while the average product per unit of labour is at the peak.
■ The second stage of production is characterized by a decrease in the average and marginal products of labour, but the efficiency of land, that is product per unit of land, continues to rise. At bounding of stages two and three, the marginal product reaches zero, while the total product per unit of load reaches the maximum.
■ The third stage of production is characterized by a decrease in the average product of labour and negative marginal product, thereby decreasing the total product. The efficiency of labour as well as the efficiency of land decrease when the firm enters into the third stage. Two things may be emphasized here:
a. The addition of labour to land, which leads to maximum efficiency of labour, lies at the bounding of stages one and two.
b. The combination of labour and land, which leads to maximum efficiency of land, lies in the boundary of stages two and three.

Summary

This chapter has discussed:
❖ The Production Possibility Curve which is a graphical presentation which shows that locus of points of levels of two quantities of X and Y which use up all the variable resources of the firm.
❖ The concepts of total physical product which refers to the total output of a commodity produced by the combination of fixed and variable factors. Average product refers to the output of one variable unit. It is calculated by dividing the total product by the number of variable inputs, while Marginal product, on the other hand, refers to the additional output, i.e. addition to the

total output for an additional input.
❖ The law of variable proportions which states that if increasing quantities of variable factors of production are used in conjunction with a fixed quantity of another factor of product, after a certain point, each successive unit of the variable brings about a decreasing marginal product.

Class Activities

(a) The teacher should write on the board hypothetical table of total, average and marginal product and instruct the students to draw the data on the table on the graph sheet.
(b) Students should study the law of variable proportions and recite it in the class.

Revision Questions

Objective Questions

1. The third stage of production on the variable proportion graph is characterized by:
(a) a decrease in the average product of labour and negative marginal product, thereby decreasing the total product.
(b) an increase in the average product of labour and positive marginal product, thereby decreasing the total product.
(c) an increase in the average product of labour and positive marginal product, thereby increasing the total product.
(d) a decrease in the average product of labour and positive marginal product, thereby increasing the total product.

Fixed Unit of Land	Variable Unit of labour	Total Output (TO)	Marginal Product (MP)
5	1	10	10
5	2	25	15
5	3	X	21
5	4	60	14
5	5	73	13
5	6	82	Y

2. Which of the following pairs gives the values of X and Y in the table?
(a) X = 20 , Y = 6
(b) X = 10 , Y = 10
(c) X = 38 , Y = 9
(d) X = 46 , Y = 9
(e) X = 46 , Y = 14
3. Decreasing returns to scale implies that if all factors of production are doubled, output will be:
(a) more than doubled
(b) less than doubled
(c) doubled
(d) unchanged

(e) trebled **(SSCE 1996)**
4. As a firm expands, it enjoys some advantages called:
(a) variable proportions
(b) diminishing marginal returns
(c) internal economies of scale
(d) decreasing returns to scale **(SSCE 2004)**
5. The relationship between Marginal Product (MP) and Average Product (AP) is such that they are equal when:
(a) Average Product is maximum
(b) Average Product is minimum
(c) Marginal Product is maximum
(d) Marginal Product is increasing **(SSCE 2009)**

Essay Questions

1. Explain each of the three stages of law of variable proportions by using the hypothetical diagram showing the behaviour of the total product, marginal product and average product.
2. Table of Input and Output

Variable Units of Labour	Fixed Factors (Hectres of land)	Total Product (kg)	Average Product (kg)	Marginal Product (kg)
1	3	8	8	-
2	3	18	9	10

Variable Units of Labour	Fixed Factors (Hectres of land)	Total Product (kg)	Average Product (kg)	Marginal Product (kg)
3	3	36	P	18
4	3	48	12	12
5	3	55	11	7
6	3	60	Q	5
7	3	60	8.6	S
8	3	56	7	T

Use the table to answer the following questions:
(a) Complete table by calculating the missing figures P, Q, R, S.T
(b) Draw the Total Product (TP) and Marginal Product (MP) curve in one diagram.
(c) Explain the relationship between TP and MP. **(SSCE 1995)**
3. The table below relates to the application of fertilizer to a fixed area of land and the production of maize. Use the table to answer the questions that follow:

Tonnes of Fertilizer Applied	Total Production in Bags	Marginal Product
0	1000	-
1	1100	100
2	1250	150
3	1500	250
4	------	400
5	-------	250
6	--------	125
7	2350	---------
8	2380	-------
9	2330	-------

(a) What will be the total output of maize when no fertilizer is applied to the land?
(b) Calculate the total product after the application of the following quantities of fertilizer: (i) 4 tonnes (ii) 5 tonnes (iii) 6 tonnes
(c) Calculate the marginal product after the application of the following quantities of fertilizers (i) 7 tonnes (ii) 8 tonnes (iii) 9 tonnes
(d) (i) After what level of the application of fertilizer does diminishing marginal returns occur?
(ii) After what level of fertilizer application will the total output decrease?
(SSCE 1999)
4a. The table below shows the various possible combinations of military and civilian goods produced by a country, using the available resources and technology. Use the table to answer the questions that follow:

Military Goods (in tonnes)	Civilian Goods (in tonnes)
0	200
20	160
40	120
60	80
80	40
100	0

(a) Draw the production possibility curve (PPC).
(b) Indicate points **S** and **K** at which production is not feasible.
(c) Indicate points **M** and **N** at which resources are **not** efficiently utilised
(d) What does the downward slope of the PPC indicate?
(e) Why is production not feasible at points **S** and **K. (SSCE 2001)**
5 (a) State the law of diminishing returns.
(b) What is (i) marginal product (ii) average product? **(SSCE 2007)**

Glossary

Production Possibility Curve: It is a graphical presentation which shows the locus of points of levels of two quantities of X and Y which use up all the variable resources of the firm.
Total Physical Product: This refers to the total output of a commodity produced by the combination of fixed and variable factors.
Average physical product: This refers to the output of one variable unit and it is calculated by dividing the total product by the number of variable inputs.
Marginal physical product: This refers to the additional output, i.e. addition to the total output as a result of an additional input.