GOVT POLYTECHNIC , MANESAR

AUTOMOBILE ENGINEERING DEPARTMENT

INDUSTRIAL ENGINEERING

UNIT-01

PRODUCTIVITY

DEFINE- Productivity is the rate at which goods are produced. Production is defined as the act of manufacturing goods for their use or sale.

Productivity is the ratio of output to input in production. It is a measure of the efficiency of production. It is related to the utilization or the use of resources to produce goods. It increases the output. It is the increase of output from each unit in the production process. If inputs remain the same and the production of output increases, then there is a rise in the level of productivity. If the output rises in a greater proportion than the increase in the input, there is still a proportionate rise in the level of productivity. However, if the output rises at a lower rate than the input, then there will be a fall in the productivity, even though there is an increase in production on the whole. Higher productivity results in a lower cost per unit of output resulting in higher levels of profit for a company. Thus, it refers to efficient utilization of resources. High productivity increase the economic well-being. It increases the income and the standard of living of the people. It brings in money for the company.

Productivity has the following advantages:

- It emphasizes the efficient utilization of all the factors of production which are scarce universally.
- It attempts to eliminate wastage.
- It facilitates the comparison of the performance of a company to its competitors or related firms, in terms of aggregate results and of major components of performance.
- It enables the management to control the performance of the company by identifying the comparative benefits rising out of the use of different inputs.

According to Wikipedia, production is the act of creating output, goods or services which have values and contributes to the utility of individuals. This may include factors of production other than labor. The factors of production are the inputs to the production process. The finished goods are the output. The input determines the quality of the output product. Input is the starting point and output is the end point of the production process, and such an input-output relationship is called as the production function.

There are three basic factors of production: land, labor and capital. All three are required in combination at a time to produce a commodity. In economics, production means creation or an addition of utility. Factors of production are any commodities or services used to produce goods or services. These factors are specifically referred to as primary factors. Energy and material are referred to as secondary factors. The primary factors facilitate production but neither become part of the product nor become significantly transformed by the production process. Human capital and entrepreneurship are also considered as factors of production. The factors affecting the production are as follows:

- Land represents all natural resources, such as timber and gold, used in the production of goods.
- Labor is all of the work that laborers and workers perform at all levels of an organization.
- The entrepreneur also takes on all of the risks and rewards of the business.
- The capital is all of the tools and machinery used to produce goods or services.

Definition of Production

Production can be defined as the systematic activity of gradually transforming one form of material into another while maintaining the requisite quality and are capable of satisfying human wants. It tends to combine, tangible inputs, i.e. raw materials, and intangible inputs, i.e. ideas, information, etc. to turn it into finished products for sale, through a mechanical or chemical process.

Types of Production

- Job-Shop Production: A production process, in which few products are created according to the demand of the customer, in the stipulated time and cost. In job-shop production, product volume is low, and variety is high.
- Batch Production: Batch production is one wherein product passes through various stages over a series of functional departments, and a number of batches are produced.
- Mass Production: It is a manufacturing technique in which discrete parts are produced with the help of continuous process.
- Continuous Production: The process of production in which the production facilities are sequenced as per the production operations chronologically.

Definition of Productivity

Productivity is a measure that gauges the efficiency of the production process, i.e. in transforming inputs such as raw material, labour, capital, etc. into the output of finished goods. It can be expressed in terms of the ratio of outputs produced to inputs consumed, in the given period.

Productivity tends to determine the overall production performance of the firms by ascertaining how efficiently the firm utilized its resources in the production of goods and services, with minimum wastage. It can be enhanced by controlling factors of production, improving process and technology.

Dynamic Concept of Productivity

Competition triggers productivity, as intense competition results in higher productivity, which in turn provides better value to the customers, leading to higher share in the market. Further, it can be evaluated with the help of the following analysis:

- Trend Analysis: It gauges the change in productivity of the firm over the years.
- Horizontal Analysis: It compares the firm's productivity, with other firms of the same size and business.
- Vertical Analysis: It compares firm's productivity, with other firms of various size in the same industry and with other industries.
- Budgetary Analysis: Establishing productivity norm as the budget for the upcoming period, on the basis of above analysis and making strategies for its achievement.

Key Differences Between Production and Productivity

The difference between production and productivity can be drawn clearly on the following premises:

1. Production is an organized activity, wherein step by step conversion of raw materials into useful output takes place. On the contrary, Productivity is an indicator of efficiency in the production in terms of optimum utilization of firm's resources in the creation of desired output.
2. Production is a process of value addition, wherein at each level, some value is added to the product. Conversely, productivity is a measure of efficiency.
3. Production exhibits the number of units produced by the firm in a given period. As against, productivity highlights the ratio of output to input consumed.

4. Production is always expressed in absolute terms, i.e. the volume of output produced. On the other hand, productivity is denoted in relative terms, meaning that it determines the quantitative relationship between output generated and resources consumed.

5. While production ascertains the value of output generated, productivity determines the how well the resources are utilized by the firm in the generation of output.

UNIT-2

WORK STUDY AND METHOD STUDY

Definition and Concept of Work Study:

Work study, as defined by British Standard Institution, is a generic term for those techniques particularly 'Method Study' and 'Work Measurement' which are used in the examination of human work in all its contexts and which lead systematically to the investigation of all the factors which effect the efficiency of the situation being reviewed, in order to seek improvements.

Actually, work study investigates the work done in an organisation and it aims at finding the best and most efficient way of using available resources, i.e., men, material, money and machinery. Every organisation tries to achieve best quality production in the minimum possible time.

The time required to manufacture an item depends upon the manufacturing procedure; and one phase of work study known as Method study aims at finding the best possible manufacturing procedure which involves, least time and does not cause fatigue to the workers.

ADVERTISEMENTS:

In brief, method study or motion study aims at finding the best way of doing a job. Method Study may be defined as the systematic investigation (i.e., recording and critical examination) of the existing method of doing a job in order to develop and install an easy, rapid, efficient, effective and less fatiguing procedure for doing the same job and at lower costs.

This is generally achieved by eliminating unnecessary motions involved in a certain procedure or by changing the sequence of operation or the process itself.

Once the method study has developed an improved procedure for doing a job, the work Measurement or Time Study will find the time allowed to complete the job by that procedure. Work Measurement may be defined as the application of different techniques to measure and establish the time required to complete the job by a qualified worker at a defined level of performance. The time necessary to complete a job is determined from number of observations.

Need for Work Study:

Principles of work study used to be employed even long ago, in order to explore improvements, when industry was simple and involved lesser problems; of course a systematic procedure was not there. Today the industries with all their complexities and modernization naturally demand a more systematic approach like the work study in its present form.

ADVERTISEMENTS:

Work study finds applications in:

1. Industries (Production operations, research and development),

2. Marketing, sales and distribution,

3. Offices, stores and warehouses,

ADVERTISEMENTS:

4. Material handling,

5. Design,

6. Building and other constructions,

7. Transport,

ADVERTISEMENTS:

8. Hospital,

9. Army, and

10. Agriculture, etc.

Advantages of Work Study:

(a) Uniform and improved production flow,

(b) Higher productive efficiency,

(c) Reduced manufacturing costs,

(d) Fast and accurate delivery dates,

(e) Better employee-employer relations,

(f) Better service to customers,

(g) Job security and job satisfaction to workers,

(h) Better working and other conditions, and

(i) Higher wages to workers.

Objectives of (or Advantages Obtained Through) Method Study:

(1) Improved working processes and standardized procedures,

(2) Better work place layout; neat and clean environments and working conditions,

(3) Less fatigue to operators,

(4) Better product quality,

(5) Effective utilization of men, materials and machinery,

(6) Efficient and fast material handling,

(7) Reduced health hazards,

(8) Efficient planning of the section, and

(9) Streamlined working procedures.

Objectives of (or Advantages Achieved Through) Work Measurement:

Work Measurement:

(1) Determines the time required to do a job; thus it compares alternative methods and establishes the fastest method;

(2) Decides man power required for a job; it helps in man power economy;

(3) Decides equipment requirements;

(4) Provides information for effective production planning and maintenance procedures;

(5) Aids in calculating exact delivery dates;

(6) Decides realistic labour budgeting and provides a basis for standard costing system;

(7) Provides a basis for fair and sound incentive schemes; and

(8) Results in effective labour control.

Irrespective of the advantages mentioned above, the introduction of work study has always been looked by the supervisors, workers or union with suspicion. They probably feel insecure and think that work study will result in reduction in their salaries. Even otherwise a sudden change is never appreciated therefore workers and union should be taken into confidence and properly convinced before introducing work study.

Operation Analysis:
Operation Analysis is a detailed study of different operations involved in doing a work. Operation analysis becomes necessary in order to investigate the shortcomings of the existing method and to develop an improved procedure.

Operation analysis suggests, whether some elements, should be eliminated or combined or their sequence should be altered in order to obtain effective utilization of existing manpower and machinery with the minimum fatigue incurred by the workers. The analysis mainly considers the movements of the limbs and aims at finding a simpler and economical method of doing the job.

Before the procedural steps of a task are analyzed and the motions (of an operator) are studied or eliminated, an operation chart is constructed. Figure 9.7 shows an operation chart of the existing method of assembling nuts and bolts.

As a next step, the different motions involved are subjected to specific and detailed questioning with a view to eliminate unnecessary motions, and to arrange the remaining motions in a better sequence. Principles of motion economy serve as a very good guide in developing a better and improved method.

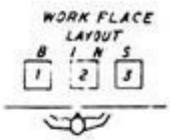
The chart (Fig. 9.7) of the existing method is tested as per the rules of motion economy and the following points are noted:

Operation : Nut & Bolt assembly.

Name of the worker.....

Location.....

Method : Present/Proposed



Left Hand Description	*Symbols*	*Right Hand Description*
Idle		Goes to bin-1
		Grasps a bolt
		Carries to left hand
Grasps and holds the bolt		Releases to left hand
		Goes to bin-2
		Grasps a nut
		Carries to left hand
		Screws nut on the bolt
Releases nut-bolt assembly		Grasps the assembly
Idle		Transfers assembly to bin-3

Fig. 9.7. Operation chart for the present method of assembling nuts and bolts.

(1) The distribution of work between the two hands is not balanced. Right hand is overloaded.

(2) The two hands do not follow opposite motions.

(3) Gravity has not been utilized for delivering the material to its destination, etc.

Besides assessing the present method a per the principles of motion economy, it is also subjected to following questions (whichever are applicable) with regard to:

(a) Worker:

1. Is he mentally and physically fit?

2. Does he incur unnecessary fatigue?

3. Does he need training to improve?

4. Does he get suitable salary?

(b) Set-Up:

1. Are tools and other equipment readily available?

2. Can the set-up be modified or can the number of set-ups be decreased?

(c) Material:

1. Is material of the proper specification i.e., composition, diameter, width, thickness of weight?

2. Can it be substituted by a less costly material?

3. Can scrap be minimized?

(d) Material Handling:

1. Can materials be transferred in big (unit) lots, thereby reducing the number of handlings?

2. Is it possible to avoid back tracking of the material?

3. Can the distances, by which the material is moved, be cut short?

(e) Operations:

1. Can some operations be eliminated?

2. Can some operations be made automatic?

3. How, re-sequencing of the operations will effect?

4. Is it possible to combine some operations?

(f) Tools and Fixtures:

1. Are they available in good condition?

2. Are they suitably located and prepositioned?

3. Is it advantageous to modify existing jigs and fixtures for better productivity?

(g) Working Conditions:

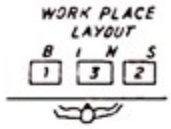
1. Is light and ventilation adequate?

2. Are the operations and working conditions safe?

3. Are facilities of wash rooms, etc., available?

Considering the existing method in the light of motion economy principles and questions mentioned above, a proposed method for the same task is as follows (Fig. 9.8).

Operation : Nut and Bolt Assembly
Name of the worker.....
.....
Location.....
Method : Present/Proposed



(3) It is a cavity in the work table, under which runs a conveyor to take each assembly at its destination.

Left hand description	*Symbols*	*Right hand description*
Goes to bin-1		Goes to bin-2
Grasps a bolt		Grasps a nut
Brings over the cavity or space cut in the work table (3)		Brings over cavity-3
Holds and grasps the bolt.		Screws the nut
Releases the assembly to drop on a conveyor through cavity-3.		Releases the assembly to drop on a conveyor through cavity-3.

Fig.9.8. Operation chart for the proposed method of assembling nuts and bolts.

UNIT-03

MOTION ANALYSIS

Analysis of Motion:

The motions or movements of the limbs of a worker play a major part in the fabrication or manufacture of the products. By carefully observing a worker while he is doing an operation, a number of movements made by him which appear to be unnecessary and unproductive can be identified and eliminated.

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

The purpose of motion analysis is to design an improved method which eliminates unnecessary motions and employs human efforts more productively. In doing so the principles of motion economy prove to be very helpful.

Steps involved in Motion Analysis are:

(a) Select the operation to be studied.

(b) List and chart various motions performed by the operator.

(c) Identify the productive and idle motions.

(d) Eliminate the unnecessary and non-productive motions.

(e) Redesign the existing operating procedure by employing minimum number of motions in the most appropriate sequence and in accordance with the principles of motion economy.

(f) Impart necessary instructions to the worker so that he develops proper habit cycle.

(g) Check once again the procedure in the light of step (e) above.

(h) The procedure may be standardized.

Therbligs:

Therbligs were suggested by Gilbreth. Therbligs are used to describe the basic elements of movements or fundamental hand motions of the work cycle. Every therblig is represented by a symbol, a definite colour and with a word or two to-record the same. For example, thereblig Grasp has symbol U, red colour and is denoted by the word G. A simo chart employs therbligs which are of microscopic nature, whereas a process chart uses symbols like operation, inspection, transportation, etc., which are macroscopic. A single operation may consist of many therbligs; for example,

Macroscopic motion	*Microscopic motion (therbligs)*
1. Operation of picking away a screw driver.	1. Reach hand for screw driver (transport empty). 2. Grasp the same (Grasp). 3. Take away the screw driver (transport loaded).

Though it looks cumbersome to deal with and to chart microscopic motions, yet they possess decided advantages over macroscopic motions.

1. One macroscopic motion may contain a number of microscopic motions. At times, it may not be possible to eliminate completely a macromotion but an unnecessary micromotion can definitely be avoided.

2. Since microsystem is very detailed, it is simpler to understand what precisely the worker is doing.

3. Therbligcolours make the charts more meaningful.

Various Therbligs along with their definition, symbols and colours are given below:

Sl. No.	*Therblig*	*Symbol*	*Colour*	*Definition*
12.	Inspect	 I	Burnt ochre	Examining an object for its quality.
13.	Preposition	 PP	Pale blue	Locating an article in pre-determined position so that it is ready for use.
14.	Grasp	 G	Red	Taking hold of something.
15.	Use	 U	Purple	Manipulating or causing a tool to do its function.
16.	Hold	 H	Gold ochre	Retention (after grasp).
17.	Select	ST	Light grey	Choosing one object from amongst many.
18.	Release load	 RL	Carmine red	Releasing an object.

PRODUCTION PLANNING AND CONTROL

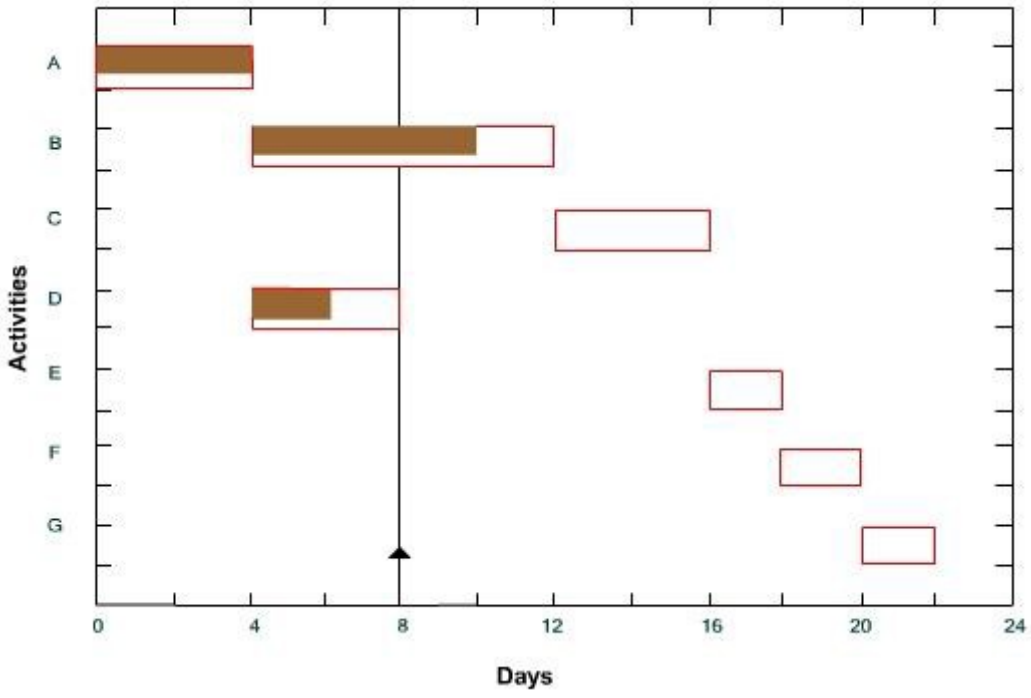
Project Management

A project is a well defined task which has a definable beginning and a definable end and requires one or more resources for the completion of its constituent activities, which are interrelated and which must be accomplished to achieve the objectives of the project. Project management is evolved to coordinate and control all project activities in an efficient and cost effective manner. The salient features of a project are:

- A project has identifiable beginning and end points.
- Each project can be broken down into a number of identifiable activities which will consume time and other resources during their completion.
- A project is scheduled to be completed by a target date.
- A project is usually large and complex and has many interrelated activities.
- The execution of the project activities is always subjected to some uncertainties and risks.

Network Techniques

The network techniques of project management have developed in an evolutionary way in many years. Up to the end of 18th century, the decision making in general and project management in particular was intuitive and depended primarily on managerial capabilities, experience, judgment and academic background of the managers. It was only in the early of 1900's that the pioneers of scientific management, started developing the scientific management techniques. The forerunner to network techniques, the Gantt chart was developed, during world war I, by Henry L Gantt, for the purpose of production scheduling. An example of Gantt chart is shown



Network Construction

A network is the graphical representation of the project activities arranged in a logical sequence and depicting all the interrelationships among them. A network consists of activities and events.

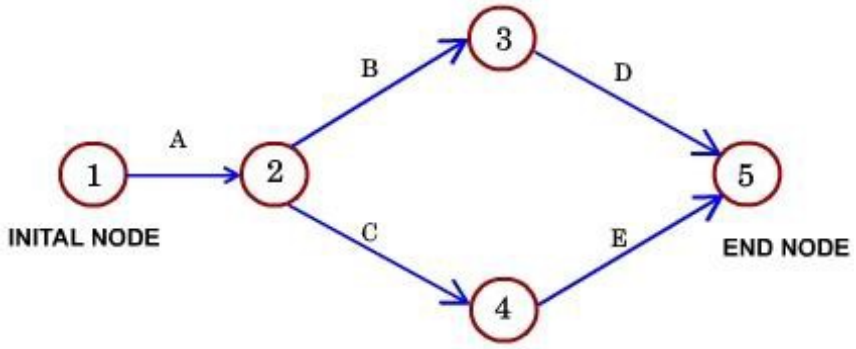
Activity

An activity is a physically identifiable part of a project, which consumes both time and resources. Activity is represented by an arrow in a network diagram (Figure 4). **Figure 4: Activity**

The head of an arrow represents the start of activity and the tail of arrow represents its end. Activity description and its estimated completion time are written along the arrow. An activity in the network can be represented by a number of ways: (i) by numbers of its head and tail events (i.e. 10-20 etc.), and (ii) by

a letter code (i.e. A, B etc.). All those activities, which must be completed before the start of activity under consideration, are called its predecessor activities. All those activities, which have to follow the activity under consideration, are called its successor activities (Figure 5).

Figure 5: Activity Precedence



Activity	Immediate Predecessor
A	_
B	A
C	A
D	B
E	C

Dummy Activity

An unbroken chain of activities between any two events is called a path.

Event

An event represents the accomplishment of some task. In a network diagram, beginning and ending of an activity are represented as events. Each event is represented as a node in a network diagram. An event does not consume any time or resource. Each network diagram starts with an initial event and ends at a terminal event. Each node is represented by a circle (Figure 7) **F**

igure 7: Event Representation 29

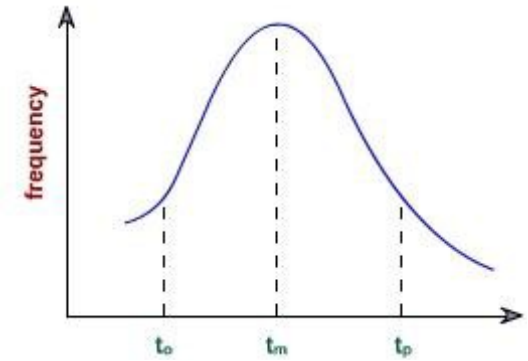
and numbered by using the Fulkerson's Rule. Following steps are involved in the numbering of the nodes:
 The initial event, which has all outgoing arrows and no incoming arrow, is numbered as 1.
 Delete all the arrows coming out from the node just numbered (i.e. 1). This step will create some more nodes (at least one) into initial events. Number these events in ascending order (i.e. 2, 3 etc.).
 Continue the process until the final or terminal node which has all arrows coming in, with no arrow going out, is numbered.

CPM and PERT

The CPM (critical path method) system of networking is used, when the activity time estimates are deterministic in nature. For each activity, a single value of time, required for its execution, is estimated. Time estimates can easily be converted into cost data in this technique. CPM is an activity oriented technique.

The PERT (Project Evaluation and Review Technique) technique is used, when activity time estimates are stochastic in nature. For each activity, three values of time (optimistic, most likely, pessimistic) are estimated. Optimistic time (to) estimate is the shortest possible time required for the completion of activity. Most likely time (tm) estimate is the time required for the completion of activity under normal circumstances. Pessimistic time (tp) estimate is the longest possible time required for the completion of activity. In PERT β-distribution is used to represent these three time estimates (Figure 12).

Figure 12: Time distribution curve

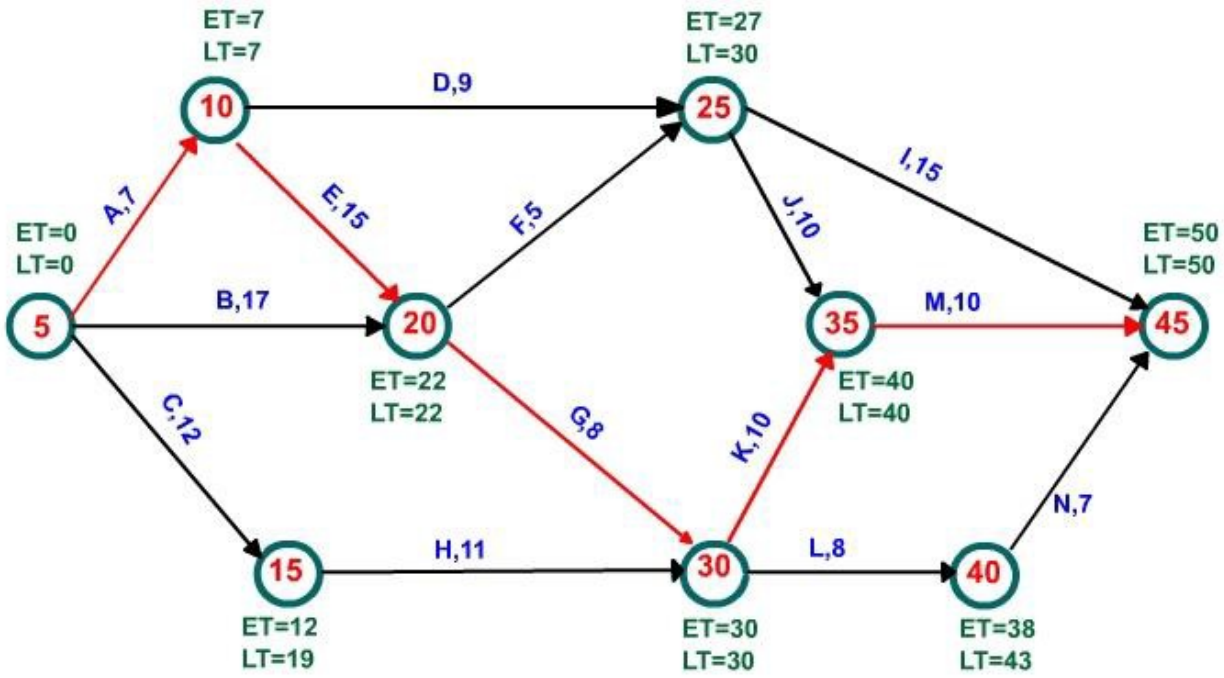


As PERT activities are full of uncertainties, times estimates can not easily be converted in to cost data. PERT is an event oriented technique. In PERT expected time of an activity is determined by using the below given formula:

$$t_e = \frac{(t_o + 4t_m + t_p)}{6}$$

Calculation of Time Estimates in CPM

In the project network given in figure below, activities and their durations are specified at the activities. Find the critical path and the project duration.



Calculations in Network Analysis

The following calculations are required in network analysis in order to prepare a schedule of the project.

a. Total completion time of the project

b. Earliest time when each activity can start (i.e. earlist start time)

c. Earliest time when each activity can finish (i.e. earlist finished time)

d. Latest time when each activity can be started without delaying the project (i.e. latest start time)

e. Latest time when each activity can be finished without delaying the project (i.e. latest finish time)

f. Float on each activity (i.e. time by which the completion of an activity can be delayed without delaying the project)

g. Critical activity and critical path

The symbols used in the calculations are shown in table below. **Symbol**	**Description**
Ei	Earliest occurance time of event i
Lj	Latest allowable occurance time of event j
tEi-j	Estimated completion time of activity (i,j)
(EST)ij	Earliest starting time of activity (i,j)