Production

Introduction

- **Production** refer to an **economic** term to describe the inputs that are used in producing the goods or services in the attempt to make an **economic** profit.

Input-> Process (Production)-> Output

- The factors of **production** include land, labor, capital and entrepreneurship.
- Basic five “M”s of production or factors of production:

i) Men

ii) Material

iii) Money

iv) Machine

v) Methods

Output, Q = f(Inputs)

Theory of production

- **Theory of production** is an effort to explain the principles by which a **business firm decides how much of each commodity that it sells (its "outputs" or "products") should be produced, and how much of each kind of input (labour, raw material, fixed capital good, etc.,) needs to be employed**.
- The theory involves some of the most fundamental principles of economics. These include the relationship between the prices of commodities and the prices (or wages or rents) of the productive factors used to produce them.

The Organization of Production

- Inputs
  - Labor, Capital, Land

Fixed Inputs and Variable Inputs

- Short Run
  - At least one input is fixed
- Long Run
  - All inputs are variable

- A firm's production function is of the form:

$$Q = f(Ld, L, K, M, T, t)$$

  - where Ld = land and building; L = labour; K = capital; M = materials; T = technology; and, t = time.

$$Q = f(K, L)$$

- Increasing production, Q, will require K and L, and whether the firm can increase both K and L or only L will depend on the time period it takes into account for increasing production, that is,
- whether the firm is thinking in terms of the short run or in terms of the long run.
- In the **short run** firms can increase production only by increasing **labour**, since the supply of capital is fixed in the short run.
- In the **long run**, the firm can employ more of both **capital and labour**, as the supply of capital becomes elastic over time.

Production Function

- **Following assumptions are made:**
  - The firm operates in a short-run production period where labor is variable, capital is fixed.
  - The firm uses the inputs to produce a single product.
  - The firm operates with a fixed level of technology.
  - The firm operates at every level of output in the most efficient way.
  - The short-run production function is affected by the law of diminishing returns.

- In the short run, capital is fixed Only changes in the variable labor input
- Can change the level of output
- Short run production function:

$Q=f(L, K)$, where K is constant

$Q= bL$

"b" gives constant returns to labor

$$b= \frac{\Delta Q}{\Delta L}$$

Assumptions for short run production

- At least one input is fixed: labor is the only variable cost
- Labor is homogeneous,
- The state of technology is given,
- Input prices are given

Production Function with Two Inputs

$$Q = f(L, K)$$

K							Q
6	10	24	31	36	40	39	
5	12	28	36	40	42	40	
4	12	28	36	40	40	36	
3	10	23	33	36	36	33	
2	7	18	28	30	30	28	
1	3	8	12	14	14	12	
	1	2	3	4	5	6	L

Total Product $TP = Q = f(L)$

Average Product $AP_L = \frac{Q}{L}$

Marginal Product $MP_L = \frac{\Delta Q}{\Delta L}$

- MP is change in total production, when we increase one worker, eg: from 3 workers now we have 4.

Production or Output Elasticity $E_L = \frac{MP_L}{AP_L}$

Practice

- Calculate Total, Marginal, and Average Product of Labor, and Output Elasticity for following Labor and Output.

S. No	L	Q
1	1	3
2	2	8
3	3	12
4	4	14
5	5	14
6	6	12

L	Q	MP_L	AP_L	E_L
0	0	-	-	-
1	3	3	3	1
2	8	5	4	1.25
3	12	4	4	1
4	14	2	3.5	0.57
5	14	0	2.8	0
6	12	-2	2	-1

Laws of Production

Two laws of production:

1. Law of Variable proportion (Short run)

$$Q=f(L)$$

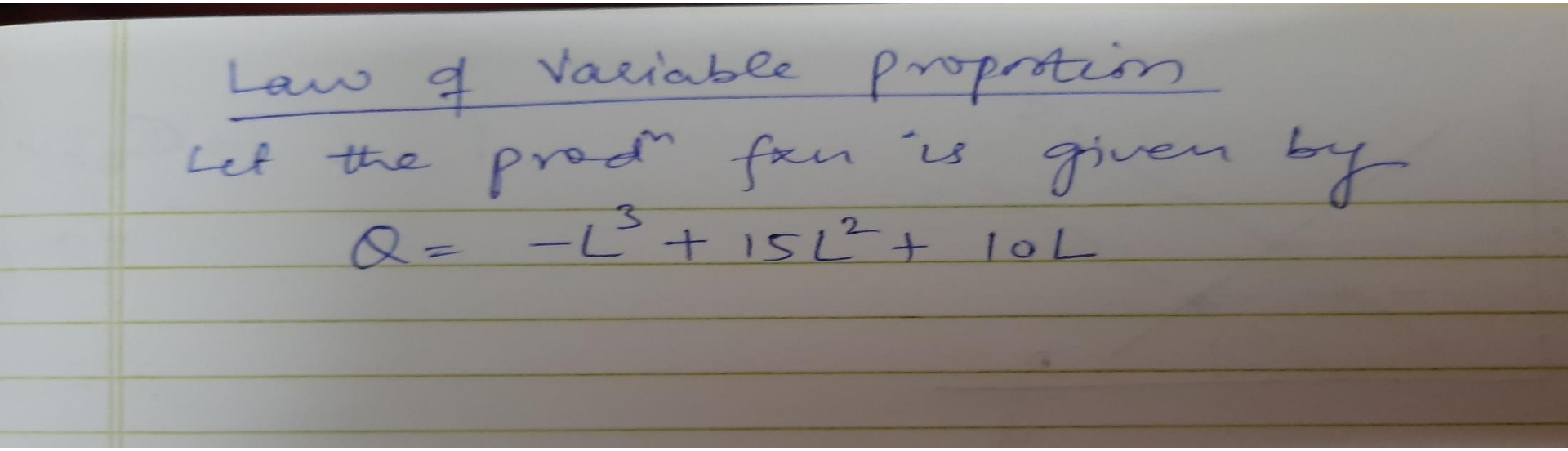
2. Law of return to scale (Long run)

$$Q=f(L, K)$$

Law of Variable proportion

Statement: When more and more number of units of variable input are applied to a given quantity of fixed input, the total output may initially increase at an increase rate then at a constant rate but it eventually increase at a diminishing rate. *We may get negative returns (Stage 4).

- The law is also called law of diminishing returns.



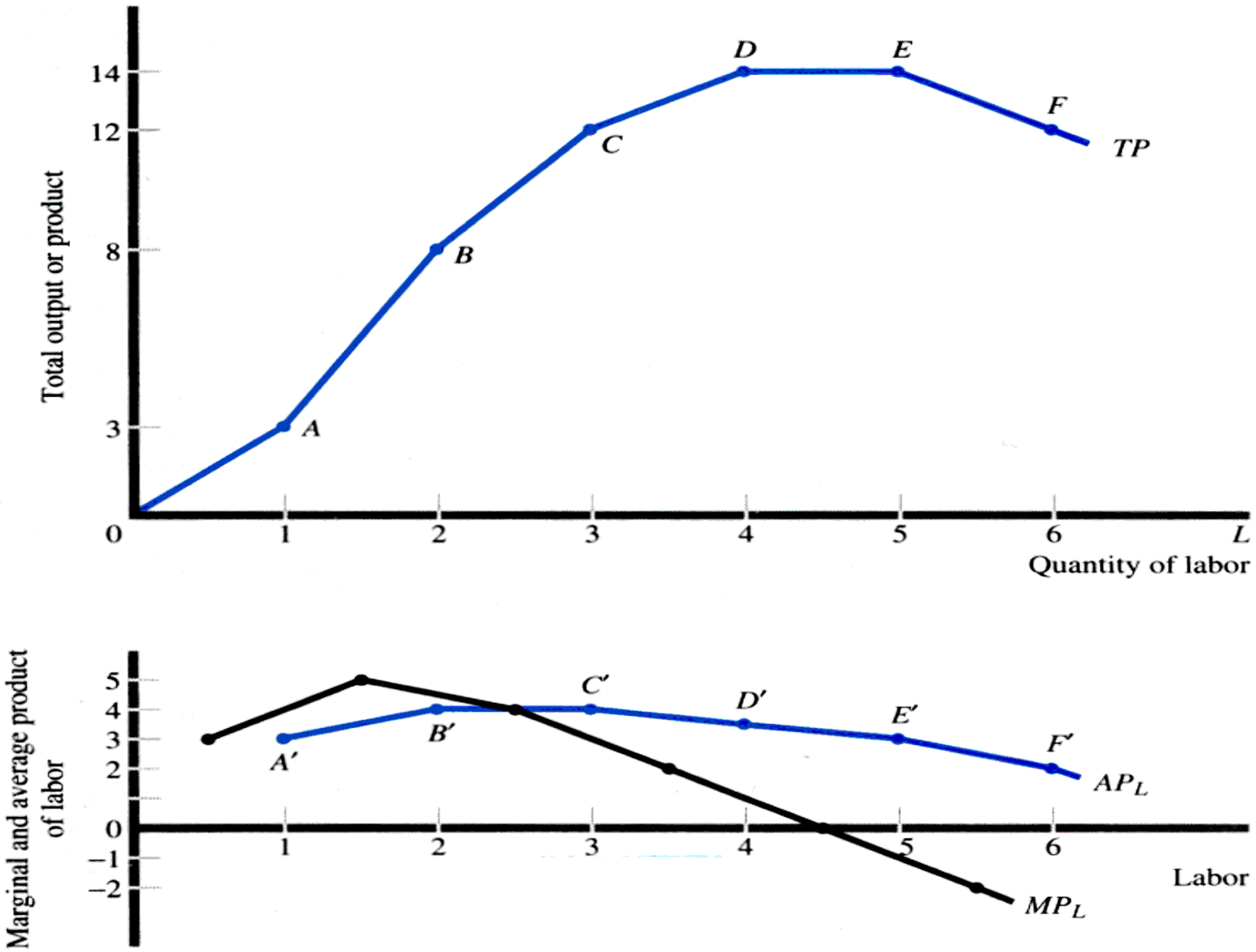
Identify the various stages of production with the given production function.

Table 1

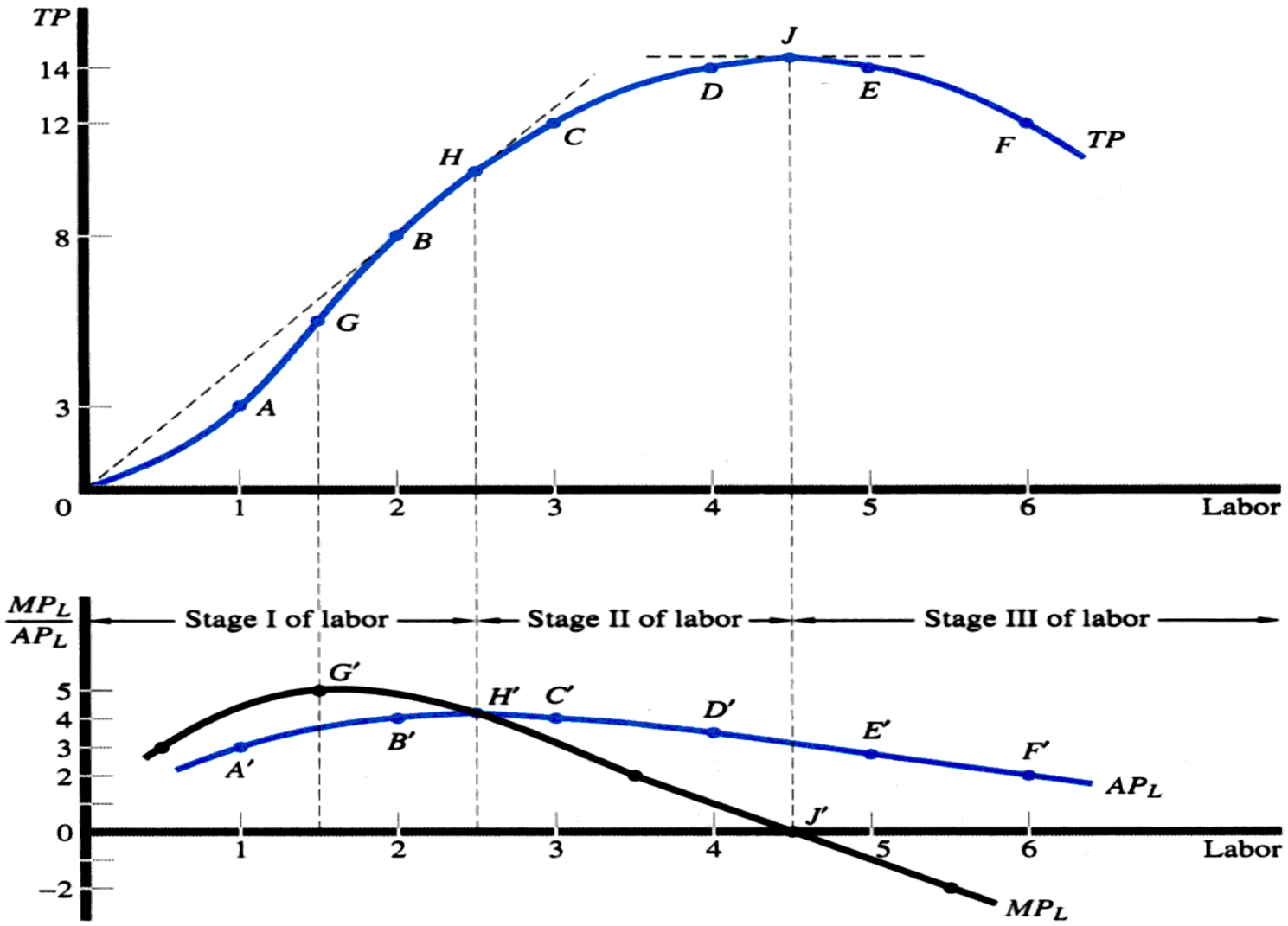
L	Q or TP	MP		AP
1	24	—		24
2	72	48	One returns	36
3	138	66		46
4	216	78		54
5	300	84		60
6	384	84	Const returns	64
7	462	78		66
8	528	66	Dec returns	66
9	576	48		64
10	600	24		60
11	594	−6	Negative returns	54
12	552	−42		46

Three stages in production

- Stage I: Stage of Increasing Returns
  - In Stage I, MP and AP both are rising, and the MP is more than AP.
- Stage II: Stage of Decreasing Returns
  - In Stage II, MP and AP both are falling and MP through positive, is less than AP.
- Stage III: Stage of Negative Returns
  - In Stage III, MP of variable factor is negative and the TP is also decreasing.


Total output or product
14
12
8
3
0
A
B
C
D
E
F
TP
1
2
3
4
5
6
L
Quantity of labor
Marginal and average product of labor
5
4
3
2
0
−1
−2
A′
B′
C′
D′
E′
F′
AP_L
MP_L
1
2
3
4
5
6
Labor

Cont…


TP
14
12
8
3
0
1
2
3
4
5
6
Labor
A
B
C
D
E
F
G
H
J
TP
MPL/APL
Stage I of labor
Stage II of labor
Stage III of labor
5
4
3
2
0
−2
A′
B′
C′
D′
E′
F′
G′
H′
J′
APL
MPL

Determining Optimum employment of labor

- How many workers will the firm employ for maximum profit.
  - Number of workers to be employed depends upon the output that maximizes the firms profit.
  - Condition for profit maximization, MC=MR (Marginal cost =marginal revenue)

  In the short run, labor is only variable input, so marginal cost= marginal wages, i.e., MC=MW
  - MR= MRP (Marginal revenue productivity)= MP* P

  [MPL , Marginal physical productivity of labor multiplied by Price (P) of the product and MP is marginal productivity of labor]

Practice

- Considering the available production function, Calculate the optimal level of input if the marginal wage is Rs. 660/- and selling price of output is Rs.10 per unit.

- For L=7, MP=78 (From Table 1)

  Marginal revenue productivity, MRP= 78*10= 780> MW
- For L=8, MP=66 (From Table 1)

  Marginal revenue productivity, MRP= 66*10= 660= MW

  Thus the optimal level of labour is 8 units.

  Considering L=9, MRP= 480<MW. This will add to cost and the company will incur losses.

1) A firm with fixed capacity of 5 units of capital has prodⁿ fⁿ
$Q = 30L + 20L^2 - L^3$
Calculate the optimal input combination if the output is sold at a constant price of Rs 5 per unit and the wage paid to a labour is Rs 500.

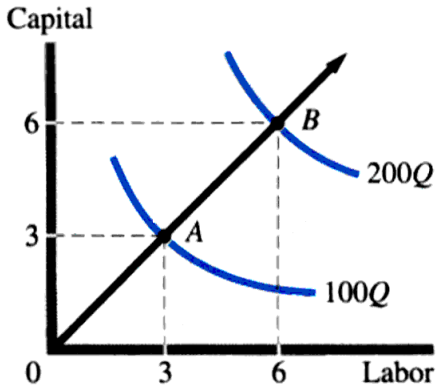
2) Calculate the no. of labours to be employed so as to get optimal input combⁿ of prodⁿ fⁿ $Q = 98L - 3L^2$. The selling price of the product is Rs 20 per unit and the wage rate is Rs 80.

Law of Return to Scale (Long run)

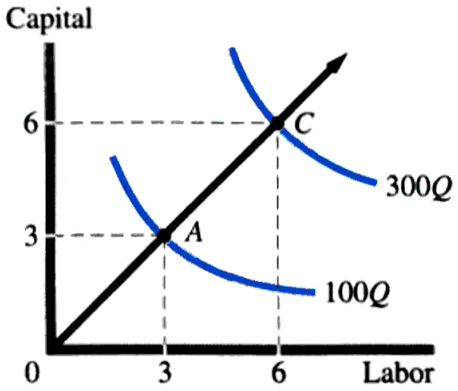
- All inputs are variable
- Output changed by varying usage of all inputs
- Average product of labor: $AP = Q/L$
- Marginal product of labor: $MP_L = \frac{\Delta Q}{\Delta L}$
- Average product of Capital: $AP = Q/K$
- Marginal product of Capital: $MP_K = \frac{\Delta Q}{\Delta K}$

Returns to Scale

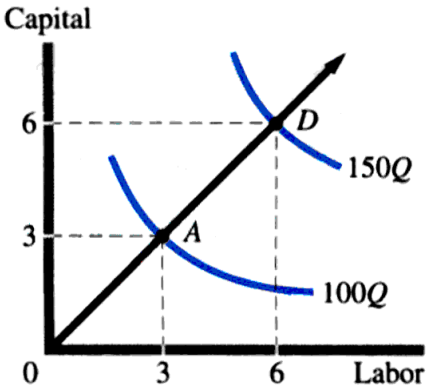
Constant Returns to Scale



Increasing Returns to Scale



Decreasing Returns to Scale



- When a firm expands its scale, i.e., both the inputs proportionately then there are three possibilities:
  - Total output may increase more than proportionately (Increasing returns),
  - Total output may increase proportionately (Constant returns),
  - Total output may increase less than proportionately (Decreasing returns)

Increasing Returns to Scale

- When inputs K, and L are increased at a certain proportion and output increases more than proportionately, it exhibits increasing returns to scale.

L	K	Q
10	10	100
20	20	240
30	30	330

Constant Returns to Scale

- When increase in input is proportionate to increase in output, it exhibits constant returns to scale.

L	K	Q
10	10	100
20	20	200
30	30	300

Diminishing Returns to Scale

- When a proportionate increase in inputs, K & L, leads to a less than proportionate increase in output.

L	K	Q
10	10	100
20	20	180
30	30	250

$$Q=f(L,K)$$

If there is an increase in the input by ‘h’ times let the output may increase by ‘k’ times.

$$kQ=f\,(hL,hK)$$

If $h<k$, this indicates increasing returns to scale

$h=k$, this indicates constant returns to scale

$h>k$, this indicates diminshing returns to scale

Optimal Input Combination or Least Cost Combination

- For Calculating the cost, price of each input must be known.
- Budget or Expenditure of a firm =

  (units of labour* price of labour)+ (units of capital*price of capital)

$$E = L*P_L + K*P_K$$

Also MRTS (Marginal rate of Technical Substitution) = $(MP_L / MP_K) = (P_L / P_K)$

1) The prodⁿ fun of a steel co. is given by

$$Q = 20K - K^2 + 12L - 0.5L^2$$

The price per unit of capital is Rs 4000/- and price per unit of labour is Rs 2000/- Calculate optimal input combⁿ if the tentative budget of the firm is Rs 28,000/-

Sol^n:

$$MRTS = \frac{MP_L}{MP_K} = \frac{P_L}{P_K}$$

$$MP_L = \frac{\partial Q}{\partial L} = 12 - L$$

$$MP_K = \frac{\partial Q}{\partial K} = 20 - 2K$$

for optimal I/P comb^n

$$\frac{20 - 2K}{12 - L} = \frac{4000}{2000}$$

$$\Rightarrow \boxed{L = K + 2}$$

Budget = 28000/-

$$L(2000) + K(4000) = 28000$$

or $2L + 4K = 28$

$$2(K+2) + 4K = 28 \Rightarrow \boxed{K = 4}$$

& $\boxed{L = 6}$

$\therefore$ $\boxed{\text{Optimal } I/P \text{ comb}^n \quad \begin{matrix} L = 6 \\ K = 4 \end{matrix}}$

2.) The prodⁿ fun of a global electronics co. is $Q = 2L^{0.5}K^{0.5}$. Assume that the Capital Stock is fixed at 9 units and price of output is Rs 6 per unit and wage Rate is Rs 2 per unit. Determine the optimal level of labour to be hired.

b) If the wage rate increases to Rs 3 per unit. Det. the optimal input level.

$MC = MR = MP_L \times S.Price$

$$\frac{\partial Q}{\partial L} = MP_L = \frac{K^{0.5}}{L^{0.5}} = \sqrt{\frac{K}{L}}$$

$MC = 2 \Rightarrow 2 = 3\sqrt{\frac{K}{L}} \Rightarrow \frac{1}{3} = \sqrt{\frac{K}{L}}$

As $K = 9$

or $L = 81$

or $\frac{1}{9} = \frac{K}{L}$

$MC = 23$

$L = 36$

Economies and Diseconomies of Scale

Economies of Scale occurs where factors of production are perfectly divisible. And technology is such that labor- capital ratio is fixed.

- When the factors of production are perfectly divisible, showing constant returns to scale.

Diseconomies of Scale:

The diminishing return to management, that is managerial economies.

- As the size of the firms expands, managerial efficiency decreases.
- Limitedness or exhaustibility of the natural resources.
  - Eg: doubling of coal mining plant may double the coal output because of limitedness of coal deposits.