Project Scheduling

Example

PROJECT SCHEDULING

- It is part of project management within the *Planning* phase of the Systems Development Life Cycle.
- Project Scheduling: Allocate resources to execute all activities in the project

- Project: Set of activities or tasks with a clear *beginning* and *ending* points. The amount of available resources (time, personnel and budget) to carry out the activities is usually limited.

CPM – CRITICAL PATH METHOD

- Objectives:
  - Establish beginning, ending and duration of each activity in the project.
  - Calculate overall completion time of the project given the amount of usually limited resources.
  - Determine the critical path and its duration.
  - Determine the slack time for all non-critical activities and the whole project.
  - Guide the allocation of resources other than time such as staff and budget.

CPM – CRITICAL PATH METHOD

- Phases:
  - Define activities or tasks according to the project objectives.
  - A task is an individual unit of work with a clear beginning and a clear end.
  - Identify precedence relationships or dependencies
  - Estimate time required to complete each task.
  - Draw an activity-on-arrow PERT diagram inserting dummy activities if required.
  - Apply CPM to calculate *earliest* and *latest starting times*, *earliest* and *latest completion times*, *slack* times, *critical path* etc.
  - Construct a GANTT chart.
  - Reallocate resources and resolve if necessary.
  - Continuously monitor/revise the time estimates along the project duration.

CPM – CRITICAL PATH METHOD

- It is determined by adding the times for the activities in each sequence.
- CPM determines the total calendar time required for the project.
- If activities outside the critical path speed up or slow down (within limits), the total project time does not change.
- The amount of time that a non-critical activity can be delayed without delaying the project is called slack-time.

CPM – CRITICAL PATH METHOD

ES	Activity	EF
LS	Duration	LF

- ES – Activity earliest start time
- LS – Activity latest start time
- EF – Activity earliest finishing time
- LF – Activity latest finishing time
- Slack Time – Maximum activity delay time

CPM – CRITICAL PATH METHOD

Step 1. Calculate ET for each node.

For each node i for which predecessors j are labelled with ES(j), ES(i) is given by:

$$ES(i) = \max_j [ES(j) + t(j,i)]$$

where t(j,i) is the duration of task between nodes

(j,i). Step 2. Calculate LT for each node.

For each node i for which successors j are labelled with LF(j), LF(i) is given by:

where t(j,i) is the duration of task between nodes (i,j).

$$LF(i) = \min_j [LF(j) - t(i,j)]$$

CPM – CRITICAL PATH METHOD

Step 3. Calculate slack time for each node.
An activity with zero slack time is a critical activity and cannot be delayed without causing a delay in the whole project.

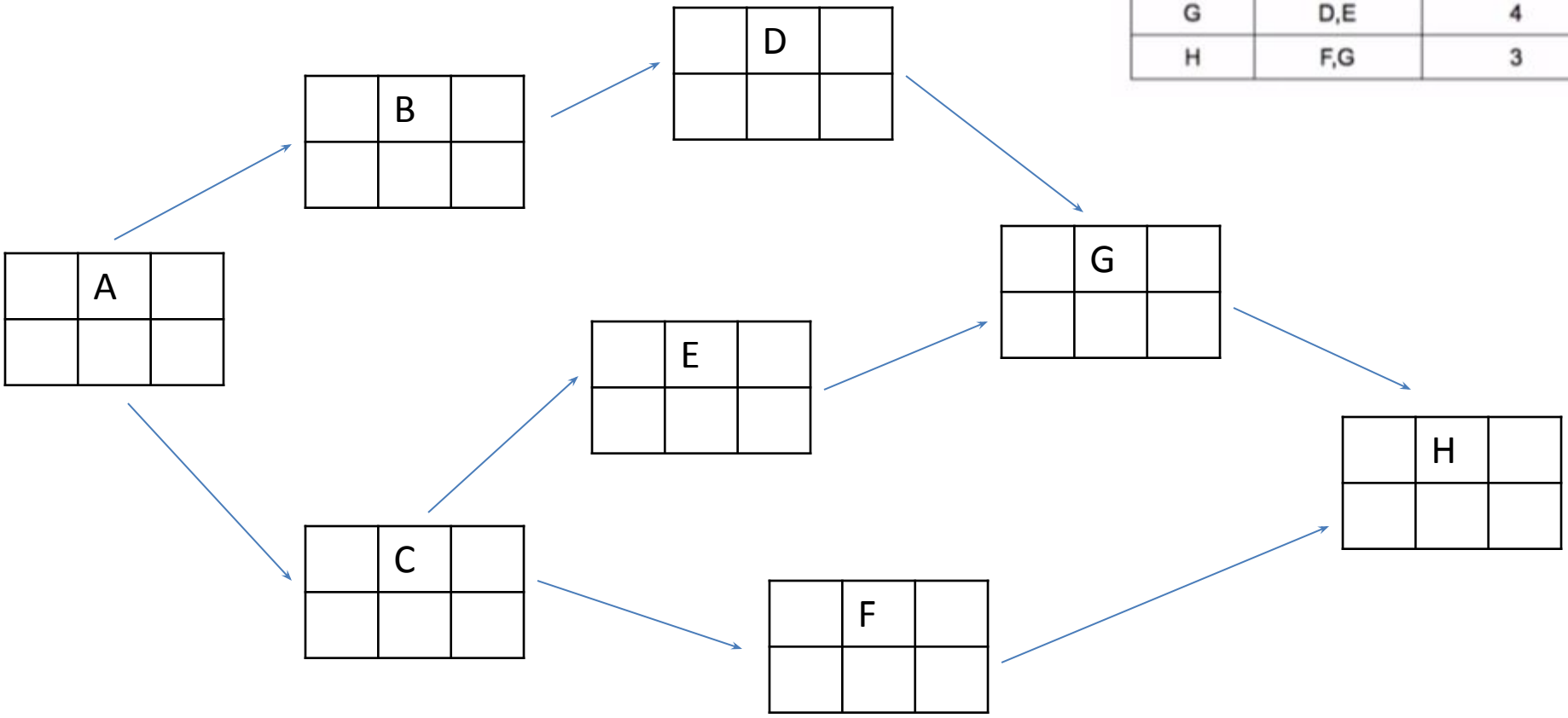
Total Float/ Slack Time: is the amount of time that an activity can be delayed from its early start date without delaying the project finish date.

Free Float: is the amount of time that an activity can be delayed without delaying the early start date of any successor activity.

Activity	Predecessor	Duration (days)
A	-	3
B	A	4
C	A	2
D	B	5
E	C	1
F	C	2
G	D,E	4
H	F,G	3

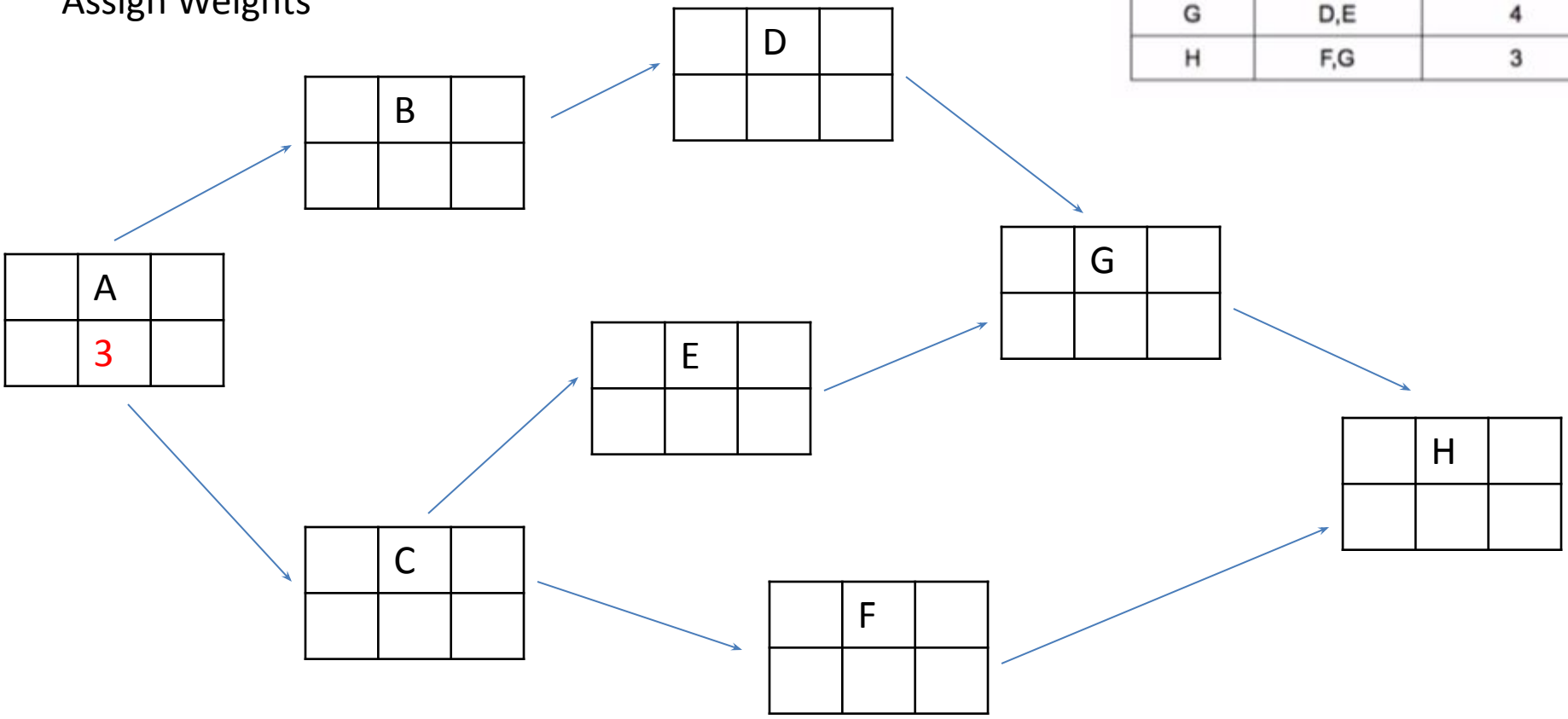
ES	Activity	EF
LS	Duration	LF

Activity	Predecessor	Duration (days)
A	-	3
B	A	4
C	A	2
D	B	5
E	C	1
F	C	2
G	D,E	4
H	F,G	3



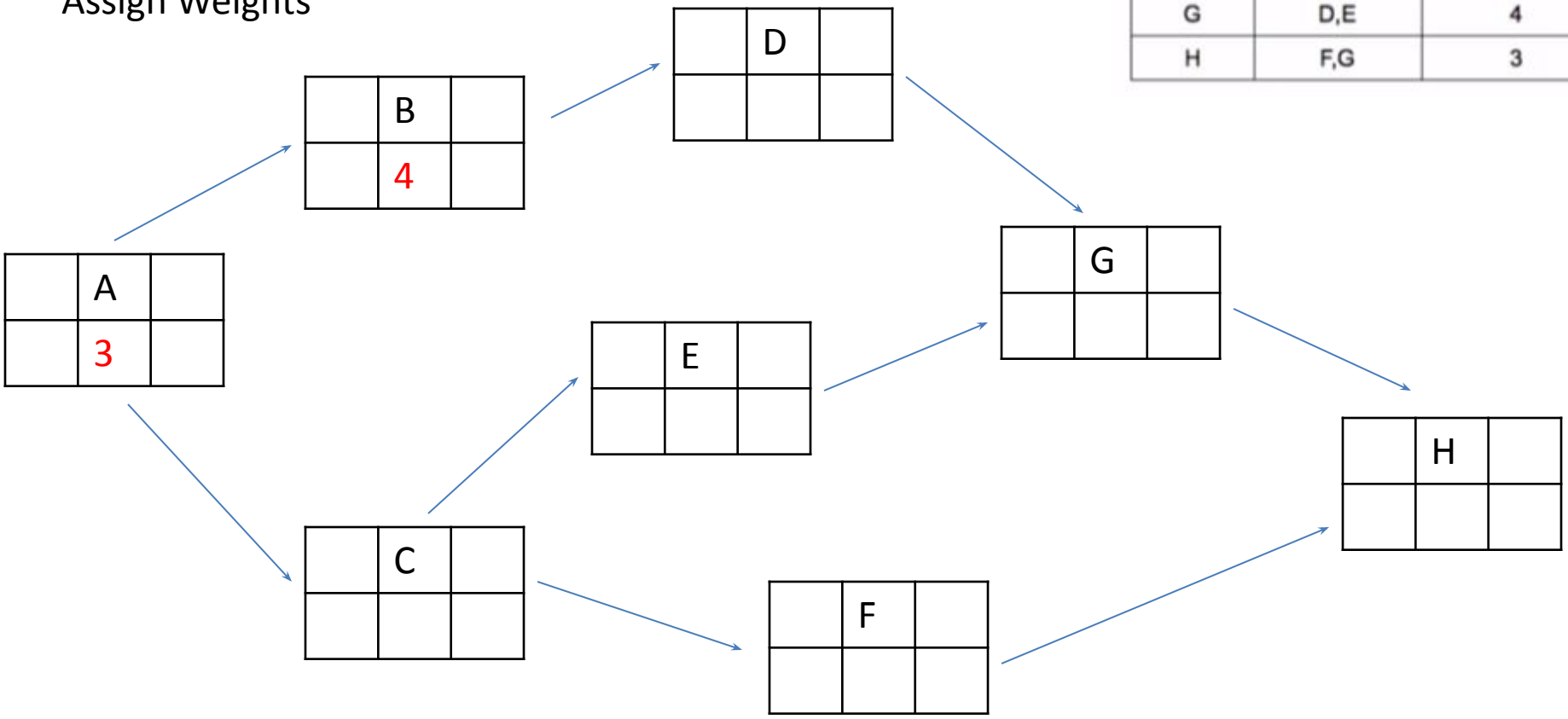
Activity	Predecessor	Duration (days)
A	-	3
B	A	4
C	A	2
D	B	5
E	C	1
F	C	2
G	D,E	4
H	F,G	3

Assign Weights



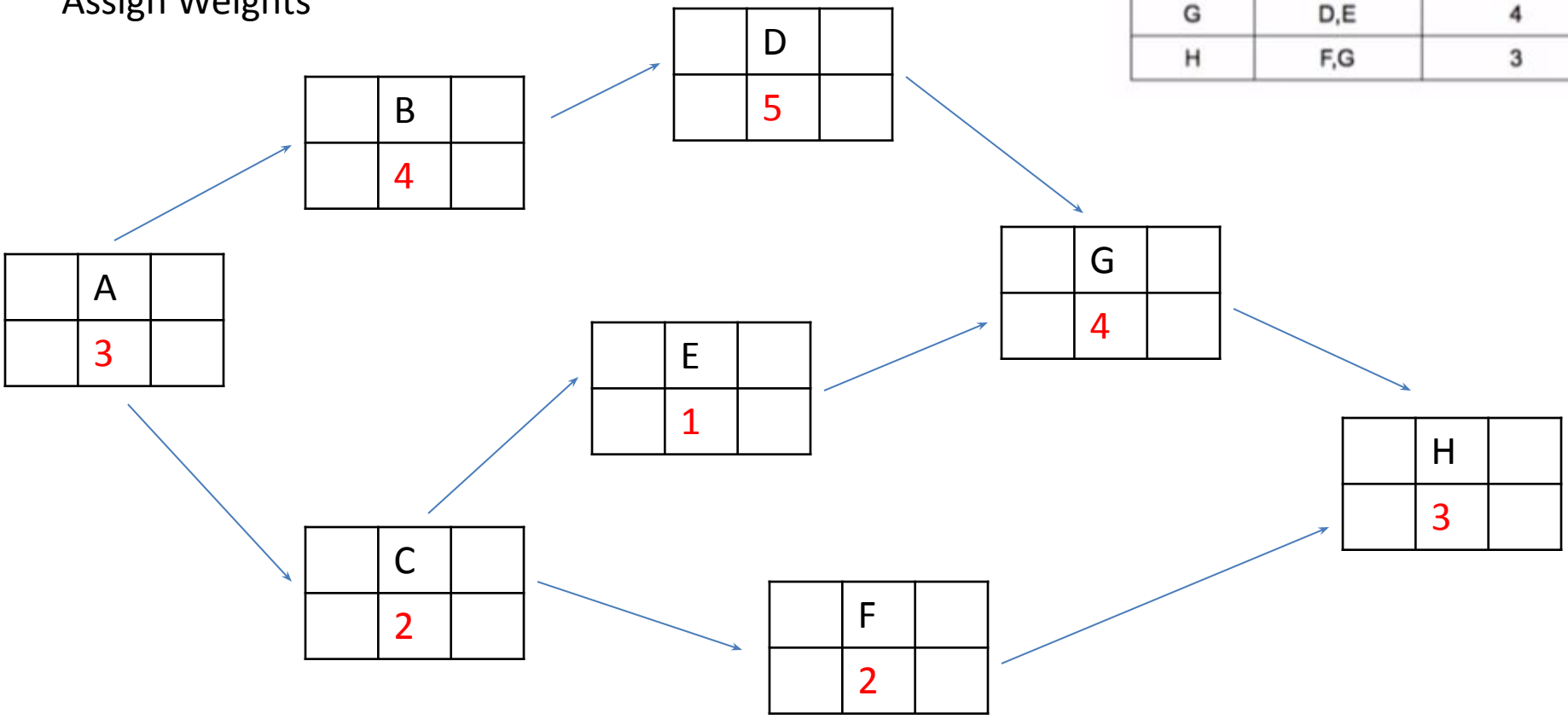
Activity	Predecessor	Duration (days)
A	-	3
B	A	4
C	A	2
D	B	5
E	C	1
F	C	2
G	D,E	4
H	F,G	3

Assign Weights



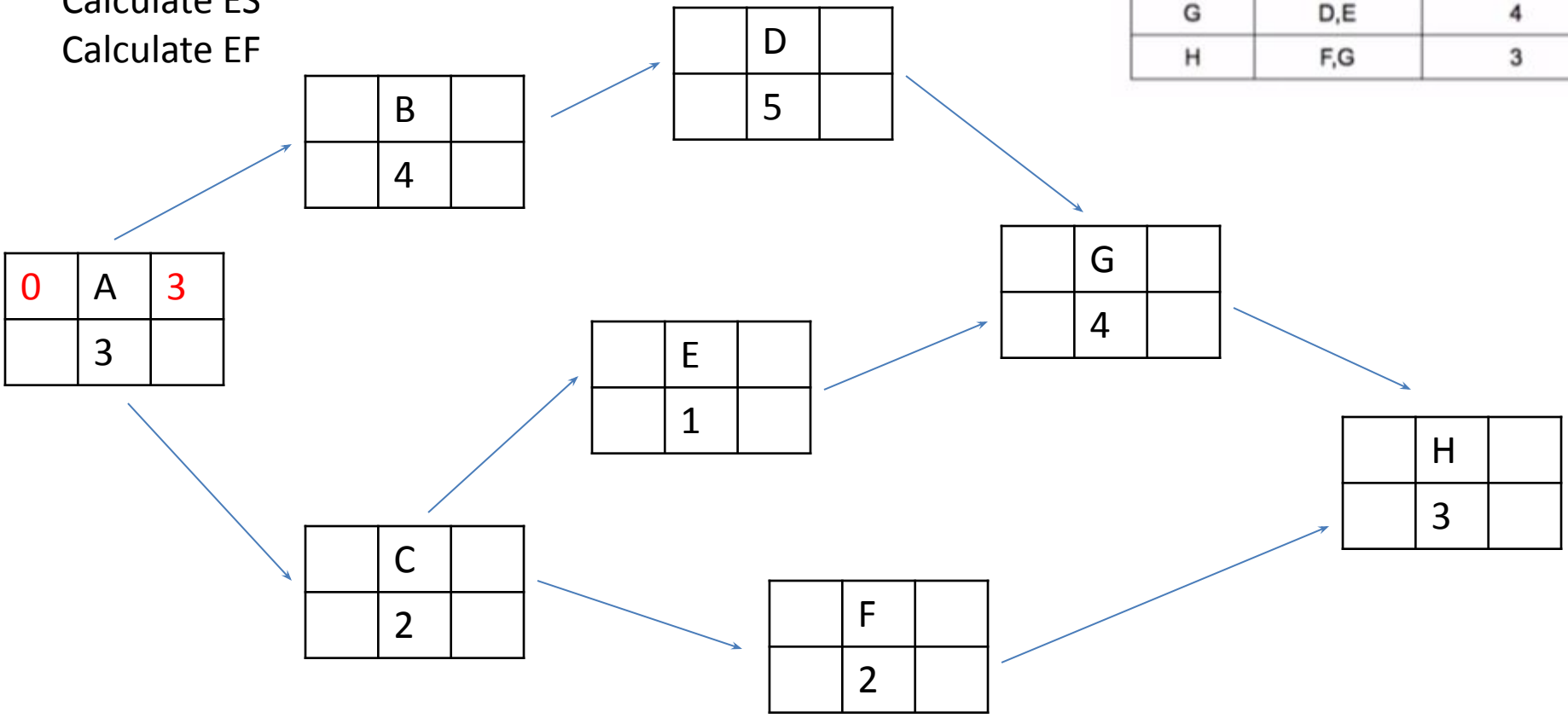
Activity	Predecessor	Duration (days)
A	-	3
B	A	4
C	A	2
D	B	5
E	C	1
F	C	2
G	D,E	4
H	F,G	3

Assign Weights



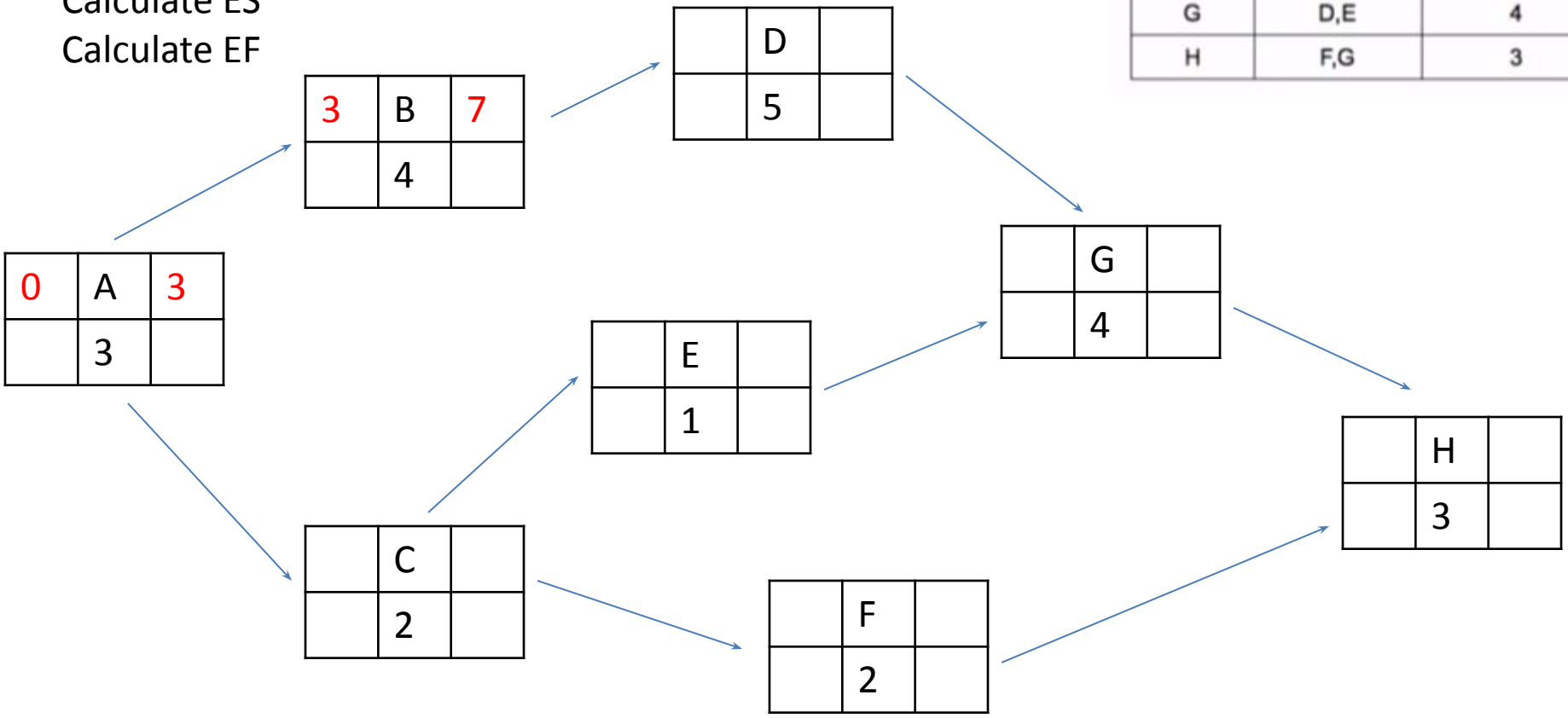
Activity	Predecessor	Duration (days)
A	-	3
B	A	4
C	A	2
D	B	5
E	C	1
F	C	2
G	D,E	4
H	F,G	3

Calculate ES
Calculate EF



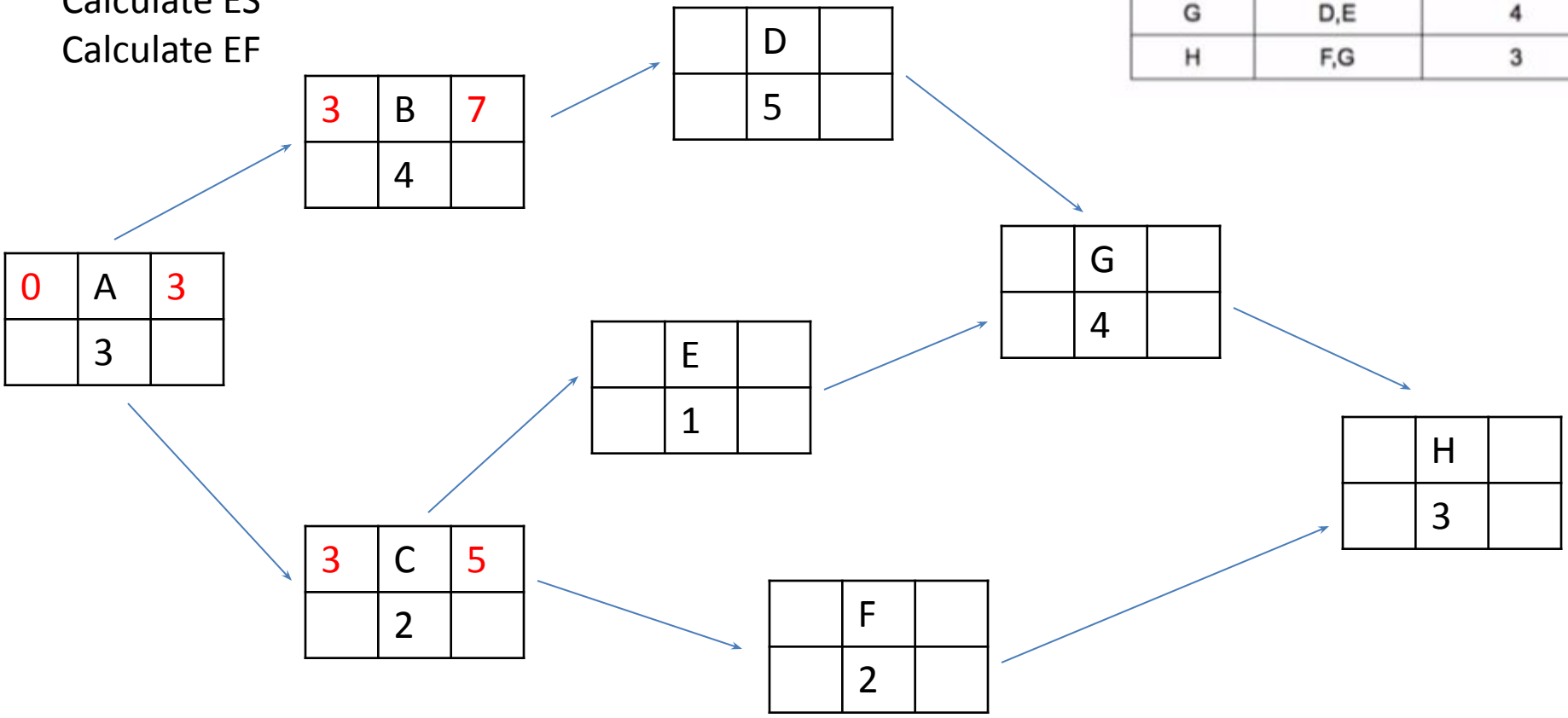
Activity	Predecessor	Duration (days)
A	-	3
B	A	4
C	A	2
D	B	5
E	C	1
F	C	2
G	D,E	4
H	F,G	3

Calculate ES
Calculate EF



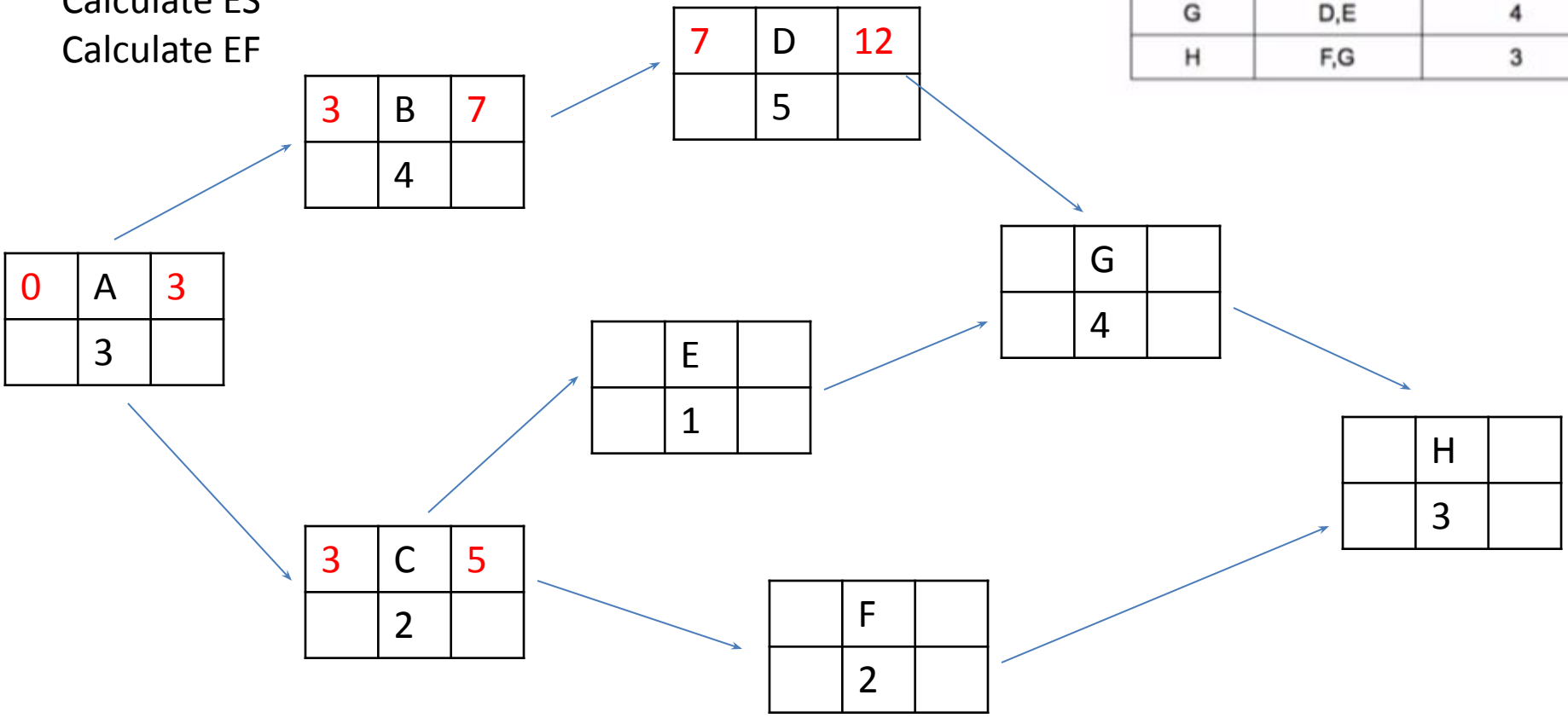
Activity	Predecessor	Duration (days)
A	-	3
B	A	4
C	A	2
D	B	5
E	C	1
F	C	2
G	D,E	4
H	F,G	3

Calculate ES
Calculate EF



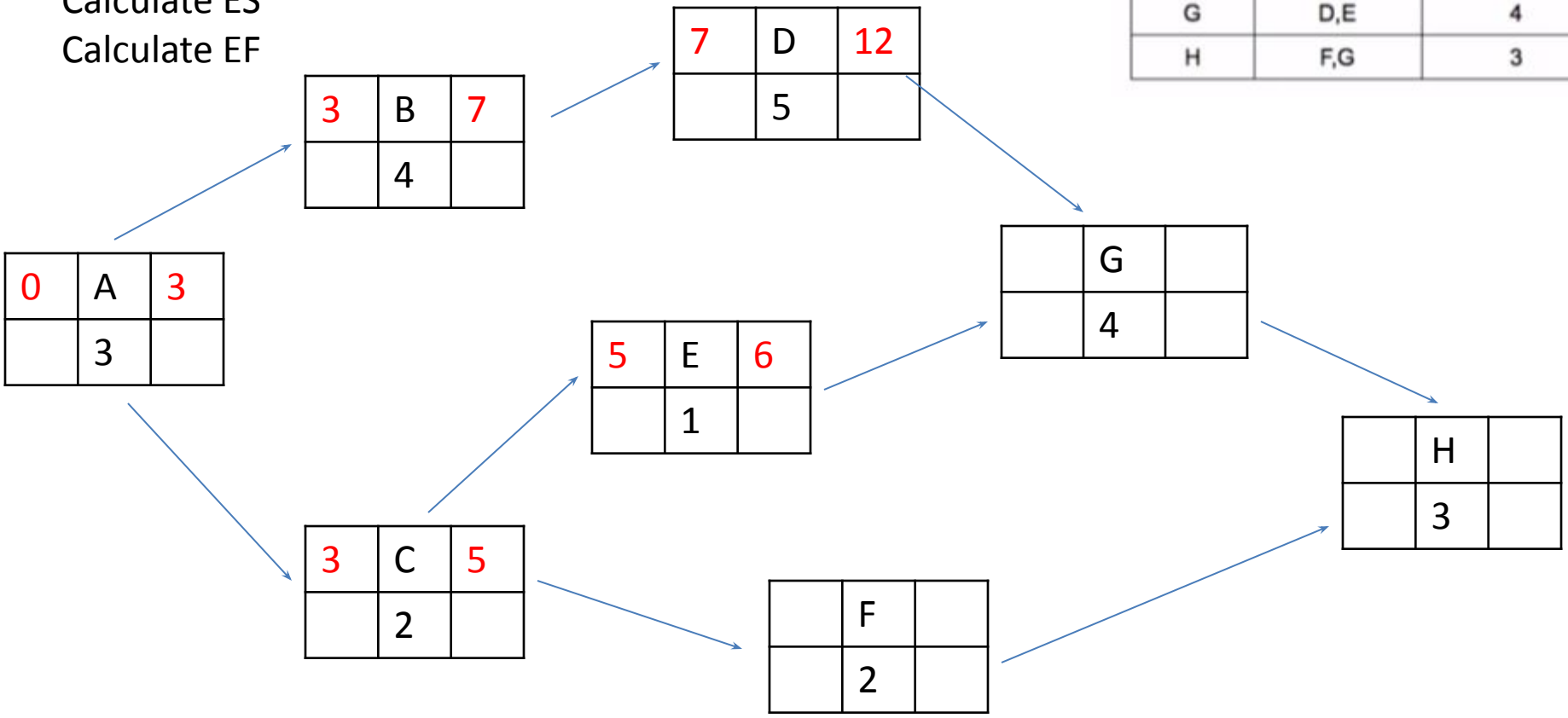
Activity	Predecessor	Duration (days)
A	-	3
B	A	4
C	A	2
D	B	5
E	C	1
F	C	2
G	D,E	4
H	F,G	3

Calculate ES
Calculate EF



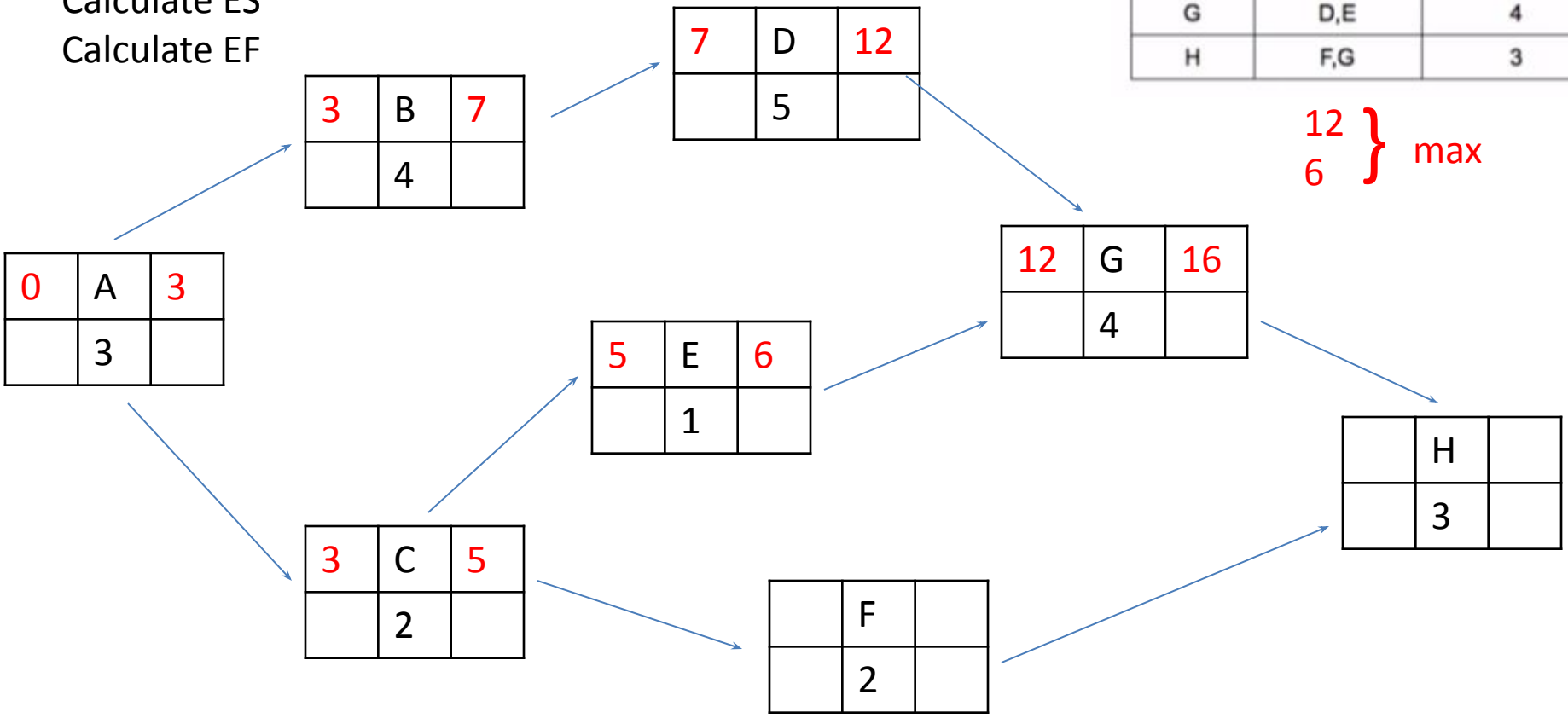
Activity	Predecessor	Duration (days)
A	-	3
B	A	4
C	A	2
D	B	5
E	C	1
F	C	2
G	D,E	4
H	F,G	3

Calculate ES
Calculate EF



Activity	Predecessor	Duration (days)
A	-	3
B	A	4
C	A	2
D	B	5
E	C	1
F	C	2
G	D,E	4
H	F,G	3

Calculate ES
Calculate EF



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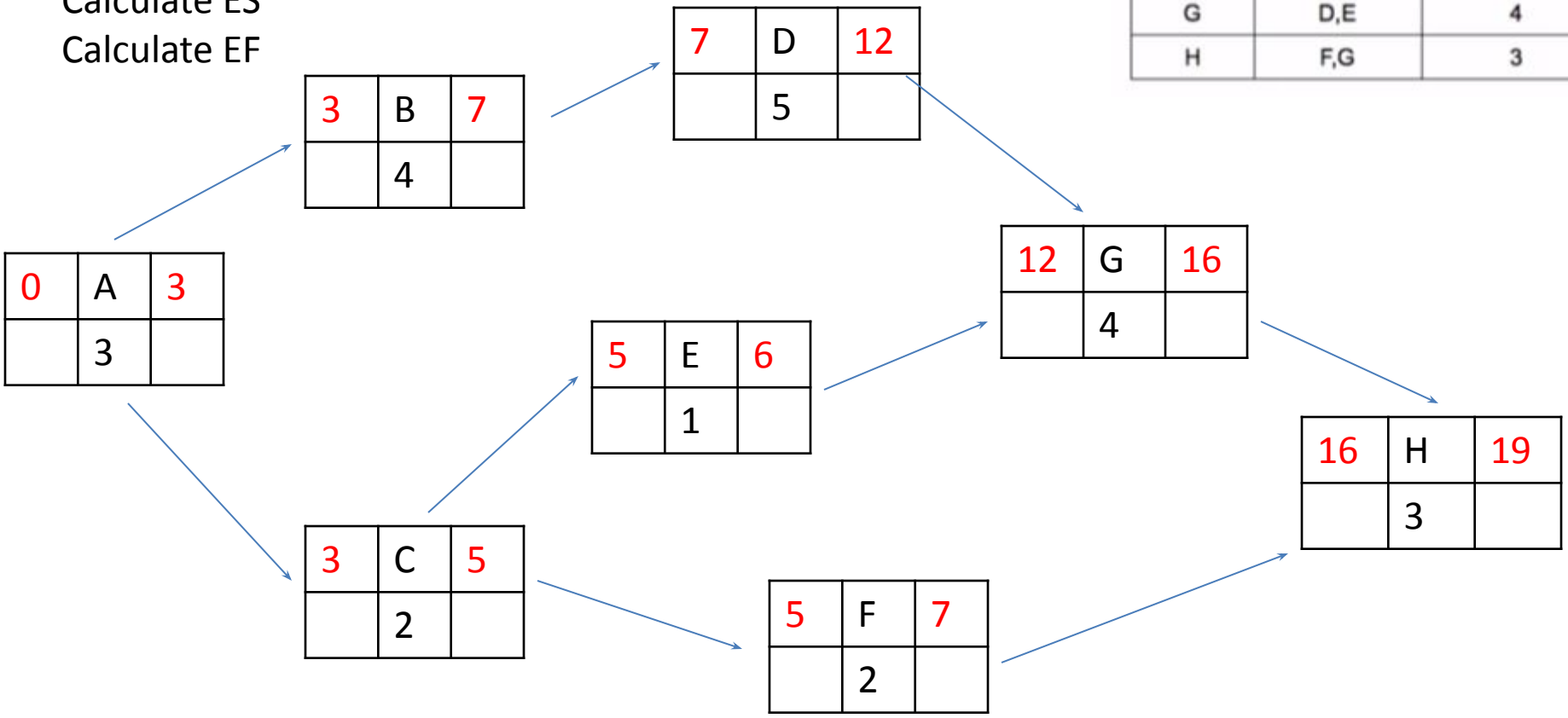
} max

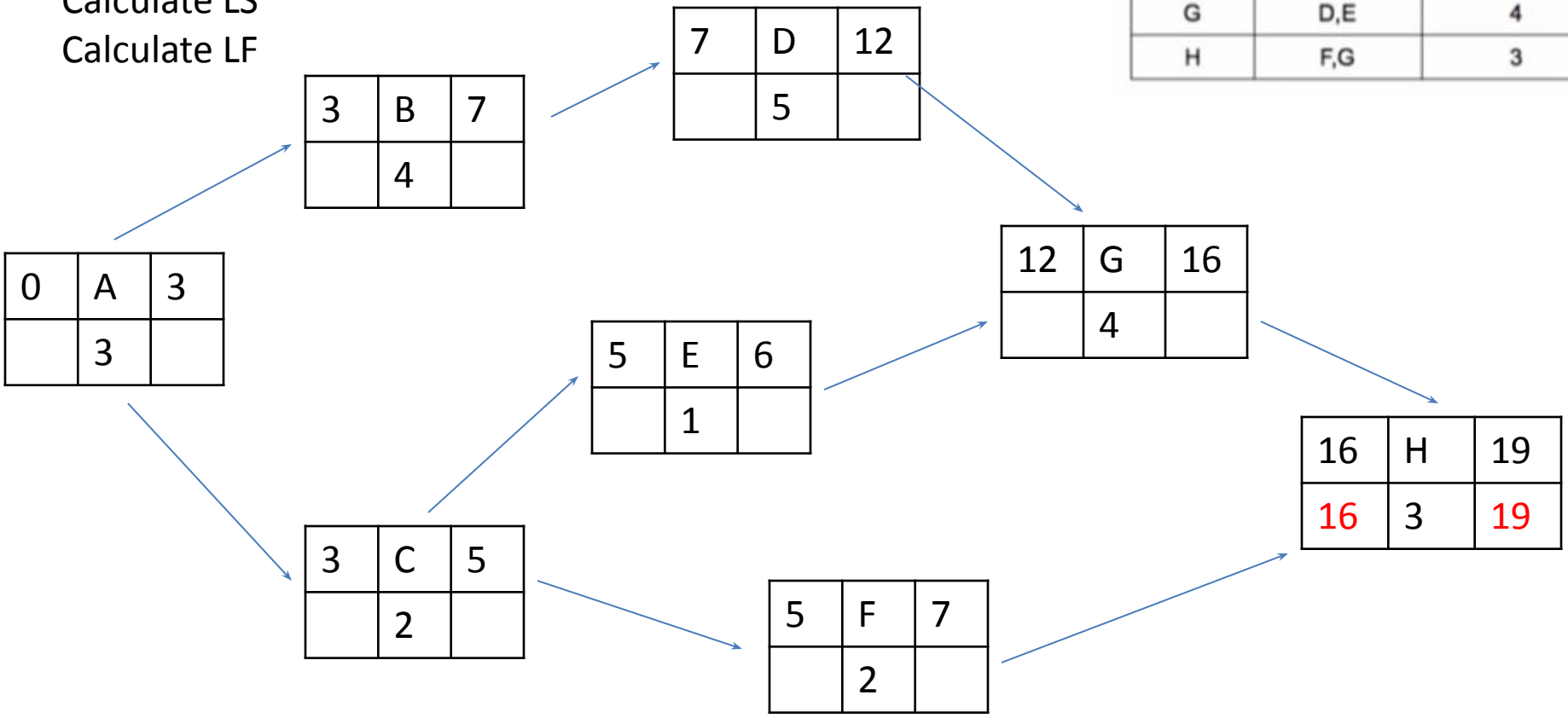
Activity	Predecessor	Duration (days)
A	-	3
B	A	4
C	A	2
D	B	5
E	C	1
F	C	2
G	D,E	4
H	F,G	3

Calculate ES
Calculate EF



Activity	Predecessor	Duration (days)
A	-	3
B	A	4
C	A	2
D	B	5
E	C	1
F	C	2
G	D,E	4
H	F,G	3

Calculate LS
Calculate LF



Activity	Predecessor	Duration (days)
A	-	3
B	A	4
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D	B	5
E	C	1
F	C	2
G	D,E	4
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Calculate LS
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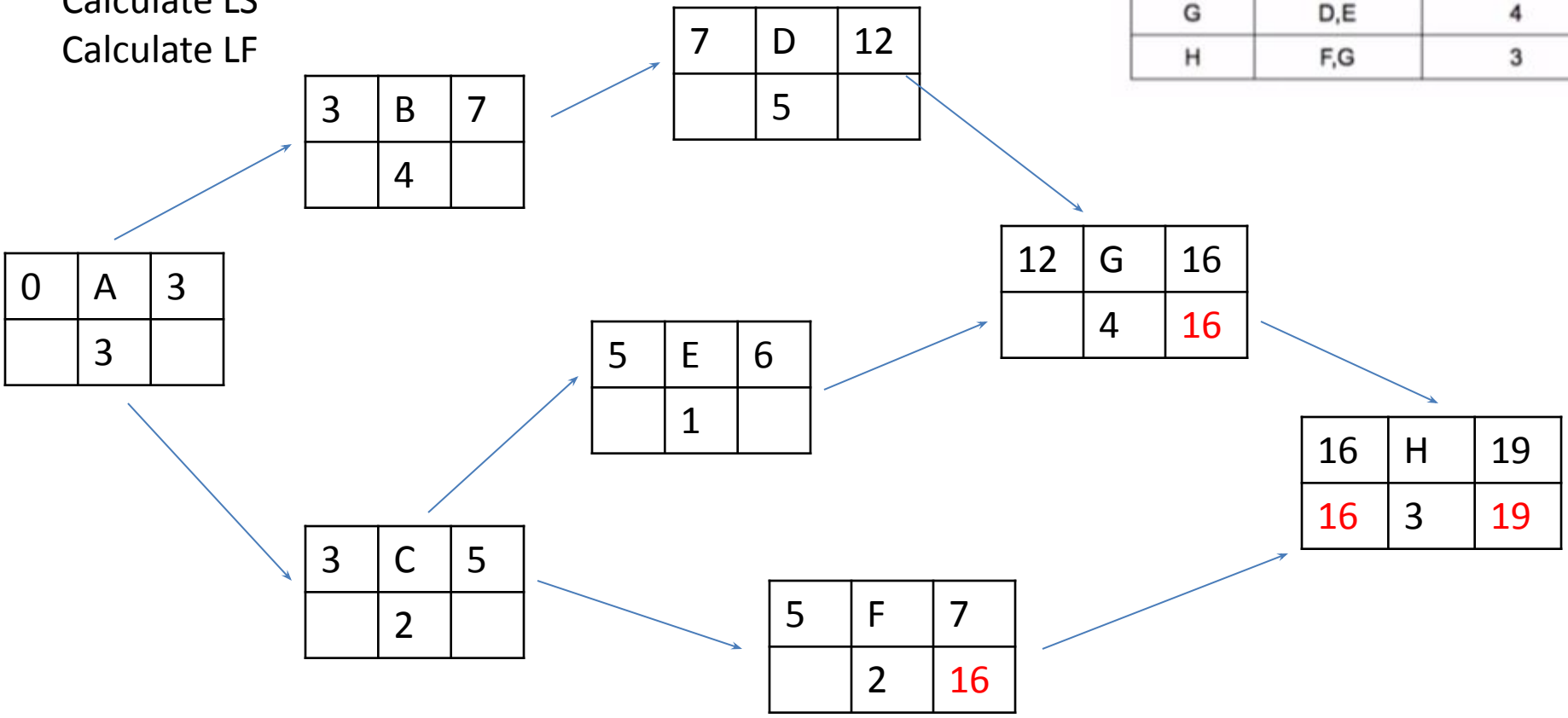

Activity	Predecessor	Duration (days)
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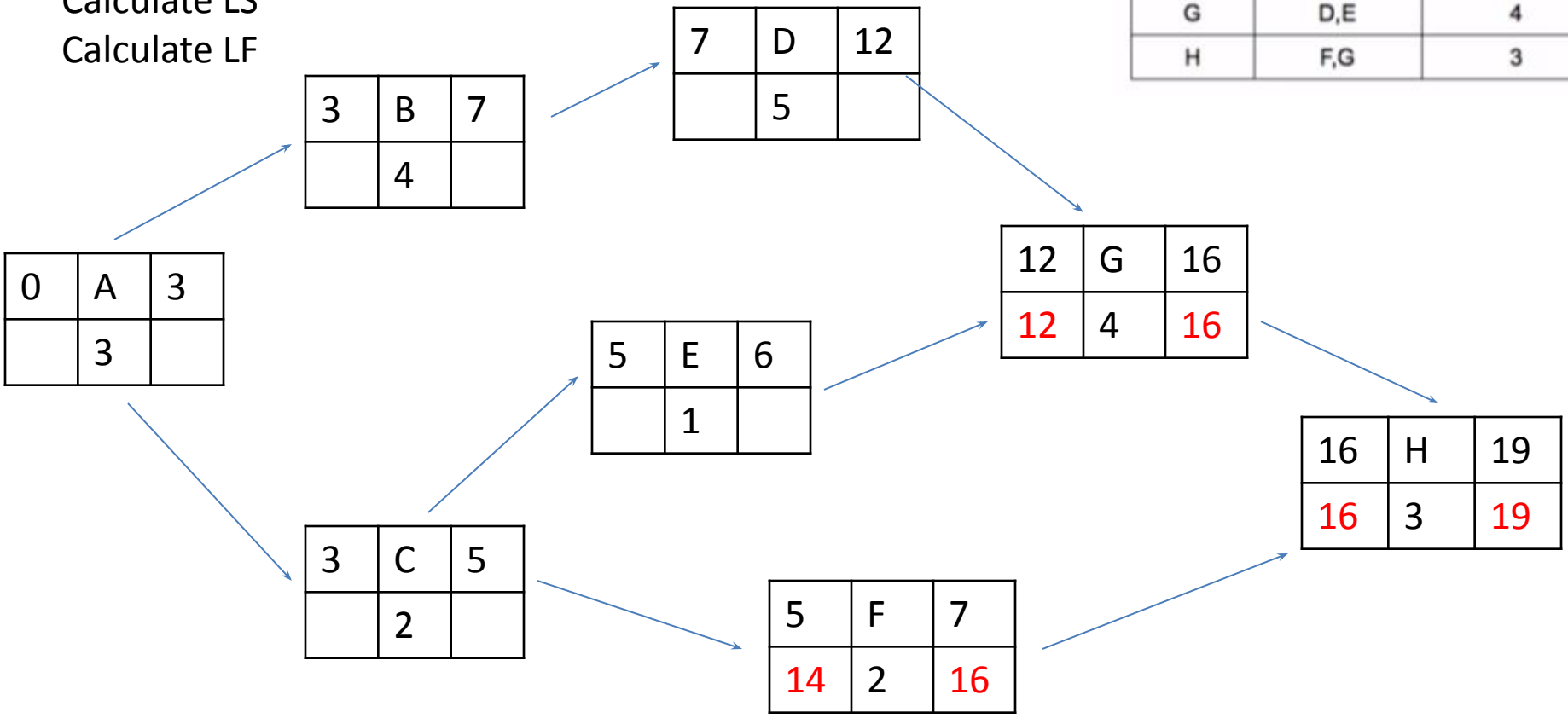

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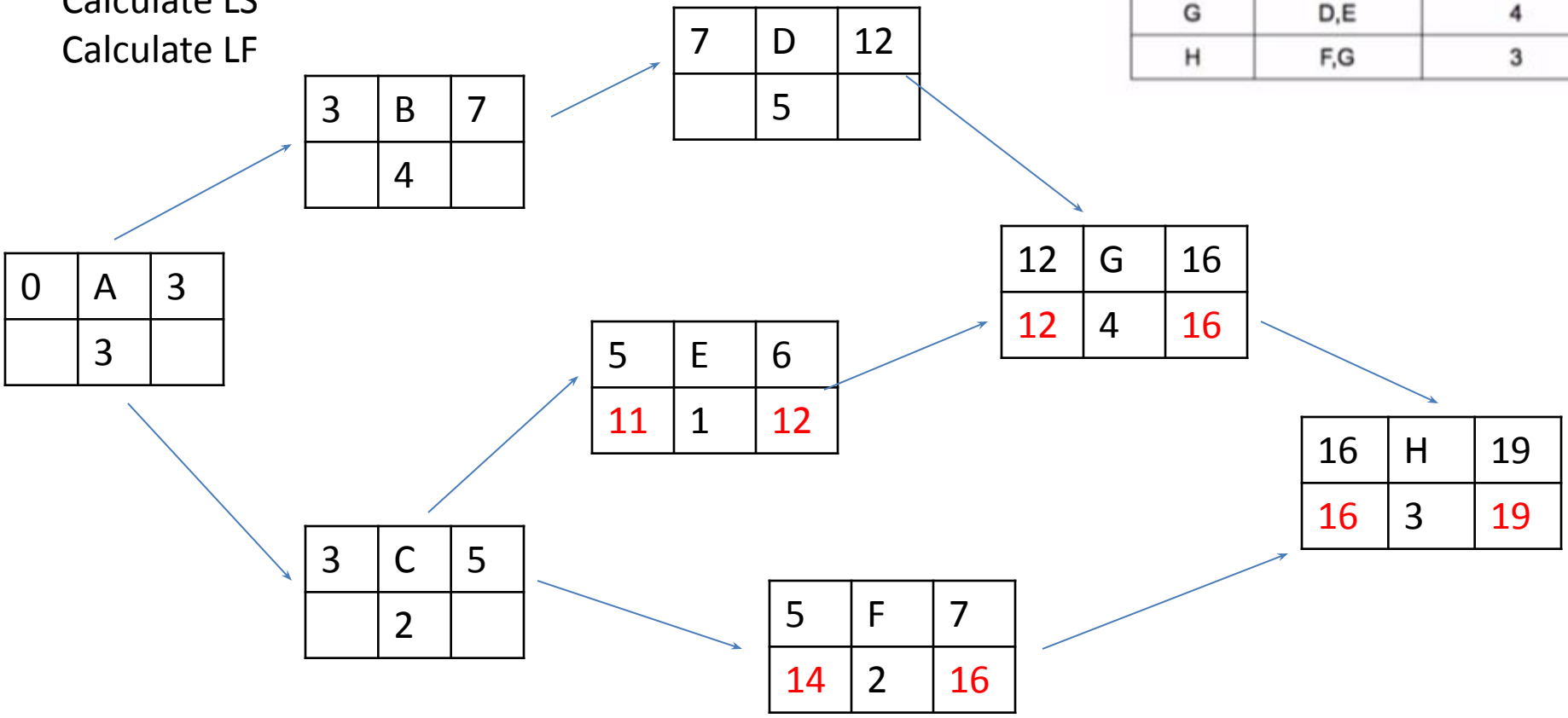
Calculate LF



Activity	Predecessor	Duration (days)
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C	A	2
D	B	5
E	C	1
F	C	2
G	D,E	4
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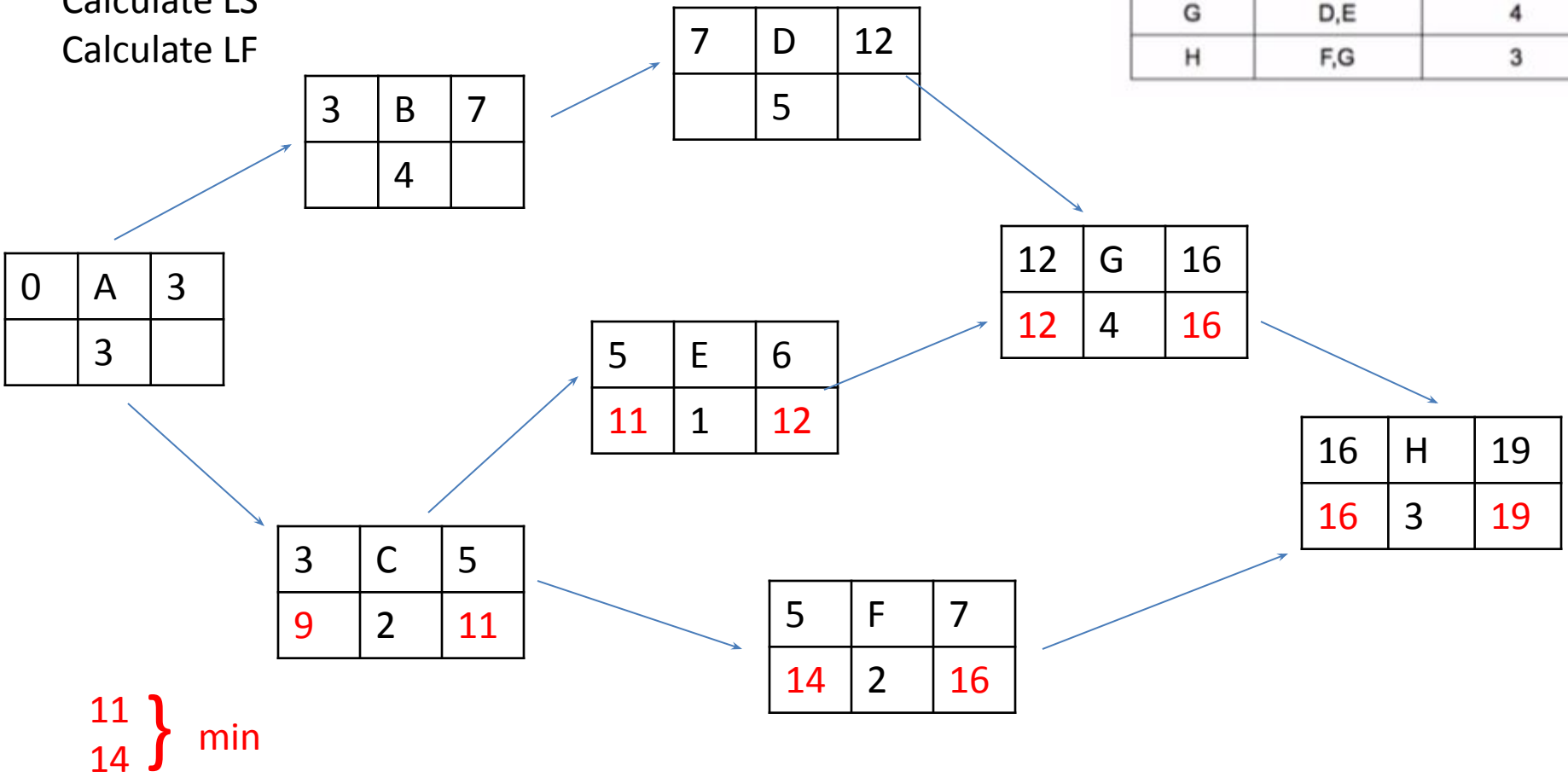
Calculate LS
Calculate LF



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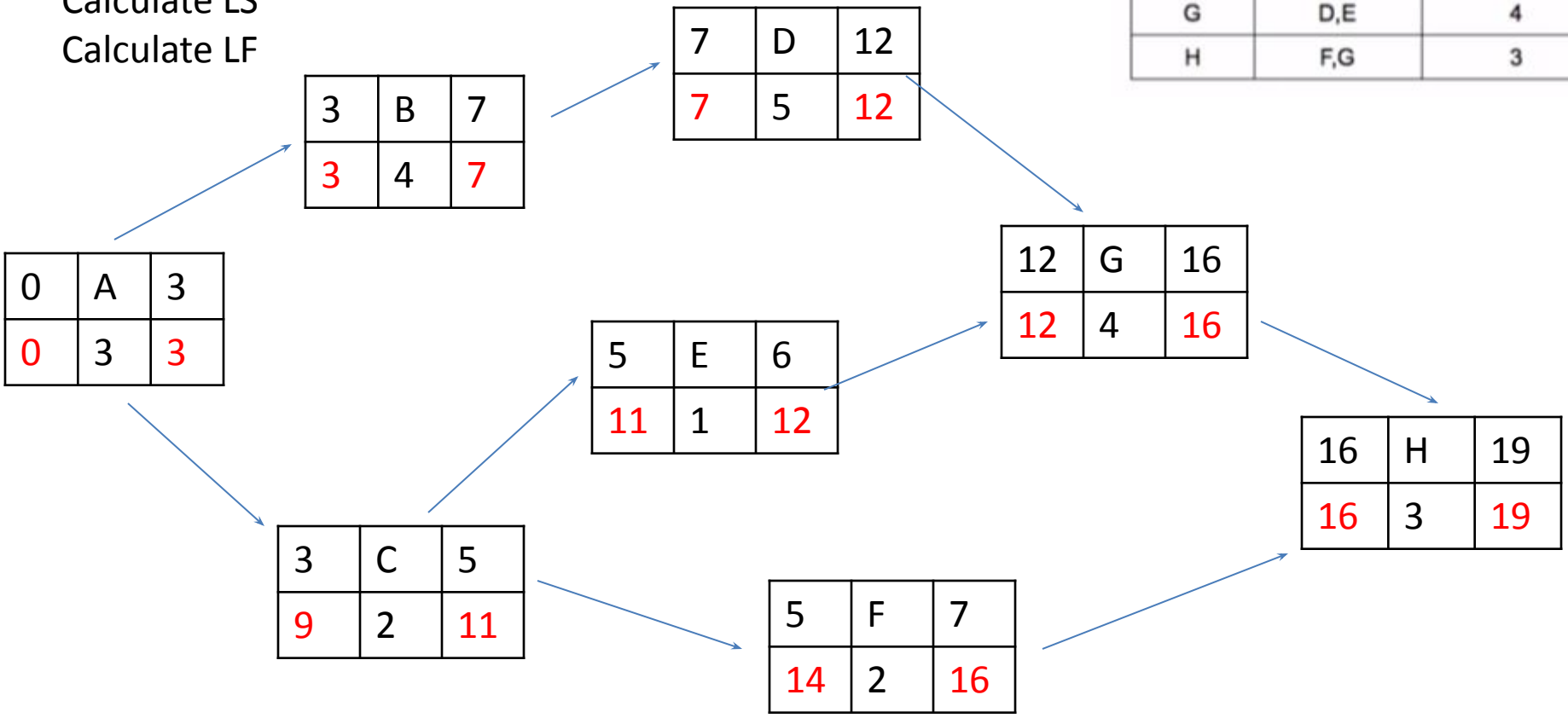
Activity	Predecessor	Duration (days)
A	-	3
B	A	4
C	A	2
D	B	5
E	C	1
F	C	2
G	D,E	4
H	F,G	3

Calculate LS
Calculate LF



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F	C	2
G	D,E	4
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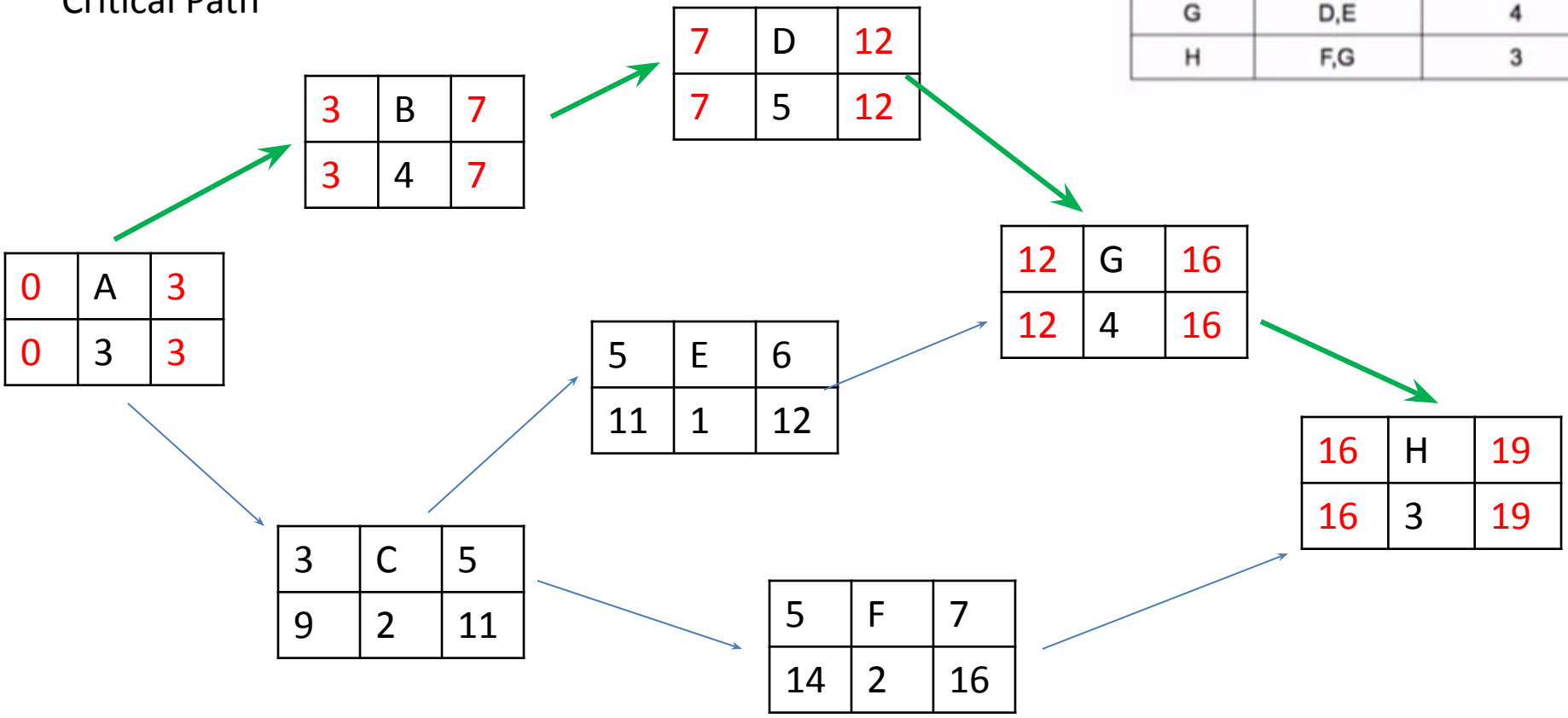
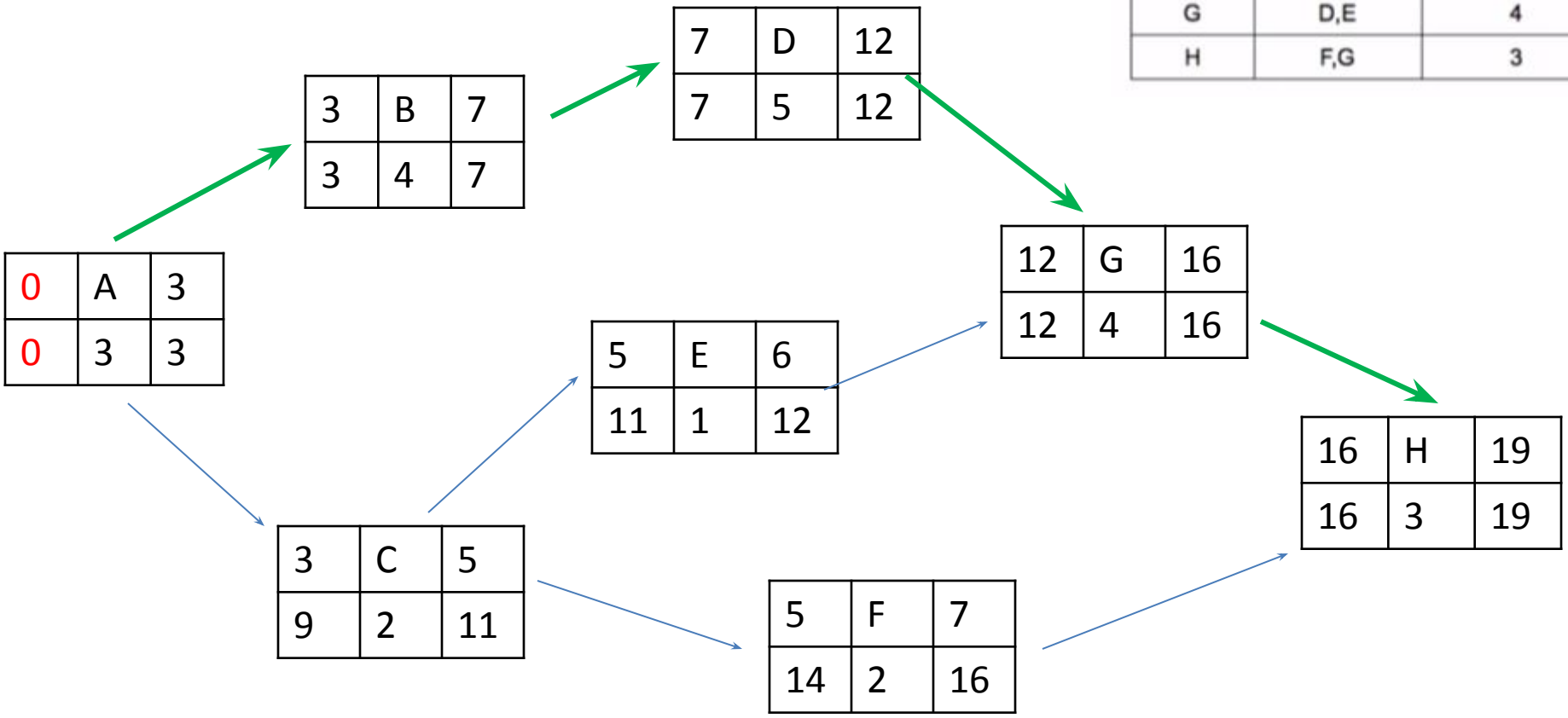
Critical Path



Activity	Predecessor	Duration (days)
A	-	3
B	A	4
C	A	2
D	B	5
E	C	1
F	C	2
G	D,E	4
H	F,G	3

Total Float (TF)/Slack
TF=LF-EF (Finish Float)
TF=LS-ES (Start Float)



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D	B	5
E	C	1
F	C	2
G	D,E	4
H	F,G	3

Total Float (TF) /Slack
TF=LF-EF (Finish Float)
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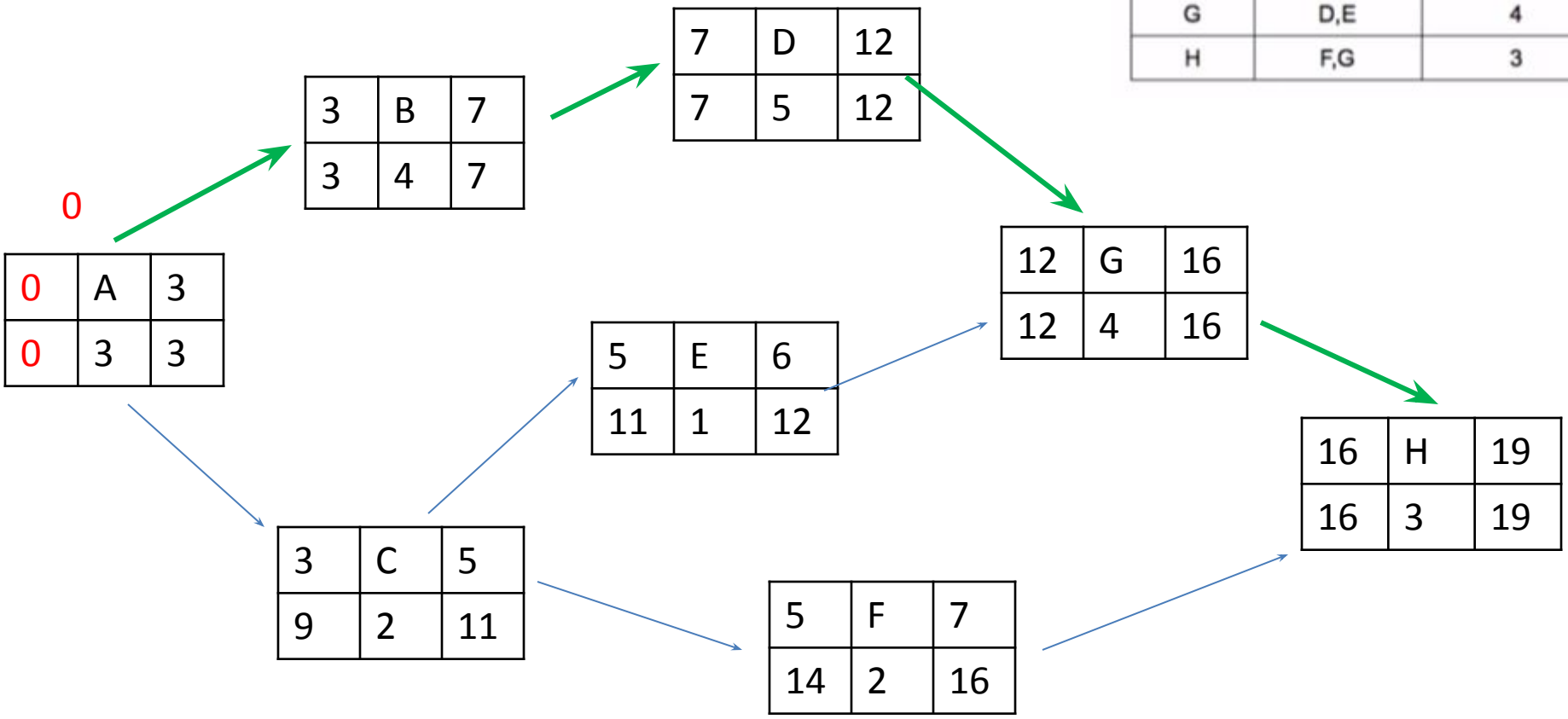

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C	A	2
D	B	5
E	C	1
F	C	2
G	D,E	4
H	F,G	3

Total Float (TF) /Slack
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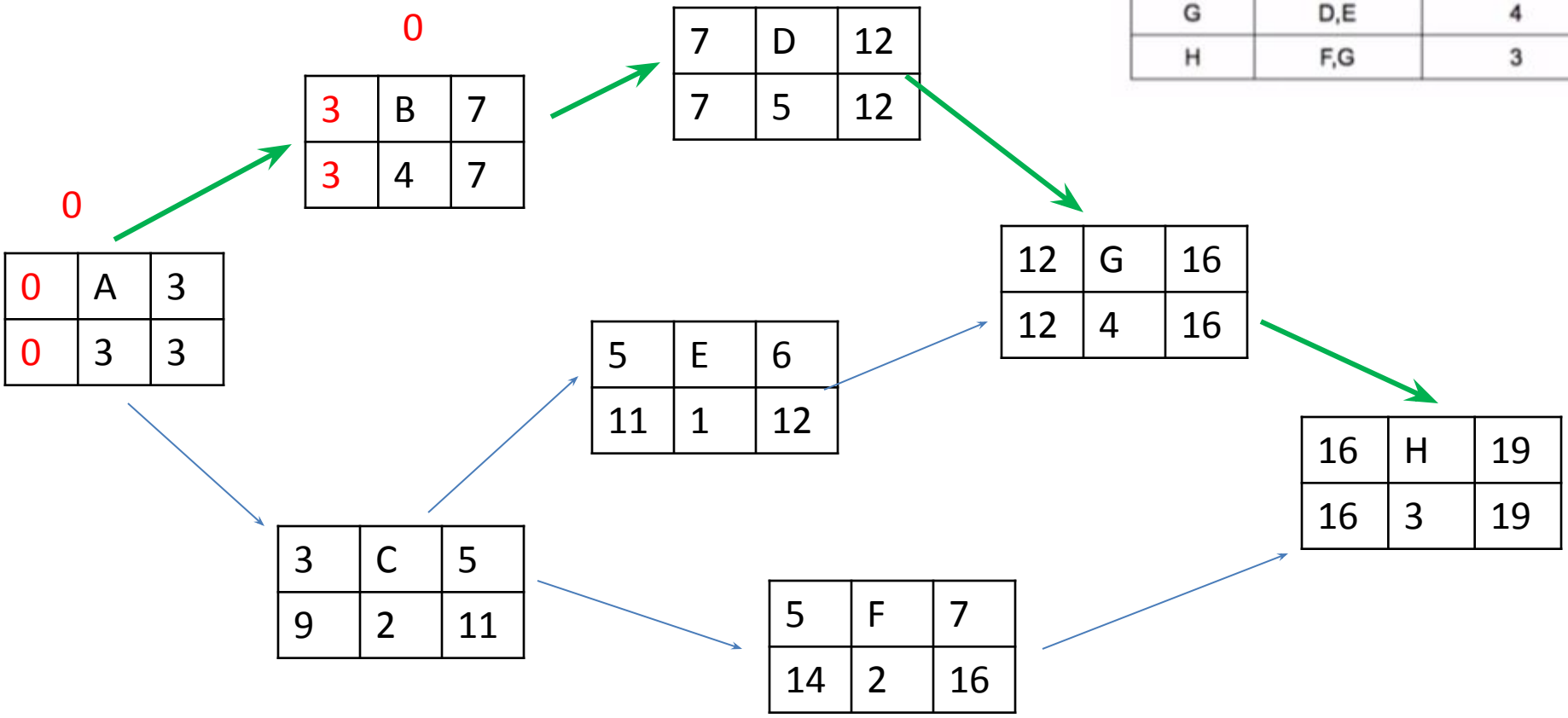

Activity	Predecessor	Duration (days)
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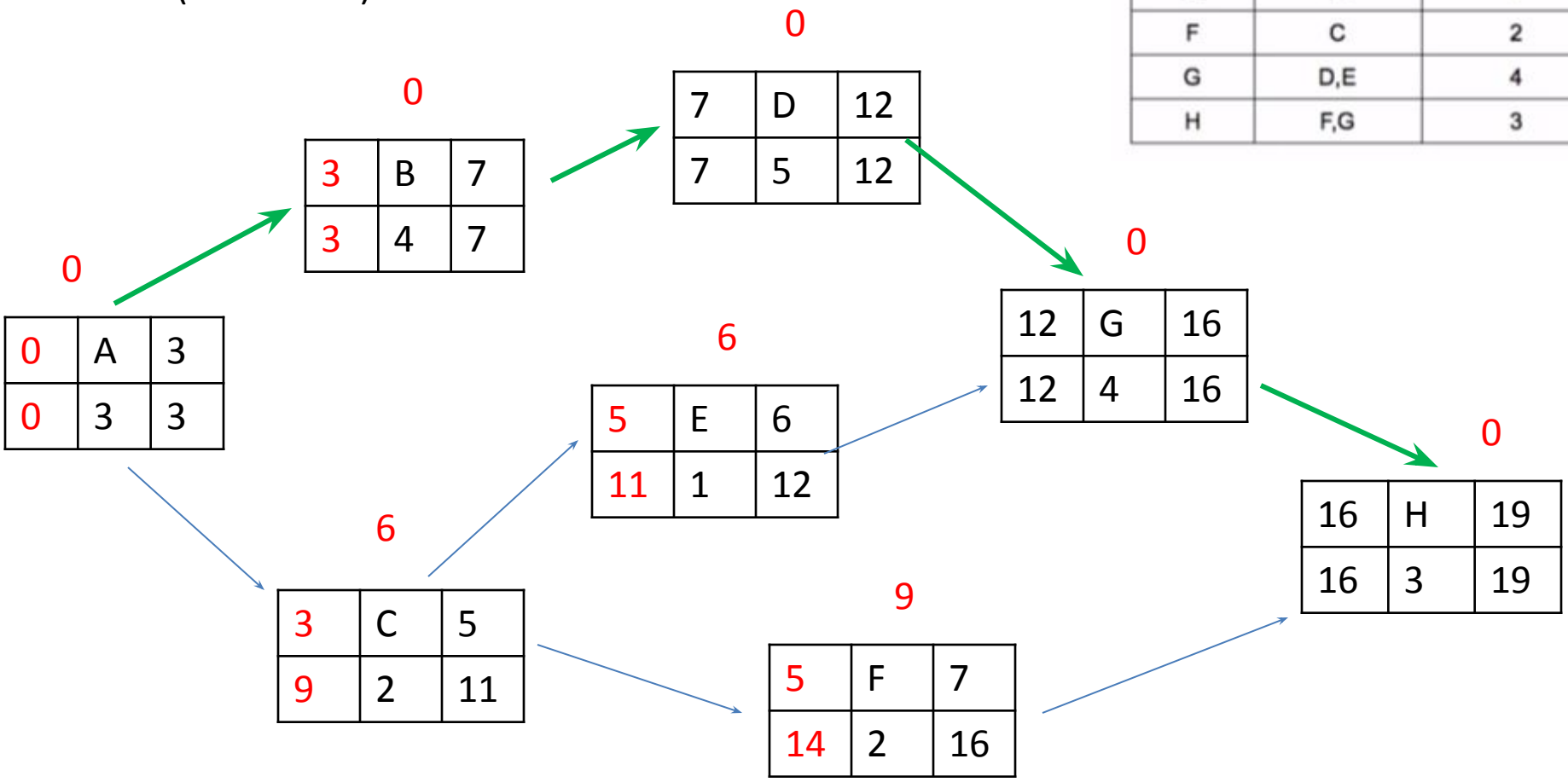
B	A	4
C	A	2
D	B	5
E	C	1
F	C	2
G	D,E	4
H	F,G	3

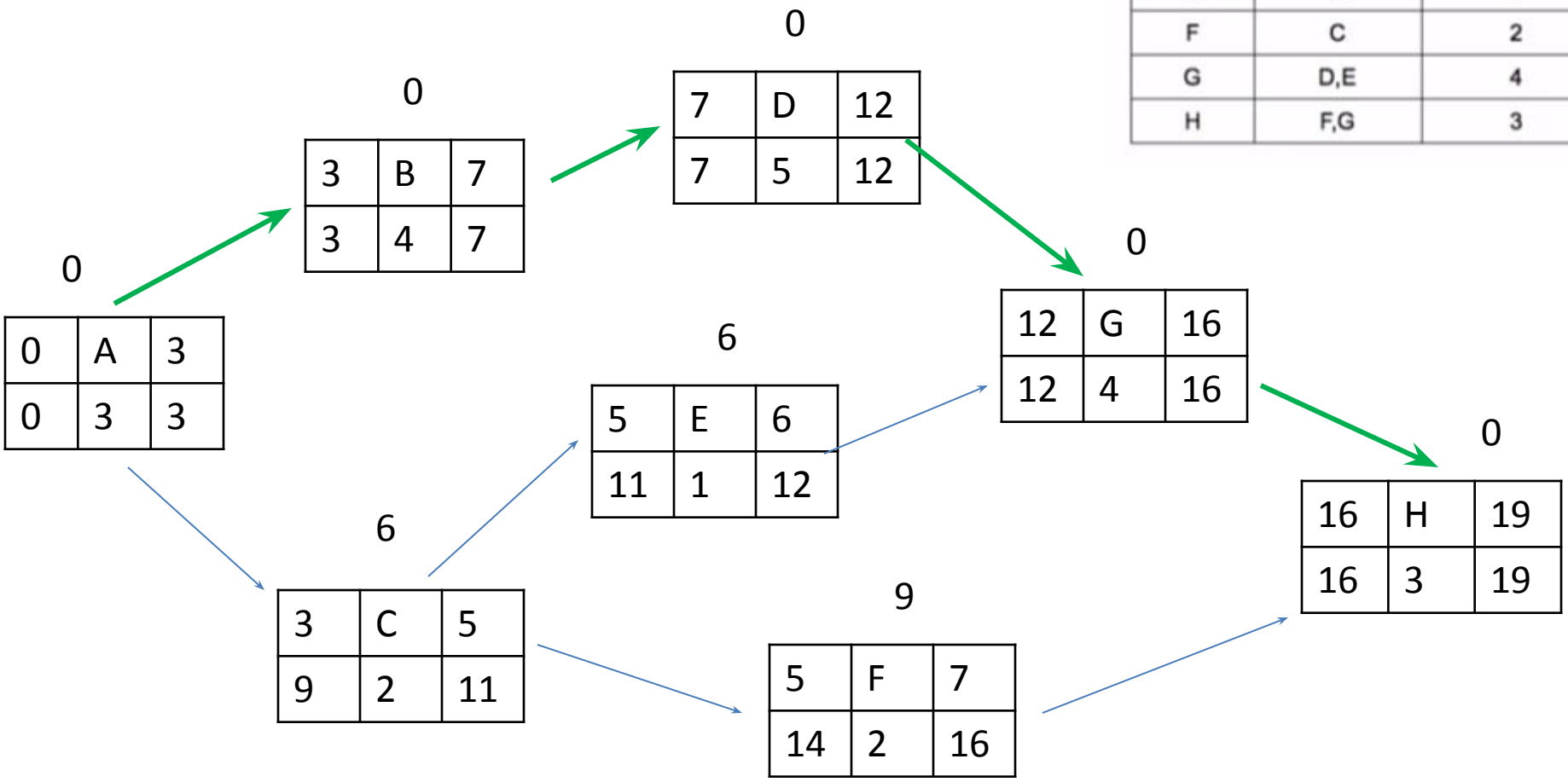
Total Float (TF) /Slack
TF=LF-EF (Finish Float)
TF=LS-ES (Start Float)



Activity	Predecessor	Duration (days)
A	-	3
B	A	4
C	A	2
D	B	5
E	C	1
F	C	2
G	D,E	4
H	F,G	3

Free Float (FF)

FF=Min(of ES of Successors)-ES(Activity)-Duration(Activity)



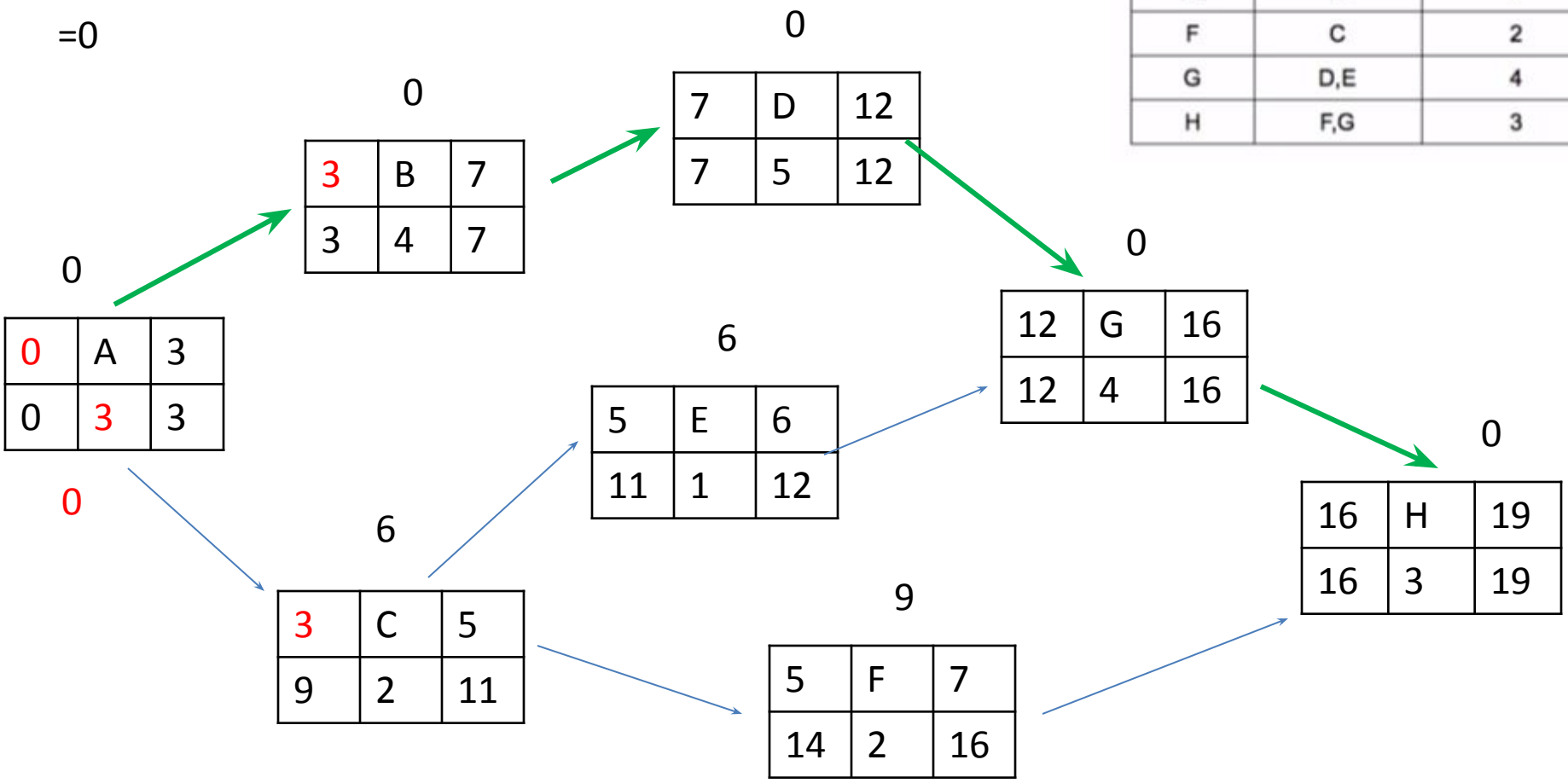
Activity	Predecessor	Duration (days)
A	-	3
B	A	4
C	A	2
D	B	5
E	C	1
F	C	2
G	D,E	4
H	F,G	3

Free Float (FF)

FF=Min(of ES of Successors)-ES(Activity)-Duration(Activity)

=3-0-3

=0



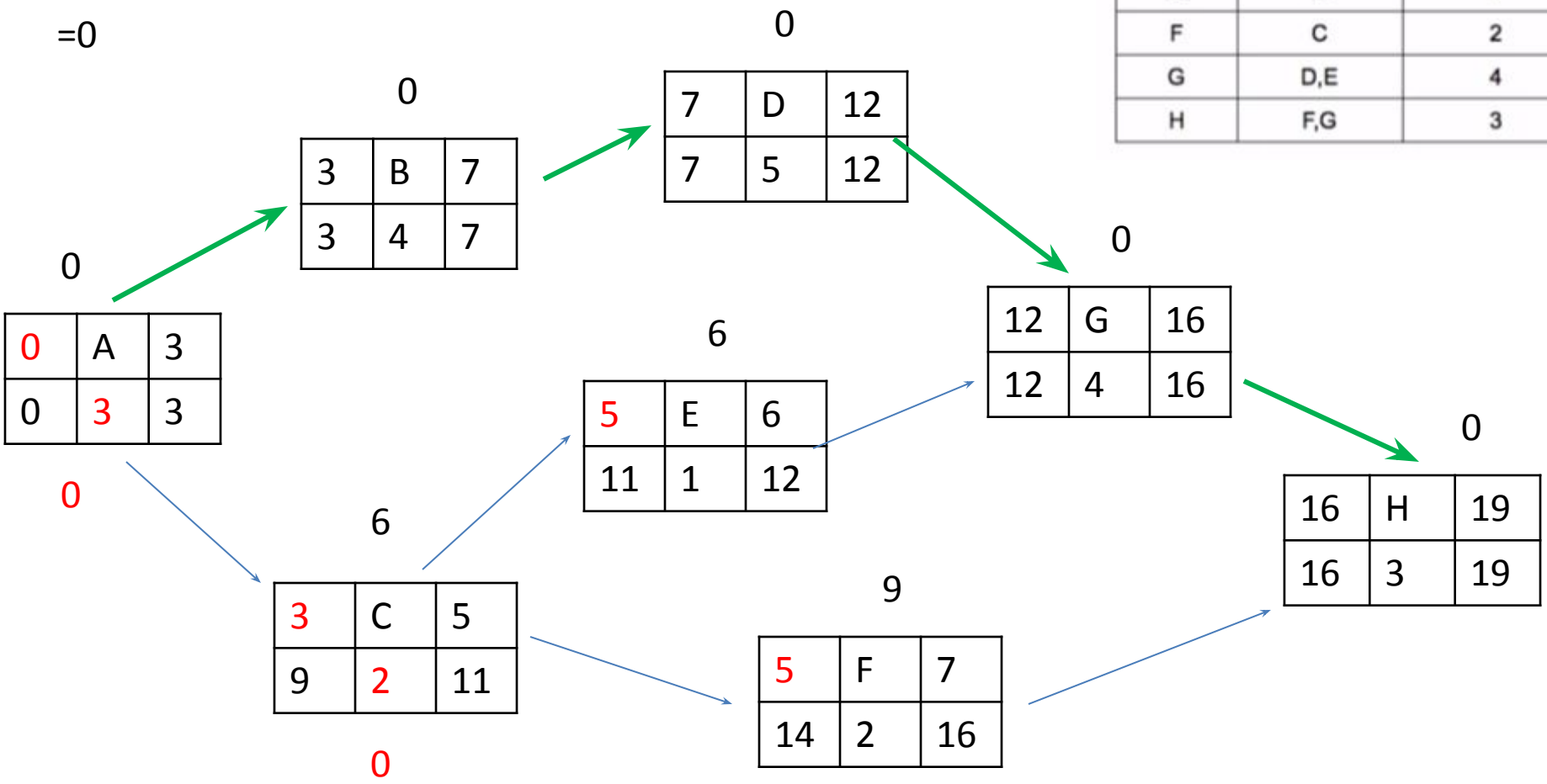
Activity	Predecessor	Duration (days)
A	-	3
B	A	4
C	A	2
D	B	5
E	C	1
F	C	2
G	D,E	4
H	F,G	3

Free Float (FF)

FF=Min(of ES of Successors)-ES(Activity)-Duration(Activity)

=5-3-2

=0



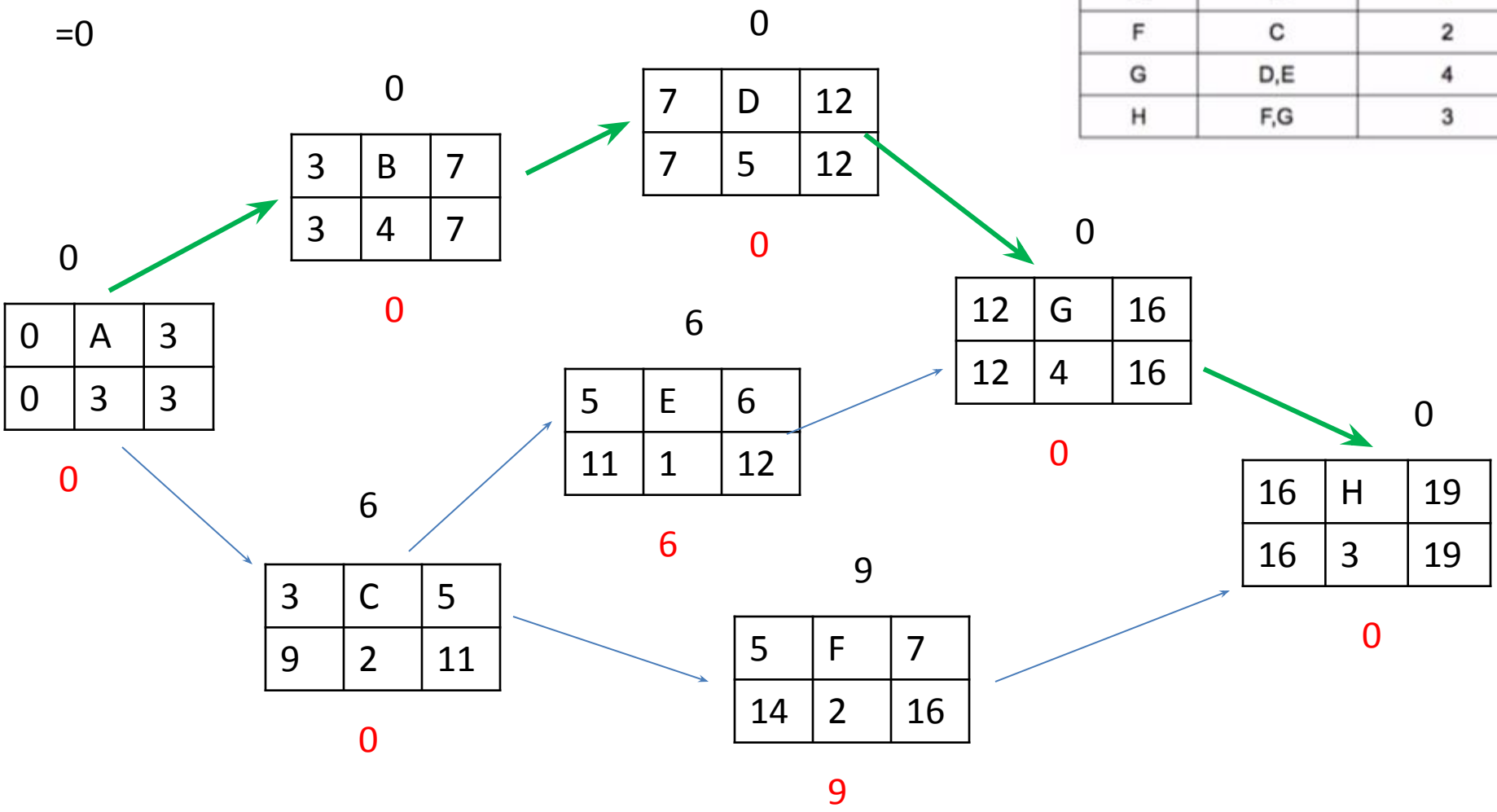
Activity	Predecessor	Duration (days)
A	-	3
B	A	4
C	A	2
D	B	5
E	C	1
F	C	2
G	D,E	4
H	F,G	3

Free Float (FF)

FF=Min(of ES of Successors)-ES(Activity)-Duration(Activity)

=5-3-2

=0



GANTT CHART

- A GANTT chart is a type of bar chart that illustrates a project schedule.
- After the PERT/CPM analysis is completed, the following phase is to construct the GANTT chart and then to re- allocate resources and re-schedule if necessary.
- GANTT charts have become a common technique for representing the phases and activities of a project work breakdown structure.
- It was introduced by Henry Gantt around 1910 – 1915.

GANTT CHART

- Characteristics:
  - The bar in each row identifies the corresponding task
  - The horizontal position of the bar identifies start and end times of the task
  - Bar length represents the duration of the task
  - Task durations can be compared easily
  - Good for allocating resources and re-scheduling
  - Precedence relationships can be represented using arrows
  - Critical activities are usually highlighted
  - Slack times are represented using bars with doted lines
  - The bar of each activity begins at the activity earliest start time (ES).
  - The bar of each activity ends at the activity latest finish time (LF).

GANTT CHART

- Advantages
  - Simple
  - Good visual communication to others
  - Task durations can be compared easily
  - Good for scheduling resources

- Disadvantages
  - Dependencies are more difficult to visualise
  - Minor changes in data can cause major changes in the chart

CONSTRUCTING GANTT CHART

- The steps to construct a GANTT chart from the information obtained by PERT CHART and CPM are:
  1. Schedule the critical tasks in the correct position.
  2. Place the time windows in which the non-critical tasks can be scheduled.
  3. Schedule the non-critical tasks according to their earliest starting times.
  4. Indicate precedence relationships between tasks.

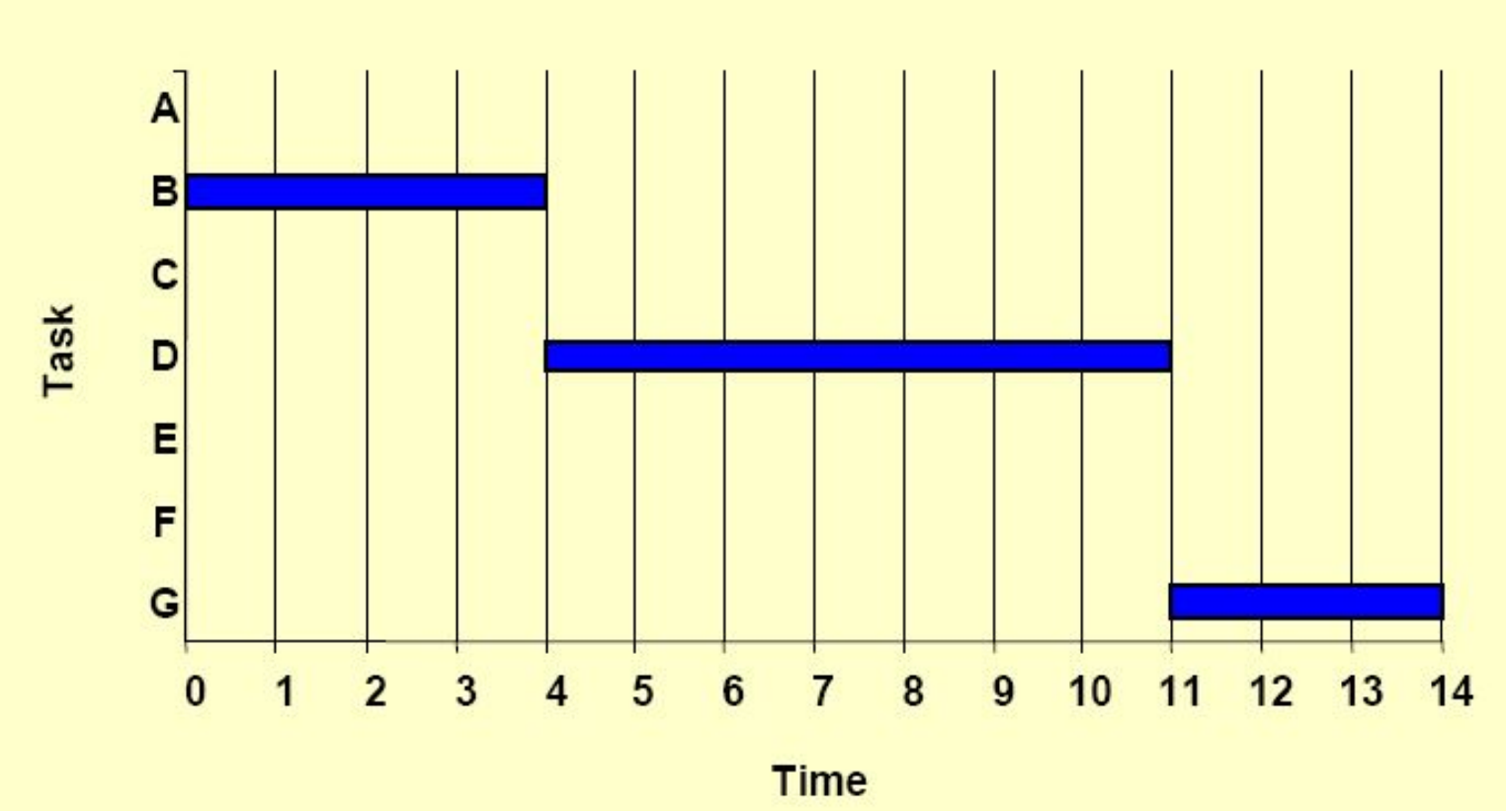
CONSTRUCTING GANTT CHART

- Example of an early GANTT chart construction:

Task	Duration	Precedence	ES	EF	LS	LF	Slack Time	Critical Task
A	3		0	3	3	6	3	N
B	4		0	4	0	4	0	Y
C	5	A	3	8	6	11	3	N
D	7	B	4	11	4	11	0	Y
E	2	B	4	6	8	10	4	N
F	4	E	6	10	10	14	4	N
G	3	C,D	11	14	11	14	0	Y

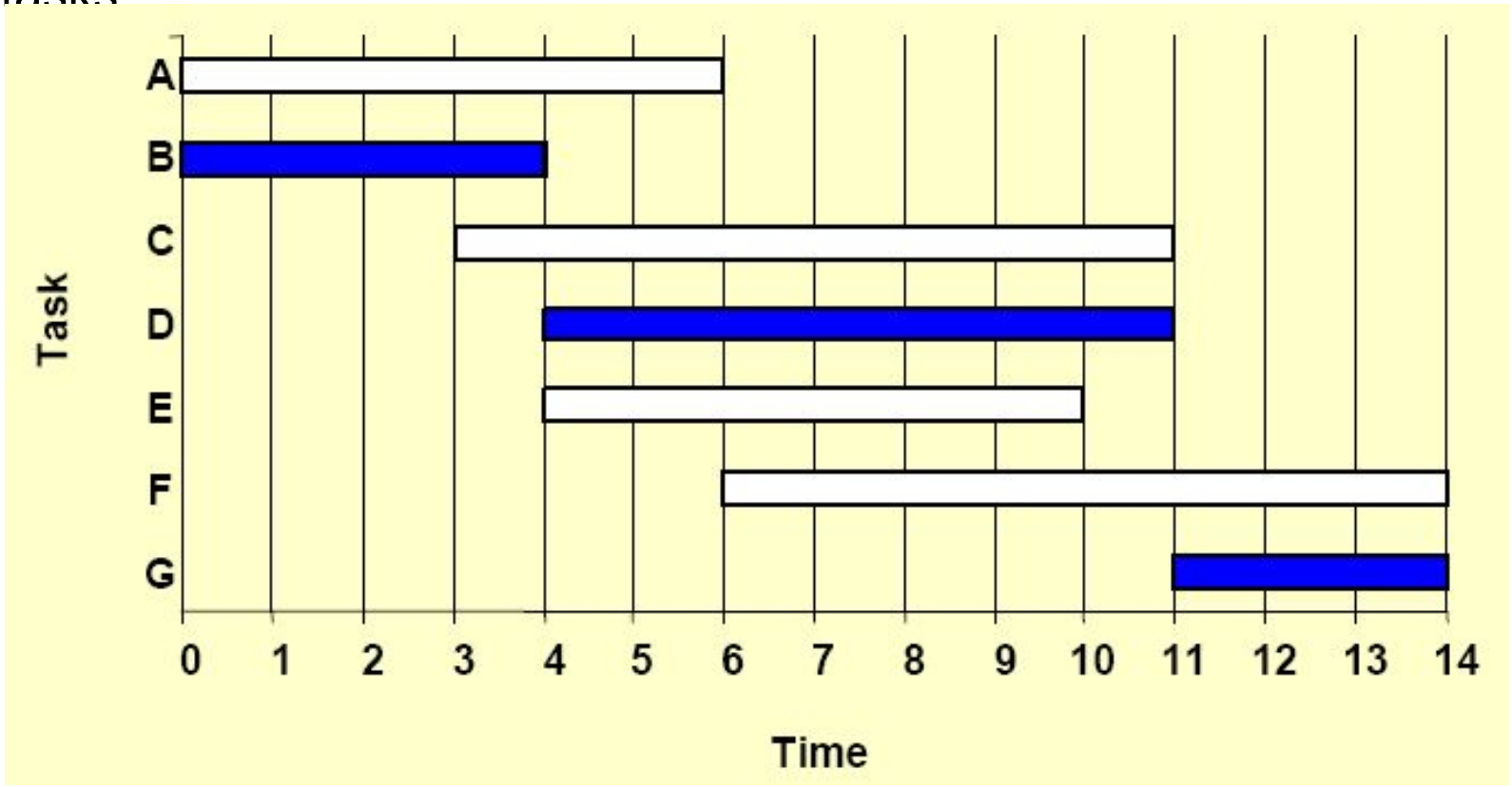
CONSTRUCTING GANTT CHART

Step 1. Schedule critical tas



CONSTRUCTING GANTT CHART

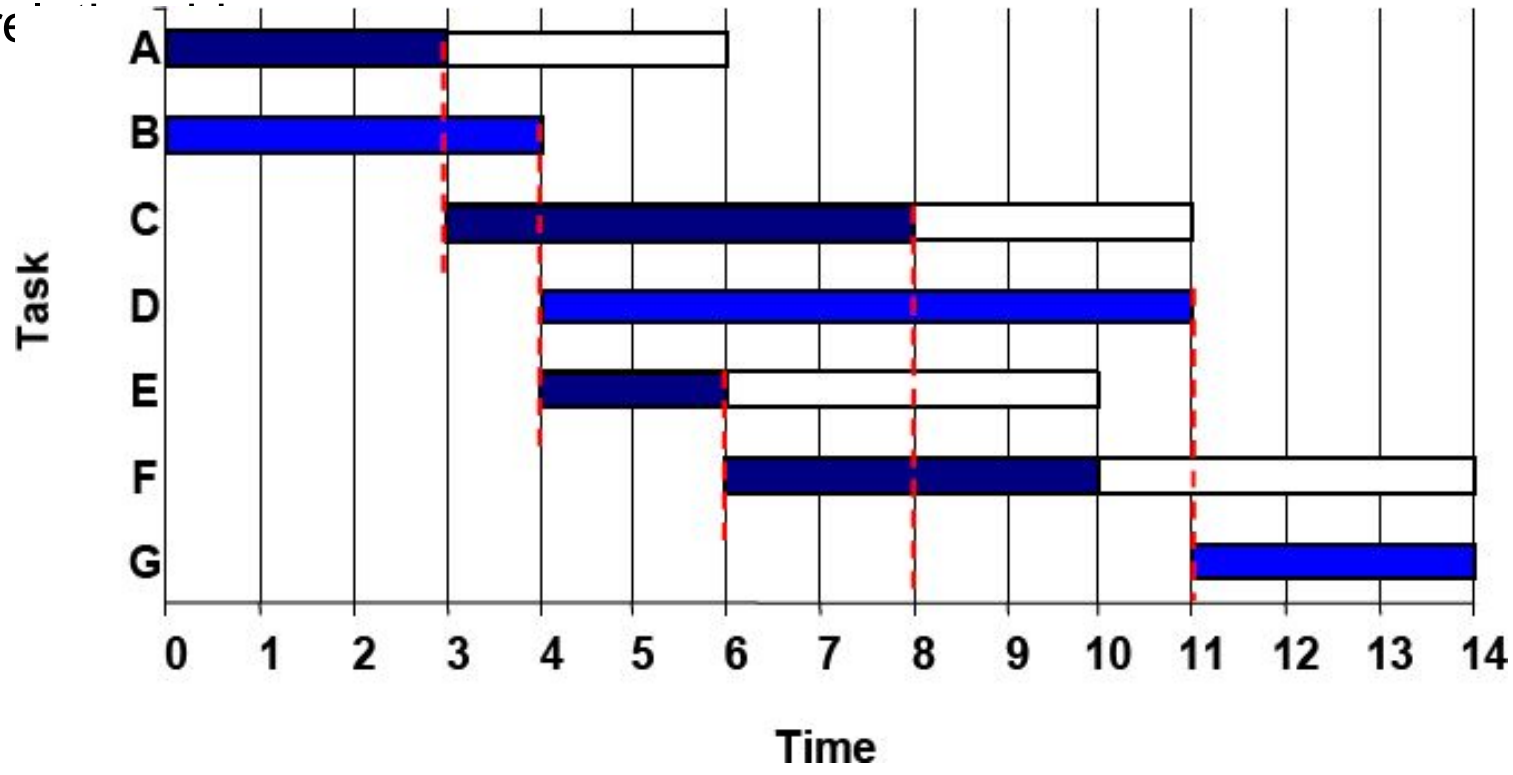
Step 2. Place time windows for non-critical tasks:



CONSTRUCTING GANTT CHART

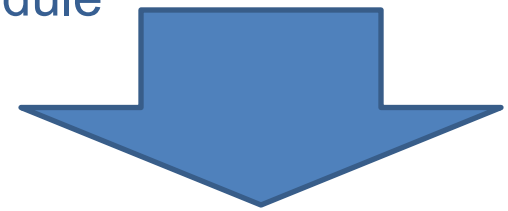
Step 3. Schedule non-critical tasks

Step 4. Indicate precedence



STAFFING & RE-SCHEDULING

- Once the project schedule, (*e.g. GANTT chart)*, has been constructed, take into account
  - available staff hours
  - slack times and
  - the project schedule



Assign staff and other resources to each activity in the project

STAFFING & RE-SCHEDULING

- Resource Smoothing is a technique used to *re-allocate resources* and *re-schedule activities*.
- In resource smoothing, non-critical tasks are re-scheduled within their time window.
- Staff Utilization: *(duration of activity x staff required for each activity*, all added together) / (*maximum staff required x duration of project*)

STAFFING & RE-SCHEDULING

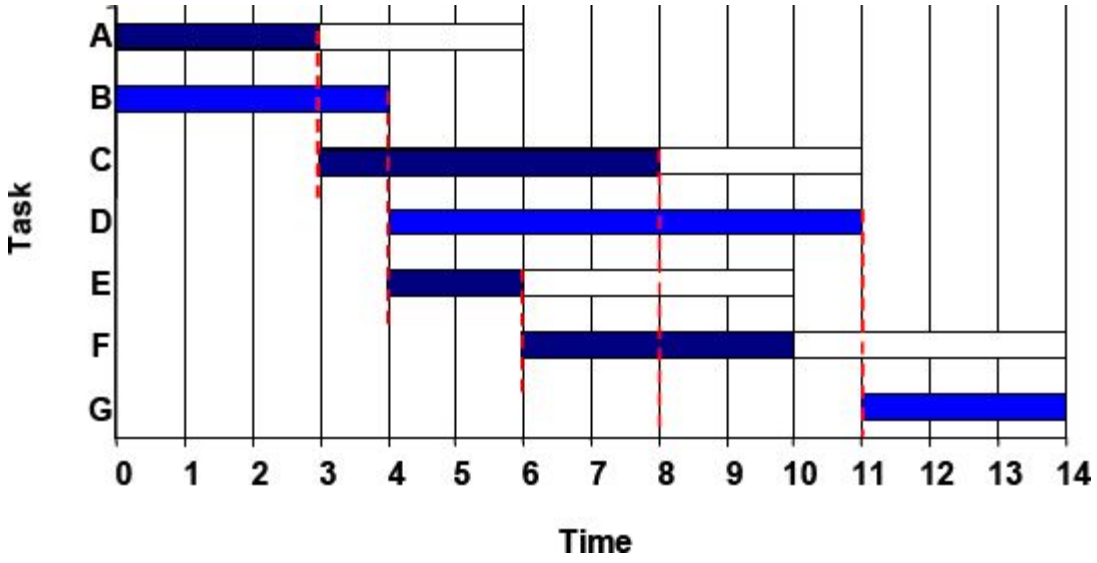
Example1

Task	Duration	Precedence	ES	EF	LS	LF	Slack Time	Critical Task
A	3		0	3	3	6	3	N
B	4		0	4	0	4	0	Y
C	5	A	3	8	6	11	3	N
D	7	B	4	11	4	11	0	Y
E	2	B	4	6	8	10	4	N
F	4	E	6	10	10	14	4	N
G	3	C,D	11	14	11	14	0	Y

STAFFING & RE-SCHEDULING

The original schedule (constructed above) for this project is as shown below.

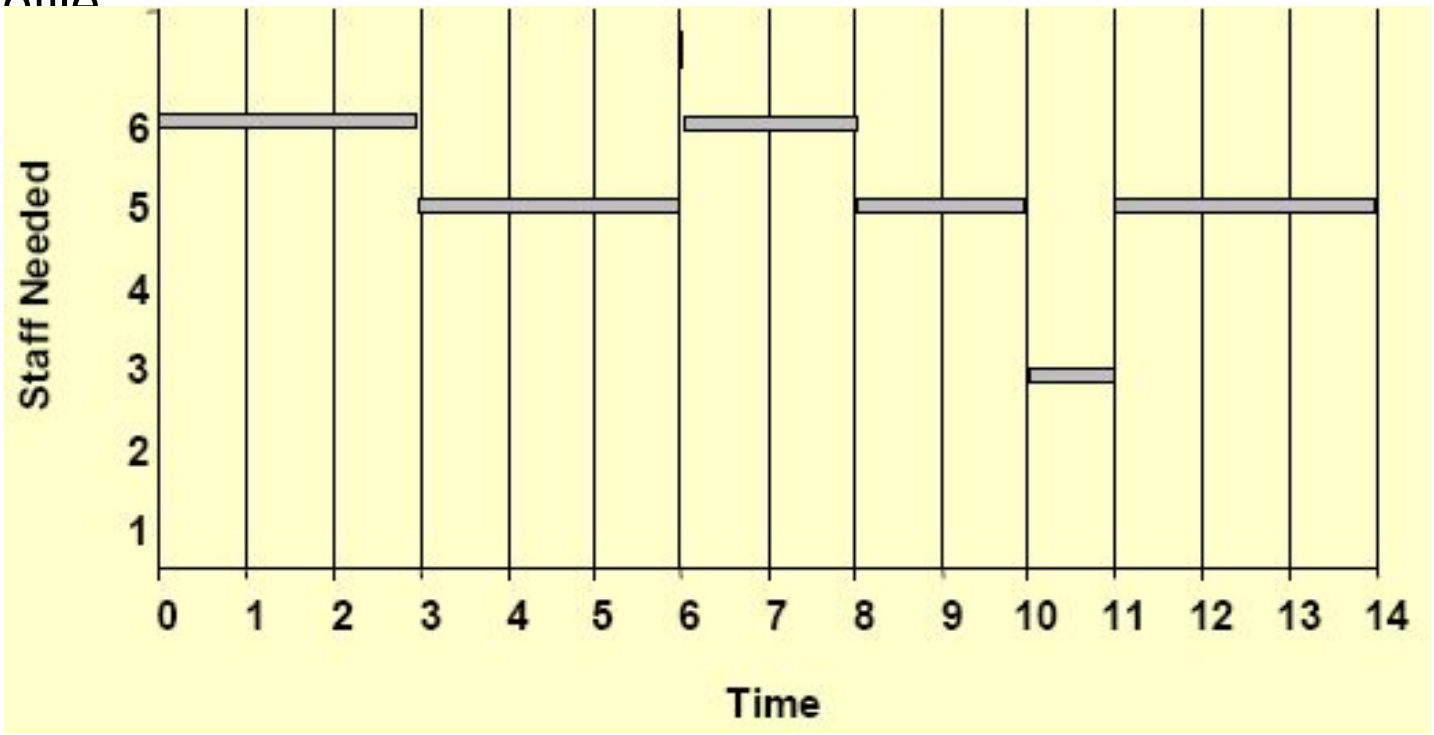
Task	Duration	Staff Needed
A	3	2
B	4	4
C	5	1
D	7	3
E	2	1
F	4	2
G	3	5



1. Staff utilisation = (3x2+4x4+5x1+7x3+2x1+4x2+3x5)/(14x6) = 0.857 = 85.5%

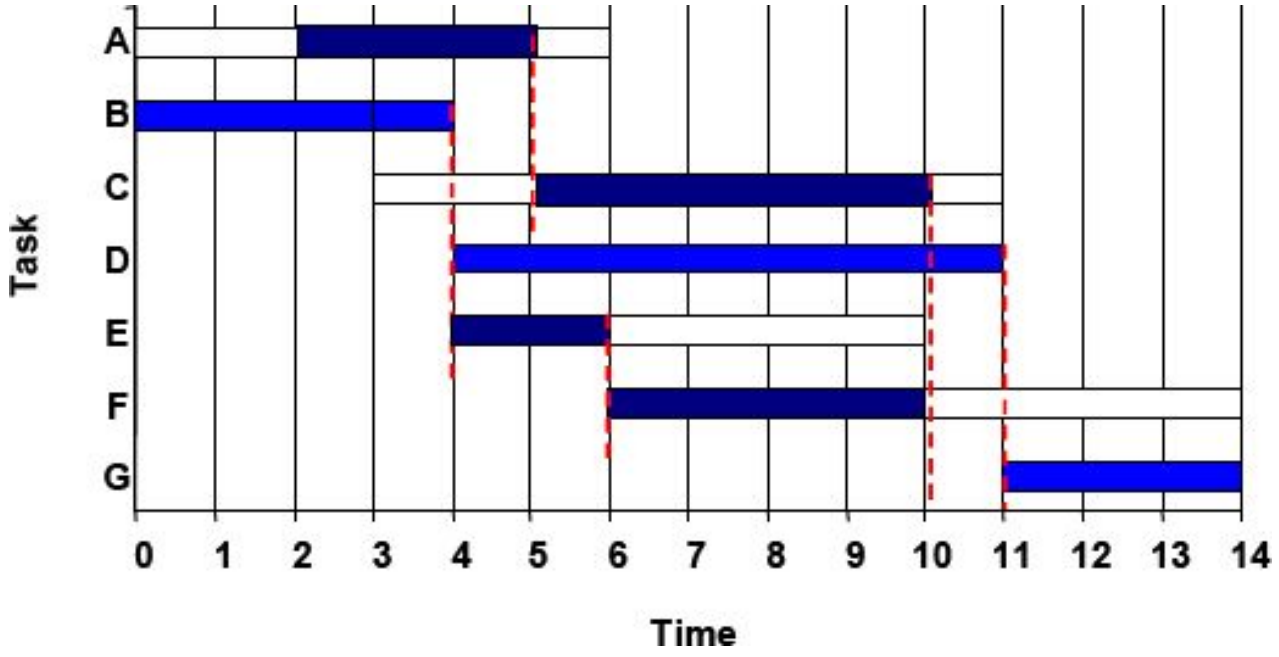
STAFFING & RE-SCHEDULING

2. Work out the Staff Profile



STAFFING & RE-SCHEDULING

- Now, assume that there are 6 people available for working in this project but one of them returns from holidays at time=2.
- So *re-scheduling* is needed because activities A and B cannot be carried out in parallel until time=2.



STAFFING & RE-SCHEDULING

- Suppose another scenario in which equipment and materials needed to carry out activities E and F are available at time=5 and time=9 respectively instead of being available at the activities ES time. Then, rescheduling is needed but the overall duration of the project is not affected.