

Industrial Engineering

UNIT –III

Work measurements

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Work measurement

- **Work measurement** is the application of techniques designed to establish the time for a qualified worker to carry out specified jobs at a defined level of performance or at a defined rate of working.

OR Application of different techniques to measure and establish time required to complete the job by a qualified worker at a defined level of performance

- **A qualified worker** is one who has acquired the skill, knowledge and other attributes to carry out the work in hand to satisfactory standards of quantity, quality and safety.
- **Defined rate of working** is the amount of work that can be produced by a qualified worker/employee when working at normal space and effectively utilizing his time and where work is not restricted by process limitation.

"Work measurement is the application of techniques designed to establish the time taken for a qualified worker to carry out a specified job at a defined level of performance."

Work Measurement

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It means to...

find out the different elements of the production process.

find out the time taken by each element.

fix the standard time for performing the production process.

Objective of work measurement

- To reveal the nature and extent of ineffective time, from whatever cause,
- So that action can be taken to eliminate it; and then,
- To set standards of performance that are attainable only if all avoidable ineffective time is eliminated and work is performed by the best method available.

Work Measurement Objectives

- Comparing alternative methods
- Assessing the correct initial manning
- Realistic costing
- Delivery date of goods
- Cost reduction & cost control
- Training new employees
- Find ineffective time in a process
- Evaluate worker's performance
- Facilitate operations scheduling
- Establish wage incentive schemes

Uses of work measurement

- To compare the efficiency of alternative methods.
- Cost estimation
- Pricing of products and services
- Incentive pay systems
- Capacity planning
- Production scheduling
- To provide information on which estimates for tenders, selling prices and delivery promises can be based.
- To reduce the waste of production delay.
- To maximize the manpower utilization by minimize the idle time of the operation .

Work Measurement - Steps

- Select the job to be measured
 - Decision mostly based on increasing productivity
- Break job into operations / elements
- Determine number of observations to be timed
- Measure with a timing device and record on time study form
 - Time study is a work measurement technique for recording the times and rates of working for the elements of a specified job
- Compute Observed time

Steps involved in Work Measurement

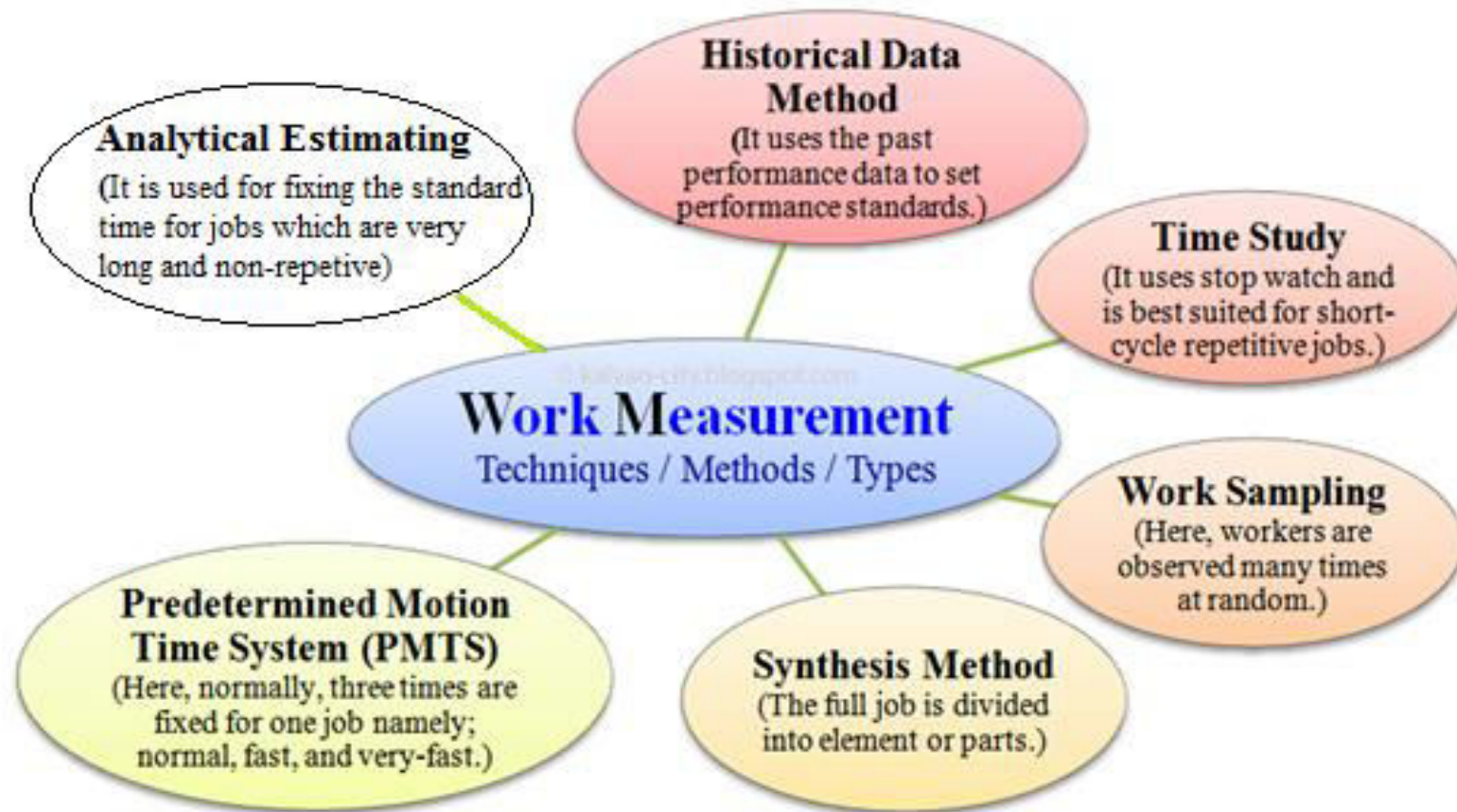
- Calculate Normal (Basic) time by using Performance Rating Factor
- Add process allowance, rest and personal allowance and special allowances to Normal (Basic) time to obtain Standard time
- Define the new method
- Install the new method as agreed standard procedure with the standard time allowed
- Maintain the new standard practice

Work Measurement - Techniques

- Time study
 - Stop watch procedure
- Work sampling
- Pre-determined Motion Time Systems (PMTS) or Elemental Motion Time Systems (EMTS) or Basic Motion Time Systems (BMTS) (work factor and M-T-M systems)
- Structured estimation
 - Analytical estimation
 - Comparative estimations

Note - Time study & Work sampling involve direct observation while remaining are data-based & analytical in nature

Work Measurement - Techniques



Work Measurement Techniques

Techniques	Applications	Unit of measurements
Time study	Short cycle repetitive jobs. Widely used for direct work	Centi-minute (0.01 min)
Work sampling	Long cycle jobs	Minutes
Synthetic data	Short cycle repetitive jobs	Centi-minute
Analytical estimating	Short cycle non-repetitive jobs	Minutes
MTM	Manual operation confined to one work centre	TMU (1 TMU = 0.006min)

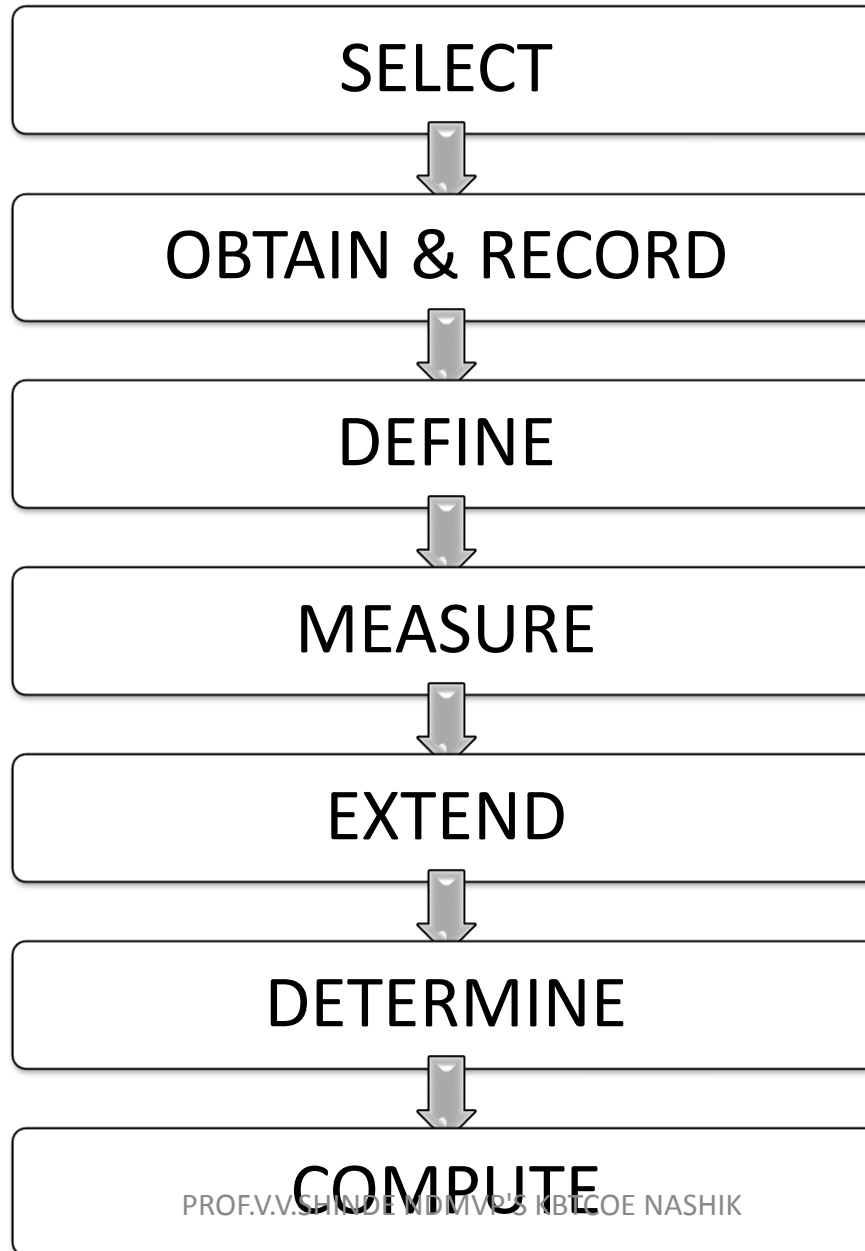
Time study

A WM technique for

1. **Recording the times and rates of working** for the elements of a specified job carried out under specified conditions,
2. Analyzing the data so as to **obtain the time necessary** for carrying out the job at a defined level of performance.

- Time study with the help of a stop watch is the most commonly used work measurement method.
- This technique was developed by Frederick Winslow Taylor (1856-1915).
- Time study is best suited for short-cycle repetitive jobs. Most of the production jobs can be easily timed by a time-study.

Time Study Procedure



Basic steps in Time Study

1. Obtaining and recording all available information about the job, operator and the surrounding conditions likely to affect the execution of the work
2. Recording the complete description of the method, breaking down the operation into 'elements'
3. Measuring with a stopwatch and recording the time taken by the operator to perform each element of the operation
4. Assessing the rating
5. Extending observed time to 'basic times'
6. Determining the allowances to be made over and above the basic time for the operation
7. Determining the 'standard time' for the operation

Types of elements

- A **repetitive element** is an element which occurs in every work cycle of the job.
- An **occasional element** does not occur in each work cycle of the job, but which may occur at regular or irregular intervals. e.g. machine setting.
- For a **constant element**, the basic time remains constant whenever it is performed. e.g. switch the machine on.
- A **variable element** is an element for which the basic time varies in relation to some characteristics of the product, equipment or process, e.g. dimensions, weight, quality etc. e.g. push trolley of parts to next shop.

Types of elements

- A **manual element** is an element performed by a worker.
- A **machine element** is automatically performed by a power-driven machine (or process).
- A **governing element** occupies a longer time than any of the other elements which are being performed concurrently. e.g. boil kettle of water, while setting out teapot and cups.
- A **foreign element** is observed during a study which, after analysis, is not found to be necessary part of the job.

Performance rating

- **Performance rating** is the step in the work measurement in which the analyst observes the worker's performance and records a value representing that performance relative to the analyst's concept of standard performance
- Performance rating helps people do their jobs better, identifies training and education needs, assigns people to work they can excel in, and maintains fairness in salaries, benefits, promotion, hiring, and firing.
- Most workers want to know how they are doing on the job. Workers need performance feedback to work effectively.
- Accessing an employee timely, accurate, constructive feedback is key to effective performance.

- **Performance Rating** can be defined as the procedure in which the time study engineer compares the performance of operator(s) under observation to the Normal Performance and determines a factor called Rating Factor.

$$\text{Rating Factor} = \frac{\text{Observed Performance}}{\text{Normal Performance}}$$

- **Performance rating methods**
- Speed rating
- Westing house method of rating (S,E,C,C)
- Synthetic rating ($R = P/A$)
- Objective rating

- **Pace Rating**

- In this method, which is also called the **speed rating method**, the time study person judges the operators speed of movements, i.e. the rate at which he is applying himself, or in other words "how fast" the operator performs the motions involved.

- **Westinghouse System of Rating**

- This method considers four factors in evaluating the performance of operator: **skill, effort, conditions, and consistency**.
- Skill may be defined as the proficiency at of an individual in following the given method. It is demonstrated by co-ordination of mind and hands. A person's skill in a given operation increases with his experience on the job, because increased familiarity with work brings speed, smoothness of motions and freedom from hesitations.

- the ratings for effort, conditions, and consistency are given using the Table for each of the factors. By algebraically combining the ratings with respect to each of the four factors, the final performance-rating factor is estimated.
- **Objective rating**
- In this system, speed of movements and job difficulty are rated separately and the two estimates are combined into a single value
- The rating factor R can be expressed as

$$\mathbf{R = P \times D}$$

Where: P = Pace rating factor, and
D = Job difficulty adjustment factor.

- **Synthetic Rating**

- This method of rating has two main advantages over other methods. These are (i) it does not rely on the judgment of time study person and (ii) it gives consistent results.
- Performance or Rating Factor,

$$\mathbf{R = P / A}$$

Where P = Predetermined motion time of the element, and
A = Average actual observed time of the element.

- The overall rating factor is the mean of rating factors determined for the selected elements. This is applied uniformly to all the manually controlled elements of the work cycle

Definitions of Standard time

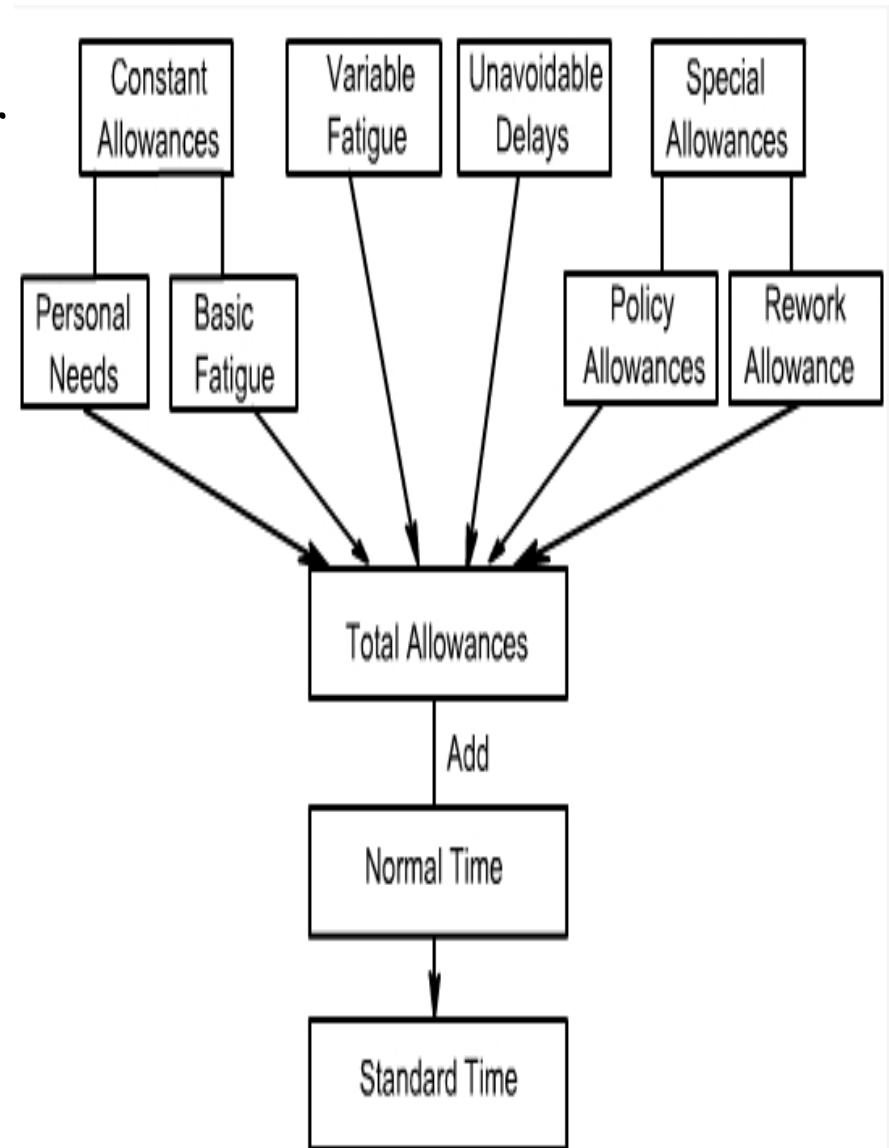
- **Standard time** is the time allowed to an operator to carry out the specified task under specified conditions and defined level of performance.
- The various allowances are added to the normal time as applicable to get the standard time.
- **Standard time** may be defined as the, amount of time required to complete a unit of work:
 - (a) under existing working conditions, (b) using the specified method and machinery, (c) by an operator, able to the work in a proper manner, and (d) at a standard pace.
- Thus basic constituents of standard time are:
 1. Elemental (observed time).
 2. Performance rating to compensate for difference in pace of working.(PRF)
 3. Relaxation allowance.
 4. Interference and contingency allowance.
 5. Policy allowance.

Allowances

- The readings of any time study are taken over a relatively short period of time.
- The normal time arrived at, therefore, does not include unavoidable delay and other legitimate lost time, for example, in waiting for materials, tools or equipment; periodic inspection of parts; interruptions due to legitimate personal needs, etc
- It is necessary and important that the time study person applies some adjustment, or allowances, to compensate for such losses so that fair time standard is established for the given job.
- No allowances are given for interruptions which may be due to factors which are within the operator's control or which are avoidable.

Most companies allow the following allowances to their employees.

- **Constant allowances** (for personal needs and basic fatigue)
- **Delay Allowance** (for unavoidable delays)
- **Fatigue Allowance** (for job dependent fatigue)
- **Personal Allowance**
- **Special Allowance**



- **Delay Allowance:**
- This time allowance is given to operator for the numerous unavoidable delays and interruptions that he experiences every day during the course of his work.
- These interruptions include interruptions from the supervisor, inspector, planners, expeditors, fellow workers, production personnel and others.
- This allowance also covers interruptions due to material irregularities, difficulty in maintaining specifications and tolerances, and interference delays where the operator has to attend to more than one machine
- **Fatigue Allowance:**
- This allowance can be divided into two parts: (i) **basic fatigue allowance** and (ii) **variable fatigue allowance**. The **basic fatigue allowance** is given to the operator to compensate for the energy expended for carrying out the work and to alleviate monotony.

- The magnitude of **variable fatigue allowance** given to the operator depends upon the severity of conditions, which cause extra (more than normal) fatigue to him.
- The major factors that cause more than just the basic fatigue includes severe working conditions, especially with respect to noise, illumination, heat and humidity; the nature of work, especially with respect to posture, muscular exertion and tediousness, and like that.
- **Personal Allowance**
- This is allowed to compensate for the time spent by worker in meeting the physical needs, for instance a periodic break in the production routine.
- The amount of personal time required by operator varies with the individual more than with the kind of work, though it is seen that workers need more personal time when the work is heavy and done under unfavorable conditions.

- **Special Allowances**
- These allowances are given under certain special circumstances.
- **Policy Allowance:** Some companies, as a policy, give an allowance to provide a satisfactory level of earnings for a specified level of performance under exceptional circumstance. This may be allowed to new employees, handicap employees, workers on night shift, etc. The value of the allowance is typically decided by management.
- **Small Lot Allowance:** This allowance is given when the actual production period is too short to allow the worker to come out of the initial learning period. When an operator completes several small-lot jobs on different setups during the day, an allowance as high as 15 percent may be given to allow the operator to make normal earnings.

- **Training Allowance:**
- This allowance is provided when work is done by trainee to allow him to make reasonable earnings. It may be a sliding allowance, which progressively decreases to zero over certain length of time. If the effect of learning on the job is known, the rate of decrease of the training allowance can be set accordingly.
- **Rework Allowance:**
- This allowance is provided on certain operation when it is known that some percent of parts made are spoiled due to factors beyond the operator's control. The time in which these spoiled parts may be reworked is converted into allowance.

Work sampling (ratio delay study)

- A technique of getting facts about utilization of machines or human beings through a **large number of instantaneous observations taken at random time intervals.**
- The **ratio of observations** of a given activity to the total observations approximates the percentage of time that the process is in that state of activity.
- **Work sampling**
- **Estimates percent of time** a worker spends on various tasks
- Determines how **employees allocate their time.**
- Used to **set** staffing levels, reassign duties, estimate costs, and set delay allowances

Work sampling Procedure

Step 1. Define the problem.

- Describe the job for which the standard time is to be determined.
- This would imply that when operator will be found engaged in any activity other than those would entitle him to be in '**Not Working**' state.

Step 2. Design the sampling plan.

- Estimate satisfactory **number of observations** to be made.
 - Decide on the **period of study**, e.g. two days, one week, etc.
 - Prepare detailed plan for taking the observations.
- This will **include** observation schedule, exact method of observing, design of observation sheet, route to be followed, particular person to be observed at the observation time, etc.

Work sampling Procedure

Step 3. Contact the persons concerned and take them in confidence regarding conduct of the study.

Step 4. Make the observations at the pre-decided random times about the working/not working state of the operator. When operator is in working state, determine his performance rating. Record both on the observation sheet.

Step 5. Obtain and record other information.

This includes operator's starting time and quitting time of the day and total number of parts of acceptable quality produced during the day.

Step 6. Calculate the standard time per piece.

Advantages of Work Sampling

The **benefits or advantages** of work sampling method are as follows:

- 1) Work sampling gives an unbiased result since workmen are not under close observation.
- 2) A work sampling study may be interrupted at any time without affecting the results.
- 3) Work sampling can be conducted by anyone with limited training. There is no need to have experts.
- 4) Team work can be studied by work sampling and not by the time-study.
- 5) Work sampling is economical and less time-consuming than time study. This is because more than one worker can be studied at the same time. Secondly, observer needs not to be present himself for a long time.

Predetermined Motion Time Study (PMTS)

- A procedure that **analyzes any manual activity** in terms of basic or fundamental motions required to perform it.
- Each of these **motions is assigned a previously established standard time value** and then the timings for the individual motions are synthesized to obtain the total time needed for performing the activity.
- **The main use of PMTS lies in the estimation of time for the performance of a task before it is performed.**
- The procedure is particularly useful to those organizations which **do not want troublesome performance rating** to be used with each study.

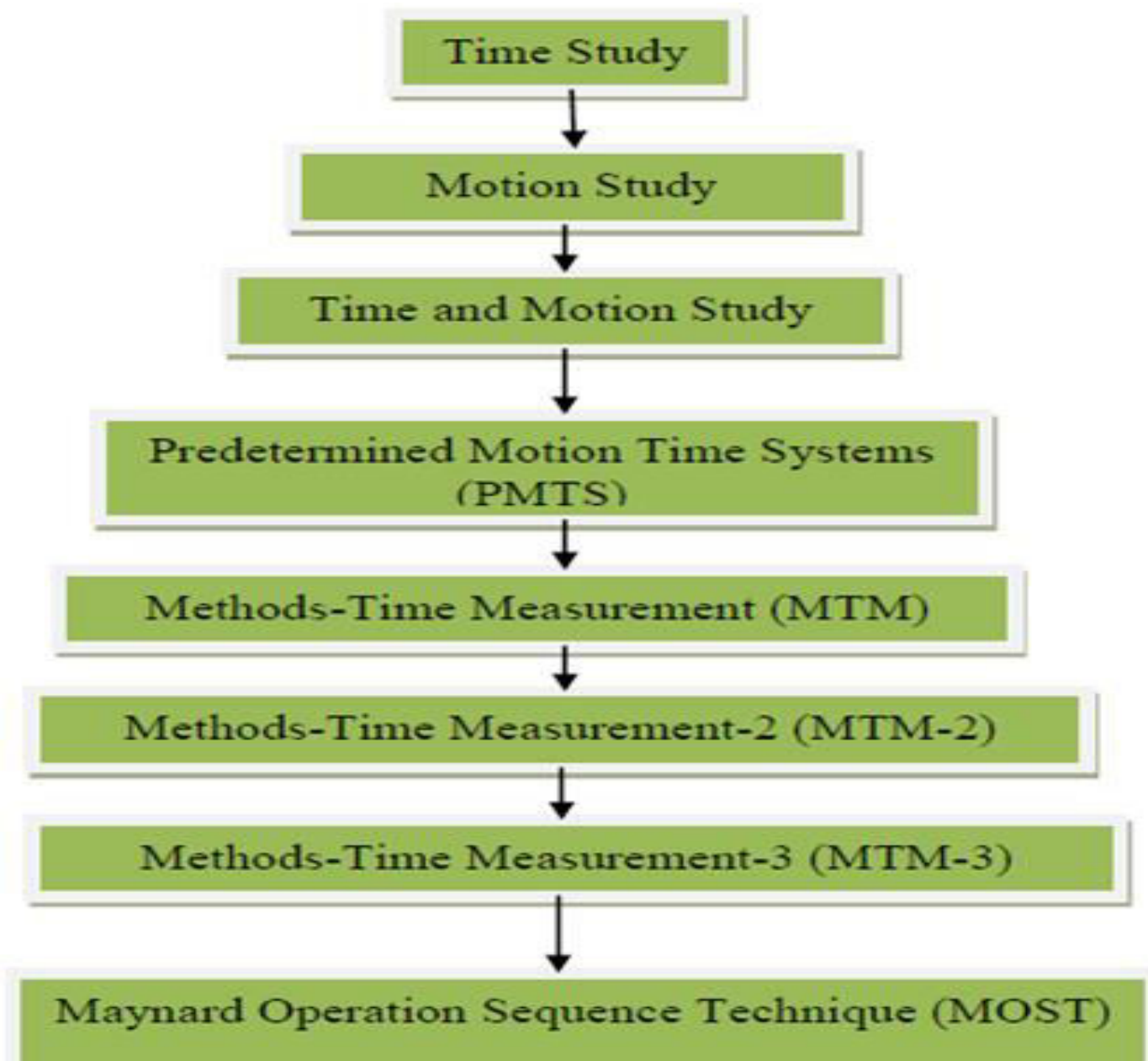
Applications of PMTS

- (i) Determination of job time standards.
- (ii) Comparing the times for alternative proposed methods so as to find the economics of the proposals prior to production run.
- (iii) Estimation of manpower, equipment and space requirements prior to setting up the facilities and start of production.
- (iv) Developing tentative work layouts for assembly lines prior to their working in order to minimize the amount of subsequent re-arrangement and re-balancing.
- (v) Checking direct time study results.

- **The benefits or advantages of PMTS method:**
- It is a very accurate method. It avoids subjective judgement or bias of rater.
- It is an effective and economical method for repetitive jobs of short duration.
- There is no interference in the normal work routine, and so it does not face any resistance from the employees.
- It helps to improve the work methods because it gives a detailed analysis of the motions.
- It is more economical and fast compared to normal time studies.

Some commonly used PMT systems are:

- Method Time Analysis
- Work Factor
- Basic Motion Time
- Method Time Measurement



Maynard Operation Sequence Technique (MOST)

- **Maynard Operation Sequence Technique (MOST)** is a **predetermined motion time system** that is used primarily in industrial settings to set the **standard time** in which a worker should perform a task.
- To calculate this, a task is broken down into individual motion elements, and each is assigned a numerical time value in units known as time measurement units, or TMUs, where 100,000 TMUs is equivalent to 1 hour.
- All the motion element times are then added together and any **allowances** are added, and the result is the standard time.

- MOST is a work measurement technique that concentrates on the movement of objects. It is used to analyze work and to determine the normal time that it would take to perform a particular process /operation.
- **Procedure:-**
 1. Break down the operation/process into smaller steps/units
 2. Analyze the motions in each step/unit by using a standard MOST method sequence
 3. Assign indices to the parameters constituting the method sequence for each task
 4. Sum up the indices to arrive at a time value for each step/unit
 5. Sum up the time values for all the steps/units to arrive at the 'normal time' required to perform that operation/process