16
Learning Curve Theory

LEARNING OBJECTIVES

After studying this unit, you will be able to :

- Understanding, of learning curve phenomenon.
- Understand how the percentage learning rate applies to the doubling of output
- Know that cumulative average time means the average time per unit for all units produced so far back to and including the first unit produced.
- Use of learning curve theory in such situations as pricing decisions, work scheduling and standard setting
- Describe and identify the situations where learn effect can be incorporated
- Calculate average hours/cost per unit of cumulative productions and incremental hours/cost per order using the learning curve

16.1 Introduction

Learning is the process by which an individual acquires skill, knowledge and ability. When a new product or process is started, performance of worker is not at its best and learning phenomenon takes place. As the experience is gained, the performance of worker improves, time taken per unit reduces and thus his productivity goes up. This improvement in productivity of workers is due to learning effect. Cost predictions especially those relating to direct labour must allow for the effect of learning process. This technique is a mathematical technique. It is a graphical technique used widely to predict cost. Learning curve is a geometrical progression, which reveals that there is steadily decreasing cost for the accomplishment of a given repetitive operation, as the identical operation is increasingly repeated. The amount of decrease will be less and less with each successive unit produced. The slope of the decision curve is expressed as a percentage. The other names given to learning curve are Experience curve, Improvement curve and Progress curve. It is essentially a measure of the experience gained in production of an article by an organisation. As more units are produced, people involved in production become more efficient than before. Each additional unit takes less time to produce. The amount of improvement or experience gained is reflected in a decrease in man-hours or cost. The application of learning curve can be extended to commercial and industrial activities as well as defence production.

The learning effect exists during a worker's start up or familiarization period on a particular job. After the limits of experimental learning are reached, productivity tends to stabilise and no further improvement is possible. The rate at which learning occurs is influenced by many factors including the relative unfamiliarity of workers with the task, the relative novelty and uniqueness of the job, the complexity of the process, the impact of incentive plans, supervision, etc.

16.2 Distinctive Features of Learning Curve Theory in Manufacturing Environment

T.P. Wright of Curtiss—Wright, Buffalo, U.S.A. introduced the theory of learning curve. When the production quantity of a given item is doubled, the cost of that item decrease at a constant rate. Theory of learning curve has been formulated on the basis of this phenomenon. It is important to note that as the quantity produced doubles, the absolute amount of cost increase will be successively lessor but the rate of decrease will remain constant.

Features of learning curve can be summarized as below:

(*i*) Better tooling methods are generated and applied;

(*ii*) More equipments are designed and used to increase the production;

(*iii*) Designed bugs are found and rectified;

(*iv*) Better design is achieve through design engineering for reducing material and labour cost.

(*v*) Rejections and rework tend to reduce.

This results into: (a) less labour; (b) less material; (c) more units produced from the same equipments; (d) cost of fewer delays and less loss time. It allows increase of production and reduction of cost per unit.

16.3. The Learning Curve Ratio

In the initial stage of a new product or a new process, the learning effect pattern is so regular that the rate of decline established at the outset can be used to predict labour cost well in advance. The effect of experience on cost is summaries in the learning ratio or improvement ratio:

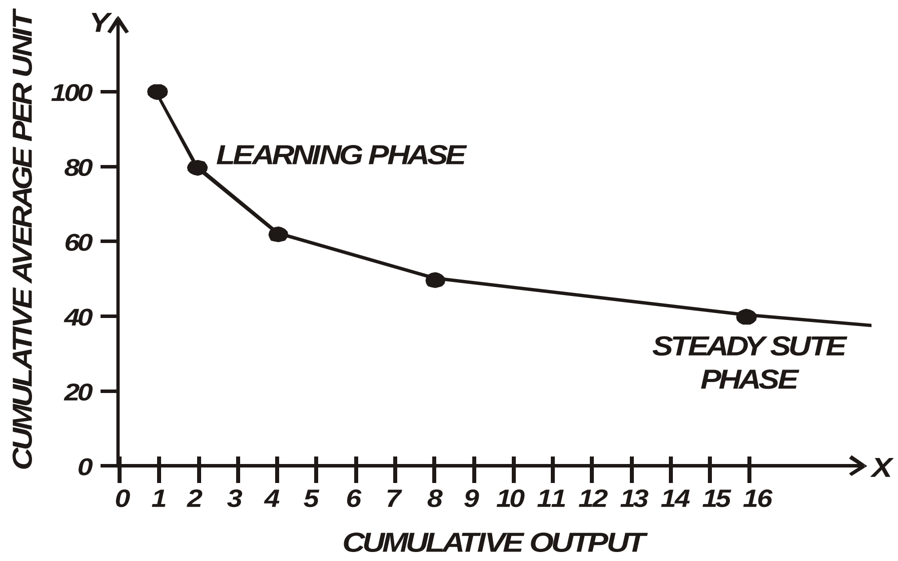
$$\text{Learning Curve Ratio} = \frac{\text{Average labour cost of first 2N units}}{\text{Average labour cost of first N units}}$$

If the average labour cost for the first 500 units of a product is ₹ 25 and the average labour cost of first 1,000 units is ₹ 20, the learning ratio will be determined as follow :

$$\text{Learning curve ratio} = \frac{₹\ 20}{₹\ 25} \times 100 \text{ or } 80\%$$

This learning curve ratio of 80% means that every time output doubles, the average cost declines to 80% of the previous amount. Since the average cost per unit of 1,000 units is ₹ 20, the average cost of first 2,000 units is likely to be 80% of this, i.e., ₹ 16 per unit. The amount of production improvement in the manufacturing of an article will determine the percentage of the learning curve. The effect of learning can be presented clearly in a diagram drawn known as learning curve. The units chosen in the progression must always have a ratio of two (Unit 2 to unit 1, unit 50 to unit 25, unit 300 to unit 150, etc.). An 80% leaning curve is drawn using the following data.

Incremental quantity	Cumulative quantity	Workings of average time	Average time per unit	Cumulative time taken
(1)	(2)	(3)	(4)	(5)
1	1		100	100
1	2	$\frac{(100 \times 80)}{100}$	80	160
2	4	$\frac{(80 \times 80)}{100}$	64	256
4	8	$\frac{(64 \times 80)}{100}$	51	408
8	16	$\frac{(51 \times 80)}{100}$	41	656



Learning Curve

Columns (2) and (4) have been used for drawing the learning curve. Last column is not used in drawing the 80 per cent learning curve. This column shows how the cumulative time consumption will increase with decrease in cumulative average per unit. Cumulative quantity is plotted on X-axis and cumulative average time consumption per unit is plotted on Y-axis. After the learning effect phase is over, steady-state phase will start. Learning effect advantage will not be there is steady-state phase, when the product or the process gets well stabilised.

16.4 Learning Curve Equation

Mathematicians have been able to express relationship in equations. The basic equation

$Y_x = KX^s$ (it can be expressed as $y = ax^{-b*}$) ...(1)

* even sometime it is expressed as $y = ax^b$, though b always has a negative value

where,

X is the cumulative number of units or lots produced

Y is the cumulative average unit cost of those units X or lots.

K is the average cost of the first unit or lot

s is the improvement exponent or the learning coefficient or the index of learning which is calculated as follows :

$$s = \frac{\text{logarithm of learning ratio}}{\text{logarithm of 2}}$$

Learning curve equation $Y_x = KX^s$ becomes a linear equation when it is written in its logarithmic form :

$$\log Y_x = \log K + s \log X \quad ...(2)$$

Each of the above two equations defines cumulative average cost. Either of them can be converted to a formula for the total labour cost of all units produced up to a given point. Total cost under equation I can be found out by the following formula :

$$\text{Total cost} = XY_x = KX^s = KX^{s+1} \quad ...(3)$$

16.5 Learning Curve Application

Knowledge of learning curve can be useful both in planning and control. Standard cost for new operations should be revised frequently to reflect the anticipated learning pattern. Its main uses are summarised below:

16.5.1 Helps to analyse CVP Relationship during familiarisation phase: Learning curve is useful to analyse cost-volume-profit relationship during familiarisation phase of product or process and thus it is very useful for cost estimates. Learning curve can be used as a tool for forecasting.

Illustration 1

XYZ Co., has observed that a 90% learning curve ratio applies to all labour related costs each time a new model enters production. It is anticipated that 320 units will be manufactured during 2012. Direct labour cost for the first lot of 10 units amounts to ₹ 10,000 at ₹ 10 per hour. Variable overhead cost is assigned to products at the rate of ₹ 2 per direct labour hour. You are required to determine:

(i) Total labour and labour-related costs to manufacture 320 units of output.

(ii) Average labour cost of (a) the first 40 units produced (b) the first 80 units, (c) the first 100 units.

(iii) Incremental labour cost of (a) units 41–80 and (b) units 101–200.

Learning index value for a 90% learning curve is –0.152.

Solution

Table showing cost projections based on 90 per cent learning curve.

Incremental quantity	Cumulative quantity	Average time per unit	Cumulative time taken	Incremental hours
10	10	100	1,000	—
10	20	90	1,800	800
20	40	81	3,240	1,440
40	80	72.9	5,832	2,592
80	160	65.61	10,497.6	4,665.6
160	320	59.049	18,895.68	8,398.08

Following cost information can be derived from the data given in the above table :

(i) Total labour cost of 320 units = 18,895.68 × ₹ 10 = ₹ 1,88,956.80

(ii) Average labour cost of first 40 units = 81 × ₹ 10 = ₹ 810 per unit.

Average labour cost of first 80 units = 72.9 × ₹ 10 or ₹ 729 per unit.

(iii) Incremental labour cost of units [41 – 80] = 2592 × ₹ 10 or ₹ 25,920.

The basic learning curve formula must be used to derive the average cost of the first 100 units and the incremental cost of units 101 – 200.

We know that $Y_x = KX^s$

The first production lot contained 10 units. K = 1,000 hrs. (Average time for first lot) and X = 10 (the number of lots needed to produce 100 units).

Taking the logarithm of the above relation, we get

$$\begin{aligned} \log Y_{10} &= \log 1000 + (-0.152 \log 10) \\ &= 3.0 - 0.152 \\ &= 2.848 \\ Y_{10} &= 704.70 \text{ hrs.} \end{aligned}$$

Y_{10} means that average processing time for the first 10 lots of output is 704.70 hours per lot. Each lot includes 10 units of output. The labour rate is ₹ 10 per hour. Therefore, the total labour cost for 100 units (or 10 lots) is ₹ 70,470.

The first production lot contained 10 units. K = 1,000 hrs. (Average time for first lot) and X = 20 (the number of lots needed to produce 200 units).

Taking the logarithm of the above relation, we get

$$\begin{aligned} \log Y_{20} &= \log 1000 + (-0.152 \log 20) \\ &= 3.0 - 0.1978 \\ &= 2.8022 \\ Y_{20} &= 634.16 \text{ hrs.} \end{aligned}$$

Y_{20} means that average processing time for the first 20 lots of output is 634.16 hours per lot. Each lot includes 10 units of output. The labour rate is ₹ 10 per hour. Therefore, the total labour cost for 200 units (or 20 lots) is ₹ 1,26,832.

The incremental cost of units 101 – 200 corresponds to the incremental cost of lots 11 – 20. This is equal to the total cost of first 20 lots minus the total cost of the first 10 lots.

Time for first 20 lots = ₹ 1,26,832

Time of first 10 lots = ₹ <u>70,470</u>

₹ <u>56,362</u>

This means that incremental cost of lots 11 – 20 will be: ₹ 56,362

16.5.2 Helps in budgeting and profit planning: Budget manager should select those costs which reflect learning effect and then he should be able to incorporate this effect in process of developing budgets or in the exercises relating to project planning.

16.5.3 Helps in pricing: The use of cost data adjusted for learning effect helps in development of advantageous pricing policy.

16.5.4 Design makers: It helps design engineers in making decisions based upon expected (predictable from past experience) rates of improvement.

16.5.5 Helps in negotiations: It is very useful to Government in negotiations about the contracts.

16.5.6 Helps in setting standards: The learning curve is quite helpful in setting standards in learning phase.

16.6 Application of Learning Curve

Learning curve can be applied in the following are:

1. Though learning curve theory was first developed in aircraft industry, however, it can be applied to other manufacturing industry as well.
2. Learning curve can be applied even to non-production activities like marketing.
3. It can be very effective in labour oriented industry.
4. It can be effective with the job which is repetitive in nature particulars with same machinery and tools.

16.7 Financial Costs effected by Learning Curve

In general following costs are affected by learning curve:

1. Direct labour cost.
2. Variable overhead cost.
3. Material cost.

16.8 Important Consequences of learning curve in Management Accounting

In the following areas of management accounting effect of learning curve applies.

1. Variable overheads.
2. Standard costing.
3. Pricing decision.
4. Output capacity.
5. Direct labour budget.

16.9 Limitations of Learning Curve Theory

Following limitations of learning curve must be kept in view:

1. All activities of a firm are not subject to learning effect. Following types of activities are subject to learning effect:
   (a) Those, which have not been performed in this present operational mode.
   (b) Those which are being performed by new workmen, new employees or others not familiar with the particular activity. In contrast, activities being performed by experienced workmen, who are thoroughly familiar with those activities will not be subject to learning effect.
   (c) Those involving utilization of material not used by firm so far.
2. It is correct that learning effect does take place and average time taken is likely to reduce. But in practice it is highly unlikely that there will be a regular consistent rate of decrease, as exemplified earlier. Therefore any cost predictions based on covernational learning curves should be viewed with caution.
3. Considerable difficulty arises in obtaining valid data that will form basis for computation of learning effect.
4. Even slight change in circumstances quickly renders the learning curve obsolete. While the regularity of conventional learning curves can be questioned, it would be wrong to ignore learning effect altogether in predicting future costs for decision purposes.

Illustration 2

A customer has asked your company to prepare a bid on supplying 800 units of a new product. Production will be in batches of 100 units. You estimate that costs for the first batch of 100 units will average ₹100 a unit. You also expect that a 90% learning curve will apply to the cumulative labour cost on this contract.

Required:

(a) Prepare an estimate of the labour costs of fulfilling this contract.

(b) Estimate the incremental labour cost of extending the production run to produce an additional 800 units.

(c) Estimate the incremental labour cost of extending the production run from 800 units to 900 units.

Solution

(a) Average cost decreases by 10 per cent every time when the cumulative production doubles.

Therefore,

Average cost of first 200 units = 0.9 × Avg. cost of 100 units

Average cost of first 400 units = 0.9 × Avg. cost of 200 units

Average cost of first 800 units = 0.9 × Avg. cost of 400 units

Combining these, we find that average cost of the first 800 units

= 0.9 × 0.9 × 0.9 × ₹100 = ₹ 72.90

Total cost = 800 × ₹ 72.90 = ₹ 58,320

(b) Average cost of the first 1,600 units = 0.9 × ₹ 72.9 = ₹ 65.61

∴ Total cost of 1,600 units = 1,600 × ₹ 65.61 = ₹ 1,04,976

Additional cost of 2nd 800 units

= ₹ 1,04,976 – ₹ 58,320 = ₹ 46,656 or ₹ 58.32 per unit (46,656/800 units)

(c) Because this increase will not increase cumulative production to twice of some figure we already have, formula has to be used:

Y = ax^b where b = $\frac{\log(0.90)}{\log(2)}$ = – 0.15216, a = ₹ 100; x = 9 batches

log Y = log 100 – 0.15216 log 9

log Y = 2 – 0.1452 = 1.8548

Average cost (Y) = ₹ 71.58 per unit

Total cost = 900 × 71.58 = ₹ 64,422

Incremental cost = ₹ 64,422 – ₹ 58,320 = ₹ 6,102 or ₹ 61.02 per unit.

SUMMARY

- Learning Curve Effect applies only to direct labour costs and those variable overheads, which are direct function of labour hours of input. It does not apply to material costs, non-variable costs or items which vary with output.
- Incremental hours cannot be directly determined from the learning curve graph or formula, as the results are expressed in terms of cumulative average hours.

Guys if you really like my efforts then comment in comment section so I can upload this thing for complete AMA.

Thank you
Vaibhav Tholiya

Note: This work is done only to support/help CA Final aspirants so that, who are interested in preparing for exams through institute's publications don't need to carry 3 different books each time.

CHAPTER 16

Learning Curve Theory

Basic Concepts

Learning Curve

"Learning curve is a geometrical progression, which reveals that there is steadily decreasing cost for the accomplishment of a given repetitive operation, as the identical operation is increasingly repeated. The amount of decrease will be less and less with each successive unit produced. The slope of the decision curve is expressed as a percentage. The other names given to learning curve are Experience Curve, Improvement Curve and Progress Curve."

Learning Curve Equation

"Mathematicians have been able to express relationship in equations. The basic equation is

$y = ax^b$

Where

y	=	*Average time per unit for x units*
A	=	*Time required for first unit*
x	=	*Cumulative number of units produced*
b	=	*Learning coefficient"*

Logarithms Formulas

$\log_a (p \times q)$	=	$\log_a p + \log_a q$
$\log_a (p / q)$	=	$\log_a p - \log_a q$
$\log_a (p^n)$	=	$n \log_a p$
$\log_a 1$	=	0
$\log_a 10$	=	1
$\log_a 100$	=	2

The Learning Curve Ratio

"In the initial stage of a new product or a new process, the learning effect pattern is so regular that the rate of decline established at the outset can be used to predict labour cost well in advance. The effect of experience on cost is summaries in the learning ratio or improvement ratio:

$$\frac{\text{Average labour cost of first 2N units}}{\text{Average labour cost of first N units}}\text{"}$$

Question-1

Discuss the application of the learning curve.

Solution:

(i) Learning curve helps to analyse cost-volume profit relationships during familiarisation phase of product or process to arrive at cost estimates.

(ii) It helps in budgeting and profit planning.

(iii) It helps in pricing and consequent decision making – e.g. acceptance of an order, negotiations in establishing contract prices etc. with the advantage of the knowledge of decreasing unit cost.

(iv) It helps in setting standards in the learning phase.

Question-2

Explain the learning curve ratio.

Solution:

As the production quantity of a given item is doubled, the cost of the item decreases at a fixed rate. This phenomenon is the basic premise on which the theory of learning curve has been formulated. As the quantity produced doubles, the absolute amount of cost increase will be successively smaller but the rate of decrease will remain fixed.

In the initial stage of a new product or a new process, the learning effect pattern is so regular that the rate of decline established at the outset can be used to predict labour cost well in advance. The effect of experience on cost is summarized in the learning curve ratio or improvement ratio.

$$\text{Learning curve ratio} = \frac{\text{Average labour cost of first 2N units}}{\text{Average labour cost of first N units}}$$

For example, if the average labour cost for the first 500 units is ₹25 and the average labour cost for the first 1,000 units is ₹20, the learning curve ratio is (₹20/25) or 80%. Since the average cost per unit of 1,000 units is ₹20, the average cost per unit of first 2,000 units is likely to be 80% of ₹20 or ₹16.

Question- 3

Explain distinctive features of learning curve theory in manufacturing environment.

Solution:

The production quantity of a given item doubled the cost of that item decrease at a fixed rate. This phenomenon is the basic premise on which the theory of learning curve has been formulated. The distinctive features of a learning curve are:

(i) Better tooling methods are developed and used.

(ii) More productive equipments are designed and used to make the product.

(iii) Design bugs are detected and corrected.

(iv) Better design engineering reduces material and labour costs.

(v) Early teething problems are overcome. As production progresses management is prompted to achieve better planning and better management.

(vi) Rejections and rework tend to diminish over time.

Question-4

The following information is provided by a firm. The factory manager wants to use appropriate average learning rate on activities, so that he may forecast costs and prices for certain levels of activity.

(i) A set of very experienced people feed data into the computer for processing inventory records in the factory. The manager wishes to apply 80% learning rate on data entry and calculation of inventory.

(ii) A new type of machinery is to be installed in the factory. This is patented process and the output may take a year for full fledged production. The factory manager wants to use a learning rate on the workers at the new machine.

(iii) An operation uses contract labour. The contractor shifts people among various jobs once in two days. The labour force performs one task in 3 days. The manager wants to apply an average learning rate for these workers.

You are required to advise to the manager with reasons on the applicability of the learning curve theory on the above information.

Solution:

The learning curve does not apply to very experienced people for the same job, since time taken can never tend to become zero or reduce very considerably after a certain range of output. This is the limitation of the learning curve.

(i) Data entry is a manual job so learning rate theory may be applied. Calculation of inventory is a computerized job. Learning rate applies only to manual labour.

(ii) Learning rate should not be applied to a new process which the firm has never tried before.

(iii) The workers are shifted even before completion of one unit of work. Hence learning rate will not apply.

Question-5

What are the limitations of the learning curve theory?

Solution:

(i) All activities of a firm are not subject to learning effect. (Activities that have not been performed in the present operational mode, those performed by new or unfamiliar employees are subjected to learning effect, while those performed by familiar or experienced workmen will not be subjected to learning effect)

(ii) It is correct that learning effect does take place and average time taken is likely to reduce. But in practice it is highly unlikely that there will be a regular consistent rate of decrease. Therefore any cost prediction based on conventional learning curves should be viewed with caution.

(iii) Considerable difficulty arises in obtaining valid data that will form basis for computation of learning effect.

(iv) Even slight change in circumstances quickly renders the learning curve obsolete. While the regularity of conventional learning curves can be questioned, it would be wrong to ignore learning effect altogether in predicting costs for decision purposes.

Question-6

State whether the learning curve theory can be applied to .the following independent situations briefly justifying your decision:

(i) A labour intensive sculpted product is carved from the metal provided to the staff. The metal is sourced from different suppliers since it is scarce. The alloy composition of the input metal is quite different among the suppliers.

(ii) Pieces of hand-made furniture are assembled by the company in a far off location. The labourers do not know anything about the final product which utilizes their work. As a matter of further precaution, rotation of labour is done frequently.

(ill) Skilled workers have been employed for a long time. The company has adequate market for the craft pieces done by these experts.

(iv) A company funds that it always has an adverse usage of indirect material. It wants to apply learning curve theory to improve the way standards have been set.

Solution:

(i) 'Learning Curve Theory' will not be applicable as alloy combination of the input metal is quite different among the suppliers hence learning experience with one type of metal may not be beneficial for the workers to deal with other metal with separate alloy composition.

(ii) 'Learning Curve Theory' will not be applicable as in this situation rotation of labour is done frequently, labours will not be able to get the benefit of learning and apply their learning. Hence, learning curve theory can not be applied.

(iii) 'Learning Curve Theory' will not be applicable as in this situation as workers are skilled and employed for a long time, they have already achieved maximum level of expertise by taking advantage of learning. Hence, at this point of time learning curve theory can not be applied.

(iv) 'Learning Curve Theory' will not be applicable as indirect materials are the materials which are not used directly in the production (not directly proportionate with volume of output) and usually used machines (e.g. lubricants, spares parts etc.) with less human interactions. Adverse usage of indirect materials can be controlled through proper monitoring and appropriate standard settings and not from applying learning curve theory.

Learning Curve - Estimating Labour Time

Question-1

A company which has developed a new machine has observed that the time taken to manufacture the first machine is 600 hours. Calculate the time which the company will take to manufacture the second machine if the actual learning curve rate is (i) 80% and (ii) 90%. Explain which of the two learning rates will show faster learning.

Solution:

(i) Actual learning curve rate is 80%

Time taken to produce the first machine	= 600 hours
Average time taken to produce two machines	= 600 × 80% hours
	= 480 hours.
Cumulative time taken to produce two machines	= 480 × 2 hours
	= 960 hours
Time taken to produce the second machine	= (960 – 600) hours
	= 360 hours

(ii) Actual learning curve rate is 90%

Time taken to produce the first machine	= 600 hours
Average time taken to produce two machines	= 600 × 90% hours
	= 540 hours
Cumulative time taken to produce two machines	= 540 × 2 hours
	= 1,080 hours
Time taken to produce the second machine	= (1,080 – 600) hours
	= 480 hours

The time taken to produce the second machine is lower at 80% learning rate and hence 80% learning rate shows faster learning rate.

Learning Curve - Estimating Labour Time
(Application of Logarithms Formulas)

Question-2

The chief officer at manufacturing plant of Boeing 777-200LR aircraft *observed that workers performing manufacturing operations at the plant showed signs of a definite learning pattern. He noted that most aircraft manufacturing tasks experienced what he called an 80 percent learning rate, meaning that workers need 20 percent fewer hours to make a part each time their cumulative experience making that part doubled. Thus, if the first part took 100 minutes, the second would require 80 minutes, the fourth would require 64 minutes, and so on. Accordingly he requires calculating the time required for parts 41 to 60. [Note: learning coefficient is -0.322 for learning rate of 80%, log2=0.30103, log3=0.47712, log5=0.69897, Antilog of 1.484 =30.48, Antilog of 1.4274 =26.75]*

Solution:

The usual learning curve model is

$y = ax^b$

Where

y = Average time per part for x parts

a = Time required for first part (100 minutes)

x = Cumulative number of parts

b = Learning coefficient and is equal to –0.322 (learning rate 80%)

Calculation of total time for 40 parts:

$y = 100 \times (40)^{-0.322}$

$\log y = \log 100 - 0.322 \times \log 40$

$\log y = \log 100 - 0.322 \times [3 \times \log 2 + \log 5]$

$\log y = 2 - 0.322 \times [3 \times 0.30103 + 0.69897]$

$\log y = 1.484$

y = antilog of 1.484

y = 30.48 minutes

Total time for 40 Parts = 40 Parts × 30.48 minutes

= 1,219 minutes (A)

Calculation of total time for 60 parts:

$y = 100 \times (60)^{-0.322}$

$\log y = \log 100 - 0.322 \times \log 60$

$\log y = \log 100 - 0.322 \times [2 \times \log 2 + \log 5 + \log 3]$

$\log y = 2 - 0.322 \times [2 \times 0.30103 + 0.69897 + 0.47712]$

$\log y = 1.4274$

y = antilog of 1.4274

y = 26.75 minutes

Total Time for 60 Parts = 60 Parts × 26.75 minutes

= 1,605 minutes (B)

Calculation of total time for 41 to 60 parts (B) – (A):

= 1,605 minutes –1,219 minutes

= 386 minutes

Learning Curve- Quoting for an Order

Question-3

The Gifts Company makes mementos for offering chief guests and other dignitaries at functions. A customer wants 4 identical pieces of hand-crafted gifts for 4 dignitaries invited to its function.

For this product, the Gifts Company estimates the following costs for the 1st unit of the product.

Particulars of Costs	*₹/ unit*
Direct Variable Costs (excluding labour)	*2,000*
Direct Labour (20 hours @ ₹50 hour)	*1,000*

90 % learning curve ratio is applicable and one labourer works for one customer's order.

(i) What is the price per piece to be quoted for this customer if the targeted contribution is ₹1,500 per unit?

(ii) If 4 different labourers made the 4 products simultaneously to ensure faster delivery to the customer, can the price at (i) above be quoted? Why?

Solution:

(i)

	₹ / u Avg. / unit (4 units)
Variable Cost	2,000
Labour	810
Target Contribution	1,500
Price to be Quoted	4,310

(ii) No, the company cannot quote this price for varying products because the learning curve Ratio does not apply to non-repeated jobs. Each product will carry a different price according to its direct labour hours.

Question-4

M Ltd. Manufactures a special product purely carried out by manual labour. It has a capacity of 20,000 units. It estimates the following cost structure:

Direct Material	*30 ₹/ unit*
Direct Labour (1 hour / unit)	*20 ₹/ unit*
Variable Overhead	*10 ₹/ unit*

Fixed Overheads at maximum capacity is ₹1,50,000.

It is estimated that at the current level of efficiency, each unit requires one hour for the first 5,000 units. Subsequently it is possible to achieve 80% learning rate. The market can absorb the first 5,000 units at ₹100 per unit. What should be the minimum selling price acceptable for an order of 15,000 units for a prospective client?

Solution:

Working Note-1:

	5,000 units	20,000 units
Material	1,50,000	6,00,000
Direct Labour	1,00,000	2,56,000 (Refer to W.N.II)
Variable Overhead	50,000	2,00,000
Total Variable Cost	3,00,000	10,56,000
Fixed Cost	1,50,000	1,50,000
Total Cost	4,50,000	12,06,000
Total Cost *per unit*	90.00	60.30
Sales (₹100 × 5,000 units)	5,00,000	5,00,000
(₹x × 15,000 units) [Assumed Selling Price 'x']	.	15,000x
Profit	50,000	15,000x – 7,06,000

Working Note-2:

Units	Hours
5,000	5,000
10,000	8,000 hours (10,000 units × 1 hr × 0.80)
20,000	12,800 hours (20,000 units × 1 hr × 0.80 × 0.80)

Working Note-3:

$$15{,}000x - 7{,}06{,}000 > 50{,}000$$

$$15{,}000x > 7{,}56{,}000$$

Or $$x > 50.40$$

Minimum Selling Price:

Total Cost *per unit* at Capacity 20,000 = ₹ 60.30

Weighted Average Selling Price > ₹ 60.30

$$\frac{5{,}000\text{ units} \times ₹100 + 15{,}000\text{ units} \times ₹x}{20{,}000\text{ units}} > 60.30$$

$$15{,}000x > 7{,}06{,}000$$

$$x > 47.06..$$

Minimum Price *to cover*

Production Cost = ₹ 47.06...

Minimum Price *to cover*

Same Amount of Profit = 50.40

Verification:

(–₹47.06… + ₹50.40) × 15,000 units = ₹50,000

Question-5

An electronics firm which has developed a new type of fire-alarm system has been asked to quote for a prospective contract. The customer requires separate price quotations for each of the following possible orders:

Order	*Number of fire-alarm systems*
First	*100*
Second	*60*
Third	*40*

The firm estimates the following cost per unit for the first order:

Direct Materials	*₹500*
Direct Labour	
Deptt. A (Highly automatic)	*20 hours at ₹10 per hour*
Deptt. B (Skilled labour)	*40 hours at ₹15 per hour*
Variable Overheads Absorbed	*20% of direct labour*
Fixed Overheads Absorbed	
Deptt. A	*₹8 per hour*
Deptt. B	*₹5 per hour*

Determine a price per unit for each of the three orders, assuming the firm uses a mark up of 25% on total costs and allows for an 80% learning curve. Extract from 80% learning curve table:

X	*1.0*	*1.3*	*1.4*	*1.5*	*1.6*	*1.7*	*1.8*	*1.9*	*2.0*
Y (%)	*100.0*	*91.7*	*89.5*	*87.6*	*86.1*	*84.4*	*83.0*	*81.5*	*80.0*

X represents the cumulative total volume produced to date expressed as a multiple of the initial order.

Y is the learning curve factor, for a given X value, expressed as a percentage of the cost of the initial order.

Solution:

(i) Price per Unit for First 100 Units

	₹	₹
Direct Material		500
Direct Labour		
Deptt. A (20 hrs. @ 10)	200	
Deptt. B (40 hrs. @ 15)	600	800
Variable Overheads (20% of ₹800)		160
Fixed Overheads		
Deptt. A (20 hrs. @ 8)	160	
Deptt. B (40 hrs. @ 5)	200	360
Total Cost		1,820
Profit (25% of ₹1,820)		455
Selling Price		2,275

(ii) Price per Unit for Second Order of 60 Units

Workings:

Learning will be applicable only in Dept. B

Cumulative output becomes 100 units + 60 units = 160 units

(1.6 times for which learning is 86.1% from the table)

Total hours for 160 units = 5,510.40 hrs

(160 units × 40 hrs × 0.861)

Hours for 60 units = Hrs for 160 units – Hrs for 100 units

= 5,510.40 – 4,000 hrs

= 1,510.40 hrs

Hours *per unit* = 1,510.40 hrs / 60 units

= 25.17

Calculation of Selling Price *per unit*

	₹	₹
Direct Materials		500.00
Direct Labour		
Deptt. A (20.00 hrs @ 10)	200.00	
Deptt. B (25.17 hrs @ 15)	377.55	577.55
Variable Overheads (20% of ₹577.55)		115.51
Fixed Overheads		
Deptt. A (20.00 hrs @ 8)	160.00	
Deptt. B (25.17 hrs @ 5)	125.85	285.85
Total Cost		1,478.91
Profit (25% of ₹1,478.91)		369.73
Selling Price		1,848.64

(iii) **Price per Unit for Third Order of 40 Units**

Workings:

Cumulative Output becomes	=	200 units
(2 times for which Learning is 80% from the table)		
Total hours for 200 units	=	6,400 hrs
		(200 units × 40 hrs × 0.80)
Hours for 40 units	=	Hrs for 200 units
		– Hrs for 160 units
	=	6,400 – 5,510.40
	=	889.60 hrs.
Hours per unit	=	889.60 hrs. / 40 units
	=	22.24 hrs

Calculation of Selling Price *per unit*

	₹	₹
Direct Material		500.00
Direct Labour		
Deptt. A (20.00 hrs @ 10)	200.00	
Deptt. B (22.24 hrs @ 15)	333.60	533.60
Variable Overheads (20% of ₹ 533.60)		106.72
Fixed Overheads		
Deptt. A (20.00 hrs @ 8)	160.00	
Deptt. B (22.24 hrs @ 5)	111.20	271.20
Total Cost		1,411.52
Profit (25% of ₹1,411.52)		352.88
Selling Price		1,764.40

Question-6

A company has 10 direct workers, who work for 25 day a month of 8 hours per day. The estimated down time is 25% of the total available time. The company received on order for new product. The first unit of the new product required 40 direct labour hours to manufacture the product. The company expects 80% (index is – 0.322) learning curve for this type of work. The company uses standard absorption costing and the cost data on a under:

Direct Materials	*₹ 60 per unit*
Direct Labour	*₹ 6 per direct labour hour*
Variable Overheads	*₹ 1 per direct labour hour*
Fixed Overheads	*₹ 7,500 per month*

Required:

(i) *Calculated the cost per unit of the first order of 30 units.*

(ii) *If the company receives a repeat order for 20 units, what price will be quoted to yield a profit of 25% on selling price?*

Solution:

Working Notes:

(1) The usual learning curve model is

$y = ax^b$

Where

y = Average time per unit for x units

A	=	Time required for first unit
x	=	Cumulative number of units produced
b	=	Learning coefficient and is equal to –0.322 (learning rate 80%)

(2) **Time required for 30 units order** (when the time required for the first unit is 40 hours)

y	=	$40 \times (30)^{-0.322}$
log y	=	log40 − 0.322 × log30
log y	=	1.6021 − 0.322 × 1.4771
log y	=	1.1265
y	=	antilog of 1.1265
y	=	13.38 hours
Total time for 30 units	=	30 units × 13.38 hours
	=	401.40 hours

(3) **Time required for 50 units order** (when the time required for the first unit is 40 hours)

y	=	$40 \times (50)^{-0.322}$
log y	=	log40 − 0.322 × log50
log y	=	1.6021 − 0.322 × 1.6990
log y	=	1.055
y	=	antilog of 1.055
y	=	11.35 hours
Total time for 50 units	=	50 units × 11.35 hours
	=	567.50 hours

(4) **Fixed overhead recovery rate per labour hour**

Total labour hours [10 men × 25 days × 8 hours]	2,000
Less: 25% downtime (hrs)	500
Total effective hours	1,500
Total fixed overheads per month (₹)	7,500
Fixed overhead recovery rate per labour hour (₹) [₹ 7,500 / 1,500 hours]	5

Computation of Requirements of Question:

(i) **Computation of cost per unit of the first order of 30 units**

	₹
Direct Material Cost (30 units × ₹60)	1,800.00
Direct Labour Cost (401.40 hours × ₹6)	2,408.40
Variable Overheads (401.40 hours × ₹1)	401.40
Fixed Overheads (401.40 hours × ₹5)	2,007.00
Total Cost of 30 units	6,616.80
Cost per unit (₹6,616.80 / 30 units)	220.56

(ii) **Cost per unit, when a repeat order for 20 units is also placed**

	₹
Direct Material Cost (20 units × ₹ 60)	1,200.00
Direct Labour [(567.50 hours – 401.40 hours) × ₹ 6]	996.60
Variable Overheads (166.10 hours × ₹1)	166.10
Fixed Overheads (166.1 hours × ₹ 5)	830.50
Total Cost of 20 additional units	3,193.20
Cost per unit (₹3,193.20 / 20 units)	159.66

Price to be quoted to yield a profit of 25% on selling price

If selling price is ₹100 then profit is ₹25 and cost is ₹75

Hence selling price per unit = $₹100.00 \times \frac{₹159.66}{₹75.00} = ₹212.88$

Question-7

A Company has two production departments KTS and KTW. Standards for the forthcoming year is as follows:

Particulars	*Department KTS*	*Department KTW*
Direct labour hours available per period	*12,000*	*8,000*
Standard wage rate per hour	*₹ 3*	*₹ 2.5*
Expected learning curve	*80%*	*70%*

Standard variable overheads per hour	*₹ 10*	*₹ 6*
Standard fixed overheads per hour	*₹ 11*	*₹ 7*
Direct labour hours required for first 100 units	*36*	*18*

The direct materials are introduced in Department KTS. The company has following quote for purchase of direct material:

Level of Outputs (Units)	*Price of direct material per unit of output*
100	*₹ 36.00*
200	*₹ 32.40*

Overtime, if required is paid at the time and half. The overhead rates as given above do not include overtime premium.

It is the policy of the company to add profit margin as under in quoting the prices:

Department	*Percentage*
KTS	*10% of labour & 15% overhead cost*
KTW	

The company has received a special order. Special tooling costs of the order amount to ₹ 5,500. If this order is for 200 units or less, it will be executed in the period which has a workload of 7,680 direct labour hours in Department KTS and 4,200 direct labour hours in Department KTW.

Required:

If the company decides to get the work executed entirely within the company, what price, on cost-plus basis, should be quoted for the order, if it consists of 100 Units, 200 units.

Solution:

Statement showing recommended Selling Price:

	100 Units (per Unit)		200 units (per Unit)	
Department KTS:				
Direct Labour	36hrs. × ₹3	108.00	36Hrs. × 0.80 × ₹3	86.40
Overtime Premium#		0.00		10.80
Total Labour Cost ...(A)		108.00		97.20
Variable Overheads	36hrs. × ₹ 10	360.00	36 Hrs. × 0.80 × ₹ 10	288.00
Fixed Overheads	36hrs. × ₹ 11	396.00	36 Hrs. × 0.80 × ₹11	316.80
Total Overheads ...(B)		756.00		604.80
Department KTW:				
Direct Labour	18hrs. × ₹ 2.5	45.00	18 Hrs. × 0.70 × ₹2.5	31.50
Overtime Premium		0.00		0.00
Total Labour Cost ...(C)		45.00		31.50
Variable Overheads	18hrs. × ₹ 6	108.00	18 Hrs. × 0.70 × ₹6	75.60
Fixed Overheads	18hrs. × ₹ 7	126.00	18 Hrs. × 0.70 × ₹7	88.20
Total Overheads ...(D)		234.00		163.80
Special Tool ...(E)	₹ 5,500 / 100	55.00	₹ 5,500 / 200	27.50
Direct Material ...(F)		36.00		32.40
Profit on Labour (10%)	₹ (108 + 45) × 10%	15.30	₹(97.20 + 31.50) × 10%	12.87
Profit on Overheads (15%)	₹ (756+234) ×15%	148.50	₹ (604.80 +163.80) × 15%	115.29
Total Profit ...(G)		163.80		128.16
Recommended Selling Price [(A) +(B)+(C)+(D)+(E)+(F)+(G)]		1,397.80		1,085.36

#Statement showing Overtime Premium:

	Department KTS	Department KTW
Direct Labour Hours Available	12,000	8,000
Present workload	7,680	4,200
Balance Direct Labour Hours	4,320	3,800
Hours Required to produce 100 units:	3,600	1,800
Hours Required to produce 200 units:	5,760 (200 x 36 x 0.80)	2,520 (200 x 18 x 0.70)

Overtime Required to produce 100 units	---	---
Overtime Required to produce 200 units	1,440 Hrs	---
Overtime Premium	10.8 per Unit (1,440 Hrs × 3 × 50% / 200 Units)	---

Learning Curve - Decision Making

Question-8

AB Ltd. makes and sells a labour-intensive product. Its labour force has a learning rate of 80%, applicable only to direct labour and not to variable overhead.

The cost per unit of the first product is as follows:

	₹
Direct Materials	*10,000*
Direct Labour (@ ₹ 4 per hour)	*8,000*
Variable Overhead	*2,000*
Total Variable Cost	*20,000*

AB Ltd. has received an order from P Ltd. for 4 units of the product. Another customer, Q Ltd. is also interested in purchasing 4 units of the product. AB Ltd. has the capacity to fulfill both the orders. Q Ltd. presently purchases this product in the market for ₹ 17,200 and is willing to pay this price per unit of AB's product. But for P Ltd. lets AB choose one of the following options:

(i) A price of ₹16,500 per unit for the 4 units it proposes to take from AB.

Or

(ii) Supply P Ltd.'s idle labour force to AB, for only 4 units of production, with AB having to pay only ₹ 1 per labour hour to P Ltd.'s workers. P Ltd.'s workers will be withdrawn after the first 4 units are produced. In this case, AB need not use its labour for producing P Ltd.'s requirement. P Ltd. assures AB that its labour force also has a learning rate of 80%. In this option, P Ltd. offers to buy the product from AB at only ₹ 14,000 per unit.

P and Q shall not know of each other's offer.

If both orders came before any work started, what is the best option that AB may choose?

Present suitable calculations in favour of your argument.

Solution:

Workings:

Units	Average hrs. /unit
1	2,000
2	1,600
4	1,280
8	1,024

Variable Cost excluding Labour:

		₹
Material Cost / unit	=	10,000
Variable Overheads	=	2,000
Variable Cost	=	12,000

Option-I:

If both the orders came together, learning rate 80% applies and 8 units can be made, with average time of 1,024 hours per unit.

Cost to AB		₹
Variable Cost excluding Labour	=	12,000
Labour Cost (1,024 hrs. × 4₹/hr)	=	4,096
	=	16,096

In this case,

Particulars	Q	P	Total
Selling Price p. u. (₹)	17,200	16,500	33,700
Variable Cost p. u. (₹)	16,096	16,096	32,192
Contribution p. u. (₹)	1,104	404	1,508
No. of Units	4	4	
Contribution (₹)	4,416	1,616	6,032

Option- II:

If P Ltd supplies its labour. 80% learning curve will apply to 4 units each of AB & P.

Hence: hrs / u = 1,280

Particulars	Q	P	Total
Selling Price p. u. (₹)	17,200	14,000	31,200
Variable Cost p. u. (₹) (Excluding Labour)	12,000	12,000	24,000
Labour Cost p. u. (₹)			
1,280 hrs. × ₹4	5,120	–	5,120
1,280 hrs. × ₹1	–	1,280	1,280
Total Variable Cost p. u. (₹)	17,120	13,280	30,400
Contribution p. u. (₹)	80	720	800
Units	4	4	
Contribution (₹)	320	2,880	3,200

Decision:

AB should not take labour from P Ltd. It should choose Option-I.

Application of Learning Curve in Standard Costing

Question-9

Genting Mfg Co. has developed a product for which the following standard cost estimates have been made for the first batch to be manufactured in Jan'13:

	₹
Direct Materials (100 Kgs. @ ₹55 per Kg.)	*5,500*
Direct Labour (100 hours @ ₹40 per hour)	*4,000*
Variable Overhead (100 hours @ ₹75 per hour)	*7,500*
	17,000

From experience the firm knows that labour will benefit from a learning effect and labour time will be reduced. This is expected to approximate to an 80% learning curve. In addition, the growing expertise of labour is expected to improve the efficiency with which materials are used. The usage of materials is expected to approximate to a 95% learning curve.

The actual production for Jan'13 to Jun'13 was 320 batches. During Jun'13 following results were recorded for the 320th batch made:

	₹
Direct Materials (80 Kgs.)	*4,000*
Direct Wages (20 hours)	*1,000*
Variable Overhead	*1,800*

You are required to calculate variances in connection with 320th batch.

[Note: Learning Coefficient is -0.322 and -0.074 for learning rate of 80% and 95% respectively, log2=0.30103, log5=0.69897, log319=2.50379, Antilog of 1.81462 =65.26, Antilog of 1.81472 =65.27, Antilog of 1.19334 =15.61, Antilog of 1.19378 =15.62]

Solution:

Working Note:

(1) Working note showing Standard Quantity of Material for 320th Batch.

Cumulative Number of Batches = 320

Average Kgs. of Material *per batch* = $100 \times 320^{-0.074}$

$t = 100 \times 320^{-0.074}$

$\log t = \log 100 - 0.074 \times \log 320$

$\log t = \log 100 - 0.074 \times \log (2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 5)$

$\log t = \log 100 - 0.074 \times [\log 2^6 + \log 5]$

$\log t = \log 100 - 0.074 \times [6 \times \log 2 + \log 5]$

$\log t = 2 - 0.074 \times [6 \times 0.30103 + 0.69897]$

$\log t = 1.81462$

$t = \text{Antilog}(1.81462)$

$t = 65.26$

Cumulative Number of Batches = 319

Average Kgs. of Material *per batch* = $100 \times 319^{-0.074}$

$t = 100 \times 319^{-0.074}$

$\log t = \log 100 - 0.074 \times \log 319$

$\log t = \log 100 - 0.074 \times \log 319$

$\log t = 2 - 0.074 \times 2.50379$

log t = 1.81472

t = Antilog (1.81472)

t = 65.27

Standard Quantity for 320th Batch = 320 × 65.26 – 319 × 65.27

= 62.07 Kgs.

(2) **Working note showing Standard Hours for 320th Batch.**

Cumulative Number of Batches = 320

Average Labour Hours *per batch* = $100 \text{x} 320^{-0.322}$

t = $100 \text{x} 320^{-0.322}$

log t = log100 – 0.322 × log320

log t = log100 – 0.322 × log (2x2x2x2x2 x2x5)

log t = log100 – 0.322 × [log2^6 + log 5]

log t = log100 – 0.322 × [6 × log2 + log 5]

log t = 2 – 0.322 × [6 × 0.30103 + 0.69897]

log t = 1.19334

t = Antilog (1.19334)

t = 15.61

Cumulative Number of Batches = 319

Average Labour Hours *per batch* = $100 \text{x} 319^{-0.322}$

t = $100 \text{x} 319^{-0.322}$

log t = log 100 – 0.322 × log319

log t = 2 – 0.322 × 2.50379

log t = 1.19378

t = Antilog (1.19378)

t = 15.62

Standard Hours for 320th Batch = 320 × 15.61 – 319 × 15.62

= 12.42 hours

Statement Showing Standard Cost and Actual Cost of 320th Batch:

Standard Data			Actual Data			
Material						
SQ	SP	SQ × SP	AQ	AP	AQ × AP	SP × AQ
62.07 Kgs. (Refer W.N.1)	₹55	₹3,414	80 Kgs.	₹ 50.00	₹ 4,000.00	₹ 4,400.00
Labour						
SH	SR	SH × SR	AH	AR	AH × AR	SR × AH
12.42 hours (Refer W.N.2)	₹ 40	₹ 497	20 hours	₹ 50.00	₹ 1,000.00	₹ 800
Variable Overhead						
SH	SR	SH × SR	AH	AR	AH × AR	SR × AH
12.42 hours (Refer W.N.2)	₹75	₹932	20 hours	₹90.00	₹1,800.00	₹1,500

Computation of Variances:

Material Variances

Cost Variance = Standard Material Cost – Actual Material Cost

= SQ × SP – AQ × AP

= ₹ 3,414 – ₹ 4,000

= ₹ 586 (A)

Usage Variance = Standard Cost of Standard Quantity – Standard Cost of Actual Quantity

= SQ × SP – AQ × SP

= ₹3,414 – ₹4,400

= ₹986 (A)

Price Variance = Standard Cost of Actual Quantity – Actual Material Cost

= AQ × SP – AQ × AP

= ₹4,400 – ₹4,000

= ₹400 (F)

<u>Labour Variances</u>

Cost Variance = Standard Cost of Labour – Actual Cost of Labour
= SH × SR – AH × AR
= ₹497 – ₹1,000
= ₹503 (A)

Efficiency Variance = Standard Cost of Standard Time – Standard Cost for Actual Time
= SH × SR – AH × SR
= ₹497 – ₹800
= ₹303 (A)

Rate Variance = Standard Cost for Actual Time – Actual Cost of Labour
= AH × SR – AH × AR
= ₹800 – ₹1,000
= ₹200 (A)

<u>Variable Overhead Variances</u>

Cost Variance = Standard Variable Overheads for Production – Actual Variable Overheads
= ₹932 – ₹1,800
= ₹868 (A)

Efficiency Variance = Standard Variable Overheads for Production – Budgeted Variable Overheads for Actual Hours
= ₹932 – 20 Hours × ₹75
= ₹568 (A)

Expenditure Variance = Budgeted Variable Overheads for Actual Hours – Actual Variable Overheads
= 20 Hours × ₹75 – ₹1,800
= ₹ 300 (A)

16
Learning Curve Theory

Question 1

An electronics firm which has developed a new type of fire-alarm system has been asked to quote for a prospective contract. The customer requires separate price quotations for each of the following possible orders:

Order	*Number of fire-alarm systems*
First	*100*
Second	*60*
Third	*40*

The firm estimates the following cost per unit for the first order:

Direct materials	*₹. 500*
Direct labour	
Deptt. A (Highly automatic) 20 hours at ₹. 10 per hour	
Deptt. B (Skilled labour) 40 hours at ₹. 15 per hour	
Variable overheads	*20% of direct labour*
Fixed overheads absorbed:	
Deptt. A	*₹. 8 per hour*
Deptt. B	*₹. 5 per hour*

Determine a price per unit for each of the three orders, assuming the firm uses a mark up of 25% on total costs and allows for an 80% learning curve. Extract from 80% Learning curve table:

X	1.0	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
Y%	100.0	91.7	89.5	87.6	86.1	84.4	83.0	81.5	80.0

X represents the cumulative total volume produced to date expressed as a multiple of the initial order.

Y is the learning curve factor, for a given X value, expressed as a percentage of the cost of the initial order. *(8 Marks) (May, 2005); (11 Marks) (May, 2010)*

Answer

(i) Price per unit for first order of 100 units

	₹	₹
Direct material		500.00
Direct labour	Dept A 20 Hrs @ 10 = 200	800.00
	Dept B 40 Hrs @ 15 = 600	
Variable Overhead	20% of ₹ 800	160.00
Fixed Overhead	Dept A 20 Hrs @ 8 = 160	360.00
	Dept B 40 Hrs @ 5 = 200	
Total cost		1,820.00
Profit 25%		455.00
Selling price per unit		2,275.00

(ii) Price per unit for second order of 60 units

Learning will be applicable only in department B.

Cumulative output becomes 100 units + 60 units = 160 units i.e 1.6 times for which learning is 86.1 % from the tables.

Therefore Total Hrs for 160 units = 160 units $\times$ 40 $\times$ .861 = 5,510.4 Hrs

Therefore Hrs for 60 units = Hrs for 160 units less Hrs for 100 units

Or 5510.4 less 40 $\times$ 100 = 1510.4 Hrs

Therefore Hrs per unit = $\frac{1510.4}{60}$ = 25.17

Calculation of selling price per unit

		₹
Direct materials		500.00
Direct labour	Dept A 20 Hrs @ 10 = 200	577.55
	Dept B 25.17 Hrs @ 15 = 377.55	
Variable Overhead	20% of 577.55	115.51
Fixed Overhead	Dept A 20 Hrs @8= 160	285.85
	Dept B 25.17 Hrs @5=125.85	
Total cost		1,478.91
Profit 25%		369.73
Selling price per unit		1,848.64

(iii) **Price per unit for third order of 40 units**

Cumulative output becomes 100 + 60 + 40 = 200 units i.e. 2 times for which learning is 80% from the table

Total Hrs for 200 units = 200 × 40 × .80 = 6,400 Hrs

Hrs for 40 units = Hrs for 200 units less Hrs for 160 units

Or 6,400 less 5510.4 = 889.6 Hrs

Therefore Hrs per unit = $\frac{889.6}{40}$ = 22.24

Calculation of selling price per unit

		₹
Direct materials		500.00
Direct labour	Dept A 20 Hrs @ 10 = 200.00	533.60
	Dept B 22.24 @ 15 = 333.60	
Variable Overhead	20% of 533.60	106.72
Fixed Overhead	Dept A 20 Hrs @ 8 = 160	271.20
	Dept B 22.24 Hrs @ 5 = 111.20	
Total cost		1,411.52
Profit 25%		352.88
Selling price per unit		1,764.40

Question 2

Explain the concept 'Learning curve'. How can it be applied for Cost management?

(4 Marks) (May, 2006)

Answer

The first time when a new operation is performed, both the workers and the operating procedures are untried. As the operation is repeated and the workers become more familiar with work, labour efficiency increases and the labour cost per unit declines. This process continues for some time and a regular rate of decline in cost per unit can be established. This rate can be used to predict future labour costs. The learning process starts from the point when the first unit comes out of the production line. In other words 'Learning curve' is a function that measures how labour hours per unit decline as units of production increase because workers are learning and becoming better at their jobs.

Cost Management Application:

1. Learning curve is useful in analysing cost volume profit relationship. The company can set low price of its product to generate high demand. As the production increases, cost per unit drops.
2. It helps in budgeting and profit planning.
3. It enables the company in price fixation. In particular, the company can fix a lower price for repeat orders.
4. It helps the design engineers to take suitable decisions based on expected rates of improvement.
5. It helps in price negotiations.
6. It is useful in setting standards and in performance evaluation.

Question 3

Discuss the application of the learning curve. *(4 Marks) (May, 2007)*

Answer

Application of Learning curve: Learning curve helps to analyse cost-volume profit relationships during familiarisation phase of product or process to arrive at cost estimates.

It helps in budgeting and profit planning.

It helps in pricing and consequent decision making – e.g. acceptance of an order, negotiations in establishing contract prices etc. with the advantage of the knowledge of decreasing unit cost.

It helps in setting standards in the learning phase.

Question 4

What are the distinctive features of learning curve theory in manufacturing environment? Explain the learning curve ratio. *(9 Marks) (Nov., 2007)*

Answer

As the production quantity of a given item is doubled, the cost of the item decreases at a fixed rate. This phenomenon is the basic premise on which the theory of learning curve has been formulated. As the quantity produced doubles, the absolute amount of cost increase will be successively smaller but the rate of decrease will remain fixed. It occurs due to the following distinctive features of manufacturing environment:

(i) Better tooling methods are developed and used.

(ii) More productive equipments are designed and used to make the product.

(iii) Design bugs are detected and corrected.

(iv) Engineering changes decrease over time.

(v) Earlier teething problems are overcome.

(vi) Rejections and rework tend to diminish over time.

In the initial stage of a new product or a new process, the learning effect pattern is so regular that the rate of decline established at the outset can be used to predict labour cost well in advance. The effect of experience on cost is summarized in the learning curve ratio or improvement ratio.

$$\text{Learning curve ratio} = \frac{\text{Average labour cost of first 2N units}}{\text{Average labour cost of first N units}}$$

For example, if the average labour cost for the first 500 units is ₹ 25 and the average labour cost for the first 1,000 units is ₹ 20, the learning curve ratio is (₹ 20/25) or 80%. Since the average cost per unit of 1,000 units is ₹ 20, the average cost per unit of first 2,000 units is likely to be 80% of ₹ 20 or ₹ 16.

Question 5

M Ltd. Manufactures a special product purely carried out by manual labour. It has a capacity of 20,000 units. It estimates the following cost structure:

Direct material	*30 ₹/ unit*
Direct labour (1 hour / unit)	*20 ₹/ unit*
Variable overhead	*10 ₹/ unit*

Fixed overheads at maximum capacity is ₹1,50,000.

It is estimated that at the current level of efficiency, each unit requires one hour for the first 5,000 units. Subsequently it is possible to achieve 80% learning rate. The market can absorb the first 5,000 units at ₹.100 per unit. What should be the minimum selling price acceptable for an order of 15,000 units for a prospective client? *(7 Marks) (May, 2008)*

Answer

	5,000 units	20,000 units
Material	1,50,000	6,00,000
Direct Labour	1,00,000	2,56,000
		Refer to W Note i
Variable Overhead	50,000	2,00,000
Total Variable Cost	3,00,000	10,56,000
Fixed Cost	1,50,000	1,50,000
Total Cost	4,50,000	12,06,000
Total cost / unit	90	60.3
Sales 100 × 5,000	5,00,000	5,00,000
15,000 × *x(assumed selling price)*		15,000 *x*
(Total Sales less Total Cost) = Profit	50,000	15,000 x – 7,06,000

Or minimum selling price = 50.4(refer to Working Note ii)

Working Note: I

Units	*Hours*
5,000	5,000
10,000	10,000 × 1 × .8 = 8,000 hours
20,000	20,000 × 1 × .8 × .8 = 12,800 hours

Working Note: II

$15,000\,x - 7,06,000 > 50,000$

$15,000\,x > 7,56,000$

or $x > 50.4$

Alternative Solution:

Total cost / unit of capacity 20,000 = 60.3

Weighted average selling price > 80.4

i.e. $\frac{5,000 \times 100 + 15,000\,x}{20,000} > 60.3$

$= 5,00,000 + 15,000\,x > 60.3 \times 20,000$

$= 15,000\,x > 12,06,000 - 5,00,000$

Or

$15,000\,x > 7,06,000$

$x > 47.06$

Minimum price to cover production Cost = 47.06

Minimum price to cover same amount of profit = 50.40 (refer to Working Note 1)

Working Note 1

(– 47.06 + 50.04) × 15,000 units = ₹ 50,000

Question 6

A company which has developed a new machine has observed that the time taken to manufacture the first machine is 600 hours. Calculate the time which the company will take to manufacture the second machine if the actual learning curve rate is (i) 80% and (ii) 90%. Explain which of the two learning rates will show faster learning. (3 Marks) (Nov., 2008)

Answer

(i) Actual learning curve rate is 80%.

Time taken to produce the first machine	= 600 hours
Average time taken to produce two machines	= 600 × 80% hours
	= 480 hours.
Cumulative time taken to produce two machines	= 480 × 2 hours
	= 960 hours.
Time taken to produce the second machine	= (960 – 600)hours
	= 360 hours.

(ii) *Actual learning curve rate is 90%.*

Time taken to produce the first machine	= 600 hours
Average time taken to produce two machines	= 600 × 90% hours
	= 540 hours.
Cumulative time taken to produce two machines	= 540 × 2 hours
	= 1080 hours.
Time taken to produce the second machine	= (1080 – 600) hours
	= 480 hours.

The time taken to produce the second machine is lower at 80% learning rate and hence 80% learning rate shows faster learning rate.

Question 7

The Gifts Company makes mementos for offering chief guests and other dignitaries at functions. A customer wants 4 identical pieces of hand-crafted gifts for 4 dignitaries invited to its function.

For this product, the Gifts Company estimates the following costs for the 1st unit of the product

	₹/unit
Direct variable costs (excluding labour)	*2,000*
Direct labour (20 hours @ ₹ 50 hour)	*1,000*

90 % learning curve ratio is applicable and one labourer works for one customer's order.

(i) What is the price per piece to be quoted for this customer if the targeted contribution is ₹ 1,500 per unit?

(ii) If 4 different labourers made the 4 products simultaneously to ensure faster delivery to the customer, can the price at (i) above be quoted? Why? (6 Marks)(Nov., 2009)

Answer

(i) ₹/u

	1st unit	*Avg/u after 4th at*
Variable Cost	2000	2000
Labour	1000	810
Target Contribution		1500
Price to be quoted		4310 (₹ /u)

(ii) No, the company cannot quote this price for varying products because the learning curve Ratio does not apply to non-repeated jobs. Each product will carry a different price according to its direct labour hours.

Question 8

Explain distinctive features of learning curve theory in manufacturing environment.

(4 Marks)(Nov., 2010)

Answer

The production quantity of a given item doubled the cost of that item decrease at a fixed rate. This phenomenon is the basic premise on which the theory of learning curve has been formulated.

The distinctive features of a learning curve are:

1. Better tooling methods are developed and used
2. More productive equipments are designed and used to make the product.
3. Design bugs are detected and corrected.
4. Better design engineering reduces material and labour costs.
5. Early teething problems are overcome. As production progresses management is prompted to achieve better planning and better management.
6. Rejections and rework tend to diminish over time.
7. As quantity produced increases the Cost per unit decreases, since each unit entails:

(i) Lesser labour (ii) Greater productivity of material and labour (iii) Fewer delays and lesser time losses.

Question 9

What are the limitations of the learning curve theory ? *(4 Marks)(Nov., 2011)*

Answer

Limitations of Learning Curve Theory

1. All activities of a firm are not subject to learning effect. (Activities that have not been performed in the present operational mode, those performed by new or unfamiliar employees are subjected to learning effect, while those performed by familiar or experienced workmen will not be subjected to learning effect)
2. It is correct that learning effect does take place and average time taken is likely to reduce. But in practice it is highly unlikely that there will be a regular consistent rate of decrease. Therefore any cost prediction based on conventional learning curves should be viewed with caution.
3. Considerable difficulty arises in obtaining valid data that will form basis for computation of learning effect.
4. Even slight change in circumstances quickly renders the learning curve obsolete. While the regularity of conventional learning curves can be questioned, it would be wrong to ignore learning effect altogether in predicting costs for decision purposes.

Question 10

What are the distinctive features of learning curve theory in manufacturing environment? Explain the learning curve ratio. *(4 Marks)(Nov, 2012)*

Answer

Learning curve ratio:

$$= \frac{\text{Average Labour cost of first 2N units}}{\text{Average Labour cost of first N units}}$$

As the production quantity of a given item is doubled, the cost of the item decreases at a fixed rate. It occurs because of the following distinctive features of manufacturing environment.

(i) Better tooling methods are developed and used

(ii) Design bugs are detected and corrected

(iii) More productive equipment is designed and used.

(iv) Engineering changes decrease over time.

(v) Earlier teething problems are overcome.

(vi) Rejections and rework tend to diminish overtime.

Question 11

Bring out the main applications of Learning Curve. *(4 Marks)(May, 2013)*

Answer

Knowledge of learning curve can be useful both in planning and control. Standard cost for new operations should be revised frequently to reflect the anticipated learning pattern. The main applications are summarised below:

- **Helps to analyse CVP relationship during familiarisation phase:** Learning curve is useful to analyse cost-volume-profit relationship during familiarisation phase of product or process and thus it is very useful for cost estimates. Learning curve can be used as a tool for forecasting.
- **Helps in budgeting and profit planning:** Budget manager should select those costs which reflect learning effect and then he should be able to incorporate this effect in process of developing budgets or in the exercises relating to project planning.
- **Helps in pricing:** The use of cost data adjusted for learning effect helps in development of advantageous pricing policy.
- **Design makers:** It helps design engineers in making decisions based upon expected (predictable from past experience) rates of improvement.
- **Helps in negotiations:** It is very useful to Government in negotiations about the contracts.
- **Helps in setting standards:** The learning curve is quite helpful in setting standards in learning phase.

Question 12

State whether the learning curve theory can be applied to .the following independent situations briefly justifying your decision:

(i) A labour intensive sculpted product is carved from the metal provided to the staff. The metal is sourced from different suppliers since it is scarce. The alloy composition of the input metal is quite different among the suppliers.

(ii) Pieces of hand-made furniture are assembled by the company in a far off location. The labourers do not know anything about the final product which utilizes their work. As a matter of further precaution, rotation of labour is done frequently.

(Ill) Skilled workers have been employed for a long time. The company has adequate market for the craft pieces done by these experts.

(iv) *A company funds that it always has an adverse usage of indirect material. It wants to apply learning curve theory to improve the way standards have been set.* ***(4 Marks)(Nov., 2013)***

Answer

(i) 'Learning Curve Theory' will not be applicable as *alloy combination of the input metal is quite different* among the suppliers hence learning experience with one type of metal may not be beneficial for the workers to deal with other metal with separate alloy composition.

(ii) 'Learning Curve Theory' will not be applicable as in this situation *rotation of labour is done frequently*, labours will not be able to get the benefit of learning and apply their learning. Hence, learning curve theory can not be applied.

(iii) 'Learning Curve Theory' will not be applicable as in this situation as *workers are skilled and employed for a long time*, they have already achieved maximum level of expertise by taking advantage of learning. Hence, at this point of time learning curve theory can not be applied.

(iv) 'Learning Curve Theory' will not be applicable as indirect materials are the materials which are not used directly in the production (not directly proportionate with volume of output) and usually used machines (e.g. lubricants, spares parts etc.) with less human interactions. Adverse usage of indirect materials can be controlled through proper monitoring and appropriate standard settings and not from applying learning curve theory.