Motion and Time Study

The Goals of Motion Study

- Improvement
- Planning / Scheduling (Cost)
- Safety

Know How Long to Complete Task for

- Scheduling (Sequencing)
- Efficiency (Best Way)
- Safety (Easiest Way)

How Does a Job Incumbent Spend a Day

- Value Added vs. Non-Value Added

The General Strategy of IE to Reduce and Control Cost

- Are people productive ALL of the time ?
- Which parts of job are really necessary ?
- Can the job be done EASIER, SAFER and FASTER ?
- Is there a sense of employee involvement?

Some Techniques of Industrial Engineering

- Measure
  - Time and Motion Study
  - Work Sampling
- Control
  - Work Standards (Best Practices)
  - Accounting – Labor Reporting
- Improve
  - Small group activities

Time Study

- Observation
  - Stop Watch
  - Computer / Interactive
- Engineering Labor Standards (Bad Idea)
- Job Order / Labor reporting data

History

- Frederick Taylor (1900's)

  Studied motions of iron workers – attempted to "mechanize" motions to maximize efficiency – including proper rest, ergonomics, etc.
- Frank and Lillian Gilbreth used motion picture to study worker motions – developed 17 motions called "therbligs" that describe all possible work.

TABLE 7–1

Therblig Name	Symbol	Color Designation	Symbol
Search	S	Black	
Select	SE	Gray, Light	
Grasp	G	Lake Red	
Reach	RE	Olive Green	
Move	M	Green	
Hold	H	Gold Ocher	
Release	RL	Carmine Red	
Position	P	Blue	
Pre-position	PP	Sky Blue	
Inspect	I	Burnt Ocher	
Assemble	A	Violet, Heavy	
Disassemble	DA	Violet, Light	
Use	U	Purple	
Unavoidable Delay	UD	Yellow Ocher	
Avoidable Delay	AD	Lemon Yellow	
Plan	PL	Brown	
Rest to Overcome Fatigue	R	Orange	

TABLE I—REACH—R

Distance Moved Inches	Time TMU				Hand In Motion	
	A	B	C or D	E	A	B
¾ or less	2.0	2.0	2.0	2.0	1.6	1.6
1	2.5	2.5	3.6	2.4	2.3	2.3
2	4.0	4.0	5.9	3.8	3.5	2.7
3	5.3	5.3	7.3	5.3	4.5	3.6
4	6.1	6.4	8.4	6.8	4.9	4.3
5	6.5	7.8	9.4	7.4	5.3	5.0
6	7.0	8.6	10.1	8.0	5.7	5.7
7	7.4	9.3	10.8	8.7	6.1	6.5
8	7.9	10.1	11.5	9.3	6.5	7.2
9	8.3	10.8	12.2	9.9	6.9	7.9
10	8.7	11.5	12.9	10.5	7.3	8.6
12	9.6	12.9	14.2	11.8	8.1	10.1
14	10.5	14.4	15.6	13.0	8.9	11.5
16	11.4	15.8	17.0	14.2	9.7	12.9
18	12.3	17.2	18.4	15.5	10.5	14.4
20	13.1	18.6	19.8	16.7	11.3	15.8
22	14.0	20.1	21.2	18.0	12.1	17.3
24	14.9	21.5	22.5	19.2	12.9	18.8
26	15.8	22.9	23.9	20.4	13.7	20.2
28	16.7	24.4	25.3	21.7	14.5	21.7
30	17.5	25.8	26.7	22.9	15.3	23.2

CASE AND DESCRIPTION
A Reach to object in fixed location, or to object in other hand or on which other hand rests.
B Reach to single object in location which may vary slightly from cycle to cycle.
C Reach to object jumbled with other objects in a group so that search and select occur.
D Reach to a very small object or where accurate grasp is required.
E Reach to indefinite location to get hand in position for body balance or next motion or out of way.

TABLE II—MOVE—M

Distance Moved Inches	Time TMU				Wt. Allowance			CASE AND DESCRIPTION
	A	B	C	Hand In Motion B	Wt. (lb.) Up to	Factor	Constant TMU	
¾ or less	2.0	2.0	2.0	1.7	2.5	0	0	A Move object to other hand or against stop.
1	2.5	2.9	3.4	2.3				
2	3.6	4.6	5.2	2.9	7.5	1.06	2.2	
3	4.9	5.7	6.7	3.6				
4	6.1	6.9	8.0	4.3	12.5	1.11	3.9	
5	7.3	8.0	9.2	5.0				
6	8.1	8.9	10.3	5.7	17.5	1.17	5.6	B Move object to approximate or indefinite location.
7	8.9	9.7	11.1	6.5				
8	9.7	10.6	11.8	7.2	22.5	1.22	7.4	
9	10.5	11.5	12.7	7.9				
10	11.3	12.2	13.5	8.6	27.5	1.28	9.1	
12	12.9	13.4	15.2	10.0				
14	14.4	14.6	16.9	11.4	32.5	1.33	10.8	
16	16.0	15.8	18.7	12.8				
18	17.6	17.0	20.4	14.2	37.5	1.39	12.5	C Move object to exact location.
20	19.2	18.2	22.1	15.6				
22	20.8	19.4	23.8	17.0	42.5	1.44	14.3	
24	22.4	20.6	25.5	18.4				
26	24.0	21.8	27.3	19.8	47.5	1.50	16.0	
28	25.5	23.1	29.0	21.2				
30	27.1	24.3	30.7	22.7				

TABLE III—TURN AND APPLY PRESSURE—T AND AP

Weight	Time TMU for Degrees Turned										
	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°	180°
Small— 0 to 2 Pounds	2.8	3.5	4.1	4.8	5.4	6.1	6.8	7.4	8.1	8.7	9.4
Medium—2.1 to 10 Pounds	4.4	5.5	6.5	7.5	8.5	9.6	10.6	11.6	12.7	13.7	14.8
Large— 10.1 to 35 Pounds	8.4	10.5	12.3	14.4	16.2	18.3	20.4	22.2	24.3	26.1	28.2

APPLY PRESSURE CASE A—10.6 TMU. APPLY PRESSURE CASE B—16.2 TMU

TABLE IV—GRASP—G

Case	Time TMU	DESCRIPTION
1A	2.0	Pick Up Grasp—Small, medium or large object by itself, easily grasped.
1B	3.5	Very small object or object lying close against a flat surface.
1C1	7.3	Interference with grasp on bottom and one side of nearly cylindrical object. Diameter larger than ½".
1C2	8.7	Interference with grasp on bottom and one side of nearly cylindrical object. Diameter ¼" to ½".
1C3	10.8	Interference with grasp on bottom and one side of nearly cylindrical object. Diameter less than ¼".
2	5.6	Regrasp.
3	5.6	Transfer Grasp.
4A	7.3	Object jumbled with other objects so search and select occur. Larger than 1" x 1" x 1".
4B	9.1	Object jumbled with other objects so search and select occur. ¼" x ¼" x ⅛" to 1" x 1" x 1".
4C	12.9	Object jumbled with other objects so search and select occur. Smaller than ¼" x ¼" x ⅛".
5	0	Contact, sliding or hook grasp.

TABLE V—POSITION*—P

CLASS OF FIT		Symmetry	Easy To Handle	Difficult To Handle
1—Loose	No pressure required	S	5.6	11.2
		SS	9.1	14.7
		NS	10.4	16.0
2—Close	Light pressure required	S	16.2	21.8
		SS	19.7	25.3
		NS	21.0	26.6
3—Exact	Heavy pressure required.	S	43.0	48.6
		SS	46.5	52.1
		NS	47.8	53.4

*Distance moved to engage—1" or less.

TABLE VI—RELEASE—RL

Case	Time TMU	DESCRIPTION
1	2.0	Normal release performed by opening fingers as independent motion.
2	0	Contact Release.

TABLE VII—DISENGAGE—D

CLASS OF FIT	Easy to Handle	Difficult to Handle
1—Loose—Very slight effort, blends with subsequent move.	4.0	5.7
2—Close — Normal effort, slight recoil.	7.5	11.8
3—Tight — Considerable effort, hand recoils markedly.	22.9	34.7

TABLE VIII—EYE TRAVEL TIME AND EYE FOCUS—ET AND EF

Eye Travel Time = $15.2 \times \frac{T}{D}$ TMU, with a maximum value of 20 TMU.

where T = the distance between points from and to which the eye travels.
D = the perpendicular distance from the eye to the line of travel T.

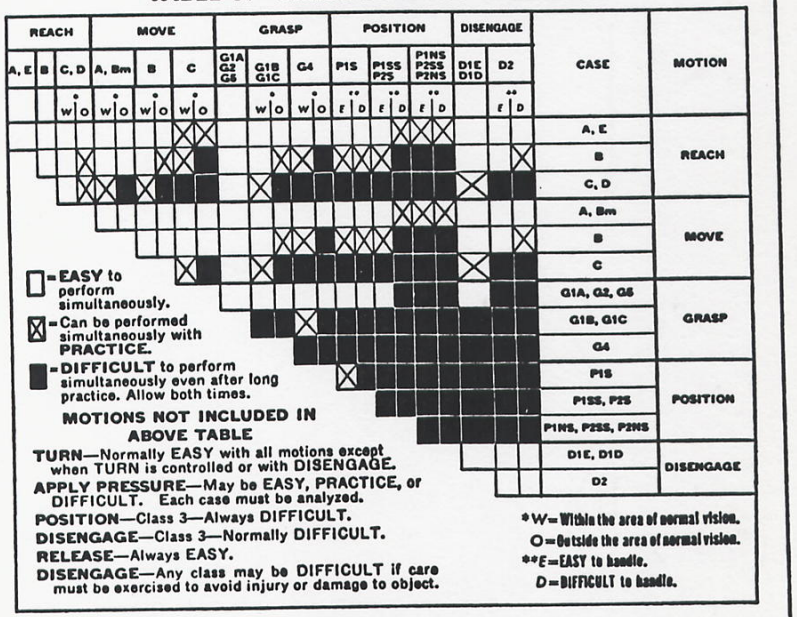
Eye Focus Time = 7.3 TMU.

TABLE 19–4 *(concluded)*

TABLE IX—BODY, LEG, AND FOOT MOTIONS

DESCRIPTION	SYMBOL	DISTANCE	TIME TMU
Foot Motion—Hinged at Ankle.	FM	Up to 4"	8.5
With heavy pressure.	FMP		19.1
Leg or Foreleg Motion.	LM —	Up to 6"	7.1
		Each add'l. inch	1.2
Sidestep—Case 1—Complete when leading leg contacts floor.	SS-C1	Less than 12"	Use REACH or MOVE Time
		12"	17.0
		Each add'l. inch	.6
Case 2—Lagging leg must contact floor before next motion can be made.	SS-C2	12"	34.1
		Each add'l. inch	1.1
Bend, Stoop, or Kneel on One Knee.	B,S,KOK		29.0
Arise.	AB,AS,AKOK		31.9
Kneel on Floor—Both Knees.	KBK		69.4
Arise.	AKBK		76.7
Sit.	SIT		34.7
Stand from Sitting Position.	STD		43.4
Turn Body 45 to 90 degrees—			
Case 1—Complete when leading leg contacts floor.	TBC1		18.6
Case 2—Lagging leg must contact floor before next motion can be made.	TBC2		37.2
Walk.	W-FT.	Per Foot	5.3
Walk.	W-P	Per Pace	15.0

TABLE X—SIMULTANEOUS MOTIONS



MTM Association for Standards and Research, Fair Lawn, New Jersey

• GET	G
• PUT	P
• GET WEIGHT	GW
• PUT WEIGHT	PW
• REGRASP	R
• APPLY PRESSURE	A
• EYE ACTION	E
• FOOT ACTION	F
• STEP	S
• BEND & ARISE	B
• CRANK	C

Time Study (Stopwatch Measurement)

1. List work elements
2. Discuss with worker
3. Measure with stopwatch (running VS reset)
4. Repeat for n Observations
5. Compute mean and std dev of work station time
6. Be aware of allowances/foreign element, etc

SHOP _____

PART NAME _____

PART NO. _____

OPERATION _____

_____

OPER. NO. _____

STUDY NO. _____

SHEET NO. _____

DATE _____

OBSERVER _____

OPERATOR _____

ELEMENTS	1	2	3	4	5	6	7	8	9	10	TOT.	AVG.	RF	BASE
TOTALS														

FOREIGN ELEMENTS	ALLOWANCES %
	STD. TIME MIN.
	HRS./C PCS. HRS.
TIME FINISHED	PIECES/HOUR PCS.
TIME STARTED	LABOR GRADE
ELAPSED TIME	

3AC 2183-R1

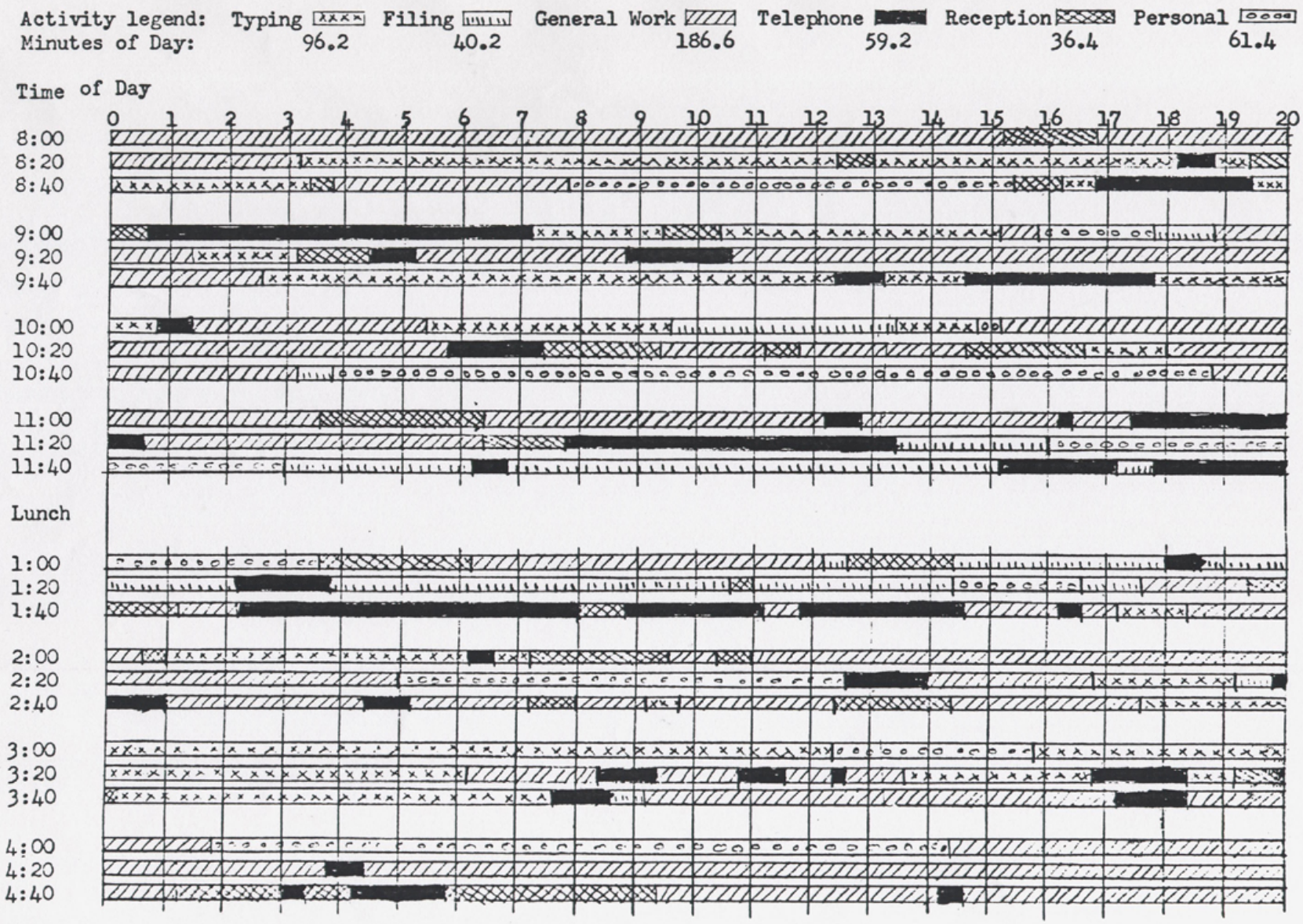


Figure 1. Activity-Timestudy of a Secretary for One Day

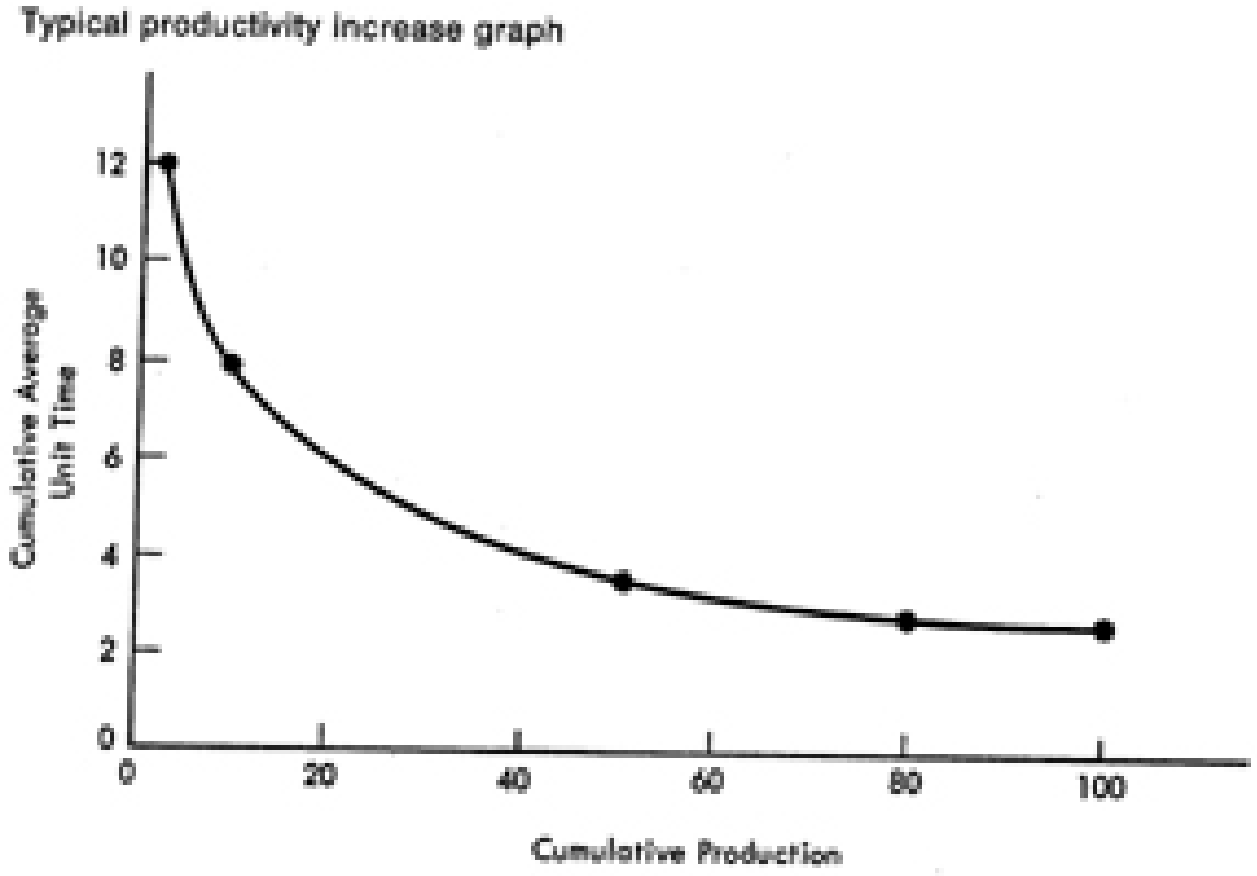
Work Sampling

- Determined what is done over typical day
- Random Reporting
- Periodic Reporting

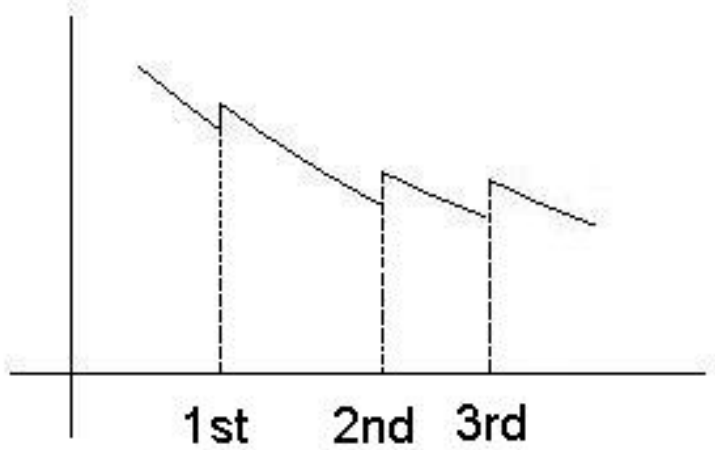
Learning Curve

- For repetitive work, worker gains skill, knowledge of product/process, etc over time
- Thus we expect output to increase over time as more units are produced over time to complete task decreases as more units are produced

Traditional Learning Curve



Actual Curve



Change, Design, Process, etc

Learning Curve

- Usually define learning as a percentage reduction in the time it takes to make a unit.
- The definition says a doubling of the total number of units made produce a constant decrease in the time per unit
- An 80% learning curve implies a 20% decrease in unit time with each doubling of the number produced (90% implies 10% decrease, 100% implies no improvement)

Learning Curve

- For an 80% learning Curve:

Unit	Unit Time (hours)
1	10
2	(.8)(10) = 8
4	(.8)(8) = 6.4
8	(.8)(6.4)= 5.12
16	(.8)(5.12)= 4.096

Learning Curve

- We can also compute the time to complete the n^{th} unit based on the learning %, and the time for the 1^{st} unit

$$Tn = T1 \times n \wedge b$$

Where, b = (natural log of learning %) / (natural log of 2)

Learning Curve

- From Previous 80% learning curve example:

  b = ln (.8) / ln (2)

  = -.22314/.69315

  = -.322

  For 3rd unit:

  T3 = T1 (3 ^ (ln(.8)/ln(2)))

  T3 = T1 (.702)

Learning Curve

- Can plot using log/log paper as a straight line and can also got unit curve and average curve

Learning Curve Applies

- Mass Production – Assembly line
- G.T. Cell – Repetitive work
- Other places where rep. Works performed.