SRM INSTITUTE OF SCIENCE AND TECHNOLOGY ,
KATTANKULATHUR

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

18MEO111T INDUSTRIAL ENGINEERING

VII SEM

Course Outcomes:

CO1- Acquire knowledge on different techniques and procedures of work study
CO2-Recognize the various plant layouts, need for site selection and about material handling
CO3-Acquire knowledge on ergonomics of work design, types and function of production and productivity measurement
CO4-Understand inventory management and resource utilization.
CO5- Acquire knowledge on job evaluation, incentive schemes and method of wage payment.
CO6-Analysis and improve the efficiency and productivity in the industries

Course Code	18MEO111T	Course Name	INDUSTRIAL ENGINEERING	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the techniques and procedures of work study*
CLR-2 :	*Know about various plant layout and material handling systems*
CLR-3 :	*Understand the ergonomics, production and productivity measurement*
CLR-4 :	*Impart the concept of production planning and control*
CLR-5 :	*Be familiar with methods of wage payment*
CLR-6 :	*Improve the efficiency, productivity and quality of products manufactured.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Acquire knowledge on different techniques and procedures of work study*	*1*	*90*	*85*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	*M*	-	-
CLO-2 :	*Recognize the various plant layouts, need for site selection and about material handling*	*1&2*	*90*	*85*	*H*	-	-	-	*H*	-	-	-	-	-	-	-	*M*	-	-
CLO-3 :	*Acquire knowledge on ergonomics of work design, types and function of production and productivity measurement*	*1&2*	*90*	*85*	*H*	*M*	*H*	-	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-4 :	*Understand inventory management and resource utilization.*	*1&2*	*90*	*85*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*M*	-	-
CLO-5 :	*Acquire knowledge on job evaluation, incentive schemes and method of wage payment*	*1*	*90*	*85*	*H*	*M*	-	-	-	-	-	*L*	-	-	-	-	-	-	*M*
CLO-6 :	*Analysis and improve the efficiency and productivity in the industries*	*1&2*	*90*	*85*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Work measurement and its Techniques*	*Plant location and site selection.*	*Introduction to work design, Work design for increased productivity*	*Objectives and Functions of PPC*	*Types of Wages and salary administration*
S-2	SLO-1	*Production study and Time study.*	*Types, need, factors influencing the plant layout.*	*The work system, design Introduction to job design.*	*Aspects of product development and design*	*Meaning principles in wage fixation, Techniques used of wage fixation*
S-3	SLO-1	*Standard time, Rating factors and Work sampling.*	*Tools and techniques for developing layout, process chart, flow diagram, string diagram, Template and Scale models.*	*Environmental factors and organizational factors*	*Introduction to Process Planning and types, Principles of Standardization*	*Method of Job evaluation*
S-4	SLO-1	*Techniques of Work study*	*Layout Planning and procedure involved in creating layout*	*Behavioral factors influencing effective job design.*	*Break even analysis*	*Steps involved in merit rating of employee*
S-5	SLO-1	*Human factors of Work study*	*Construction and Improvement algorithms-Automated Layout Design Program (ALDEP)*	*Ergonomics, Objectives system approach of ergonomic model*	*Introduction to Group Technology. and various types*	*Various Methods of wage payment*
S-6	SLO-1	*Method study, Techniques and procedures of improving Productivity.*	*Construction and Improvement algorithms-Computerized Relative Allocation of Facilities Techniques(CRAFT)*	*Man machine system, Production and Productivity*	*Method of finding optimum Batch size. Equipment.*	*Types, Advantages and disadvantages of Incentive scheme*
S-7	SLO-1	*Motion economy principles.*	*Introduction and procedure on Assembly and line balancing*	*Definition of production and function*	*ABC analysis.*	*Productivity base incentives*
S-8	SLO-1	*Charging Techniques*	*Material Handling, scope and importance. Types of material handling systems.*	*Type of production systems*	*Introduction to Value Engineering and its importance, Case studies*	*Case Example of Evaluation of incentive scheme*
S-9	SLO-1	*SIMO chart, Ergonomics and Industrial design.*	*Methods of material handling*	*Definition of productivity and productivity measurement.*	*Types of cost-Cost of production and Labour cost-Simple problems*	*Importance of Environmental pollution and control*

Program Outcomes :

PO1: Engineering Knowledge
PO2: Problem Analysis
PO3: Design and Development
PO4: Modern Tool Technology
PO5: Ethics

Duration (hour)		9
S-1	SLO-1	*Introduction to Work measurement and its Techniques*
S-2	SLO-1	*Production study and Time study.*
S-3	SLO-1	*Standard time, Rating factors and Work sampling.*
S-4	SLO-1	*Techniques of Work study*
S-5	SLO-1	*Human factors of Work study*
S-6	SLO-1	*Method study, Techniques and procedures of improving Productivity.*
S-7	SLO-1	*Motion economy principles.*
S-8	SLO-1	*Charging Techniques*
S-9	SLO-1	*SIMO chart, Ergonomics and Industrial design.*

Work study is a generic term for the techniques of method study and work measurement.
These are used in the examination of human work in all its contexts.

This is a systematic investigation of all the factors which affect the efficiency and economy at the work place in order to have improvement.

Significance : Increasing productivity.

Method study

A systematic recording and critical examination of existing and proposed ways of doing work and developing an easier and economical method.

Objectives of Method Study

1. Improvement of manufacturing processes and procedures.
2. Improvement of working conditions.
3. Improvement of plant layout and work place layout.
4. Reducing the human effort and fatigue.
5. Reducing material handling
6. Improvement of plant and equipment design.
7. Improvement in the utility of material, machines and manpower.
8. Standardization of method.
9. Improvement in safety standard.

Method study Procedure:

1.Select the work to be studied.
2.Record all facts about the method by direct observation.
3. Examine the above facts critically.
4. Develop the most efficient and economic method.
5. Refine and define the new method.
6. Implement the new method
7.Maintain the new method by regular checking.

1.Select

Factors considered while selecting a job for doing method study

)Economical factors. (b) Human factors. (c) Technical factors.

)Economical Factors :

When method study results in saving of money, then the study will be worthwhile.

Based on the economical factors, generally the following jobs are selected.

)Operations having bottlenecks (which holds up other production activities).

)Operations done repetitively.

)Operations involving great amount of manual work.

)Operations where Inventory moves for a long distance.

(b) Human Factors

The involvement and co-operation of all people concerned viz., workers, supervisor, trade unions etc results in successful method study.

Workers may show reluctancy to method study due to

1. The fear of unemployment.
2. The fear of reduction in wages.
3. The fear of increased work load.

(c) Technical Factors

To improve the method of work all the technical details about the job should be available.

Machine tool should not be loaded above its own capacity. Above which issues occur.

For example, a work study man feels that speed of the machine tool may be increased and HSS tool may be used. But the capacity of the machine may not permit increased speed. In this case, the suggestion of the work study man cannot be implemented. These types of technical factors should be considered.

2. Record

All activities of the existing method are record. Done by directly observing the work. Symbols used to represent the activities like operation, inspection, transport, storage and delay. Different charts and diagrams are used in recording.

.Operation process chart: All the operations and inspections are recorded.

.Flow process chart

(a) Man type All the activities of man are recorded

(b) Material type All the activities of the material are recorded

(c) Equipment type All the activities of equipment or machine are recorded. iii. Two-handed process chart: Motions of both lands of worker are Right hand-Left hand chart recorded independently.

iv. Multiple activity chart: Activities of a group of workers doing a single job or the activities of a single worker operating a number of machines are recorded.

v. Flow diagram: Path of flow of material in the shop is recorded.

vi. String diagram: The movements of workers are recorded using a string in a diagram drawn to scale.

3. Examine

Critical examination is done by questioning technique.

This is done after recording the method by suitable charts and diagrams.

The Merit of activity is examined by putting questions,which depend on the factors

Purpose – To eliminate the activity, if possible.

Place – To combine or re-arrange the activities.

Sequence

Person

Means – To simplify the activity.

The Sequence of questions is used:

1. Purpose –

What is actually done?

Why is it done?

What else could be done?

What should be done?

2. Place –

Where is it being done?

Why is it done there?

Where else could it be done?

Where should it be done?

3. Sequence –

When is it done?

Why is it done then?

When could it be done?

When should it be done?

4. Person – Who is doing it?

Why does that person do it?

Who else could do it?

Who should do it?

5. Means – How is it done?

Why is it done that way?

How else could it be done?

How should it be done?

The following are achieved.

Unwanted activities can be eliminated.

Number of activities can be combined or re-arranged.

Method can be simplified.

Reduction in production time

4. Develop The development of a better method can be obtained by following quesitons1. Purpose – What should be done?

2. Place – Where should it be done?

3. Sequence – When should it be done?

4. Person – Who should do it?

5. Means – How should it be done?

5. Define After complete study,a new method is developed and need to obtain the approval of the management before implementing.A report has to be prepapred giving details of the existing and proposed methods. Also reasons for the changes should be given.

The report includes

(a) Brief description of the old method.

(b) Brief description of the new method.

(c) Reasons for change.

(d) Advantages and limitations of the new method.

(e) Savings expected in material, labour and overheads.

(f) Tools and equipment required for the new method.

(g) The cost of installing the new method including.

.Cost of new tools and equipment.

.Cost of re-layout of the shop.

.Cost of training the workers in the new method.

4. Cost of improving the working conditions.

6. Install

The most difficult stage in method study.Active support of both management and trade union is required. Here the work study man requires skill in getting along with other people and winning their trust.

Installing consists of

)Gaining acceptance of the change by supervisor.
)Getting approval of management.
)Gaining the acceptance of change by workers and trade unions.
)Giving training to operators in the new method.
)To be in close contact with the progress of the job until it is satisfactorily executed.

7. Maintain

Ensure that workers follow the new method and did not follow the old one.

The new method may have defects and difficulties and same should be rectified in time.

Periodical review is made.

The reactions and suggestions from workers and supervisors are recorded which may lead to further improvement.

The differences between the new written standard practice and the actual practice are found out.

Reasons for variations are analysed.

Changes due to valid reasons are accepted.

The instructions are suitably modified.

CHARTS AND DIAGRAMS USED IN METHOD STUDY (TOOLS AND TECHNIQUES)

.Operation process chart (or) Outline process chart.

.Flow process chart.

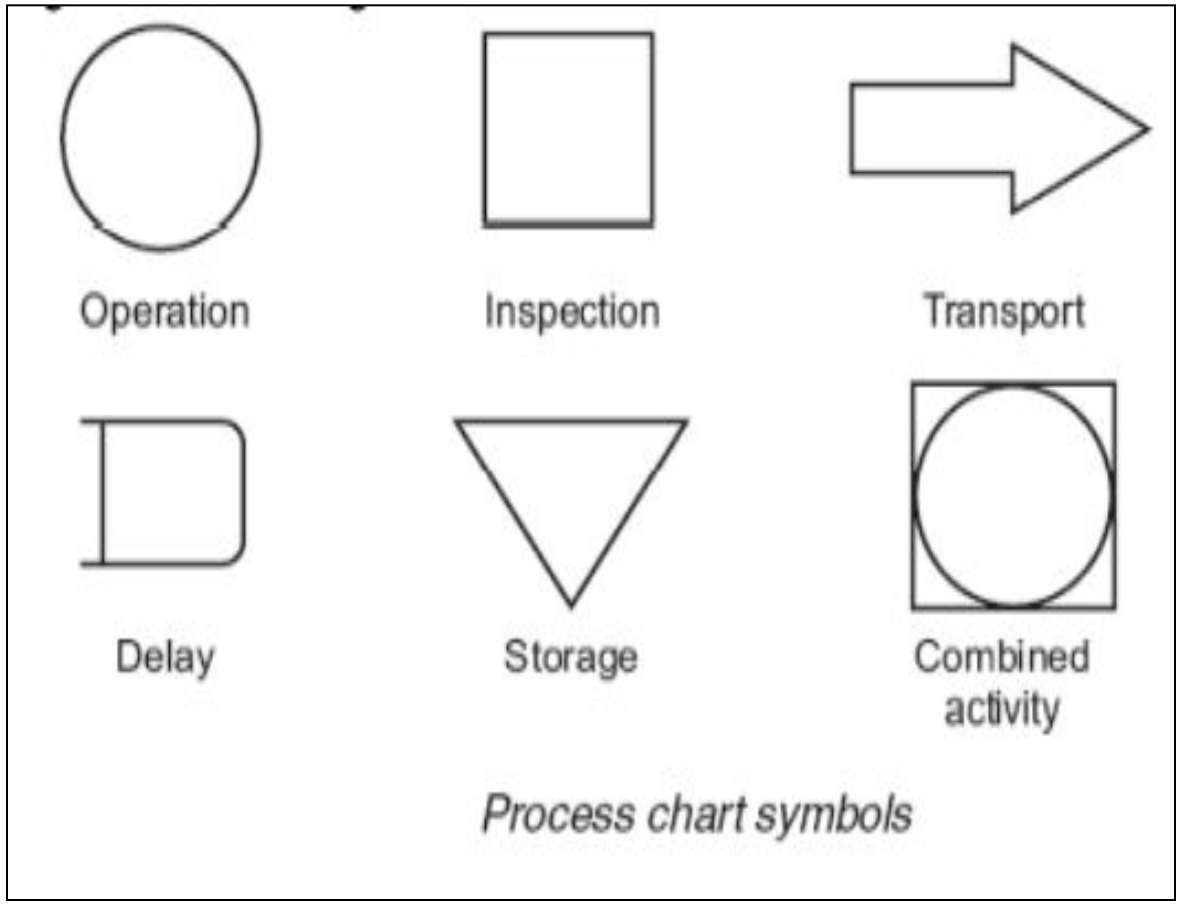
(a) Material type

(b) Operator type

(c) Equipment type

3. Two-handed process chart. (or) Left hand-Right hand chart
4. Multiple activity chart.
5. Flow diagram.
6. String diagram.

Process Chart Symbols



A large circle indicates operation.

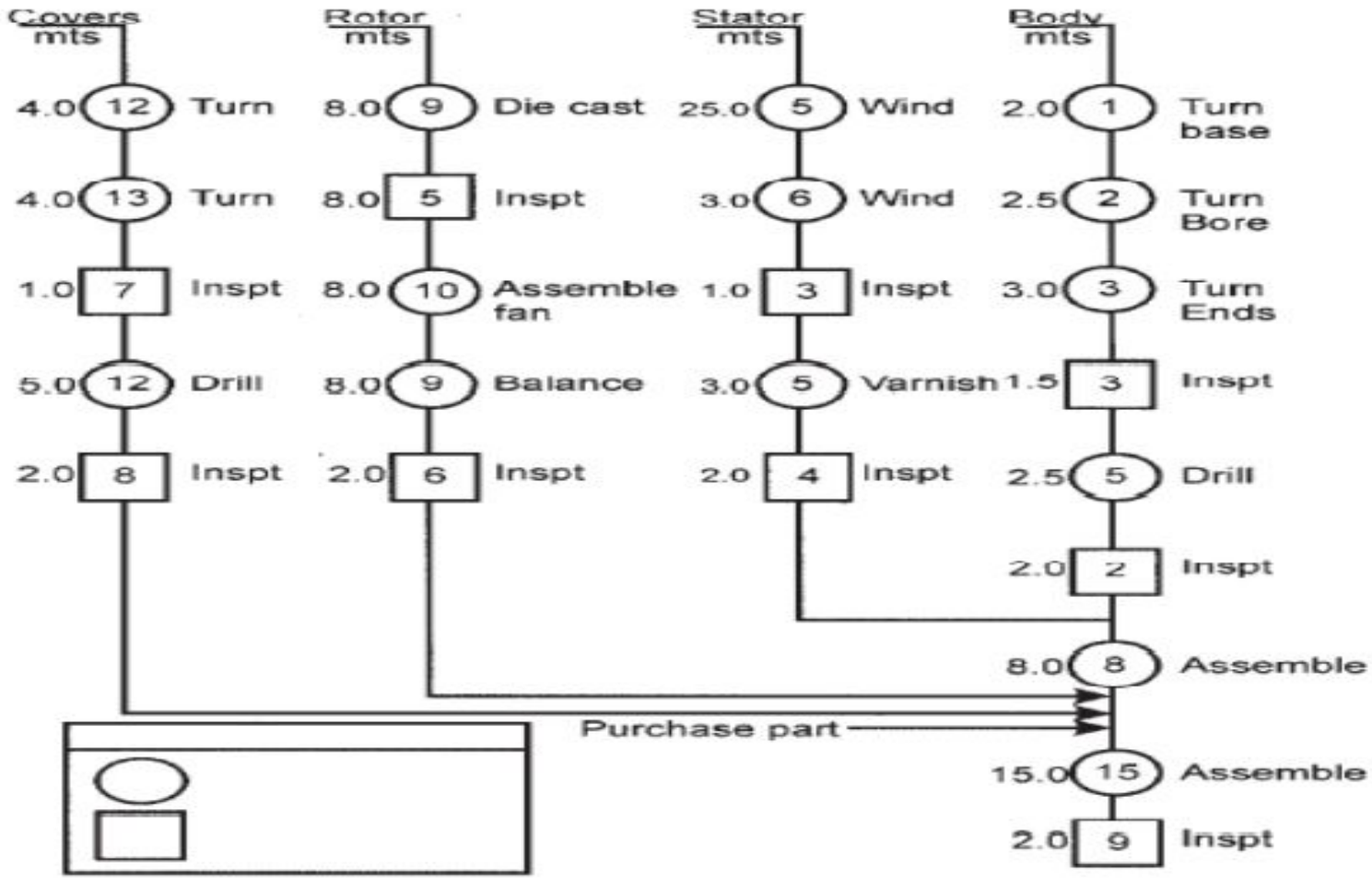
A square indicates inspection.

An arrow indicates transport.

A large capital letter D indicates delay.
An equilateral triangle standing on its vertex represents storage.

When two activities take place at the same time or done by the same operator or at the same place, the two symbols of activities are combined.

Operation Process Chart : It is a graphic representation of the sequence of all operations and inspections taking place in a process. Also known as outline process chart giving a bird's eye view of the overall activities. Entry points of all material are noted in the chart.



Operation process chart

The conventions followed in preparing the chart are
Write title at the top of the chart.
Begin the chart from the right hand side top corner.
Represent the main component at the right extreme.
Represent the sequence of operations and inspections by their symbols. Connect them by vertical flow lines.
Record the brief description of the activity to the right side of the symbols.
Note down the time for each activity to the left of the symbol.
Number all operations in one serial order. Start from the right hand top (from number 1).
Similarly number all inspections in another serial order (starting from 1).
Continue numbering, till the entry of the second component.
Show the entry of purchased parts by horizontal lines.

Flow Process Chart

It is a graphical representation of the sequence of all the activities (operation, inspection, transport, delay and storage) taking place in a process.
Process chart symbols are used here to represent the activities.

Three types of flow process charts.

.Man type flow process chart; This flow process chart records what the worker does.
.Material type flow process chart :This flow process chart records how the material is handled or treated.
.Equipment type flow process chart : This flow process chart records how the equipment or machine is used.

Example :

Draw the Flow Process chart of a stenographer preparing a letter.

Chart No.	: 001	Date :	
Job	: Typing A letter	Charted by:	.....
Chart begins	: Steno in her seat	Chart ends-putting the typed letter in the way	
Method	: Present/Proposed		

Sl. No.	*Description of the activities*	*Distance*	*Time in Sec.*	*Symbols*	*Remarks*
				O □ ⇒ D ∇	
1.	Steno in her seat	-	-		
2.	Hears the bell	-	3		
3.	Goes to manager's room	6m	10		
4.	Takes down dictation	-	120		
5.	Returns to her seat	6m	10		
6.	Prepares typewriter	-	15		
7.	Types the letter	-	150		
8.	Checks the matter	-	40		
9.	Goes to manager's room	6m	10		
10.	Waits till the manager signs	-	20		
11.	Returns to her seat	6m	10		
12.	Types envelope	-	20		
13.	Puts the letter inside envelope	-	5		
14.	Puts the envelope in dispatch tray	-	5		

General guidelines for making a flow process chart

.The details should be extracted by direct observation

.All the facts must be recorded without flaw.

.Avoid assumptions

.Make it easy for future reference.

.The following details should be there in the chart

(i) Product name, material name or equipment name that is studied.

(ii) Starting point and ending point.

(iii) Location where the activities take place.

(iv) Chart reference number, sheet number and number of total sheets.

(v) Key to the symbols used must be stated.

Two-Handed Process Chart (or) Right Hand, Left Hand Chart

It is the process chart in which the activities of two hands of the operator/person are recorded.

It will show whether the two hands of the operator /person are idle or moving in relation to one another, in a proportional timescale.

Used for repetitive operations.

Operation:

Represents the activities grasp, position, use, release etc. of a tool, component or material.

Transport: Represents the movement of the hand or limb to or from the work or a tool or material.

Delay: Refers to the time when the hand or limb is idle.

Storage (Hold): The term hold is used here instead of storage. This refers to the time when the work is held by hand. The activity inspection by hand is considered as an operation. **Hence, the symbol for inspection is not used in this chart**

General guidelines for preparing the chart

.Furnish all information about the job in the chart.
.Study the operation cycle a repeatedly before starting to record.
. Record one hand at a time.
.First record the activities of the hand which starts the work first.
.Do not combine the different activities like operations, transport etc.

Example of a two-handed process chart

Assembly of a nut and washer over a bolt is recorded.
The work place layout is shown in the right hand corner.
The activities of left hand are recorded at left half of the chart.
The activities of the right hand are recorded at the right half of the chart.

Job	: Assembly of washer and nut to a bolt				
Chart begins	: Both hands free before assembly	Assembly	Bolt	Washer	Nut
Chart ends	: Both hands free after assembly				
Chart	: Existing method/Proposed method	Date	:		Operator
Operator	:	Chart No	:		

	Left hand			**Right hand**	
Sl. No.	*Description of the activities*	*Symbols*	*Sl. No.*	*Description of the activities*	*Symbols*
		O ⇒ ∇			O ⇒ ∇
1.	To the bolt tray		1.	To the washer tray	
2.	Picks up one bolt		2.	Picks up one washer	
3.	Returns to original position		3.	Returns to the initial position	
4.	Holding the bolt		4.	Assembles washer over bolt	
5.	Idle		5.	To the nut tray	
6.	Idle		6.	Picks up one nut	
7.	Idle		7.	Returns to initial position	
8.	Idle		8.	Assemble nut to the bolt	
9.	To the assembly tray		9.	Idle	
10.	Puts the bolt in the tray		10.	Idle	
11.	Returns to the original position		11.	Idle	

Man-Machine Chart

It is a chart in which the activities of more than one worker or machine are recorded.

Activities are recorded on a common time scale to show the inter-relationship.

It is also known as multiple activity chart.

It is used when a worker operates a number of machines at a time.

It is also used when a number of workers jointly do a job.

Activities of workers or machines are recorded in separate vertical columns (bars) with a horizontal time scale.

To record the time, ordinary wrist watch or stop watch is used.

Example : One operator in two semiautomatic machines simultaneously.

The activities of the operator is recorded in a separate vertical column.

The activities of the two machines are recorded in two separate vertical columns.

The different activities like loading, machining and unloading are represented by different symbols.

Blank space shows the idle time.

Man-machine chart–present method

Job: One operator operating two machines

Operator: _____

Charted by: _____

Date: _____

Activity	MCI	MCII	Symbol
Loading	1mt	1mt	
Machining	8mt	5mt	
Unloading	1mt	1mt	

Time in mts		Operator	M/C I	M/C II
1				
2				
3		Idle		
4				
5				
6				
7				
8				
9				
10				
11				
12		Idle		

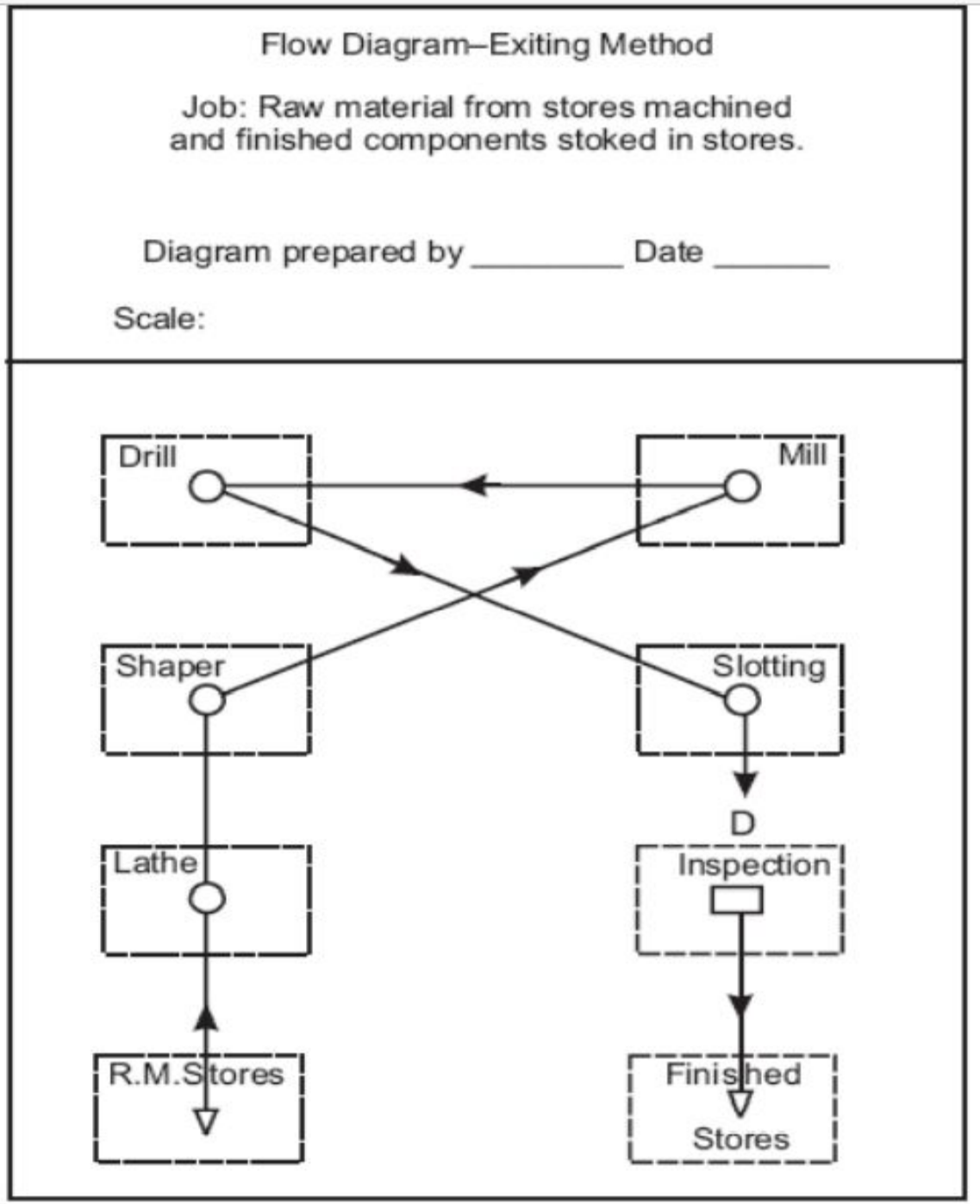
Flow Diagram

In any production shop, repair shop etc, movements of men and material takes place from one place to another.

Process charts shows sequence of activities. They don't exhibit the frequent movements of men and material.

By minimizing movements, a lot of savings can be achieved in cost and effort.

If the path of movement of material is not frequent and simple, a flow diagram is used for recording the movement.



The flow diagram are used for:

To remove unwanted material movement. To avoid traffic congestion
To remove back tracking. To improve the plant layout.

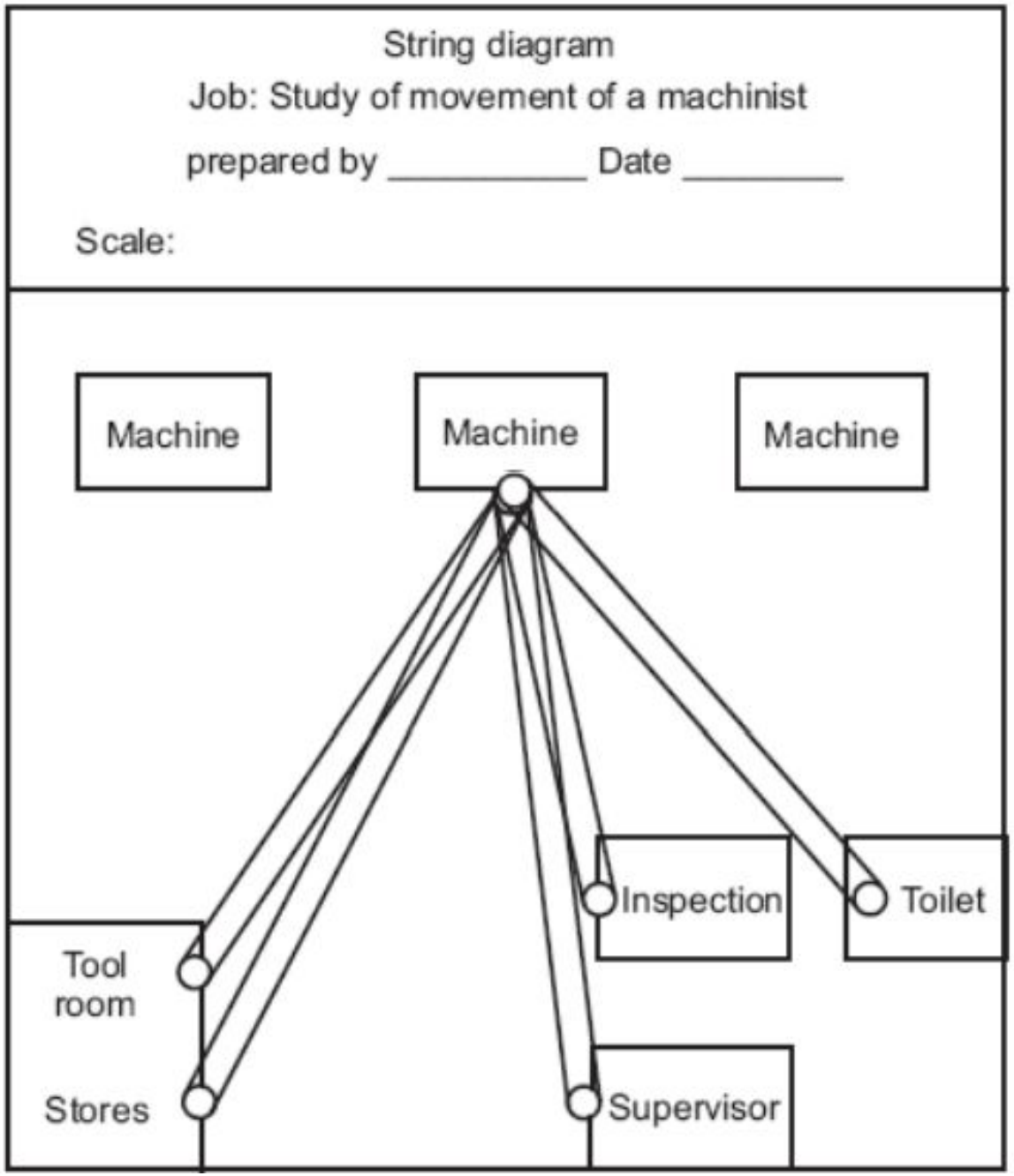
Conventions

1. Heading and description of the process should be given at the top of the diagram.
2. Other informations like location, name of the shop, name of the person drawing the diagram are also given.
3. The path followed by the material is shown by a flow line.
4. Direction of movement is shown by small arrows along the flow lines.
5. The different activities are represented by the symbols on the flow lines. (Same symbols used in flow process chart are used here).
6. If more than one product is to be shown in the diagram different colours are used for each path

String Diagram

Flow diagram made recording the movement of men or material for simple movements and the path is almost fixed. But when the paths are many and are repetitive, flow diagram is not feasible.

Here a string diagram is used which is scaled plan of the shop. Location of machines and various facilities are drawn to scale in a drawing sheet.
Pins are fixed at the various work centres in the drawing sheet. A continuous coloured thread or string is taken round the pins where the material or worker moves during the process.



Constructions

Draw the layout of the shop to scale in a drawing sheet.

Mark the various work centres like machines, stores, work bench etc. in the diagram.

Hold the drawing sheet on a soft board and fix pins at the work centres.

Tie one end of a coloured string to the work centre from which the movement starts.

Follow the path of the worker to different work centre and accordingly take the thread to different points on the drawing board.

At the end of the session note down the number of movements from one work centre to another.

Remove the string and measure the total length of the string. Multiply by the scale and get the actual distance of movement.

Applications :

Used for recording the complex movements of material or men.

Back tracking, congestion, bottlenecks, under utilized paths are easily found out.

To check whether the work station is correctly located.

Used to record irregular movements.

Used to find out the most economical route.

WORK MEASUREMENT

Work measurement is a technique which determines the time required for a qualified worker to carry out a specified job at a defined level of performance.

Objectives of work measurement

To eliminate or reduce non-productive time.
2. To determine standard time for doing a job.
3.To create standard data for future reference.
4. To improve methods.

Uses of work measurements

To determine and compare the efficiency of alternate methods. When two or more methods are available for doing the same job, the time for each method is found out by work measurement. The method which takes minimum time is selected.

Standard time is used as a basis for wage incentive schemes.

3. Use for estimation of cost. Knowing the time standards, it is possible to work out the cost of the product. This helps to quote rates for tenders.

4. Plan the workload of man and machine.

5. Determine the requirement of men and machine. When we know the time to produce one piece and also the quantity to be produced, it is easy to calculate the total requirement of men and machines.

6. Better production control. Time standards help accurate scheduling. So the production control can be done efficiently.

7. It helps to control the cost of production. With the help of time standards, the cost of production can be worked out. This cost is used as a basis for control.

8. It helps to fix the delivery date to the customer. By knowing the standard time we will be able to calculate the time required for manufacturing the required quantity of products.

The different techniques used in work measurement are

.Stop watch time study.

.Production study.

.Work sampling or Ratio delay study.

.Synthesis from standard data.

.Analytical estimating.

.Predetermined motion time system.

Stop Watch Time Study

It is one of the techniques of work measurement commonly used.

We use a stop watch for measuring the time.

Procedure for conducting stop watch time study

Selecting the job.

Recording the specifications.

Breaking operation into elements.

Examining each element.

Measuring using stop watch.

Assessing the rating factor.

Calculating the basic time.

Determining the allowances.

Compiling the standard time.

1.Selection of job :Time study is always done after method study.

.A new job, new component or a new operation.

.When new time standard is required.

.To check the correctness of the existing time standard.

. When the cost of operation is found to be high.

. Before introducing an incentive scheme.

.When two methods are to be compared.

2. Record

.About the product-name, product-number, specification.

. About the machine, equipment and tools.

. About the working condition-temperature-humidity-lighting etc.

.About the operator name-experience-age etc.

3. Break down operation into elements Each operation is divided into a number of elements. This is done for easy observation and accurate measurement.

4. Examine each element

The elements are examined to find out whether they are effective or wasteful. Also examined to check the correctness of method.

5. Measure using a stop watch The time taken for each element is measured using a stop watch. Methods are : Fly back method and Cumulative method. Cumulative is most preferable. **The time measured through stop watch is called as observed time**. Time for various groups of elements should be recorded separately.
This measurement may be repeated for number of times.
The repetition of observations depend upon the type of operation, the accuracy required and time for one cycle.

6. **Assess the rating factor**

Rating determines efficiency of a worker. The operator‘s rating is calculated by comparing workers speed with standard performance

The rating of an operator is decided by the work study man in consultation with the supervisor.

The standard rating is taken as 100. If the operator is slow, his rating will be less than 100 say 90. If the operator is above average, his rating is more than 100, say 120.

7. Calculate the basic time

Basic time is calculated as follows by applying rating factor.

$$\text{Basic time} = \text{Observed time} \times \frac{\text{Operator rating}}{\text{Standard rating}}$$

$$BT = OT \times \frac{OR}{SR}$$

8. Determine the allowance A work cannot be done in tandem. Workers may need time for rest going for toilet, drinking water etc. Unavoidable delays may occur because of tool breakage etc. Hence extra time is added to the basic time. The extra time is known as allowance.

9. Compile the standard time

The standard time is the sum of basic time and allowances. The standard time is also known as allowed time.

Breaking a Job into Elements

Job has to be broken in to elements to enable the following:

.To differentiate productive time and unproductive time.
.To assess the rating of the worker more accurately.
.To find different types of elements and to measure their timings separately.
.To determine the fatigue allowance accurately.
.To prepare a detailed work specification.
.To fix standard time for repetitive elements
 (such as switch on or switch off of machine).

Classification of

.Repetitive elements: It is an element which occurs in every work cycle of the job. Example: Loading the machine, locating a job in a fixture.

.Constant element : element for which the basic time remains constant whenever it is performed. Eg: Switching on the machine, switching off the machine.

.Variable element: It is an element for which the basic time varies depending on the characteristics of the product, equipment or process.

Example Saving a log of wood-time changes with diameter or the work.

4. Occasional element :It is an element which does not occur in every work cycle of the job. Example :Regrinding of tools, re-setting of tools.

5. Foreign element :It is an element which is not a part of the job. Eg Cleaning a job that is to be machined.

6. Manual element It is an element performed by the worker. Example Cleaning the machine, loading the machine.

7. Machine element It is the element automatically performed by a power driven machine. Example Turning in a lathe using automatic feed

General rules to be followed in breaking down a task into elements

.Element should have a definite beginning and ending.

. An element should be as short as possible so that it can be conveniently timed. The shortest element that can be timed using a stop watch is 0.04 mt.

.Manual elements and machine elements should be separately timed.

.Constant element should be separated from variable elements.

.Occasional and foreign elements should be timed separately

Measuring Time with a Stop Watch

Two Methods

.Fly back or Snap back method.

.Continuous or Cumulative method.

Fly back method Here the stop watch is started at the beginning of the first element. At the end of the element the reading is noted in the study sheet (in the WR column). At the same time, the stop watch hand is snapped back to zero. This is done by pressing down the knob, immediately the knob is released. The hand starts moving from zero for timing the next element. In this way the timing for each element is found out. This is called observed time (O.T.) .

Continuous method Here the stop watch is started at the beginning of the first element. The watch runs continuously throughout the study. At the end of each element the watch readings are recorded on the study sheet. The time for each element is calculated by successive subtraction. The final reading of the stop watch gives the total time. This is the observed time (O.T.).

CALCULATION OF BASIC TIME

Basic time is the time taken by an operator of standard performance (rating of 100). A man whose work is observed, may be a slow worker or a fast worker. His rating may be less than 100 or above 100.

The observed time cannot be taken as the basic time. Here the rating factor is applied and basic time is calculated as follows.

$$\text{Basic time} = \text{Observed time} \times \frac{\text{Operator rating}}{\text{Standard rating}}$$

For example, assume that observed time for an operation is 0.7 mts. The rating of the operator is found to be 120

$$\text{The Basic Time or Normal Time} = 0.7 \times \frac{120}{100} = 0.84 \text{ mts.}$$

ALLOWANCES

Various types of allowance are

1. Rest and personal allowance.
2. Process allowance.
3. Contingency allowance.
4. Special allowance.
5. Policy allowance.

CALCULATION OF STANDARD TIME

Standard time or allowed time is the total time in which a job should be completed at standard performance.

It is the sum of normal time (basic time) and allowances.

Policy allowance is not included.

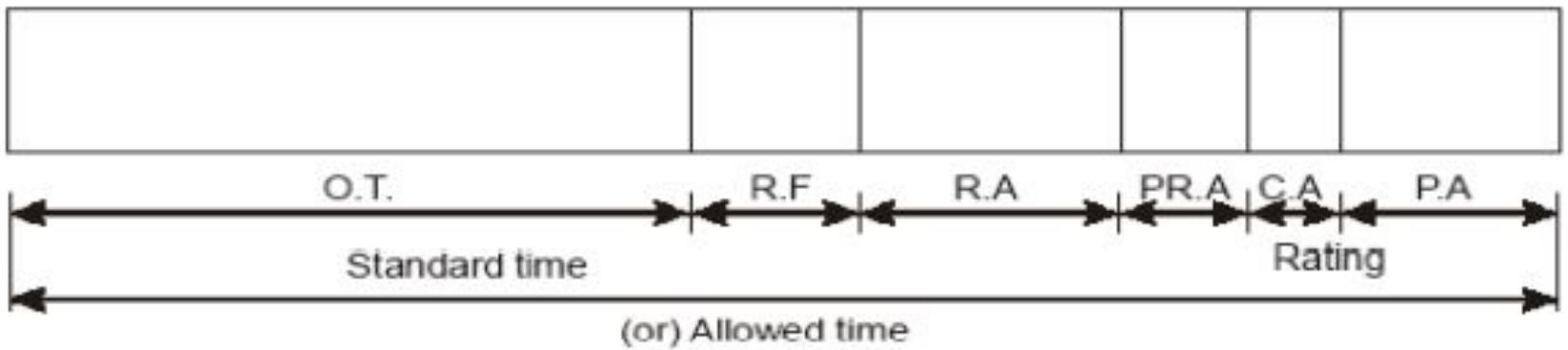
Standard time is worked out in a stop watch time study in the following manner.

Basic or normal time

Basic time is the time taken by a worker with standard performance. Basic time is calculated from
the observed time by applying the rating factor.

Basic time or

$$\text{Normal time} = \text{Observed time} \times \frac{\text{Rating of the operator}}{\text{Standard rating (100)}}$$



OT – Observed time
RF – Rating factor
RA – Rest allowance
PRA – Process allowance
CA – Contingency allowance
PA – Policy allowance

Illustration 1:

On average, a task takes 22 minutes for a worker whose performance level (P) is judged to be 90%.

)Compute the normal time. Tn = …… mins

)Calculate the performance level of worker 'j' who performs the same task in 19 minutes.

P j = …… %

)How fast may the same task be performed by a worker with a performance level of 130%-os?

Tobs = …… mins

)Calculate the standard time if the total time allowance (APFD) is 15%.

Tstd = …… mins

Solution

a) Tn = 22.00 · 0.90 = 19.80 mins.

b) Pj = 19.80 / 19.00 = 104.21%

c) Tobs = 19.80 / 1.30 = 15.23 mins

d) Tstd = 19.80 (1.00 + 0.15) = 22.77 mins

An industrial engineer has obtained the following data in connection with a time study on the lines of the Hawthorne studies taking four different elements and five cycle of the job.

Element	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Performance rating (%)
A	1.57	1.63	1.48	1.57	1.65	100
B	2.48	2.34	2.37	2.36	2.40	90
C	1.85	3.70	1.82	1.78	1.75	95
D	1.25	1.15	1.32	1.15	1.23	115

1. Calculate the normal time for the job based on the above data.
2. Calculate the standard time for the job if the permissible allowance is 25% of the normal time

Element	Mean actual time	Performance rating %	Normal or basic time
A	1.58	100	1.58X100/100=1.580
B	2.39	90	2.39X90/100= 2.151
C	2.18	95	2.18X95/100= 2.071
D	1.22	115	1.22X155/100= 1.403

Normal time for the total job which include all the four element= 7.205 minutes

Standard time = normal time +Allowance

= 7.205+25/100X7.205

= 7.205+1.801= 9.006 minutes

A time study is carried out for a spot welding operation which is being performed by an operator. The time taken (in seconds) for five observations are recorded as 40, 35, 45, 37 and 43, respectively. If the standard time and the allowance for this operation are 45 seconds and 9 seconds, respectively, then the performance rating (in percentage) of the operator is _____.

Given:

Time taken for five observations are recorded as 40, 35, 45, 37 and 43 seconds

Stadard Time (ST) = 45 seconds, Allowance = 9 seconds

Average Observation Time:

$$\text{OT} = \frac{40 + 35 + 45 + 37 + 43}{5} = 40 \text{ seconds}$$

ST = NT + Allowance

45 = NT + 9

∴ NT = 36

NT = OT × RF

36 = 40 × RF

RF = 0.9 = 90 %

In a welding shop, a direct time study was done on a welding operation. One inexperienced industrial engineer and one experienced industrial engineer conducted the study simultaneously.
They agreed precisely on cycle time but their opinion on rating the worker differed. The experienced engineer rated the worker 100% and the other engineer rated the worker 120%. They used a 10% allowance

Cycle time (in minutes)	Number of times observed
20	2
24	1
29	1
32	1

From the above statement,

)Determine the standard time using the experienced industrial engineer's worker rating.

)Find the standard time using the worker rating of inexperienced industrial engineer.

Solution:

(a) Rating of worker at 100% by the experienced industrial engineer

Cycle time (CT) = (20×2+24×1+29×1+32×1)/5 = 25 min

Normal time (NT) = CT×PR = 25×100% = 25 min

Standard time (ST) = NT/(1-%A) = 25/(1-0.10) = 27.78 min

(b) Rating of worker at 120% by the inexperienced industrial engineer

Cycle time (CT) = (20×2+24×1+29×1+32×1)/5 = 25 min

Normal time (NT) = CT×PR = 25×120% = 30 min

Standard time (ST) = NT/(1-%A) = 30/(1-0.10) = 33.33 min

PRODUCTION STUDY

Production study is a technique of work measurement to check accuracy of the original time study. This study is done to find the time delay due to occasional elements.

These elements may occur at irregular intervals. Example: Tool grinding, setting tools etc. There are chances of missing these elements in the stop watch time study. Production study is conducted for a longer period—at least for half a day or one shift.

RATIO DELAY STUDY

This study is also known as work sampling or activity sampling.

Here the ratio of the delay time and working time to the total time of an activity is found out. This is done by random (irregular) observations. This study is applied to 1. Long cycle operations. 2. Activities where time study is not possible

SYNTHESIS FROM STANDARD DATA

Synthesis is a work measurement technique to work out standard time for a job by totaling the elemental times already obtained from previous time studies. Many operators in an industry have several common elements.

Example: starting the machine, stopping the machine etc. Whenever these activities occur, they take the same duration of time. These elements are called constant elements.

Time for some elements vary proportionately with the speed, feed, length of cut etc. in machining operation. These elements are known as variable elements. Time for all these constant elements and variable elements are collected from the time studies previously made. These are stored in a file. This is called time standard data bank.

Data bank contains data in the form of 1. Tabulated standard time for constant elements. 2. Charts and graphs. 3. Formulae etc.

ANALYTICAL ESTIMATING Setting the time standards for long and non-repetitive operations by stop watch method are uneconomical. Analytical estimating technique determines the time values for such jobs either by using the synthetic data or on the basic of the past experience of the estimator when no synthetic or standard data is available. In order to produce accurate results the estimator must have sufficient experience of estimating, motion study, time study and the use of synthesized time standards.

PREDETERMINED MOTION TIME SYSTEM (PMTS)

PMTS is a work measurement technique where by times, established for basic human motions (classified according to the nature of the motion and the conditions under which it is made) are used to build up the time for a job at a defined level of performance.

Few well known systems using this concept are

.M.T.M. : Method Time Measurement.

. W.F.S. : Work Factor System.

. M.T.A. : Motion Time Analysis.

.D.M.T. : Dimensional Motion Times.

.B.M.T. : Basic Motion Times.

The following table shows the application of each technique and unit of measurement.

Technique	Application	Unit of measurement
Time study using stop watch	Short cycle repetitive jobs	Centiminute (0.01 min)
PMTS	Manual operations confined to one work centre	TMU (I TMU = 0.006 min)
Work sampling	Long cycle jobs/ Heterogeneous operation	Minute
Analytical estimating	Short cycle non-repetitive job	Minute

Time Study Equipment

The following equipment is needed for time study work.

- Timing device
- Time study observation sheet
- Time study observation board

Timing Device.

The stop watch is the most widely used timing device used for time study, although electronic timer is also sometimes used.

To perform the same function with the difference that electronic timer can measure time to the second or third decimal of a second and can keep a large volume of time data in memory.

Time Study Observation Sheet. It is a printed form with spaces provided for noting down the necessary information about the operation being studied, like name of operation, drawing number, and name of the worker, name of time study person, and the date and place of study.

Spaces are provided in the form for writing detailed description of the process (element-wise), recorded time or stop-watch readings for each element of the process, performance rating(s) of operator, and computation.

OBSERVATION SHEET

SHEET 1 OF 1 SHEETS	DATE
OPERATION	OP.NO.
PART NAME	PART NO.
MACHINE NAME	MACH.NO.
OPERATOR'S NAME & NO.	MALE ☐ FEMALE ☐
EXPERIENCE ON JOB	MATERIAL
FOREMAN	DEPT.NO.

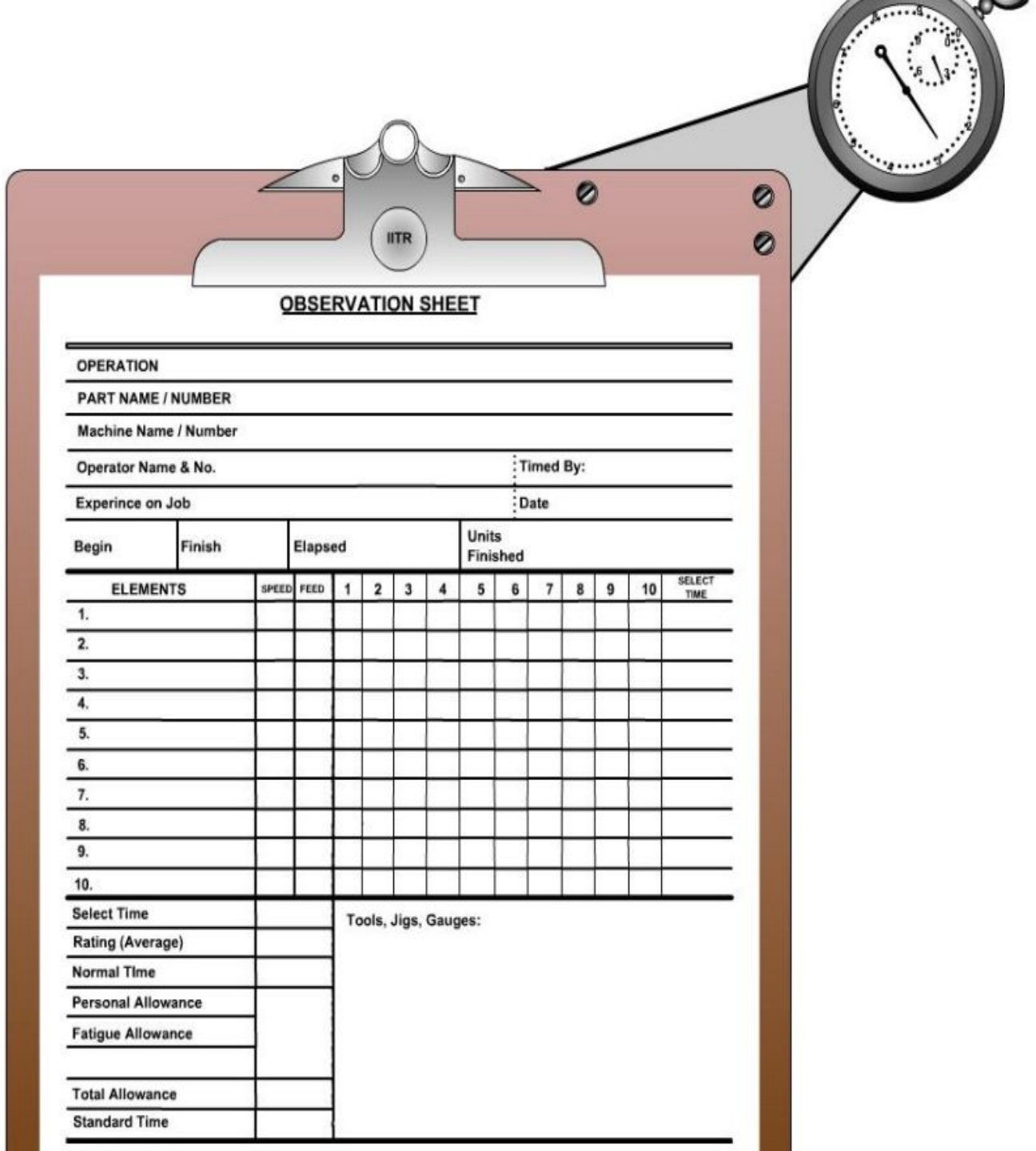
BEGIN	FINISH	ELAPSED	UNITS FINISHED	ACTUAL TIME PER 100	NO. MACHINES OPERATED

ELEMENTS	SPEED	FEED		1	2	3	4	5	6	7	8	9	10	SELECTED TIME
1.			T											
			R											
2.			T											
			R											
3.			T											
			R											
4.			T											
			R											
5.			T											
			R											
6.			T											
			R											
7.			T											
			R											
8.			T											
			R											
9.			T											
			R											
10. (1)			T											
			R											
11. (2)			T											
			R											
12. (3)			T											
			R											
13. (4)			T											
			R											
14. (5)			T											
			R											
15. (6)			T											
			R											
16. (7)			T											
			R											
17. (8)			T											
			R											
18.			T											
			R											

SELECTED TIME	RATING	NORMAL TIME	TOTAL ALLOWANCE	STANDARD TIME

SKETCH OF COMPONETS:	TOOLS.JIGS.GAUGES:
	TIMED BY:

Time Study Board. It is a light -weight board used for holding the observation sheet and stopwatch in position. Slightly larger than that of observation sheet used. The watch is mounted at the center of the top edge or near the upper righthand corner of the board. The board has a clamp to hold the observation sheet. During the time study, the board is held against the body and the upper left arm by the time study person in such a way that the watch could be operated by the thumb/index finger of the left hand. Watch readings are recorded on the observation sheet by the right hand



ERGONOMICS

Ergons means _work‘ and Nomos means _Natural laws‘.

Ergonomics or Human Engineering may be defined as the scientific study of the relationship between man and his working environments. It implies _Fitting the job to the worker‘.

Objectives Is to optimize the integration of man and machine in order to increase work rate and accuracy. It involves

The design of a work place befitting the needs and requirements of the worker.

The design of equipment, machinery and controls in such a manner so as to minimize mental and physical strain on the worker thereby increasing the efficiency

The design of a conductive environment for executing the task most effectively.

Both work study and Ergonomics are complementary and try to fit the job to the workers; however Ergonomics adequately takes care of factors governing physical and mental strains


ERGONMICS

Applications

1. Working environments
2. The work place, and
3. Other areas

Working environments

(a) The environment aspect includes considerations regarding light, climatic conditions (i.e., temperature, humidity and fresh air circulation), noise, smokes, fumes, etc., which affect the health and efficiency of a worker.

(b) Day light should be reinforced with artificial lights, depending upon the nature of work.

(c) The environment should be well-ventilated and comfortable.

(d) Dust and fume collectors should preferably be attached with the equipments giving rise to them.

(e) Glares and reflections coming from glazed and polished surfaces should be avoided.

(f) For better perception, different parts or sub-systems of equipment should be coloured suitably. Colours also add to the sense of pleasure.

(g) Excessive contrast, owing of colour or badly located windows, etc., should be avoid.

Work place layout Design considerations

)Materials and tools should be available at their predetermined places and close to the worker.

) Tools and materials should preferably be located in the order in which they will be used.

) The supply of materials or parts, if similar work is to be done by each hand, should be duplicated. That is materials or parts to be assembled by right hand should be kept on right hand side and those to be assembled by the left hand should be kept on left hand side.

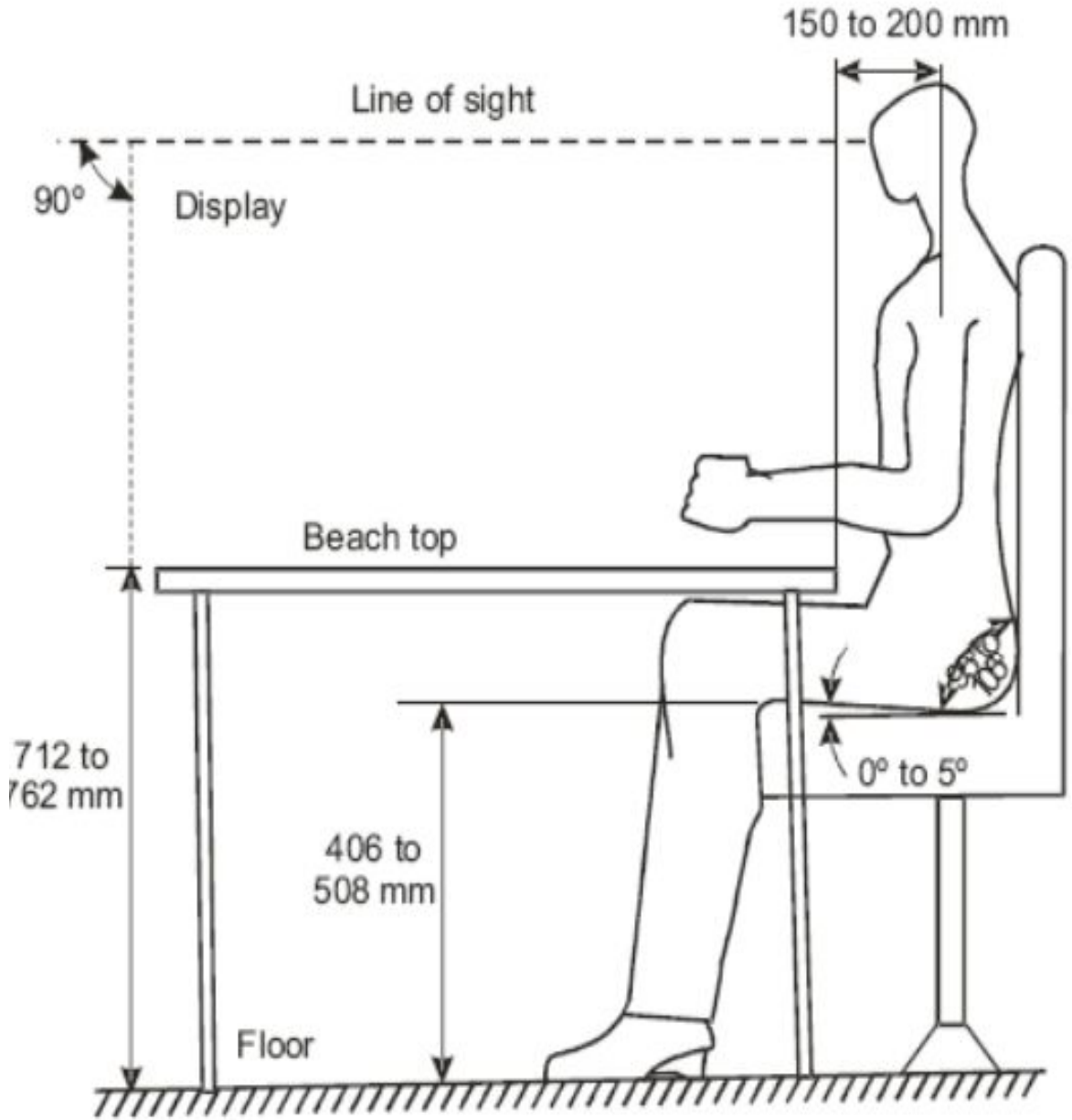
) Gravity should be employed, wherever possible, to make raw materials reach the operator and to deliver material at its destination (e.g., dropping material through a chute).

(e) Height of the chair and work bench should be arranged in a way that permits comfortable work posture

Height of the table should be such that worker can work in both standing and sitting positions.

Flat foot rests should be provided for sitting workers.
The height and back of the chair should be adjustable.

Display panel should be at right angles to the line or sight of the operator.



Bench and seat heights

f) An instrument with a pointer should be employed for check readings where as for quantitative readings, digital type of instrument should be preferred.

(g) Hand tools should be possible to be picked up with least disturbance or rhythm and symmetry of movements.

(h) Foot pedals should be used, wherever possible, for clamping declamping and for disposal of finished work.

(i) Handles, levers and foot pedals should be possible to be operated without changing body position.

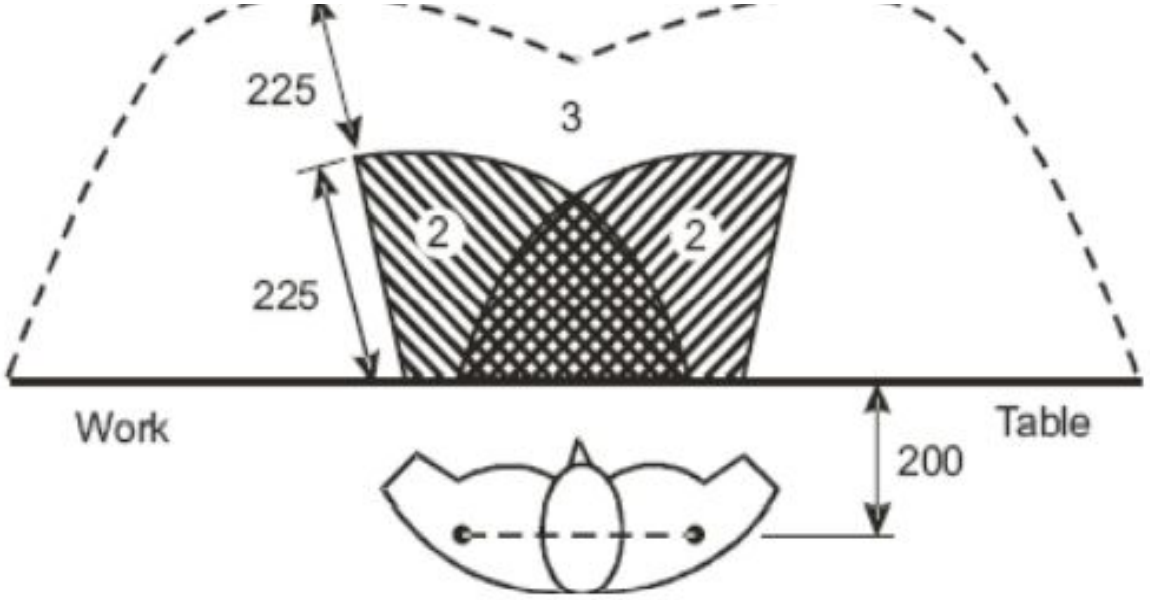
(j) Work place must be properly illuminated and should be free from glare to avoid eye strain.

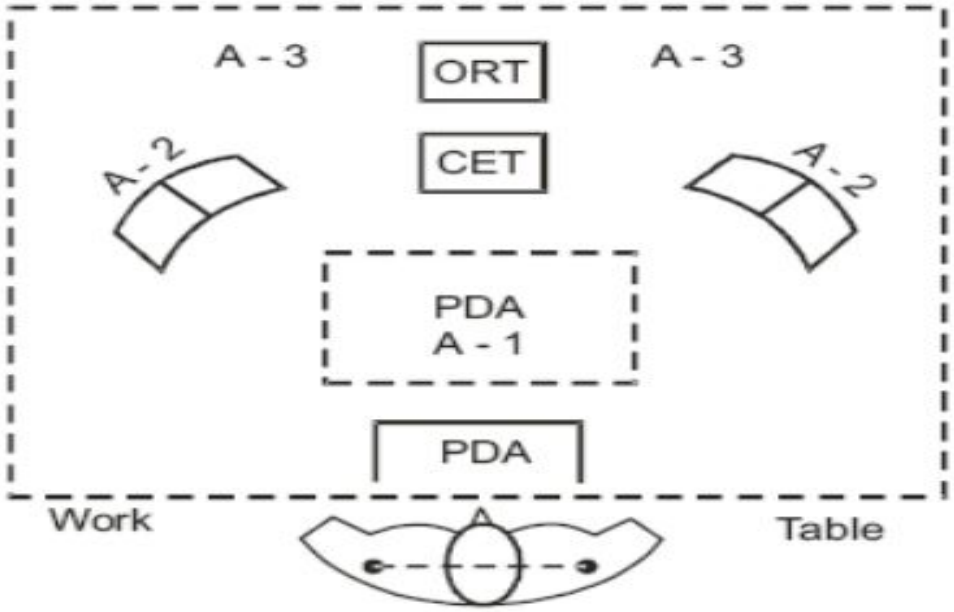
(k) Work place should be free from the presence of disagreeable elements like heat, smoke, dust, noise, excess humidity, vibrations etc.

Suggested work place layout Figure shows a work place layout with different areas and typical dimensions.

It shows the left hand covering the maximum working area and the right hand covering the normal working area.

Normal working area It is within the easy reach of the operator.

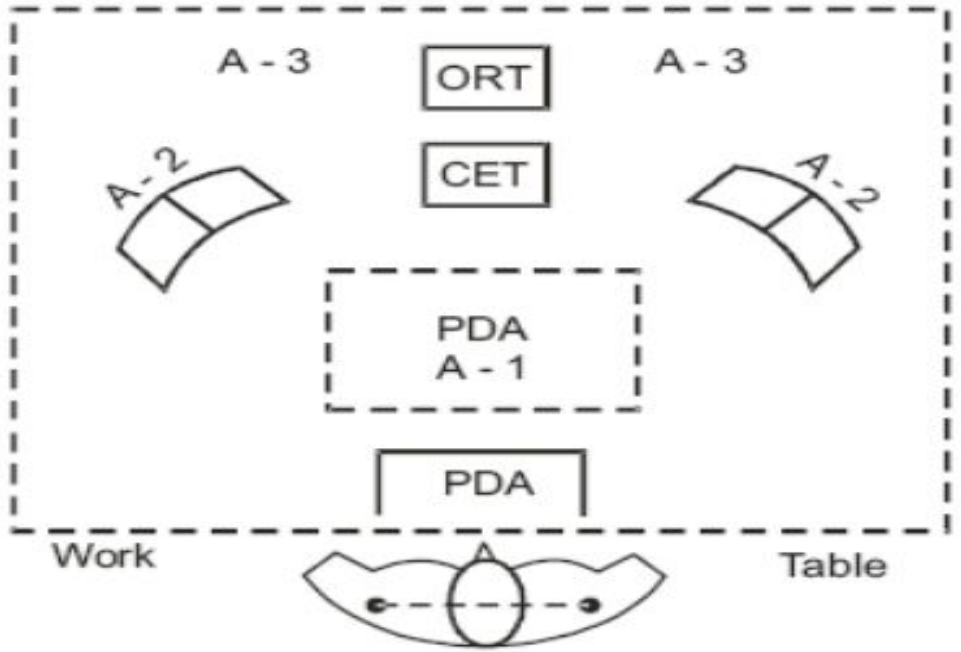




Work place layout for an assembly job

Maximum working area is accessible with full arm stretch. Figure shows work place layout for assembling small component parts. A-1 is the actual working area and the place of assembly (POA) where four component parts P-1, P-2, P-3, and P-4 are assembled together.

Bins containing P-1, P-2, P-3, and P-4 and commonly employed tools (CET) (like screw driver, plier, etc.) lie in the normal working area A-2. ORT Occasionally required Tools (ORT) (hammers etc.) lie in the maximum working area A3. After the assembly has been made at POA, it is dropped into the cut portion in the work table – PDA (Place for dropping assemblies) from where the assembly is delivered at its destination with the help of a conveyer. This work place arrangement satisfies most of the principles of motion economy.



Work place layout for an assembly job

Principles of motion economy

Analysis of an operation when carried out in terms of individual motion of a worker is known as Motion analysis.

The purpose of motion analysis is to design an improved method which would eliminate unnecessary motion and employs human effort more productively.

Principle of motion economy consists of a set of rules designed by Gilbreth and later rearranged and amplified by others (Branes Lowry et al) to develop better methods.

Classified into following 04 categories:

Rules concerning human body,

workplace layout and material handling,

Tools and Equipment Design and

Time conservation.

Rules concerning human body

.Both hands should be used for productive work.

.Both hands should start and finish their motion at the same time.

.Except for the rest period, the two hands should not be idle at one time.

.Motion of both the hands and arms are symmetrical, simultaneous and opposite to each other.

.Motions should be simple and involve minimum number of limbs. (The purpose-shortest duration and minimum fatigue)

.Motion should be smooth and continuous. There should not be sharp direction change and frequent stop.

. It is desirable for a worker to employ momentum to assist him.

. A worker may use mechanical aids to assist him to overcome muscular effort.

Rules concerning workplace layout and material handling

.There should be a definite, fixed and easy accessible location for materials and tools.

. As far as possible, materials, tools and other mechanical devices should be kept close to work place.

. Gravity should preferably be employed wherever feasible with a conveyor for transportation and delivering materials at the workplace between various workstations and departments.

.An assembled and final product should preferably be dropped on a conveyor near the workplace so that gravity delivers the job at the required place.

. Tools and materials should preferably be located in the order/sequence in which they will be required for use.

. Good illumination is required for proper seeing, fast operating and reducing the accidents.

Rules concerning Tools and Equipment Design

Jigs, fixtures and foot operated devices should be employed to reduce the work load on hand.

Tools should be multipurpose and easy to handle.

Foot-operated switches and controls should be designed as far as possible to reduce the workload on the hands.

Tools and materials should be properly arranged and located near the workpiece.

Tools and materials should be located in the order of their use.

There should be maximum surface contact between the tool handle and hand. It helps proper application of hand force and minimizes fatigue.

Gravity should be used for delivery of materials and finished goods.

Where the work is supposed to be carried out by fingers, the load distribution on each finger should be as per normal capacity of finger.

A worker should have the flexibility to stand or sit comfortably while working.

Rules concerning time conservation

Even temporary ceasing of work by a man or m/c should not be encouraged.

Machine should not run idle as it leads to loss of production and power.

Two or more jobs should be done at the same time, or two or more operations should be carried out on a job simultaneously.

Number of motions involved in completing a job should be minimized.

The loading and unloading of the job and the cycle time should be synchronized in such a manner that one operator can be multi-functional or can simultaneously operate a number of machines

Recording Technique	Information Recorded
(a) Charts	
1. Outline process chart	Principle operations and inspection of the processes.
2. Flow process chart	Activities of men, material or equipment are analyzed into five events viz., operation, transport, inspection, delay and storage.
3. Two-handed process chart	Movements of two hands or limbs of the operator.
4. Multiple activity chart	Simultaneous/interrelated activities of operators and/or machines on a common time scale.
5. Simultaneous Motion Cycle Chart (SIMO)	Movement of body members of the operator, expressed in terms of therbligs on a common time scale.
(b) Diagrams and Models	
1. Flow diagram	Path of men, materials and equipments on a scale model.
2. String diagram	Same as above except for the variation that it uses string to trace the path.
(c) Photographic aids	
1. Cyclegraph	Movement of hand obtained by exposing a photographic plate to the light emitted from small bulbs attached to the operator's fingers.
2. Chrono-cyclegraphs	Modification of cyclegraph in which recording is made using flash light.

Therbligs

refer primarily to the motions of the human body at the workplace and to the mental activities associated with them. Hand and Eye motions.
The human body movements are divided into divisions of movements or group of movements for the micromotion study. These divisions of movements or groups of movements are known as Therbligs.

Micromotion study is done for operation with a very short cycle time that repeated many times.

The origin of the Therblig term is very interesting. **Therblig** is an anagram of **Gilbreth (**Frank B. Gilbreth), the founder of the motion study. The divisions of the human body movements (activity) were devised by Frank B. Gilbreth.

Symbol	Name	Abbreviation
	Search	Sh
	Find	F
	Select	ST
	Grasp	G
	Hold	H
	Transport Loaded	TL
	Transport Empty	TE
	Position	P

	Position	P
	Assemble	A
	Use	U
	Disassemble	DA
	Inspect	I
	Preposition	PP
	Release Load	RL
	Unavoidable Delay	UD
	Avoidable Delay	AD
	Plan	Pn