Scheduling & Resource Levelling

Slides available at
tomlogan.co.nz/edi_slides.pdf

Handout available at
tomlogan.co.nz/edi_notes.pdf

Building a house

- What are the steps?
  - Foundation
  - Design
  - Paint
  - Walls and ceiling

- Roof
- Wiring
- Plumbing
- etc

How long will the project take?
When do you need to start each of the <u>activities</u> to finish on time?

This is scheduling

Learning Objectives

- Understand the precedence diagram method (PDM)
- Be able to construct a resource unconstrained schedule using the PDM
- Understand how resource levelling provides a resource constrained schedule

Example

Say we have five activities (sub tasks that make up some project):

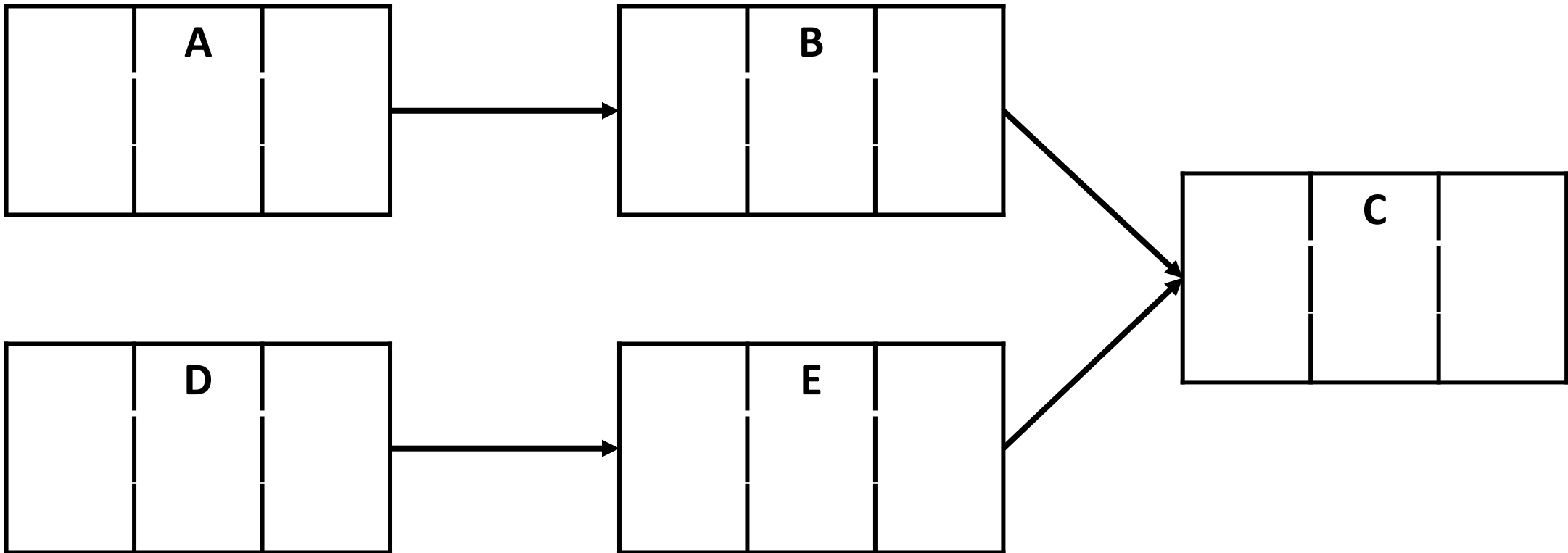| Activity ID	Predecessor	Expected time (days)
A	-	8
B	A	4
C	B, E	5
D	-	3
E	D	2

Precedence Diagram Method (PDM)

Precedence diagram conceptualises which activities precede and succeed one another.

We say A precedes B (or B requires A to finish before it can start):
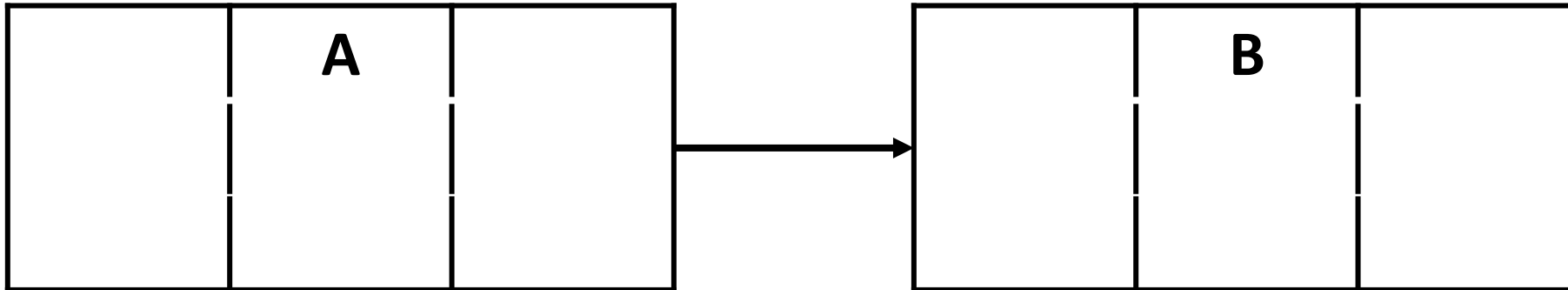
Example: PDM

Activity ID	Predecessor
A	-
B	A
C	B, E
D	-
E	D

PDM

- Scheduling: When should we start each activity so the project finishes on time
- Precedence diagram helps determine this
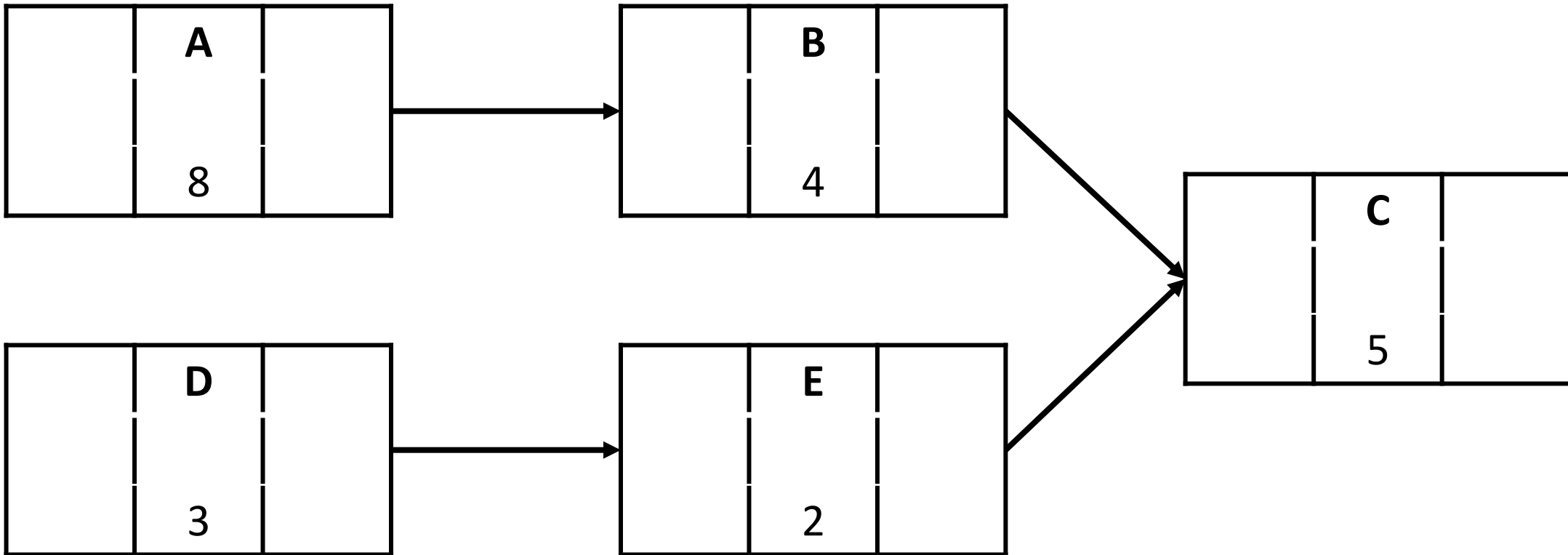
PDM: Early start and finish

- First step is to determine the earliest that an activity can start
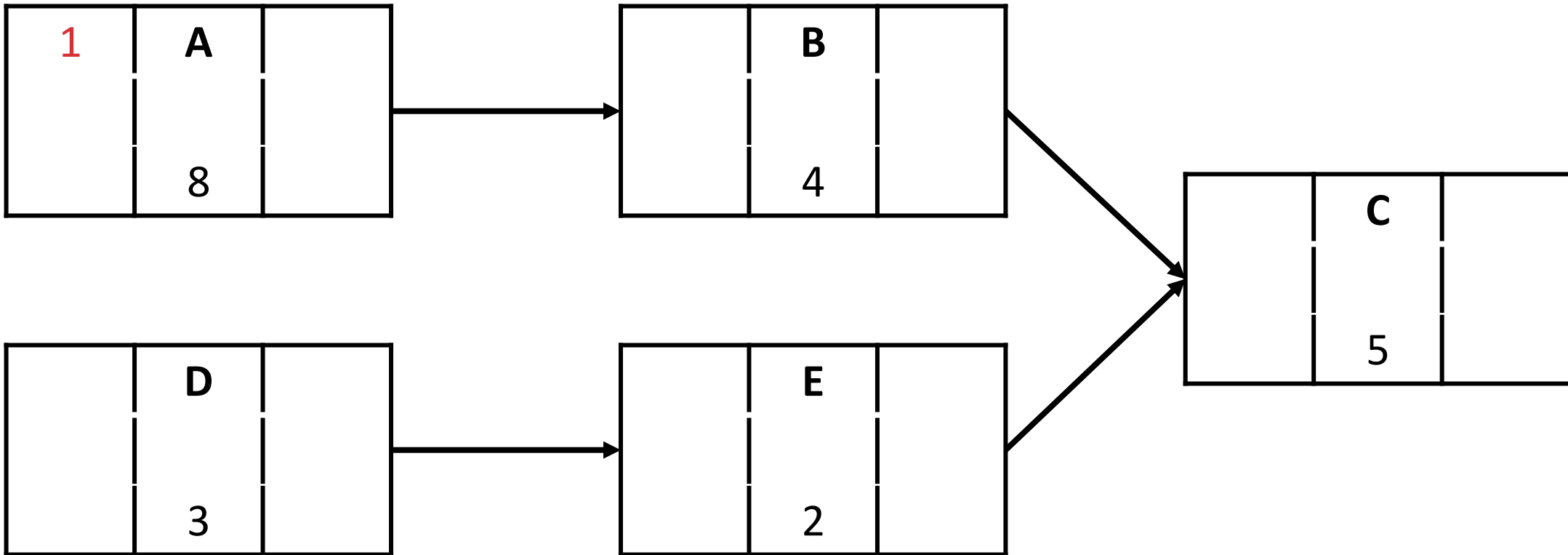- Early start (ES)
- What's the ES of A?

ES	**A**	EF
	dur	

Example: PDM

Activity ID	Expected time (days)
A	8
B	4
C	5
D	3
E	2

Example: PDM

Activity ID	Expected time (days)
A	8
B	4
C	5
D	3
E	2

PDM: Early start and finish

- First step is to determine the earliest that an activity can start

- Early start (ES)

- ES = max of
  - First time step
  - Early finish of predecessor + 1
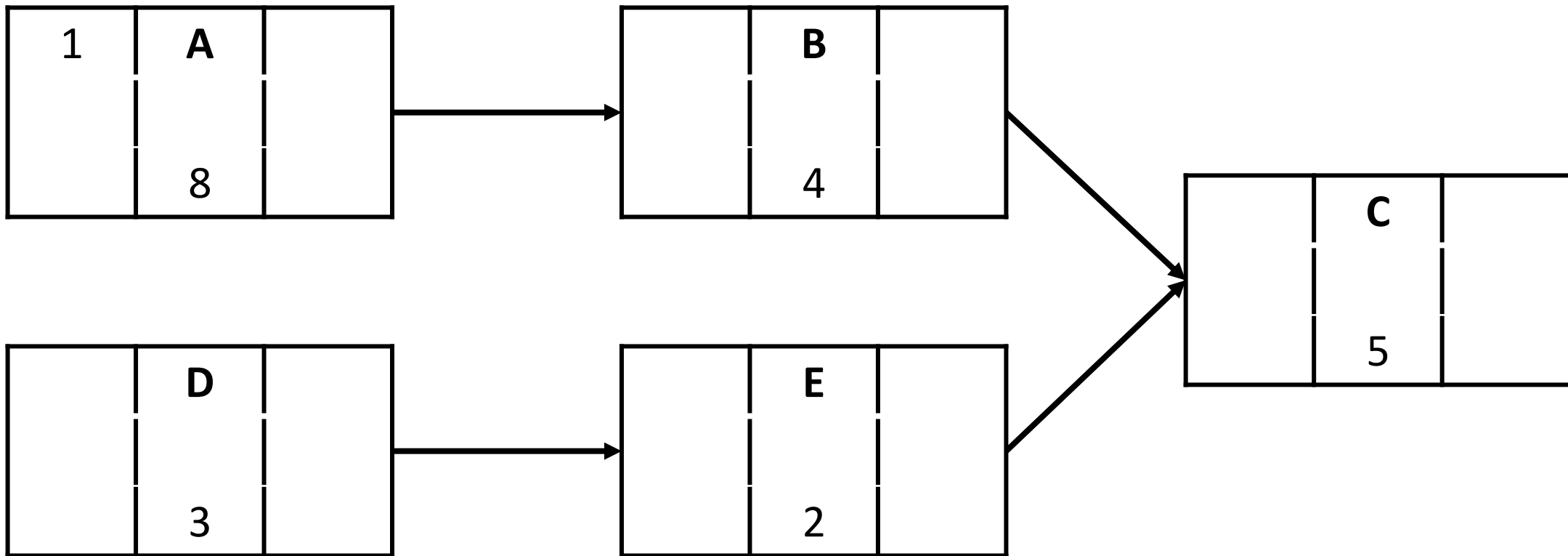
ES	**A**	EF

PDM: Early start and finish

- Then we can determine the earliest date each activity can finish
- Early finish (EF)
- EF = ES + duration – 1
- EF(A) = 8 because A is completed on the eighth day

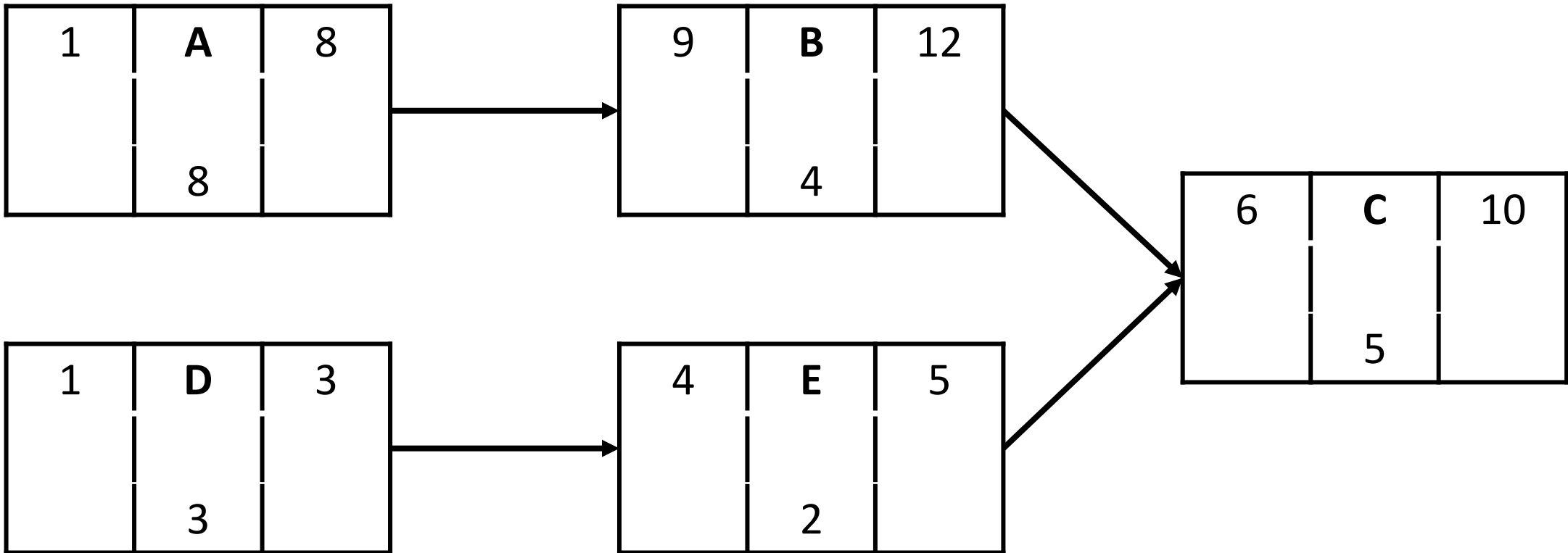| 1	**A**	8
	8	

Example: PDM

Activity ID	Expected time (days)
A	8
B	4
C	5
D	3
E	2

Example: Forward pass

1	**A**	8
	8	

9	**B**	12
	4	

6	**C**	10
	5	

1	**D**	3
	3	

4	**E**	5
	2	

Example: Forward pass

Example: Forward pass

1	A	8
	8	

9	B	12
	4	

13	C	17
	5	

1	D	3
	3	

4	E	5
	2	
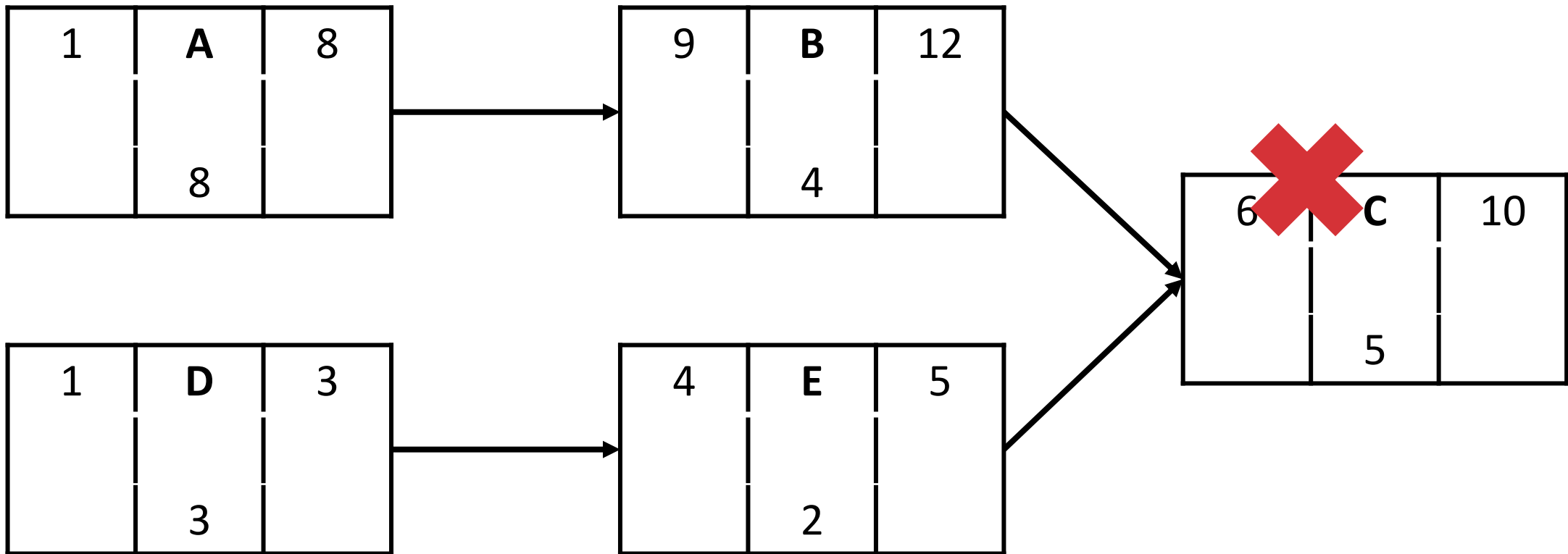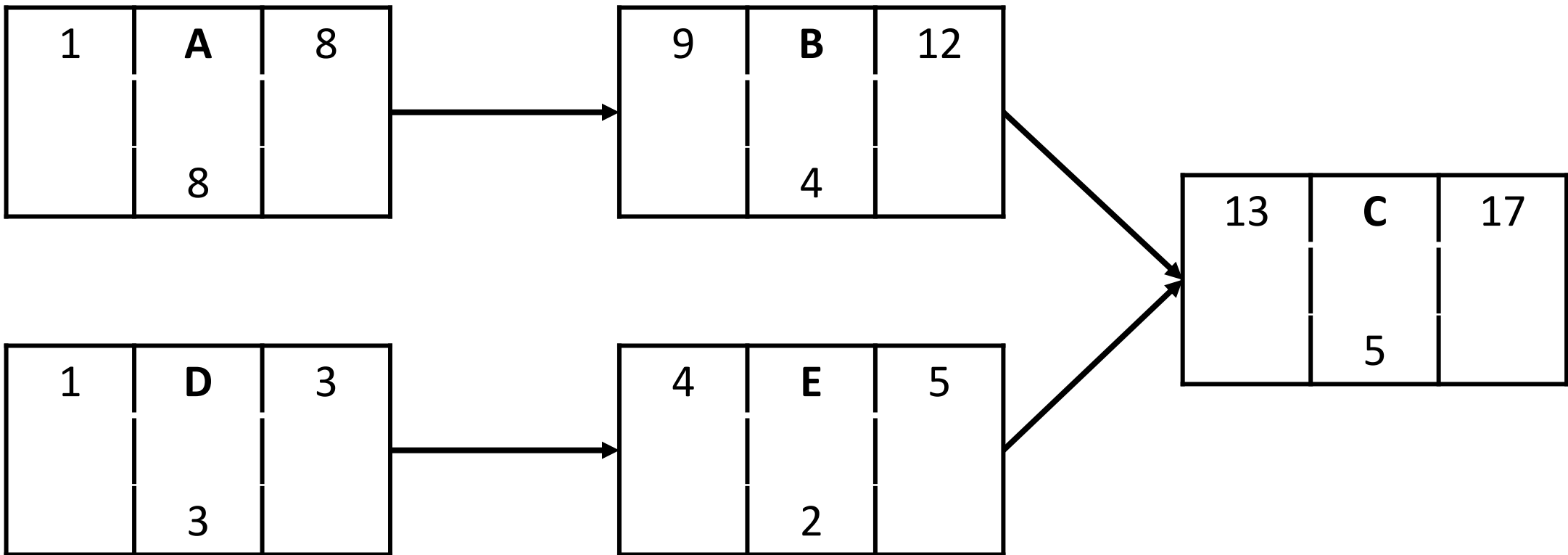
PDM: Late start and finish
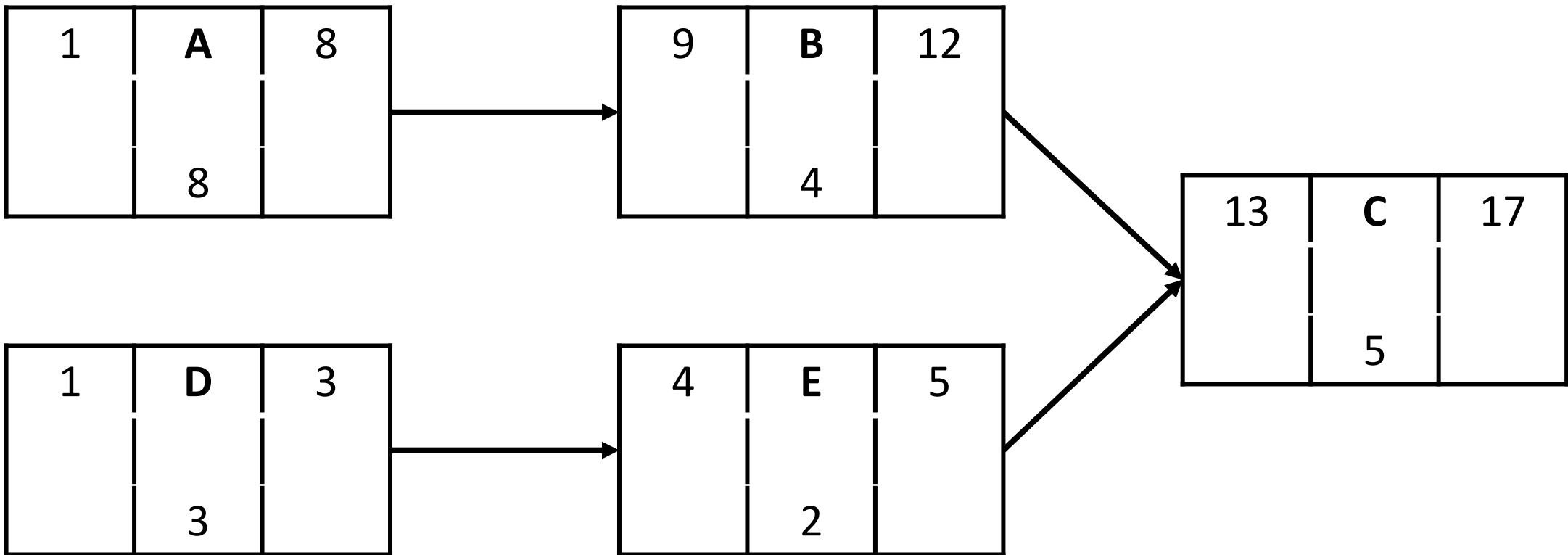
- Calculating the ES and EF is known as the forward pass

- ES tells us the earliest we can start an activity

- We also want some wiggle room – when is the latest we can start an activity without affecting the deadline?

- LS (late start)

- What is the LS of A?

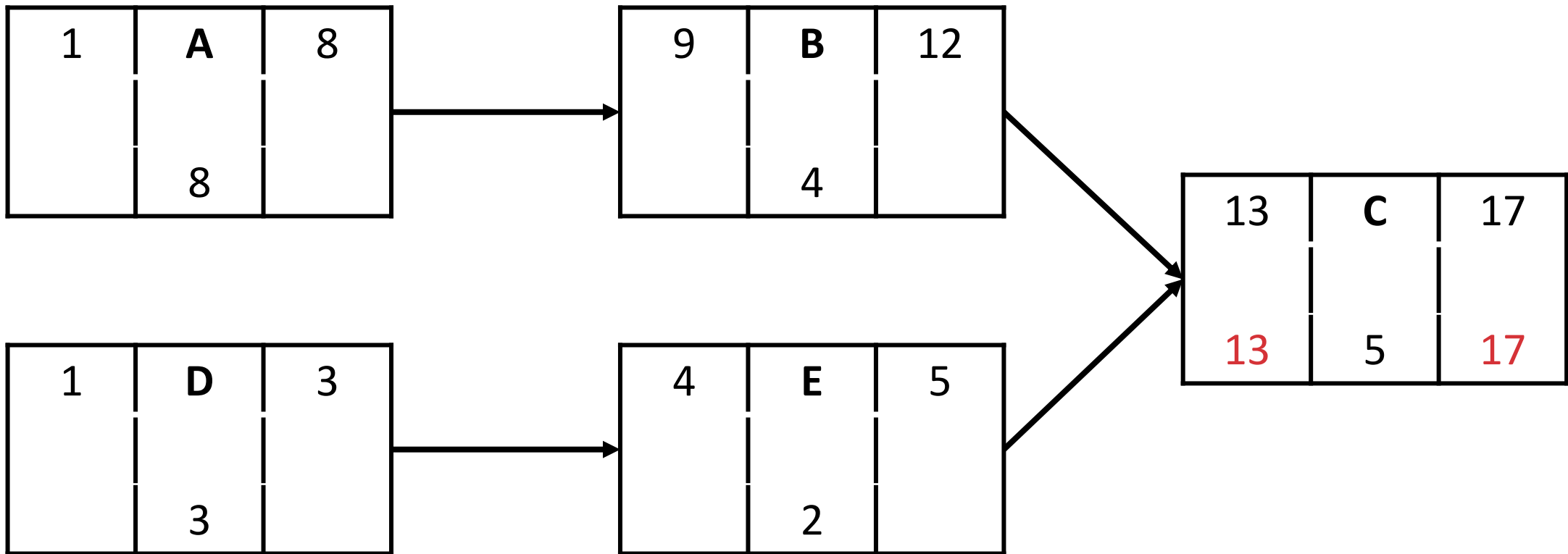| ES	**A**	EF
LS	dur	LF

Example: PDM

PDM: Late start and finish
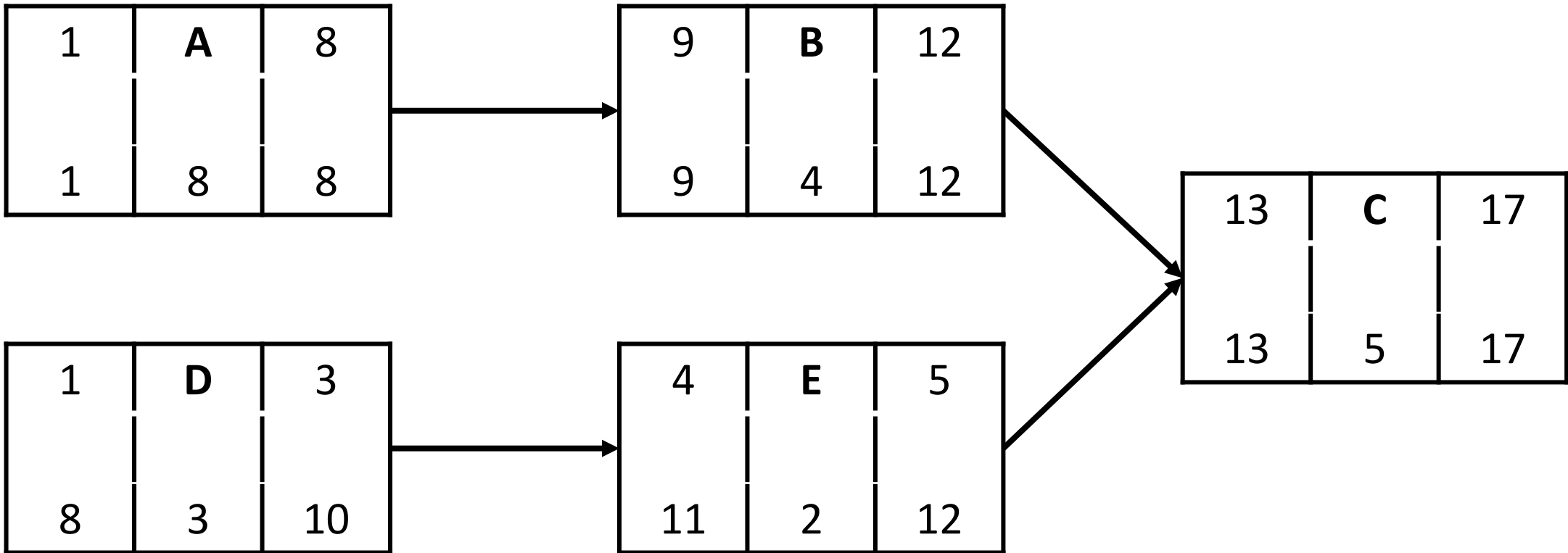
- Need to work <u>backwards</u> (hence backward pass)

- What is the LS of C?

- First – what is the late finish (LF) of C

- LF = min of
  - Project finish date (if unspecified, default is to use the largest EF)
  - Late start of successor - 1

- LS = LF – duration + 1

ES	**C**	EF
LS	dur	LF

Example: Backward pass

Example: Backward pass
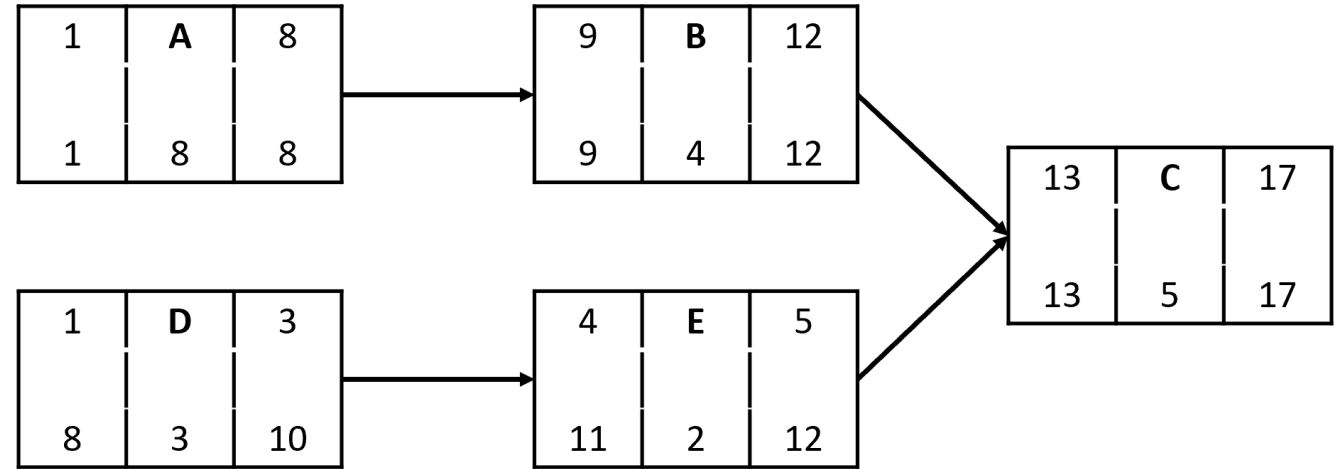
1	A	8
1	8	8

9	B	12
9	4	12

13	C	17
13	5	17

1	D	3
8	3	10

4	E	5
11	2	12

PDM: Float

1	A	8
1	8	8

9	B	12
9	4	12

13	C	17
13	5	17

1	D	3
8	3	10

4	E	5
11	2	12

- Note the EF and LF are the same for some activities

- This means there is no "wiggle room" – any delay will delay the entire project

- Float is the number of days an activity can be delayed without impacting the project

- Float = ?

ES	A	EF
	float	
LS	dur	LF

PDM: Float

1	A	8
1	8	8

9	B	12
9	4	12

13	C	17
13	5	17

1	D	3
8	3	10

4	E	5
11	2	12

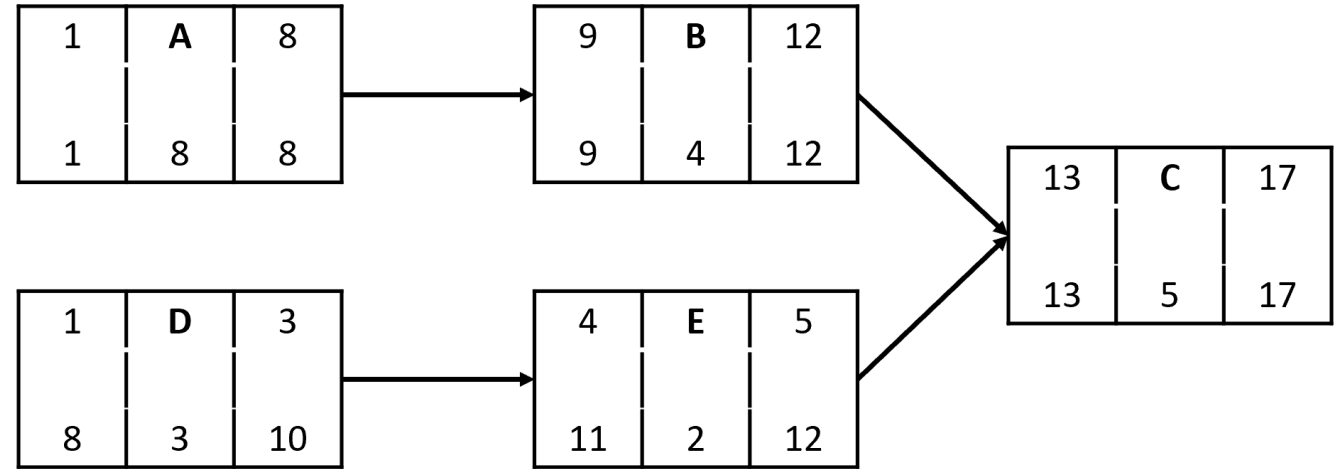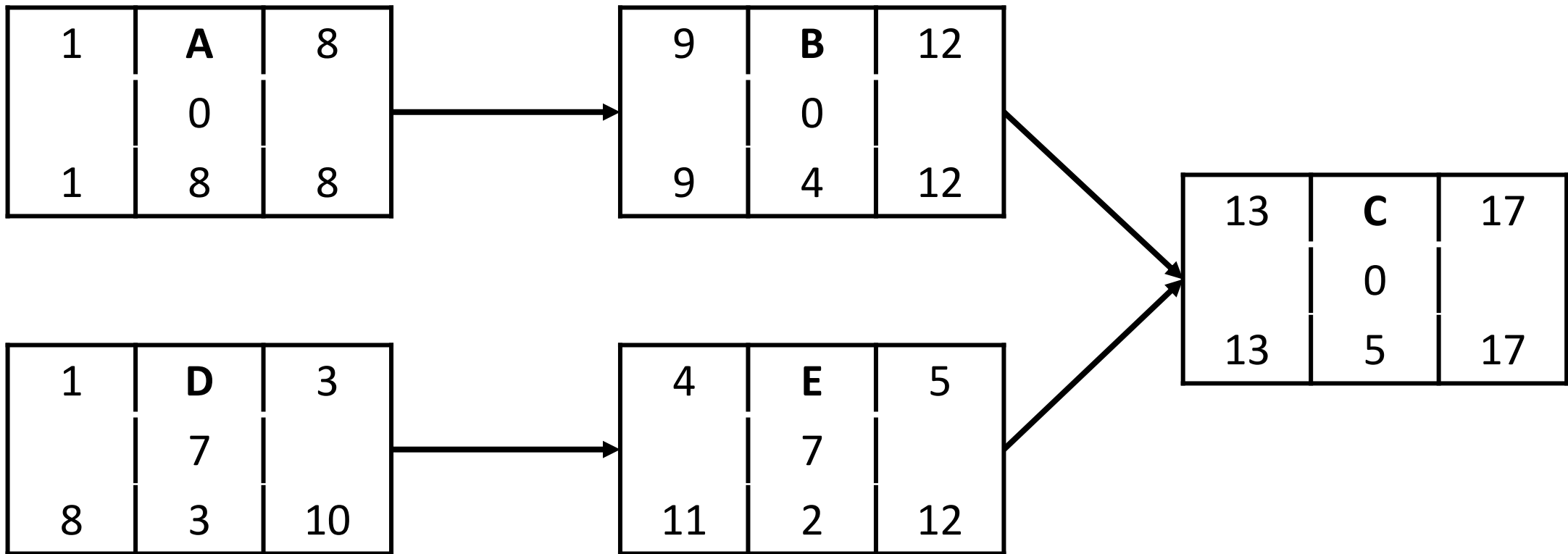- Note the EF and LF are the same for some activities

- This means there is no "wiggle room" – any delay will delay the entire project

- Float is the number of days an activity can be delayed without impacting the project

- Float = LF – ES – duration + 1

ES	A	EF
	float	
LS	dur	LF

Example: Float

1	**A**	8
	0	
1	8	8

9	**B**	12
	0	
9	4	12

13	**C**	17
	0	
13	5	17

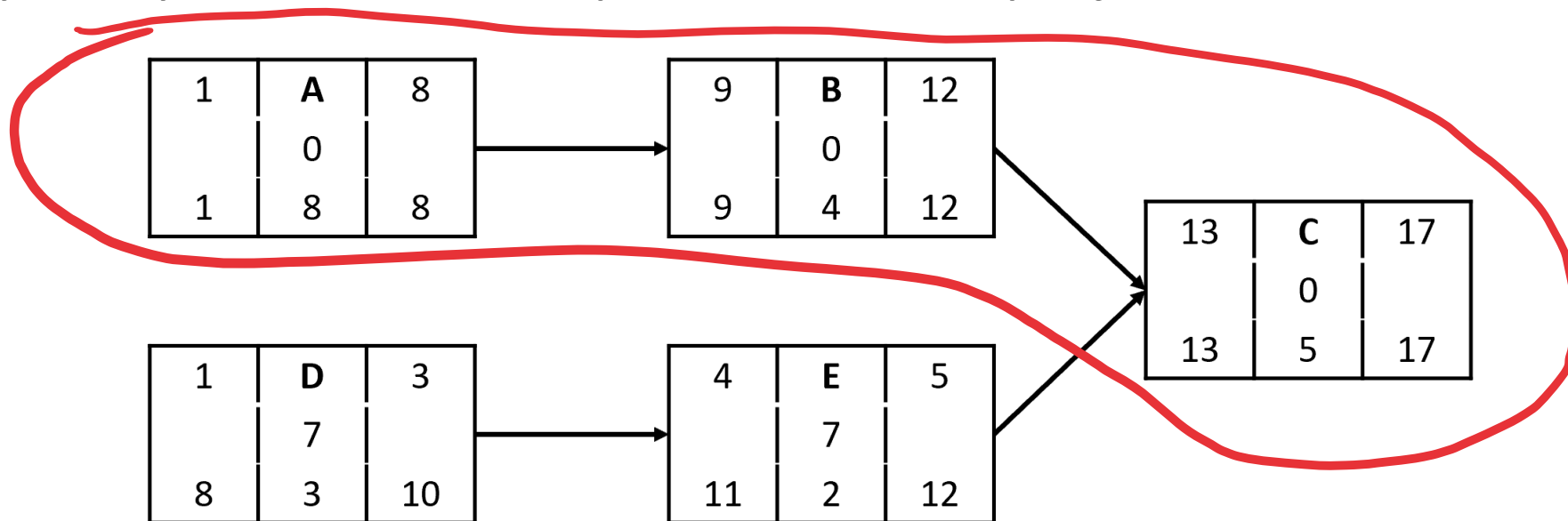| 1	**D**	3
	7	
8	3	10

4	**E**	5
	7	
11	2	12

Critical path

- The series of activities with float = 0 is the critical path
- The critical path is the one that dictates when the project will be complete
- Any delays to the critical path affect the project deadline

Resource constraining

- This has given us a schedule that is resource unconstrained
- However, there are likely constraints on resources
- Resources = labour, equipment, material
- Resource levelling is used to determine a resource constrained schedule
- Software is required for the optimization

Resource levelling: essentials

1	A	8
	0	
1	8	8

- (first determine the resource unconstrained schedule)
- For each activity: what resources are required at each timestep
    - E.g. activity A requires a digger (excavator) for the first four days
- Consider each time step sequentially:
    - What resources are needed by the activities currently scheduled?
    - Are the required resources available?
    - If not, assign the resources to the activity with the highest priority (common to use the lowest float)
    - Activity without resources is pushed to start at the next time step
    - Repeat for the next timestep

Resource levelling: example

1	**A**	8
	0	
1	8	8

- Let's say that
  - Activity A is the foundations of a road
  - Activity D is the swale (stormwater ditch) off the road

1	**D**	3
	7	
8	3	10

- Both require diggers
  - A requires it for the first four time steps
  - D requires it for the first two

- Only one digger is available

- D must therefore start on day 5 – this is the resource start (RS)

Resource levelling

- Two alternatives
  - Limited resources – delay project completion
  - Meet deadline – identify resource limitations

- Options for manager
  - Get more resources
  - Extend deadline
  - New project plan

Key concepts

- Construct a precedence diagram from activity list
- Calculate the float for each activity
- Understand the differences between and uses of ES, EF, LS, LF, RS, RF
- Understand how resource levelling determines a resource constrained schedule

- Example problems on the handout