CPA

The need to plan complex projects

- CPA is a project analysis and planning method that allows a project to be completed in the shortest time
- Many larger businesses get involved in projects that are complex and involve significant investment and risk
- As the complexity and risk increase there is a need to identify the relationships between the activities involved and to work out the most efficient way of completing the project

Information needed for CPA

- A list of all activities required to complete the project
- The time (duration)that each activity will take to completion
- The dependencies between the activities (eg activity x cannot be started until w and t are complete)

CPA calculates

- The longest path of planned activities to the end of the project
- The earliest start time (EST) and latest finish time (LFT) that each activity can start and finish without making the project longer
- Which activities are critical (a delay in these delays the whole project)
- Which have “float” (can be delayed without affecting the project end)

What is the critical path?

- The sequence of project activities which add up to the longest overall duration
- The critical path determines the shortest time possible to complete the project

Why is the critical path so important?

- Any delay of an activity on the critical path directly impacts the planned project completion date – there is no float on the critical path.

Example – making tea

- List of Activities
- Activity A - Boil the kettle
- Activity B - Put teabag in mug
- Activity C - Pour water into mug
- Activity D - Take teabag out of mug
- What is the relationship between these tasks?

Example – making tea

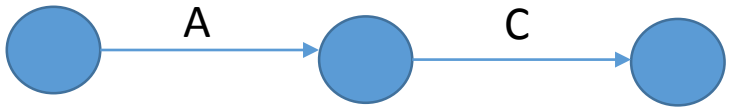
- List of Activities
- Activity A - Boil the kettle
- Activity B - Put teabag in mug
- Activity C - Pour water into mug
- Activity D - Take teabag out of mug
- A must be completed before C can start
- A,B,C must be completed before D can start

Activity	Prior Activity
A	None
B	None
C	A
D	A,B,C

Example – making tea

- List of Activities
- Activity A - Boil the kettle
- Activity B - Put teabag in mug
- Activity C - Pour water into mug
- Activity D - Take teabag out of mug
- A must be completed before C can start
- This is an activity on arrow diagram

Activity	Prior Activity
C	A



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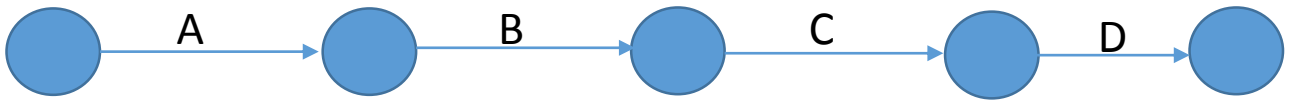
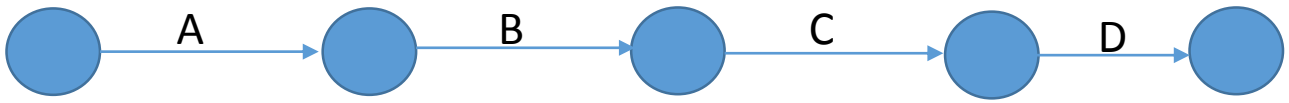


Example – making tea

- List of Activities
- Activity A - Boil the kettle
- Activity B - Put teabag in mug
- Activity C - Pour water into mug
- Activity D - Take teabag out of mug
- But wait! There is something wrong.

Activity	Prior Activity
D	A,B,C



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- Activity A - Boil the kettle
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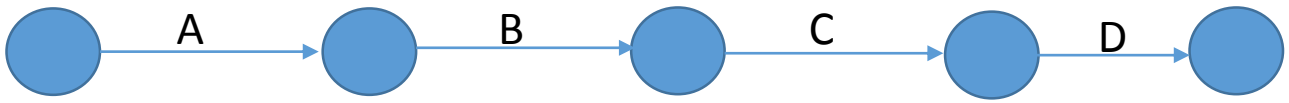
- But wait! There is something wrong.
- B doesn’t have to wait for A and C doesn’t have to wait for B



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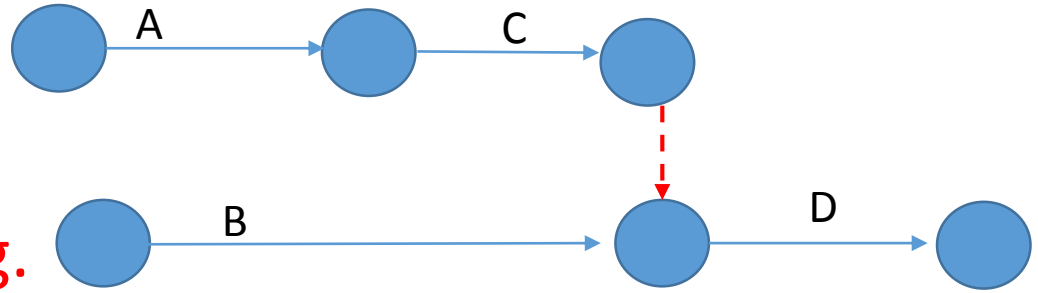
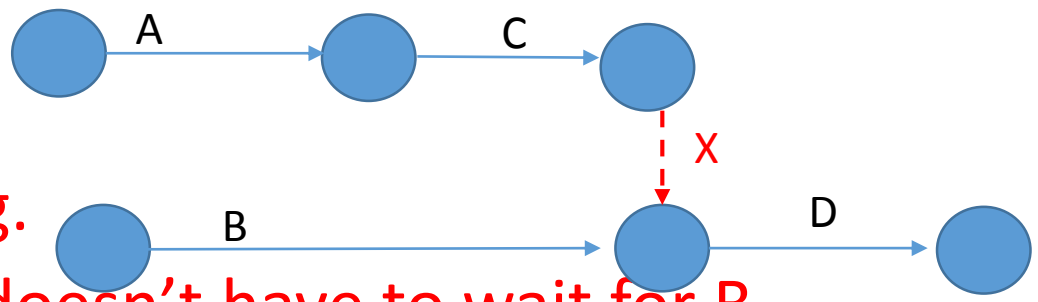


Example – making tea

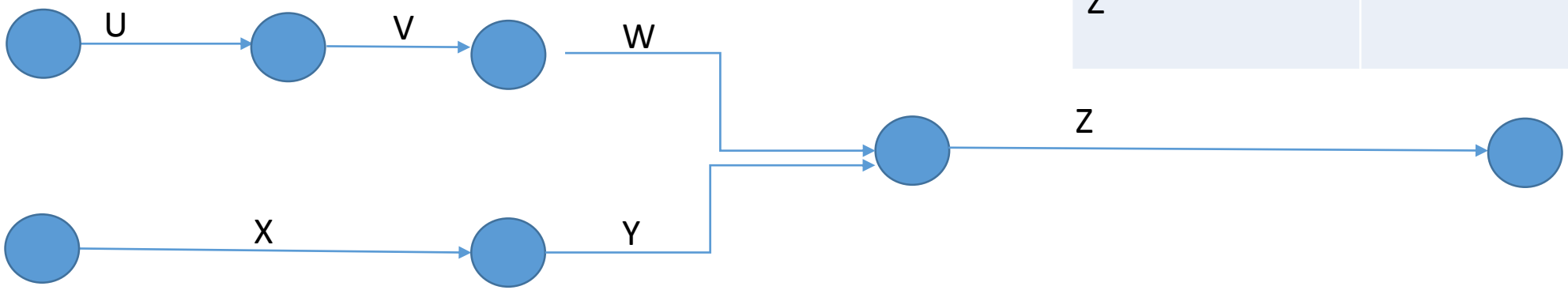
Activity	Prior Activity
A	None
B	None
C	A
D	A,B

- List of Activities
- Activity A - Boil the kettle
- Activity B - Put teabag in mug
- Activity C - Pour water into mug
- Activity D - Take teabag out of mug
- But wait! There is something wrong.
- B doesn't have to wait for A and C doesn't have to wait for B
- X is not an activity. It is a dummy activity with zero duration
- X would NOT be labelled on the diagram normally



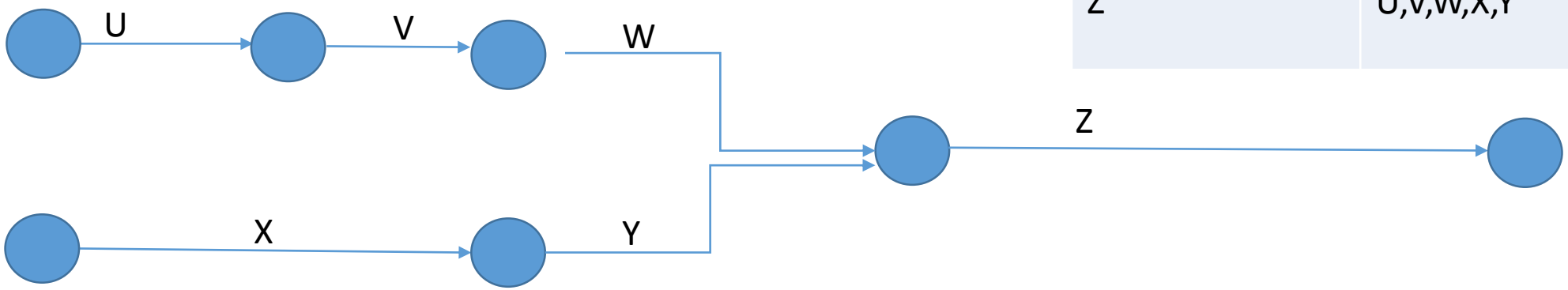
Complete the activity table

Activity	Prior Activity
U	None
V	
W	
X	
Y	
Z	



Complete the activity table

Activity	Prior Activity
U	None
V	U
W	U,V
X	None
Y	X
Z	U,V,W,X,Y



Complete the activity table

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U	None
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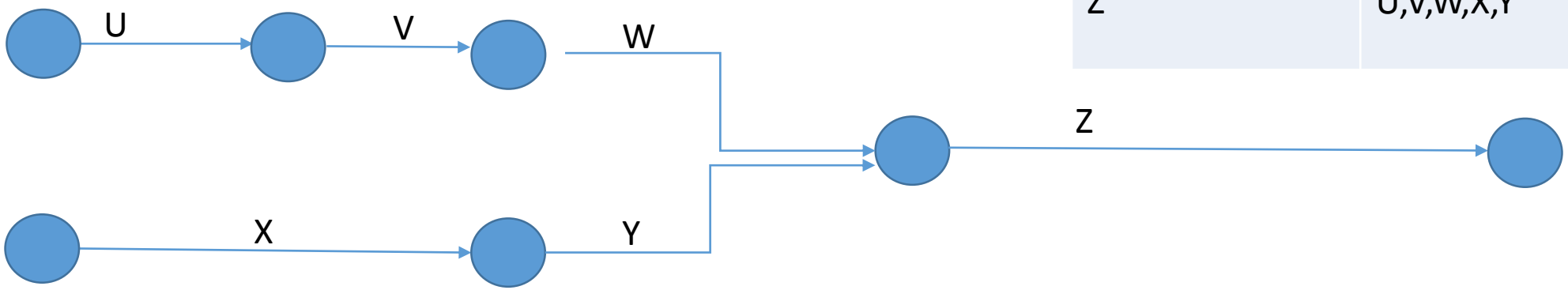

V and X must now be complete before W can start. Sketch the CPA network and add a dummy activity to indicate this.

Complete the activity table

Activity	Prior Activity
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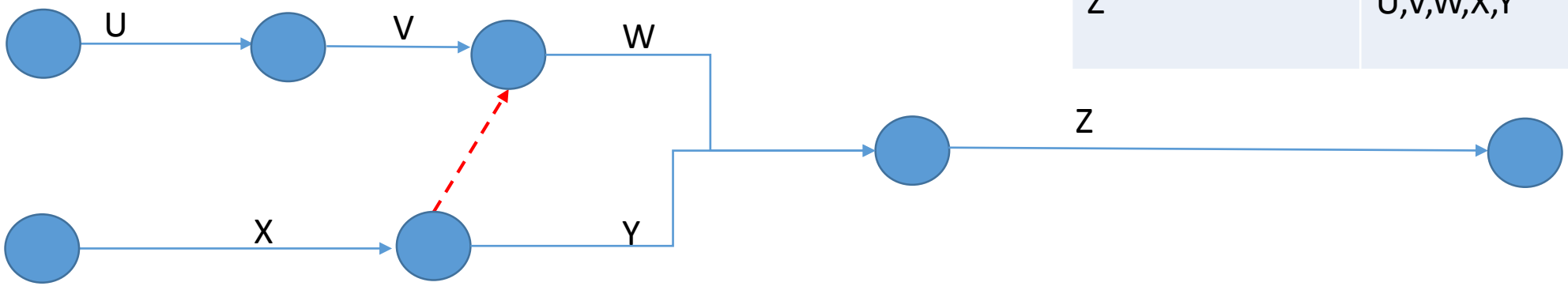
V	U
W	V,X
X	None
Y	X
Z	U,V,W,X,Y



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What about duration?

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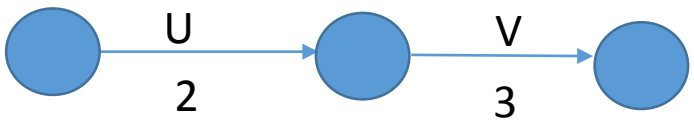
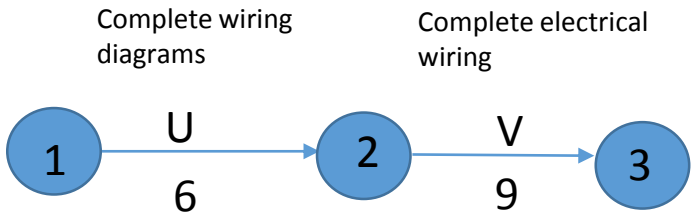


What about duration?

- We need to estimate how long each activity will take and add this in to the diagram.
- We can add a description of the activity above the arrow.



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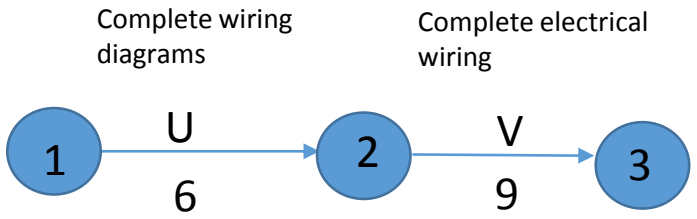
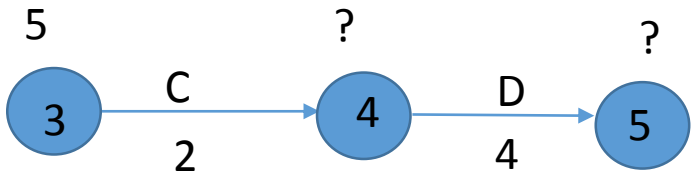


Activity U can be identified as 1,2
Activity V can be identified as 2,3

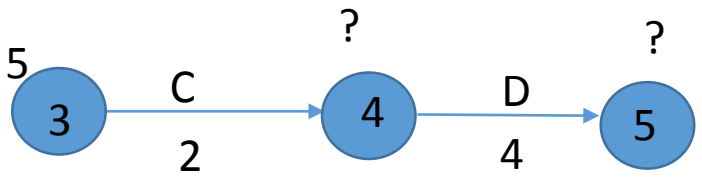
Float

- The earliest time of an event is defined as the earliest time by which all activities leading into that event can be completed.



Float

- The earliest start time (EST) of an event is defined as the earliest time by which all activities leading into that event can be completed.
- EST = EST of preceding event + duration
- The first node has an EST of 0



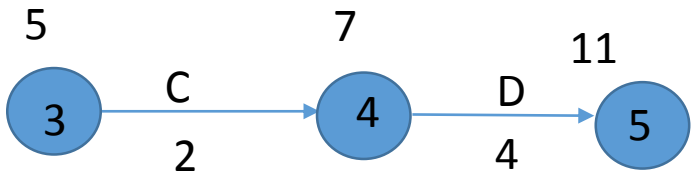
- Add the duration
- If more than one activity leads to a node, the highest figure is the new EST

Float

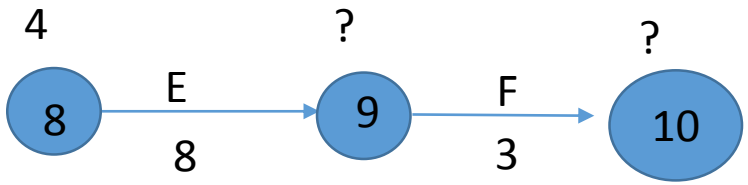
- EST’s are calculated from left to right
- This process is known as a FORWARD PASS

Float

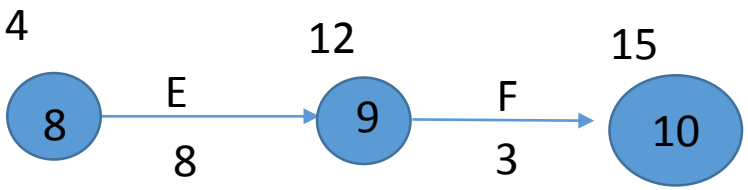
- The earliest start date(EST) of an event is defined as the earliest date by which all activities leading into that event can be completed.
- Earliest Date = Earliest date of preceding event + duration



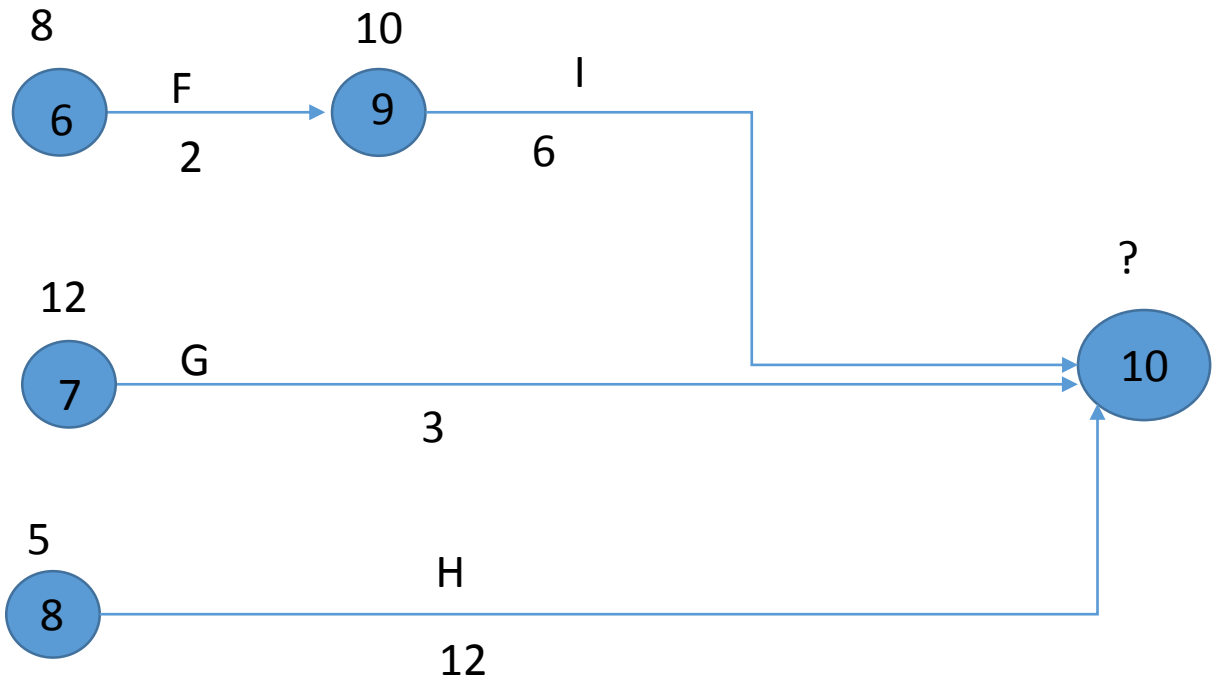
Float



Float

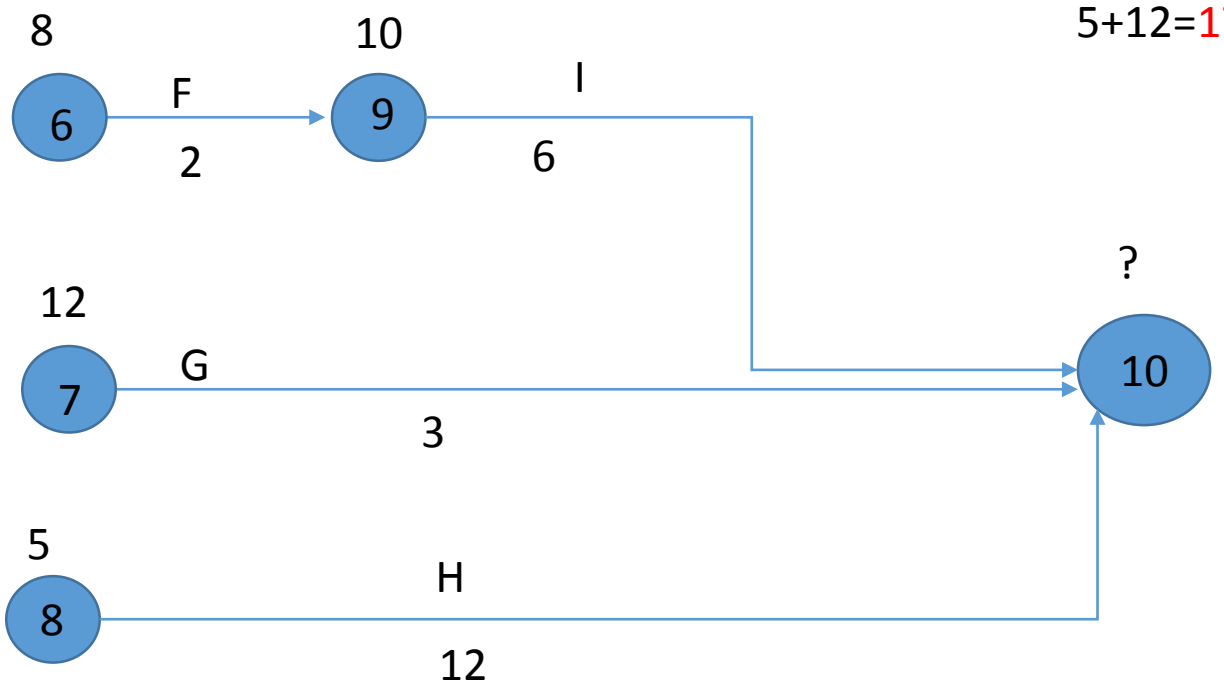


What is the earliest date for event 10?



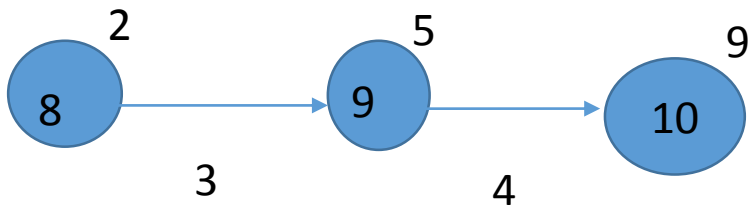
What is the earliest date for event 10?

10+6=16
12+3=15
5+12=17

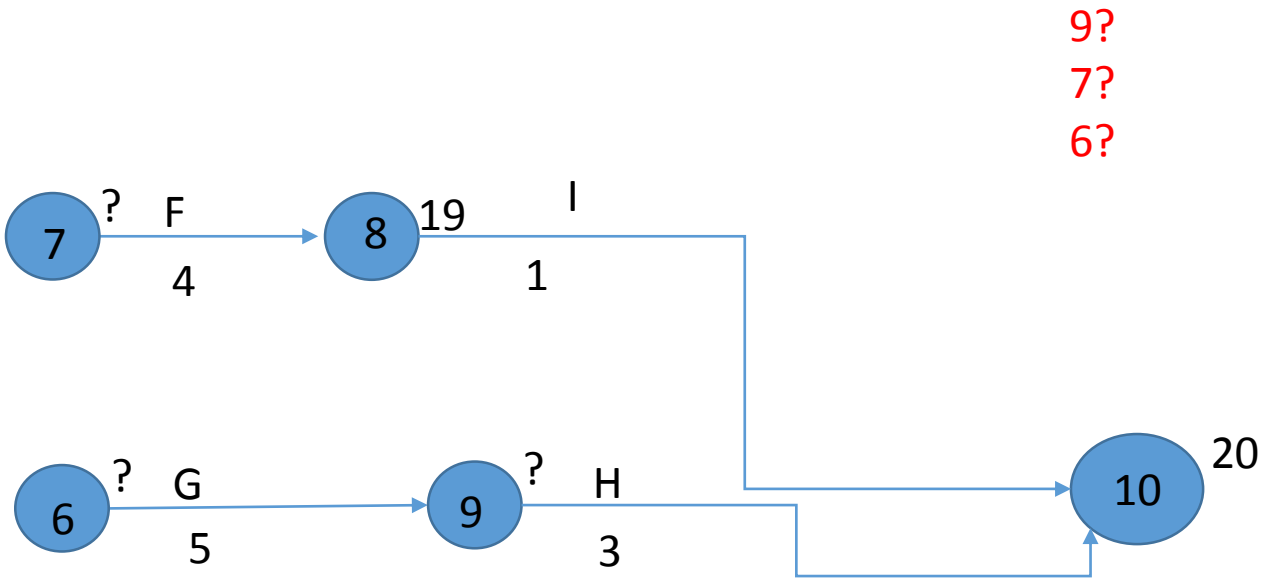


Latest Finish Time (LFT)

- The latest time is obtained by a process called the BACKWARD PASS
- Give the last node of the project an LFT = to the EST
- Work backwards from right to left
- Subtract the duration of the activity from the LFT
- Where there is more than one activity take the lowest figure

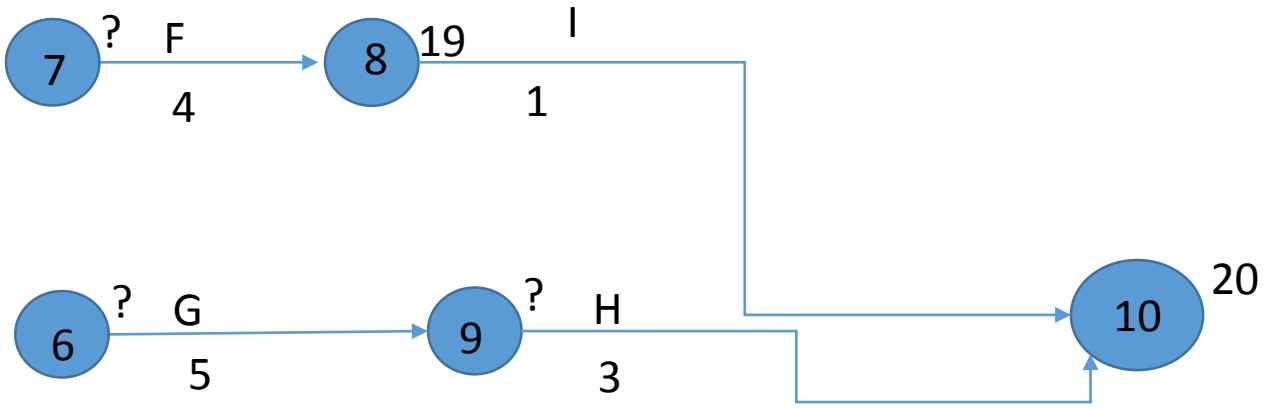


What is the latest date for events 9, 7 and 6?

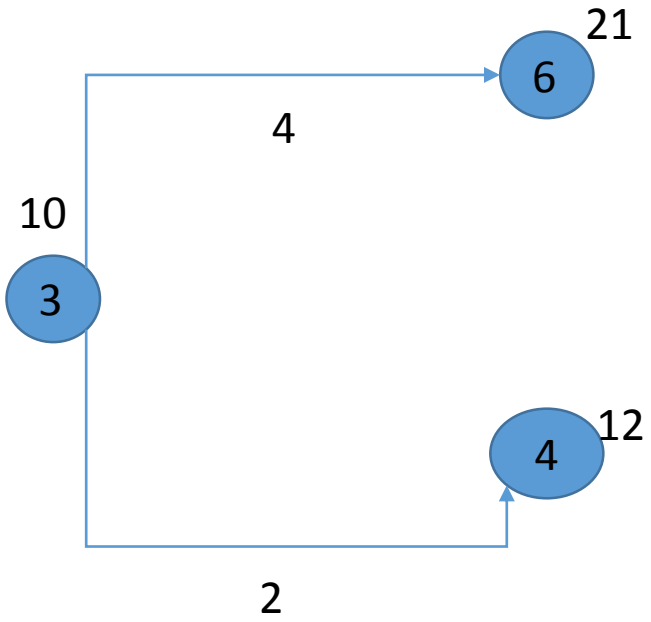


What is the latest date for events 9, 7 and 6?

9=20-3=17
7=19-4=15
6=17-5=12

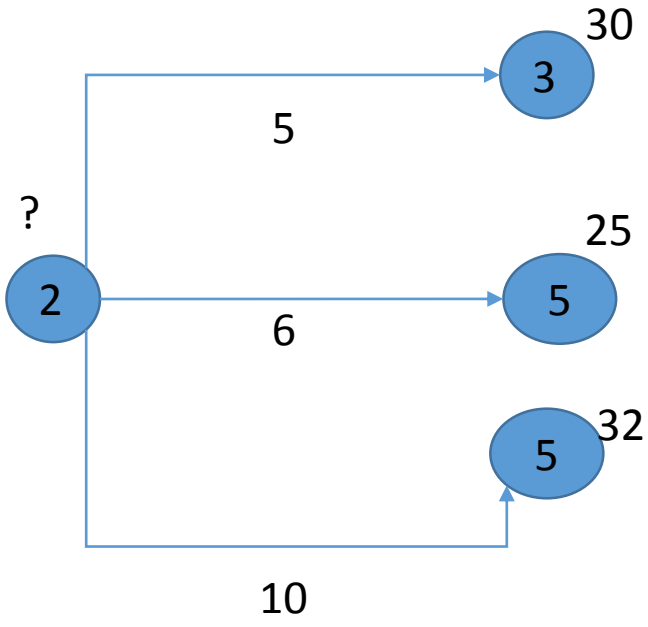


Where more than one activity leads from an event take the lowest figure.



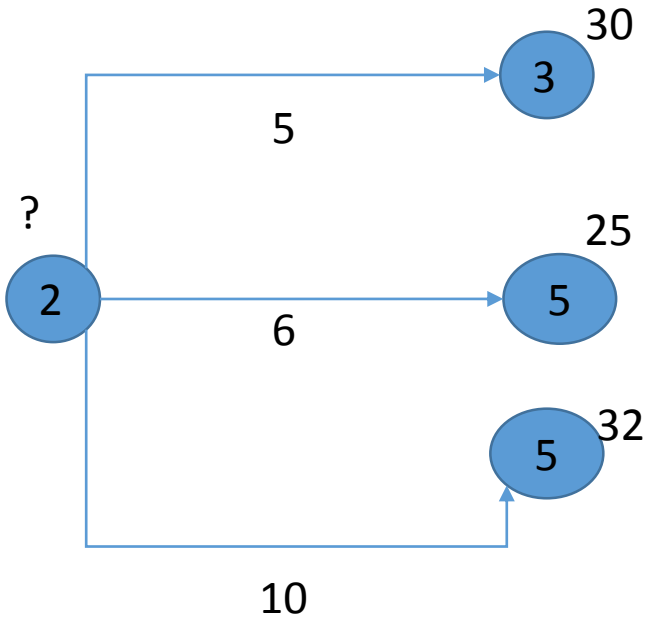
21-4=17
12-2=10

Give the latest date of event 2



21-4=17
12-2=10

Give the latest date of event 2

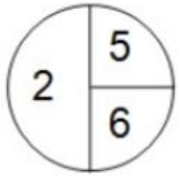


19
30-5=25
25-6=19
32-10=22

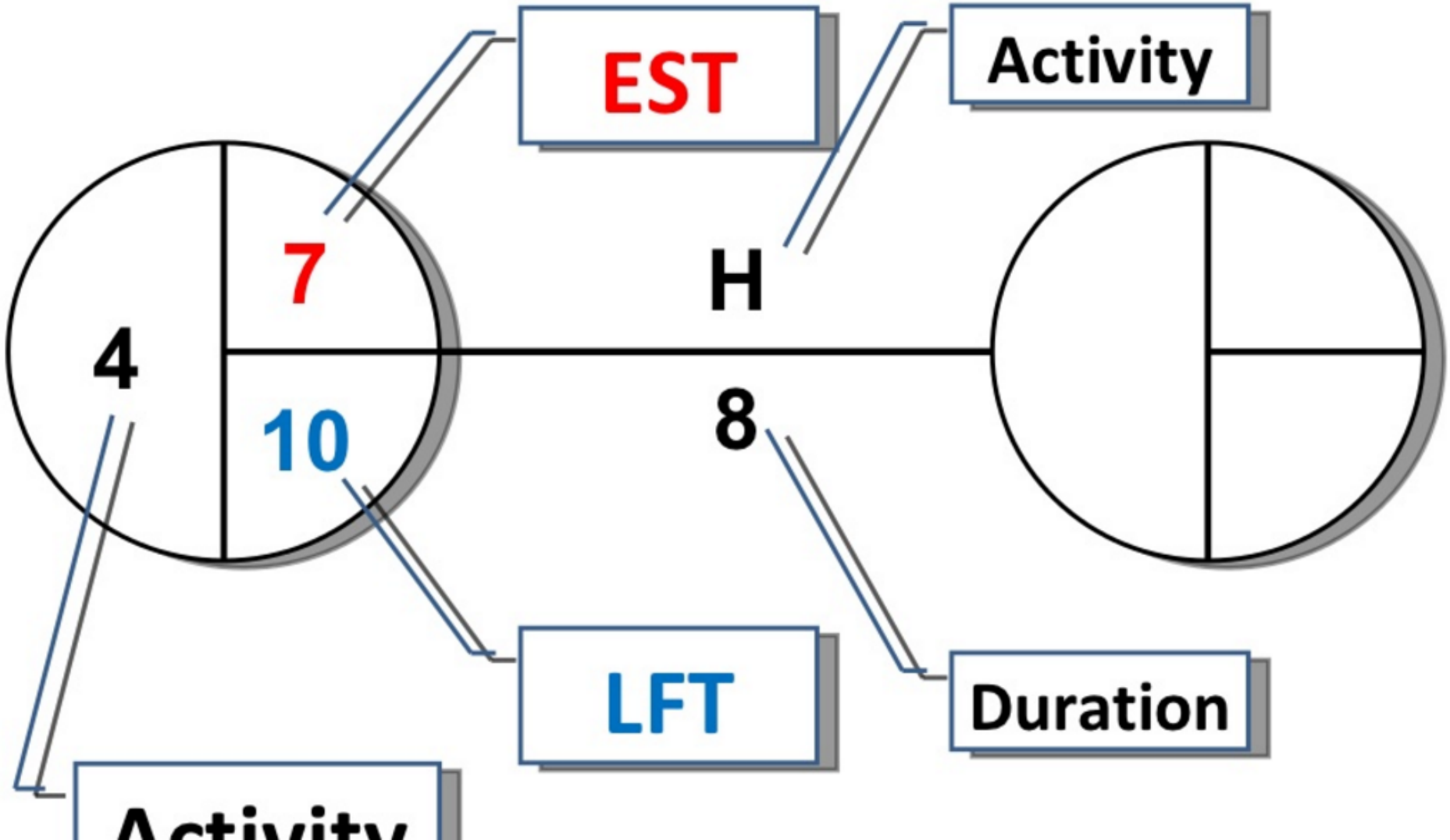
CPA Network Diagrams

- Another method of drawing the critical path is the network diagram
- Here the information is shown in the node

Drawing the network

Component	Description
Node	A **circle** that represents a point in time where an activity is started or finished. The node (circle) is split into three sections:
	The left half of the circle is the **unique node (activity) number** – the network diagram draws these in order The top right section shows the **earliest start time (EST)** that an activity can commence based on the completion of the previous activity The bottom right section shows the **latest finish time (LFT)** by which the previous activity must be completed
Activities	An activity is something that takes time. An activity is shown on the network as a **line**, linking the nodes (circles). A description of the activity, or a letter representing the activity, is usually shown above the relevant line
Duration	The length of time it takes to complete an activity – shown as a number of the relevant units (e.g. hours, days) **under the activity line**

The network diagram - layout



- https://www.youtube.com/watch?v=YndeX-U04HA

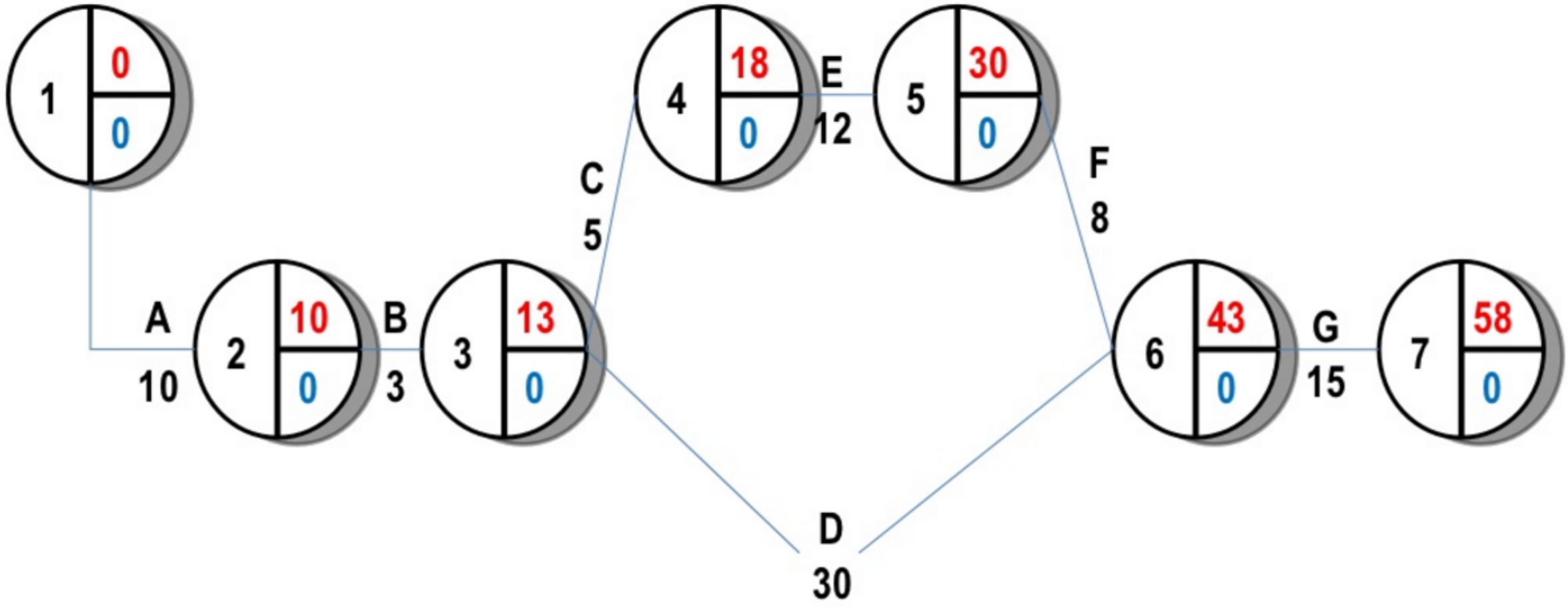
Simple project example – revising for exams

Task	Activity	Dependent on	Duration (hours)
A	Gather lesson notes and read through	Starting activity	10
B	Identify gaps in knowledge	Completion of task A	3
C	Research online sources	Completion of task B	5
D	Procrastinate and browse Facebook	Completion of task B	30
E	Write revision plan & revision notes	Completion of task B & C	12
F	Practice past exam papers	Begin when E complete	8
G	Complete last minute cramming		15

Calculating ESTs

- The first node will always have an EST of zero!
- ESTs are calculated from left to right
- Add the **duration** of an activity to the EST of a previous node
- If more than one activity leads to a node, the highest figure becomes the new EST

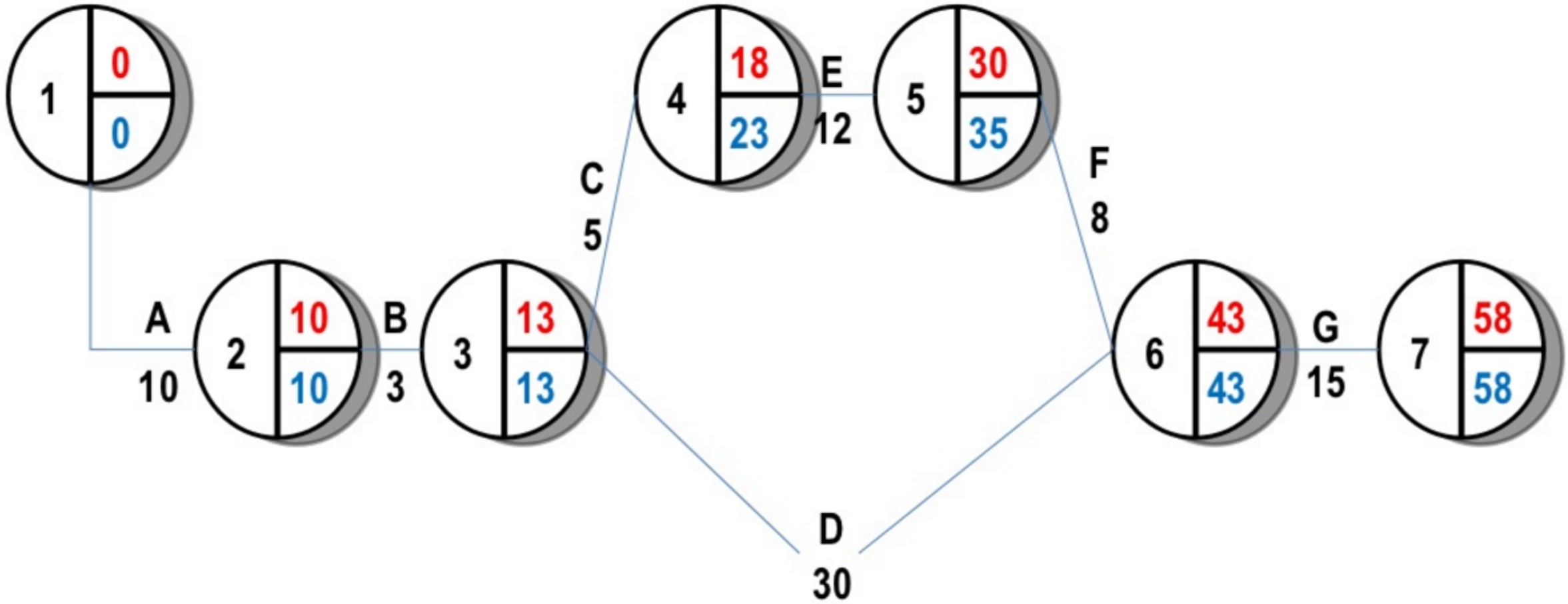
Calculating ESTs – Exam Project



Calculating LFTs

- Give the last node of the project an LFT = to the EST
- Work backwards from right to left
- Subtract the duration of the activity from the LFT

Calculating EFTs – Exam Project



Calculating the float

The **float** is the duration an activity can be extended or postponed so that the project still finishes within the minimum time

Calculated as:

LFT less Activity Duration less **EST**

Calculated float – Exam Project

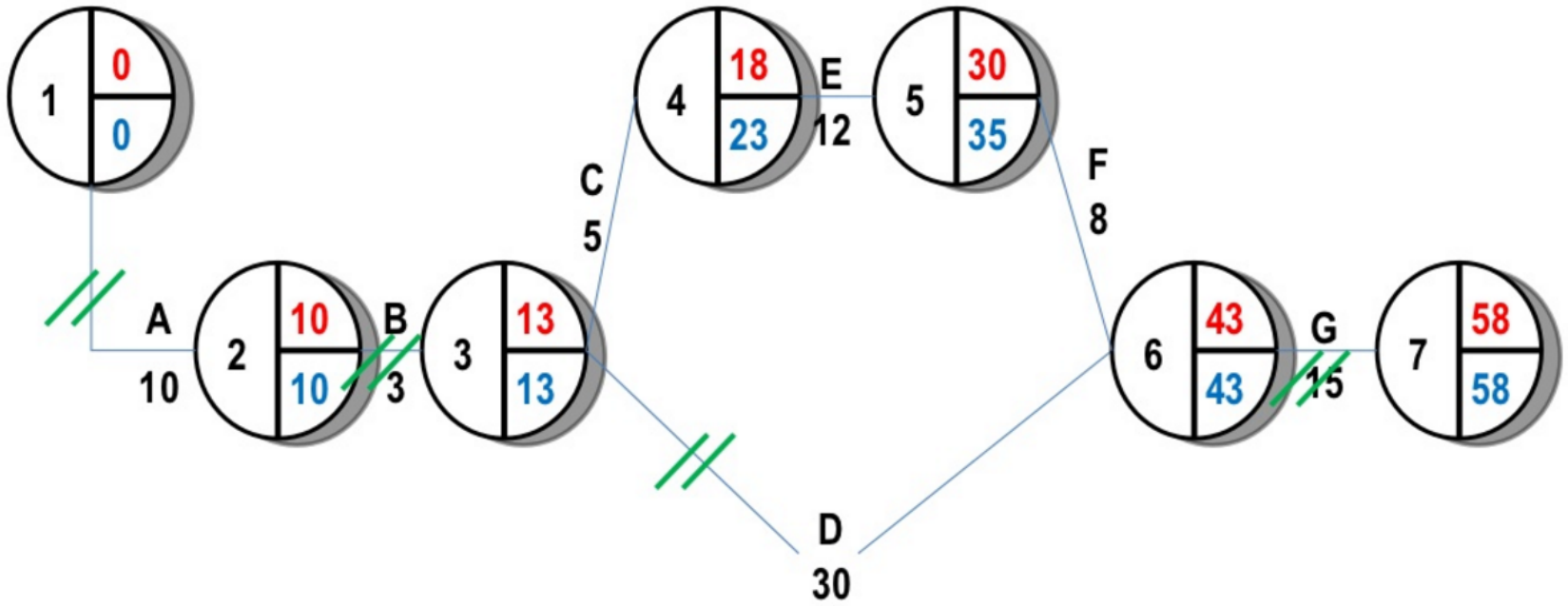
Activity	LFT	Duration	EST	Total Float
A	10	10	0	0
B	13	3	10	0
C	23	5	13	5
D	43	30	13	0
E	35	12	18	5
F	43	8	30	5
G	58	15	43	0

Identifying the critical path

- Activities with a float of 0 (zero) cannot be delayed without delaying the entire project
- Such activities represent the “critical path”
- On the critical path, activities have an **equal** EST and LET

Clip slide

Identifying the critical path



Represents the Critical Path for this Project

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Uses of critical path analysis

- Estimate and minimise project time
- Support project costing and evaluation
- Plan and organise resources
- Prioritise tasks
- Help provide direction (more motivating?

Benefits and drawbacks of CPA

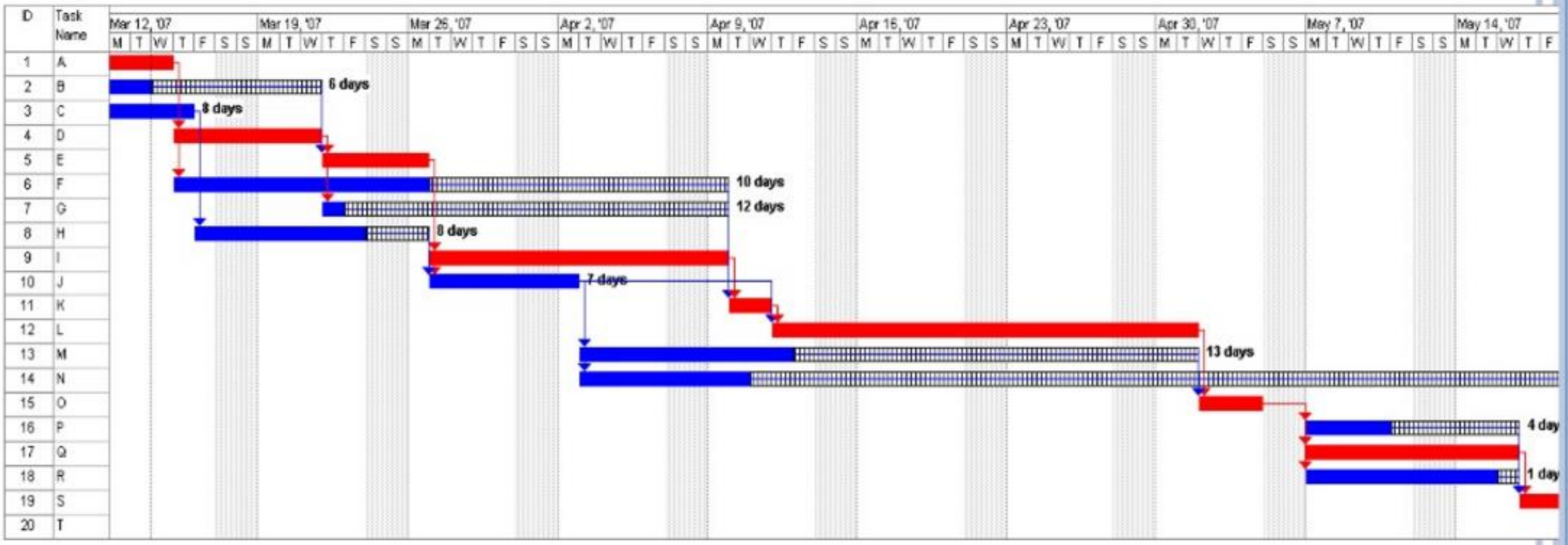
Advantages	Disadvantages
Most importantly – helps reduce the risk and costs of complex projects	Reliability of CPA largely based on accurate estimates and assumptions made
Encourages careful assessment of the requirements of each activity in a project	CPA does not guarantee the success of a project
Help spot which activities have some slack ("float") and could therefore transfer some resources = better allocation of resources	Resources may not actually be as flexible as management hope when they come to address the network float
A decision-making tool and a planning tool – all in one!	Too many activities may the network diagram too complicated. Activities might themselves have to be broken down into mini-projects
Provides managers with a useful overview of a complex project	
Links well with other aspects of business planning, including cash flow forecasting and	

Gantt chart

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


ID
Task Name
Mar 12, '07
Mar 19, '07
Mar 26, '07
Apr 2, '07
Apr 9, '07
Apr 16, '07
Apr 23, '07
Apr 30, '07
May 7, '07
May 14, '07
6 days
8 days
10 days
12 days
8 days
7 days
13 days
4 day
1 day

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/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.

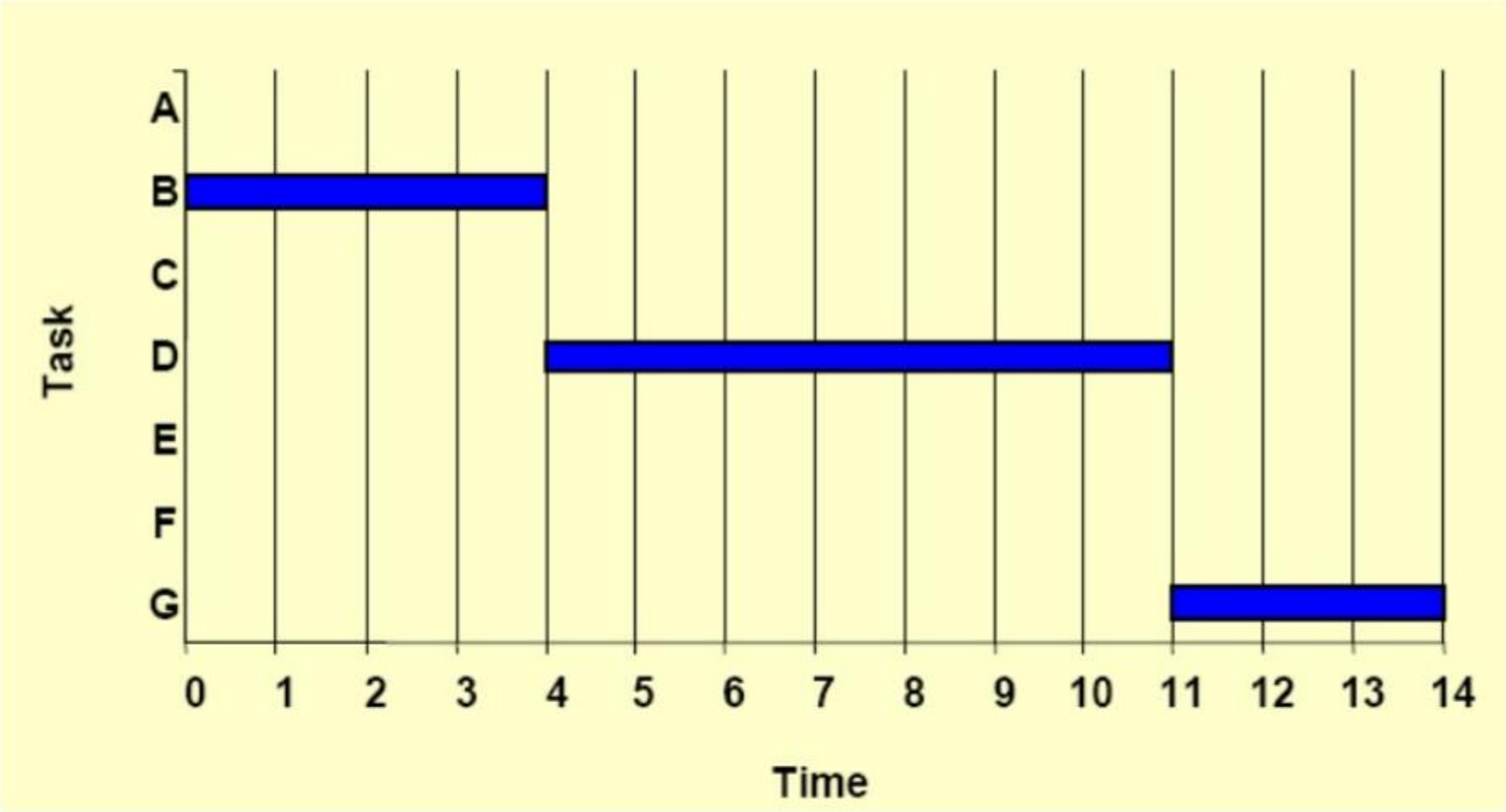
CONSTRUCTING GANTT CHART

- 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

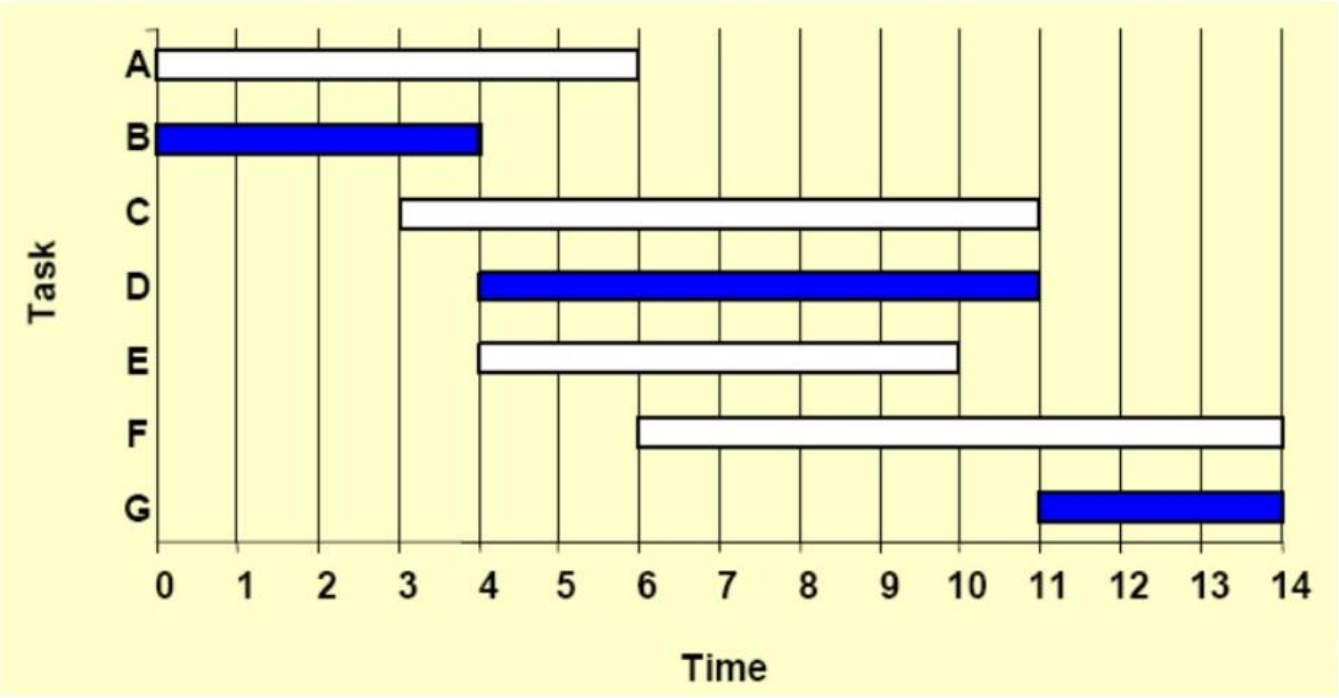
CONSTRUCTING GANTT CHART

Step 1. Schedule critical tasks:



CONSTRUCTING GANTT CHART

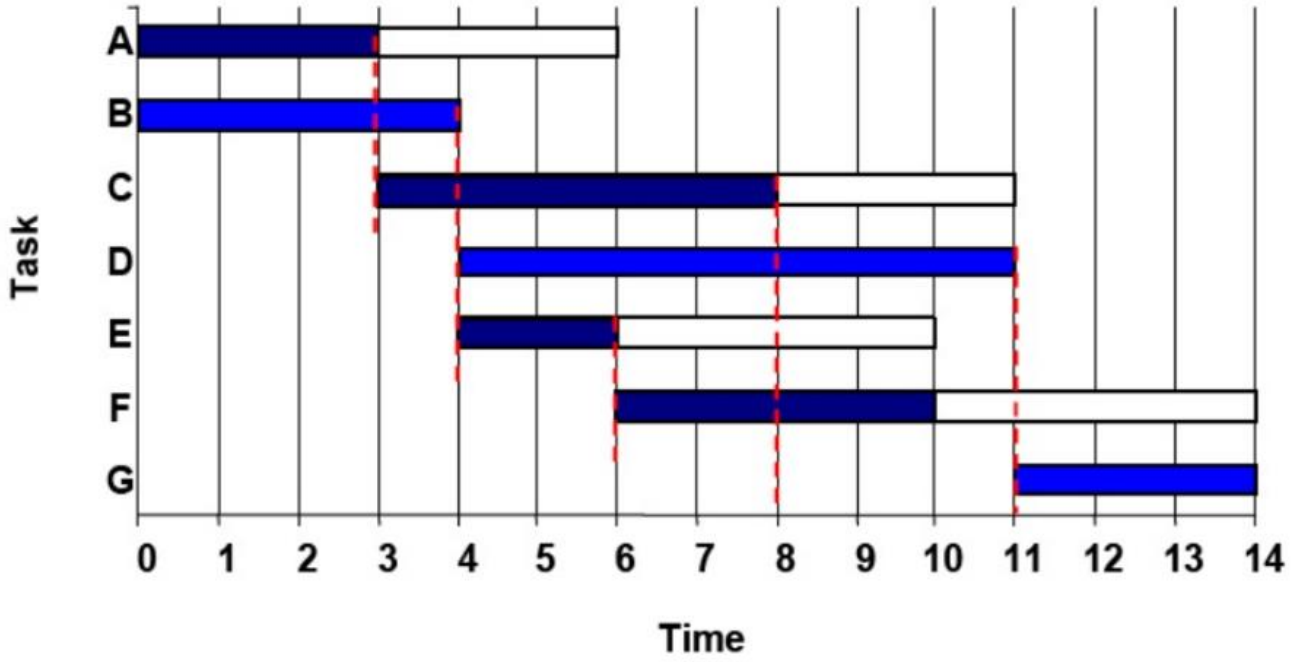
Step 2. Place time windows for non-critical tasks:



CONSTRUCTING GANTT CHART

Step 3. Schedule non-critical tasks

Step 4. Indicate precedence relationships:



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

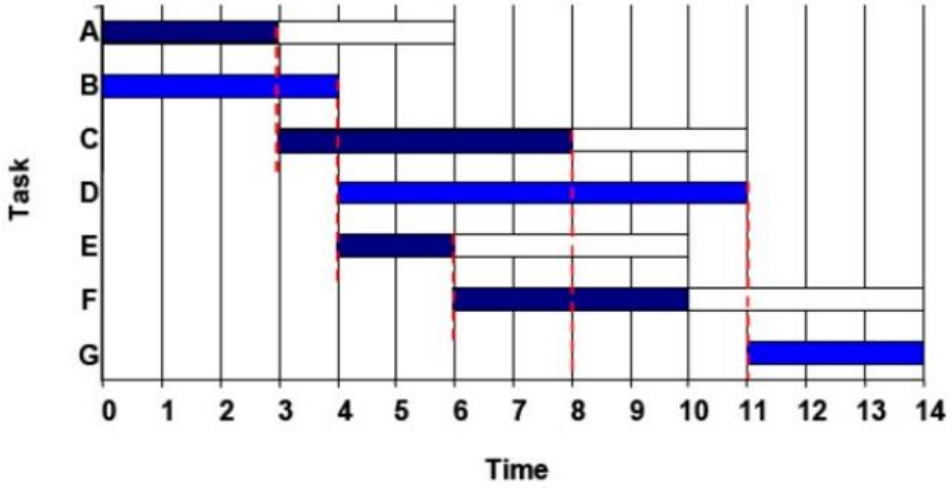
Example1

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.

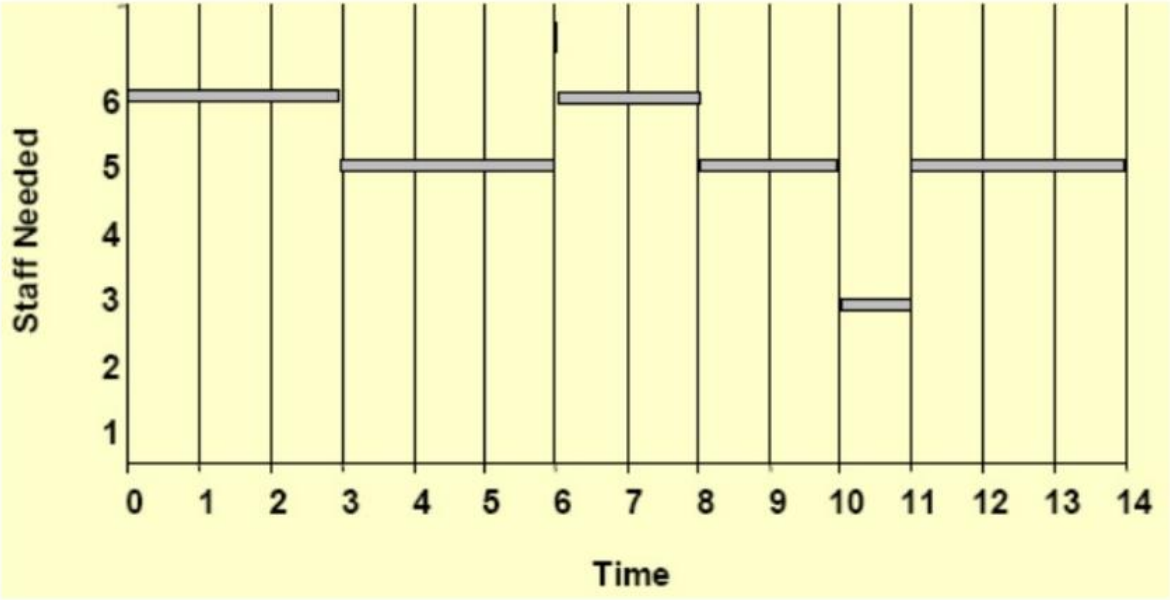
Task	Duration	Staff Needed
A	3	2
B	4	4
C	5	1
D	7	3
E	2	1
F	4	2
G	3	5



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

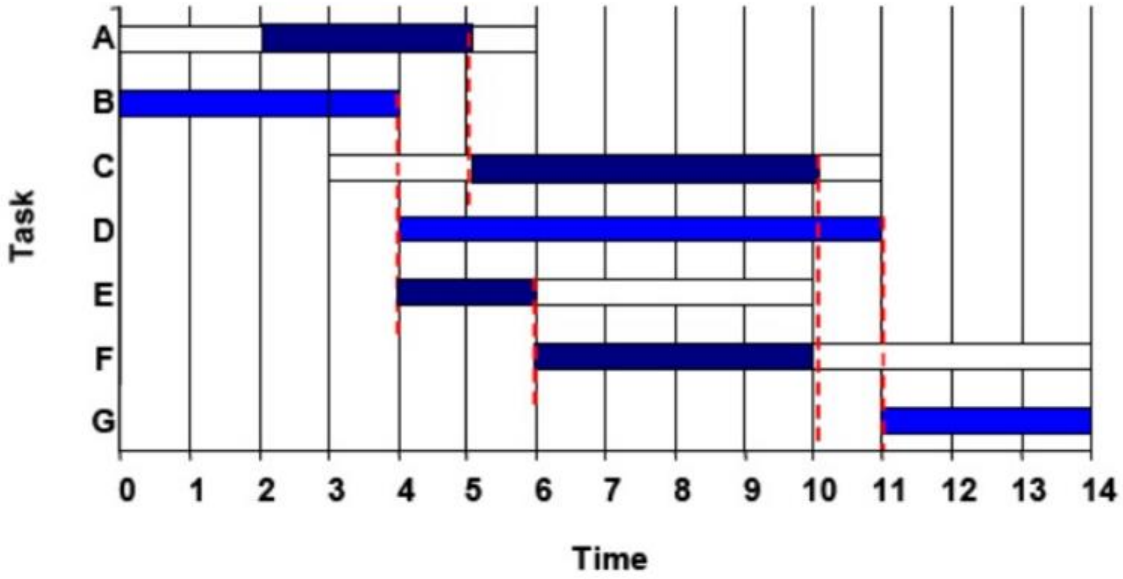
STAFFING & RE-SCHEDULING

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.



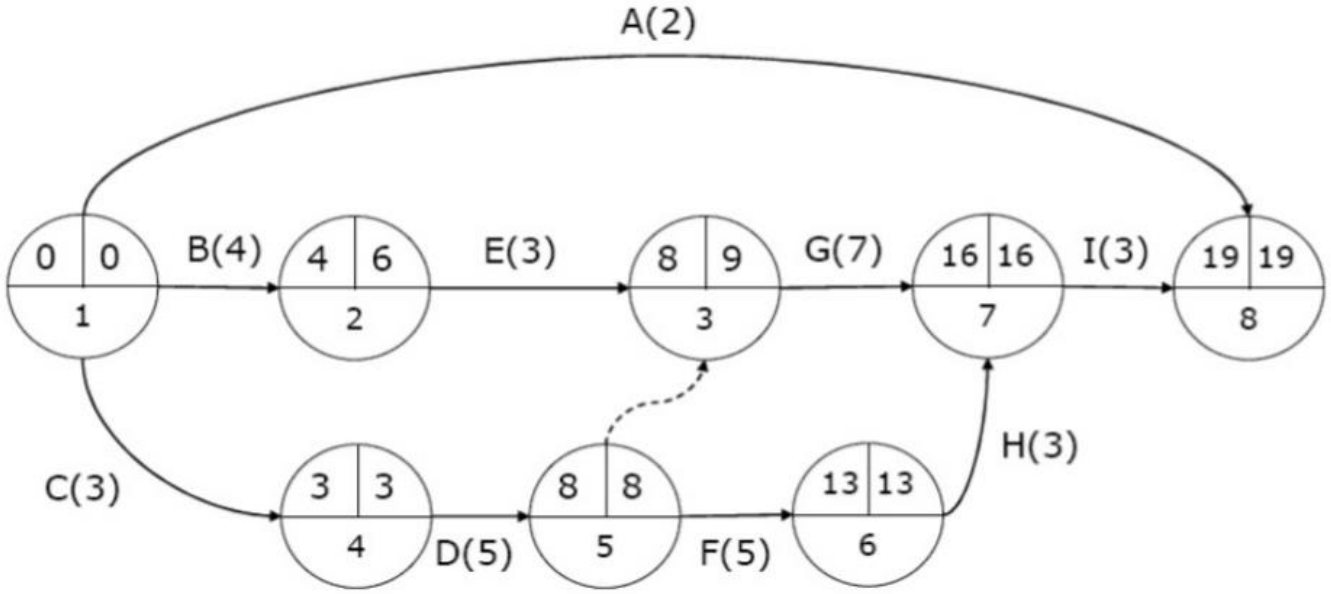
STAFFING & RE-SCHEDULING

- The obvious way to reduce the overall project duration, it is by reducing the duration of the critical activities.
- Crashing Critical Activities refers to reducing the duration of a critical activity by allocating more resources to it.
- The risk is that crashing activities may actually reduce productivity and increase costs.

STAFFING & RE-SCHEDULING

- **Example 2**

  Apply the PERT/CPM method and construct a GANTT chart for the following list of activities with precedence and duration.

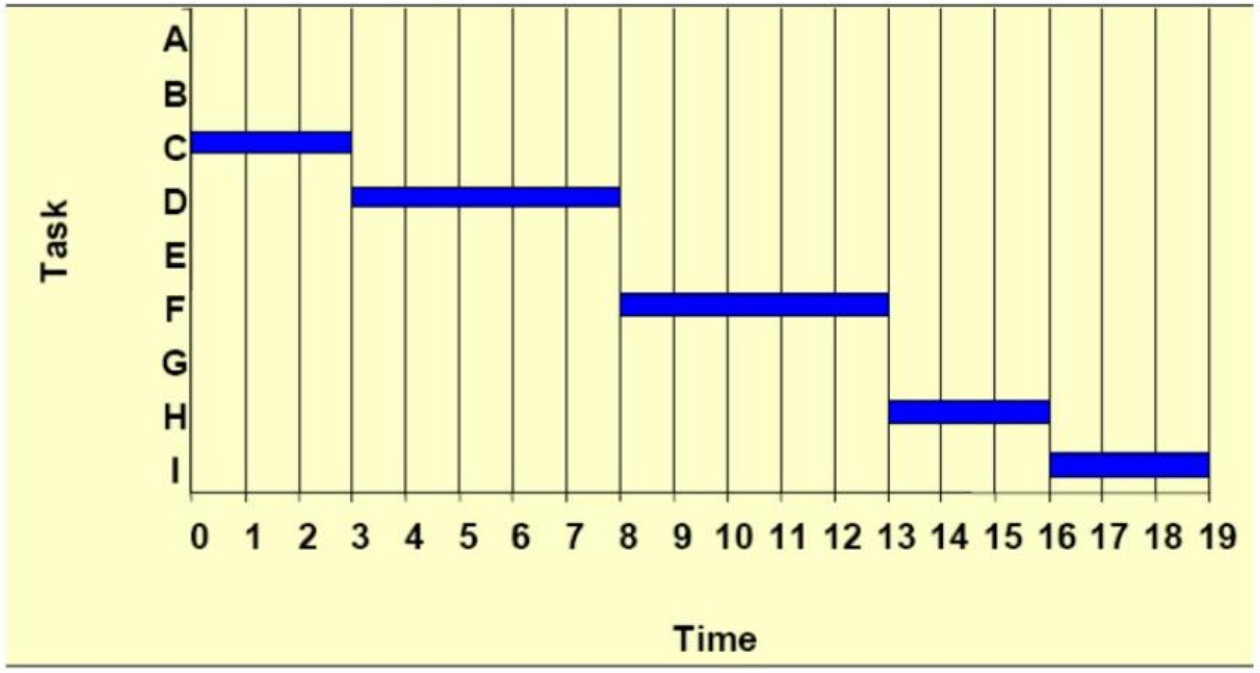


STAFFING & RE-SCHEDULING

Task	Precedence	Duration	ES	EF	LS	LF	Slack Time	Critical Task
A		2	0	2	17	19	17	No
B		4	0	4	2	6	2	No
C		3	0	3	0	3	0	Yes
D	C	5	3	8	3	8	0	Yes
E	B	3	4	7	6	9	2	No
F	D	5	8	13	8	13	0	Yes
G	D,E	7	8	15	9	16	1	No
H	F	3	13	16	13	16	0	Yes
I	G,H	3	16	19	16	19	0	Yes

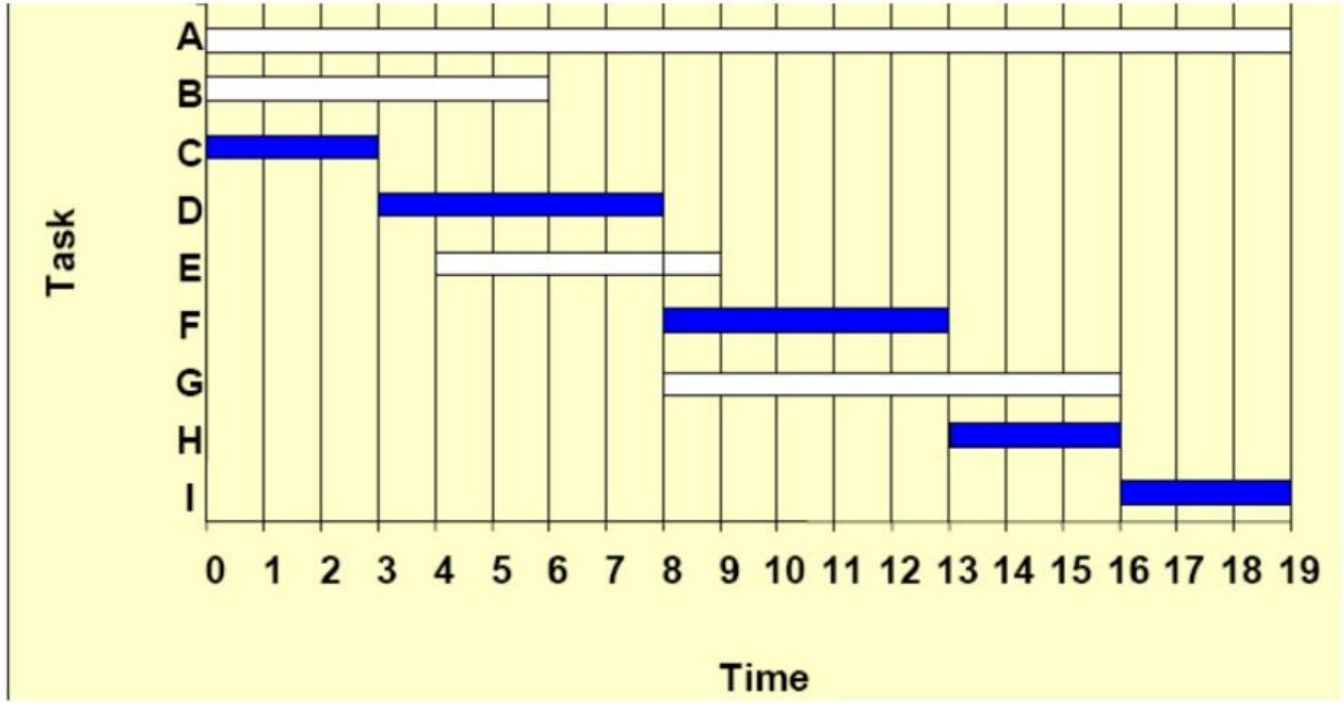
STAFFING & RE-SCHEDULING

Step 1. Schedule critical tasks.



STAFFING & RE-SCHEDULING

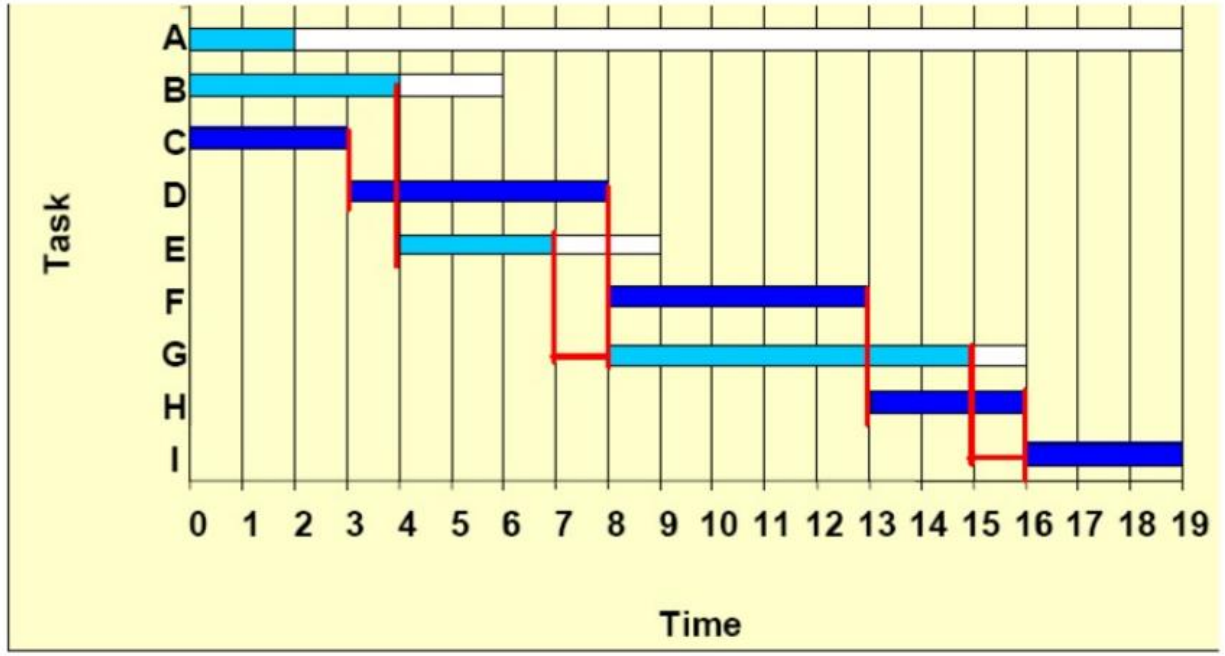
Step 2. Place time windows for non-critical tasks:



STAFFING & RE-SCHEDULING

Step 3. Schedule non-critical tasks:

Step 4. Indicate precedence relationships:



PROJECT MANAGEMENT SOFTWARE

- Benefits of project management software:
  - Calculate project schedule
  - Resource smoothing
  - Automatic generation of reports and charts

- Limitations of project management software
  - Allocation of resources to tasks
  - Estimation of tasks durations
  - Make decisions

Reading: (Kendall&Kendall, chapter 3), (Dennis &Wixom, chapter 3).