

**WELCOME**



**SRI AKILANDESWARI WOMENS COLLEGE WANDIWASH**

**NETWORK ANALYSIS IN OPERATION RESEARCH**

**CLASS : III UG MATHEMATICS**

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# INTRODUCTION

Network analysis is a technique which determines the various sequences of jobs concerning a project and the project completion time. Network analysis has been successfully used to a wide range of significant management problems. There are two types. This method differentiates between planning and scheduling. Planning refers to the determination of activities (jobs may be accomplished) and the order in which such activities should be performed to achieve the objective of the project. Scheduling refers to introduction of time in performing the jobs concerning the project taken in the plan. CPM technique is generally applied to well known projects where the time schedule to perform the activities can exactly be determined. Using this technique the management was able to obtain the expected project completion time and the bottle neck activities in a project. Apart from these two types we will also see about crashing.

# PRELIMINARIES

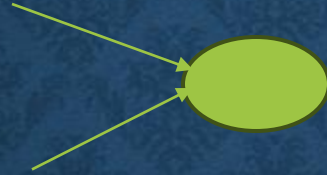
## EVENTS (OR) NODES :

- The beginning & end of an activities are called an events.
- Events are represented by numbered circles called nodes.



## TYPES OF EVENTS :

✓ Merge event



✓ Burst event



✓ Merge & Burst event



## Activity:

- Activity are identified by the number of a starting (initial) event and ending (terminal) events.
- There are three types :
- **Predecessor activity** : Activities that must be completed immediately prior to the start of another activity are called predecessor activities.
- **Successor activity** : Activities that cannot be started until one or more of other activities are completed but immediately succeed them are called successor activities.
- **Dummy activity** : An activity which does not consume either any resource or time is known as dummy activity.
- **Looping** : looping is known as cycling error and creates an impossible situation and it appears that none of the activities could ever be completed.
- **Dangling** : sometimes a project network includes an activity which does not fit into the end objective of the project and is carried out without any result related with completion of the project. Such an error in network is called dangling.

# RULES FOR CONSTRUCT THE NETWORK

- i. Network diagram should be clearly understandable.
- ii. Event names should be unique.
- iii. Arrow should not cross each other.
- iv. Arrows should be kept straight and not curve and bend.
- v. No two activities can be identified by the same head and same tail event.
- vi. Dummy activities should be avoided.

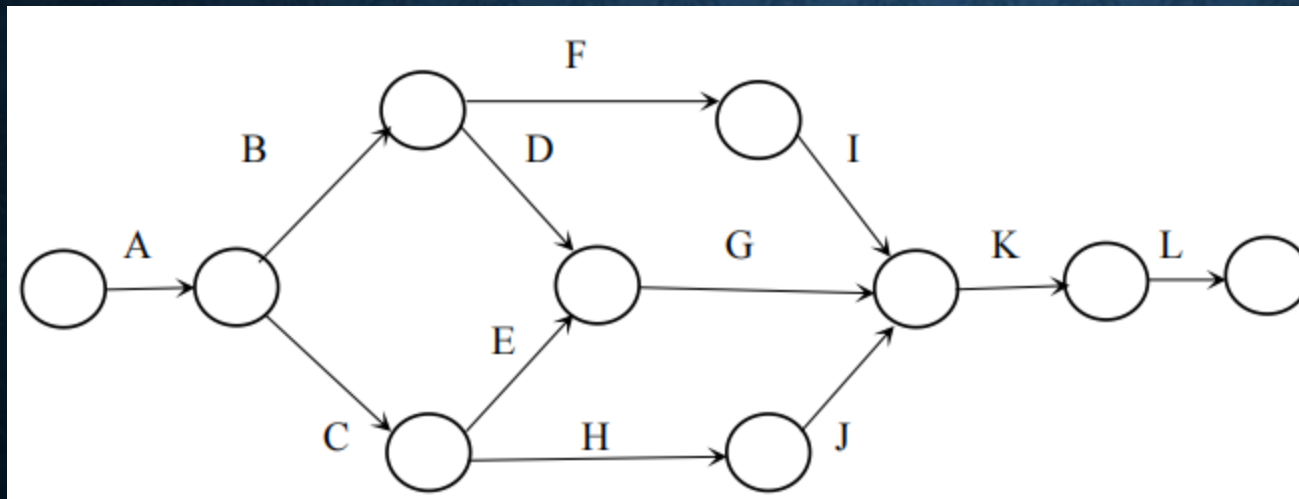


# EXAMPLE

Draw a network diagram

Activity:	A	B	C	D	E	F	G	H	I	J	K	L
Predecessors:	-	A	A	B	C	D	D,E	C	F	H	G,I,J	K

**SOLUTION:**



# CRITICAL PATH METHOD

**Definition** : The critical path is the longest path in the network from the starting event to ending event & defines the minimum time required to complete the project. The critical path is denoted by darker or double lines.

**PATH** : A path is defined as a set of nodes connected by lines which begin at the initial node of network and at the terminal node.

**CRITICAL ACTIVITY** : The starting delay in these types of activities generates the further delay in project completion time.

**NON – CRITICAL ACTIVITY**: The activities which resist delay in their start, without affecting the total project duration.

**FLOAT OF ACTIVITY**: It is the time by which it is possible to delay the completion time without affecting the total project duration.

**EARLIER START TIME[EST]**: Earlier start time for an activity represents the time at which an activity can begin at the earliest.

**EARLIER FINISH TIME[EFT]** : Earlier finish time of an activity is its Earlier start time the time required the program the activity.

**LATEST FINISH TIME[LFT]** : The left of an activity represents the latest by which an activity must be completed without delaying the completion of the project.

**LATESTSTARTTIME [LST]** : The latest start time for an activity is its latest by which an activity must be completed without delaying the completion of the project.

$$LST = LFT - \text{Time duration}$$

**ACTIVITY FLOAT** : It is the time difference of activity time estimates. An activity float is basically of following types.

**TOTAL FLOAT [TF]** : It is the difference between LST and EST of the same activity mathematically.

$$TF = LST - EST$$

**FREE FLOAT[FF]** : It is an activity is the difference between EST and EFT of all its immediate success.

$$FF = EST - EFT$$

- **ALGORITHM :**
- **STEP 1 :** List all the jobs and draw a network diagram. Each jobs is indicated by an arrow with the direction of the arrow showing the sequence of jobs. Place the jobs on the diagram one by one keeping in mind what precedes and follows each job as well as what job can be done simultaneously.
- **STEP 2:** Consider the job's times to be deterministic.
- **STEP 3:** Calculate the EST and EFT for each event and calculate the LST and LFT.
- **STEP 4:** Tabulate various times, i.e.), activity normal times, earliest times and latest times and mark EST and LFT on the arrow diagram.
- **STEP 5:** Determine the total float for each activity by taking difference between EST and LFT.
- **STEP 6:** Identify the critical activities and connect them with the beginning node and ending node in the network diagram by double line arrow. This gives the critical path.
- **STEP 7:** Calculate the total project duration.

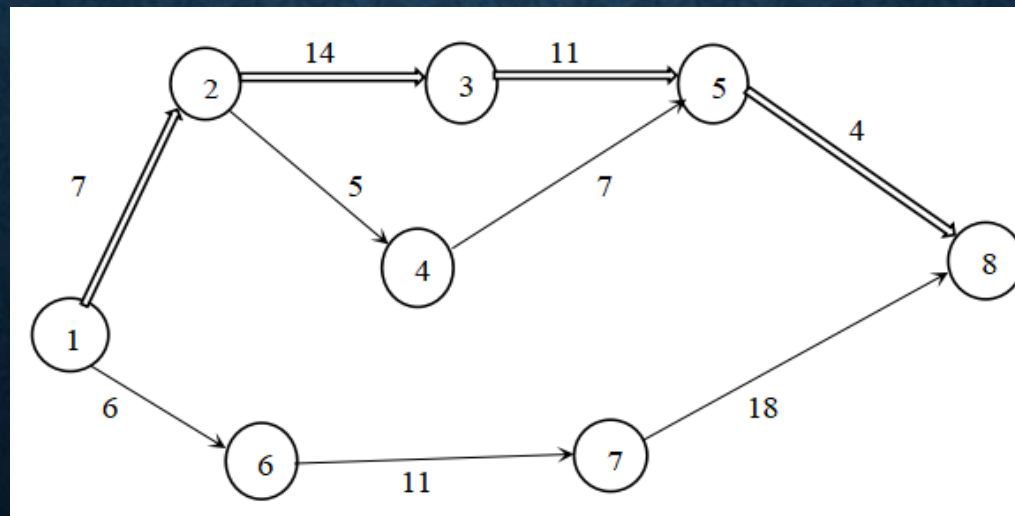
# EXAMPLE

The following table gives the activities of a project and their duration in days.

Activity	1-2	1-6	2-3	2-4	3-5	4-5	6-7	5-8	7-8
Duration	7	6	14	5	11	7	11	4	18

Draw the network diagram and find the critical path.

**SOLUTION:**



The paths are

	Path	Duration
1.	1-2-3-5-8	36
2.	1-2-4-5-8	23
3.	1-6-7-8	35

The critical path is 1-2-3-5-8

The project duration is 36 days.

# ADVANTAGES OF CPM

- ❖ It shows the activities and their outcomes as a network diagram.
- ❖ It gives a fair and concise procedure of documenting of project.
- ❖ It is extensively used in industry.
- ❖ It helps the project manager in identifying the most critical elements of the project.
- ❖ It gives a practical and disciplined base which helps in determining how to reach the objectives.

# DISADVANTAGES OF CPM

- ❖ In CPM, it is difficult to estimate the completion time of an activity.
- ❖ For bigger projects, CPM network can be complicated too.
- ❖ In CPM, critical path needs to be calculated precisely.
- ❖ It also does not handle the scheduling of the resource allocation.
- ❖ The critical path is not always clear.



# PERT METHOD

**Definition :** A PERT network diagram is drawn in the same way a CPM network. In PERT network we need only three estimate the duration of each activity.

- **Optimistic time ( $t_o$ ) :** It is that time estimate of an activity when everything is assumed to go as per plan. In other words it is the estimate of minimum possible time which an activity takes in completion under ideal conditions.
- **Most likely time ( $t_m$ ) :** The time which the activity will take most frequently if repeated number of times.
- **Pessimistic time ( $t_p$ ) :** The unlikely but possible performance time if whatever could go wrong , goes wrong in series. In other words it is the longest time the can take.

## ALGORITHM :

**STEP 1 :** Make a list of activities that make up the project including immediate predecessors.

**STEP 2 :** Making use of step 1 sketch the required network.

**STEP 3 :** Denote the most likely time by  $t_m$ , the optimistic time by  $t_o$  and pessimistic time by  $t_p$ .

**STEP 4 :** The expected time  $t_e$ , for each activity is computed by using the formula;

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

**STEP 5 :** Tabulate various time, i.e.), expected activity times, earliest and latest times and mark the EST and LFT on the arrow diagram.

**STEP 6 :** Determine the total float for each activity by taking the difference between EST and LFT.

**STEP 7 :** Identify the critical activities and connect them with the beginning node and the ending node, in the network diagram by double line arrows, this gives the critical path and the expected date of completion of the project.

**STEP 8:** Using the values of  $t_p$  and  $t_0$ , compute the variance ( $\sigma^2$ ) of each activity's time estimates by using the formula;

**STEP 9:** compute the standard normal deviate;

$$z_0 = \frac{\text{Due date} - \text{Expected data of completion}}{\sqrt{\text{project variance}}}$$

**STEP 10 :** Use standard normal tables to find the probability  $P(z \leq z_0)$  of completing the project within the scheduled time, where  $z \sim N(0, 1)$ .

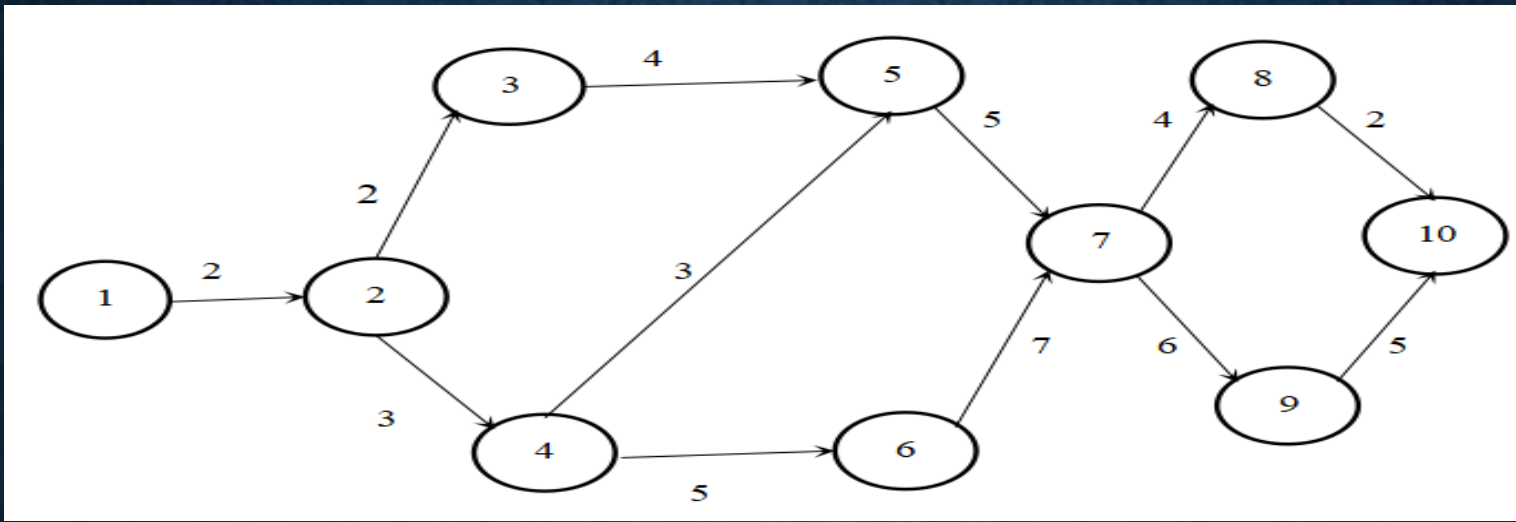
# EXAMPLE

A project has the following characteristic and time estimate- optimistic time (a), most likely time (m) and pessimistic time (b). Construct the PERT network . Find the critical path and the project duration.

Activity	1-2	2-3	2-4	3-5	4-5	4-6	5-7	6-7	7-8	7-9	8-10	9-10
a	1	1	1	3	2	3	4	6	2	4	1	3
b	5	3	5	5	4	7	6	8	6	8	3	7
m	1.5	2	3	4	3	5	5	7	4	6	2	5

**SOLUTION :**

Activity	a	b	m	4m	$T_e = \frac{a + b + 4m}{6}$
1-2	1	5	1.5	6	2
2-3	1	3	2	8	2
2-4	1	5	3	12	3
3-5	3	5	4	16	4
4-5	2	4	3	12	3
4-6	3	7	5	20	5
5-7	4	6	5	20	5
6-7	6	8	7	28	7
7-8	2	6	4	16	4
7-9	4	8	6	4	6
8-10	1	3	2	8	2
9-10	3	7	5	20	5



The various path	Duration
1). 1-2-3-5-7-8-10	$2+2+4+5+4+2=19$
2). 1-2-4-6-7-9-10	$2+3+5+7+6+5=28$
3). 1-2-4-6-7-8-10	$2+3+5+7+4+2=23$
4). 1-2-4-5-7-9-10	$2+3+3+5+6+5=24$
5). 1-2-4-5-7-8-10	$2+3+3+5+4+2=19$
6). 1-2-3-5-7-9-10	$2+2+4+5+6+5=24$

The critical path is 1-2-4-6-7-9-10 .

The expected project duration is 28 days.

# ADVANTAGES OF PERT

- ❖ **Planning for Large Project:** It is used in scheduling large project by the project manager.
- ❖ **Visibility of Critical Path:** It is used to show the critical path in a clear way. The critical path those paths were activities cannot be paused under any conditions.
- ❖ **Analysis of Activity:** The will provide the management with the progress report and the completion of the project including the budget.
- ❖ **Coordination Ability:** This helps in improving the communication within different departments of the company.
- ❖ **The What-if Analysis:** This analysis benefits the company to recognize the risk linked with any

# DISADVANTAGES OF PERT

- ❖ **Time Focused Method:** PERT is a time- bound method, so finishing project or activities on time is of high importance. If it does not happen than a problem can arise.
- ❖ **Subjective Analysis:** Here, the project activities are recognized according to the available data. However, it is difficult in PERT projects a sit is applicable for the only new projects are which is not repetitive in nature, therefore, the collection of information to be subjective in nature.
- ❖ **Prediction Inaccuracy:** PERT does not have any past records for a framework of a project, so prediction comes into play. The project will be ruined if the prediction is not accurate.
- ❖ **Expensive:** Too expensive in terms of time consumed, research, prediction, and resources utilized.



# CRASHING

**NORMAL COST** : This is the cost required to finish an activity in normal duration.

**CRASH COST** : The crash duration of an activity is the minimum duration in which an activity could be finished with the increased manpower, machine power etc., the crash cost required finish an activity in this reduced duration. The crash cost will always be greater than the normal cost.

**COST SLOPE** : This is the average cost of reducing the duration of an activity by one unit of time. The cost slope is generally assumed to be linear and is defined as

$$\text{Cost slope} = \frac{\text{crash cost} - \text{Normal cost}}{\text{Normal Time} - \text{Crash time}}$$

## ALGORITHM

**Step 1:** Analyze the critical path.

**Step 2:** Identify tasks that can be shortened with additional skilled resources.

**Step 3:** Create a table showing the trade-off of time reduction vs. increased costs.

**Step 4:** Choose the least costly approach.

**Step 5:** Provide and deploy the updated.

# DIFFERENCE BETWEEN PERT & CPM

## PERT

- ❖ Its origin is military
- ❖ It is an event-oriented approach oriented approach
- ❖ It allows uncertainty uncertainty
- ❖ It is a probabilistic model model
- ❖ It is time based
- ❖ It average time

## CPM

- Its origin is industry
- It is an activity-
- It doesn't allow
- It is a deterministic
- It is cost based
- It doesn't average time

# APPLICATIONS OF NETWORK ANALYSIS

- Planning, scheduling, monitoring and control of large and complex projects.
- Construction of factories, highways, building, bridges, cinemas etc.
- Control of traffic, flow in metropolitan cities.
- Assembly line scheduling
- Installation of computers and high tech machineries
- To make marketing strategies

# LIMITATION AND ADVANTAGE OF NETWORK ANALYSIS

## LIMITATION:

- ❖ It requires clearly defined, independent, and stabilized activities in a project.
- ❖ It considers only preceding activities of an activity in a project network formulation.
- ❖ It plays a crucial attention to critical path (activities) of the project.

## AVANTAGES OF NETWORK ANALYSIS:

- ❖ Resolving management related issues and problems on a project, when the project appears to be in complexity and large in scale, consists of many constraints and needs to be completed in a specific time.
- ❖ Maintaining and functioning with the relationship of activities with their preceding activities in a project.
- ❖ Contributing effectively to an organization in the processes of planning, designing, implementing and completing projects in accordance with the resources available and with their respective costs.

# CONCLUSION

- In this project we learned about event, activities ,path and their definition, different parts, crashing and limitations of network analysis . It offers an insight into network communications to identify performance problems, locate security breaches, analysis application behavior and perform capacity planning. We used to diagram for analysis the path and formula and include some simple problems. A lot of information in network analysis ,here we presented some information

**THANK YOU**