

# The Critical Path Method (CPM)

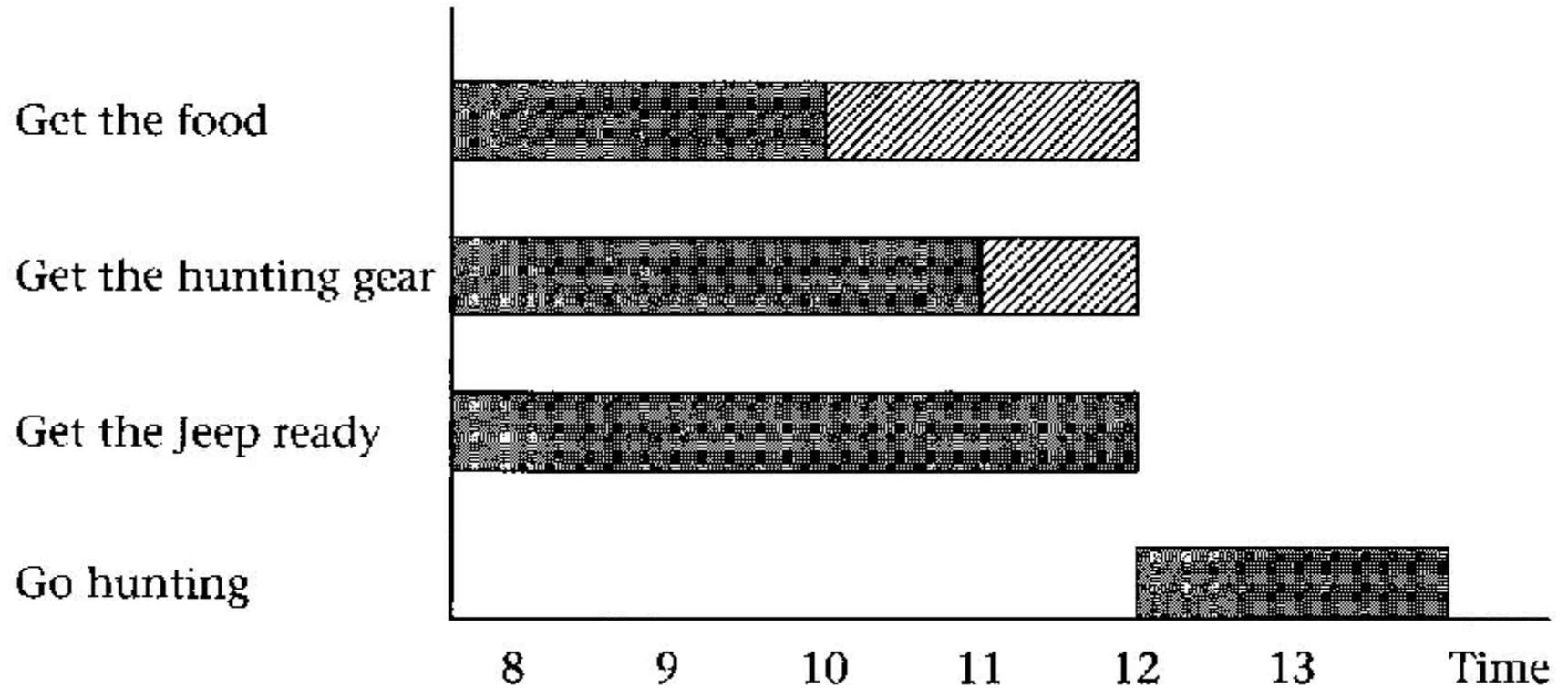
# Introduction

Suppose you decide with your friend to go in hunting trip.

You must do specific activity such that the trip well be at the right way

The following activity must be done

# Introduction



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From chart you can see that the 3<sup>rd</sup> activity (preparing the jeep have the longest period of time any delay with this activity leads to delay in the trip

This activity is a **critical activity**

# Difinition

**Critical activity** : An activity on the critical path any delay on the start or finish of a critical activity will result in a delay in the entire project

**Critical path** : The longest path in a network from start to finish

# Steps Required To Schedule a Project

Many steps are required that may not be apart of scheduling

The preparation of **CPM** includes the following four steps:

Determine the work activities: .l

The project must be divided into smaller activities or tasks

The activity ***shouldn't*** be more than 14-20 days  
(*long durations should be avoided*)

Use **WBS** in scheduling by using an order of letters and numbers

## II. Determine activity duration:

the duration estimating depending on many factors according to situation , but the most likely method to determine the duration as follows :

$$\textit{Duration} = \textit{Total Quantity} / \textit{Crew Productivity}$$

The productivity has many sources :

\*The company \*The market \* Special books

The most duration unit used and the most practical is ***working days*** , but we may use working week (*5-day, or 6-days*)

The scheduler ***must be aware*** about the non-working days , such as holydays or rain days, etc.....

Determine the logical relationships: .III

This step is a technical matter and obtained from the project manager and technical team,

and logical relationships **shouldn't confused with constraints**

IV. Draw the logic network and perform the **CPM** calculations:

You may use the computer but you ***should check*** by yourself the input and the output and don't rely on the computer totally.

( ***the computer software : trash in , trash out*** )

# ADDITIONAL STEPS FOR PROJECT SCHEDULING

WE GOING TO TALK ABOUT ADDITIONAL STEP'S  
MAKE YOUR SCHEDULING SUCCESSFUL ,  
ACCURATE AND GOOD

## 5-)REVIEW AND ANALYZE THE SCHEDULE:

- \* REVIEW THE LOGIC

- \* Make sure the activity has the correct predecessor

- \* make sure there is no redundant activity

In this step we face a lot of error's the common error's: •

Wrong relation ship •

Missing relation ship •

Redundant relation ship •

Logic loop •

6-) implement the schedule :

Def : take the schedule from paper to the execution .

-----Three point must take into consideration :-----

- Realistic and accurate schedule •
- Upper manager must take it seriously •
- Implementation and commitment must continue throughout the project . •

## 7-)Monitor and control the schedule :

Def: comparing what we planed with what actually done .

The important part of control is forecasting : •

By making extrapolation of actual work of the remaining portion of the project.

8-)Revise the database and record feedback :

this process is continuous and iterative

used for estimation time and cost for activity and resource

used to make the next cycle of project more accurate and success

# Resource allocation and leveling

Def: resource include labor ,material's and equipment's . •

Resource allocation : assign the correct amount of labor •  
,material's and equipment's needed for this project.

the objective of this step's are :

Link scheduling with estimating and accounting

to improve the efficiency of the resource's used

# Example 4.1

Draw the logic network and perform the CPM calculations for the schedule shown next.

ACTIVITY	IPA <sup>a</sup>	DURATION <sup>b</sup>
A	—	5
B	A	8
C	A	6
D	B	9
E	B, C	6
F	C	3
G	D, E, F	1

<sup>a</sup>Immediately preceding activity.

<sup>b</sup>In days.

# Forward pass calculation

In mathematical terms, the ES time for activity  $j$  ( $ES_j$ ) is as follows:

$$ES_j = \max(EF_i) \dots\dots\dots (4.1)$$

where ( $EF_i$ ) represents the EF times for all preceding activities.

Likewise, the EF time for activity  $j$  ( $EF_j$ ) is as follows:

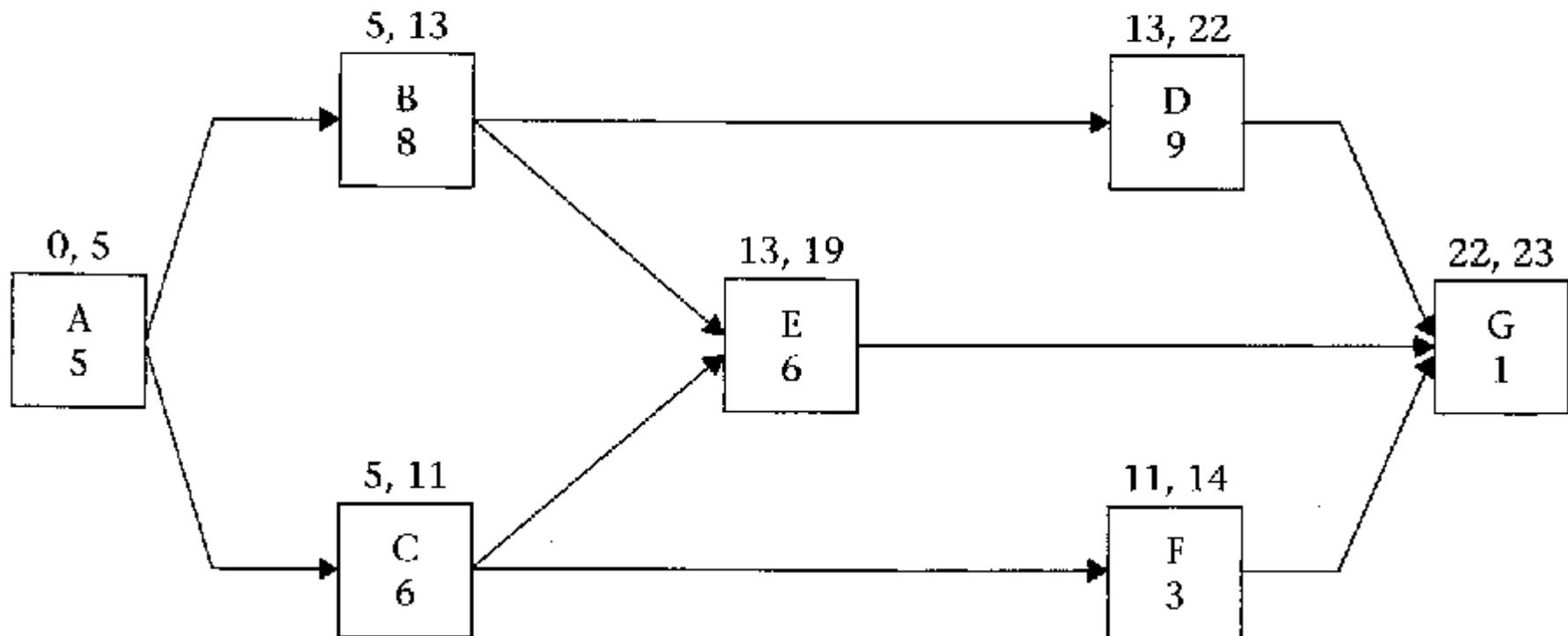
$$EF_j = ES_j + Dur_j \dots\dots\dots (4.2)$$

where  $Dur_j$  is the duration of activity  $j$ .

The **forward pass** is defined as *the process of navigating through a network from start to finish and calculating the **early dates** for each activity and the completion date of the project.*

# Example Solution

## a) forward pass calculation



# Backward pass calculation

In mathematical terms, the *late finish (LF)* time for activity  $j$  ( $LF_j$ ) is as follows:

$$LF_j = \min(LS_k) \dots\dots\dots (4.3)$$

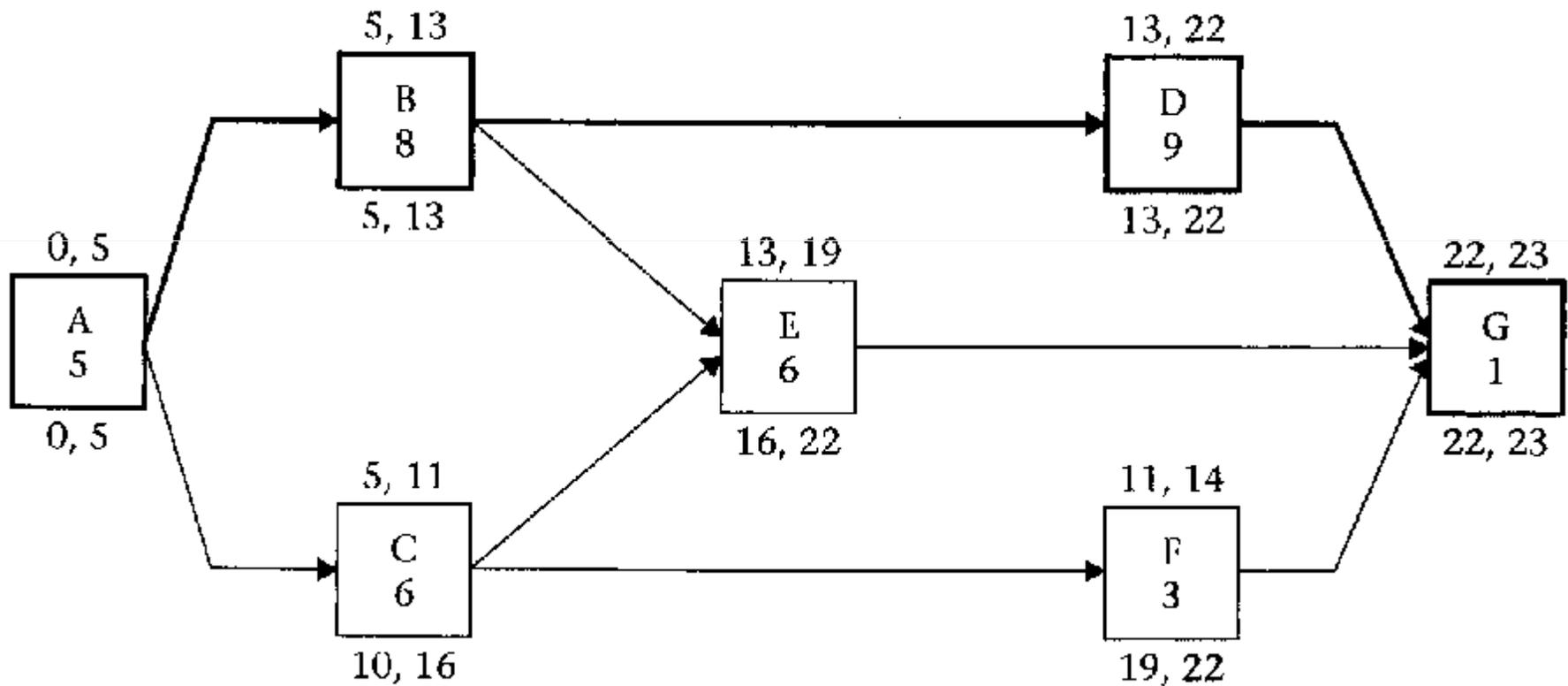
where ( $LS_k$ ) represents the late start times for all succeeding activities.

Likewise, the **late start (LS)** time for activity  $j$  ( $LS_j$ ) is as follows:

$$LS_j = LF_j - Dur_j \dots\dots\dots (4.4)$$

The **backward pass** is defined as *the process of navigating through a network from finish to start and calculating the **late dates** for all activities.*

## b) Backward pass calculation



# Total float value

There are several types of float. The simplest and most important type of float is **total float (TF)**:

$$TF = LS - ES \quad \text{or} \quad TF = LF - EF \quad \dots \dots \dots (4.5)$$

If we tabulate the results, we get the following table (boldface activities are critical):

ACTIVITY	DURATION	ES	EF	LS	LF	TF
<b>A</b>	<b>5</b>	<b>0</b>	<b>5</b>	<b>0</b>	<b>5</b>	<b>0</b>
<b>B</b>	<b>8</b>	<b>5</b>	<b>13</b>	<b>5</b>	<b>13</b>	<b>0</b>
C	6	5	11	10	16	5
<b>D</b>	<b>9</b>	<b>13</b>	<b>22</b>	<b>13</b>	<b>22</b>	<b>0</b>
E	6	13	19	16	22	3
F	3	11	14	19	22	8
<b>G</b>	<b>1</b>	<b>22</b>	<b>23</b>	<b>22</b>	<b>23</b>	<b>0</b>

# Notes

1. In every network, at least one critical path must exist.
2. More than one critical path may exist. Multiple paths may share some activities.
3. Any critical path must be continuous from the start of the project till its end.
4. Unless a constraint is imposed (which is discussed later), a path cannot be partially critical. The entire path must be either critical or noncritical.

# Con.

5. If all paths in a network must go through one particular activity, this activity must be critical (e.g., activities A and G in example 4.1).
6. Some people like to define the critical path as the path with zero float. This definition is correct only if no **imposed finish date** is used in the backward-pass calculations (again, this point is discussed later). However, our definition—the longest path in a network, from start to finish—is more appropriate because it is always true.

# Definition

**Activity, or task.** A basic unit of work as part of the total project that is easily measured and controlled. It is time and resource consuming.

**Backward pass.** The process of navigating through a network from end to start and calculating the late dates for each activity. The late dates (along with the early dates) determine the critical activities, the critical path, and the amount of float each activity has.

**Critical activity.** An activity on the critical path. Any delay in the start or finish of a critical activity will result in a delay in the entire project.

**Critical path.** The longest path in a network, from start to finish.

**Early dates.** The early start date and early finish date of an activity.

**Early finish (EF).** The earliest date on which an activity can finish without violating the logic.

**Early start (ES).** The earliest date on which an activity can start without violating the logic.

# cont.

**Forward pass.** The process of navigating through a network from start to end and calculating the finish date for the entire project and the early dates for each activity.

**Late dates.** The late start date and late finish date of an activity.

**Late finish (LF).** The latest date on which an activity can finish without extending the project duration.

**Late start (LS).** The latest date on which an activity can start without extending the project duration.

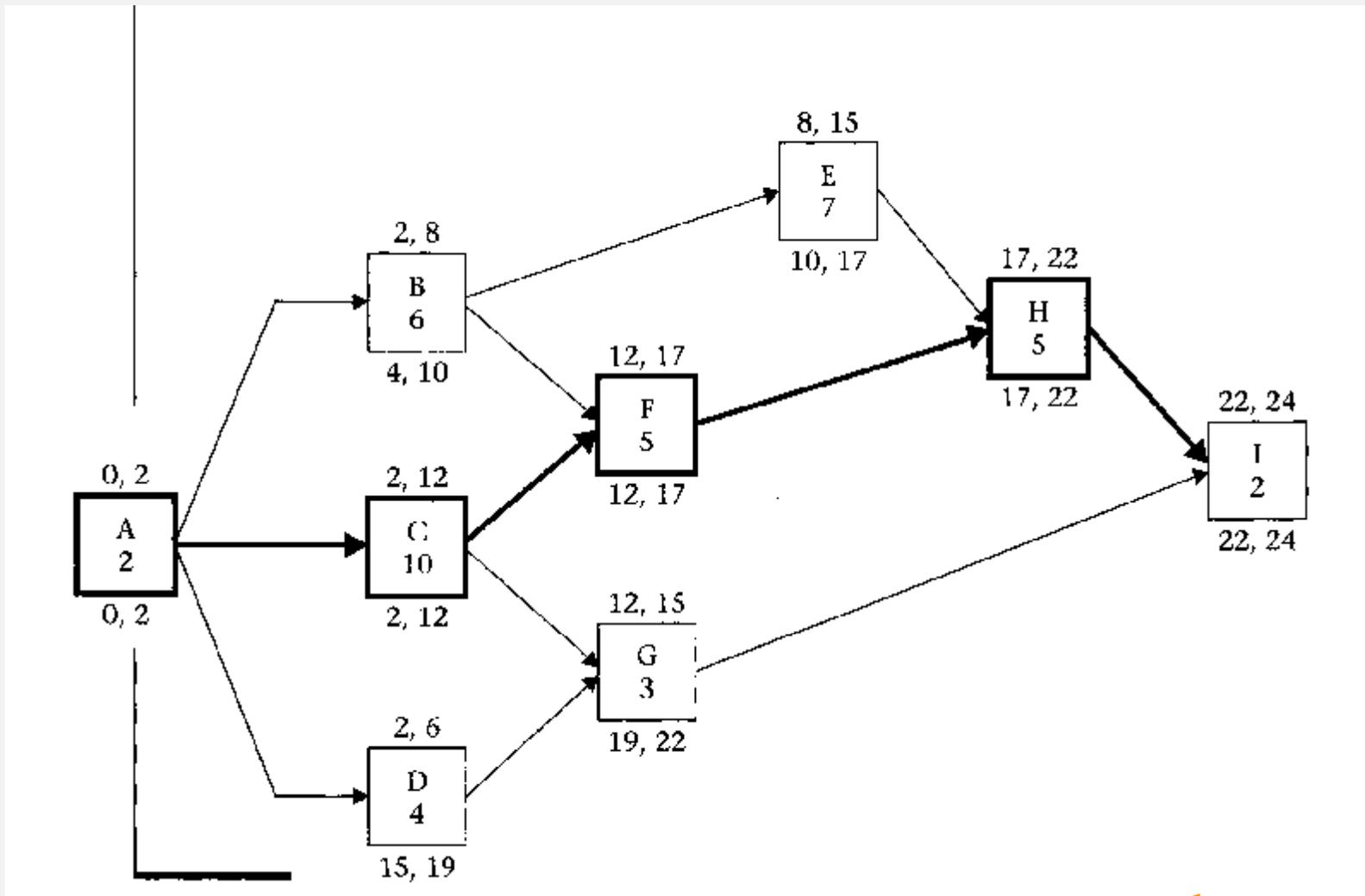
**Total float (TF).** The maximum amount of time an activity can be delayed from its early start without delaying the entire project.

# Example 4.2

## performe the CPM

ACTIVITY	IPA	DURATION
A	—	2
B	A	6
C	A	10
D	A	4
E	B	7
F	B, C	5
G	C, D	3
H	E, F	5
I	G, H	2

# Solution



# Float Value

free float , interfering float , independent float

$$FF_i = \min(ES_{i+1}) - EF_i$$

$$Int. F = TF - FF$$

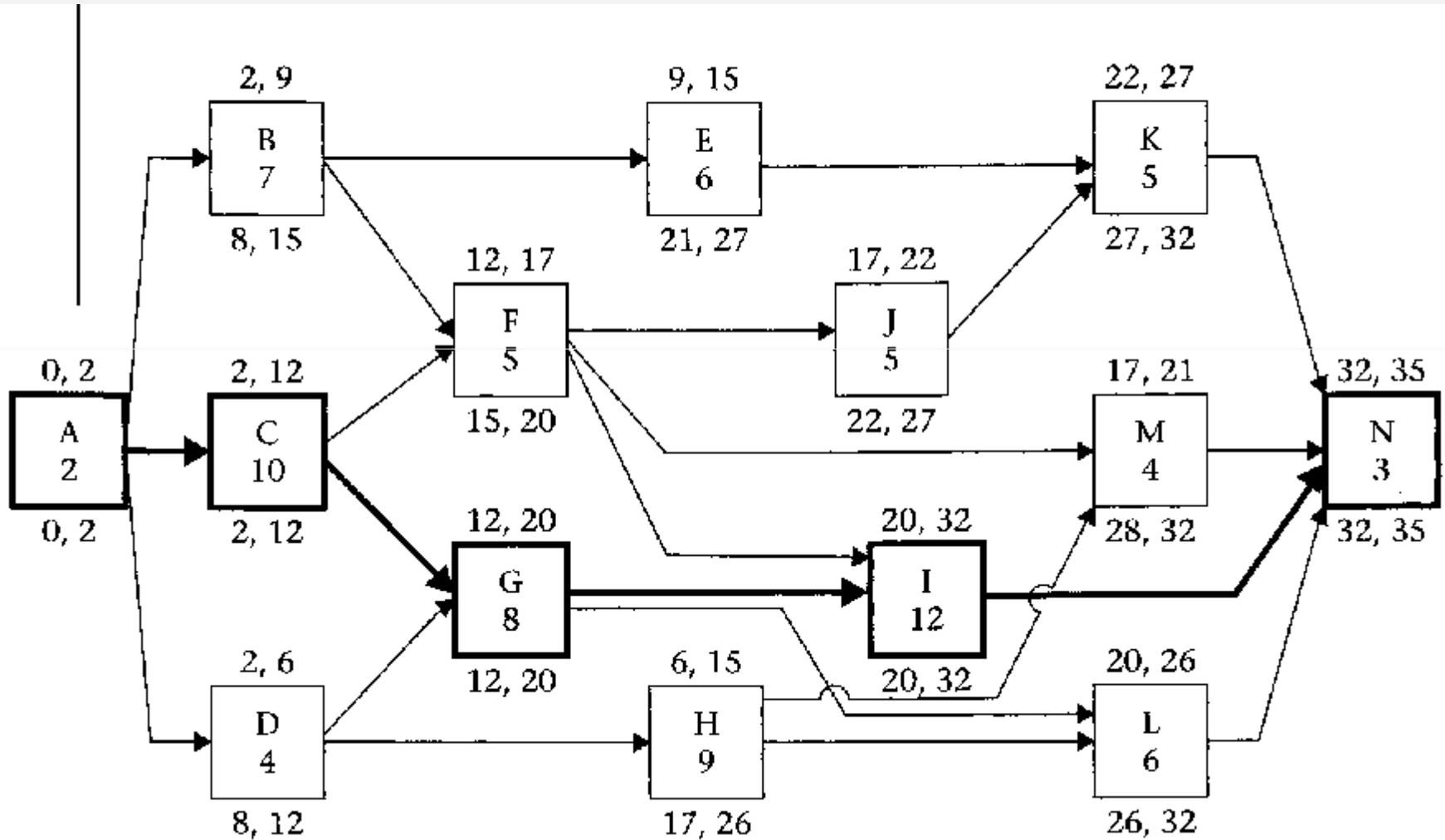
$$Ind. F_i = \min(ES_{i+1}) - \max(LF_{i-1}) - Dur_i$$

# Example 4.3

Draw the node diagram and perform the CPM computations for the schedule shown next.

ACTIVITY	IPA	DURATION	ACTIVITY	IPA	DURATION
A	—	2	H	D	9
B	A	7	I	F, G	12
C	A	10	J	F	5
D	A	4	K	E, J	5
E	B	6	L	G, H	6
F	B, C	5	M	F, H	4
G	C, D	8	N	I, K, L, M	3

# Solution



cont.

ACTIVITY	DURATION	ES	EF	LS	LF	TF	FF
<b>A</b>	<b>2</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>0</b>
B	7	2	9	8	15	6	0
<b>C</b>	<b>10</b>	<b>2</b>	<b>12</b>	<b>2</b>	<b>12</b>	<b>0</b>	<b>0</b>
D	4	2	6	8	12	6	0
E	6	9	15	21	27	12	7
F	5	12	17	15	20	3	0
<b>G</b>	<b>8</b>	<b>12</b>	<b>20</b>	<b>12</b>	<b>20</b>	<b>0</b>	<b>0</b>
H	9	6	15	17	26	11	2
<b>I</b>	<b>12</b>	<b>20</b>	<b>32</b>	<b>20</b>	<b>32</b>	<b>0</b>	<b>0</b>
J	5	17	22	22	27	5	0
K	5	22	27	27	32	5	5
L	6	20	26	26	32	6	6
M	4	17	21	28	32	11	11
<b>N</b>	<b>3</b>	<b>32</b>	<b>35</b>	<b>32</b>	<b>35</b>	<b>0</b>	<b>0</b>