CHAPTER-3

NETWORK ANALYSIS

* General and Specific Objectives
* Trainer's Notes and Guidelines
* Self-Learning Package for the Trainees and Assignments

GENERAL OBJECTIVE

The participant will for a given short-run project, prepare an activity network, determine project duration and critical path, free and total floats of activities in the network.

SPECIFIC OBJECTIVES

The participant will -

(a) Identify activities that constitute projects in which he would be involved.

(b) Develop dependencies between the activities on the basis of logic and translate a set of interdependent activities into a network using relevant norms and rules.

(c) For given or assumed activity durations, determine Earliest Start and Finish Times and Latest Start and Finish Times for each activity in the network. (EST, EFT, LST AND LFT).

(d) From the information available in (c) above,locate Critical Path, determine Free and Total Floats of activities.

(e) Given a network with complete information as described above in (d), list out the precise implications of Critical Path, Free and Total Floats and other such information in the implementation of the network.

TRAINER'S NOTES AND GUIDELINES

NETWORK ANALYSIS

THEME OF THE CHAPTER

Network Analysis is a technique associated with Planning. It is normally employed after the objectives and current situation of a project have been finalised. The activity set which is necessary to traverse from current situation to objectives can be presented diagrammatically in the form of networks. Such networks are very useful for :

- scheduling project in detail
- specifying and providing resources
- following up on project progress.

Amongst the many techniques available for network analysis, the one chosen in this Chapter is known as CRITICAL PATH METHOD (CPM).

PREREQUISITES

(a) This Chapter has to be taken up only after completion of the Chapter on Planning (Chapter - 2).

(b) Both the Tutor and the participants must be familiar with the self-learning mode.

(c) The Tutor should have sufficient expertise in :

(i) decomposing a project objective into an activity set, and

(ii) establishing the inter-dependency between activities through logic.

(d) The participants should have experience in managing youth programmes.

(e) the Tutor should be familiar with :
- guiding self learning of participants
- conducting individual and group assignments.

PREPARATORY ACTIVITIES FOR TUTOR

(a) The Tutor should have throughly gone through the Learning Experiences of the Chapter including assignments.
(b) The Tutor should have studied References 2 and 3 and solved some sample exercises.
(c) The Tutor should have prepared and analysed at least 3 networks for projects managed by him.
(d) The Tutor should keep in mind the specific instructions provided in the Chapter at various places.

INSTRUCTIONAL GUIDELINES

(a) The Chapter consists of 11 units and 16 exercises. Instructions to users (i.e. participants) are set forth at the beginning of the Chapter.
(b) The whole Chapter is in the Self-Learning mode. The expected time for learning the topic is 10 1/2 hours (minimum). The suggested break-up is as follows :

Sl. No.	Activity	Time in hours
1.	Units 1 to 4	2 3/4
2.	Use of OHP Transparency 3.1	1/4
3.	Units 5 to 8	3
4.	Units 9 to 11 (except Exercise - Sixteen)	2 3/4
5.	Use of OHP Transparency 3.2	1/4
6.	Exercise - Sixteen	1 1/2

(c) The Tutor will link this Chapter with the appropriate stage in Planning and also briefly mention the purposes of network analysis (5 to 10 minutes).

(d) (i) The Tutor will keep in mind the instructions to participants given in the Learning Package. While the participants would learn at their own pace, he will be sensitive to learning needs of participants and provide assistance as and when need arises. Assignment Answers may be distributed by the Tutor all at once when the participants start learning or as and when required by the learners.

(ii) The Tutor will take special care in ensuring that the participants learn the significance and application of certain difficult concepts such as dummy, total and free floats, decomposition of project objectives into activity set.

(e) The Tutor has to guide the participants in completing Exercise - Sixteen which is a group exercise. The Tutor is welcome to modify or change the project titles. He has to ensure also that the group answer is satisfactory.

(f) The Tutor will use the OHP transparencies 3.1 and 3.2 as per the schedule presented earlier to reinforce learning and to clarify any difficulties of the participants.

(g) Since this is a self-learning package, it is not essential to have a concluding plenary session.

ANSWERS AND SUGGESTED RESPONSES TO EXERCISES

EXERCISE - ONE

(i) Event representing end of an activity is allocated a higher numeral than the event for the beginning of the activity.

(ii) Activities are represented by letters of the alphabet.

(iii) More than one activity may start from an event.

(iv) More than one activity may end at an event.

(v) Activities B and D may be performed concurrently (i.e. at the same time).They are known as parallel activities.

(vi) Event numbers are not repeated.

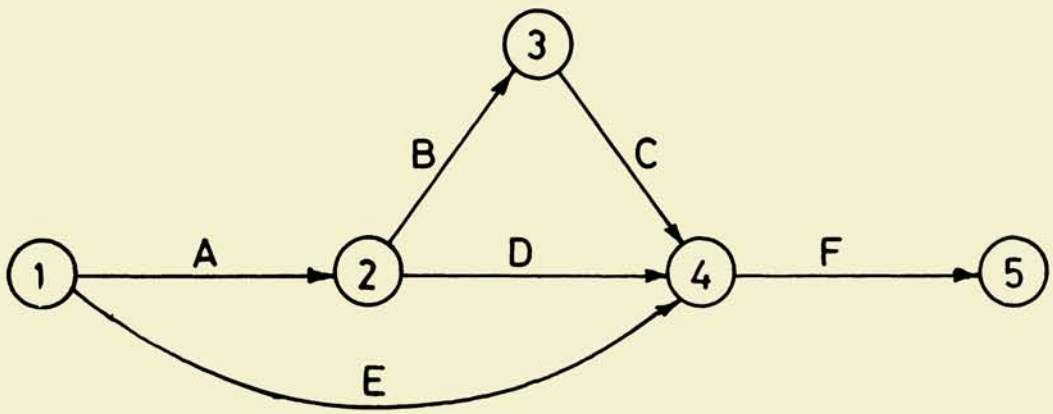
(vii) Activity names are not repeated.

The participant may proceed to the next unit if he has identified at least two of the above conclusions.

EXERCISE - TWO

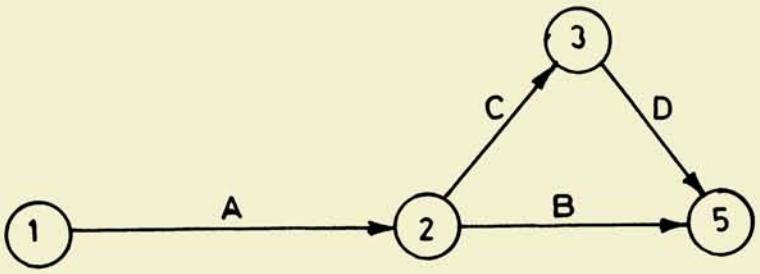
ACTIVITY	START EVENT	END EVENT	DEPENDS ON	ACTIVITY	START EVENT	END EVENT	DEPENDS ON
A	1	2	-	G	4	6	J,B,K
B	1	4	-	H	5	7	D
C	1	3	-	I	6	7	G,E
D	2	5	A	J	2	4	A
E	3	6	C	K	3	4	C
F	4	7	J,B,K	-	-	-	-

EXERCISE - THREE



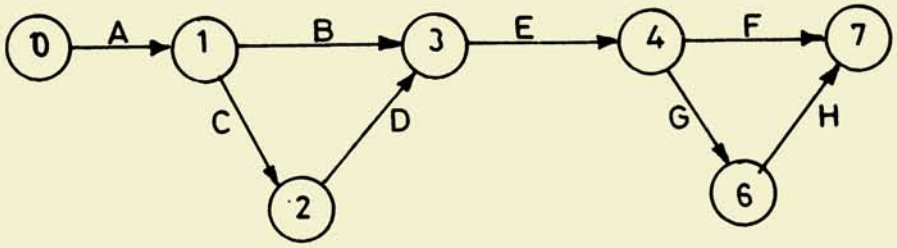
EXERCISE - FOUR

(a)



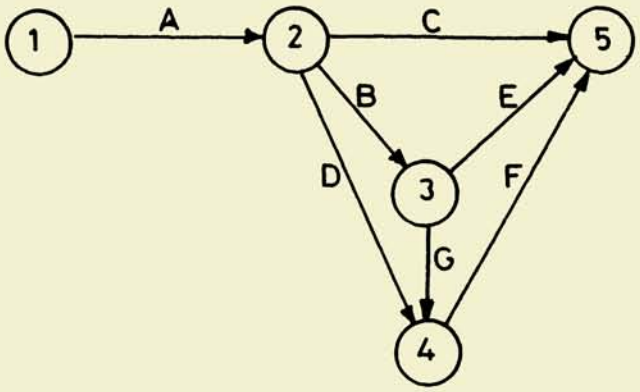
The network should end with only one event.

(b)



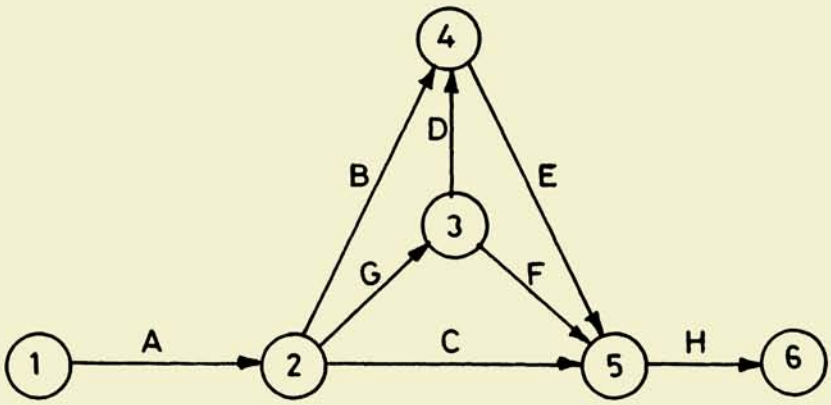
Network should end with only one event and an activity should have its end event numbered higher than its start event.

(c)



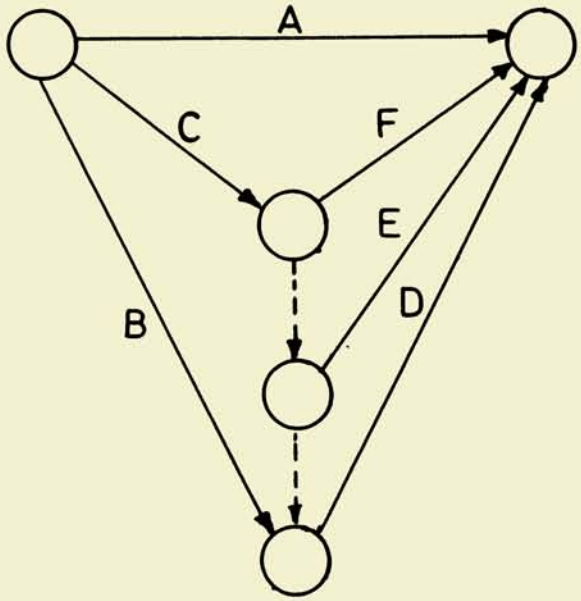
An end event of an activity should be numbered higher than its start event and two activity lines may not cross each other.

(d)

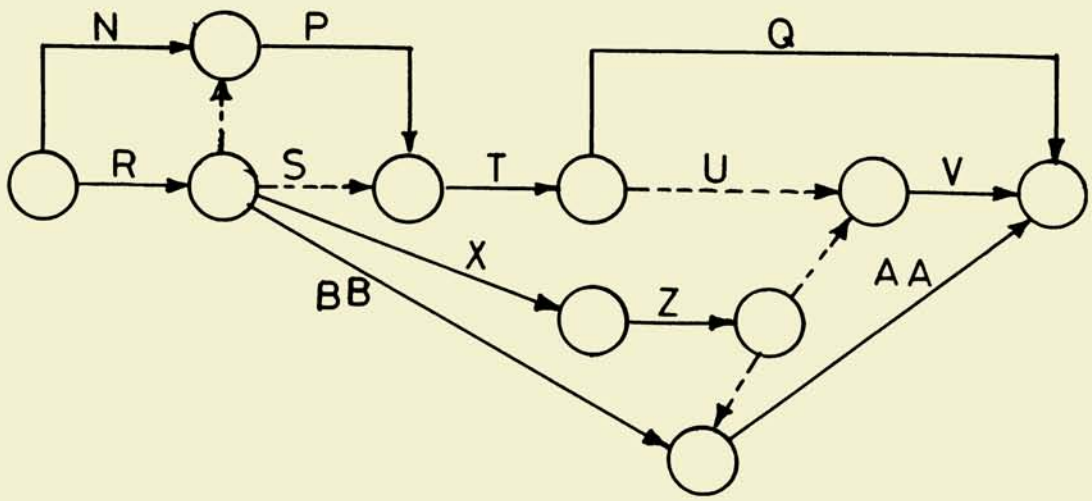


There should not be two nodes having the same number and criss-crossing of activity lines should be avoided.

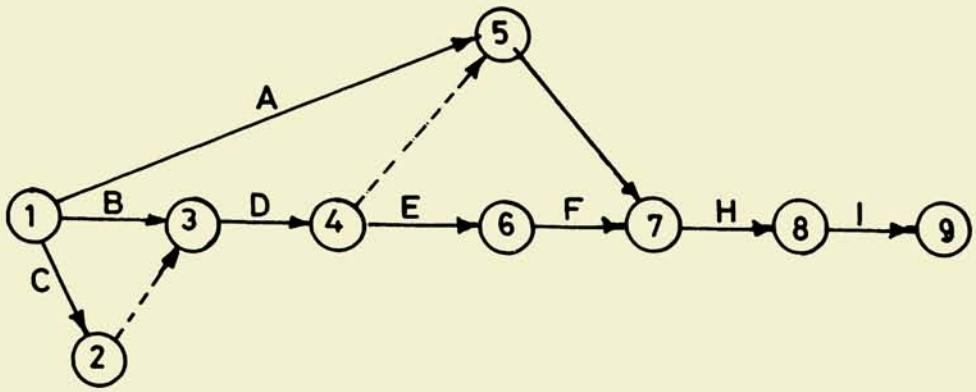
EXERCISE - FIVE



EXERCISE - SIX



EXERCISE - SEVEN

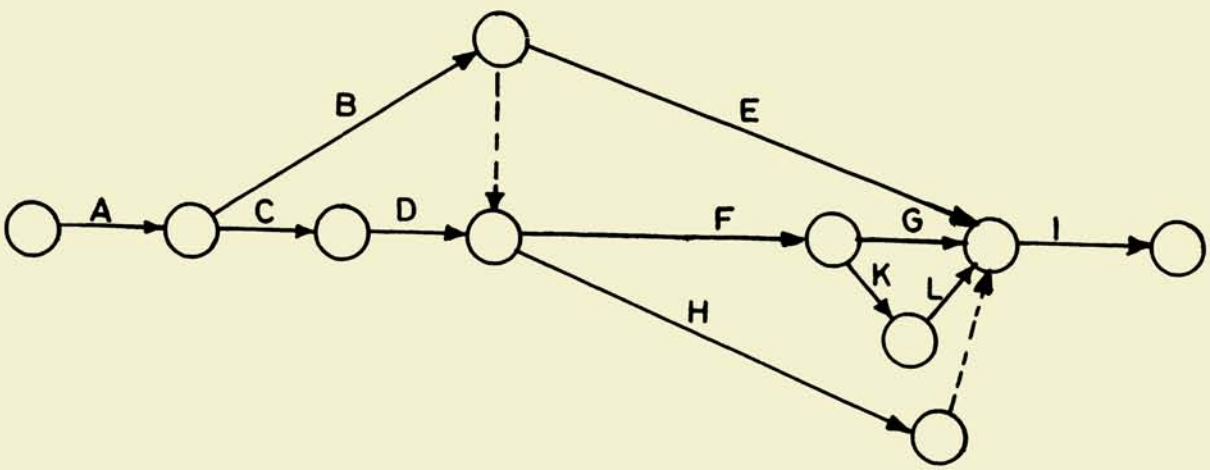


The Tutor will collect the suggestions for improving the match between the activities and the objective from the participants, scrutinise them and present to the participant group the acceptable suggestions.

EXERCISE - EIGHT

SYMBOL	DEPENDS ON
A	-
B	A
C	A
D	C
E	B
F	B,D
G	F
H	B,D
I	E,G,H,L
K	F
L	K

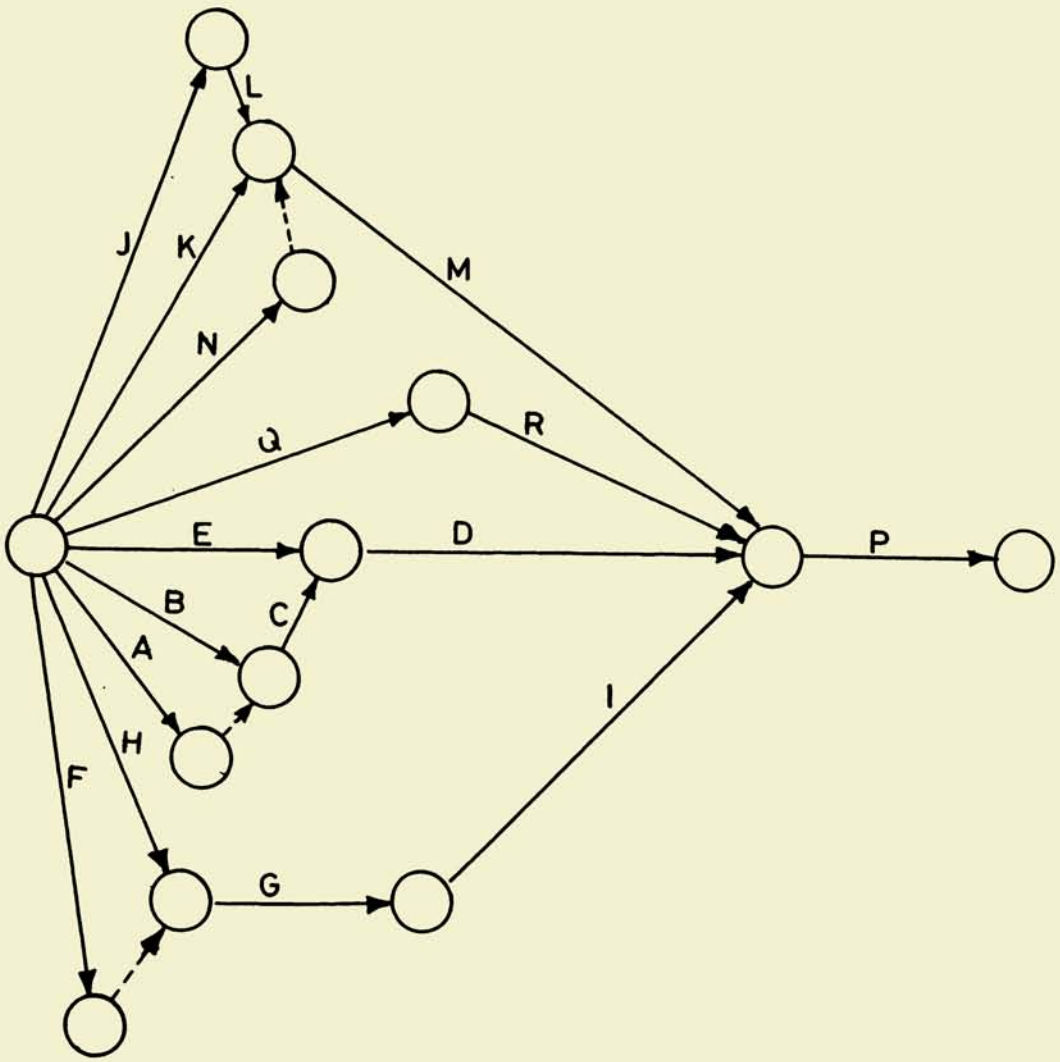
The network for this project is given below.



EXERCISE - NINE

The set of activities for the Drug Addiction Campaign is given below.

Act. Name	Activity Description	Depends on
A	Devising Illustration for newspaper advertisement	-
B	Writing the accompanying text for illustration	-
C	Making half-tone blocks	A,B
D	Sending blocks to newspapers	C,E
E	Negotiating contract for press advertising	-
F	Designing poster	-
G	Printing poster	F,H
H	Contracting for printing poster	-
I	Distributing poster	G
J	Preparing script for television film	-
K	Negotiating contract with the film company	-
L	Completing film	J,K
M	Sending films to the programme company	L,N
N	Reaching agreement with the programme company	-
P	Arranging a press conference	D,I,M,R
Q	Agreeing upon date for launching the campaign	-
R	Drawing a detailed plan of the campaign	Q



NOTE : TUTOR WILL CLARIFY TO THE PARTICIPANTS THAT THE ALPHABETS REPRESENTING ACTIVITIES NEED NOT BE IN SEQUENTIAL ORDER.

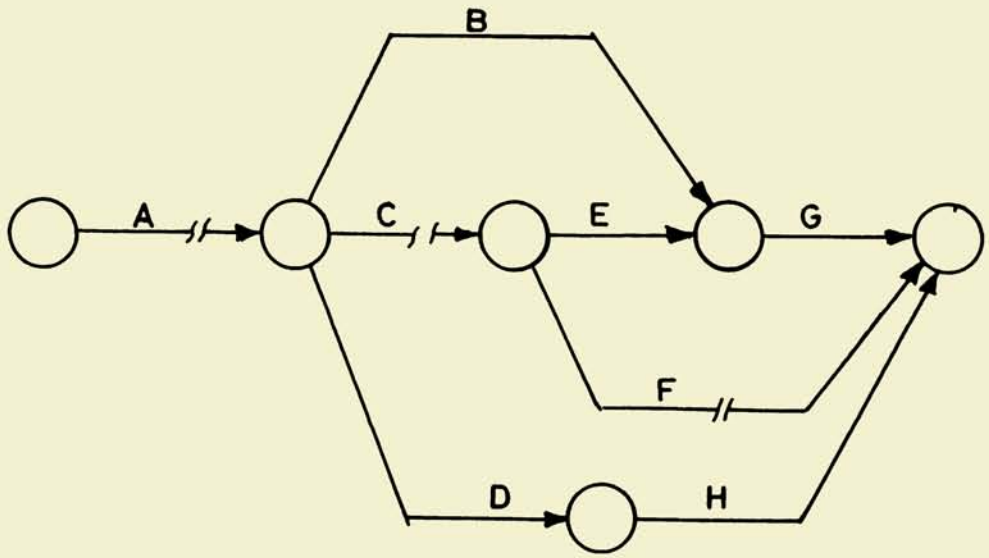
EXERCISE - TEN

The Tutor will collect all suggestions - eliminations, additions, combinations of activities, modifications, etc. of the participants, scrutinise them and present the acceptable suggestions.

EXERCISE - ELEVEN

PROJECT DURATION

= 25 days



EXERCISE - TWELVE

(a) Non-critical Activities: C,F,D,G and H

(b)

Non-critical activities	Total Float (days)
C	6
F	6
D	1
G	1
H	1

(c)

Path	Total Float (days)
A-C-F-I	6
A-D-G-H-I	1

EXERCISE - THIRTEEN

Total float = LPO of succeeding event - EPO of preceding event - duration of activity.

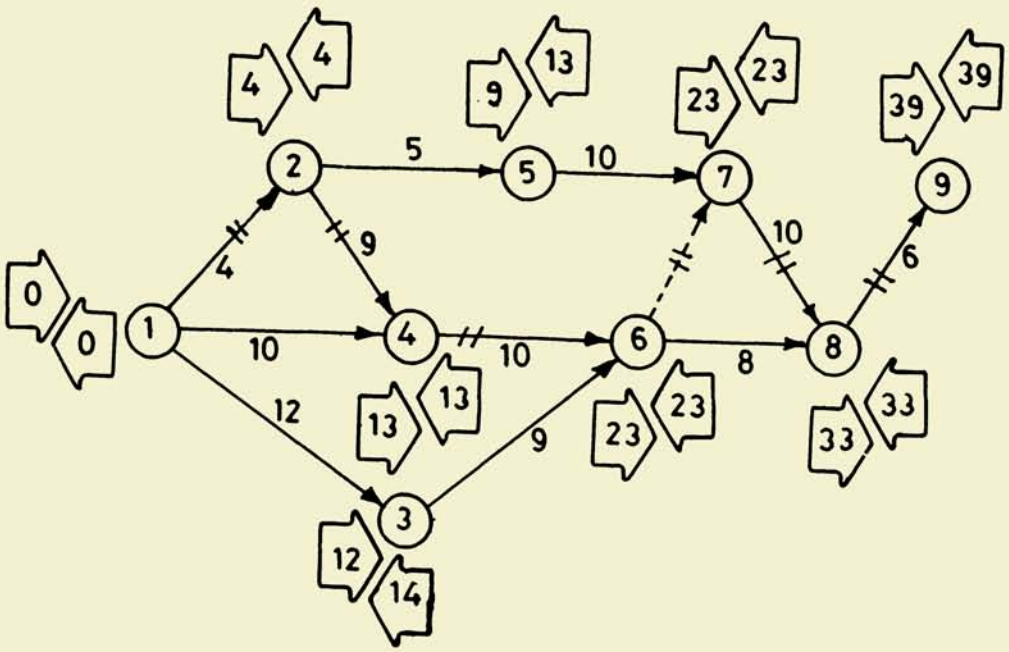
EXERCISE - FOURTEEN

Activity	Duration in days	EST	EFT	LST	LFT	Free Float	Total Float
A	4	0	4	0	4	-	-
B	18	0	18	6	24	6	6
C	2	4	6	6	8	2	2
D	4	4	8	4	8	-	-
E	9	4	13	13	22	-	9
F	1	8	9	17	18	-	9
G	7	8	15	8	15	-	-
H	3	8	11	12	15	4	4
I	2	15	17	22	24	2	7
J	2	17	19	18	20	1	1
K	5	15	20	15	20	-	-
L	4	20	24	20	24	-	-

Critical Path is A-D-M-G-K-L = 24 days, where M is a dummy activity.

EXERCISE - FIFTEEN

(a)



(b)

Activity	Duration (Days)	EST	FFT	LST	LFT	FF	TF
1-2	4	0	4	0	4	0	0
1-3	12	0	12	2	14	0	0
1-4	10	0	10	3	13	3	3
2-4	9	4	13	4	13	0	0
2-5	5	4	9	8	13	0	4
3-6	9	12	21	14	23	2	2
4-6	10	13	23	13	23	0	0
5-7	10	9	19	13	23	4	4
6-7	0	23	23	23	23	0	0
6-8	8	23	31	25	33	2	2
7-8	10	23	33	23	33	0	0
8-9	6	33	39	33	39	0	0

(c) CRITICAL PATH IS 1 - 2 - 4 - 6 - 7 - 8 - 9
and PROJECT DURATION = 39 Days

(d) The new CRITICAL PATH is 1 - 2 - 4 - 6 - 8 - 9
and new PROJECT DURATION = 40 Days.

EXERCISE - SIXTEEN

It is suggested that this final exercise of the Structured Assignment be done in groups of 4-6 participants. Each group will select a different project. The list of the projects suggested may be increased by the Tutor, if he so desires. The suggested duration of group work is one and a half hours, but the Tutor may provide more time if the groups are unable to complete the exercise in the allotted time. The Tutor will request spokesman of each group to present the group analysis in a plenary session. The Tutor will finally suggest the improvements that could be brought about in the group analyses.

REFERENCES

1. `Learning Package on Industrial Management' by R.K. Mani and others, published by Vikas Publicatons, Bhopal on behalf of TTTI, Bhopal, 1982.
2. `Network Analysis' by Battersby, Macmillan, London, 1967.
3. `Planning and Control with PERT/CPM' by Levin and Kirkpatrick, McGraw-Hill, New York, 1966.
4. `Modern Production Management' by E.S.Buffa, Wiley-Eastern, Delhi, 1971.
5. `Youth Mobilisation for Development in Asian Settings', UNESCO, 1978.
6. `Youth Work Series - No 5' by Banmala, Vishwa Yuva Kendra Publications, Delhi, 1976.

SELF-LEARNING PACKAGE
AND
TRAINEE'S ASSIGNMENTS

NETWORK ANALYSIS

INSTRUCTIONS TO USERS

This is a self-instructional package. You are expected to learn from it primarily through your own efforts. The Tutor will be available for guidance and clarification.

The topic "Network Analysis" has been divided into a number of units and each unit has been provided with a title. You are advised to proceed unit by unit.

As part of learning each unit, you will be required to understand the unit and attempt exercises. You are expected to check your answers with the Tutor. The Tutor may either suggest that you go through the unit again or that you proceed to the next unit.

You are now welcome to start the module.

GOOD LUCK !

C O N T E N T S

UNIT - 1 ACTIVITIES AND EVENTS

What is a network?

A network is a diagrammatic representation of all jobs that need to be carried out in the implementation of a project and provides information about how the various jobs are interrelated with one another. In other words, it is a graphic representation of a project plan.

Networks have two significant features. These are:

(a) ACTIVITY

represented by an arrow 

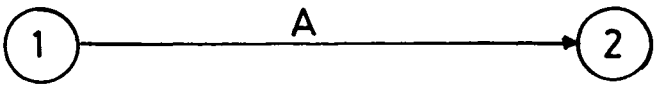
(b) NODE or EVENT

represented by a circle 

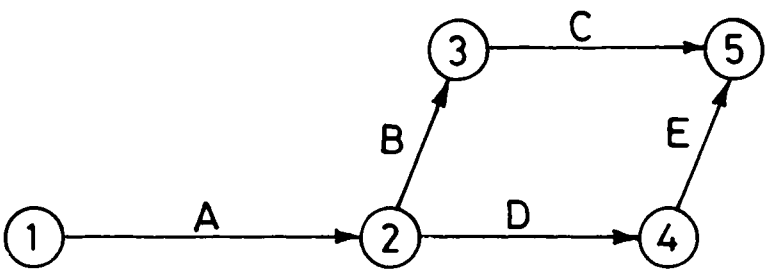
The physical meaning associated with these two terms can be derived from the following description.

Writing a page is an activity. However, the instant of starting to write the page and the instant of completing it are events. Activities involve actions and operations and consume time. They may continue for hours, days, or months. On the other hand an event is a momentary or instantaneous occurrence. It occupies no time but it identifies the beginning or end of an activity. The instant of beginning a meal and the instant of completing the meal are events, while the act of eating the meal itself is an activity.

In the diagram shown below:



1 and 2 are EVENTS and A is the ACTIVITY. The event 1 denotes the beginning of the activity A and 2 denotes the end. The arrow head is always placed alongside the end node. When more than one activity is considered in a network the diagram will appear as follows:



The interpretation of this diagram will be:

a) 2 denotes the end of the activity A and also the beginning of B. Hence, B cannot start until A is completed.

b) The activities A, B, and C are in sequence. So are A, D and E.

c) Arrow heads are placed at the end of the activity lines.

d) Events are usually identified by numerals.

EXERCISE - ONE:

Some more conclusions can be drawn. Can you identify them? Write them down below and check with the Tutor.

(i)

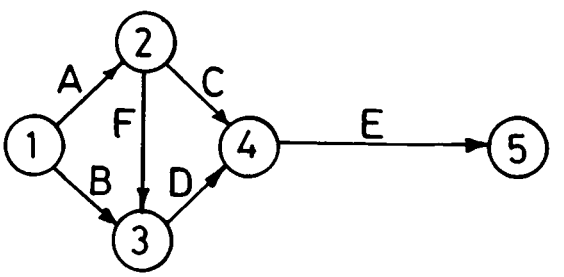
(ii)

(iii)

(iv)

UNIT - 2 INTERRELATIONS BETWEEN ACTIVITIES AND EVENTS

A project consists of many activities. Some are done in sequence, some are done in parallel. Definite interrelationships exist between various activities and, consequently, the events. An example can help you to explore these.



(a) The project starts with the event 1 and ends with the event 5.

(b) The activities A and B start simultaneously from the event 1 and are parallel to each other. However, they may not end at the same time. A and B are <u>independent</u> of each other.

(c) The activities C and F can commence only when A is over. In other words, C and F are <u>dependent</u> on A, but independent of each other.

(d) D can only start when B and F are both completed. Hence D is dependent on both B and F.

(e) Similarly the activities C and D control the activity E.

(f) Activity A has C and F as its successor activities.

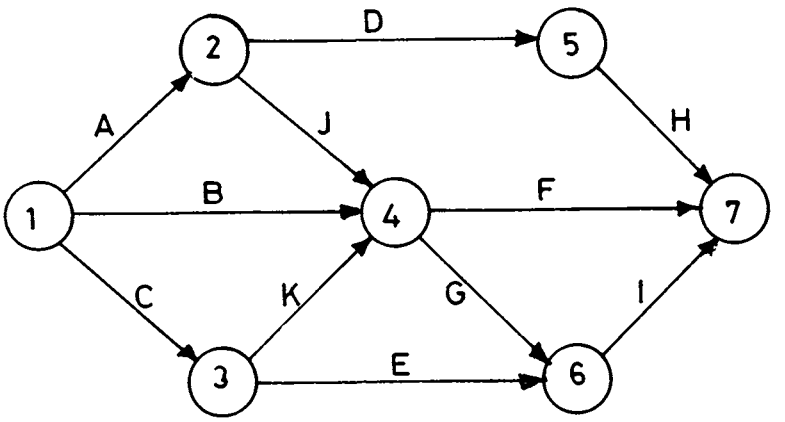
(g) Activity D has B and F as its predecessor activities.

This can be summarised in the table given below:

ACTIVITY	STARTING EVENT	END EVENT	DEPENDS ON ACTIVITY/ ACTIVITIES
A	1	2	-
B	1	3	-
C	2	4	A
D	3	4	B, F
E	4	5	C, D
F	2	3	A

EXERCISE - TWO:

A project has the following network



Fill up the table given below indicating the dependency relations.

ACTIVITY	START EVENT	END EVENT	DEPENDS ON
A			
B			
C			
D			
E			
F			
G			
H			
I			
J			
K			

EXERCISE - THREE:

On the basis of the table shown draw a network in the space given below:

ACTIVITY	START EVENT	END EVENT	DEPENDS ON
A	1	2	-
B	2	3	A
C	3	4	B
D	2	4	A
E	1	4	A
F	4	5	C, D, E

UNIT - 3 RULES FOR DRAWING NETWORKS

Some rules which are to be kept in mind while drawing networks are:

1. A project will begin with only one event and similarly end with only one event. These are usually denoted as START of Project and FINISH of Project.

2. While numbering the network, each activity shall start with an event of a number lower than that of the end event of the activity.

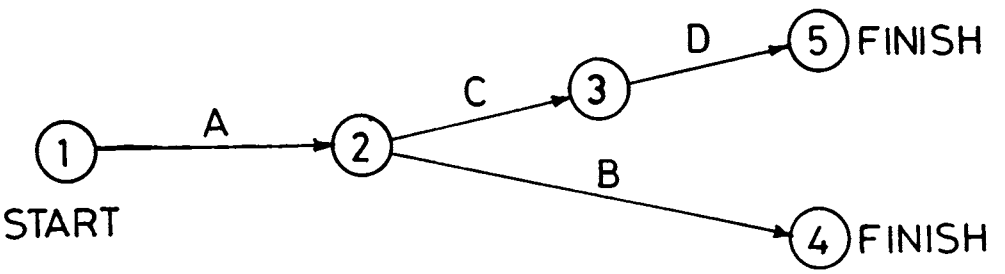
3. Activities are denoted by letters of the alphabet or by description like conducting a 100-m race, presenting a drama, etc. and designated by the node numbers at their two ends.

4. The arrangements of activity arrows in a network should be such that criss-crossing of arrows is avoided as far as possible.

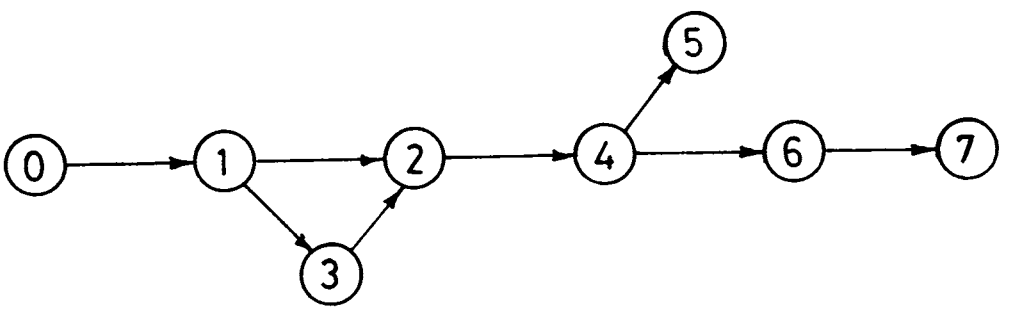
5. An event number or an activity alphabet should appear only once in the network to avoid confusion.

EXERCISE - FOUR:

The following are incorrectly drawn networks of projects. Redraw each network using the network rules, in the space provided.

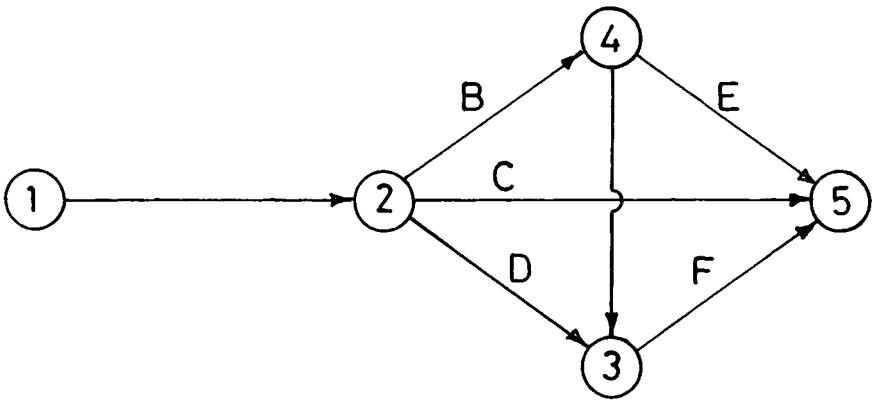


(a)

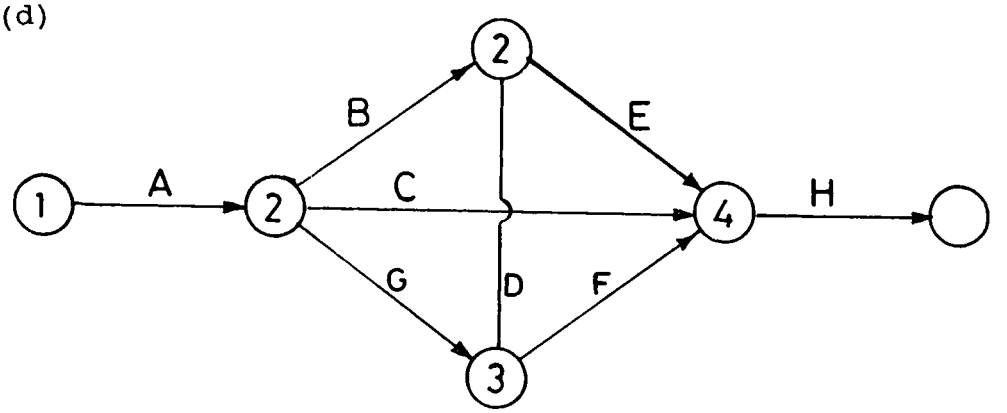


(b)

(c)

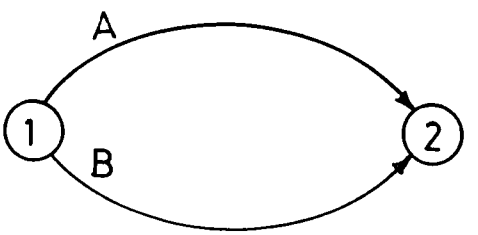


(d)

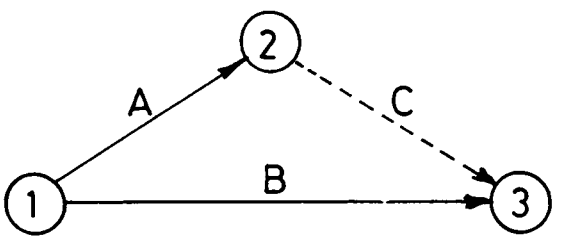


UNIT - 4 DUMMY ACTIVITIES

In drawing networks sometimes situations arise where between two successive events two activities may exist. An illustration would be :



Since such a representation would create confusion and difficulties in analysis, the representation should be modified, as follows.

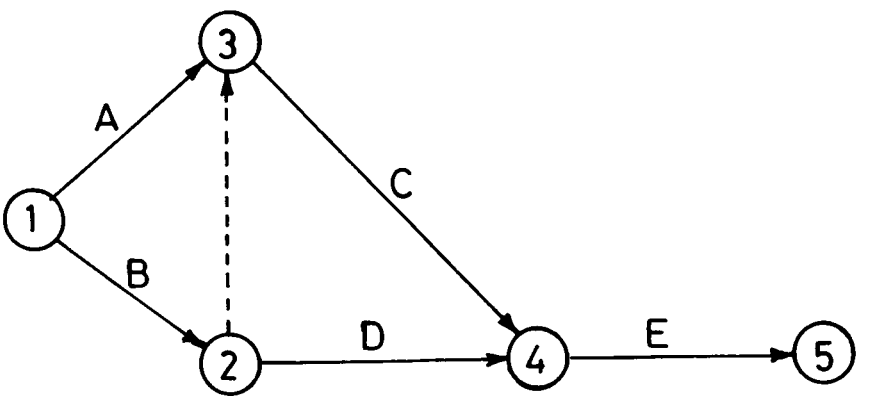


You will notice that an additional event '3' has been introduced and also a new activity 'C' has appeared. Activity C is called DUMMY activity. It has no physical significance, i.e. it will not consume any time or manpower or other resources. It is therefore a fictitious activity introduced for the sake of computational convenience. If dummies are not used many advantages of event numbering and

identity of activities will be lost in project networks. Dummies prove very useful additions. Consider a project with five activities A, B, C, D, E. Their relationships are indicated in the table.

ACTIVITY	DEPENDS ON
A	-
B	-
C	A, B
D	B
E	C, D

The corresponding network would be:



Can you notice the need for the dummy activity? Notice the placement of the dummy arrowhead to conform with the dependencies.

EXERCISE - FIVE:

Draw a network in the space given below to represent the following six activities. Activities A, B and C are concurrent. Activity D is dependent on B , E on B , C and F on C. The project is completed when A, D, E and F are completed.

EXERCISE - SIX:

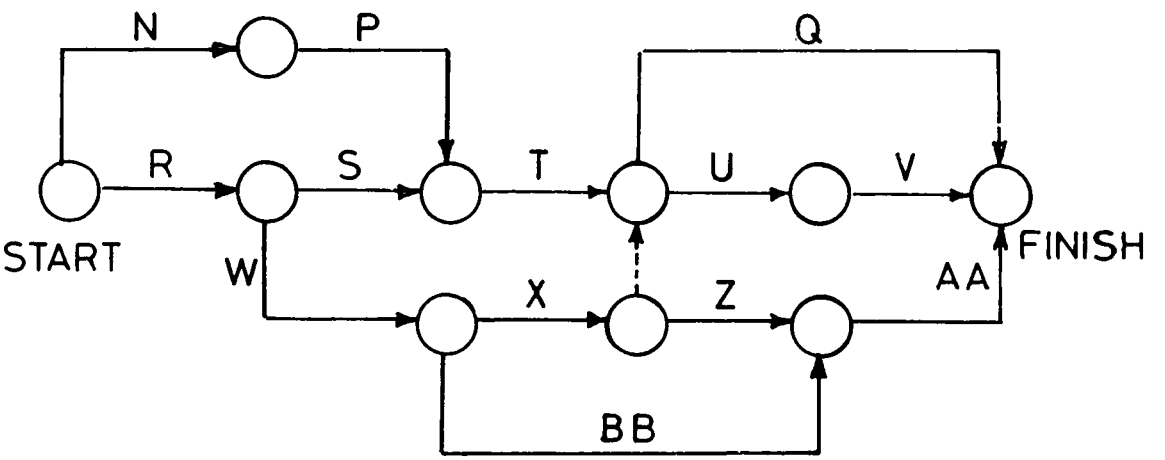
Change the network given below to allow the following alterations.

(a) Q is not dependent on X

(b) V dependent also on Z but not on BB

(c) P dependent also on R

(d) W no longer necessary at all.



UNIT - 5 CONSOLIDATION OF LEARNING

A consolidation step is now necessary. The essential rules or conventions to be adhered to in preparing a network for a project may be summarised as follows:

1. Each activity is represented by an arrow which starts at one event and finishes at another event.
2. Each activity is denoted by the numbers of the events at its two ends.
3. The event number at the tail of an arrow should be smaller than that at the head.
4. The sequence through the network should be from left to right.
5. Dummy activities which consume no time and cost are used in order to preserve the logical sequence of the activities.
6. An activity may have more than one predecessor activities and more than one successor activities.

EXERCISE - SEVEN:

Draw the network for a project which has the following activities. Seek feedback from Tutor.

Project: Slum Community Development Initiation

Objective: Initiating two simple group activities for slum communities.

Activity Identification	Activity Description	Immediate Predecessor(s)
A	Youth worker contacts different people in community	-
B	Youth worker discusses welfare activities to be organised by youth and obtains acceptance from community	-
C	Data collection on community by organisers and youth volunteers	-
D	Welfare ideas generated in meetings between organisers and community	B, C
E	Plans cast for welfare areas- sports club and sewing classes	D
F	Formation of infrastructure for the two welfare areas	E
G	Selection of community groups to benefit from the welfare areas	A, D
H	Organising sports club functions and sewing classes	F,G
I	Review at end of year.	H

Offer suggestions for improving the list of activities suggested above so that there is a satisfactory match between the activities and the objective.

UNIT - 6 IDENTIFICATION OF ACTIVITY DEPENDENCIES

One of the first operations in network formulation is the identification of activities which comprise the project. Once this is done the next step is to derive, through logic, the dependencies among them. This second operation is as complex as the first and demands considerable technical expertise about the project.

EXERCISE - EIGHT:

You may now try to identify dependencies for a project whose activities are listed below in the column adjacent to the activities. And then draw the network.

Project: ORGANISING THE COMMUNITY TO BUILD A 1\2 KM ACCESS ROAD, THROUGH VOLUNTARY SERVICE

Symbol	Activity Description	Depends on
A	Youth worker suggests project idea and builds a youth team	
B	Youth team contacts villagers through meetings and convinces them about project idea	
C	Engineer in nearby town contacted to provide technical expertise for converting foot track to access road	
D	Engineer submits plans	
E	Voluntary donation of land by landowners	
F	Organising community into work groups	
G	Allocation of tasks to work groups	
H	Collection of road construction hand implements from villagers	
I	Construction of road	
J	Inauguration of road	
K	Funds raised for refreshments	
L	Refreshments arranged for	

UNIT - 7 IDENTIFICATION OF PROJECT ACTIVITIES

As mentioned earlier the first step in formulating a project network is to identify various jobs involved. While it is easy to provide an overall description of a project it is a difficult task to break the entire project into clear-cut activities without gaps and duplications. A practice example will be worthwhile at this stage.

EXERCISE - NINE:

A description of a project is given below. After going through it, you are to:

(a) List component activities of the project

(b) Establish dependencies

(c) Draw the network

After each step check up with your TUTOR before proceeding ahead.

An agency is planning an advertising thrust to launch a new Campaign against Drug Addiction' among youth, usino poster, television and newspaper displays. The illustration for the newspaper advertisement will be devised while its accompanying text is being written, and half-tone blocks will be made when both are ready. The blocks will then be sent to newspapers, but only after the contract for the press advertising has been negotiated. This part of work is then finished. The poster is to be designed and printed after which, again subject to a satisfactory contract, it will be distributed, so completing this part of the campaign. The script for the television film is to be prepared while the contract with the film company is negotiated. The film when completed must be sent to the programme company, with whom a separate agreement has to be reached before hand.

As soon as all these preparations are made, a press conference has to be arranged with the help of an agency for a previously agreed date on which this campaign will be officially launched. The agency allows a fortnight for drawing up a detailed plan of the campaign.

UNIT - 8 ACTIVITY ANALYSIS

When we are interested in preparing a network for a project, our first aim is to list all activities. When the list is ready, it is likely that some activities are very significant with large durations and some activities are of very short durations. Further, there may be a logical way of combining or breaking up activities or eliminating some of them. Then, before we proceed further with establishing dependencies and preparing a network, it becomes necessary to make a critical analysis of the listed activities and preparing a revised list.

EXERCISE - TEN:

The list of activities given below pertains to a project for 'enabling the elderly in a community to get engaged in useful occupation.' The project is to be taken up by youth. You are required to analyse critically the list and suggest modifications such as eliminations, additions, combinations of activities and modifications if necessary. Provide justifications.

ACTIVITIES

- Youth team formed
- Generation of ideas on relevant schemes
- Identification of interests of elderly
- Survey performed for determining suitability of schemes
- Action plans formulated
- Preparatory work in community
- Programmes launched
- Programmes conducted
- Review of programmes.

UNIT - 9 CRITICAL PATH AND TOTAL FLOAT

So far in the previous units we have been concentrating on drawing the network. This involved decomposing the project in terms of activities, establishing inter-dependencies between activities, and completing the network for the whole project. This needs both creative and analytical skills.

The networks we have seen so far are sometimes called Arrow Diagrams. It does provide useful information to a youth worker for planning and implementing of project. However, the youth worker is also interested in setting targets. A most obvious target is the duration required to complete the project, may be in days, weeks, months, or even in years in some cases. Which means additional data are required, namely the duration of each activity in the Arrow Diagram. The youth worker in consultation with his co-workers will have to fix the duration of each activity. These are in the nature of estimates drawn from the total experience of the group entrusted with this job. Some of the considerations that affect the estimation of such time durations are:

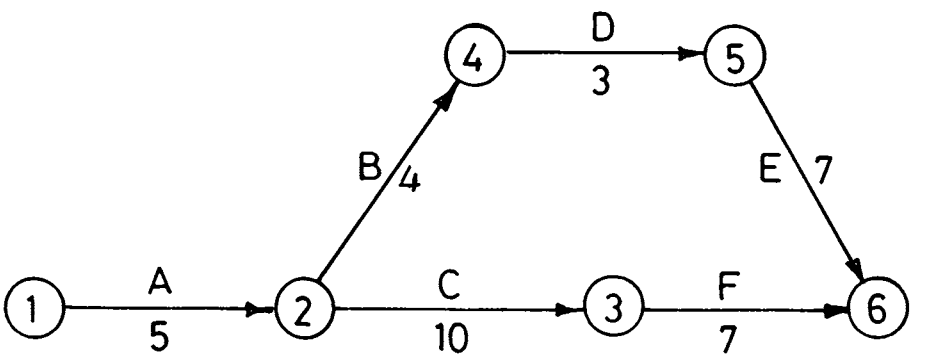
* Estimators' previous experiences
* Risk-taking capacity
* Consequences of making errors in estimates
* Resources available and resources that can be procured

* Methods and techniques that will be used during implementation
* Possible unforseeable delays
* Commitment of the group to the successful implementation of project.

Once the duration estimates are available, we may move on to the analysis of networks. This includes :

(a) determining the shortest possible time to complete the project.
(b) Identifying the activities which are critical, i.e. such activities which control the completion of the project in the shortest possible time and which demand concentrated attention and concern to avoid delays.
(c) Determining the amount of time by which the completion of non-critical activities can be delayed without affecting the shortest possible time of project completion.

Let us take a simple example and look into these aspects of analysis. The network for a project is shown below. The duration of each activity in days is given beneath the alphabetic symbol of each activity. It may be noted that the length of the activity line bears no relationship with the duration of the activity.



We can traverse from the beginning to end of the project along two paths, viz.

I Path : 1 → 2 → 3 → 6 via A, C and F

II Path : 1 → 2 → 4 → 5 → 6 via A, B, D and E.

The total time path I will take is 5 + 10 + 7 = 22 days and path II will take 5 + 4 + 3 + 7 = 19 days.

Since the completion of the project involves completion of all activities, the project will get completed only in <u>22 days</u> and NOT in 19 days. You will also notice that the activity A is common to both the paths.

A few conclusions could be drawn from the above network.

i) While the activities C and F are going on, the activities B, D and E will also be under operation.

ii) The minimum time required to complete the project is 22 days. This is the time by which the project can be finished earliest.

iii) The path II can be delayed by 3 days without affecting the earliest finish time of the project.

iv) Since A is common for both the paths, the duration of A cannot be increased but the duration of either B or D or E, or combination of them can be increased without affecting the completion date of project.

v) Any delay in activities A, C and F will delay the project completion. Hence to ensure that the project gets completed in 22 days, no delays or increase of duration can be permitted in the activities of path I. Therefore, the path I is called the CRITICAL PATH and the activities A,C, and F the CRITICAL ACTIVITIES. The term 'Critical' is related to planned implementation and completion of project.

A chain of critical activities from project start to finish form the critical path. There will be at least one such chain in every project. All activities (critical) in the critical path will have zero total float and hence zero free float (discussed later).

Normally the critical path in a network is indicated by thickening the activity lines or by placing a double strokes sign (//) on the critical activity lines.

The following characteristics of critical paths are significant:

a) All critical jobs or activities lie on at least one critical path.

b) There may be more than one critical path in a project.

c) The project duration equals the sum of durations along any critical path from project start to project finish.

d) A delay in the start or finish of a critical activity will delay the project completion by an equal amount.

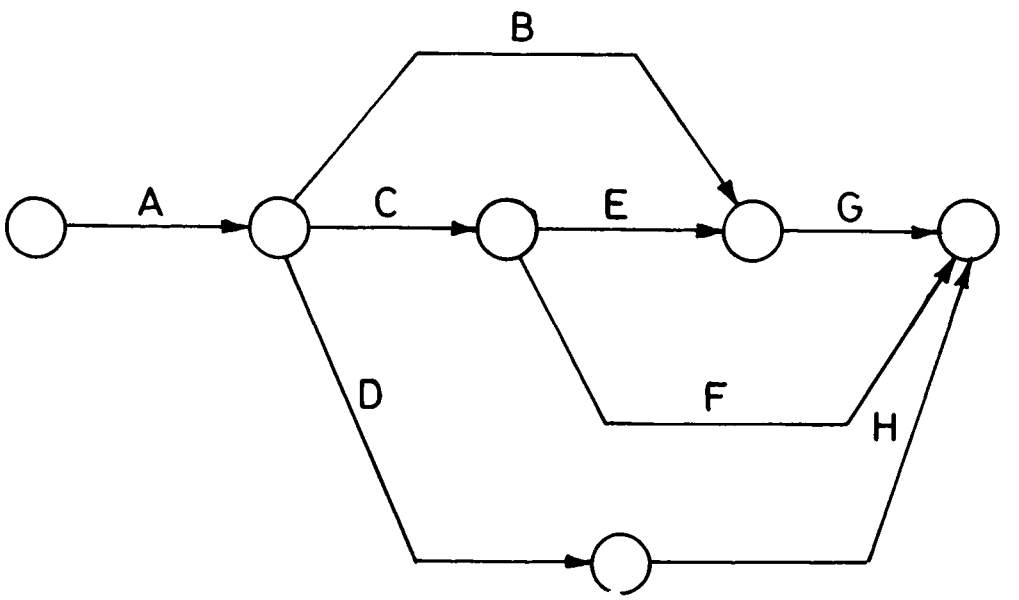
e) If more resources become available then, to reduce project duration, they must be used on jobs that are critical.

f) Priority of resource allocation must be given to critical jobs to ensure no delays.

EXERCISE - ELEVEN:

In the project network given below :

Write in ACTIVITY DURATIONS (using data provided in the table). Mark CRITICAL PATH and find PROJECT DURATION.



ACTIVITY	DURATION (Days)	ACTIVITY	DURATION (Days)
A	6	E	5
B	2	F	10
C	9	G	3
D	5	H	7

From the illustration network given previously in this unit it is clear that the activities B, D, and E have some built-in margin of time reserve in completion time. This margin is called FLOAT. A non-critical activity can be delayed upto an extent represented by the float without delaying the scheduled start of critical activities. The complete critical path has a float of zero.

Total float for activities B, D and E is 3 days. Total float for activity B will be 3 days if no reserve time is allowed for activities D and E. Similarly either D or E could have a total float of 3 days.

Alternately, if activity B needs to have a reserve time of one day, then activities D and E taken together, can have a total float of only 2 days.

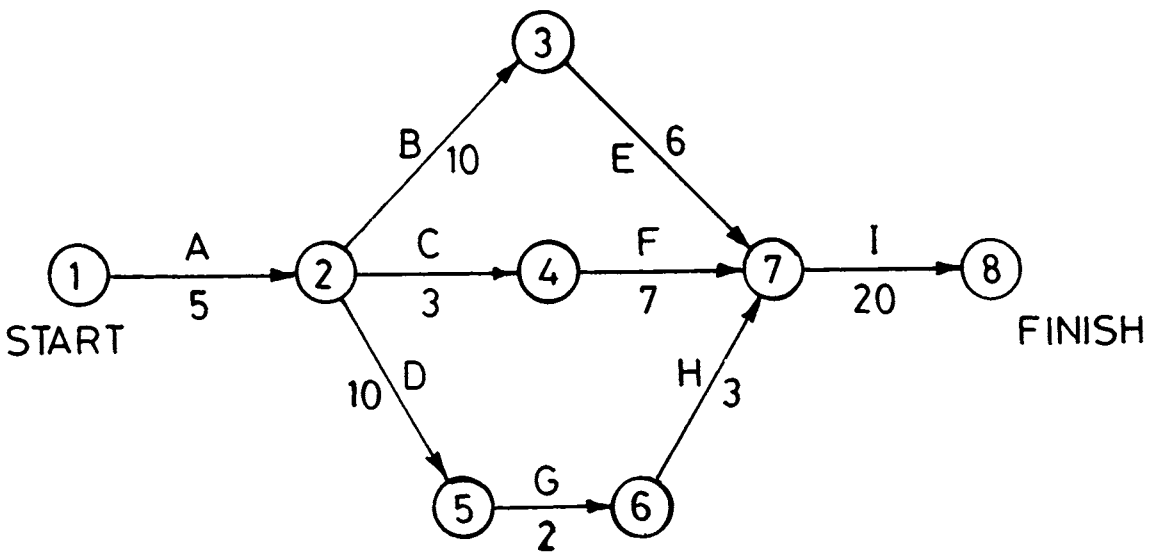
EXERCISE - TWELVE:

In the network given below :

a) identify the non-critical activities

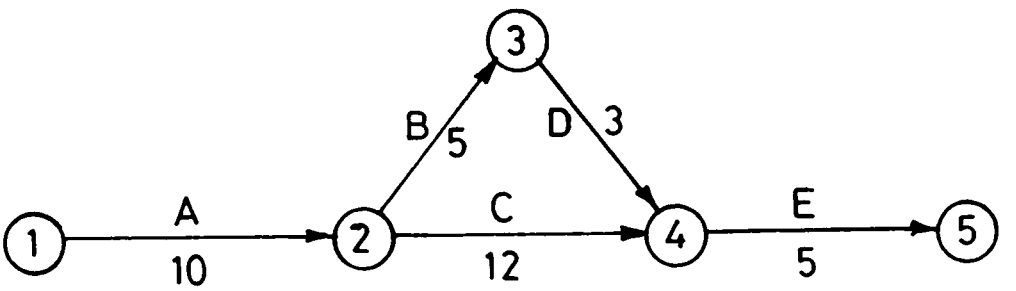
b) determine the total float for each non-critical activity

c) determine the total float for each path between the start and finish of the project.



UNIT - 10 FREE FLOAT, START TIMES AND FINISH TIMES

In analysing a network it would be of great use if each event is marked with the time when it should occur. Consider the network given below:



Event 2 occurs when activity A has finished. So the earliest time for event 2 is 10 days after the start of the project.

Event 3 can occur 15 days after the start.

Event 4 cannot occur until activities C and D are both completed.

Event 4 can occur only 22 days after the start.

Event 5 can occur only 27 days after the start.

These times are the earliest times for the events.

They are called EARLIEST POSSIBLE OCCURRENCE (EPO) and are calculated by proceeding from left to right in the network.

In this case the critical activities are A, C and E and the project duration is 27 days. As we want to keep the duration of the project to 27 days, event 5 should be completed in 27 days. This time is called LATEST POSSIBLE OCCURRENCE (LPO) for that event, and these are calculated from proceeding from the last event of the network backwards.

Latest time for event 4 is 22 days.

Consider the event 3 Although it can occur 15 days after the start, it does not have to occur until 19 days after the start (22-3=19). This will still allow 3 days for activity D. This can be summarised as shown below:

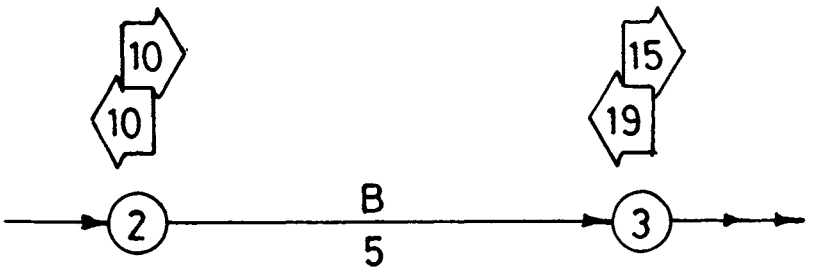
Event	EPO(days)	LPO(days)
1	0	0
2	10	10
3	15	19
4	22	22
5	27	27

Note that for some events the earliest and latest times are the same.

These events lie along the critical path.

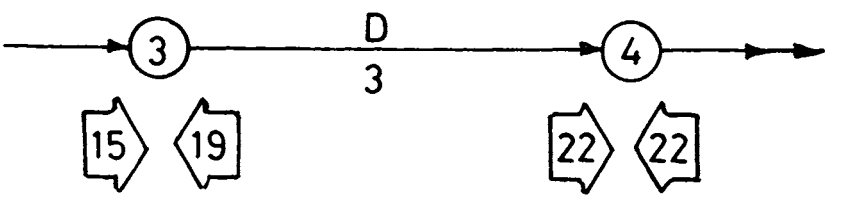
Let us see now how total float can be calculated from LPOs and EPOs.

Consider activity B (No other activity emanates from 2).



Activity B can start on day 10 but it does not have to finish until day 19. This leaves a total of (19-10=9) days for activity B. Therefore, B has a margin of 9-5=4 days. This implies activity B could be delayed for upto 4 days without extending the project duration. Activity B has a total float of 4 days.

Now consider activity D.



Consider again activity B. This can be delayed for upto 4 days without extending the project duration. If it was delayed for 4 days, event 3 would occur at its latest time i.e. 19th day. This would mean that activity D could not start until then. If we want to start the activity D as early as possible, activity B must finish by day 15. This leaves (15-10) = 5 days for activity B.
Then spare time for B = 5-5 = 0.

Thus, the amount of time an activity can be delayed without affecting the earliest possible start of the immediately following activity is called FREE FLOAT.

Free float for activity D = 22-15-3 = 4 days.
In general, Free float = EPO of succeeding event - EPO of preceding event-duration of activity.

Looking at the equations for Total Float (TF) and Free Float (FF), it can be seen that:

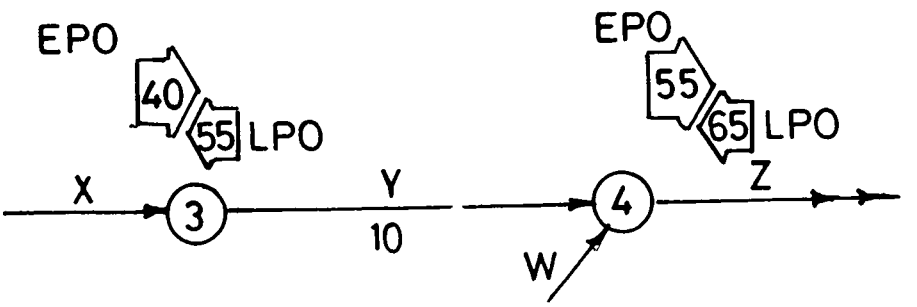
TF - FF = (LPO-EPO) of the immediately following event.

Now let us look into the relationships between event times and activity times. We know that EPO is the earliest time for the occurrence of an event and LPO is the latest occurrence time for an event.

EXERCISE - THIRTEEN:

Now can you write down the formula for total float in terms of EPO,LPO, and activity duration ?

Consider a section of a network shown below.



EVENT	EPO	LPO
3	40	55
4	55	65

Activity	Free Float	Total Float
Y	5	15

Activity Y can be started only when event 3 has occurred. This means Y can be started by earliest on day 40. This time is known as EARLIEST START TIME (EST)

It is clear that EST = EPO of the preceding event.

Activity Y, by latest, can be started on day 55

This latest time for the start of an activity is called LATEST START TIME (LST).

LST = LPO of the following event
- duration of activity.

Similarly the earliest time the activity Y can be finished is 50 days and the latest time Y can be finished is 65 days. They are called EARLIEST FINISH TIME (EFT) and LATEST FINISH TIME (LFT) respectively.

EFT = EPO of the preceding event + duration of the event

LFT = LPO of the immediately following event.

For activity Y,

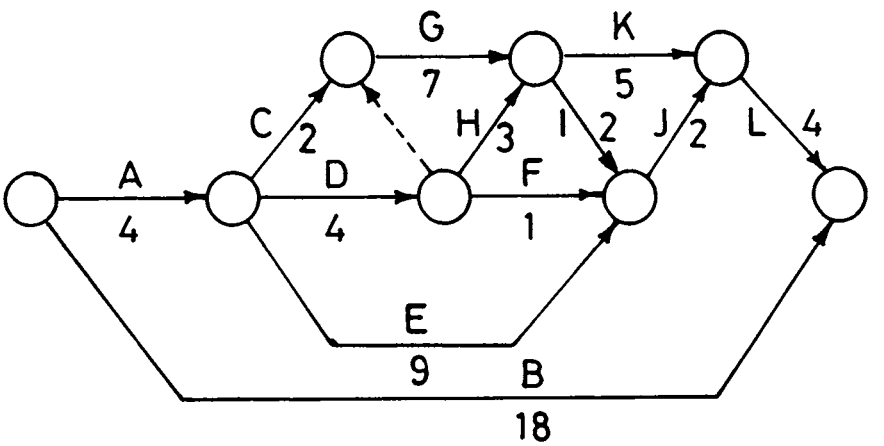
EST = 40 LST = 55

EFT = 50 LFT = 65

Total float can help in deciding which activity can be extended or delayed. When EPO and LPO are equal to each other at the nodes of an activity, the activity has zero total float and is critical. The absence of float is the indication of criticality of an activity. This means that there is no leeway or margin available for extending or delaying an activity. No latitude can be taken with critical activity. It demands attention and concern to ensure that no delays occur. In fact it lies on the critical path.

EXERCISE - FOURTEEN:

For the network shown below estimate EST, EFT, LST, LFT, free float and total float for each activity. Complete the Table given on next page. Check up your answer with the Tutor.



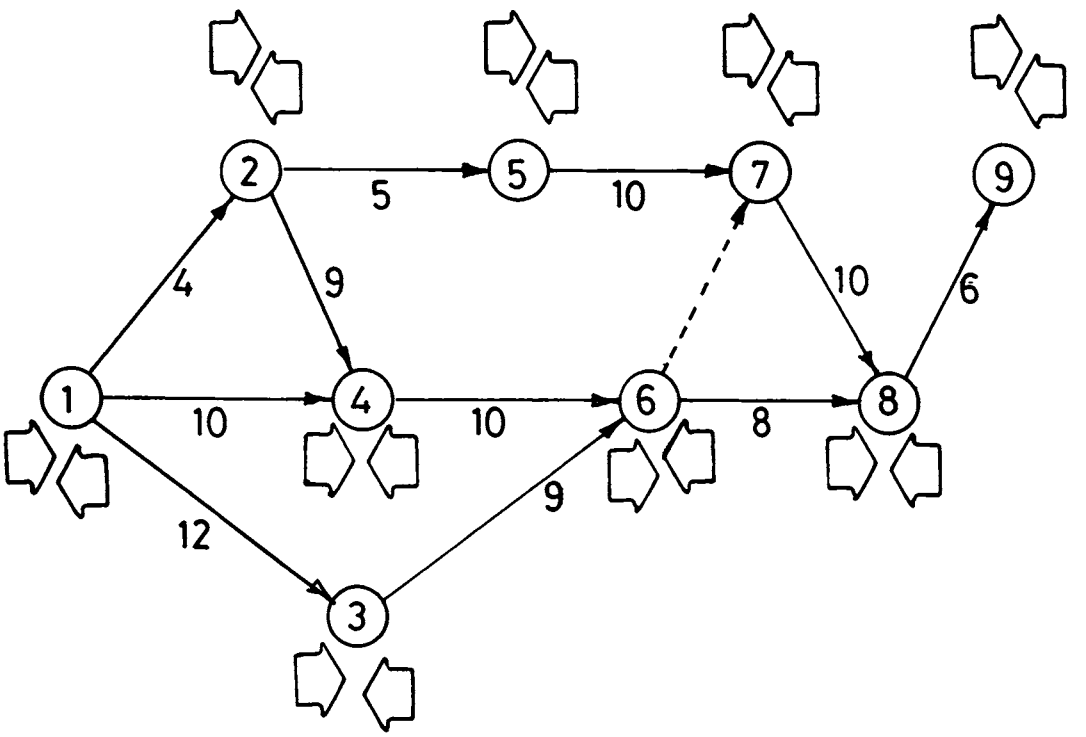
It is useful and convenient to indicate the EST, EFT, LST and LFT of all activities in a systematic manner.

Activity	Duration in days	EST	EFT	LST	LFT	Free Float	Total Float
A							
B							
C							
D							
E							
F							
G							
H							
I							
J							
K							
L							

UNIT - 11 CONSOLIDATION OF NETWORK ANALYSIS CONCEPTS

This unit will help you to reinforce some of the major concepts you have learnt in the last two units. It is in the form of an exercise.

EXERCISE - FIFTEEN:



FOR THE NETWORK SHOWN ON PREVIOUS PAGE :

a) FILL UP THE EPOs AND LPOs OF EACH EVENT IN THE NETWORK.

b) FILL UP THE FOLLOWING TABLE.

ACTIVITY	DURATION (DAYS)	EST	EFT	LST	LFT	FF	TF
1 - 2	4						
1 - 3	12						
1 - 4	10						
2 - 4	9						
2 - 5	5						
3 - 6	9						
4 - 6	10						
5 - 7	10						
6 - 7	0						
6 - 8	8						
7 - 8	10						
8 - 9	6						

(C) WHAT IS THE CRITICAL PATH ?

(D) IN CASE ACTIVITY 6-8 IS EXTENDED BY 3 DAYS IN DURATION WHAT IS LIKELY TO HAPPEN TO THE CRITICAL PATH ?

EXERCISE - SIXTEEN:

A. For any one of the following projects, identify important activities (in groups of 5 to 10):

1. ENABLING SELECTED YOUTH TO BECOME SELF-EMPLOYED
2. PROMOTING SOCIAL FORESTRY IN A VILLAGE
3. CONDUCTING ADULT LITERACY CAMPAIGN IN A CLUSTER OF VILLAGES
4. PRESERVING TRADITIONAL CRAFTSMANSHIP AND ENABLING CRAFTSMEN TO MARKET PRODUCTS

B. Establish dependencies between the activities

C. Draw the Network for the project

D. Estimate the project duration and identify critical path after assuming appropriate activity durations.

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