CPM AND PERT

Critical Path Method (CPM) – Basics:

The CPM is a technique for analyzing, planning and scheduling large complex projects. The technique aims at completing the project in time and within the budget. The technique can be applied only if the project can be divided into a number of well defined activities.

Some Basic Points:

(I) A project consists of different types of activities:

(a) Start activity: it is one which does not have any preceding activity.

(b) Finish or terminal activity: it is one which does not have any succeeding activity.

(c) Concurrent or parallel activity: these activities can be started simultaneously.

(d) Dummy activity: it is used merely to show the logical dependencies between the activities. It is an imaginary activity that does not consume any time. It is represented by a dotted arrow.

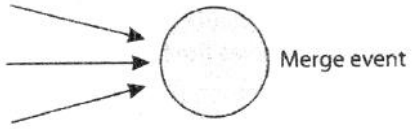
(e) Dangling activity: an activity (other than the terminal activity) that does not have a succeeding activity is termed as a dangling activity. It is connected to the last node through a dummy activity.

The two major components of PERT/CPM network are as follows:

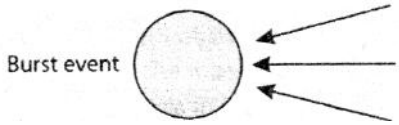
(II) Events: Events in the network diagram represent project milestones. It represents a point in time satisfying the completion of some activities and the beginning of new ones. This s generally represented by a circle 'O' in a network which is also called a node or connector.

The events can be further classified into following two categories:

(a) Merge Events: When more than one activity comes and joins an event. Such event is known as merge events.



(b) Burst event : When more than one activity leaves an events, such event is known as burst event.



(III) Activity Duration: This can be defined as time taken to complete a given activity.

(IV) Completion: The project is said to be completed if and only if all the activities of the project are complete.

Networking:

CPM is used to coordinate and schedule the sequential activities of a project. It presents the activities of a project as a net work. Network graphically presents the how each activity is related to the others. When all the activities are connected with each other in a logical manner, it gives rise to a network.

The network is drawn using the NODE -ARC principle. Nodes are circles indicating either the start of an activity or finish of an activity or start of one activity and finish of the other activity. An arrow joining any two nodes is called as ARC and each ARC represents a given activity on the network. The networks are not drawn to scale. While drawing the networks, as for as possible, the crisscrossing should be avoided.

Dummy activity:

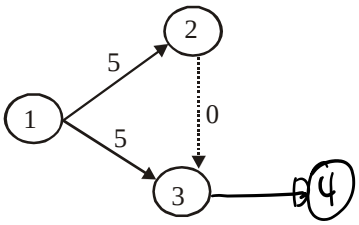
It is used merely to show the logical dependencies between the activities. It is an imaginary activity that does not consume any time. It is represented by a dotted line.

Dummy activities are inserted in following cases:

(i) In network, two or more activities are not allowed to have the same starting ending nodes. Hence, if two activities begin and end at the same time, a dummy activity is inserted into the network to distinguish the two activities.

Example:

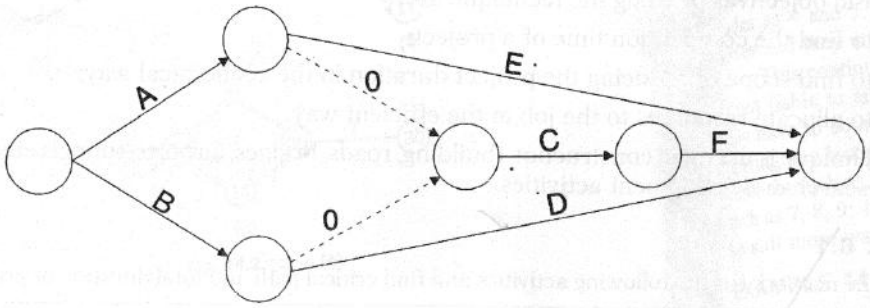
Activity	1 – 2	5 days
Duration	1 - 3	5 days



(ii) Dummy activity is used to identify precedence relationships correctly.

Example:

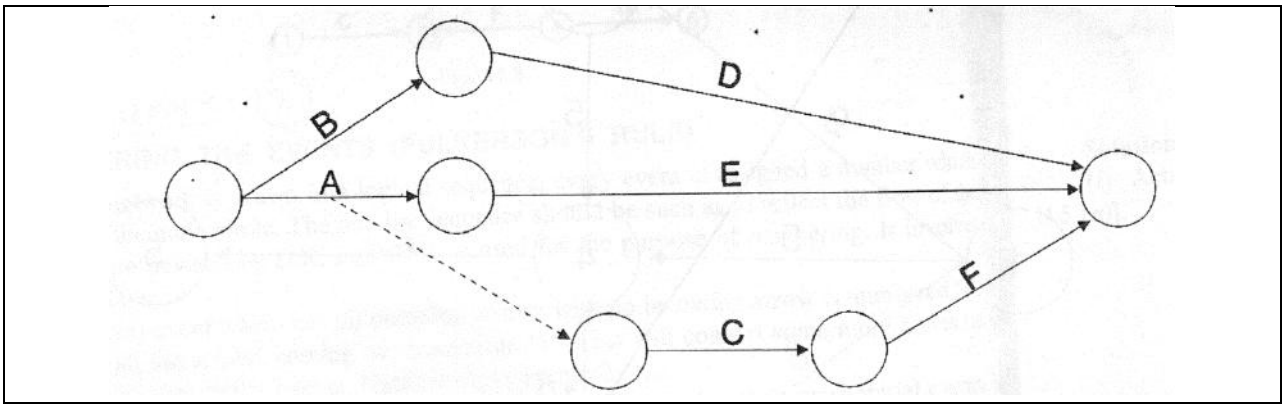
Activity	A	B	C	D	E	F
Preceding activity	-	-	A, B	B	A	C



(iii) If a second activity can be started after part of a first activity is complete, a dummy activity is inserted.

Example:

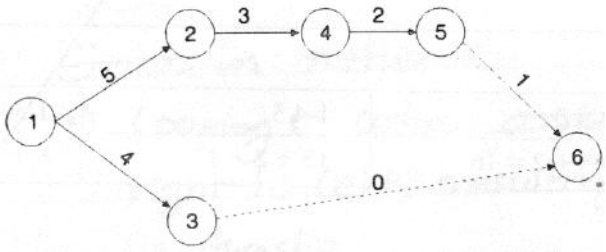
Activity	A	B	C	D	E	F
Preceding activity	-	-	50% completion of A	B	A	C



(iv) Dummy is inserted to connected the dangling activities

Examples:

Activity	1-2	1-3	2-4	4-5	5-6
Duration	5	4	3	2	1



Critical Path:

The longest-duration path through the network is known as critical path (It is the minimum time required to complete the project). Activities that lie on the critical path cannot be delayed without delaying the completion time for the whole project; such activities are known as critical activities.

Basic Objectives:

The basic objectives of using the technique are:

(i) to find the competition time of a project;

(ii) to find scope of reducing the project duration in the economical way;

(iii) to allocate resources to the job in the efficient way.

The technique is useful in construction (building, roads, bridges, airports, tunnels etc.), maintenance and research & development activities.

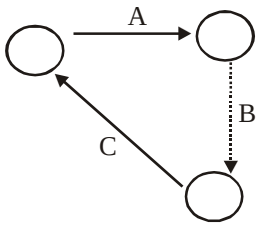
NUMBERING THE EVENTS (FULKERSON'S RULE)

After the network is drawn in a logical sequence, every event is assigned a number which is placed inside the node circle. The number sequence should be such as to reflect the flow of the network. The rule devised by D.R. Fulkerson is used for the purpose of numbering. It involves the following steps:

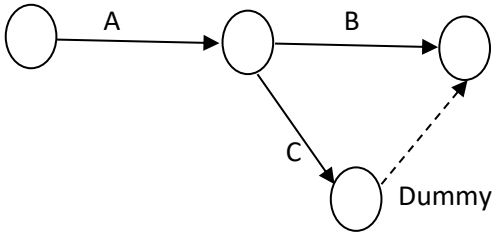
1. The initial event which has all outgoing arrows with no incoming arrow is numbered `1'.
2. Delete all the arrows coming out from node 'I'. This will convert some more nodes (at least one) into initial events. Number these events 2, 3,...
3. Delete all the arrows going out from these numbered events to create more initial events. Assign the next numbers to these events.
4. Continue until the final or terminal node, which has all arrows coming in with no arrow going out, is numbered.

(3) Errors in Network :

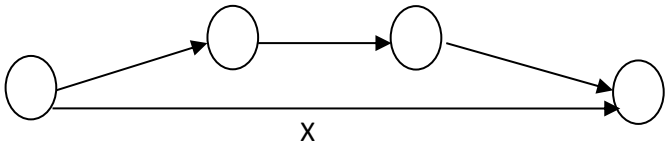
1) Looping: When arrows are drawn from right to left, resulting into error in relationship



2) Dangling: When an activity (other than terminal activity) is not connected to any succeeding activity. It should be connected to terminal activity by a dummy activity.



3) Redundancy: When unnecessary predecessors are used. It should be eliminated.



NETWORK CONSTRUCTION

Q1. Draw a network for the simple project of erection of steel works for a shed. The various activities of the project are as under:

Activity	Description	Preceded by
A	Erect site workshop	–
B	Fence site	–
C	Bend reinforcement	A
D	Dig foundation	B
E	Fabricate steel work	A
F	Install concrete pillars	B
G	Place reinforcement	C, D
H	Concrete foundation	G, F
I	Erect steel work	E
J	Paint steel work	H, I
K	Give finishing touch	J

Q2. Draw the network diagram for the following list of activities :

Activity	Immediate predecessor	Activity	Immediate predecessor
A	–	L	K
B	A	M	K
C	B	N	K
D	C	O	D
E	D	P	O
F	E	Q	B
G	E	R	N
H	C	S	L,M
I	C,F	T	S
J	G,H,I	U	P,Q
K	J	V	U

Q3. Depict the following dependency relationships by means of network diagrams. The alphabets stand for activities.

(i) A and B control F; B and C control G

(ii) A and B control F; B controls G while C controls G and H.

(iii) A controls F and G; B controls G while C controls G and H.

(iv) F and G are controlled by A; G and H are controlled by B with H controlled by and C.

(v) A controls F, G and H, B controls G and H with H controlled by C.

Q4. The activities along with their dependency relationship are given below. Draw an arrow diagram.

Activity:	A	B	C	D	E	F	G	H	I
Immediate Predecessor:	–	–	–	C	A, B	C	E, F	D	F, H

Q5. The activities along with the dependency relationship are given below. Draw the arrow diagram.

Activity	Immediate predecessor	Activity	Immediate predecessor
A	–	G	B, C
B	–	H	C
C	–	I	E,F
E	A	J	G,H
F	A,B	K	H

CRITICAL PATH

Q6. Draw the network for the following activities and find critical path the total duration of project:

Activity	Duration (months)	Activity	Duration (months)
1-2	1	3-6	1.5
2-3	4	4-7	3.5
2-4	5	5-7	2.5
3-4	3	6-7	1
4-5	1.5	7-8	4

Q7. Draw the network for the following activities and find critical path and total duration of project:

Activity	Duration (months)	Activity	Duration (months)
1-2	2.5	4-5	2.0
2-3	2.5	5-6	3.0
2-4	1.5	6-7	1.5
3-4	1.0	5-7	1.5
3-5	1.0		

Q8. Draw the network for the following activities and find critical path and total duration of project:

Activity	Dependence	Duration (Days)	Activity	Dependence	Duration (Days)
A	–	6	F	C	3
B	–	3	G	D	5
C	A	5	H	B, E	5
D	A	4	I	D, H	2
E	A	3	J	F, G, I	3

ANALYSIS OF TIMING

This is to be studied in two parts:

(i) Computing Earliest start (this is referred as forward numbering process): Earliest time at which the activity can start.

(ii) Computing Latest finish (this is referred as backward numbering process): Latest time by which the activity should be finished without delaying the project completion.

Forward Numbering Process: (Earliest start)

(i) Start putting zero in the first node. It is designated as 'E'.

(ii) Proceed sequentially to the next adjacent node.

(iii) If there is more than one way of reaching to the next adjacent node, find the maximum time of reaching and write on top at the next node as 'E'.

(iv) Number on the top of node indicates the earliest possible time to start the activity.

(v) Proceed in this way till terminal node is reached.

Backward Numbering Process: (Latest finish)

(i) Write the number obtained in the terminal node in the forward process as latest finish. It is designated by L.

(ii) Work sequentially backward by travelling through head to tail of the arrow.

(iii) If there are more than one ways of reaching back, find the maximum time of reaching back.

L = critical path duration minus the maximum time of reaching back.

(iv) Proceed in this way, till start node is reached.

Connected the nodes in a sequential order which has got both – forward and backward numbers identical. The activities so connected are known as critical activities. The path is known as critical path.

Head event slack: It is the difference between L and S at the end node of an activity.

Tail event slack: It is the difference between L and S at the starting node of an activity.

Float Analysis

Float is defined as the maximum permissible delay that can be tolerated without delaying the total project competition. Float can be associated only with non-critical activities. Float of a critical activity is zero. The critical path has no float.

Writing the Float Table:

(i) Draw the net work diagram and note the E and L

(ii) Write the activities and their respective durations in columnar form.

(iii) Write the respective earliest start time of different activities (with the help of diagram prepared under (i)

(iv) Write the respective earliest finish time of different activities. Earliest finish time is E+ activity duration.

(v) Write the respective latest finish time of different activities (with the help of diagram prepared under (i)

(vi) Write the respective latest start time of different activities. Latest start time is L minus activity duration.

Total float: The total flout of an activity is the amount of time by which it may be extended or delayed without delaying completion of the project.

A critical activity can be defined as one which has a total float of zero.

Total Float is the difference of LS and ES or LF and EF, i.e. LS-ES or LF-EF.

Free float Free float is an amount of time that an activity can be delayed without delaying the start of its succeeding activity. It is computed as total float minus head event slack.

Independent float

It is that amount of time within which an activity can be delayed without delaying the completion of the project even if the preceding activities have consumed their total float.

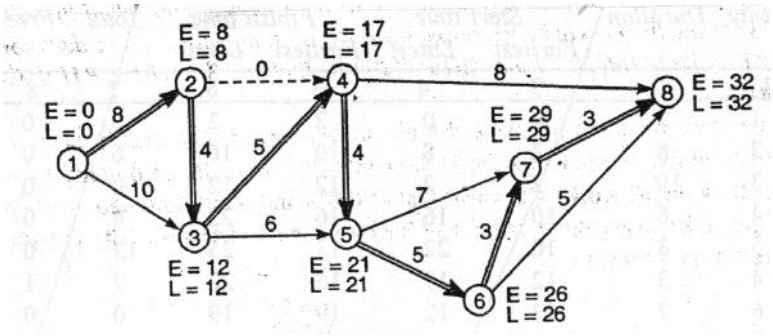
It is computed as free float minus tail event slack. (If negative, it is taken as zero).

Interference float is the difference between total float and free float.

Q9. The utility data for a network are given below. Determine the total, free, independent and interfering floats and identify the critical path.

Activity:	0-1	1-2	1-3	2-4	2-5	3-4	3-6	4-7	5-7	6-7
Duration:	2	8	10	6	3	3	7	5	2	8

Q10. For the network given in fig. determine the total, free, independent and interfering floats for each activity. Times for activities are in months.


E = 8
L = 8
E = 17
L = 17
E = 32
L = 32
E = 0
L = 0
E = 29
L = 29
E = 12
L = 12
E = 21
L = 21
E = 26
L = 26
1
2
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