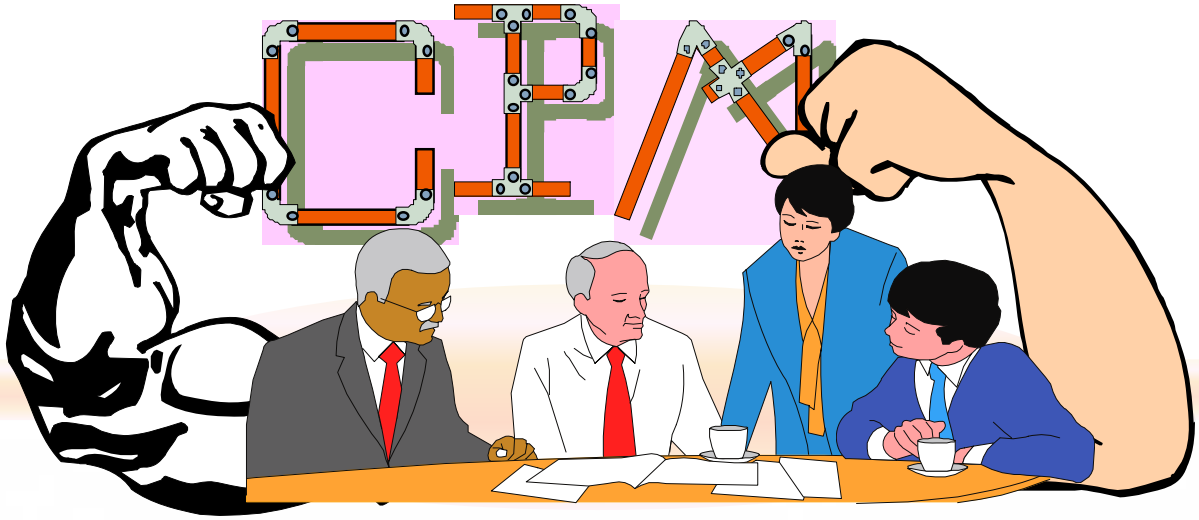
CRITICAL PATH METHOD



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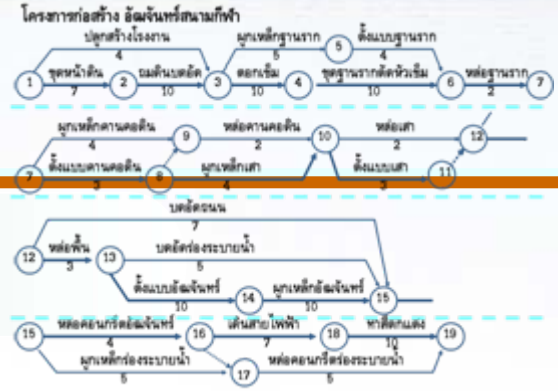
KHON KAEN UNIVERSITY,
THAILAND.

Critical path method

Has been designed to meet this need.

- Effectively plan and control a project.
- They need to be able to process large amounts of data quickly.
- And accurately to enable them to create. order in a complex situation.

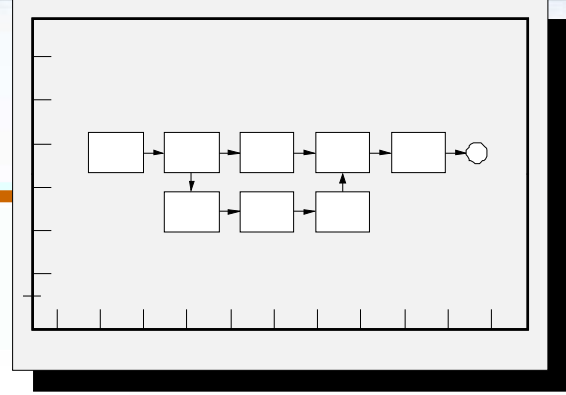
Critical path method



1. Network Diagram

The work breakdown structure *(WBS)* provides a structured breakdown of the **scope** of work into manageable **work packages** that can be further developed into a list of **activities** (see WBS chapter). The **next process** is to establish a logical relationship between the activities using a network diagram.

Critical path method



1. Network Diagram

Cont.

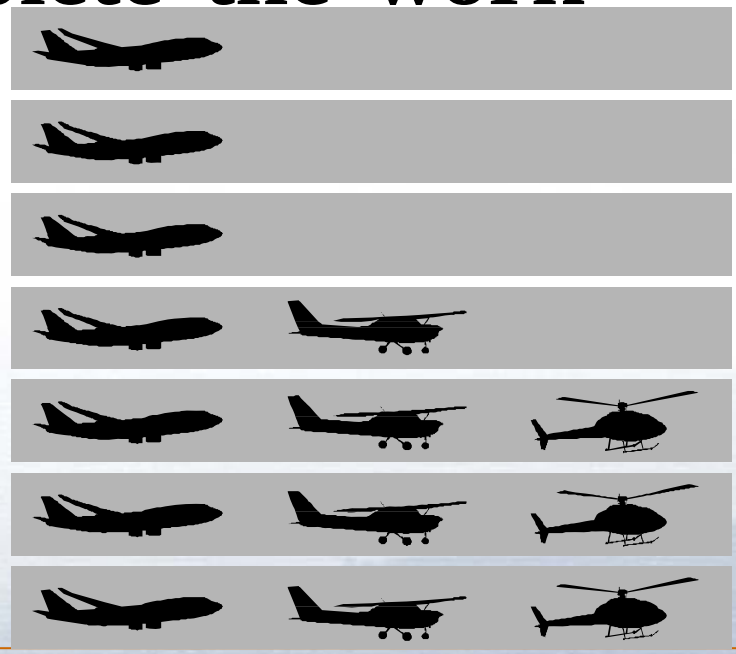
The network diagram may be defined as a graphical presentation of the project's activities showing the planned sequence of work. In its simplest form only two items of information are required:

- **List of activities**
- **Logic constraints, also called logical links, logical dependency or logical relationships between the activities.**

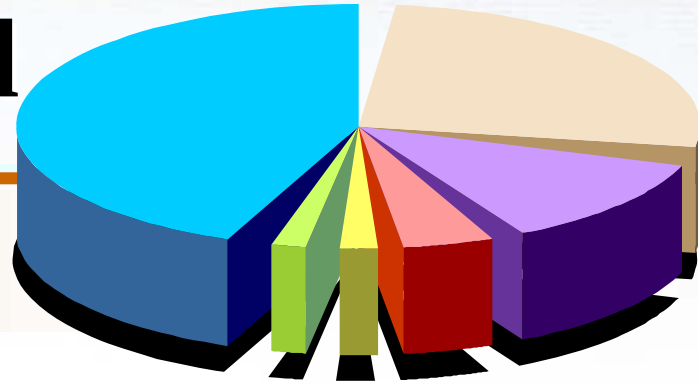
Critical path method

2. Definition of an Activity

An activity may be defined as any task, job or operation that must be performed to complete the work package or project.



Critical path method



3. Logical Relationships

- The *network diagram* shows the sequence of the activities
- Where these logical relationships can be either mandatory.
- Or discretionary.
- *Mandatory* or hard dependencies are limitations of the build method.
- *Discretionary* logic is the preferred or best practice defined by the body of knowledge.

Critical path method

3. Logical Relationships *Cont.*

The logical relationships between all the activities. There are two basic relationships:

- **Activities in series.**
- **Activities in parallel.**

Critical path method

3. Logical Relationships *Cont.*

A 100 (Task 1)
FOUNDATIONS

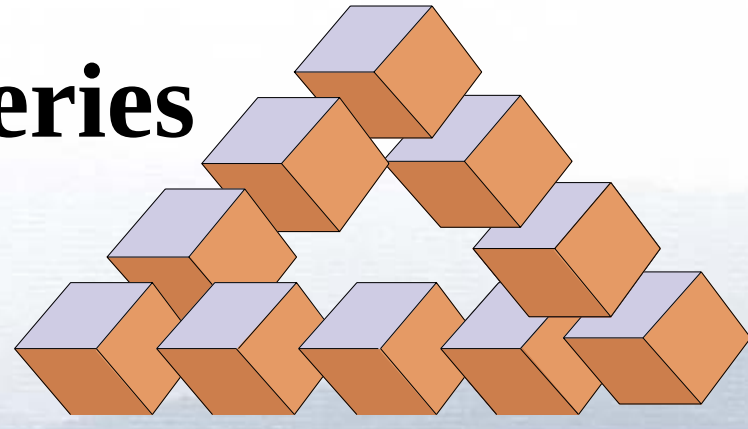
→

A 200 (Task 2)
WALLS

→

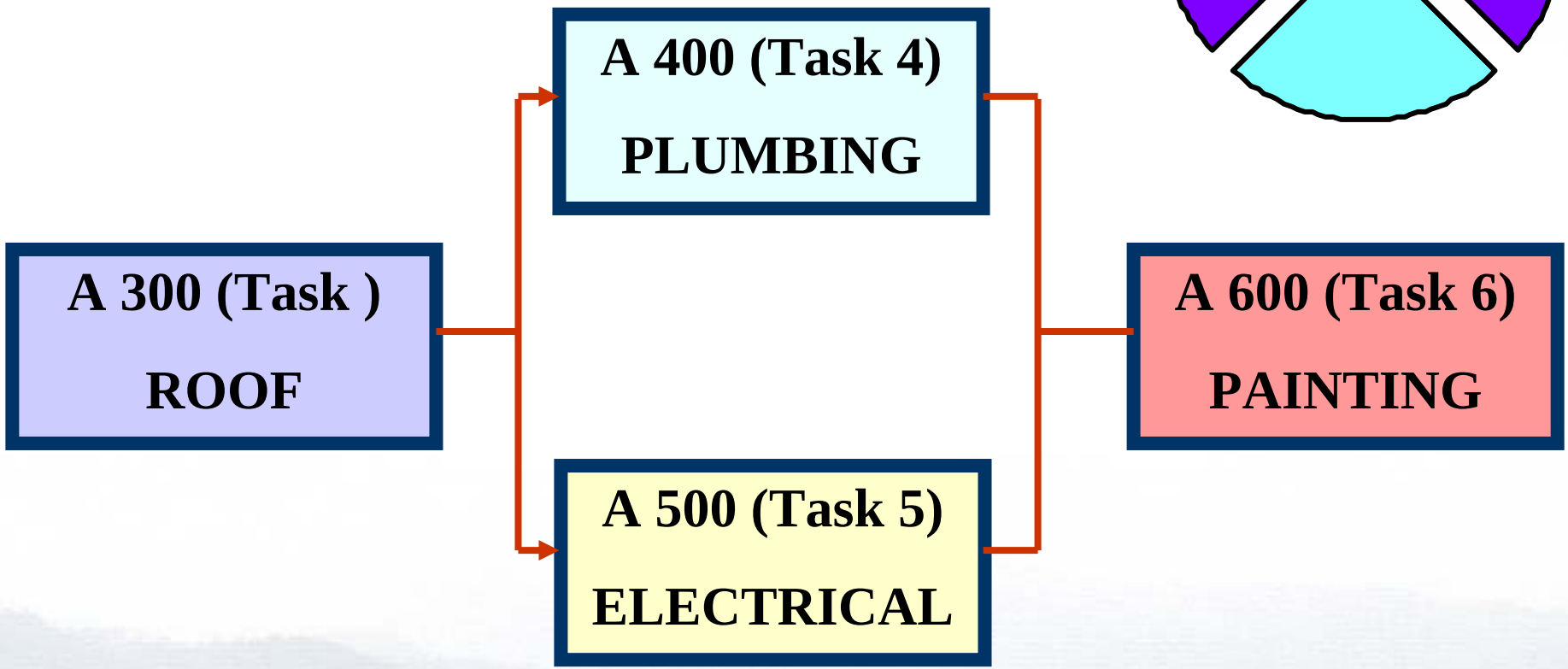
A 300 (Task 3)
ROOF

Activities in Series



Critical path method

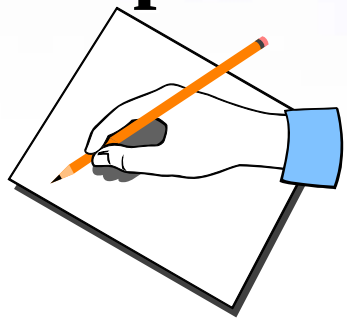
3. Logical Relationships *Cont.*



Activities in Parallel

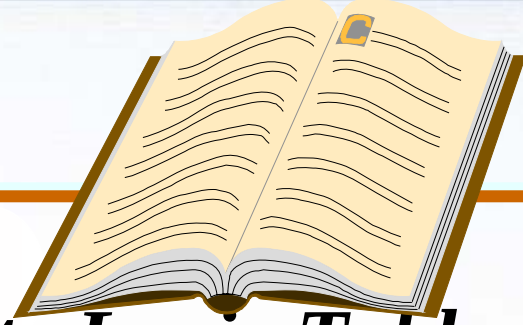
Critical path method

4. How to Draw the Logical Relationships



How to Draw Activity Constraints

Critical path method



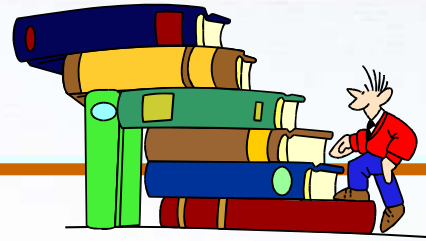
5. Activity Logic Table

Activity Logic Table

Before Activity	Constraint	Fallowing Activity

Preceding Activity	Constraint	Succeeding Activity

Critical path method



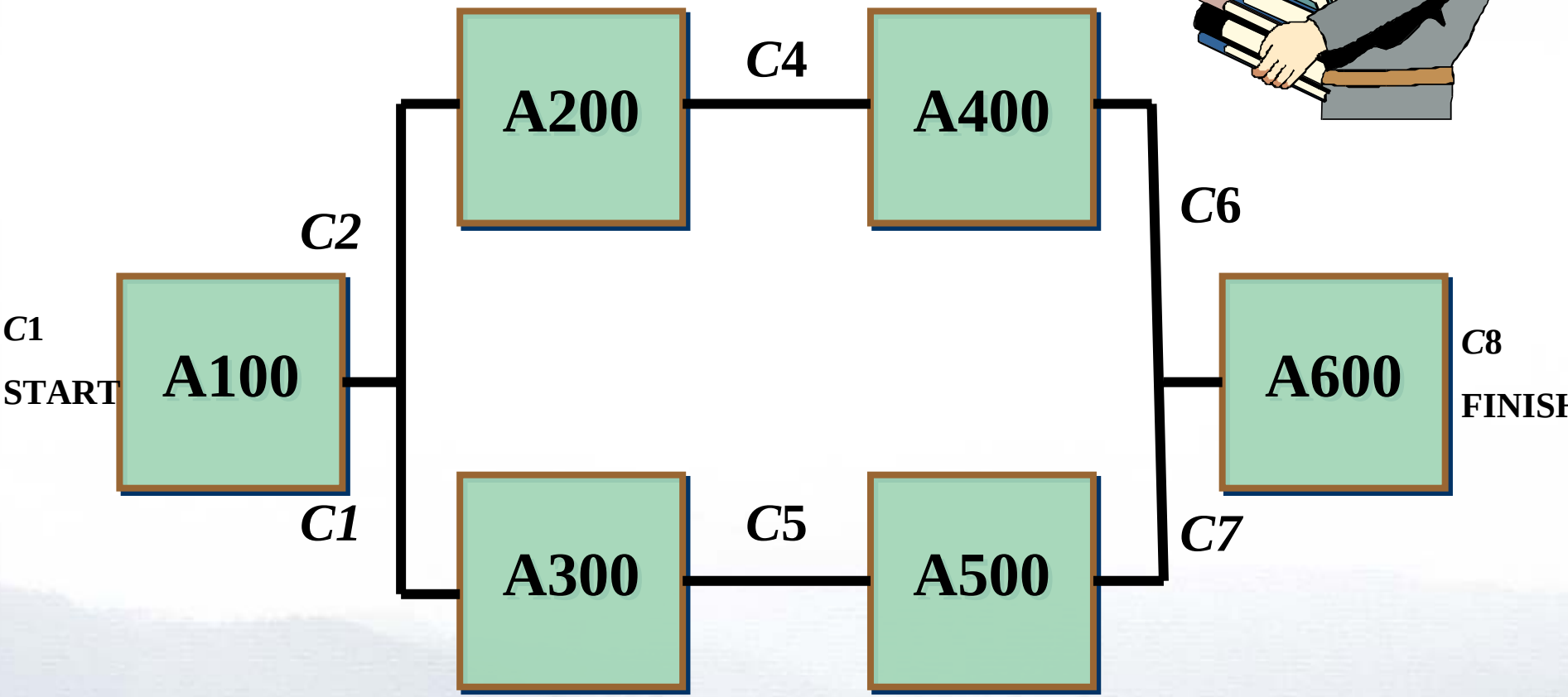
5. Activity Logic Table Cont.

(CPM example)

Preceding Activity	Constraint	Succeeding Activity
Start	*C*1	A100
A100	*C*2	A200
A100	*C*3	A300
A200	*C*4	A400
A300	*C*5	A500
A400	*C*6	A600
A500	*C*7	A600
A600	*C*8	Finish

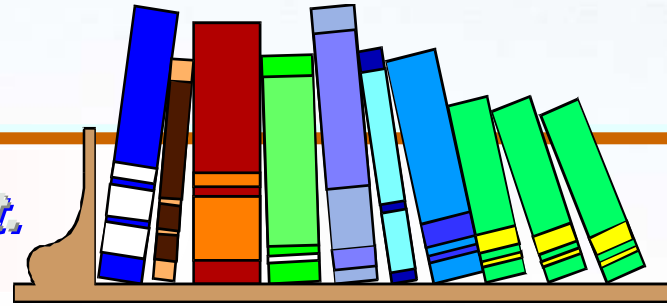
Critical path method

5. Activity Logic Table *Cont.*



Network Diagram

Critical path method



5. Activity Logic Table Cont.

Activity	Preceding Activity	Duration
A100		2
A200		2
A300		1
A400		4
A500		2
A600		2

Critical path method

5. Activity Logic Table Cont.

Solution to Table

Activity	Preceding Activity	Duration
A100	Start	2
A200	A100	2
A300	A100	1
A400	A200	4
A500	A300	2
A600	A400, A500	2

Critical path method

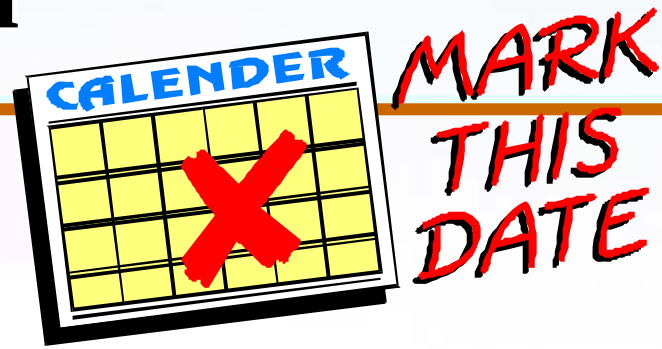
6. Activity Duration

We need two more items of information before we can proceed with the CPM time analysis:

- Activity duration
- Activity calendar or work pattern.

Critical path method

7. Calendar / Work Pattern



Calendar or work pattern are common terms used in the planning software to describe an activity's working profile, in other words. On what days of the week the resources or activity will be working.

Critical path method

8. Critical path Method Steps

- Draw the logic network diagram.
- Assign durations to all the activities.
- Impose a work calendar.

Activity Logic Table

Activity Number	Description	Duration	Calendar

Critical path method

8. Critical path Method Steps

Cont.

Start Date : We need to give the project a start date (this can always be changed later.

Early Start : The earliest date by which an activity can start assuming all the preceding activities are completed as planned.

Early Finish: The earliest date by which an activity can be completed assuming all the preceding activities are completed as planned.

Critical path method

8. Critical path Method Steps *Cont.*

Late Start : the latest date an activity can start to meet the planned completion date.

Late Finish : the latest date an activity can finish to meet the planned completion date.

Target Start and Target Finish : In addition to the calculated dates there may be a number of imposed dates.

Critical path method

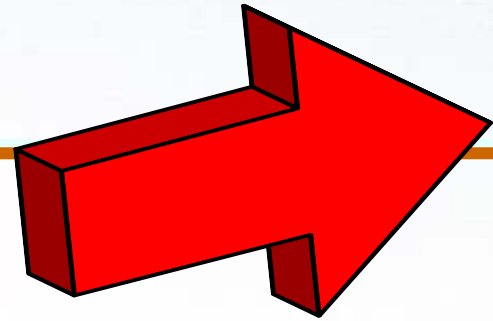
8. Critical path Method Steps *Cont.*

Activity Box : The activity box key indicates where to position the values in the activity box.

EARLY START		EARLY FINISH
FLOAT	ACTIVITY NUMBER DESCRIPTION	DURATION
LATE START		LATE FINISH

Activity Box (typical layout)

Critical path method



9. Forward Pass

We use the term forward pass to define the process of calculating the early start date (ES) and early finish date (EF) for all the activities.

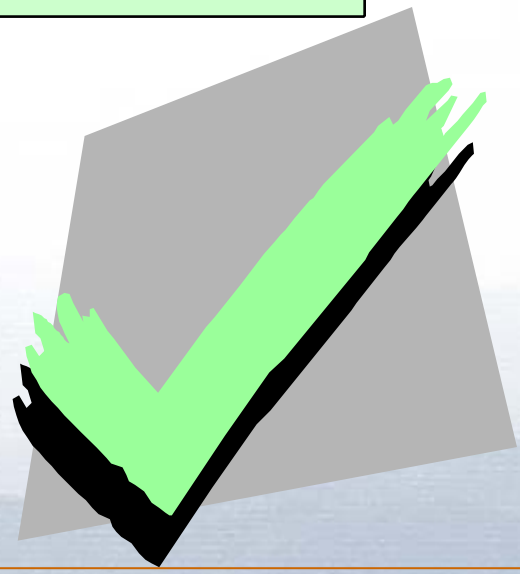
Consider a simple project with two activities A and B. The relationship between A and B is finish – to – start, this means activity A must be completed before B can start.

Critical path method

9. Forward Pass *Cont.*

Activity Logic Table

Activity Number	Description	Duration
A	-	3
B	A	4



Critical path method

9. Forward Pass *Cont.*

Forward Pass

The early finish date of an activity is calculated by adding the activity duration to the early start date, using the following formula.

$$EF = ES + Duration - 1$$

Critical path method

9. Forward Pass *Cont.*

Barchart

	1 Mon	2 TUE	3 WED	4 THU	5 FRI	6 SAT	7 SUN
ACTIVITY A **3 DAYS DURATION**	**ES**		**EF**				
ACTIVITY B **4 DAYS DURATION**				**ES**			**EF**

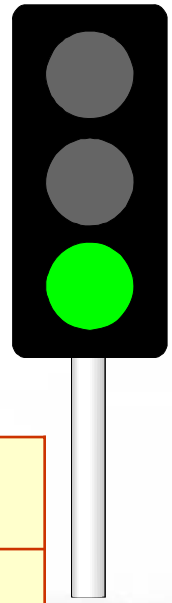
Critical path method

9. Forward Pass *Cont.*

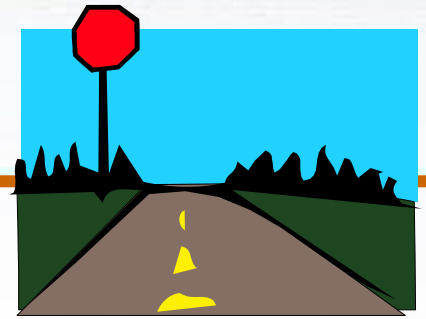
Using the above equation to find the early finish date (EF) of activity

$$EF(A) = ES(A) + Duration(A) - 1$$

$$= 1 + 3 - 1 \quad = 3$$



Critical path method



9. Forward Pass Cont.

To calculate the early start date (ES) of activity B use the following formula (Activity (B) can only start the day after Activity (A) has finished)

$$ES(B) = EF(A) + 1$$

$$= 3 + 1 \qquad = 4$$

Critical path method

9. Forward Pass *Cont.*

To calculate the early finish date (EF) of B use the same formula as we used previously on activity A.

$$BF(B) = ES(B) + Duration(B) - 1$$

$$= 4+4-1 = 7$$

1		3
	A	3

FS

Finish–To-Start

4		7
	B	4

Critical path method

10. Backward Pass Cont.

Backward pass to calculate the late start date (LS) and late finish date (LF) of each activity.

$$LF(B) = EF(B) = 7$$

Critical path method

10. Backward Pass *Cont.*

To calculate the late start date (LS) of activity B use the following formula:

$$LS(B) = LF(B) - Duration(B) + 1$$

$$= 7 - 4 + 1$$

$$= 4$$

Critical path method

10. Backward Pass *Cont.*

Note the plus one in the formula to keep the mathematics correct.

$$LF(A) = LS(B) - 1$$
$$= 4 - 1$$
$$= 3$$

$$LS(A) = LF(A) - Duration(A) + 1$$
$$= 3 - 3 + 1 = 1$$

1		3
	A	3
1		3

FS

Finish–To-Start

4		7
	B	4
4		7

Critical path method

11. Activity Float

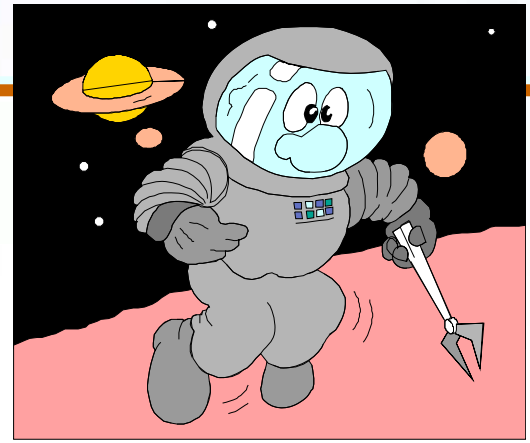
- Activity <u>float,</u> also called <u>slack</u>, is a measure of flexibility, or inherent surplus time in an activity's
- This indicates how many working days the activity can be delayed or extended the completion date of the project or any target finish dates (milestones). Float is calculated by either of the two equations.

$$\text{Float} = \text{Late Start} - \text{Early Start}$$

$$\text{Float} = \text{Late Finish} - \text{Early Finish}$$

Critical path method

11. Activity Float *Cont.*



Float (A) = LS(A) - ES(A)

= 1 – 1

= 0

The float for activity B is also 0. Where an activity has zero float this indicates it is on the *critical path*.

1		3
0	A	3
1		3

FS

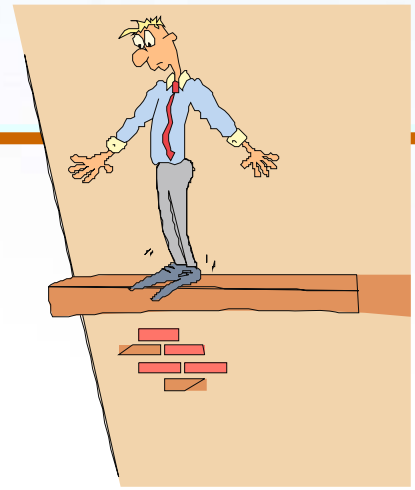
Finish–To-Start

4		7
0	B	4
4		7

Network Diagram Showing Float

Critical path method

11. Activity Float *Cont.*



Network Diagram

1		2
0	A100	2
1		2

3		4
0	A200	2
3		4

5		8
0	A400	4
5		8

3		3
3	A300	1
6		6

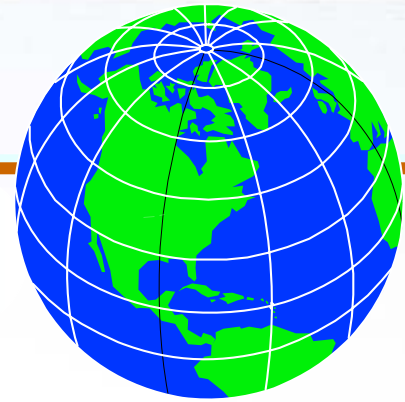
4		5
3	A500	2
7		8

9		10
0	A200	2
9		10

Key

ES		EF
F	NO	Dur
LS		LF

Critical path method



12. Network Diagrams

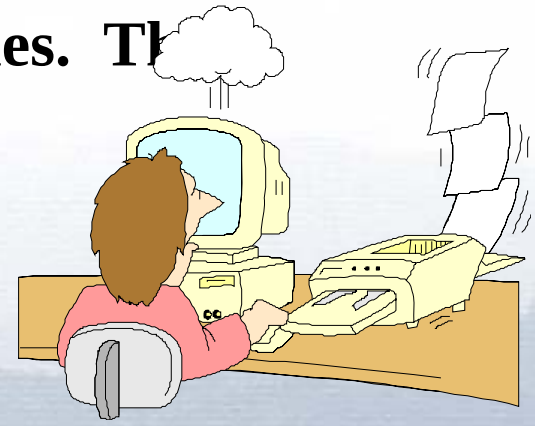
- To develop the network diagram it is advisable that the planner walks through the sequence of work with the managers, supervisors or the people who are going to perform the work.
- Partly to ensure the build method is correct.
- But mostly to gain their commitment (buy – in) and ensure the project achieves its objectives.

Critical path method

12. Network Diagrams *Cont.*

- ***Developing*** **the** ***network diagram*** **can be a juggling act, particularly if you have a long list of work packages, One way to get started is to select a key activity and work outwards:**
  - **What activities must be done before?**
  - **What activities can be done at the same time?**
  - **What activities can be done next?**

- **Types of constraints between activities. Th abbreviation is shown in brackets:**
  - **Finish – to – Start (FS)**
  - **Start – to – Start (SS)**
  - **Finish – to – Finish (FF)**
  - **Start – to – Finish (SF)**



Critical path method

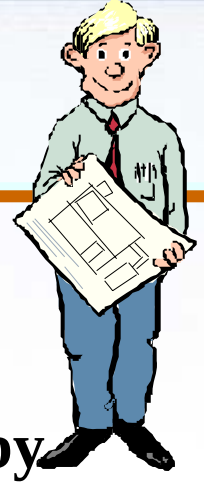
12. Network Diagrams Cont.

Finish – to – Start (FS) : The finish – to – start (FS) constraint is the most common type of relationship. In the example below activity 200 cannot start until activity 100 is finished. So if activity 100 is completed on Monday then 200 can start on Tuesday

Finish – to – Start (FS)

Critical path method

12. Network Diagrams *Cont.*

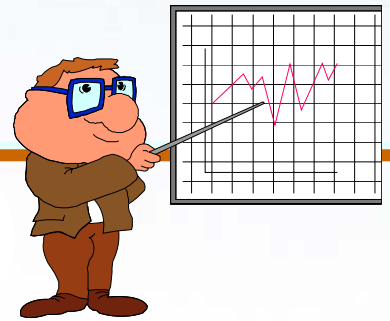


This relationship can be further developed by imposing a delay, or lag, between the activities, For example, if the concrete needs 2 days to cure and the foundations (activity 100) are thrown on Monday, then the building of the walls (activity 200) cannot start before Thursday

Finish – to – Start (with 2 bays lag)

Critical path method

12. Network Diagrams Cont.



Finish – to – Start Barchart (with 2 days lag)

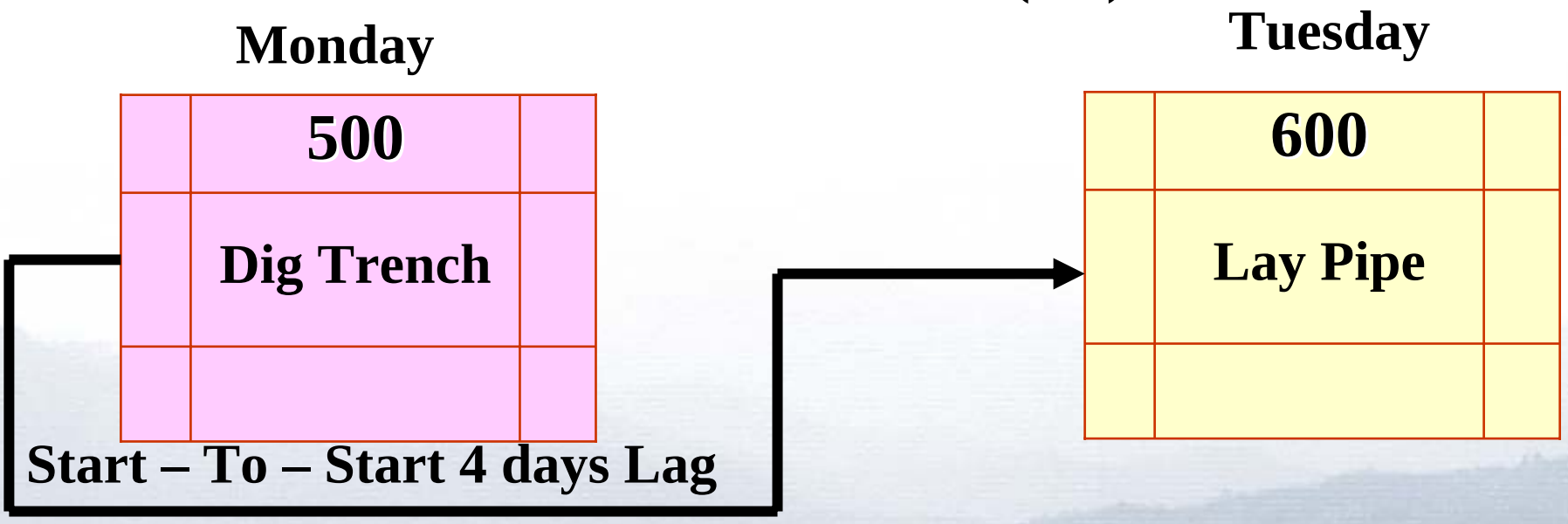
	1 Mon	2 TUE	3 WED	4 THU	5 FRI	6 SAT	7 SUN
Foundation 100	→						
Lag 2 Days		→	→				
Walls 200				→	→	→	→

Critical path method

12. Network Diagrams Cont.

Start – to – Start (SS): The start – to – start (SS) constraint represents the relationship between the start dates of the two activities.

Start – to – Start (FS)



Critical path method

12. Network Diagrams Cont.

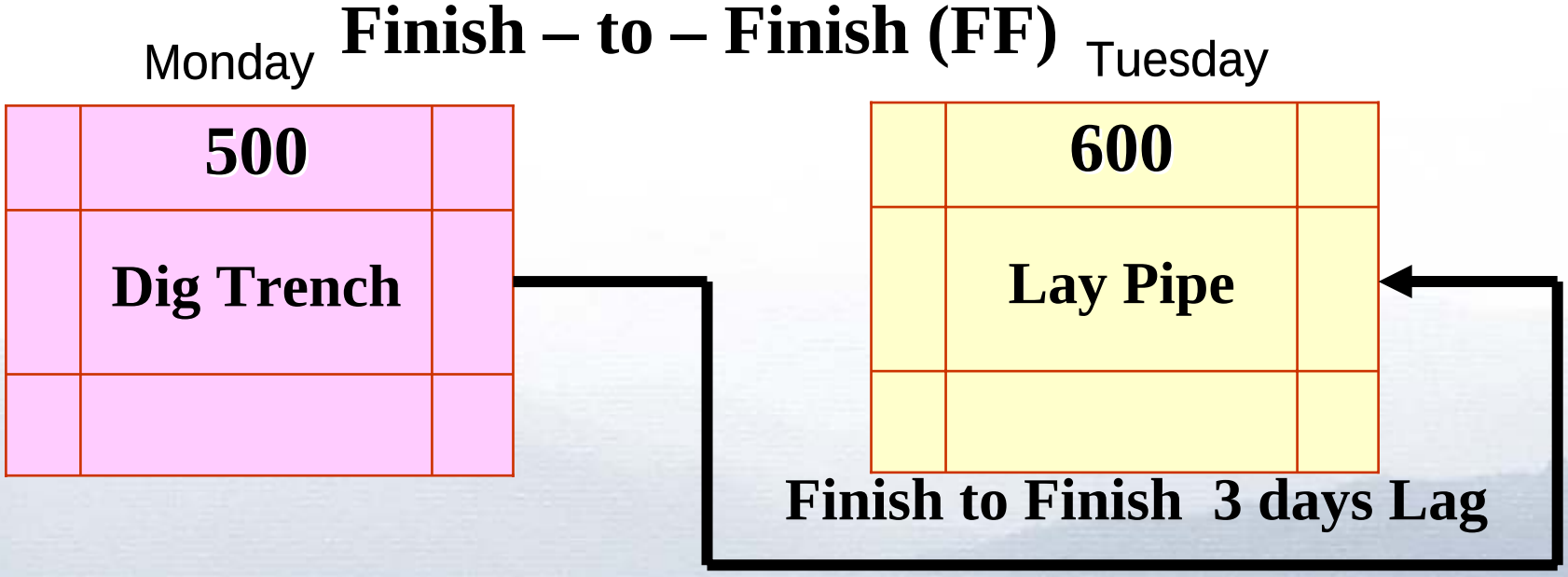
Start – to – Start Barchart (SS) Barchart

	1 Mon	2 TUE	3 WED	4 THU	5 FRI	6 SAT	7 SUN
Activity 500 Dig Trench							
Lag 4 Days							
Activity 600 Lay Pipe							

Critical path method

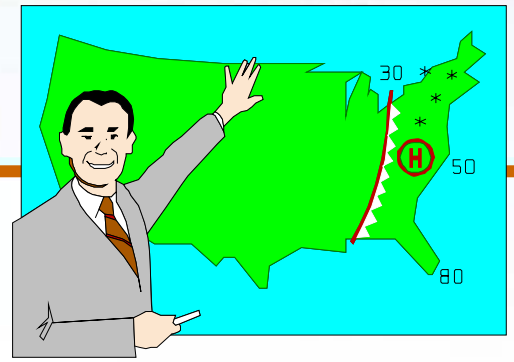
12. Network Diagrams Cont.

Finish – to – Finish (FF) : The finish – to – finish (FF) constraint represents the relationship between the finish of two activities.



Critical path method

12. Network Diagrams Cont.



Finish – to – Finish (FF) Barchart

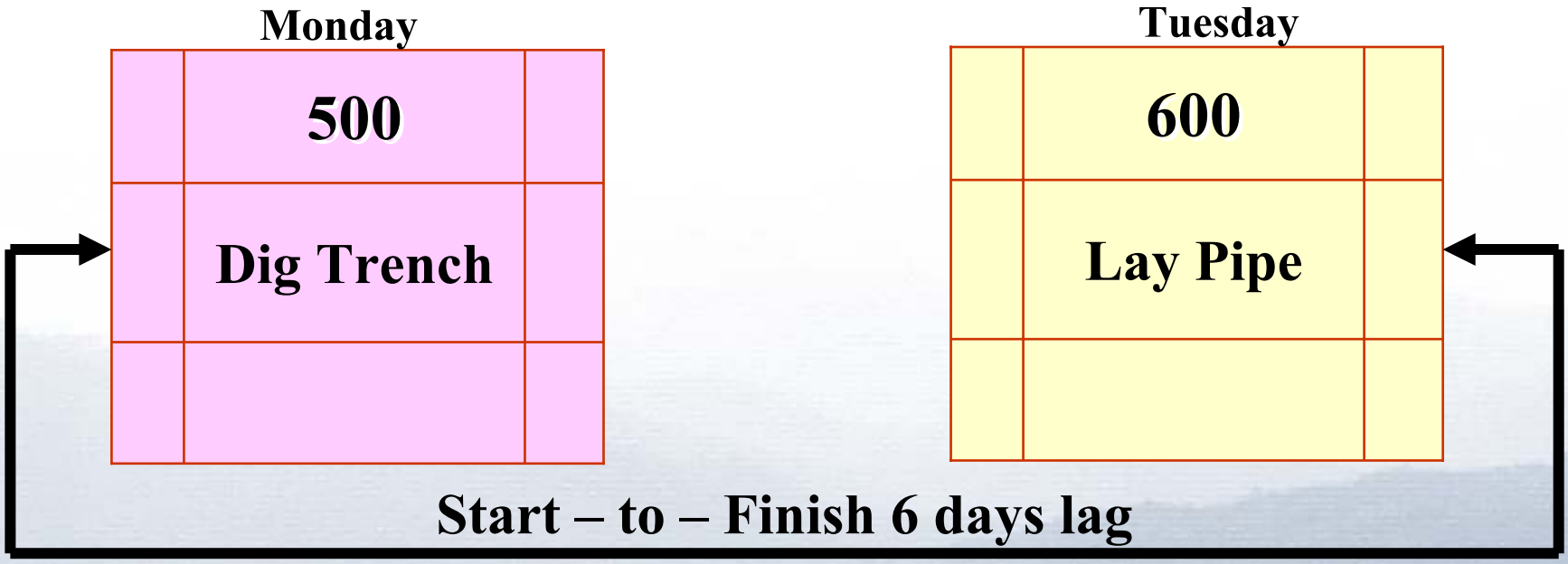
	1 Mon	2 TUE	3 WED	4 THU	5 FRI	6 SAT	7 SUN
Fabrication 1000	→						
Lag 3 Days		→	→	→			
Painting 2000	→	→	→	→			

Critical path method

12. Network Diagrams Cont.

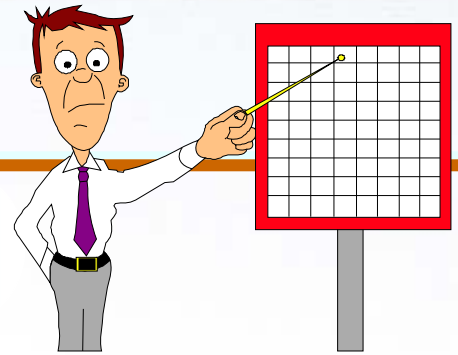
Start – to – Finish (SF) : The start – to – finish (SF) constraint shows the relationship linking the start of an activity with the finish of another activity.

Start – to – Finish (SF)



Critical path method

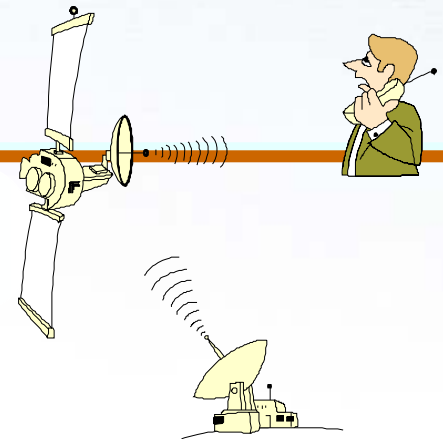
12. Network Diagrams Cont.



Finish – to – Finish (FF) Barchart

	1 Mon	2 TUE	3 WED	4 THU	5 FRI	6 SAT	7 SUN
Lift 1 A 100	→						
Lag 6 Days						→	
Lift 2 A 200						→	

Critical path method



12. Network Diagrams Cont.

Leads and lags:

- **Adelay may be given to the start or finish of an activity.**
- **by assigning the constraint a duration (the default is zero).**
- **These delays are termed lead time before an activity and.**
- **Lag time after the activity.**

Critical path method

13. Logical Errors

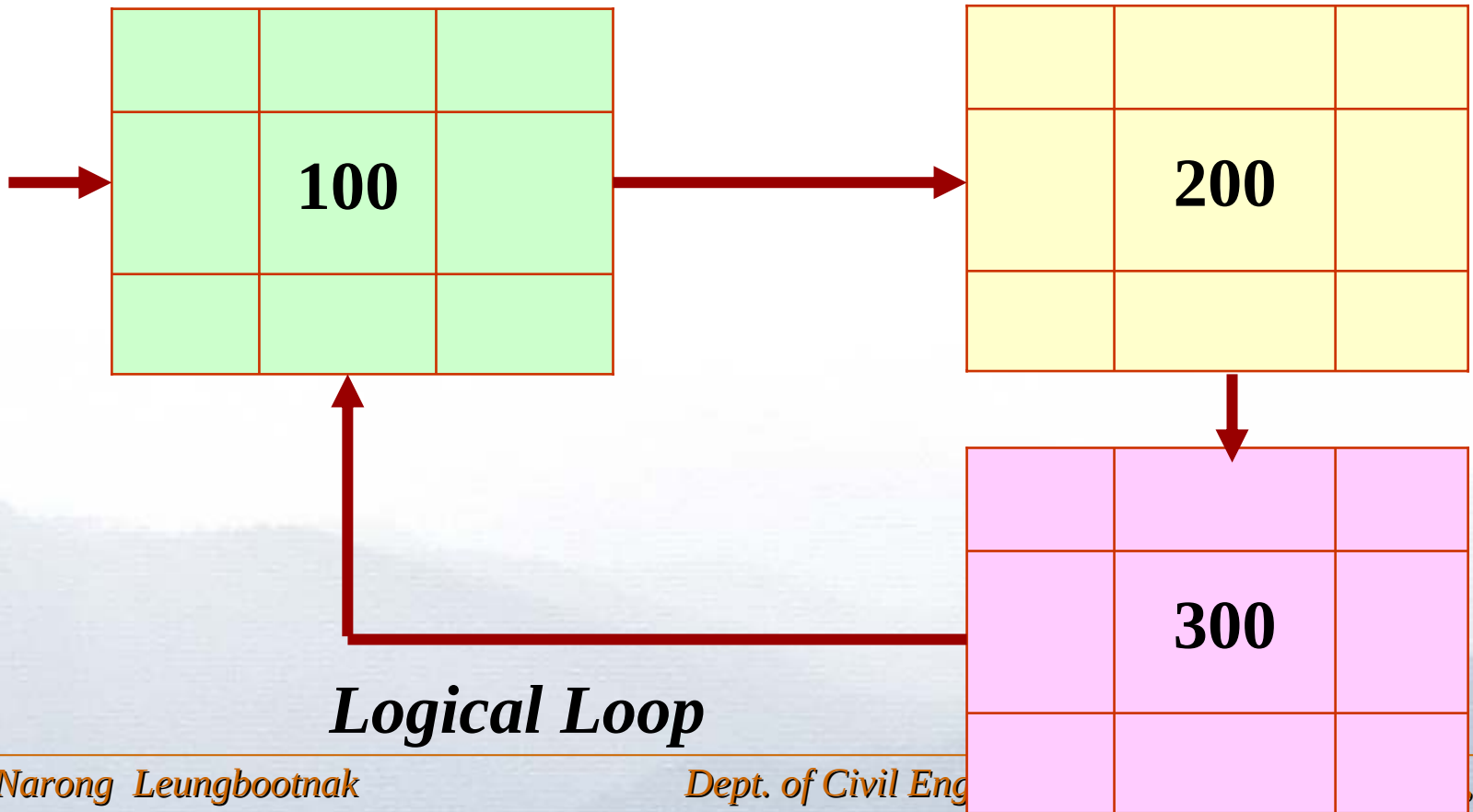
There are a number of basic logical errors:

- Logical loop.
- Logical dangle.
- Redundant precedence relationship.

Critical path method

13. Logical Errors Cont.

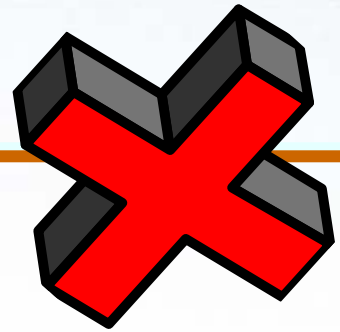
Logical Loop : Consider the following logical loop that represents an impossible situation.



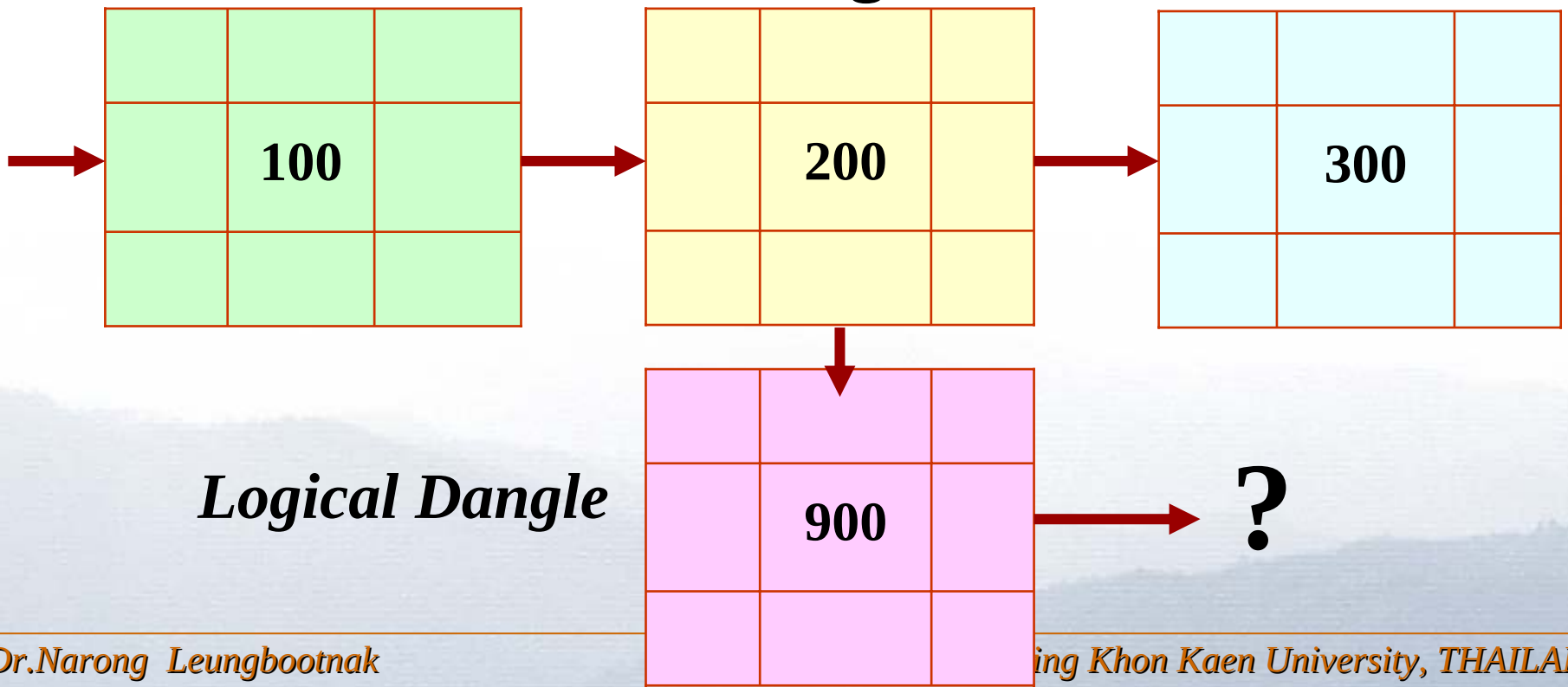
Logical Loop

Critical path method

13. Logical Errors Cont.



Logical Dangle : As the name suggests a dangling activity is where the activity either comes from nowhere or goes to nowhere.



Logical Dangle

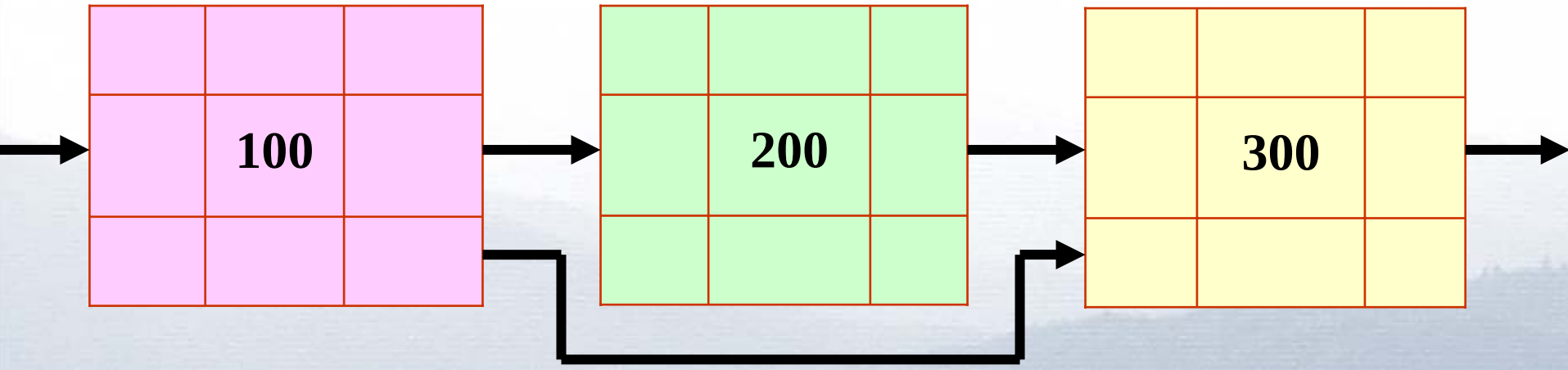
Critical path method

13. Logical Errors Cont.

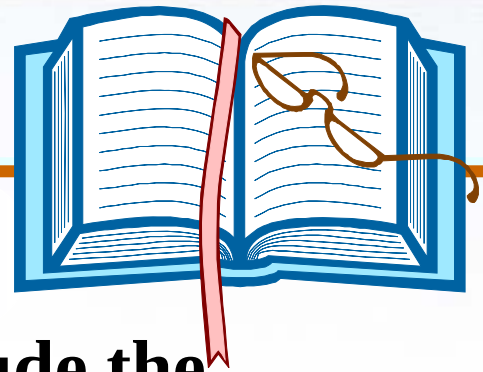
Redundant Precedence Relationship:

When developing the network diagram it is only necessary to indicate an activity's immediate predecessors.

Redundant Precedence Relationship



Critical path method



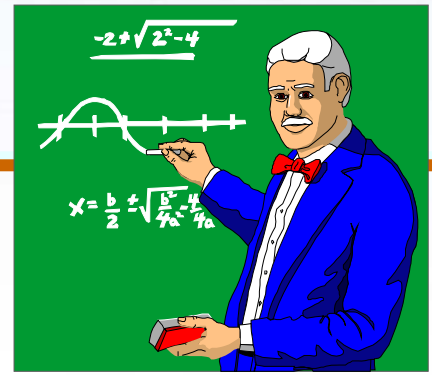
14. Definition of an Activity

The characteristics of an activity include the following:-

- An activity must have a unique activity code or number.
- If multi – project resource scheduling is required the activity numbers from the various projects need to be different.
- An activity must have a description. The description should be as informative and clear as possible.
- There will be logical relationships between the activities.

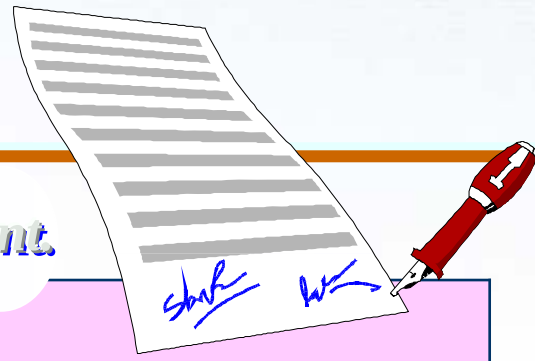
Critical path method

14. Definition of an Activity Cont.



- All activities will have a time duration for completing the task, even if it is zero.
- All activities will have a calendar or work pattern to indicate when the work can be scheduled.
- The activity can have target start and finish dates assigned.
- An activity may need items to be procured, by linking the procurement to the activity.

Critical path method



14. Definition of an Activity Cont.

Identity	A100
Description	Dig the house foundations
Calendar	5 days per week / Mon to Fri
Duration	20 working days
Procurement	Bought in items
Resources	5 men per day
Budget	Baht 200,000
WBS	1.1.1
Logic	List preceeding activities
Target date	Assigned start or finish dates

Activity Details

Critical path method

15.Calendar / Work Pattern

Listed below are the characteristics associated with a calendar:

- The calendar defines the days on which work can be scheduled.
- A number of calendars can be defined.
- Rest days are the days of the week that are always taken off.
- Holidays can be defined as public holidays, works holidays, or your own personal holidays.
- Activities and resources can be linked to a calendar number.
- If the activity does not have a calendar.

Critical path method

15.Calendar / Work Pattern Cont.

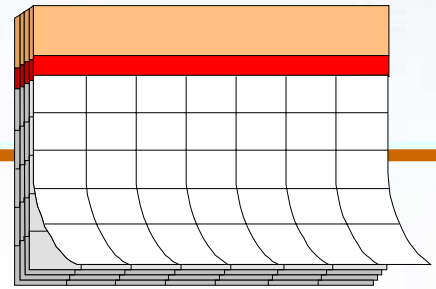
Example : The calendar and start date can change the duration of the activity.

Calendar Barchart

	Man	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
a Days duration (Takes 10 days)	→	→	→	→	→			→	→	→					
a Days duration (Takes 12 days)				→	→			→	→	→	→	→			→

Critical path method

15.Calendar / Work Pattern Cont.



Calendar Barchart

ACTIVITY	CALENDAR	FRI	SAT	SUN	MON
DATE		5	6	7	8
100	MON TO FRI	→			
200	MON TO FRI				→

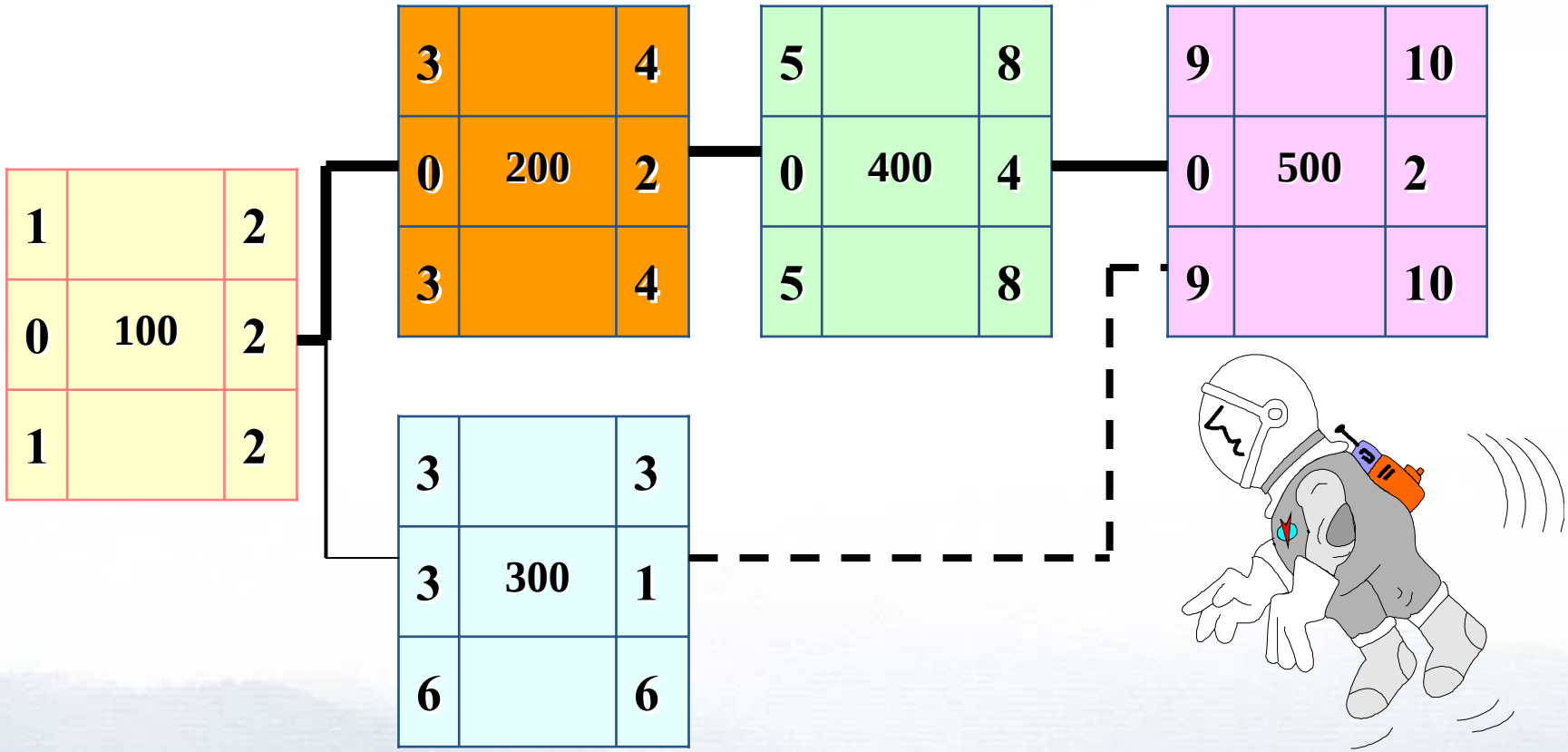
Critical path method

16. Activity Float

- Float is a measure of an activity's flexibility.
- Quantifying how many working days the activity can be delayed before is will extend
- The completion date of the project, or any target finish dates.

Critical path method

16. Activity Float *Cont.*



Activity Float (showing activity 300 linked to activity 500 to prevent it becoming critical)

Critical path method

16. Activity Float

There are three main types of float in CPM and it is important to be able to distinguish between them to avoid confusion and errors.

Total Float : **Here the float is shared with all the other activities in the arm.**

- If some of the float is used by one activity.
- This will reduce the amount of float available for the other activities on the arm.
- Care must be taken not to assume each activity has all the float to itself

Critical path method

16. Activity Float

Free Float :

- This is a measure of the amount of float the activity
- Can use up without effecting the early start of any other activity
- This only happens when there is one activity in the network arm linked to a critical activity or milestone.

Negative Float:

- When calculations show that an activity must start before the preceding activities are finished.
- This is indicated as negative float.

Critical path method

References

Rory B. Project Management. 4th ed. London: John wiley & Sons; 2003.

Ted K. Project Management. New York: John wiley & sons; 2004.

Harold K. Project Management. 7th ed. New York: John wiley & sons; 2001.

_____, Project Management. 9th ed. New York: John wiley & sons; 2006.

Critical path method

การบ้าน

1. อ่านบทที่ 11 (Schedule Barcharts)
   - สรุปแล้วส่ง A4 ไม่เกิน 2 แผ่น
2. เตรียมสอบบทที่ 11 (Schedule Barcharts)

END