IE 400
Principles of Engineering Management

Project Management

Project Organization Works Best When

- ☑ Work can be defined with a specific goal, deadline, and budget
- ☑ The job is unique or somewhat unfamiliar to the existing organization
- ☑ The work contains complex interrelated tasks requiring specialized skills
- ☑ The project is temporary but critical to the organization

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

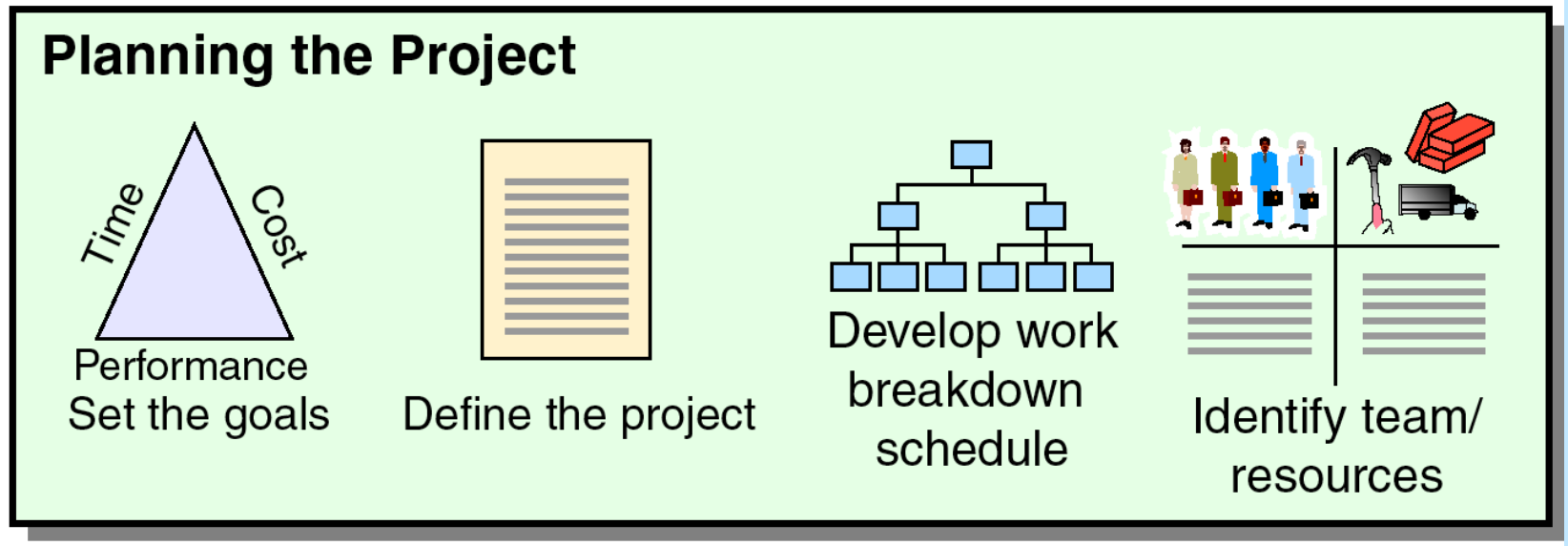


Figure 3.1

Project Planning, Scheduling, and Controlling

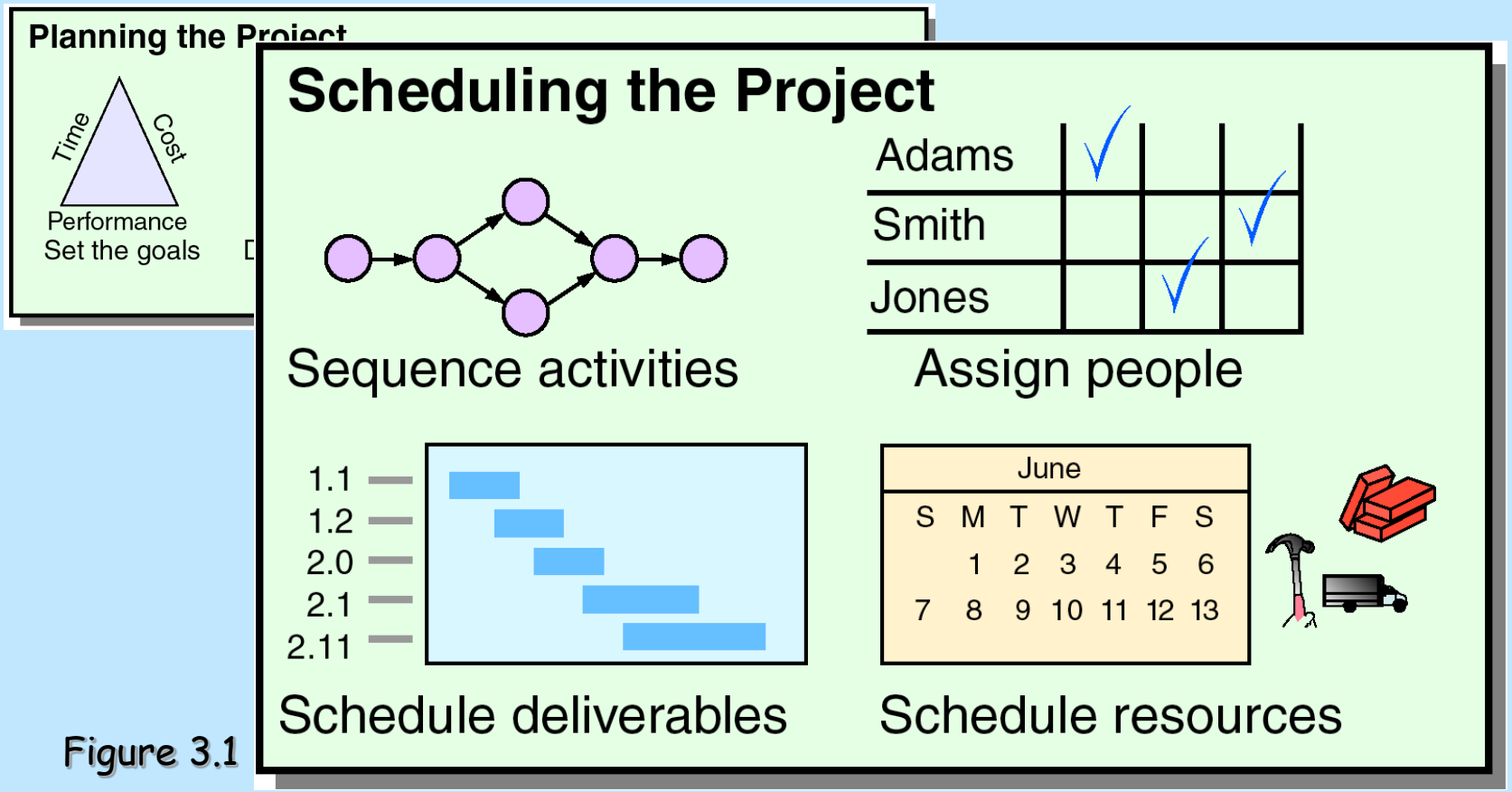


Figure 3.1

Project Planning, Scheduling, and Controlling

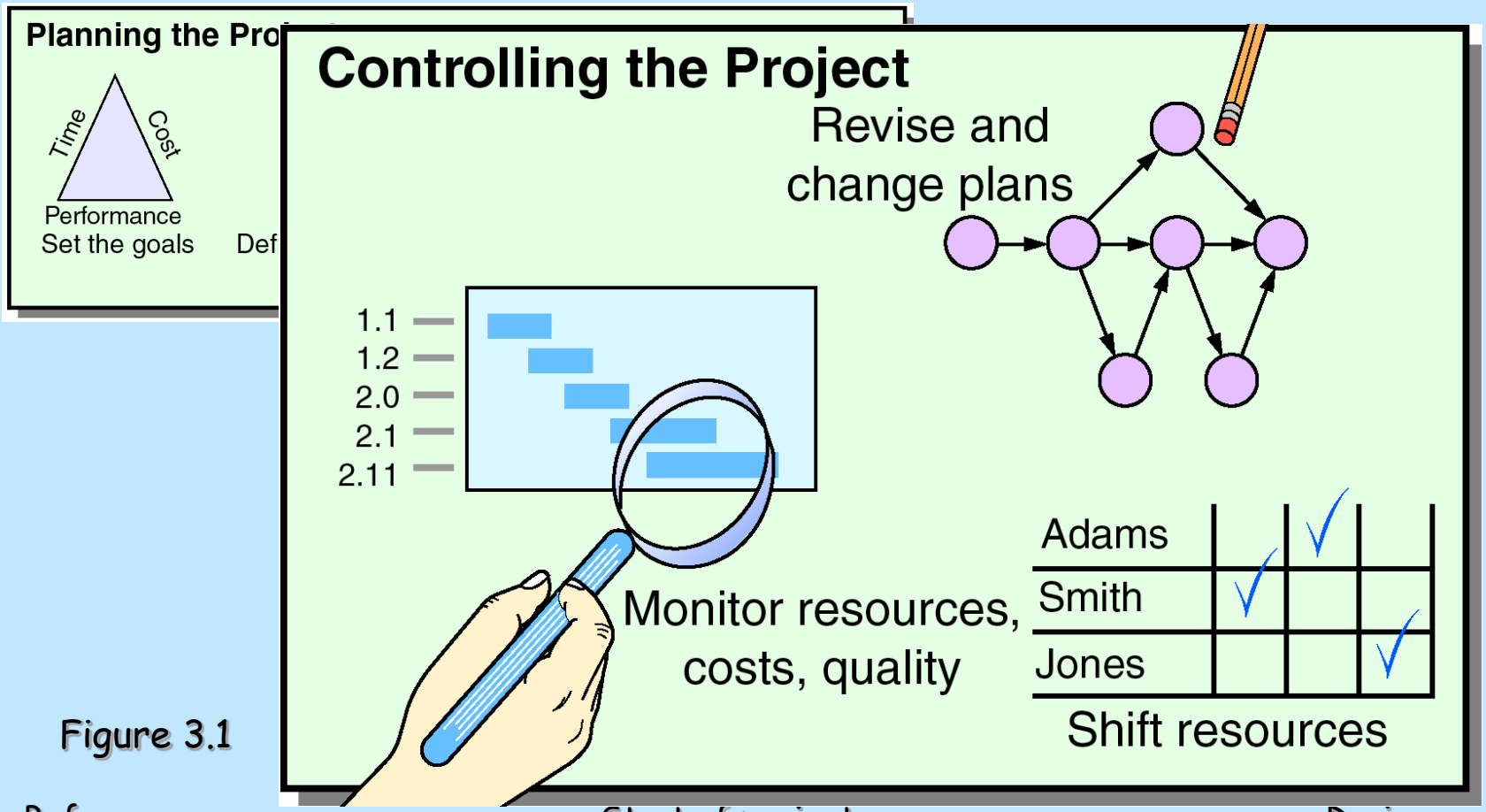


Figure 3.1

Project Planning, Scheduling, and Controlling

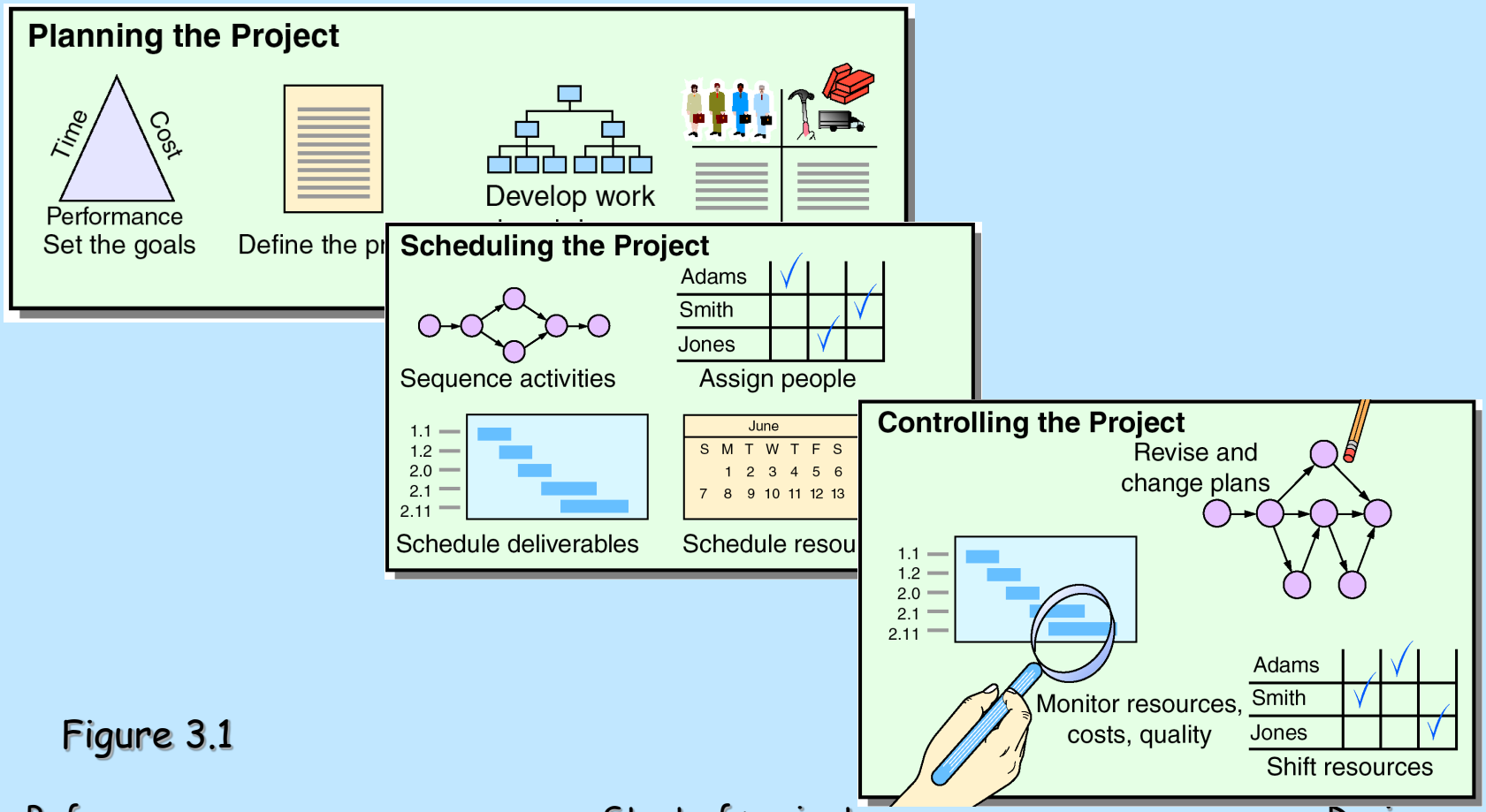
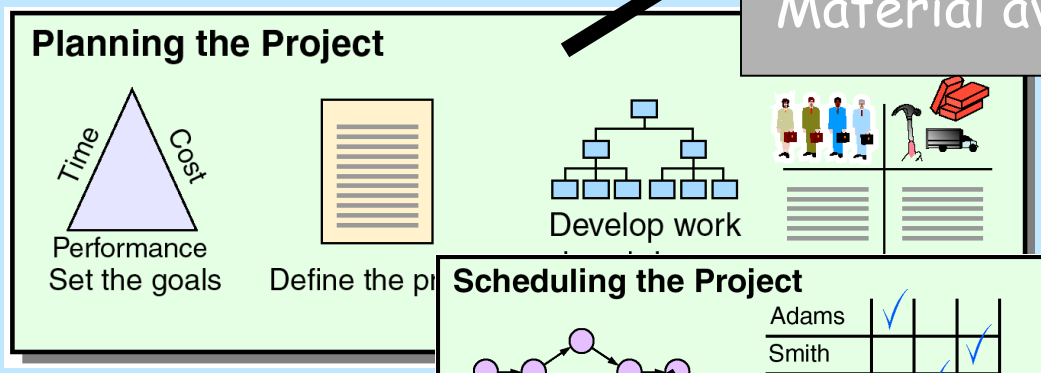
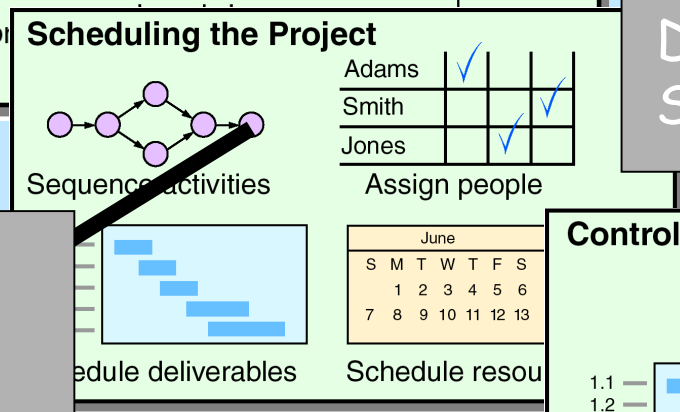


Figure 3.1

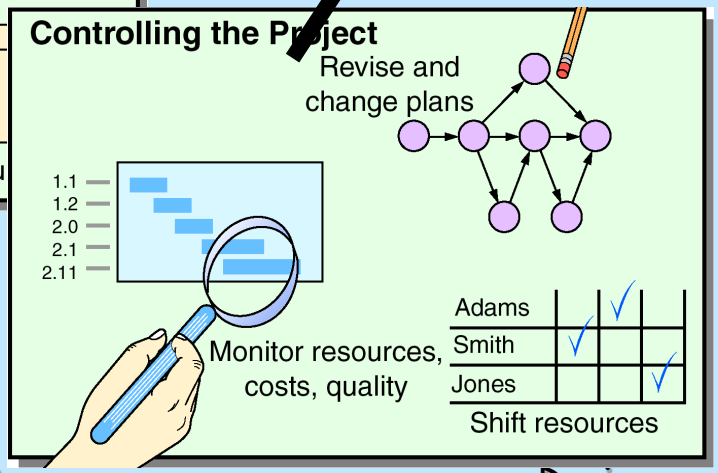
Project Plann ng, and C

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





Budgets
Delayed activities report
Slack activities report



CPM/PERT
Gantt charts
Milestone charts
Cash flow schedules

Figure 3.1

Before project | Start of project | During project

Timeline

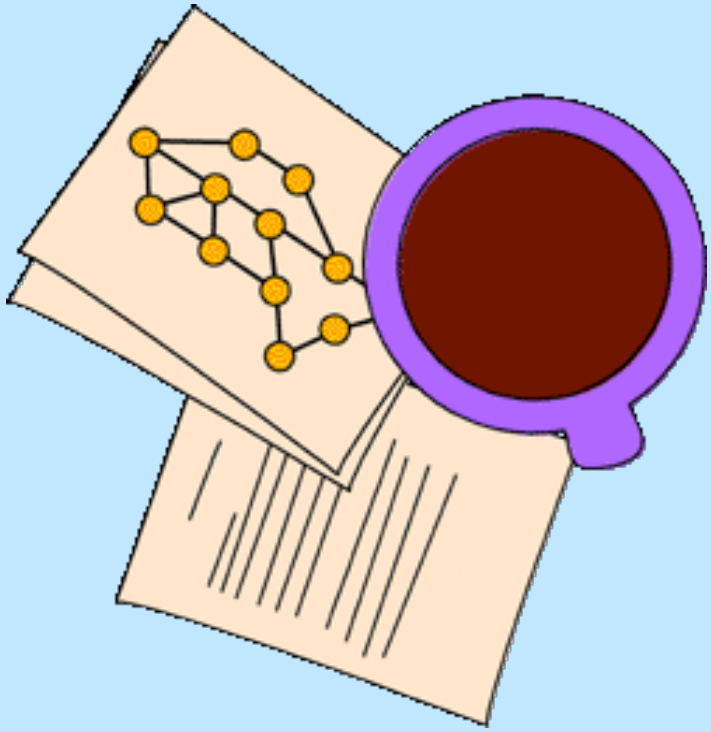
Project Scheduling

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

Purposes of Project Scheduling

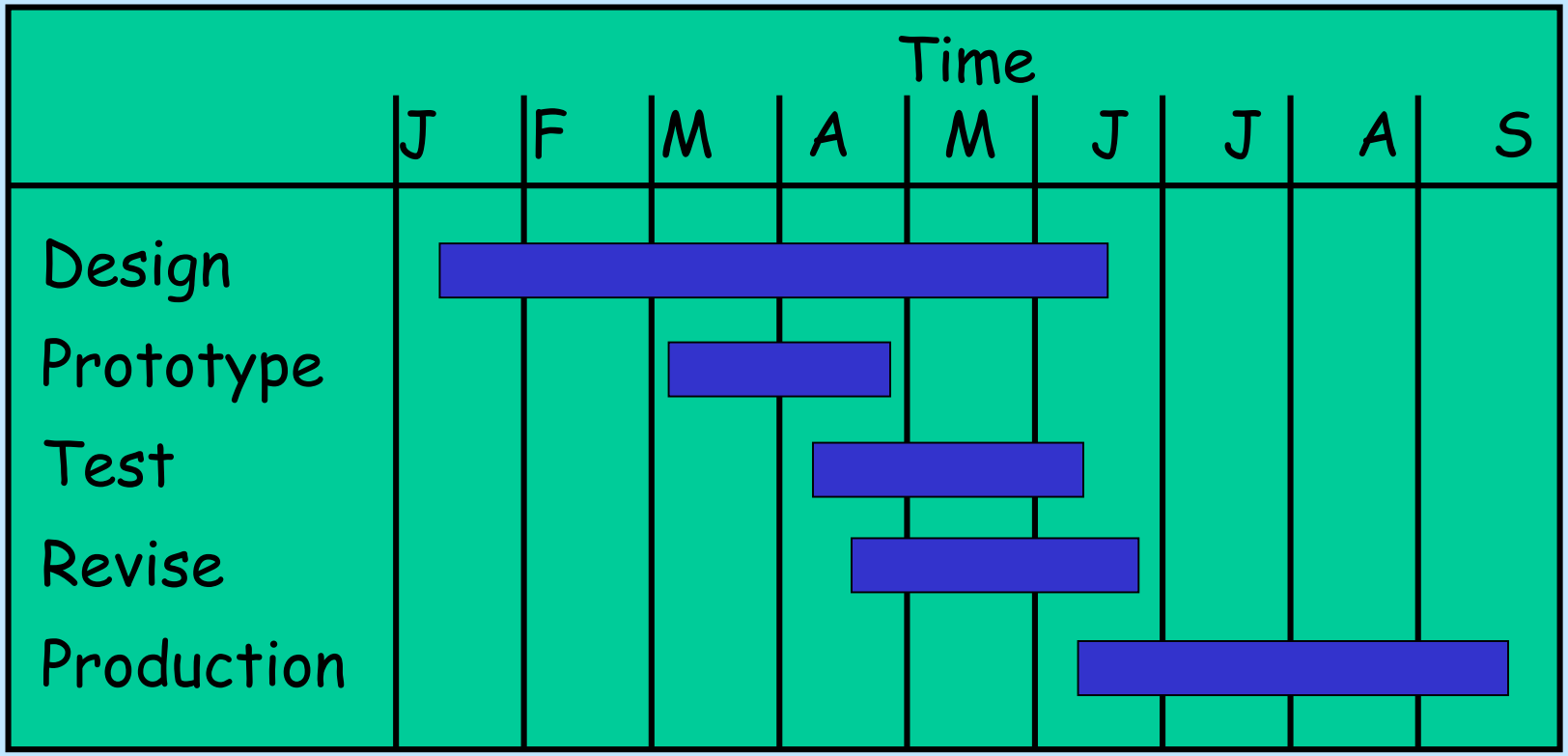
1. Shows the relationship of each activity to others and to the whole project
2. Identifies the precedence relationships among activities
3. Encourages the setting of realistic time and cost estimates for each activity
4. Helps make better use of people, money, and material resources by identifying critical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

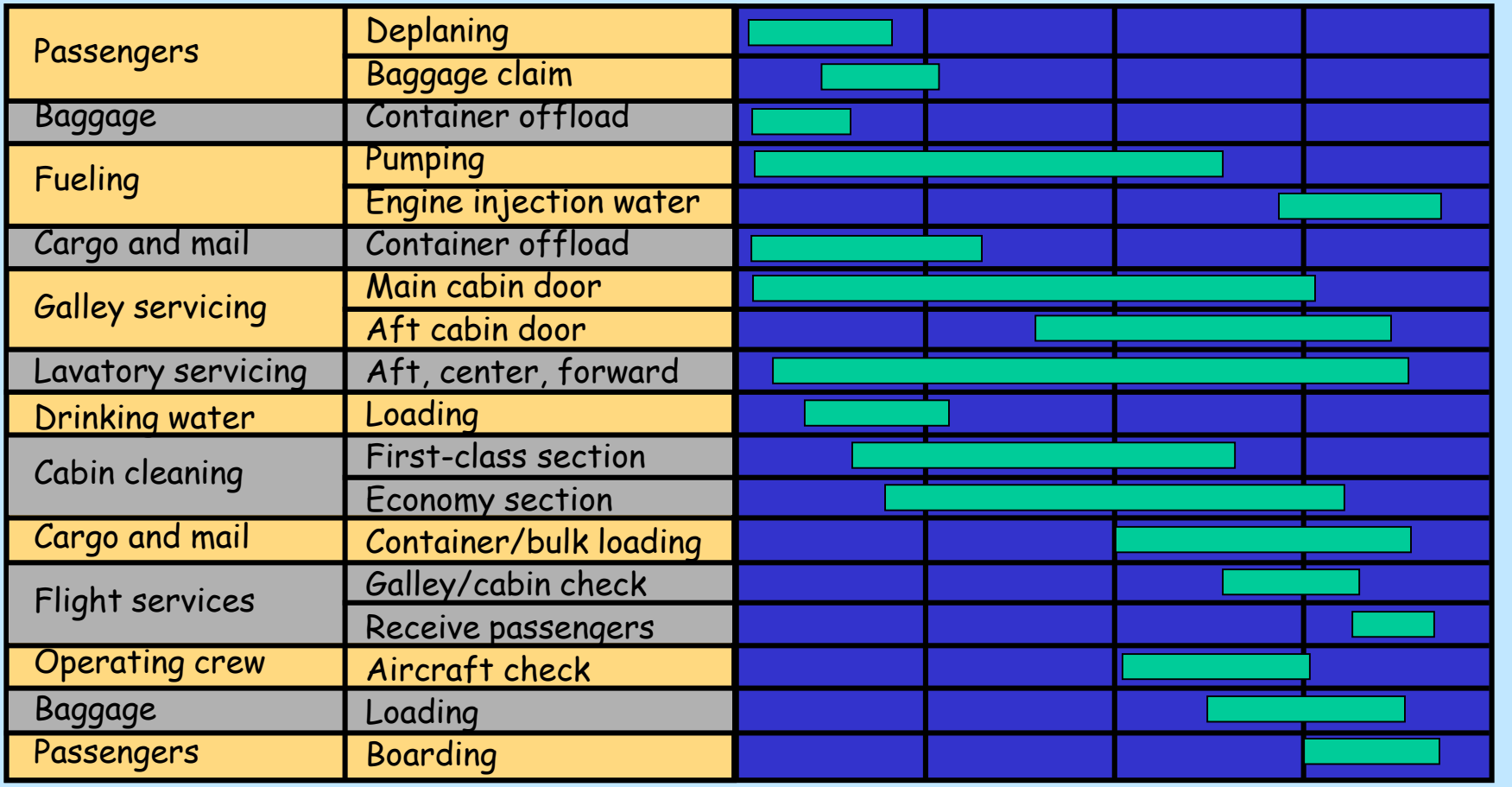


Figure 3.4

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?

A Comparison of AON and AOA Network Conventions

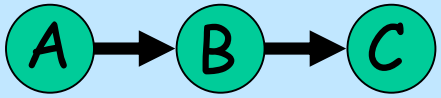
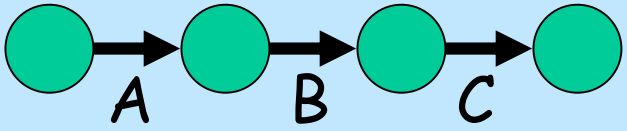
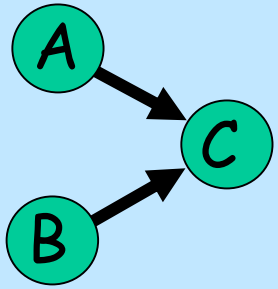
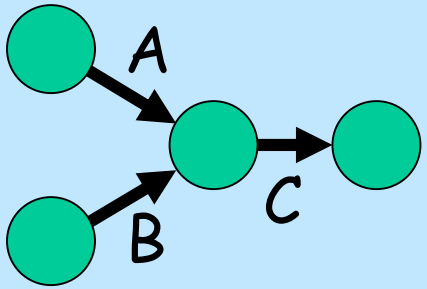
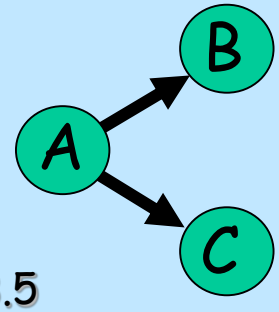
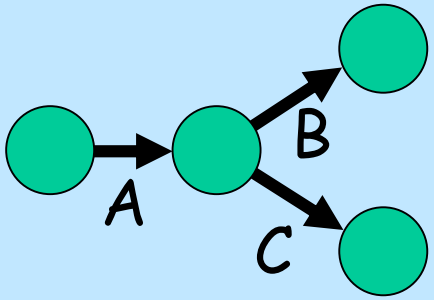
Activity on Node (AON)	Activity Meaning	Activity on Arrow (AOA)
(a) 	A comes before B, which comes before C	
(b) 	A and B must both be completed before C can start	
(c) 	B and C cannot begin until A is completed	

Figure 3.5

A Comparison of AON and AOA Network Conventions

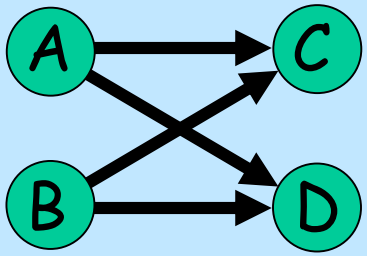
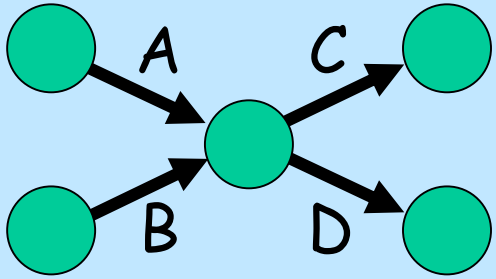
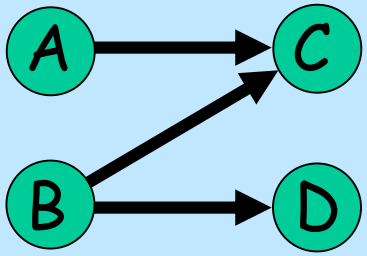
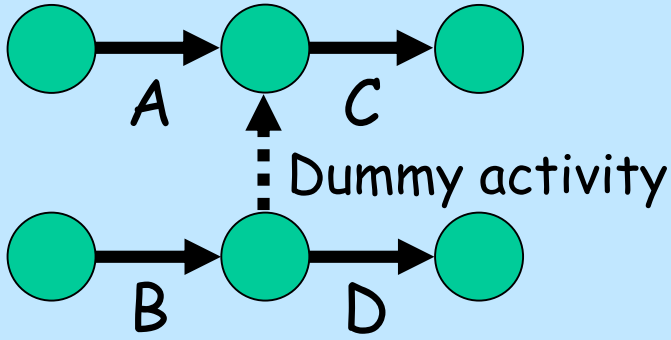
Activity on Node (AON)	Activity Meaning	Activity on Arrow (AOA)
(d) 	C and D cannot begin until A and B have both been completed	
(e) 	C cannot begin until both A and B are completed; D cannot begin until B is completed. A dummy activity is introduced in AOA	

Figure 3.5

A Comparison of AON and AOA Network Conventions

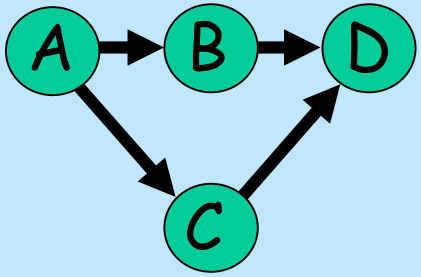
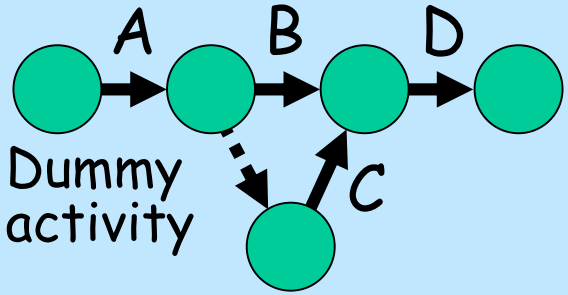
Activity on Node (AON)	Activity Meaning	Activity on Arrow (AOA)
(f) 	B and C cannot begin until A is completed. D cannot begin until both B and C are completed. A dummy activity is again introduced in AOA.	

Figure 3.5

AON Example

Milwaukee Paper Manufacturing's Activities and Predecessors

Activity	Description	Immediate Predecessors
A	Build internal components	—
B	Modify roof and floor	—
C	Construct collection stack	A
D	Pour concrete and install frame	A, B
E	Build high-temperature burner	C
F	Install pollution control system	C
G	Install air pollution device	D, E
H	Inspect and test	F, G

Table 3.1

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

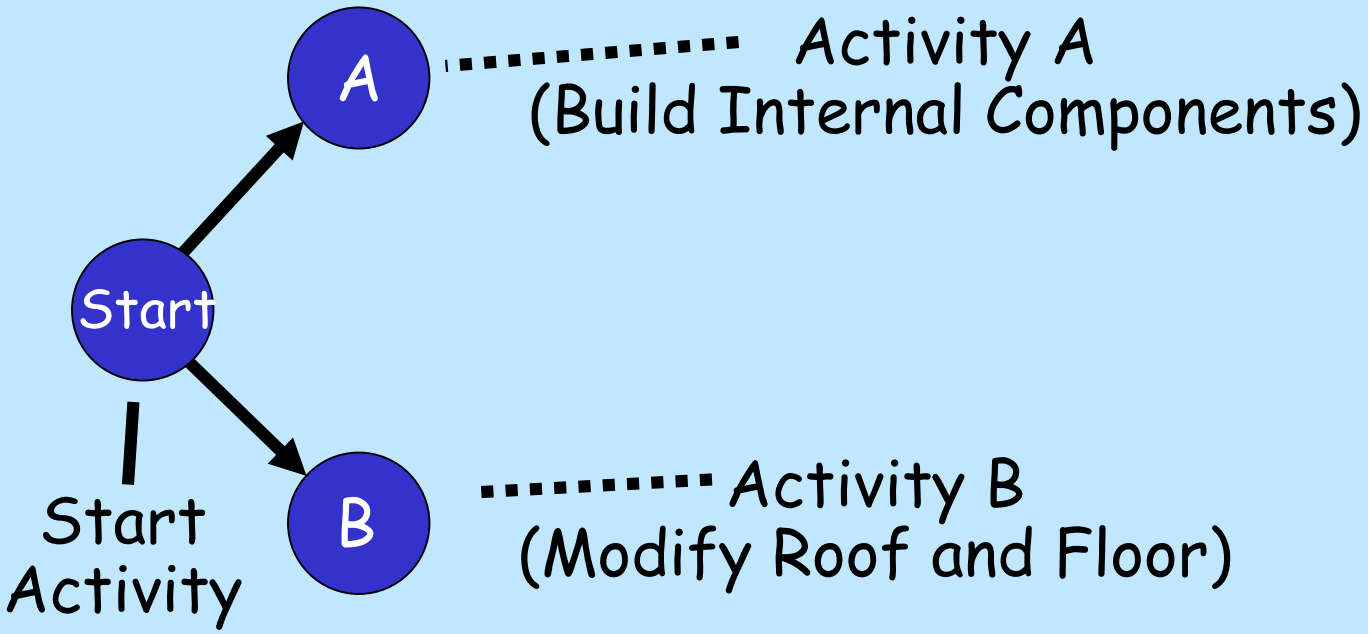


Figure 3.6

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

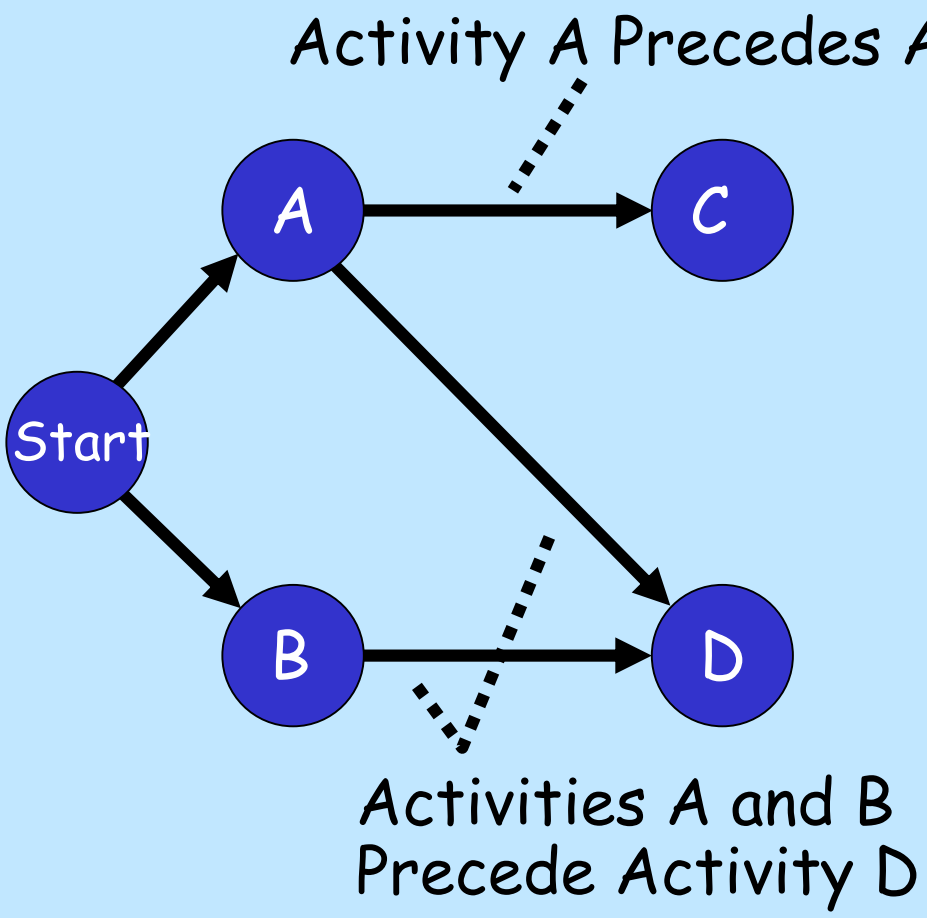


Figure 3.7

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

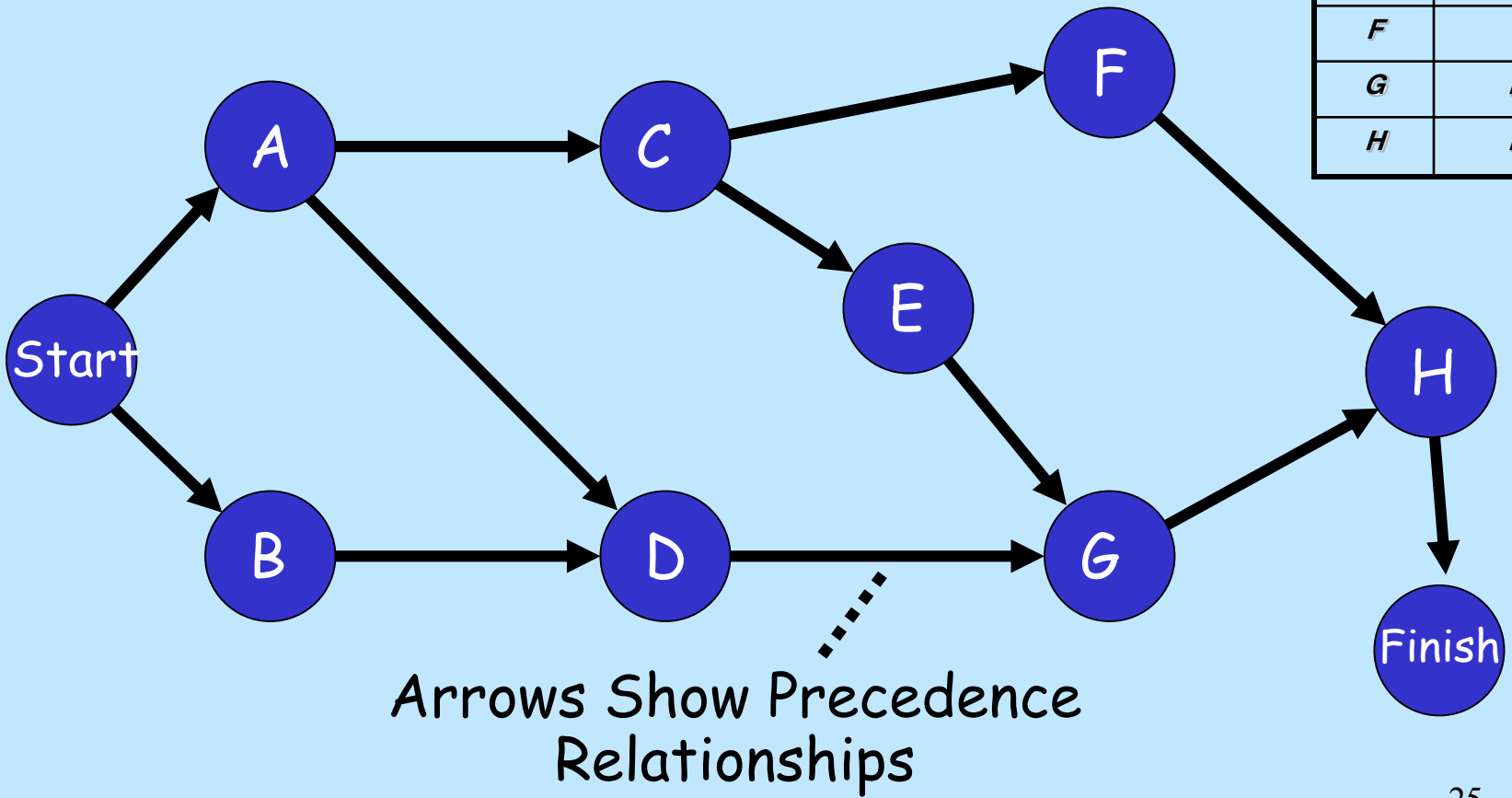


Figure 3.8

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

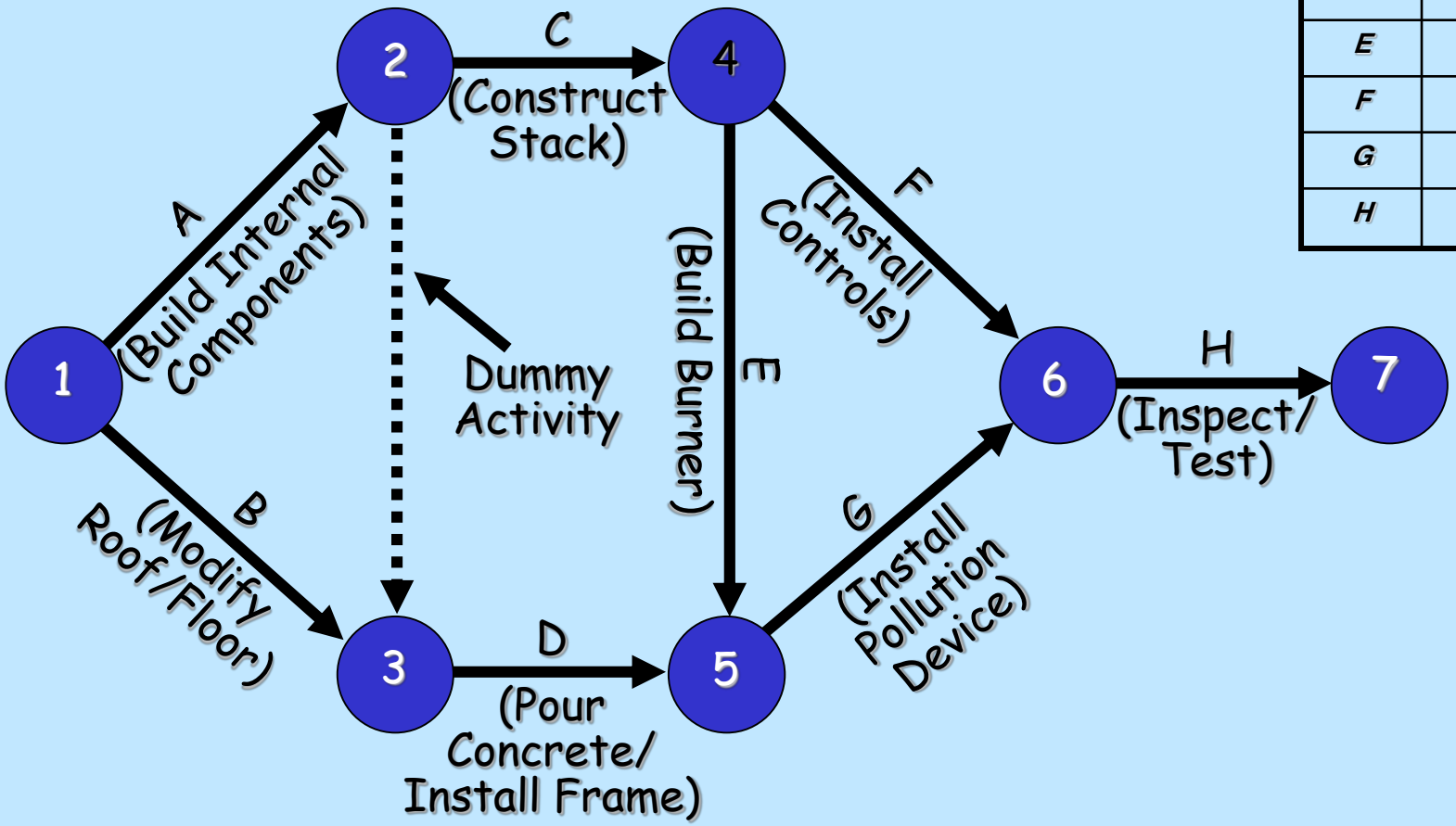


Figure 3.9

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

Table 3.2

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 Rule:

- ☑ 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 = Max (EF of all immediate predecessors)

Forward Pass

Begin at starting event and work forward

Earliest Finish Time Rule:

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

EF = ES + Activity time

Backward Pass

Begin with the last event and work backwards

Latest Finish Time Rule:

- ☑ 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 = Min (LS of all immediate following activities)

Backward Pass

Begin with the last event and work backwards

Latest Start Time Rule:

- ☑ 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

Slack = LS – ES or Slack = LF – EF

Computing Slack Time

Activity	Earliest Start ES	Earliest Finish EF	Latest Start LS	Latest Finish LF	Slack LS - ES	On Critical 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

Table 3.3

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

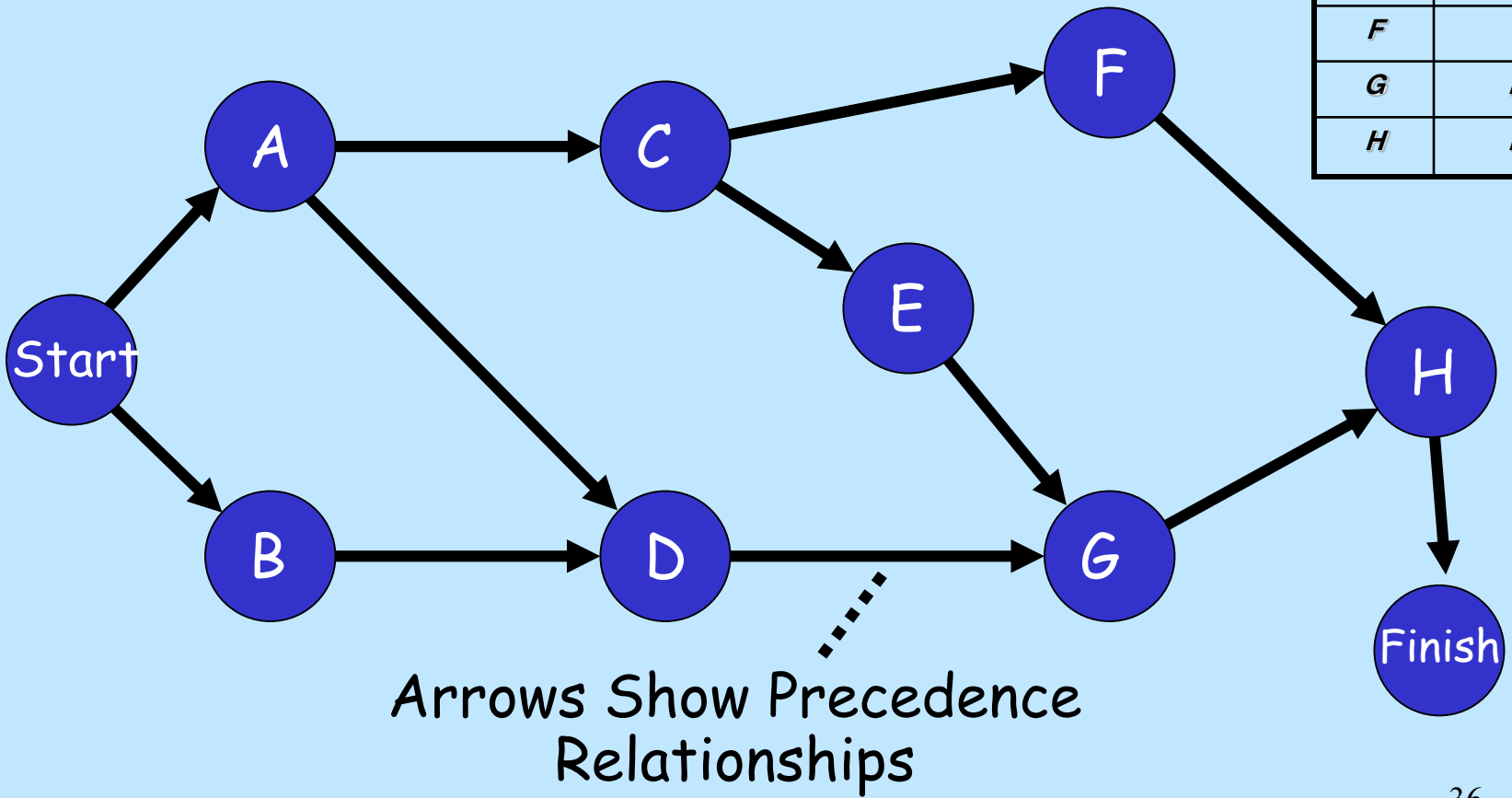
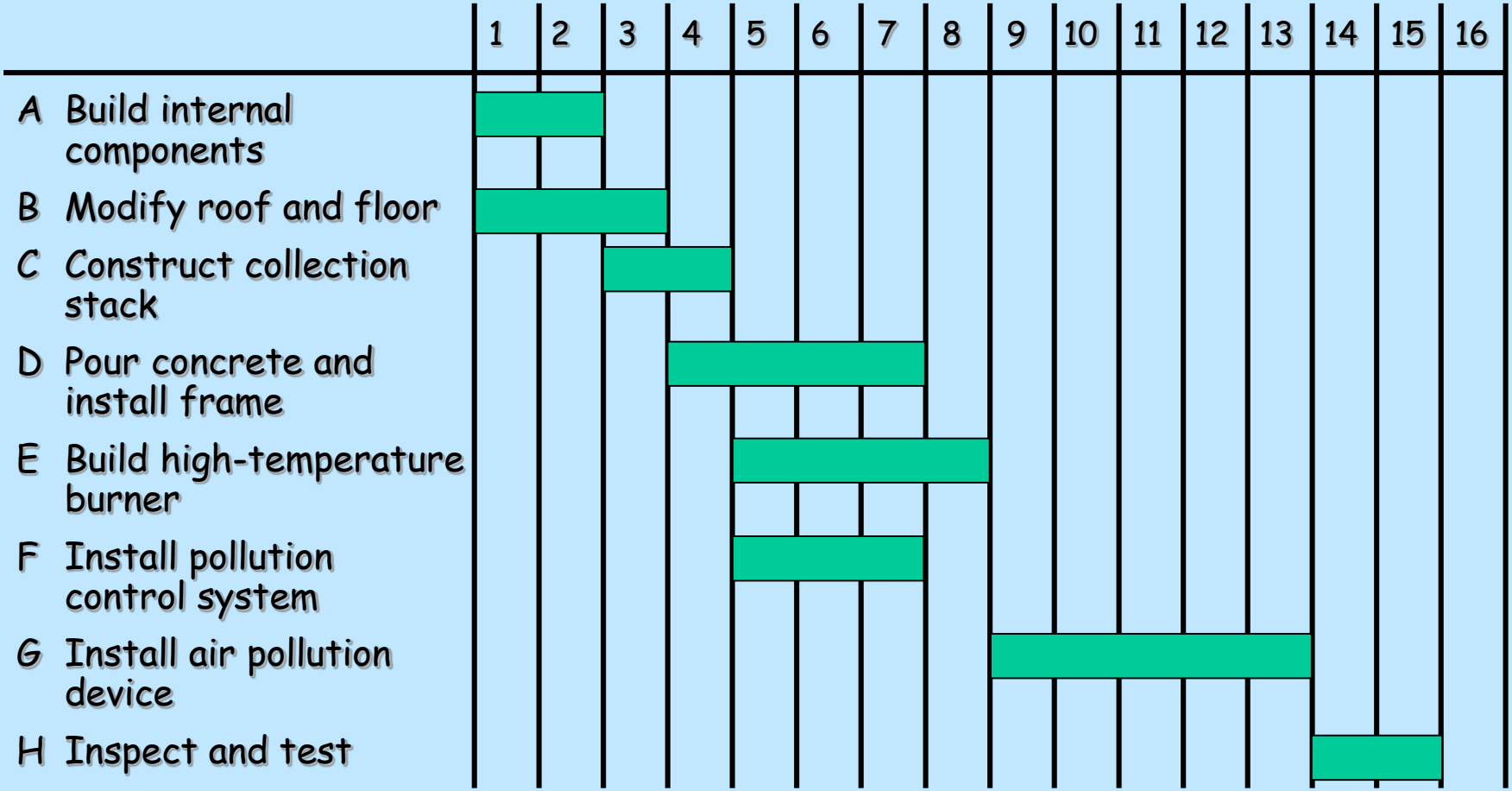
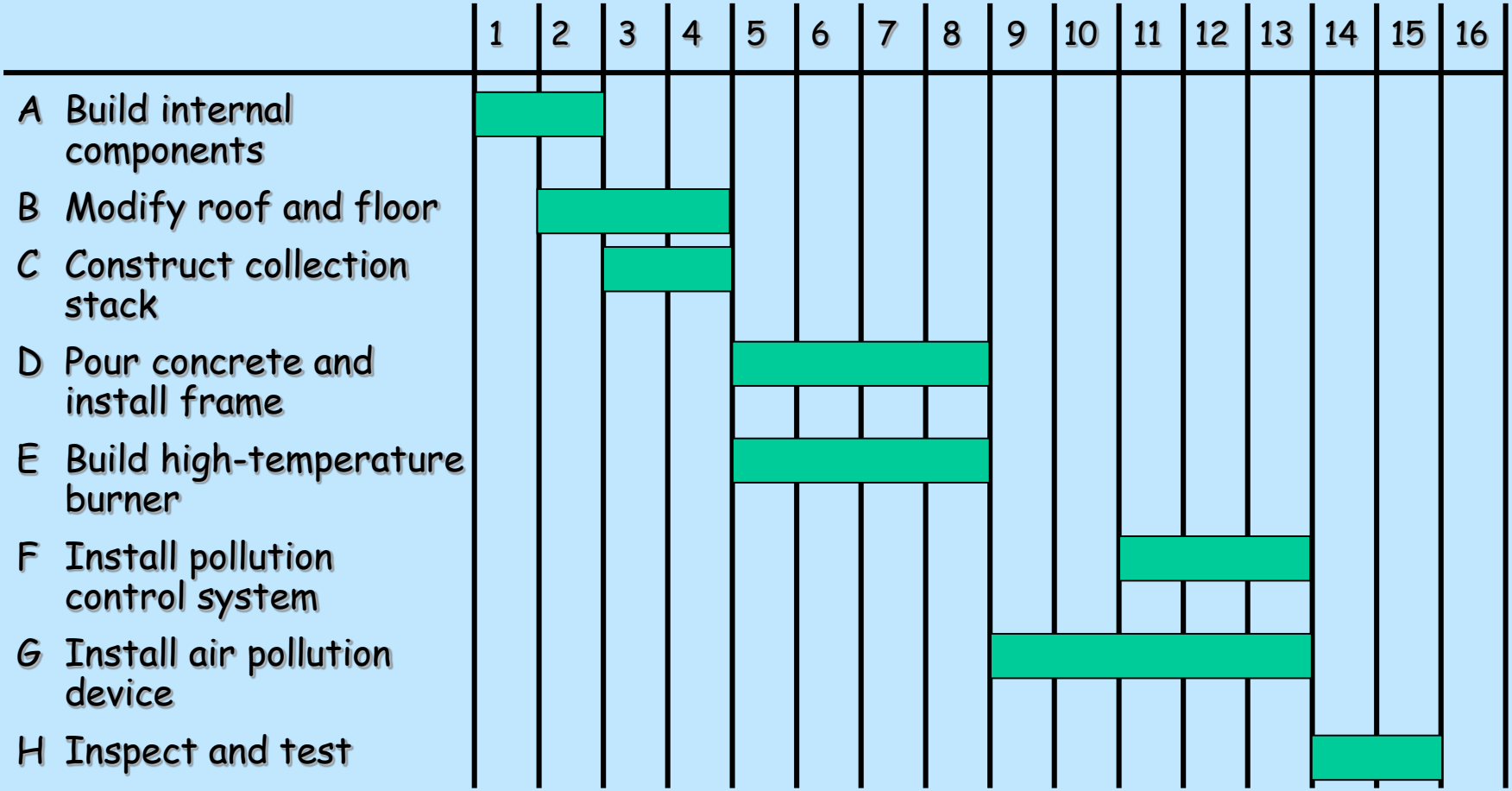


Figure 3.8

ES – EF Gantt Chart for Milwaukee Paper



LS – LF Gantt Chart for Milwaukee Paper



Example:

Activities	Duration	Immediate Predecessor
A: Purchase Raw Material	9	-
B: Train workers	6	-
C: Produce part 1	8	A,B
D: Produce Part 2	7	A, B
E: Test part 2	10	D
F: Assemble parts 1 and 2	12	C,E

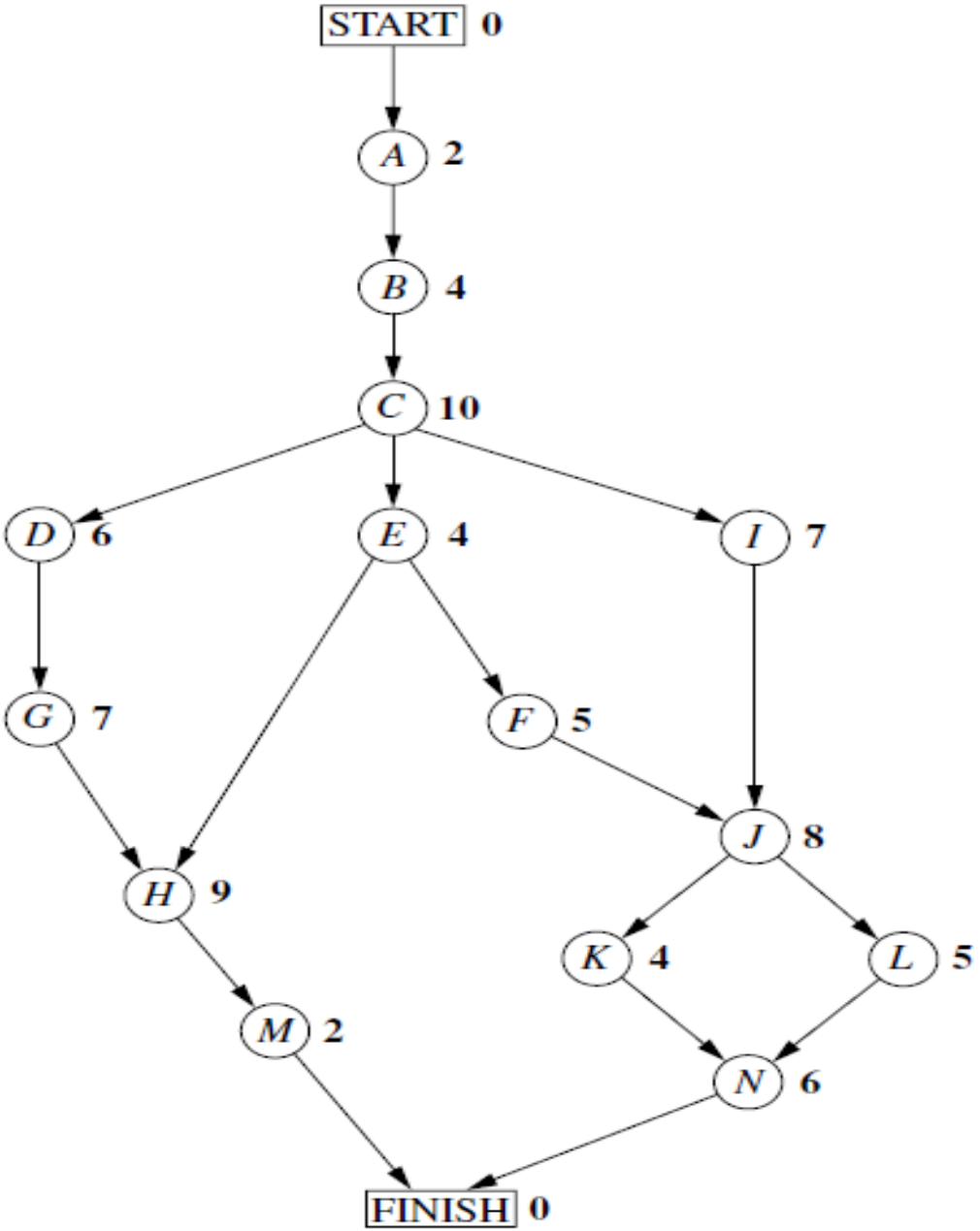
An example will be solved in the class.

CPM-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

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.