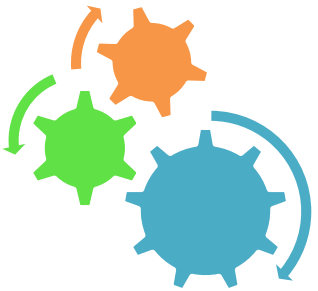
IT1311 Decision Analysis

Project Scheduling: CPM/PERT



Introduction

- **CPM** (Critical path method) and **PERT** (Program evaluation and review technique) are network-based project scheduling procedure to coordinate the activities of the projects
- They help to the project managers to answer the following questions:
  - What is the ***total time*** to complete the project?
  - What are the scheduled ***start and finish dates*** for each specific activity?
  - Which activities are ***critical*** and must be completed exactly as scheduled in order not to miss the deadlines?
  - How long can ***non-critical*** activities be delayed before they cause an increase in the total project completion time?

Learning Objectives

- To understand the critical path method (**CPM, deterministic approach**) and the program evaluation and review technique (**PERT, probabilistic approach**) in planning project schedule
- To apply linear programming model to determine the crashing decisions for minimizing the cost of reducing project completion time

Reference

- Main Text : “Quantitative Methods for Business” 12th edition, Chapter 13

CPM: Project scheduling with known activity times

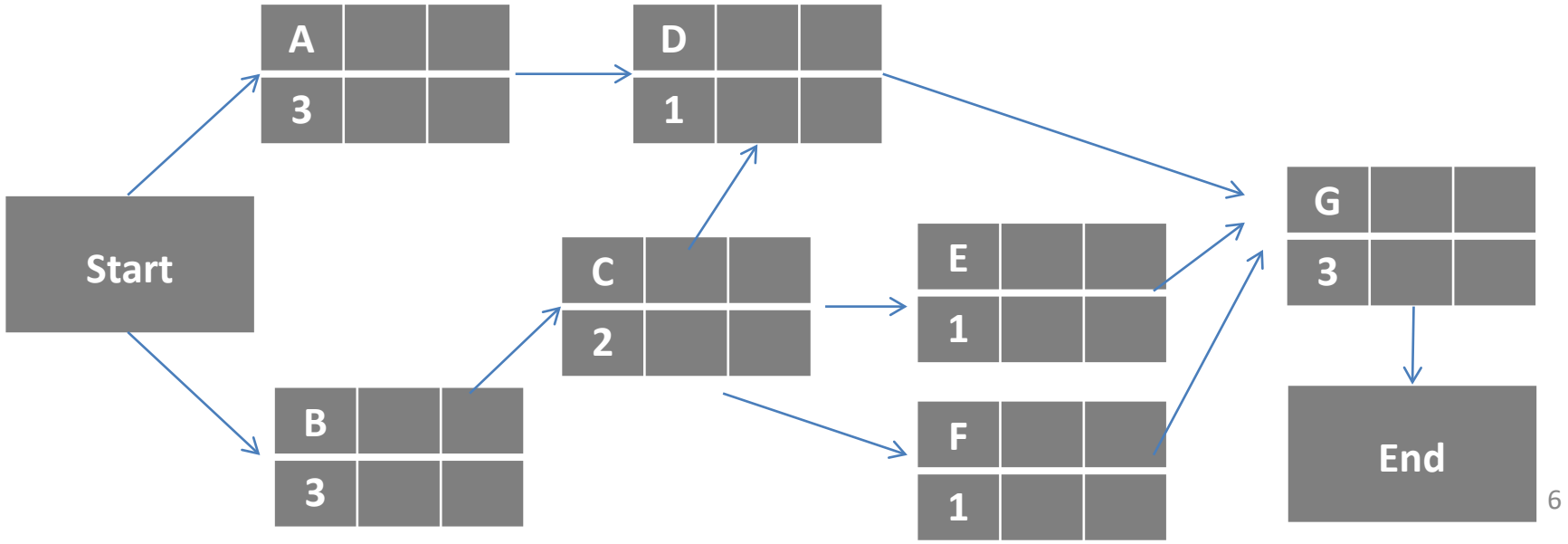
- First, let's understand what is a Project Network
  - A project network can be constructed to model the precedence of the activities
  - The nodes of the network represent the activities
  - The arcs (arrows) of the network reflect the precedence relationships of the activities
  - A critical path for the network is a path consisting of activities that determines the duration to complete the project (and no slack)

Simple project network with the following info

Activity	Immediate Predecessor	
A	-	3 (duration in days)
B	-	3
C	B	2
D	A, C	1
E	C	1
F	C	1
G	D, E, F	3

What can you see from the project network shown below?

Task ID	ES	EF
Dur	LS	LF



Western Hills Shopping Centre Example

- The owner of Western Hills shopping centre is considering modernising and expanding the current 32-business shopping complex. He hopes to add 8 to 10 new business or tenants to the shopping complex. The specific activities that make up the 5 expansion project, together with information on immediate predecessor and completion time, are listed in the table below.

Activity	Activity Description	Immediate Predecessor	Completion Time (weeks)
A	Prepare architectural drawings	-	5
B	Identify potential new tenants	-	6
C	Develop prospectus for tenants	A	4
D	Select contractor	A	3
E	Prepare building permits	A	1
F	Obtain approval for building permits	E	4
G	Perform construction	D, F	14
H	Finalise contracts with tenants	B, C	12
I	Tenants move in	G, H	2

We are now asked to answer the following questions:

1) What is the total completion time of the project?

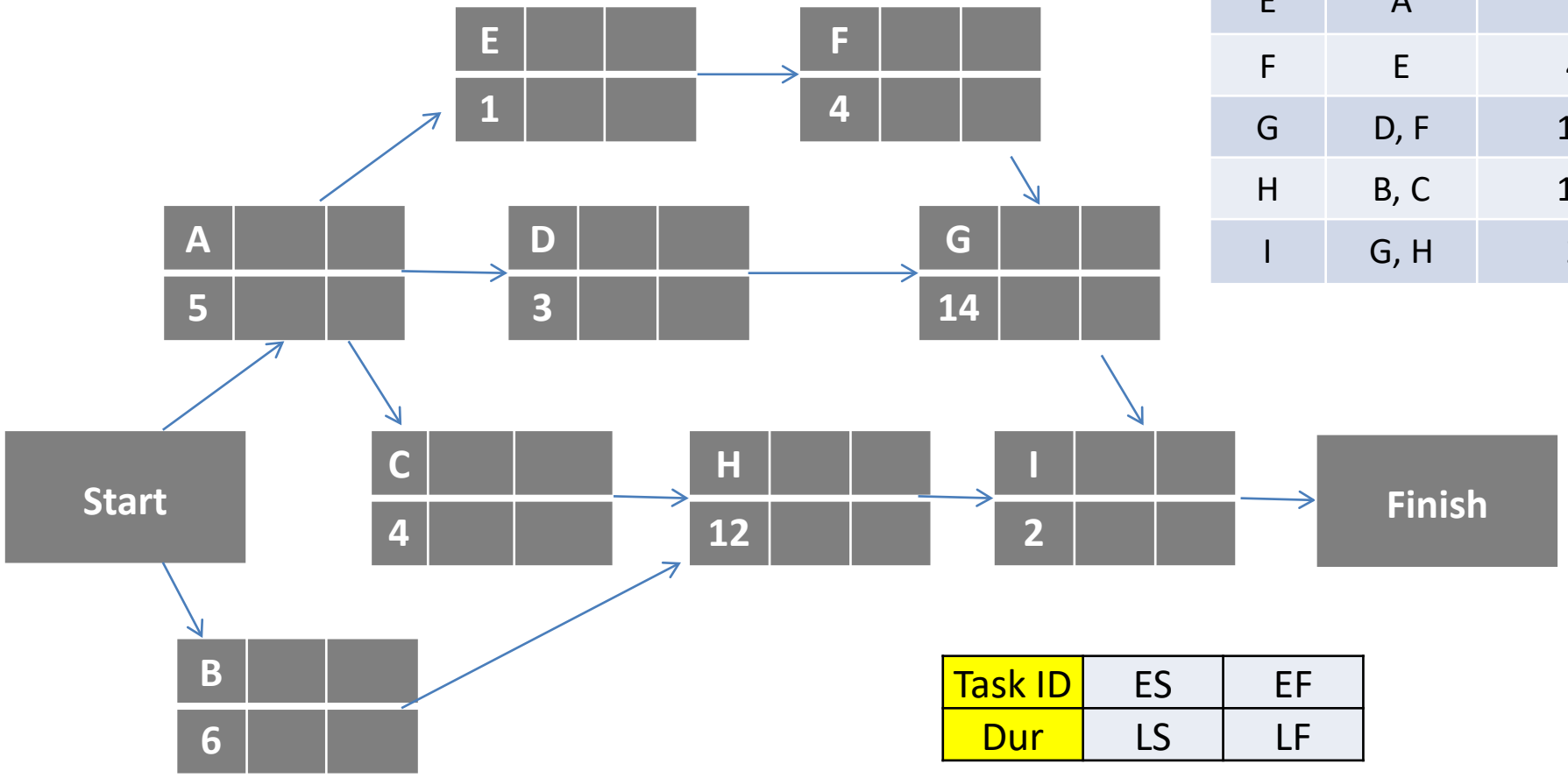
2) What are the scheduled start and completion time for each activity?

3) Which activities are critical and must be completed exactly as scheduled in order to keep the project on schedule?

4) How long can the non-critical activities to be delayed before they cause a delay in the completion time for the project?

Western Hills Shopping Centre
Project Network with Activity Duration

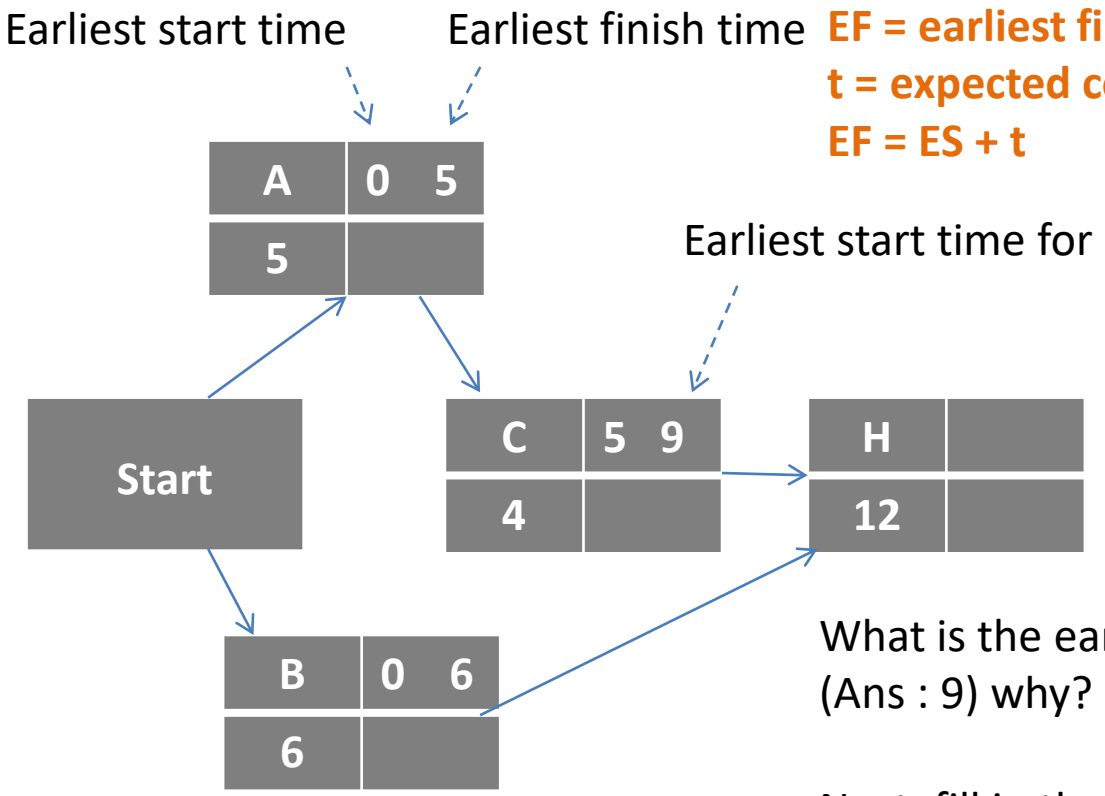
Activ -ity	Predec -essor	Duration
A	-	5
B	-	6
C	A	4
D	A	3
E	A	1
F	E	4
G	D, F	14
H	B, C	12
I	G, H	2



Task ID	ES	EF
Dur	LS	LF

Portion of project network showing activities A, B, C and H (Forward Pass)

ES = earliest start time for a particular activity
EF = earliest finish time for a particular activity
t = expected completion time for the activity
EF = ES + t

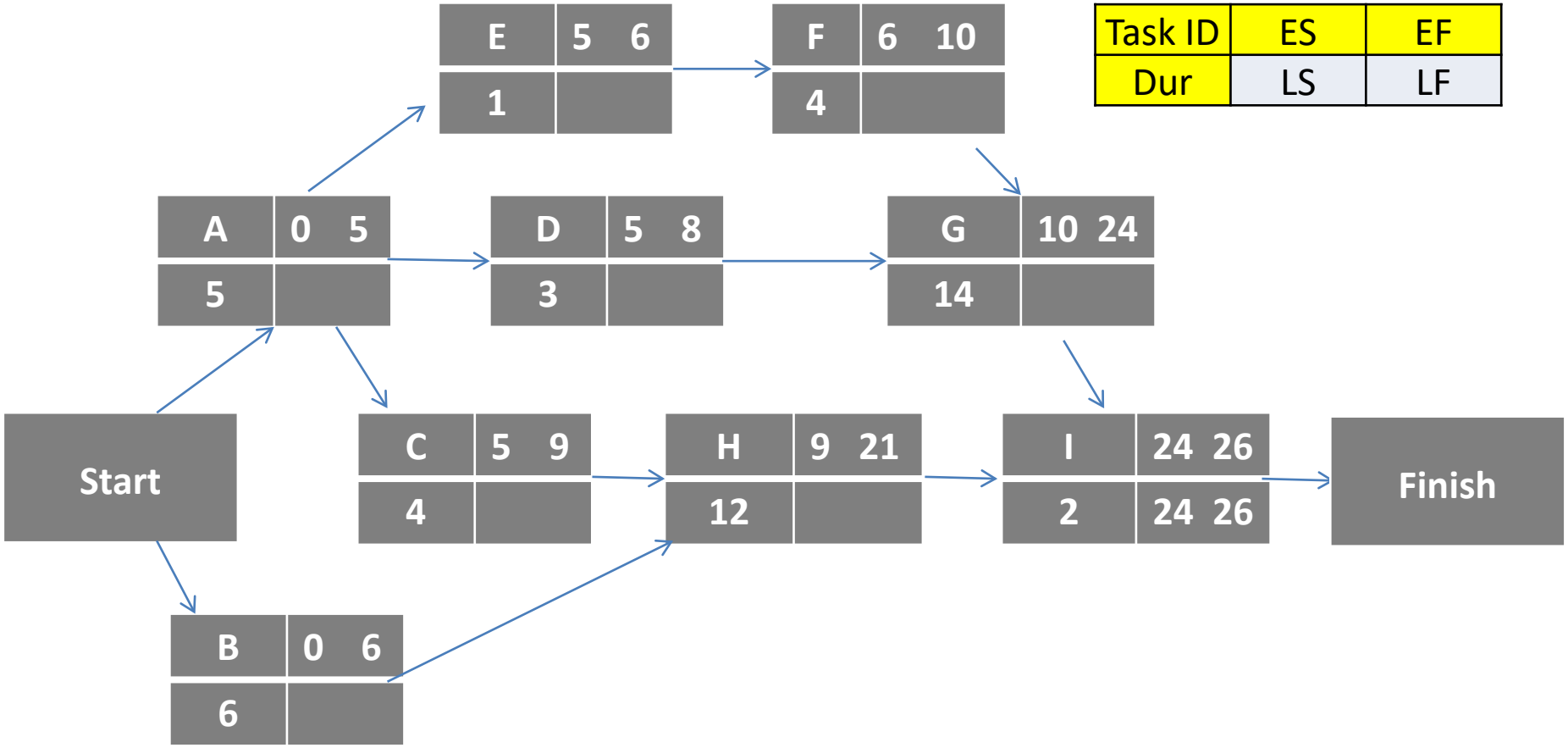


Task ID	ES	EF
Dur	LS	LF

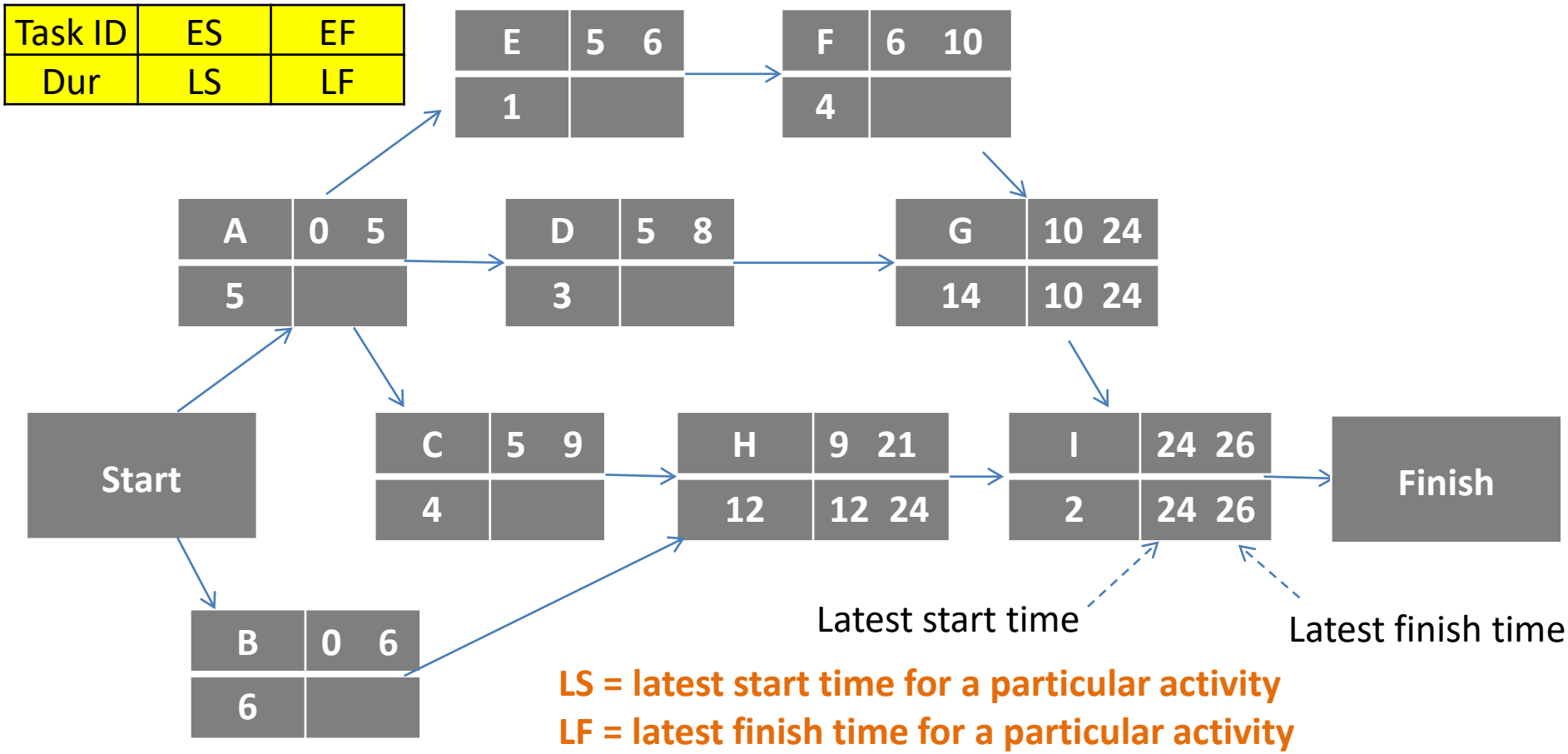
What is the earliest start time for activity H? (Ans : 9) why?

Next, fill in the earliest start and finish time of the remaining activities.

Western Hills Shopping Centre Project Network with ES and EF (Forward Pass)



Latest start and finish times (Reverse Pass) (For activity I, G and H)



LS = latest start time for a particular activity

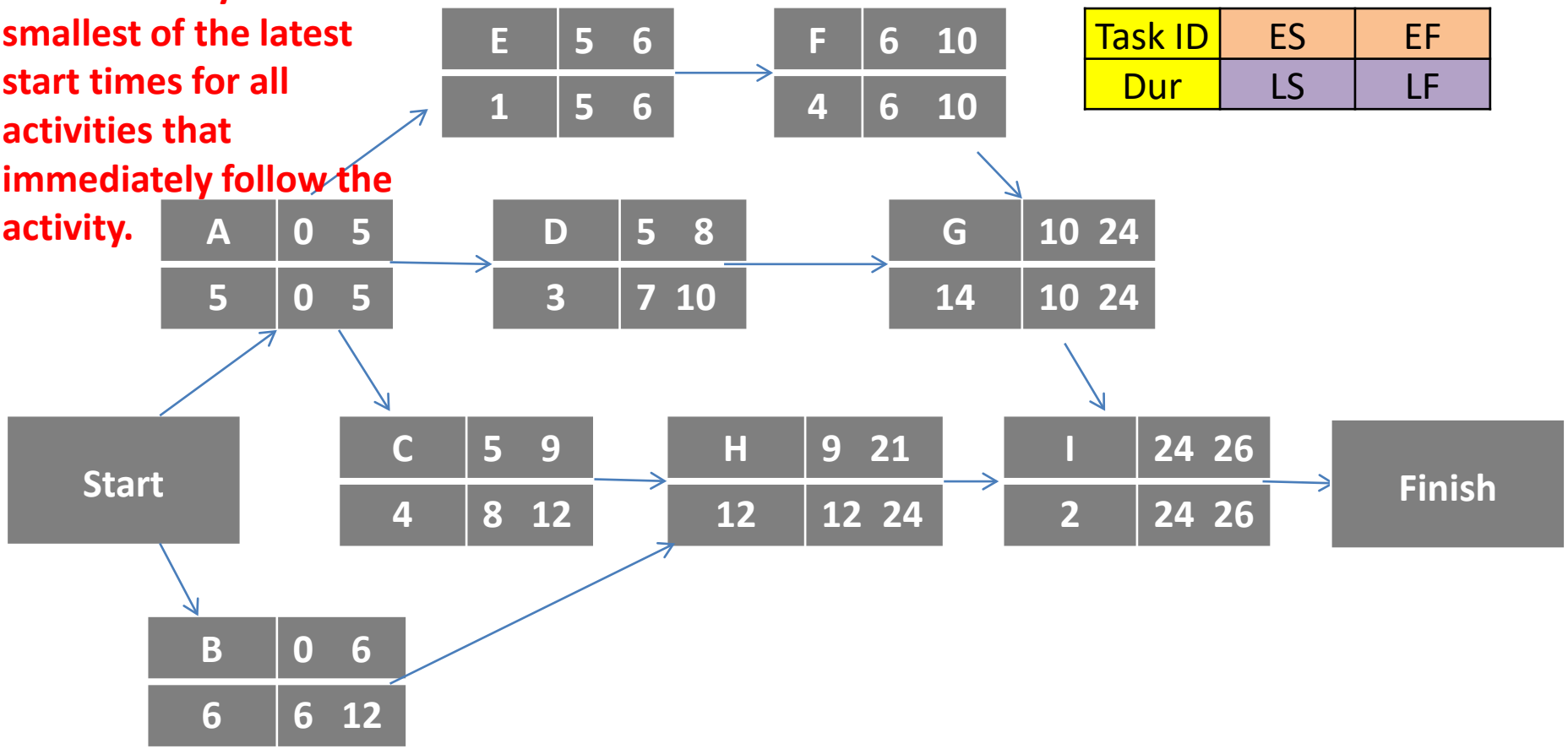
LF = latest finish time for a particular activity

LS = LF - t

Next, fill in the earliest start and finish time of the remaining activities.

Western Hills Shopping Centre
Project Network with ES, EF, LS and LF

The latest finish time for an activity is the smallest of the latest start times for all activities that immediately follow the activity.



Slack Time

- Slack is the length of time an activity can be delayed without increasing the project completion time. It is defined as:

  Slack = LS – ES = LF – EF

- Using this definition, we obtain the following:

Activity	ES	LS	EF	LF	Slack	Critical Path?
A	0	0	5	5	0	Yes
B	0	6	6	12	6	
C	5	8	9	12	3	
D	5	7	8	10	2	
E	5	5	6	6	0	Yes
F	6	6	10	10	0	Yes
G	10	10	24	24	0	Yes
H	9	12	21	24	3	
I	24	14	26	26	0	Yes

Answer the questions

1) What is the total completion time of the project?

The project can be completed in 26 weeks if the individual activities are completed on schedule

2) What are the scheduled start and completion time for each activity?

Shown in previous table

3) Which activities are critical and must be completed exactly as scheduled in order to keep the project on schedule?

A, E, F, G, and I are the critical path activities

4) How long can the non-critical activities to be delayed before they cause a delay in the completion time for the project?

Refer to previous table

Conclusions that we can draw from this example

- It is the critical paths that determine the project completion time;
- Changing time of the non-critical activities within the permissible range will not affect the project completion time; but changing time of the critical activities may cause the project completion time to change

Example on NOT leaving nodes hanging

Construct a PERT/CPM network for a project having the following activities. The project is completed when activities F and G are both completed.

Activity	Immediate Predecessor	Duration (in months)
A	-	4
B	-	6
C	A	2
D	A	6
E	C, B	3
F	C , B	3
G	D, E	5

Example on NOT leaving nodes hanging

Activity	Predecessor	Duration
A	-	4
B	-	6
C	A	2
D	A	6
E	C, B	3
F	C , B	3
G	D, E	5