Chapter 1

Work Study

CHAPTER HIGHLIGHTS

- *Work Study*
- *Method Study*
- *Steps in Method study*
- *Flow Diagram*
- *String Diagram*
- *Time Study*
- *Performance Rating*
- *Work Sampling*
- *PMTS*
- *MTM Procedure*
- *Work Factor System*
- *Basic Motion Time Study*

Work Study

In order to carry out a specific job or activity, the best use of human labour, machine and material resources must be ensured. Method study and work measurement are important to optimise the resources. Work study involves the technique of method study and work measurement. The objectives of work study are generally to ensure:

1. The most effective use of plant and equipment.
2. The most effective use of human effort.
3. The evaluation of human labour from all angles.

The broad areas dealt by work study are:

1. Method study
2. Time study.

Method Study

Method study is defined as the process of systematic recording, analysing, and then the critical examination of the existing movements made by men, materials and equipments in performing any work. It examines the existing and proposed ways of doing a work and develops and applies an easier and new way of doing it.

Motion study is the analysis of flow and processing of materials and the movement of men. In motion study, the best way of doing a work is determined and the operators are trained to follow the methods so determined. Before commencing the time study, the person undertaking the time study should ensure that motion studies have been carried out.

Time study is concerned with the establishment of time standards for a qualified worker to perform a specified job at a defined level of performance. Method study should precede time study. Once the method study has developed an improved procedure for doing a work, time study must be carried out to establish the time required to do the job.

Steps in Method Study

It is required to list all the alternative methods of doing work. Then, they are to be evaluated critically, and all the relevant facts be Collected.

The steps are as follows:

1. Select, the work to be studied.
2. Record all the relevant facts of the present and proposed methods.
3. Examine the facts critically in sequence.
4. Develop the best method that is most practical, economical and effective.
5. Introduce the best method as the standard practice.
6. Maintain the standard practice by routine follow up.

There are some charts and diagrams commonly used for method study. These charts are a graphical representation of the work that has been broken into basic components. Infact, these charts are the tools of 'Method Engineering'.

1. Charts showing the sequence of events in logical order:
   (a) Operation process chart
   (b) Flow process chart
   (c) Two hand process chart.

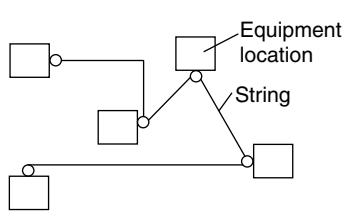
2. Diagrams indicating the movement of man/material/equipment in the logical order:
   (a) Flow diagram
   (b) String diagram
   (c) Travel chart
   (d) Cycle graph.

Table 1 *Some of the Symbols Used in the Chart are Important.*

No.	Symbols	Activities
1.		Operation
2.		Inspection
3.		Transport
4.		Storage
5.		Inspection and operation

Flow Diagram A flow diagram is a guide for method study. It is a diagram drawn to scale, to indicate the relative positions of the equipments and devices. It also has markings showing the path followed by men and materials.

String Diagram String diagram is another guide for method study. This is a diagram in which a point or a square is marked to show the area where a facility or equipment is located. A colored trace line connecting the facilities shows the path taken by material and work men.



Time Study

This was originally proposed by Frederik Taylor and was modified to include Performance Rating. Time study is considered as the most widely used means of work measurement. In time study, the analyst takes a small sample of a worker's activity and derives a standard for the tasks involved.

Steps in the time study are as follows:

1. Break down the work content of the jobs into smallest possible elements and define the best method.
2. Observe the time for appropriate number of repetitions (cycles).
3. Determine the average cycle time.
4. Determine the normal time using the performance rating.
5. Apply the allowance factor and find the standard time.

Performance Rating

Different organizations resort to different methods for merit rating depending on the purpose for which the rating is performed. The rating may include the factors like experience, knowledge, skill, dependability, adaptability, attitude, etc. which have a bearing on the performance of the job.

Some of the methods are:

1. Point rating scale
2. Symbolic comparison system
3. Paired comparison system
4. Forced distribution system.

In any rating system, as human judgement is involved, there are probabilities of errors. The rating errors are expressed as:

1. Halo effect
2. Leniency effect
3. Central tendency effect.

By organising a well managed system, the errors which stem out of biasedness can be reduced to a large extent.

Performance rating is an index expressed in percentage which denotes the performance level of the employee. The time taken by an employee who is rated to 100%, to perform a job is known as the Normal time. A worker of performance rating greater than 100% will be able to complete the job with a time less than normal time. Also, a worker with performances rating less than 100%, will take more time than normal time to complete the job.

That means:

$$\text{Normal time} = \text{Observed time} \times \text{Performance rating}$$

or

$$\frac{\text{Normal time}}{\text{Observed time}} = \text{Performance rating.}$$

Normal time is given by the general formula on a daily basis or a shift basis as

$$\text{Normal time} = \text{Total time} \times (\%\ \text{Activity time}) \times \frac{\text{Performance rating}}{\text{No. of units produced}}$$

$$\text{But } \frac{\text{Total time} \times (\%\ \text{activity times})}{\text{Number of units produced}} = \text{observed time/unit produced}$$

$$\therefore \text{Normal time} = \frac{\text{Observed time}}{\text{Unit produced}} \times \text{Performance rating}$$

$$\text{Standard time} = \frac{\text{Normal time}}{1 - \%\ \text{allowance}} \quad (1)$$

(% allowance is expressed as fraction) or

Standard time = Normal time (1 + % allowance expressed as fraction) (2)

Standard time is the larger value between (1) and (2).

Work Sampling

Work sampling is a technique which tells us what percentage of time of a working day a person spends for a particular job. It is based on the statistical theory of sampling and probability. The limit of accuracy (L) for a parameter in a sampling activity is given by % such as ±1%, ±2%, ±5% etc.

Standard error : $\pm 1.96\sigma$ or 2σ (for 95% confidence level)
: $\pm 3\sigma$ (for 99.7% confidence level)
: $\pm\sigma$ (for 67% confidence level)

Standard error

(For 95% confidence level) $= \pm 2\sqrt{\frac{pq}{n}}$ where, $q = 1 - p$

But standard error with an accuracy of 'L'% (expressed as fraction) $= LP$

$$\therefore LP = \pm 2\sqrt{\frac{pq}{n}}$$

where, $L = 0.01$ if ±1% accuracy
$= 0.05$ if ± 5% accuracy
$= 0.02$ if ± 2% accuracy.

From this, 'n' can be calculated.

When an activity is timed repeatedly a number of times, the average of the values is taken as the representative value. It is to be known as to how many readings are to be taken so that the average is reliable. The formula for the number of observations to be taken for having 95% chance so that the observed average value will be within ±5% of the true average is given by

$$n = \frac{Z^2\left[n_1 \Sigma x^2 - (\Sigma x)^2\right]}{L^2 (\Sigma x)^2}$$; n_1 being the preliminary number of observations.

Some of the Terms Used

A Qualified Worker

A worker is accepted as qualified if—he possesses the required skill and knowledge, he possesses the required education and intelligence and he can perform the job to the satisfactory standards of safety, quality and quantity.

Standard Performance

Consider a normally motivated candidate who knows and adheres to the specific method of performing a job. The rate of output of such a man would naturally achieve over a working day of shift without over exertion and is known as standard performance.

Multiple Activity Chart

It is a chart in which the activities of more than one subject are recorded with respect to a common time scale. The subjects shall be men, materials or equipments/machines.

Process Chart (Two – handed)

It is a chart in which the activities of the worker's hands are recorded. If the activities of the operator and movements are recorded, it is known as flow process chart (man type).

Similarly, we have flow process chart (material type) and flow process chart (equipment type).

Operation Process Chart

This gives an overall picture of the process but does not include how the operations are being performed. It gives only a bird's eye view of the whole process.

Micromotion Study

It is the ultimate approach to analyse the body and hand movements at the micro level and to bring about fine improvement in the motion patterns.

In micromotion study, we have to visualise the operations that are necessary to perform each step of the job, recognise which are the motions that are to be avoided or modified.

According to Gilbreth, who extensively studied hand motions at the micro level, every manual work consists of fundamental hand motions which are repeated again and again. These hand movements as recognised by Gilbreth are called 'Therbligs'.

SIMO Chart (Simultaneous Motion Chart)

A simo chart is a chart based on the film analysis used to record simultaneously on a common time scale, the therbligs or group of therbligs performed by the different parts of the body of one or more workers. Simo chart is the micromotion form of man–type flow process chart where the work elements are recorded in terms of therbligs. As the work cycle is very short and performed very rapidly, the information is recorded through high speed camera films.

PMTS (Predetermined Motion Time System)

The primary concept of PMTS technique was to establish a practicable technique which can be used in industries. It is impractical that each time an efficient method is discovered and is introduced. Also, it is not correct to introduce every new method without assessing its perfection.

Putting together the work of F.W. Taylor, (i.e., subdividing the operations into elements of work and writing description of each elements of work) and FB Gilbreth (study of motion picture camera) – standard operations are built up. This resulted in Predetermined Elemental Times (PET) which is also called Pre-determined Motion Time System (PMTS). While applying Gilbreth therbligs on Taylor's work elements and time values evaluated for work elements, allowances were also provided to cover unavoidable delays and fatigues.

Solved Examples

Example 1: Micro motion analysis is done by the following techniques
(A) flow process chart (B) SIMO chart
(C) string diagram (D) multiple activity chart.

Solution:
Simo chart is used for micro motion analysis by using high speed camera film.

Example 2: In a time study–exercise the performance rating is applied to determine
(A) how to fix incentive rate
(B) standard time
(C) normal time
(D) relaxation time for the worker.

Solution:
Normal time = observed time × performance rating.

Example 3: Work study involves
(A) only work measurement
(B) Time and motion study
(C) only motion study
(D) method study and work measurement.

Solution:
The two aspects of work study are method study and work measurement.

Example 4: An operator has a performance rating equal to 120. A stop watch time study shows that the average time taken by him to complete a job is 4 min. If 10% of the total available time is given as allowances, the standard time for the job is
(A) 5.3 min (B) 4.8 min
(C) 5 min (D) 6.2 min.

Solution:
Average observed time = 4 min
Performance rating 120%
∴ Normal time = $4 \times 1.2 = 4.8$ min.
Allowance is 10%

$$\therefore \text{Standard time} = \frac{\text{Normal time}}{1 - \%\text{ allowance (as fraction)}} \text{ or}$$

normal time (1 + % allowance)
whichever is larger.

$$\text{Standard time} = \frac{4.8}{1-0.1} = 5.3 \text{ min or}$$

4.8 (1 + 0.1) = 5.28,
we may take 5.3 min.

Example 5: In a time study exercise, the standard time for a job is fixed as 72 sec. The performance rating of the worker is 120. The personal allowance permitted was 10%, the observed time was
(A) 68 sec (B) 65 sec
(C) 62 sec (D) 54 sec.

Solution:
Standard time = 72 sec.
Personal allowance = 10%
∴ Normal time = $72 \times (1 - 0.1)$
$= 72 \times 0.9$
$= 64.8$ sec.
The performance rating is 120.
∴ Normal time = Observed time × performance rate
i.e., 64.8 = Observed time $\times 1.2$
∴ Observed time = 54 sec.

Example 6: In a time study exercise, 50 observations were measured and found to take 600 min when performed by an operation whose rating factor is 90. The standard time if allowance is 5%.
(A) 12.6 min (B) 12.1 min
(C) 11.4 sec (D) 10.8 sec.

Solution:

$$\text{Average observed time} = \frac{600}{50} = 12 \text{ min}.$$

Normal time = $12 \times 0.9 = 10.8$ min.
Allowance is 5%

$$\text{Standard time} = \frac{10.8}{1-0.05} = \frac{10.8}{0.95}$$
$$= 11.36 \text{ min.}$$

Example 7: The time study of a machinery operation recorded a cycle time of 8.0, 7.0, 8.0, 9.0 min. The analyst rated the observed worker 90%. The allowance fraction is 0.15. The standard time is
(A) 8.47 min (B) 8.34 min
(C) 9.21 min (D) 9.6 min.

Solution:

$$\text{Average observed time} = \frac{8+7+8+9}{4} = 8 \text{ min.}$$

Performance rating 90%
Normal time = $8 \times 0.9 = 7.2$ min.

$$\text{Standard time } \frac{7.2}{1-0.15} = 8.47 \text{ min.}$$

Example 8: Two thousand five hundred observations were examined and it was observed that a particular activity occurred 1200 times. The accuracy limit will be (at 95% confidence limits.)
(A) 4% (B) 6% (C) 8% (D) 9%.

Solution:

$$\text{Probability } P = \frac{1200}{2500} = 0.48$$

$$N = 2500.$$

$$LP = \sqrt{\frac{4P(1-P)}{N}}$$

$$L = \sqrt{\frac{4 \times 0.48 \times 0.52}{2500}} \Big/ 0.48$$

$$L = 4\%.$$

Example 9: Idle time for a machine is to be evaluated. Out of 100 different observations, the machine was found to remain idle during 40 observations. For a confidence of 95% and accuracy limit 5%, the number of observations required is
(A) 800 (B) 1000 (C) 1800 (D) 2400.

Solution:

$$\text{Probability } P = \frac{40}{100} = 0.4$$

$$L \times P = \sqrt{\frac{4P(I-P)}{N}}$$

$$L \times 0.4 = \sqrt{\frac{4 \times 0.4 \times 0.6}{N}}$$

$$0.05 \times 0.4 = \sqrt{\frac{4 \times 0.24}{N}}$$

$$N = \frac{4 \times 0.24}{(0.05 \times 0.4)^2} = 2400.$$

Example 10: Match the list of charts with their corresponding applications.

Chart	Application
1. Simo chart	**A.** Working of two or more men
2. M T M	**B.** Movement of maternal
3. String diagram	**C.** Pre-determined motion time system
4. Multiple activity	**D.** Micromotion of chart study

(A) 1 – B, 2 – A, 3 – D, 4 – C
(B) 1 – C, 2 – B, 3 – A, 4 – D
(C) 1 – D, 2 – A, 3 – C, 4 – B
(D) 1 – D, 2 – C, 3 – B, 4 – A

Solution: (D)

PMTS

The following cases are related to the Pre-determined Motion Time System (PMTS):

1. Method Time Measurement (MTM)
2. Work Factor System
3. Basic Motion Time study (BMTS).

MTM Procedure

Even though there are many techniques to analyse the manual operations, MTM system is considered to be the most popular system in industries.

MTM procedure recognises eight manual movements, nine pedal movements and two occular movements.

In all the three, there are 19 fundamental motions to be covered in establishing any motion pattern.

Work Factor System

According to this system, the performance standard was fixed in terms of work factors. In this method, all the manual works are measured correctly in terms of defined work factors. A particular element of motion is understood as to contain factors of work. This is work factor of motion. Based on these factors of work, all the movements are evaluated. Ultimately, the work content of every motion can be established.

Basic Motion Time Study

It is the process of evaluating the normal time and standard time through stop – watch time study.

EXERCISES

Practice Problems I

1. Standard time means
(A) Observed time + allowance
(B) Observed time × rating factors – allowances
(C) Normal time + allowance
(D) Normal time – allowances.

2. Machine interference means
(A) A situation when one worker is responsible to attend more than one machine.
(B) A situation of improper machine layout.
(C) A situation of operation of more than one machine.
(D) A situation of a number of spares for an equipment.

3. A micromotion study is advisable for
(A) non repetitive long cycle jobs
(B) repetitive long cycle jobs
(C) applicable to jobs of intense manual labour
(D) applicable to jobs of repetitive short cycle jobs.

4. In work study, the symbol used to represent storage is
(A) → (B) □ (C) ∇ (D) ○

5. In a work study, exercise, the individual human variability is taken care of by considering
(A) Normal time (B) Performance rating
(C) Standard time (D) Observed time

6. Work factor system is one considered for
(A) work sampling study
(B) standard time evaluation
(C) PMTS
(D) micromotion study.

7. Match the lists given below:

List-I	List-II
A. ⇒	**1.** Delay
B. ▭	**2.** Transportation
C. ○	**3.** Inspection
D. □	**4.** Operation

(A) A – 2, B – 1, C – 4, D – 3
(B) A – 1, B – 4, C – 3, D – 2
(C) A – 4, B – 2, C – 1, D – 1
(D) A – 3, B – 3, C – 2, D – 4.

8. For a 95% confidence level, the number of standard deviations to be considered is
(A) 2 (B) 2.58 (C) 3.5 (D) 4.

9. In a trial study during 100 observations, a machine was found idle during 25 observations. Assuming a confidence level of 95% and accuracy of 5%, the number of random observations required to get the desired result is
(A) 3200 (B) 4800 (C) 5200 (D) 6000.

10. In a time study over a manual operation, the time for five observations is 20 min, 22 min, 24 min, 21 min and 25 min. The performance rating of the operator is 120%. If the allowance is 15%, the standard time (min) is
(A) 31.6 (B) 28.4 (C) 27.6 (D) 27.1

11. A job has a normal time of 10 min. The performance rating fraction of the worker is 0.8. If allowance permitted is 20%, the standard time is
(A) 12.5 (B) 12
(C) 11.6 (D) 11.2 min.

12. An analyst wants to obtain a cycle time estimate that is within ±5% of the true value. The preliminary run of 20 cycles took 40 min to complete and has a calculated standard deviation of 0.3 min. The coefficient of variation is
(A) 0.08 (B) 0.10 (C) 0.15 (D) 0.22.

13. The path followed by men and materials while performing a task is shown in a diagram. The diagram is
(A) Flow diagram (B) Process chart
(C) String diagram (D) Track chart

14. Job evaluation is undertaken for the purpose of
(A) improving wage and incentives
(B) improving the jobs
(C) to find relative worth of a job
(D) for a value addition.

15. In a firm, the management is interested to know the percentage idle time of an equipment. A trial study revealed that the percentage idle time is 20%. The number of random observations required for 95% confidence level and 5% accuracy is
(A) 1600 (B) 3200 (C) 6400 (D) 6700.

16. In an assembling operation of an electronic unit, the average time for assembling is 15 min. The performance rating of the worker is 105%. The allowances are set at 8% of the total time. The standard time is
(A) 16.2 min (B) 16.6 min
(C) 17 min (D) 18 min.

17. 'Fly back' timing method of time study means
(A) adding the time elements quantitatively one after another.
(B) bring back the hands of a stop watch to zero at the end of each activity.
(C) make the time reading of various activities simultaneously.
(D) evaluation of average of the average timings.

18. The symbol  in the method study chart indicates
(A) Operation and inspection
(B) Delay and storage
(C) Operation and transportation
(D) Inspection and transportation

19. Time study is
(A) a work measurement technique
(B) a job evaluation technique
(C) a performance measuring technique
(D) a waste reduction technique.

20. In a work sampling study of total number of 1000 observations, 112 observations were found to be idle operations. For a 68.27% confidence limit, to keep the accuracy 5%, the number of observations required is
(A) 2400 (B) 2215 (C) 3170 (D) 3480.

Practice Problems 2

1. Work study involves
(A) Method study and work measurement
(B) Work measurement and time study
(C) Time study and performance rating
(D) Method study and time study.

2. The study which is concerned with the reduction of work content in an operation is
(A) time study (B) motion study
(C) method study (D) work measurement

3. Of the method study and work measurement,
(A) method study must be done before work measurement.
(B) work measurement must be done before method study.
(C) it can be both the ways depending on the situation.
(D) time study must be done before method study and work measurement.

4. Material type process chart indicates
(A) the flow of material from one point to another.
(B) the requirement of material at a point both in terms of quality and quantity.
(C) the list of various materials required for the process.
(D) what happens to the material at the location.

5. 'String diagram' is important and needed when
(A) the flow diagram becomes congested and when there are too many paths.
(B) the layout of the equipment is made.
(C) when the layout is a process type.
(D) the path of the equipment arrangement is to be specified.

6. SIMO chart represents the
(A) relation between the time and work content.
(B) relation between different limbs of an operator.
(C) relation between the time and motion when the operator is at work.
(D) relation of men and materials with respected to time.

7. When the 'Normal time' is equal to standard time, the meaning is
(A) performance rating is 100%.
(B) observed time is equal to normal time
(C) observed time is less than normal time
(D) no allowance is given.

8. A workman of performance rating 120 is observed to complete a repetitive job in 20 min. If the rest allowance to be provided is 3%, the standard time for the job is
(A) 24.8 min (B) 26.2 min
(C) 26.7 min (D) 27.3 min.

9. With 5% rest allowance, the standard time for a job is 18 min. A person with a performance rating 80 would complete the job in
(A) 23.6 min (B) 21.4 min
(C) 20.2 min (D) 18.6 min.

10. In an operation, the average time consumed by a machine is 8 min. The average time consumed manually is 6 min. Performance rating of the operator is 120%. Rest allowance to be provided is 10%. Then the standard time for the job is
(A) 18.5 min (B) 17.6 min
(C) 16.9 min (D) 16.1 min.

11. Twenty observations are taken on a standard job. The mean cycle time for the job was found to be 5.83 min. with a standard deviation of 2.04 units. The number of total observations to be taken for 95% confidence so that the mean actual time has been determined within 10% accuracy is
(A) 52 (B) 47
(C) 42 (D) 39.

12. In a time study experiment, an operator spends a total time of 600 min to produce 450 prices of a product. The percentage of time during which he works is 85%. The performance rating of the operator is 120%. The allowance provided is 15%. The standard time for the above operation is
(A) 2.8 min (B) 2.2 min
(C) 2 min (D) 1.6 min.

13. A preliminary works sampling study revealed the following: An equipment was idle for 35% of the time based on 100 observations. For a confidence limit of 95%, the number of observations to be taken for an accuracy level of 5% is
(A) 2972 (B) 2418
(C) 2372 (D) 2243.

14. The diagrammatic representation showing the path followed by men and materials while performing a job is known as
(A) sting diagram (B) flow diagram
(C) travel chart (D) flow process chart.

15. The very purpose of work study is
(A) to find the optimum method for performing a job.
(B) to establish the minimum time required for the job.
(C) to find a standard method and standard time for the job.
(D) to attain economy of operation.

16. In a workshop a turner was rated 120%. To turn a standard piece he takes 10 min. If the allowance factor in the job is 8%, the expected standard production rate in an 8 hour day is
(A) 46 pieces (B) 42 pieces
(C) 36 pieces (D) 32 pieces.

17. In a time study exercise, an operator is observed while doing a particular job 10 times and the time taken is listed as follows: 12 min, 11 min, 12 min, 14 min, 10 min, 12 min, 12 min, 13 min, 11 min, 13 min.

The operator has a performance rating of 90. Taking the personal allowance to be 10%, the standard time for the job is
(A) 10.8 min (B) 12 min
(C) 12.4 min (D) 12.8 min.

18. A job is spilled into three elemental jobs. The normal time for each of the elemental jobs is 8 min, 7.8 min, 8.2 min. The normal time of the composite jobs is
(A) 8 min (B) 24 min
(C) 2.67 min (D) 26 min.

Direction for questions 19 and 20: In a process of standard time computation, the time taken by an operator in performing a job was taken. Ten readings were taken. The readings were 8 min, 6 min, 8 min, 7 min, 8 min, 8 min, 6 min, 6 min, 8 min, 7 min. The performance rating of the operator is 120% and the personal allowance is 12%.

19. Then, the standard time for the job is
(A) 8.6 min (B) 9.2 min
(C) 9.8 min (D) 10.5 min.

20. If the observed average is to be within ±5% accuracy level, the number of observations to be taken is
(A) 13 (B) 18 (C) 20 (D) 23.

21. The techniques used for studying proportion of the delays and stopping of production is
(A) time study (B) work sampling
(C) motion study (D) micro motion study.

22. The allowance to be provided for the performance of a work sampling is determined by using the techniques
(A) performance rating (B) work sampling
(C) PMTS (D) micro motion study.

23. A preliminary study indicates that the proportion of idle time of a machine is 30%. For the remaining time, the machine is working. To set a good estimate of the idle time with a precision of ±5% at 95% confidence level, the sample size should be
(A) 3733 (B) 10000
(C) 11500 (D) 11850.

Direction for questions 24 and 25: In a stop watch time study, an operator is found to perform a job in 10 occasions consuming a time of 3 min, 4 min, 3 min, 3 min, 5 min, 4 min, 3 min, 5 min, 4 min. The rating factor of the operation is 70%, personal allowance is 15%.

24. The standard time is
(A) 2.6 min (B) 3.3 min
(C) 4.4 min (D) 4.9 min.

25. If the operator turns out a product during this operation in an 8 hour shift, the number of products he would produce is
(A) 160 nos (B) 152 nos
(C) 145 nos (D) 136 nos.

26. The man – machine chart is used to
(A) show various activities of man and machines in a single chart.
(B) show the distance moved by the man to reach the machine.
(C) show the location of man and machine.
(D) separate the jobs between man and machine.

27. The ASME symbol '  ' used in flow chart indicates
(A) operation (B) inspection
(C) temporary storage (D) transport.

Direction for questions 28 to 30: An operator rated 120% is put to time study and 15 reading of time are taken for the performance of a job. They are 0.05, 0.06, 0.05, 0.05, 0.05, 0.06, 0.06, 0.05, 0.06, 0.06, 0.06, 0.05, 0.06, 0.05 (min).

Initially, the first 10 readings are taken and the normal time is evaluated.

28. The normal time is
(A) 0.066 (B) 0.054
(C) 0.052 (D) 0.050.

29. With confidence level 95%, to attain an accuracy of 5% to the mean value, the number of observations to be taken is
(A) 5 (B) 14
(C) 13 (D) 12.

30. When three or more readings are taken along with, the new normal time for the job is
(A) 0.062 (B) 0.063
(C) 0.065 (D) 0.066.

Previous Years' Questions

1. A soldering operation was work-sampled over two days (16 hours) during which an employee soldered 108 joints. The actual working time was 90% of the total time and the performance rating was estimated to be 120%. If the contract provides allowance of 20% of the total time available, the standard time for the operation would be **[2004]**
(A) 8 min (B) 8.9 min
(C) 10 min (D) 12 min.

2. An assembly activity is represented on an operation process chart by the symbol **[2005]**
(A) T (B) A
(C) C (D) O.

3. A welding operation is time-studied during which an operator was performance-rated as 120%. The operator took on an average 8 min. for producing the weld-joint. If a total of 10% allowances are allowed for this operation, the expected standard production rate of the weld-joint (in units per 8 hour day) is **[2005]**
(A) 45 (B) 50
(C) 55 (D) 60.

4. Vehicle manufacturing assembly line is an example of **[2010]**
(A) product layout (B) process layout
(C) manual layout (D) fixed layout.

Answer Keys

Exercises

Practice Problems 1

1. C	**2.** A	**3.** D	**4.** C	**5.** B	**6.** C	**7.** A	**8.** A	**9.** B	**10.** A
11. A	**12.** C	**13.** A	**14.** C	**15.** C	**16.** C	**17.** B	**18.** C	**19.** A	**20.** C

Practice Problems 2

1. A	**2.** C	**3.** C	**4.** D	**5.** A	**6.** B	**7.** D	**8.** A	**9.** B	**10.** C
11. B	**12.** D	**13.** A	**14.** B	**15.** C	**16.** C	**17.** B	**18.** B	**19.** C	**20.** D
21. B	**22.** B	**23.** A	**24.** B	**25.** C	**26.** A	**27.** C	**28.** A	**29.** C	**30.** D

Previous Years' Questions

1. D	**2.** D	**3.** A	**4.** A