

Network Scheduling
by CPM and PERT
(Project Management)

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Important Questions:

1. Explain the basics steps in PERT/CPM (i.e., Network Scheduling).

Ans:

Basic Steps in PERT / CPM: Project scheduling by PERT / CPM consists of four main steps

1. Planning :

- In this phase the total project is divided in to a no. of smaller projects.
- These smaller projects are then divided into activities and are analyzed by the concern department or section.
- The relationship between the activities are defined and established in a logical manner.
- The possibility of overlooking any task that necessary for the completion of the project is reduced substantially.

2. Scheduling :

- The main objective of this phase is to prepare a time chart showing the start and finish times for each activity as well as its relationship to other activities of the project.
- Moreover the schedule must pinpoint the critical path activities which require special attention in order to complete the project in time.
- For non-critical activities, the schedule must show the amount of float times which can be used advantageously when such activities are delayed or when limited resources are to be utilized effectively.

3. Allocation of resources :

- Allocation of resources is performed to achieve the desired objective. A resource is a physical variable such as labour, finance, equipment and space which will impose a limitation on time for the project.
- When resources are limited and conflicting, demands are made for the same type of resources a systematic method for allocation of resources become essential.
- Resource allocation usually incurs a compromise and the choice of this compromise depends on the judgment of managers.

4. Controlling:

- The final phase in project management is controlling. Critical path methods facilitate the application of the principle of management by expectation to identify areas that are critical to the completion of the project.
- By having progress reports from time to time and updating the network continuously, a better financial as well as technical control over the project is exercised.
- Arrow diagrams and time charts are used for making periodic progress reports. If required, a new course of action is determined for the remaining portion of the project.

2. Explain the rules of constructing a network.

Ans:

The following are some basic rules to construct a network of a project with events(with circles) and activities(with arrows) in a logical manner.

- i) Network starts and ends in an event and time flows from left to right
- ii) No event can occur until every activity preceding it has been completed.
- iii) An activity succeeding an event cannot be started until that event has occurred.

iv) An event cannot occur twice.

(avoid formation of loops)

v) Each activity must start from an event and end in an event

vi) An activity must be completed in order to reach the end event.

vii) Each activity must be connected with starting and ending event. (avoid dangling)

viii) Dummy activity should be used only if necessary. (Redundant unnecessary dummies)

ix) Unique numbers should be assigned to the events in increasing order from left to right.

3. Explain the forward pass and backward pass time computations in a network.

Ans:

Let t_{ij} = time duration of the activity (i,j)

EST_{ij} = Earliest starting time of (i,j)

EFT_{ij} = Earliest finishing time of (i,j)

E_i = Earliest occurrence time of ith event

LST_{ij} = Latest starting time of (i,j)

LFT_{ij} = Latest finishing time of (i,j)

L_i = Latest occurrence time of ith event

(Earliest Starting Time of an activity means earliest possible time when the activity can begin.)

Latest Starting Time of an activity means latest time at which the activity can start if target time of project is to be maintained.)

Forward Pass time calculations:

(Earliest times)

-> Starting time of project = 0

i.e., $E_1=0$ and $EST_{1j} = 0$ for all possible $j=2,3,\dots$

-> $EFT_{ij} = EST_{ij} + t_{ij}$ for all (i,j)

-> $E_j = EFT_{ij}$, if j^{th} event is non-merge event

$E_j = \max_i\{EFT_{ij}\}$, if j^{th} event is merge event

-> $EST_{ij} = E_i$

-> $E_n =$ Earliest occurrence time of end event
or Project duration (target time)

Backward Pass time calculations:

(Latest times)

-> $L_n = \text{Latest time of end event} = E_n$

-> $LFT_{ij} = L_j$

-> $LST_{ij} = LFT_{ij} - t_{ij}$

-> $L_i = LST_{ij}$, if i^{th} event is non-brust event

$L_i = \min_j \{LST_{ij}\}$, if j^{th} event is brust event

-> $L_1 = 0$

Float/Slack times:

Float/Slack = Available time – Required time
(excess time available)

-> float related to activity, slack related to event

-> **Total float** = $LFT_{ij} - EST_{ij} - t_{ij}$

4. Explain Critical Path Method.

Ans:

Critical Activity: An activity is said to be critical if its **total float = 0**.

(or) If a delay in an activity results in a delay of the project, the activity is called a critical activity.

Critical Path: The path connecting critical activities is called a critical path.

-> critical path may not be unique in a project

-> In CPM, t_{ij} are deterministic.

Critical Path Method (CPM):

1. Draw a network by identifying all events and activities of the project applying the rules
2. Indicate the time durations (t_{ij}) on the arrows representing the activity.
3. Calculate the Earliest times for each activity and each event and mark the event earliest time in the box

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4. Calculate the Latest times for each activity and each event and mark the event latest time in the box

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5. Tabulate the timings of each activity and calculate the total float.
6. Identify the critical activities for which total float is zero.
7. Identify the critical path by double line arrows in the network
8. Find the optimum total project duration, which is the finishing time of end event.

5. Write the differences between CPM and PERT and Describe the PERT Algorithm.

Ans:

CPM

- Activity-oriented
- Time durations of activities are well known
- Deterministic model
- Used in repetitive jobs like constructions

PERT

- Event-oriented
- Time durations of activities are uncertain
- Probabilistic model
- Used in non-repetitive jobs like planning and scheduling

Project Evaluation and Review Technique

(PERT)- Algorithm:

1. Draw a network by identifying all events and activities of the project applying the rules
2. Calculate the expected time t_e for each activity by using the formula,

$$t_e = (t_p + 4t_m + t_o) / 6$$

where, t_p = pessimistic time

t_m = most likely time

t_o = optimistic time

3. Indicate the expected time durations (t_e) on the arrows representing the activity.

4. Calculate and tabulate the Earliest and latest times for each activity and each event and mark E and L times at the respective events in the network.
5. Calculate the total float and identify the critical activities and critical path by double arrows.
6. Find the expected time of completion of project.
7. Calculate the variances of each activity's time estimates by the formula,

$$\sigma^2 = [(t_p - t_o)/6]^2$$

8. Find the probability of completing the project within the scheduled time using standard normal tables and calculating the standard normal ordinate,

$$Z = (\text{schedule time} - \text{expected duration}) / \sqrt{\text{project variation}}$$

here, project variation = sum of variances of critical activities

6. The following table gives the activities of a construction project and duration.

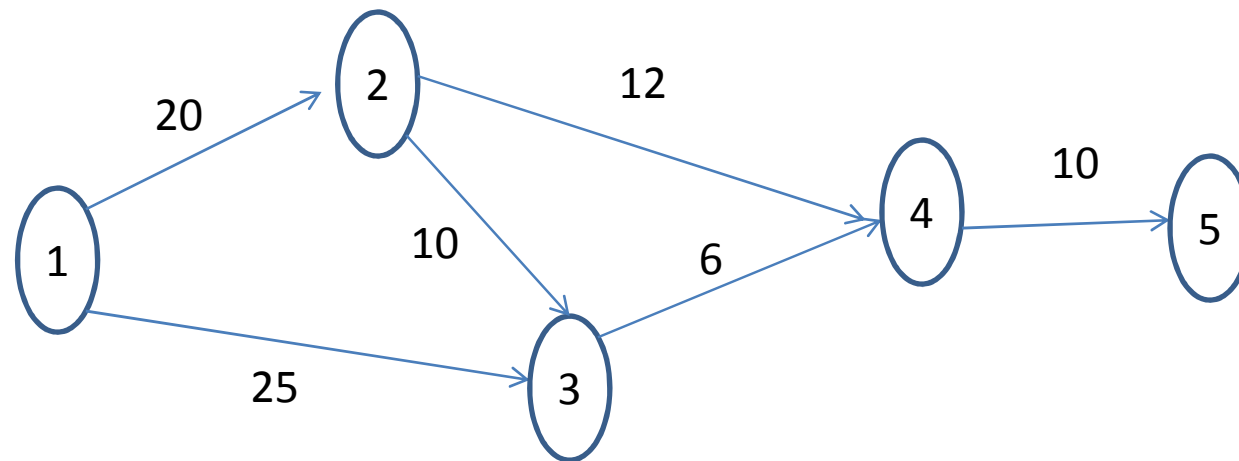
Activity : 1-2 1-3 2-3 2-4 3-4 4-5

Duration: 20 25 10 12 6 10

i) Draw the network ii) find critical path and project duration

Ans:

Network



Time calculations:

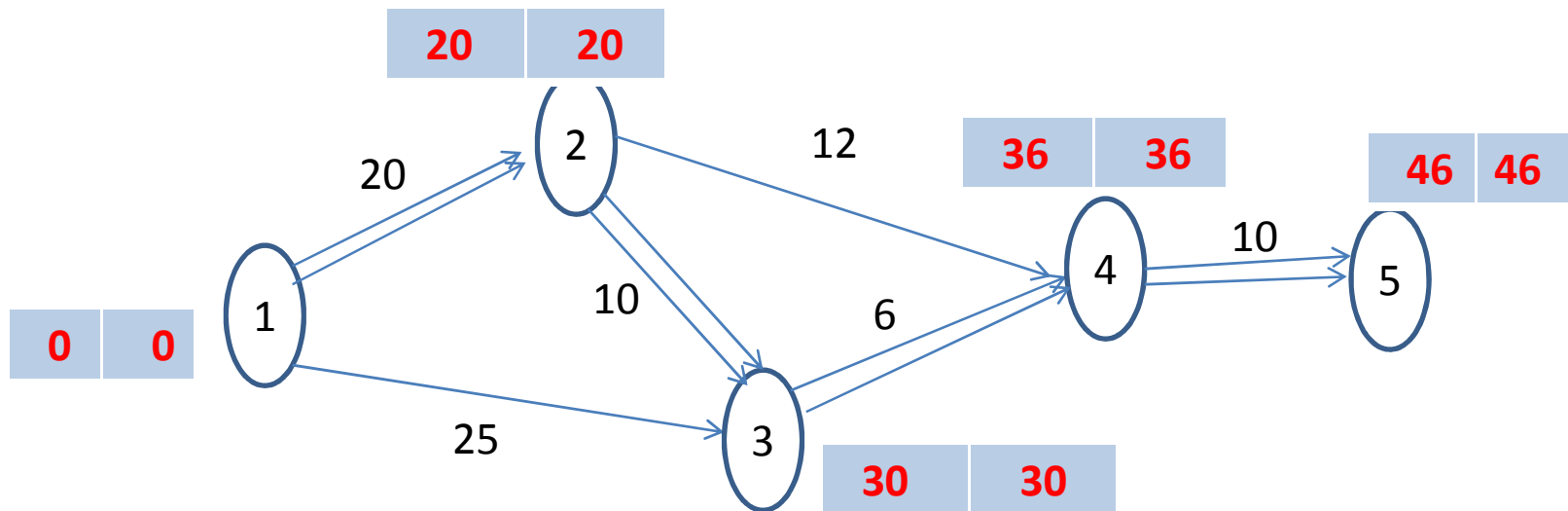
Earliest times

- $E1 = 0 = EST12 = EST13$
- $EFT12 = EST12 + t12 = 0 + 20 = 20$
 $\Rightarrow E2 = EFT12$
 $\Rightarrow E2 = 20 = EST23 = EST24$
- $EFT13 = EST13 + t13 = 0 + 25 = 25$
 $EFT23 = EST23 + t23 = 20 + 10 = 30$
 $\Rightarrow E3 = \text{Max}\{25, 30\}$ (merge event)
 $\Rightarrow E3 = 30 = EST34$
- $EFT24 = EST24 + t24 = 20 + 12 = 32$
 $EFT34 = EST34 + t34 = 30 + 6 = 36$
 $\Rightarrow E4 = \text{max}\{32, 36\}$ (merge event)
 $E4 = 36 = EST45$
- $EFT45 = EST45 + t45 = 36 + 10 = 46$
 $\Rightarrow E5 = EFT45$
 $\Rightarrow E5 = 46$

Latest times

- $L5 = E5 = 46 = LFT45$
- $LST45 = LFT45 - t45 = 46 - 10 = 36$
 $\Rightarrow L4 = LST45$
 $\Rightarrow L4 = 36 = LFT24 = LFT34$
- $LST34 = LFT34 - t34 = 36 - 6 = 30$
 $\Rightarrow L3 = LST34$
 $\Rightarrow L3 = 30 = LFT13 = LFT23$
- $LST24 = LFT24 - t24 = 36 - 12 = 24$
 $LST23 = LFT23 - t23 = 30 - 10 = 20$
 $\Rightarrow L2 = \text{Min}\{24, 20\}$ (burst event)
 $\Rightarrow L2 = 20 = LFT12$
- $LST12 = LFT12 - t12 = 20 - 20 = 0$
 $LST13 = LFT13 - t13 = 30 - 25 = 5$
 $\Rightarrow L1 = \text{Min}\{0, 5\}$ (burst event)
 $\Rightarrow L1 = 0$

Activity	Duration (t)	EST	EFT	LST	LFT	Total float (LFT-FST-t)
1-2	20	0	20	0	20	0
1-3	25	0	25	5	30	5
2-3	10	20	30	20	30	0
2-4	12	20	32	24	36	4
3-4	6	30	36	30	36	0
4-5	10	36	46	36	46	0



Critical path: 1->2->3->4->5 and project duration = 46