

IE 102  
Spring 2018

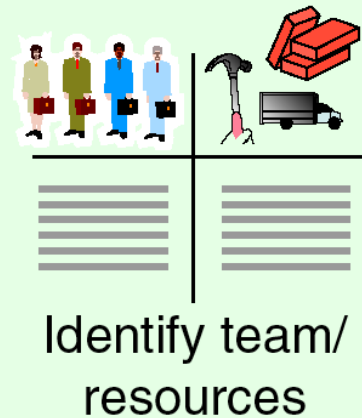
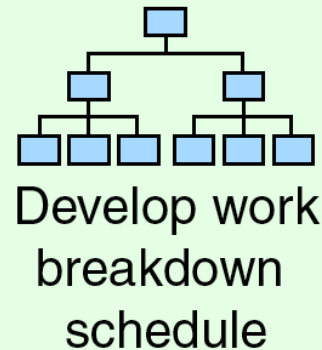
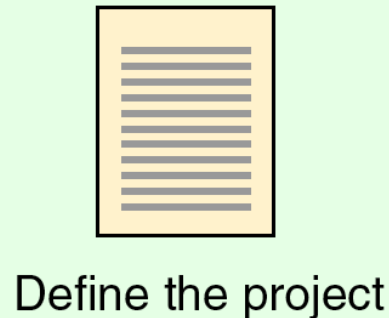
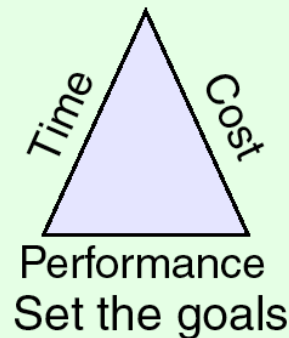
Project Management

# Management of Projects

- ✓ **Planning** - goal setting, defining the project, team organization
- ✓ **Scheduling** - relates people, money, and supplies to specific activities and activities to each other
- ✓ **Controlling** - monitors resources, costs, quality, and budgets; revises plans and shifts resources to meet time and cost demands

# Project Planning, Scheduling, and Controlling

## Planning the Project



Before  
project

Start of project  
Timeline

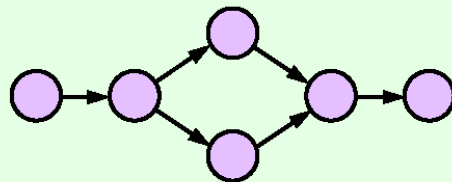
During  
project

# Project Planning, Scheduling, and Controlling

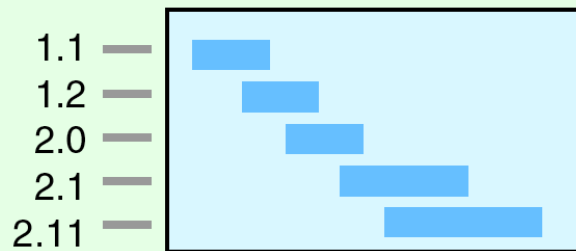
## Planning the Project



## Scheduling the Project



Sequence activities

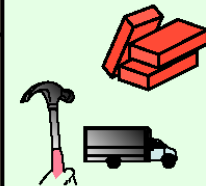


Schedule deliverables

|       |   |   |  |   |
|-------|---|---|--|---|
| Adams | ✓ |   |  |   |
| Smith |   |   |  | ✓ |
| Jones |   | ✓ |  |   |

Assign people

| June |   |   |    |    |    |    |
|------|---|---|----|----|----|----|
| S    | M | T | W  | T  | F  | S  |
|      | 1 | 2 | 3  | 4  | 5  | 6  |
| 7    | 8 | 9 | 10 | 11 | 12 | 13 |



Schedule resources

Before  
project

Start of project  
Timeline

During  
project

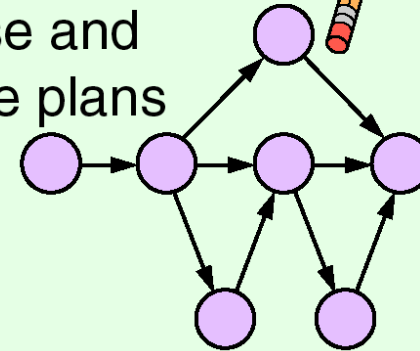
# Project Planning, Scheduling, and Controlling

## Planning the Project

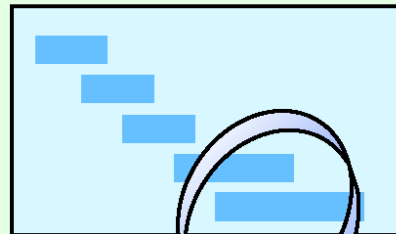


## Controlling the Project

Revise and change plans



1.1  
1.2  
2.0  
2.1  
2.11



Monitor resources,  
costs, quality

|       |   |  |   |   |
|-------|---|--|---|---|
| Adams |   |  | ✓ |   |
| Smith | ✓ |  |   |   |
| Jones |   |  |   | ✓ |

Shift resources

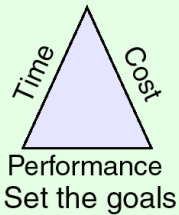
Before  
project

Start of project  
Timeline

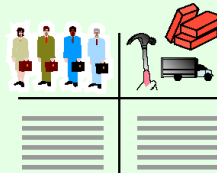
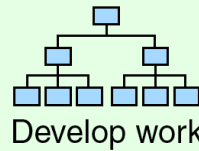
During  
project

# Project Planning, Scheduling, and Controlling

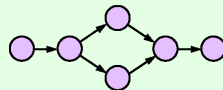
## Planning the Project



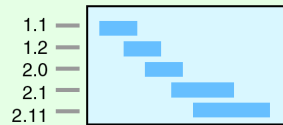
Define the project



## Scheduling the Project



Sequence activities



Schedule deliverables

|       |   |  |   |  |   |
|-------|---|--|---|--|---|
| Adams | ✓ |  |   |  |   |
| Smith |   |  |   |  | ✓ |
| Jones |   |  | ✓ |  |   |

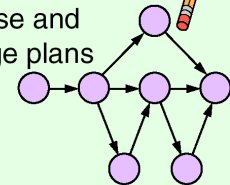
Assign people

| June |   |   |    |    |    |    |
|------|---|---|----|----|----|----|
| S    | M | T | W  | T  | F  | S  |
| 1    | 2 | 3 | 4  | 5  | 6  |    |
| 7    | 8 | 9 | 10 | 11 | 12 | 13 |

Schedule resources

## Controlling the Project

Revise and change plans



Monitor resources, costs, quality

|       |   |  |   |  |   |
|-------|---|--|---|--|---|
| Adams |   |  | ✓ |  |   |
| Smith | ✓ |  |   |  |   |
| Jones |   |  |   |  | ✓ |

Shift resources

Before  
project

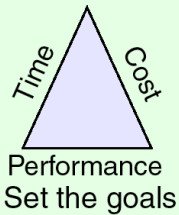
Start of project  
Timeline

During  
project

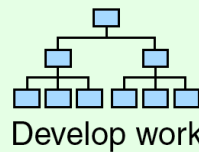
# Project Planning and Control

Time/cost estimates  
Budgets  
Engineering diagrams  
Cash flow charts  
Material availability details

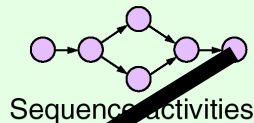
## Planning the Project



Define the project



## Scheduling the Project



|       |   |  |   |  |   |
|-------|---|--|---|--|---|
| Adams | ✓ |  |   |  |   |
| Smith |   |  |   |  | ✓ |
| Jones |   |  | ✓ |  |   |

Assign people



| June |   |   |    |    |    |    |
|------|---|---|----|----|----|----|
| S    | M | T | W  | T  | F  | S  |
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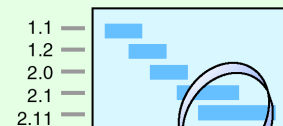
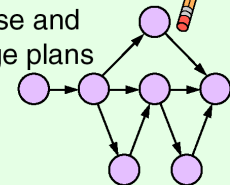
Schedule resources

CPM/PERT  
Gantt charts  
Milestone charts  
Cash flow schedules

Budgets  
Delayed activities report  
Slack activities report

## Controlling the Project

Revise and change plans



|       |   |  |  |  |   |
|-------|---|--|--|--|---|
| Adams |   |  |  |  |   |
| Smith | ✓ |  |  |  |   |
| Jones |   |  |  |  | ✓ |

Shift resources

Before  
project

Start of project  
Timeline

During  
project

# Project Scheduling

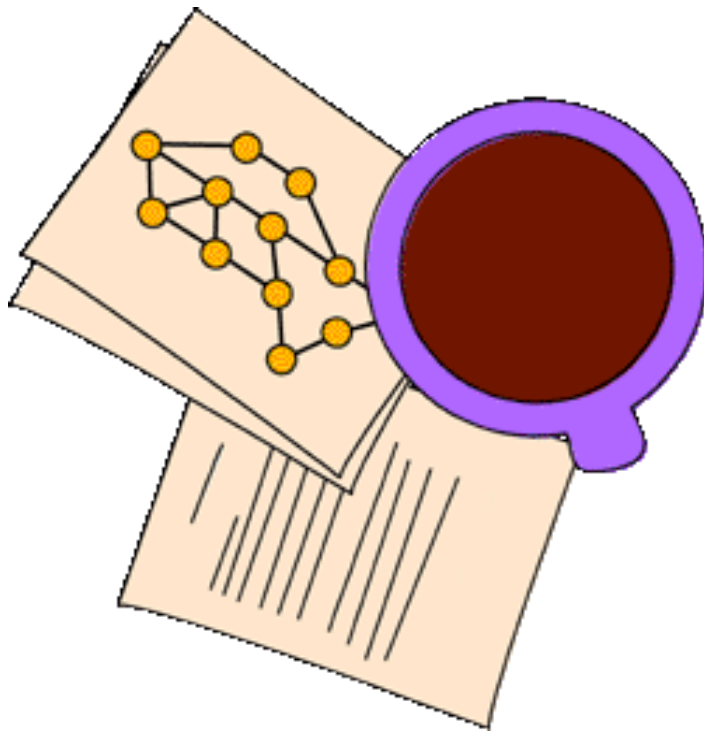
- ☒ Identifying precedence relationships
- ☒ Sequencing activities
- ☒ Determining activity times & costs
- ☒ Estimating material and worker requirements
- ☒ Determining critical activities



# Purposes of Project Scheduling

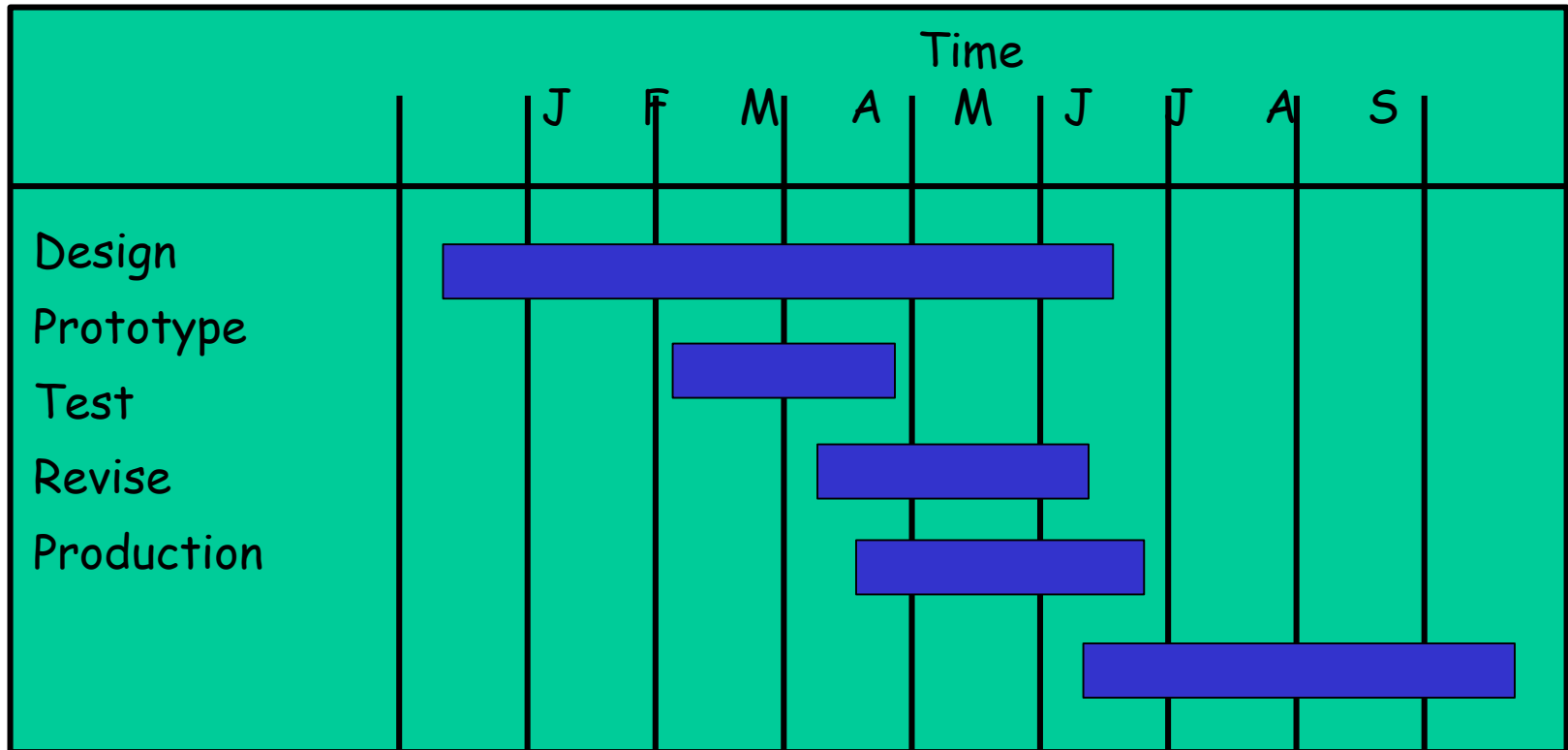
1. Shows the relationship of each activity to others and to the whole project
2. Identifies the precedence relationships among activities
3. Encourages the setting of realistic time and cost estimates for each activity
4. Helps make better use of people, money, and material resources by identifying critical bottlenecks in the project

# Project Management Techniques

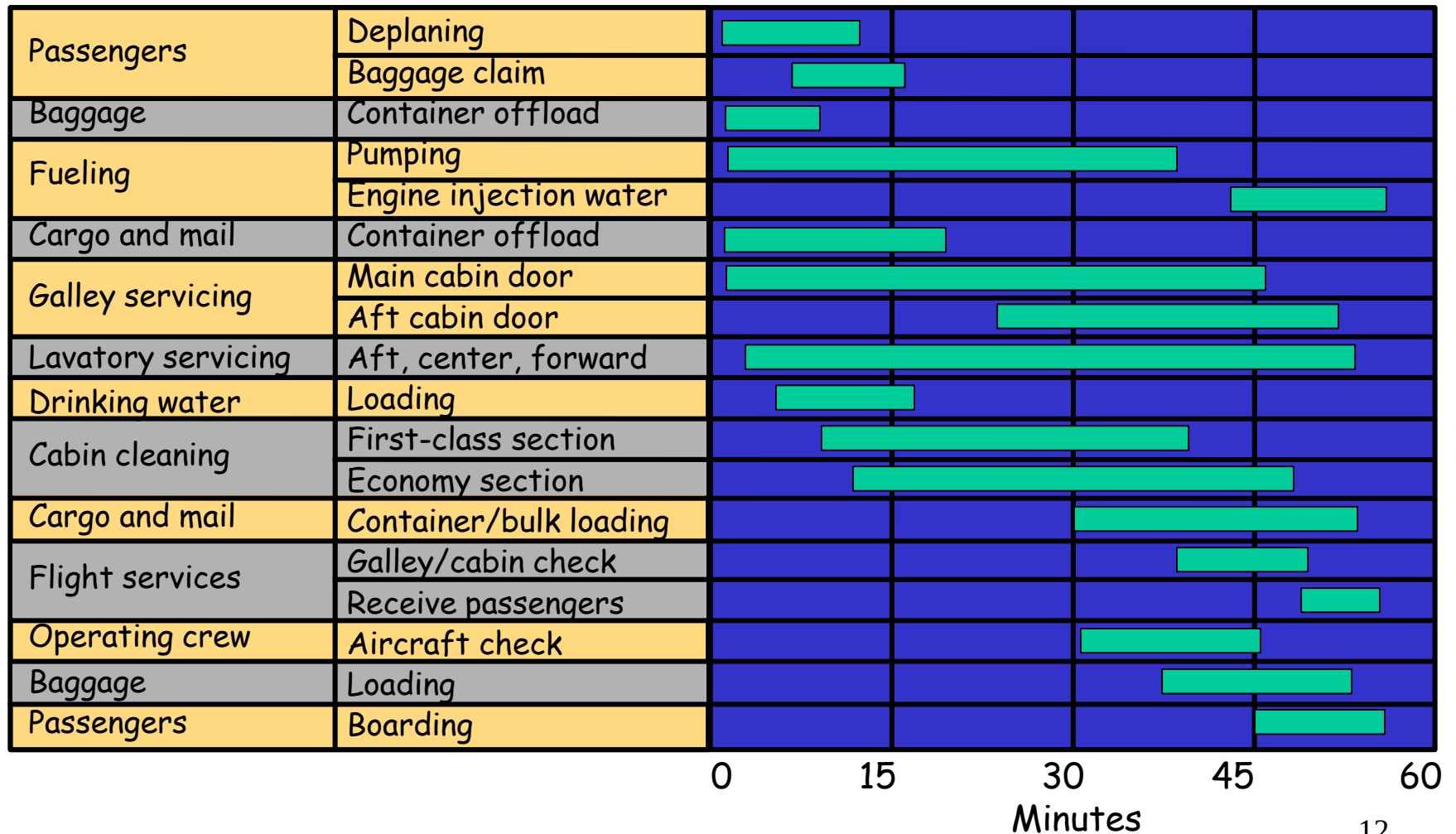


- ☒ Gantt chart
- ☒ Critical Path Method (CPM)
- ☒ Program Evaluation and Review Technique (PERT)

# A Simple Gantt Chart



# Service For A Delta Jet



# CPM & PERT

- ☒ Network techniques
- ☒ Developed in 1950's
  - ☒ CPM by DuPont for chemical plants (1957)
  - ☒ PERT by Booz, Allen & Hamilton with the U.S. Navy, for Polaris missile (1958)
- ☒ Consider precedence relationships and interdependencies
- ☒ Each uses a different estimate of activity times

# Six Steps CPM & PERT

1. Define the project and prepare the work breakdown structure
2. Develop relationships among the activities - decide which activities must precede and which must follow others
3. Draw the network connecting all of the activities

# Six Steps CPM & PERT

4. Assign time and/or cost estimates to each activity
5. Compute the longest time path through the network - this is called the critical path
6. Use the network to help plan, schedule, monitor, and control the project

# Questions CPM & PERT Can Answer

1. When will the entire project be completed?
2. What are the critical activities or tasks in the project?
3. Which are the noncritical activities?
4. What is the probability the project will be completed by a specific date?



# Questions CPM & PERT Can Answer

5. Is the project on schedule, behind schedule, or ahead of schedule?
6. Is the money spent equal to, less than, or greater than the budget?
7. Are there enough resources available to finish the project on time?
8. If the project must be finished in a shorter time, what is the way to accomplish this at least cost?

# CPM

AON (Activity on Node) Network  
Conventions

AOA (Activity on Arc) Network  
Conventions

# AON (Activity on Node) Network Conventions

Notes on board:)

# AON (Activity on Arc) Network Conventions

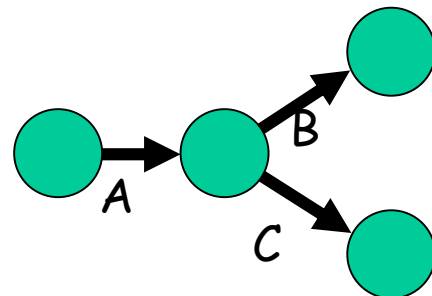
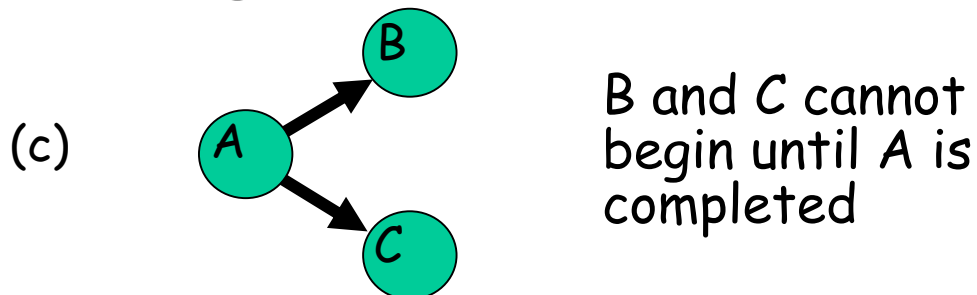
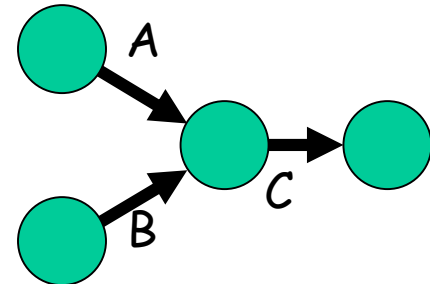
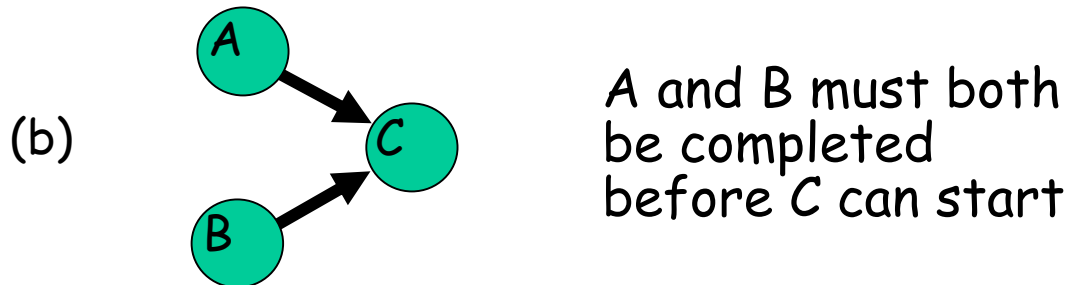
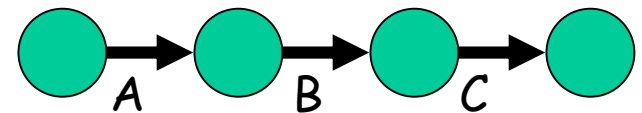
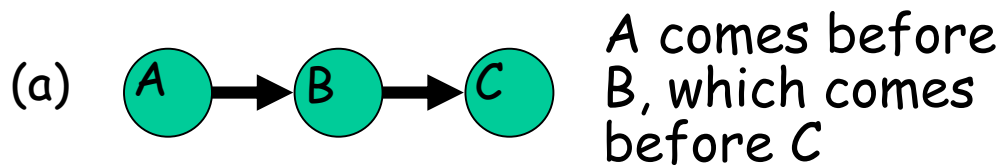
Notes on board:)

# AON and AOA Network Conventions

Activity on  
Node (AON)

Activity  
Meaning

Activity on  
Arrow (AOA)



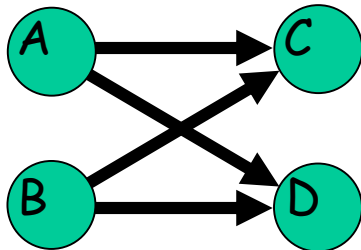
# AON and AOA Network Conventions

Activity on  
Node (AON)

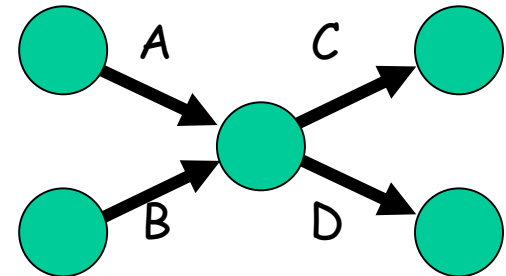
Activity  
Meaning

Activity on  
Arrow (AOA)

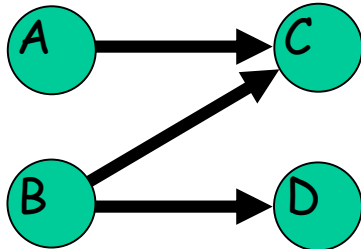
(d)



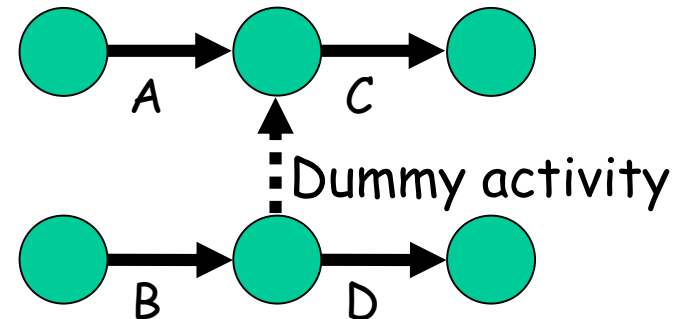
C and D cannot begin until A and B have both been completed



(e)



C cannot begin until both A and B are completed; D cannot begin until B is completed. A dummy activity is introduced in AOA



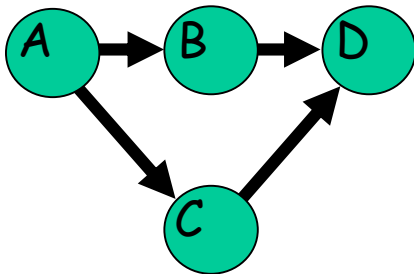
# AON and AOA Network Conventions

Activity on  
Node (AON)

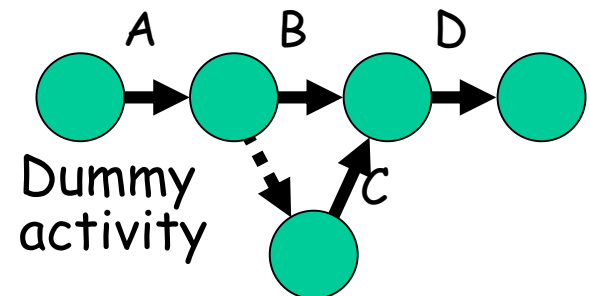
Activity  
Meaning

Activity on  
Arrow (AOA)

(f)



B and C cannot begin until A is completed. D cannot begin until both B and C are completed. A dummy activity is again introduced in AOA.



Example on board:)



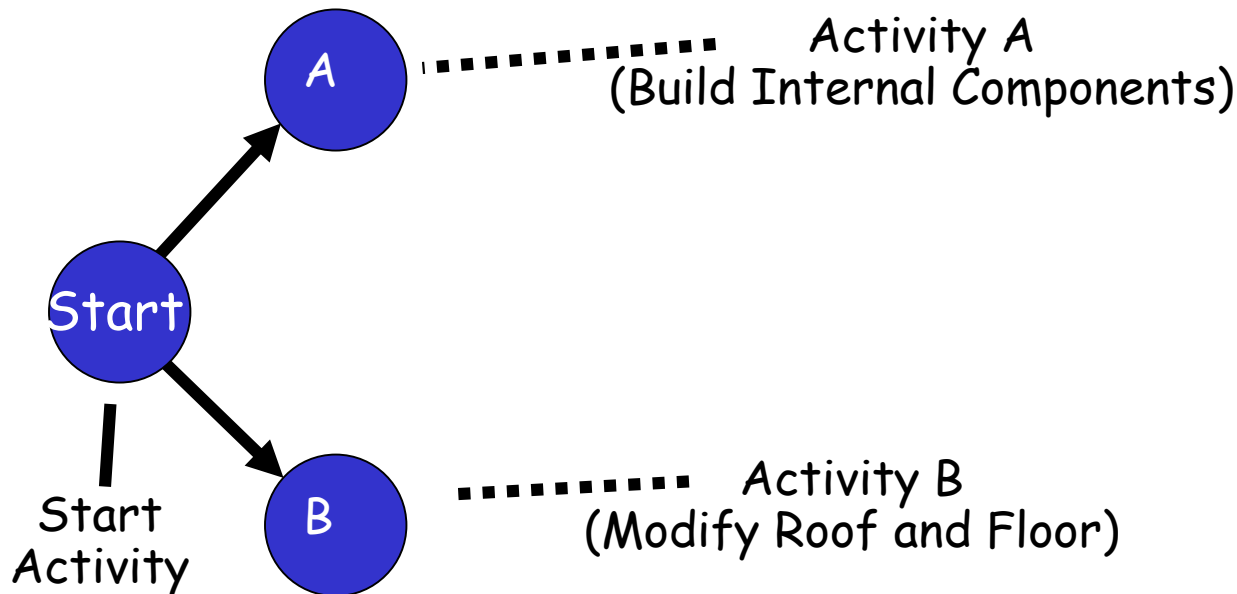
# AON Example

## Milwaukee Paper Manufacturing's Activities and Predecessors

| <b>Activ<br/>ity</b> | <b>Durati<br/>on</b> | <b>Description</b>                      | <b>Immediate<br/>Predecessors</b> |
|----------------------|----------------------|-----------------------------------------|-----------------------------------|
| <b>A</b>             | <b>2</b>             | <b>Build internal components</b>        | <b>—</b>                          |
| <b>B</b>             | <b>3</b>             | <b>Modify roof and floor</b>            | <b>—</b>                          |
| <b>C</b>             | <b>2</b>             | <b>Construct collection stack</b>       | <b>A</b>                          |
| <b>D</b>             | <b>4</b>             | <b>Pour concrete and install frame</b>  | <b>A, B</b>                       |
| <b>E</b>             | <b>4</b>             | <b>Build high-temperature burner</b>    | <b>C</b>                          |
| <b>F</b>             | <b>3</b>             | <b>Install pollution control system</b> | <b>C</b>                          |
| <b>G</b>             | <b>5</b>             | <b>Install air pollution device</b>     | <b>D, E</b>                       |
| <b>H</b>             | <b>2</b>             | <b>Inspect and test</b>                 | <b>F, G</b>                       |

# AON Network for Milwaukee Paper

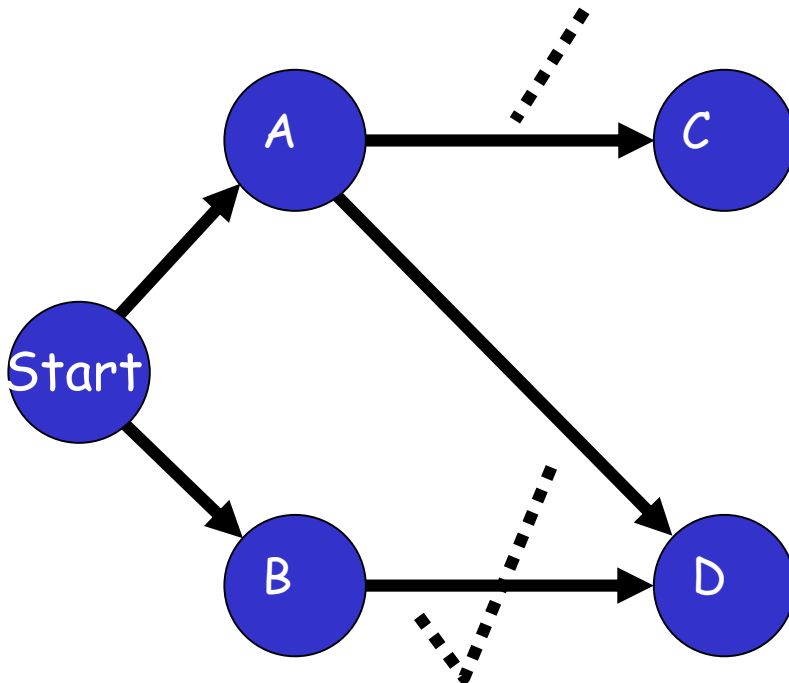
| Activity | Immediate Predecessors |
|----------|------------------------|
| A        | —                      |
| B        | —                      |
| C        | A                      |
| D        | A, B                   |
| E        | C                      |
| F        | C                      |
| G        | D, E                   |
| H        | F, G                   |



# AON Network for Milwaukee Paper

| Activity | Immediate Predecessors |
|----------|------------------------|
| A        | —                      |
| B        | —                      |
| C        | A                      |
| D        | A, B                   |
| E        | C                      |
| F        | C                      |
| G        | D, E                   |
| H        | F, G                   |

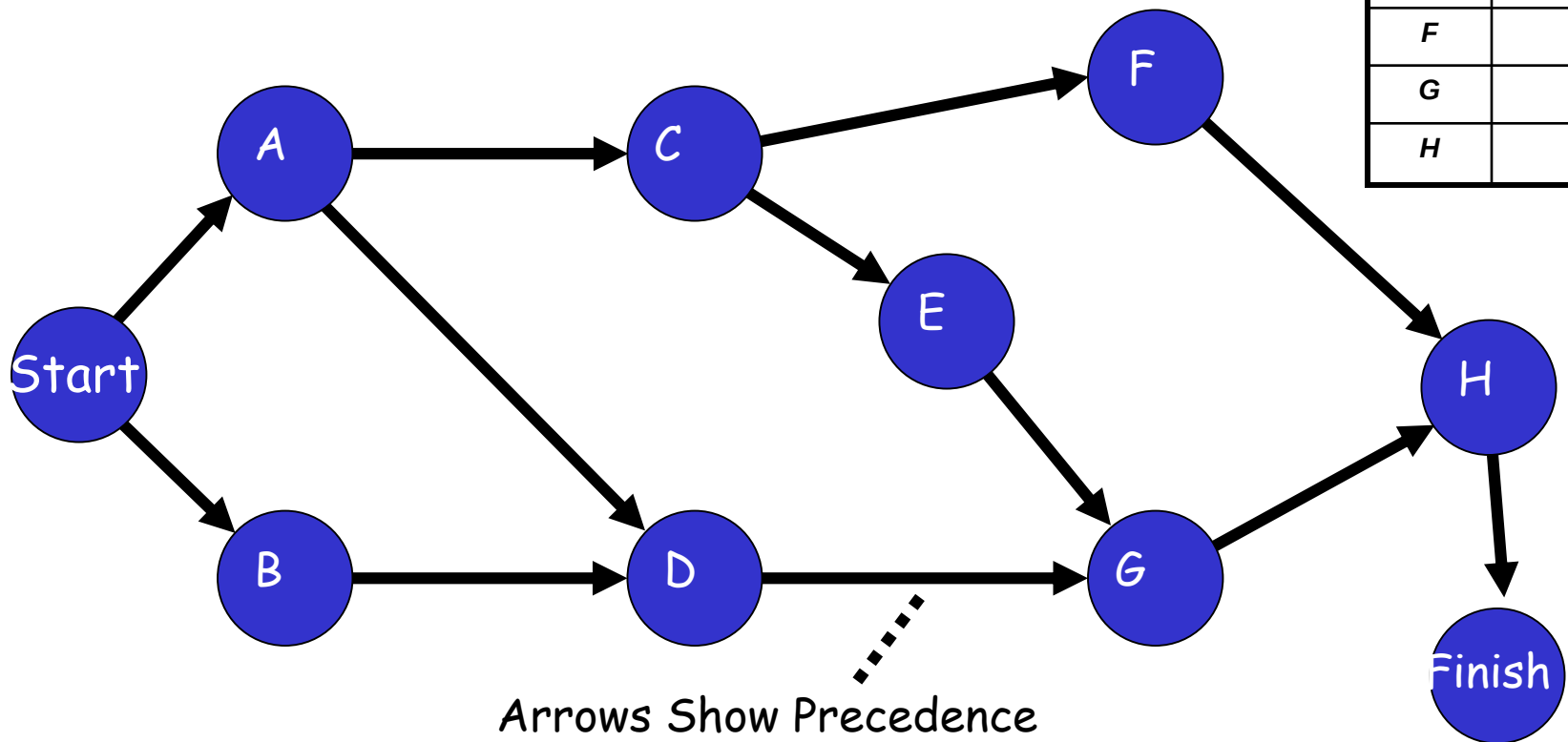
Activity A Precedes Activity C



Activities A and B Precede Activity D

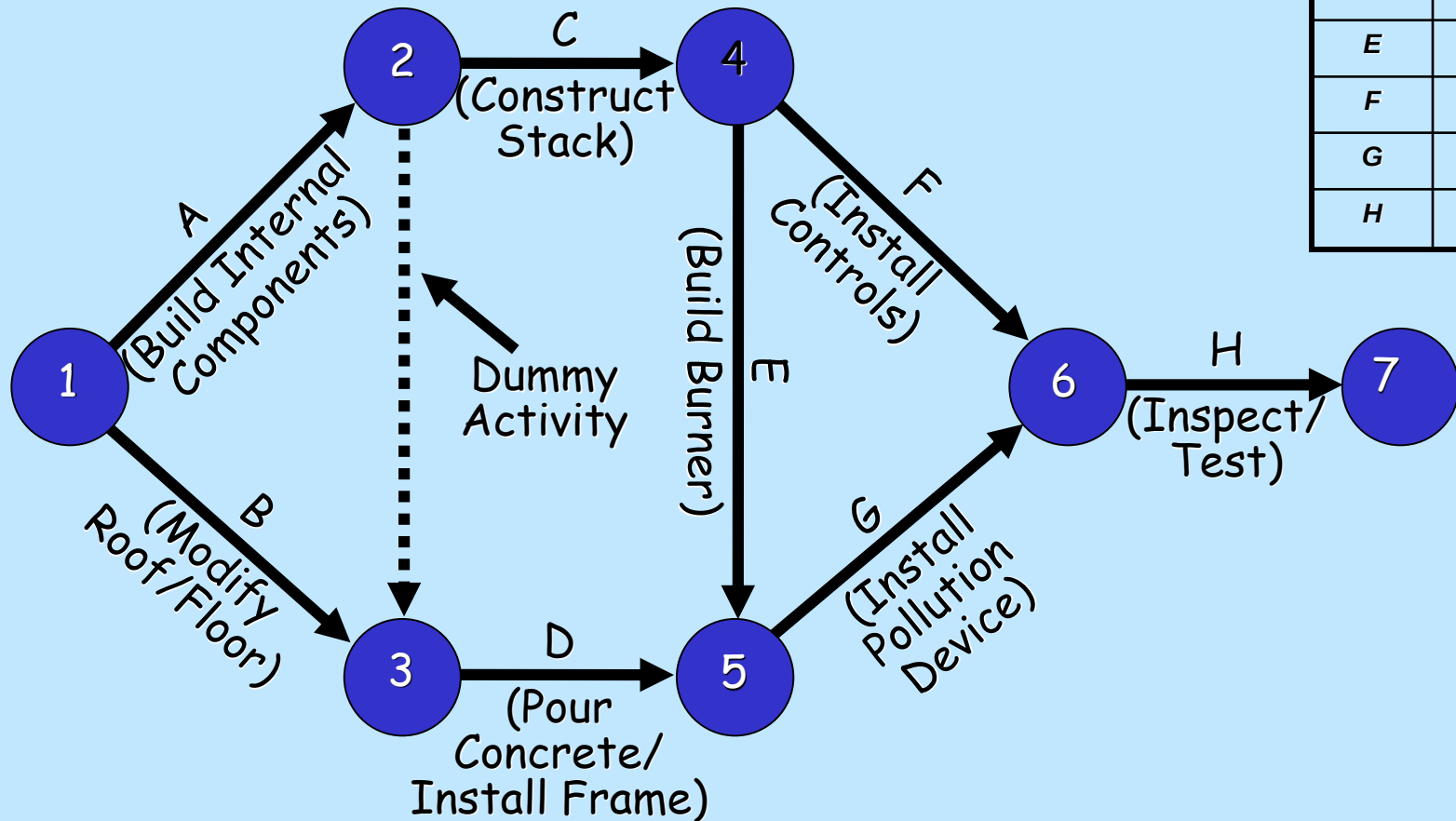
# AON Network for Milwaukee Paper

| Activity | Immediate Predecessors |
|----------|------------------------|
| A        | —                      |
| B        | —                      |
| C        | A                      |
| D        | A, B                   |
| E        | C                      |
| F        | C                      |
| G        | D, E                   |
| H        | F, G                   |



# AOA Network for Milwaukee Paper

| Activity | Immediate Predecessors |
|----------|------------------------|
| A        | —                      |
| B        | —                      |
| C        | A                      |
| D        | A, B                   |
| E        | C                      |
| F        | C                      |
| G        | D, E                   |
| H        | F, G                   |



# Determining the Project Schedule

## Perform a Critical Path Analysis

- ☒ The critical path is the longest path through the network
- ☒ The critical path is the shortest time in which the project can be completed
- ☒ Any delay in critical path activities delays the project
- ☒ Critical path activities have no slack time

# Determining the Project Schedule

## Perform a Critical Path Analysis

| Activity           | Description                      | Time (weeks) |
|--------------------|----------------------------------|--------------|
| A                  | Build internal components        | 2            |
| B                  | Modify roof and floor            | 3            |
| C                  | Construct collection stack       | 2            |
| D                  | Pour concrete and install frame  | 4            |
| E                  | Build high-temperature burner    | 4            |
| F                  | Install pollution control system | 3            |
| G                  | Install air pollution device     | 5            |
| H                  | Inspect and test                 | 2            |
| Total Time (weeks) |                                  | 25           |

# Determining the Project Schedule

## Perform a Critical Path Analysis

Earliest start (ES) = earliest time at which an activity can start, assuming all predecessors have been completed

Earliest finish (EF) = earliest time at which an activity can be finished

Latest start (LS) = latest time at which an activity can start so as to not delay the completion time of the entire project

Latest finish (LF) = latest time by which an activity has to be finished so as to not delay the completion time of the entire project



# Forward Pass

Begin at starting event and work forward

Earliest Start Time:

- ✓ If an activity has only one immediate predecessor, its ES equals the EF of the predecessor
- ✓ If an activity has multiple immediate predecessors, its ES is the maximum of all the EF values of its predecessors

$ES = \text{Max (EF of all immediate predecessors)}$

# Forward Pass

Begin at starting event and work forward

Earliest Finish Time:

- ☑ The earliest finish time (EF) of an activity is the sum of its earliest start time (ES) and its activity time

$$EF = ES + \text{Activity time}$$

# Backward Pass

Begin with the last event and work backwards

Latest Finish Time:

- ☑ If an activity is an immediate predecessor for just a single activity, its LF equals the LS of the activity that immediately follows it
- ☑ If an activity is an immediate predecessor to more than one activity, its LF is the minimum of all LS values of all activities that immediately follow it

$LF = \text{Min (LS of all immediate following activities)}$

# Backward Pass

Begin with the last event and work backwards

Latest Start Time:

- ✓ The latest start time (LS) of an activity is the difference of its latest finish time (LF) and its activity time

$$LS = LF - \text{Activity time}$$

# Computing Slack Time

After computing the ES, EF, LS, and LF times for all activities, compute the slack or free time for each activity

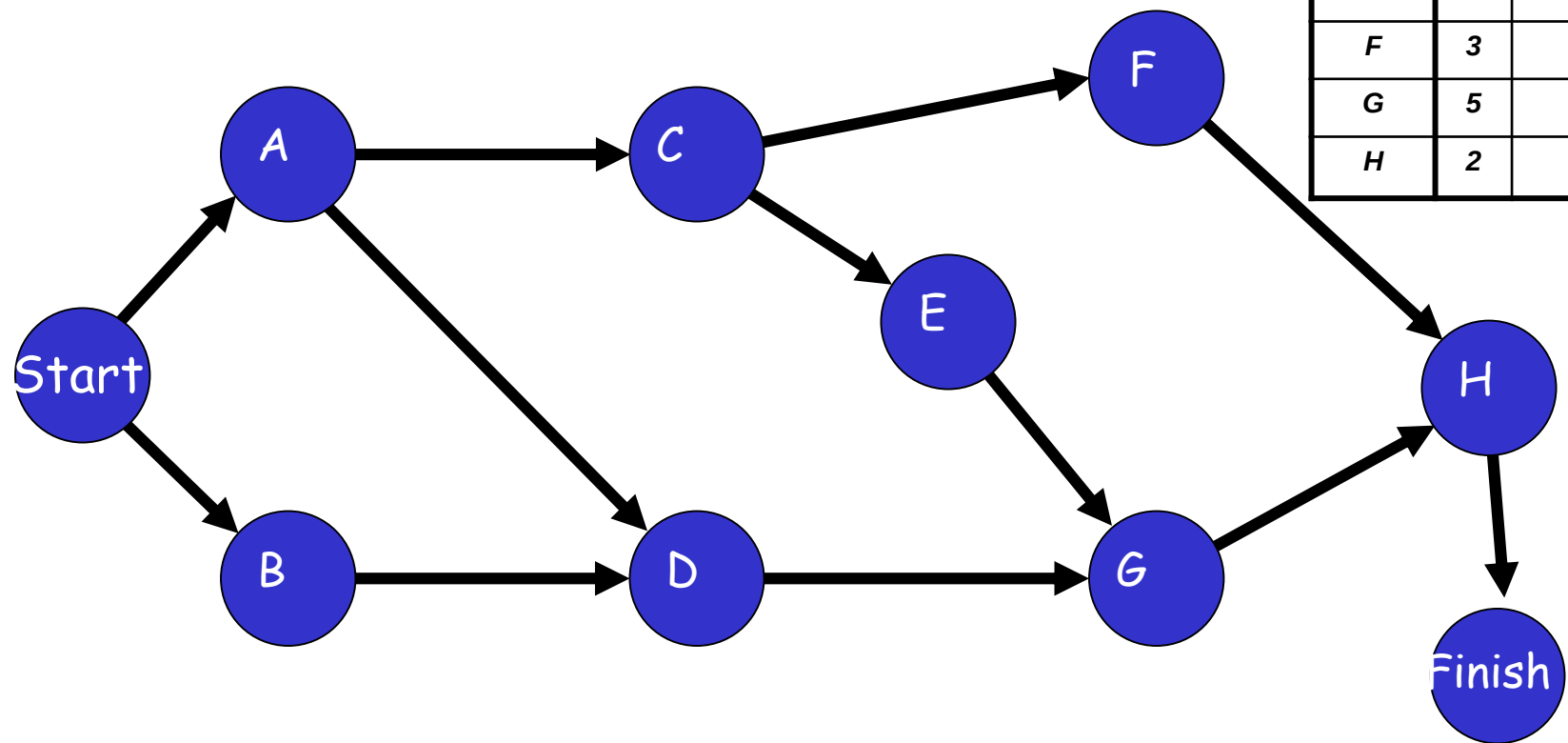
- ☑ Slack is the length of time an activity can be delayed without delaying the entire project

$$\text{Slack} = \text{LS} - \text{ES} \quad \text{or} \quad \text{Slack} = \text{LF} - \text{EF}$$

# Project Duration Calculations board:)

# AON Network for Milwaukee Paper

| Activity |   | Immediate Predecessors |
|----------|---|------------------------|
| A        | 2 | —                      |
| B        | 3 | —                      |
| C        | 2 | A                      |
| D        | 4 | A, B                   |
| E        | 4 | C                      |
| F        | 3 | C                      |
| G        | 5 | D, E                   |
| H        | 2 | F, G                   |

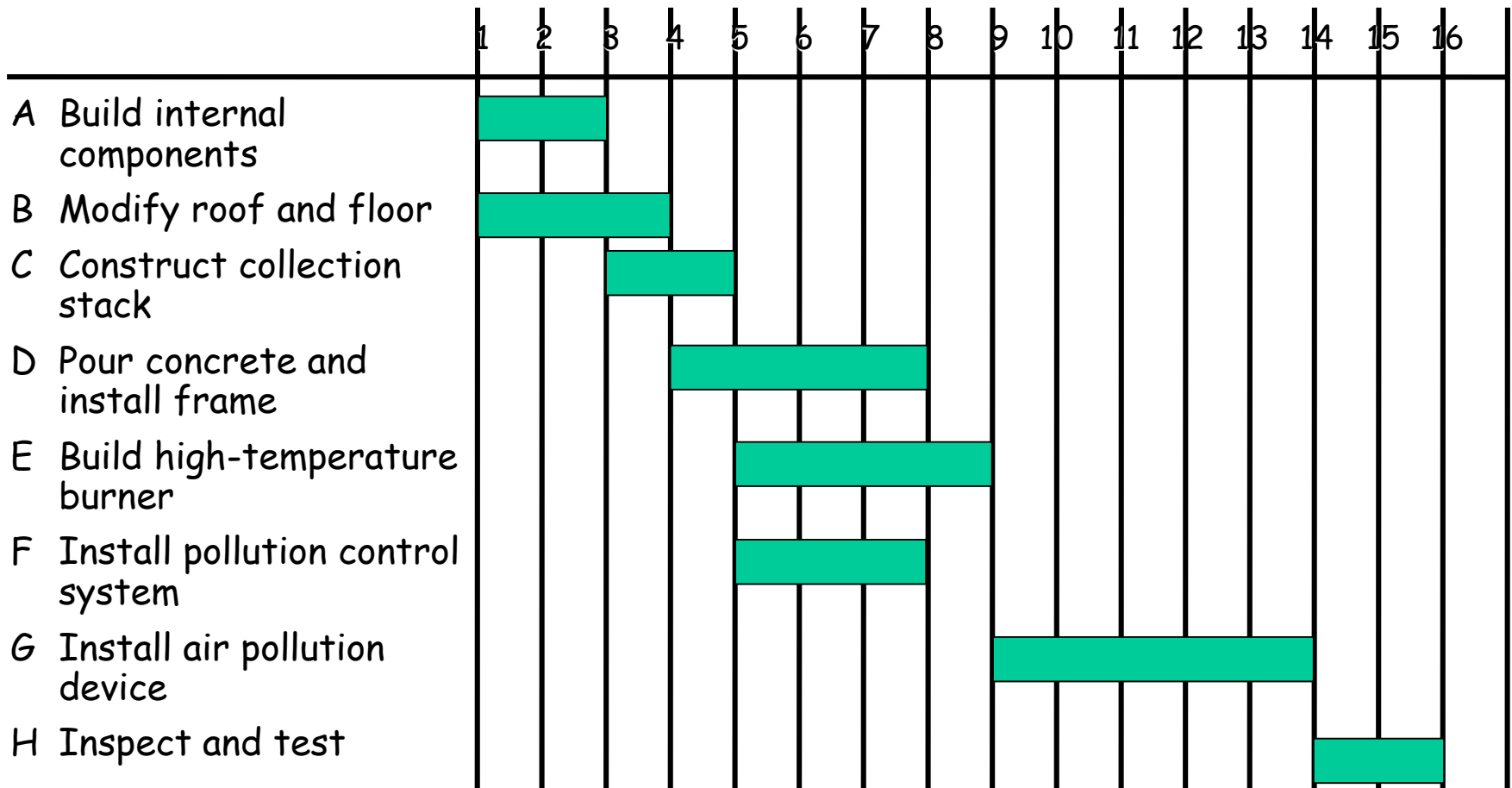


# Computing Slack Time

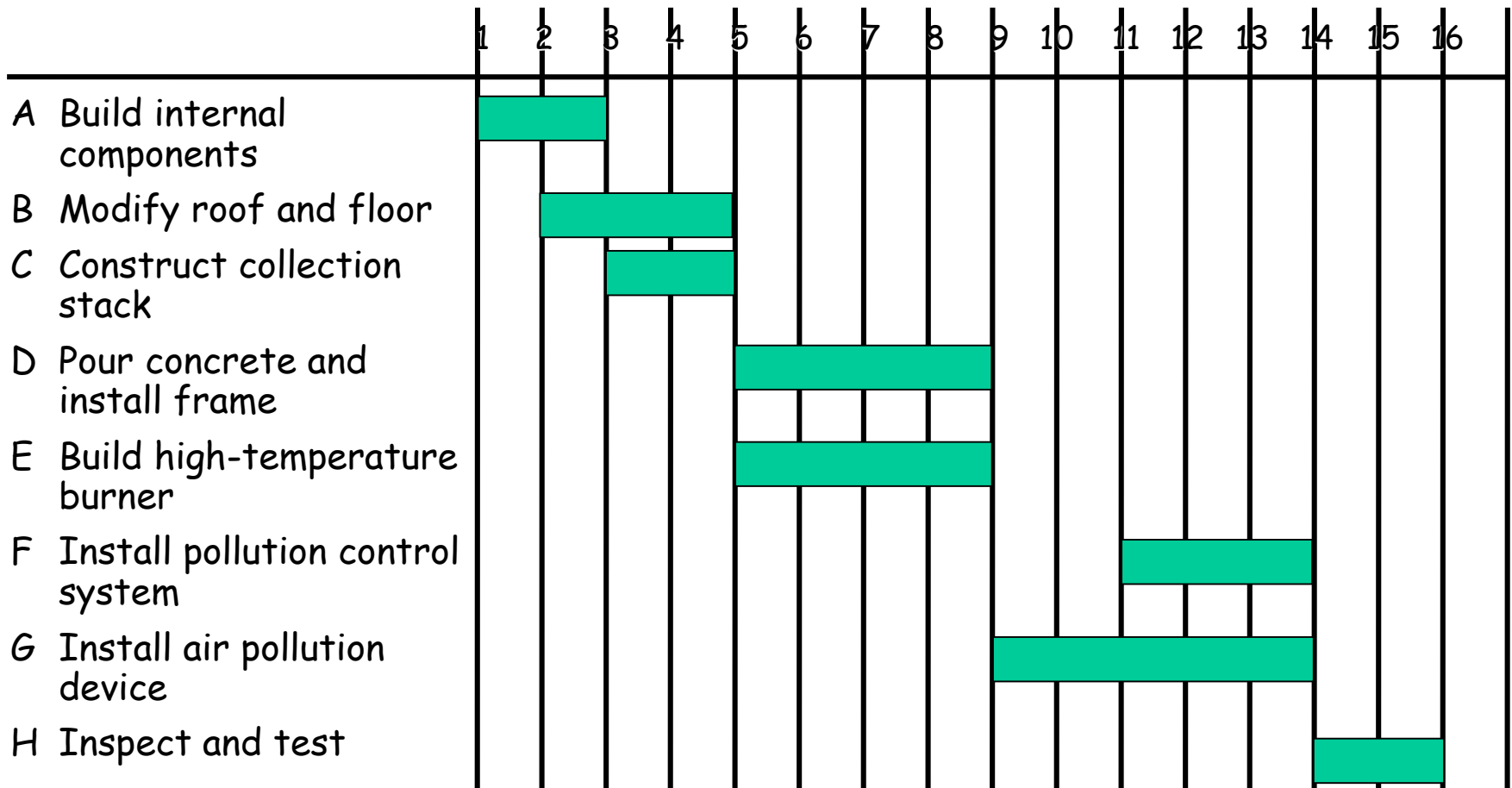
| Activity | Earliest<br>Start<br>ES | Earliest<br>Finish<br>EF | Latest<br>Start<br>LS | Latest<br>Finish<br>LF | Slack<br>LS - ES | On<br>Critical<br>Path |
|----------|-------------------------|--------------------------|-----------------------|------------------------|------------------|------------------------|
| A        | 0                       | 2                        | 0                     | 2                      | 0                | Yes                    |
| B        | 0                       | 3                        | 1                     | 4                      | 1                | No                     |
| C        | 2                       | 4                        | 2                     | 4                      | 0                | Yes                    |
| D        | 3                       | 7                        | 4                     | 8                      | 1                | No                     |
| E        | 4                       | 8                        | 4                     | 8                      | 0                | Yes                    |
| F        | 4                       | 7                        | 10                    | 13                     | 6                | No                     |
| G        | 8                       | 13                       | 8                     | 13                     | 0                | Yes                    |
| H        | 13                      | 15                       | 13                    | 15                     | 0                | Yes                    |



# ES - EF Gantt Chart for Milwaukee Paper



# LS - LF Gantt Chart for Milwaukee Paper



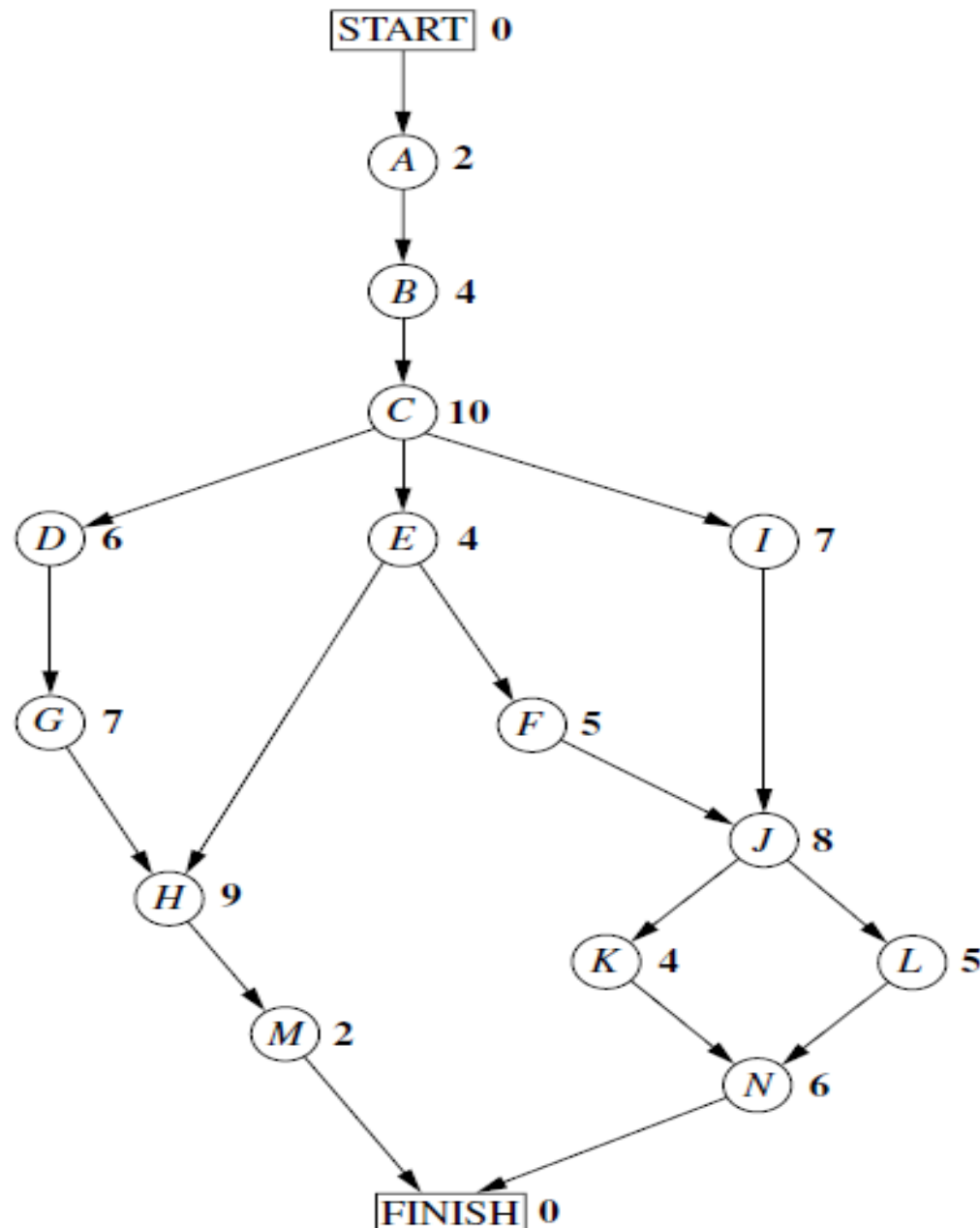
# Another-Example

**TABLE 10.1** Activity list for the Reliable Construction Co. project

| Activity | Activity Description          | Immediate Predecessors | Estimated Duration |
|----------|-------------------------------|------------------------|--------------------|
| A        | Excavate                      | —                      | 2 weeks            |
| B        | Lay the foundation            | A                      | 4 weeks            |
| C        | Put up the rough wall         | B                      | 10 weeks           |
| D        | Put up the roof               | C                      | 6 weeks            |
| E        | Install the exterior plumbing | C                      | 4 weeks            |
| F        | Install the interior plumbing | E                      | 5 weeks            |
| G        | Put up the exterior siding    | D                      | 7 weeks            |
| H        | Do the exterior painting      | E, G                   | 9 weeks            |
| I        | Do the electrical work        | C                      | 7 weeks            |
| J        | Put up the wallboard          | F, I                   | 8 weeks            |
| K        | Install the flooring          | J                      | 4 weeks            |
| L        | Do the interior painting      | J                      | 5 weeks            |
| M        | Install the exterior fixtures | H                      | 2 weeks            |
| N        | Install the interior fixtures | K, L                   | 6 weeks            |

Example on board:)

# CPM-Example

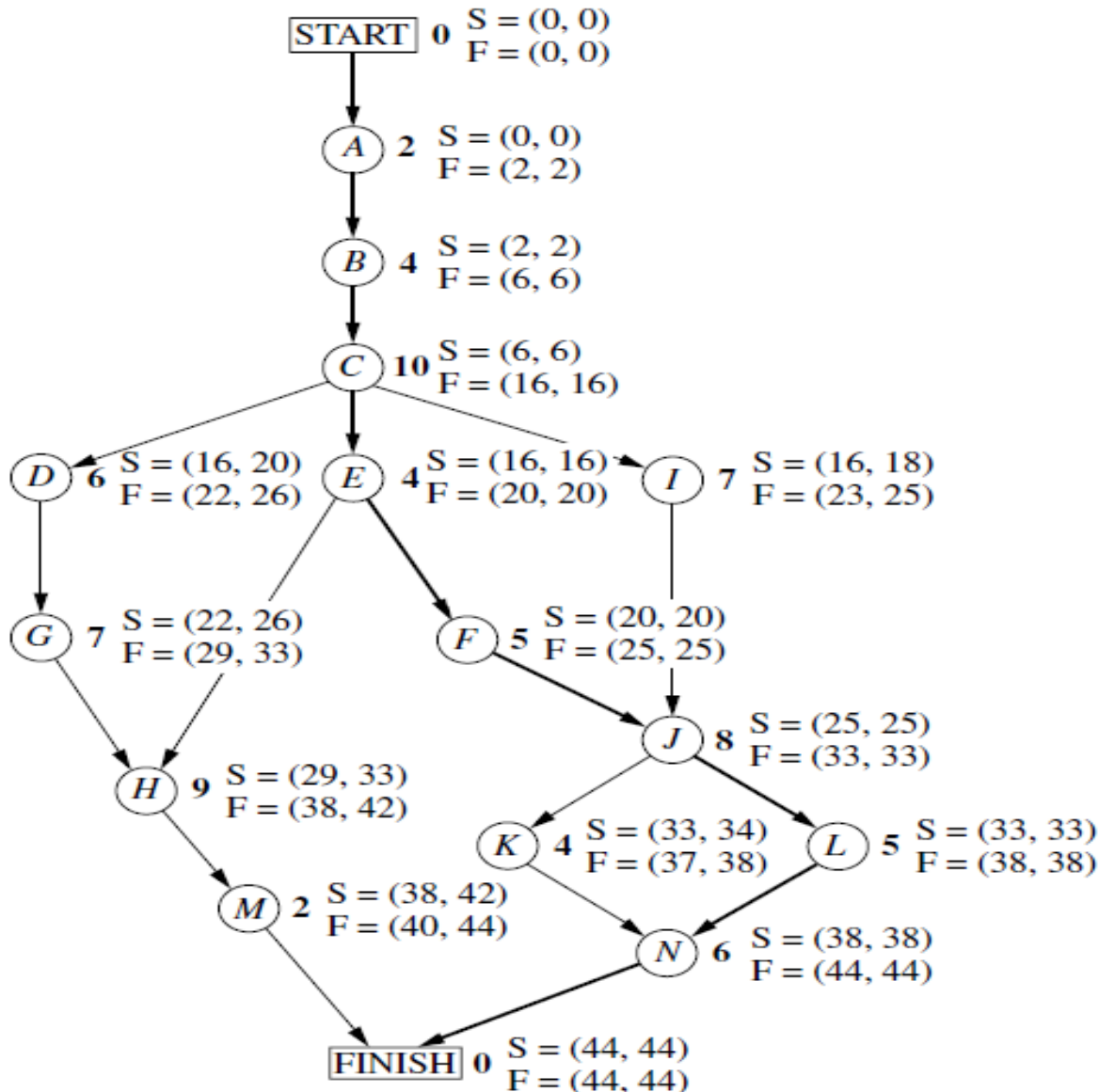


## Activity Code

- A. Excavate
- B. Foundation
- C. Rough wall
- D. Roof
- E. Exterior plumbing
- F. Interior plumbing
- G. Exterior siding
- H. Exterior painting
- I. Electrical work
- J. Wallboard
- K. Flooring
- L. Interior painting
- M. Exterior fixtures
- N. Interior fixtures

# CPM-Example

The complete project network showing ES and LS (in parentheses above the node) and EF and LF (in parentheses below the node) for each activity of the Reliable Construction Co. project. The darker arrows show the critical path through the project network.



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