Project Scheduling: Lagging, Crashing and Activity Networks

Chapter 10

Course Structure

- Introduction
- Projects and Strategy
- Project Selection and Portfolio Management
- Project Cost Estimation and Budgeting
- Project Scheduling: Networks, Duration estimation, and Critical Path
- **Project Scheduling: Lagging, Crashing and Activity Networks**
- **Risk Management**
- **Resource Management**
- **Project Evaluation and Control**
- **Agile Project Management**
- **Critical Chain Project Scheduling**

Lags in Precedence Relationships

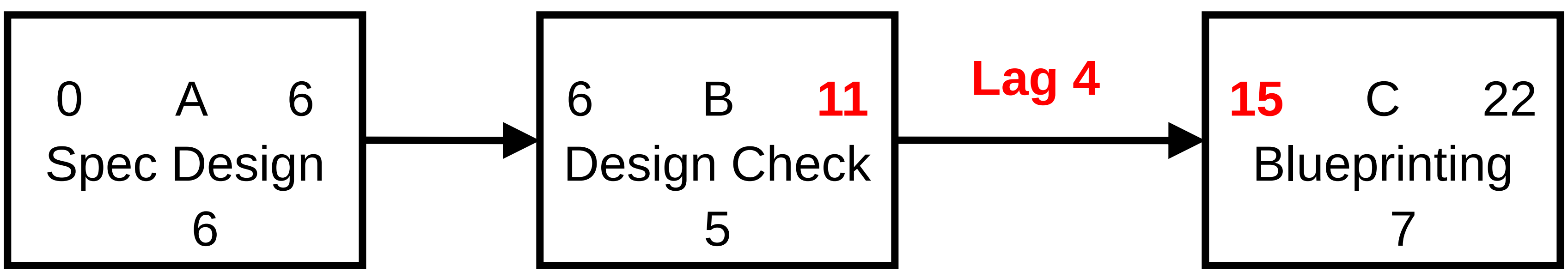
The logical relationship between the start and finish of one activity and the start and finish of another activity.

Four logical relationships between tasks

1. Finish to Start
2. Finish to Finish
3. Start to Start
4. Start to Finish

Finish to Start Lag

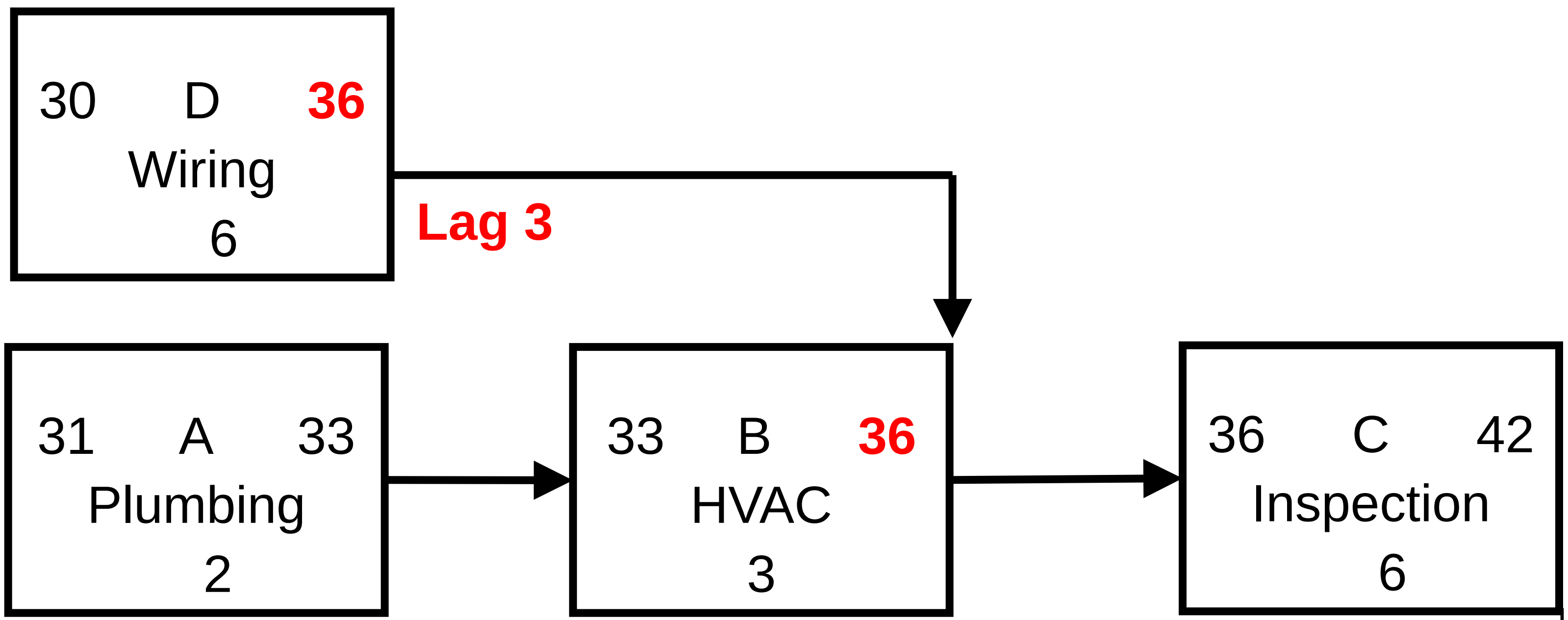
- Most common type of sequencing
- Shown on the line joining the modes
  - Added during forward pass
  - Subtracted during backward pass



Finish to Finish Lag

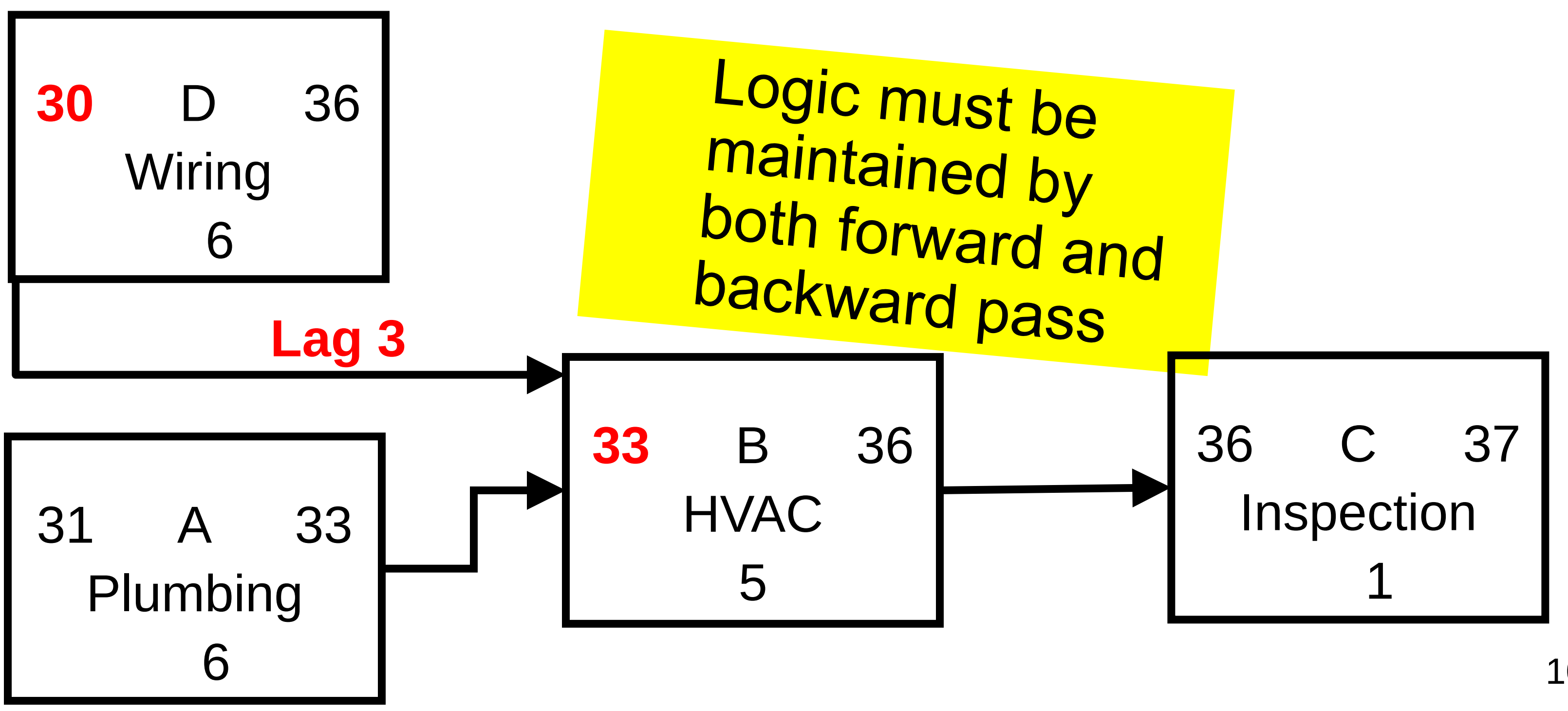
Two activities share a similar completion point

- The mechanical inspection cannot happen until wiring, plumbing, and HVAC installation are complete



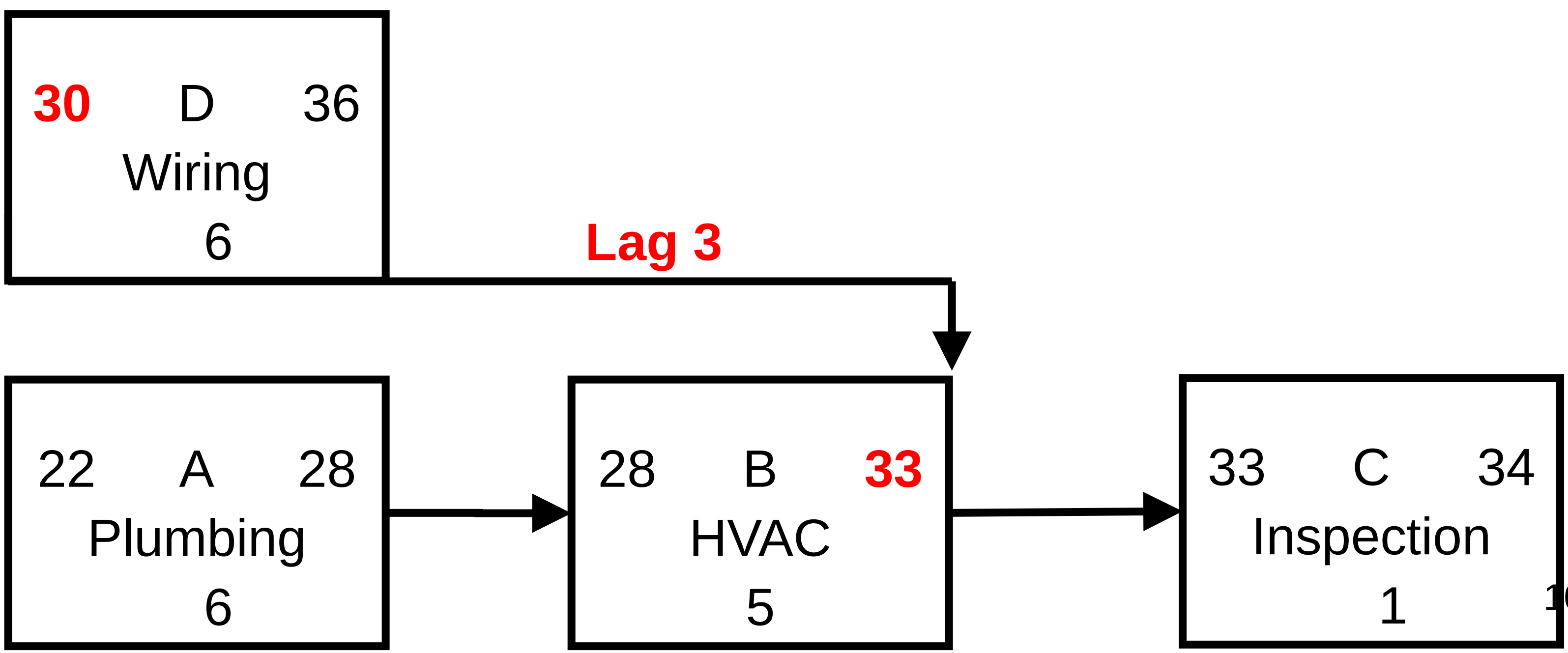
Start to Start Lag

A logical relationship in which a successor activity cannot start until a predecessor activity has started. Example: Level concrete (successor) cannot begin until pour foundation (predecessor) begins.



Start to Finish Lag

- A logical relationship in which a successor activity cannot finish until a predecessor activity has started. Example: The first security guard shift (successor) cannot finish until the second security guard shift (predecessor) starts.
- Successor's finish dependent on predecessor's start



In PM, finish-to-start is the most commonly used type of precedence relationship. The start-to-finish relationship is very rarely used.

Gantt Charts

- ✓ Establish a time-phased network
- ✓ Can be used as a tracking tool

Benefits of Gantt charts

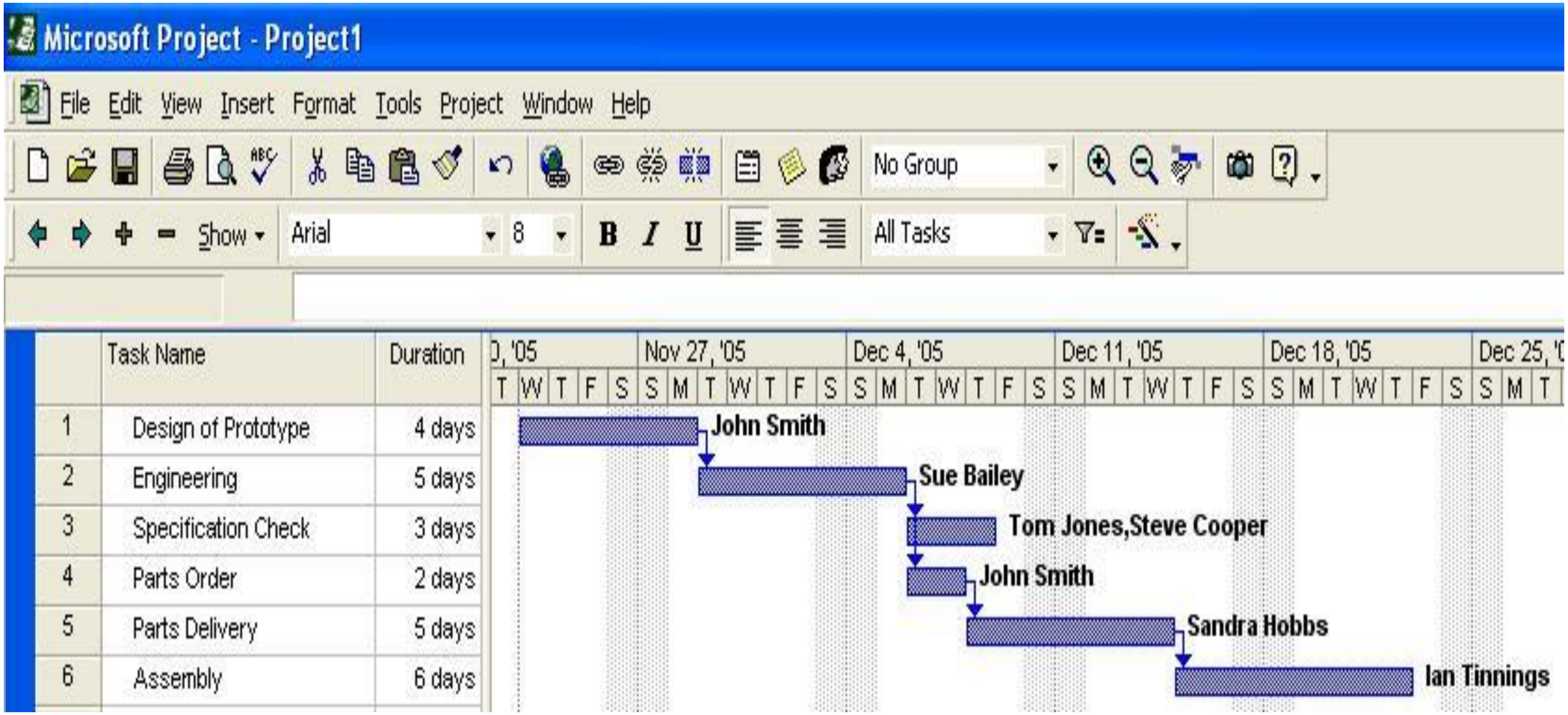
1. Easy to **create** and **comprehend**
2. Identify the schedule **baseline** network
3. Allow for **updating** and **control**
4. Identify **resource needs**

Create a Gantt chart based on the activities listed in the table.

Task	Time	Pred	Task	Time	Pred
Z	8	--	U	3	W
Y	5	Z	T	6	V
X	8	Z	S	7	U,T
W	4	Y,X	R	9	S
V	5	W			

Task	ES	EF	LS	LF
Z	0	8	0	8
Y	8	13	11	16
X	8	16	8	16
W	16	20	16	20
V	20	25	20	25
U	20	23	28	31
T	25	31	25	31
S	31	38	31	38
R	38	47	38	47

Gantt Chart With Resources in MS Project



Crashing

The **process of accelerating** a project

Principal methods for crashing

- Improving existing resources' **productivity**
- Changing work **methods**
- Increasing the **quantity** of resources

Crashing

- Project duration can be reduced **by assigning more resources** to project activities. But, doing this would somehow increase our project cost!

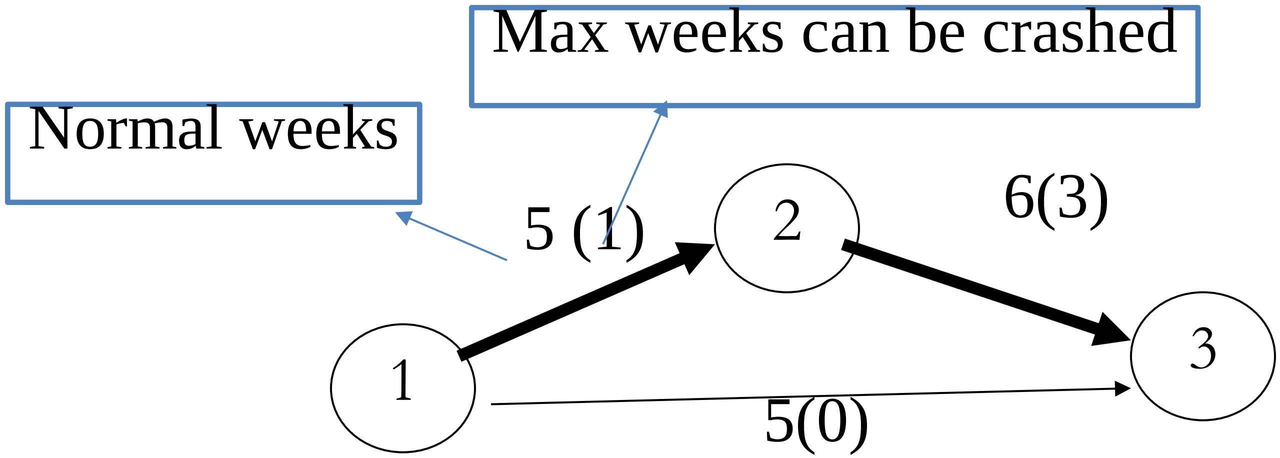
- **How do we strike a balance?**

1. ***Project crashing*** is a method for shortening project duration by reducing one or more
2. ***critical activities*** to a time less than normal activity time.

Crashing

Question: What criteria should it be based on when deciding to crashing critical times?

Crashing



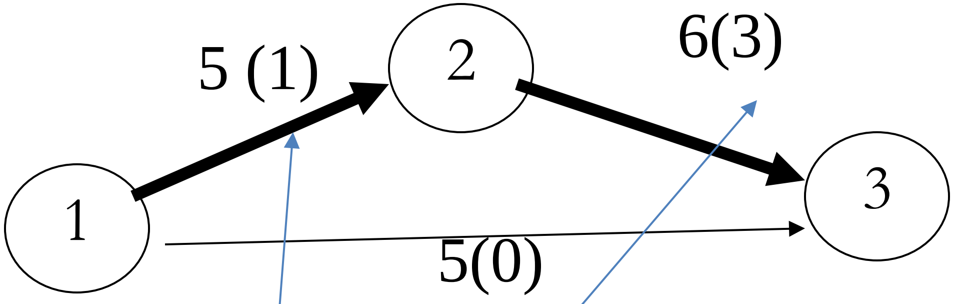
The critical path is 1-2-3, the completion time =11

How? Path: 1-2-3 = 5+6=11 weeks

Path: 1-3 = 5 weeks

Now, how many days can we “crash” it?

Crashing



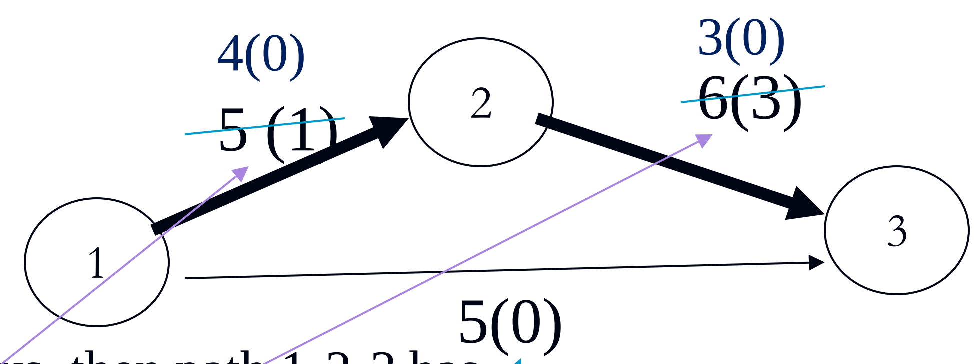
The maximum time that can be crashed for:

Path 1-2-3 = 1 + 3 = 4

Path 1-3 = 0

Should we use up all these 4 weeks?

Crashing



If we used all 4 days, then path 1-2-3 has

(5-1) + (6-3) = 7 completion weeks

Now, we need to check if the completion time for path 1-3 has lesser than 7 weeks (why?)

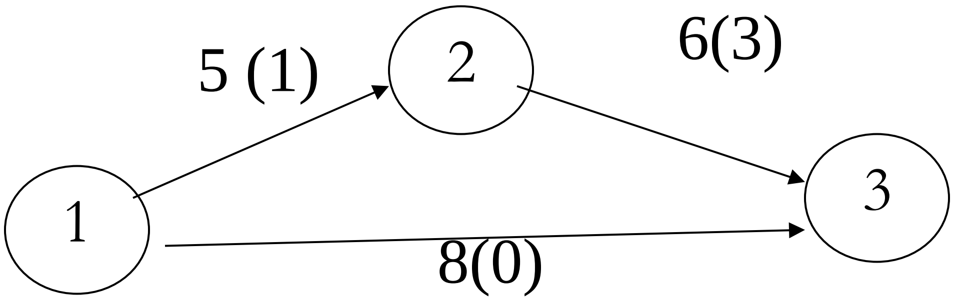
Now, path 1-3 has (5-0) = 5 weeks

Since path 1-3 still shorter than 7 weeks, we used up all 4 crashed weeks

Question: What if path 1-3 has, say 8 weeks completion time?

Crashing

Such as



Now, we cannot use all 4 days (Why?)

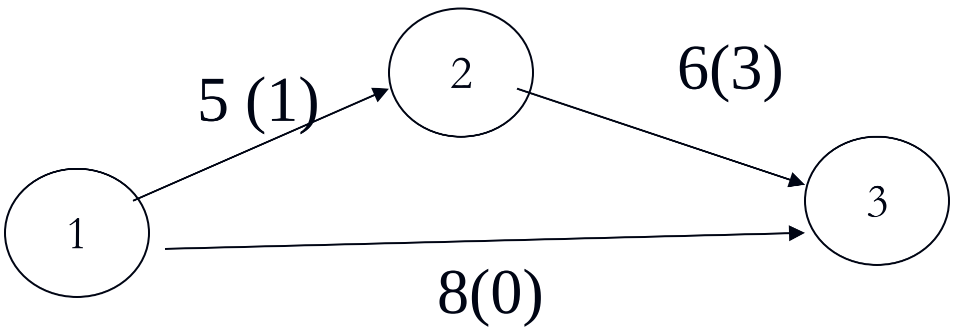
Because path 1-2-3 will not be critical path anymore as

path 1-3 would now has longest hour to finish

- **Rule: When a path is a critical path, it will not stay as a critical path**
- **So, we can only reduce the path 1-2-3 completion time to the same time as path 1-3. (HOW?)**

Crashing

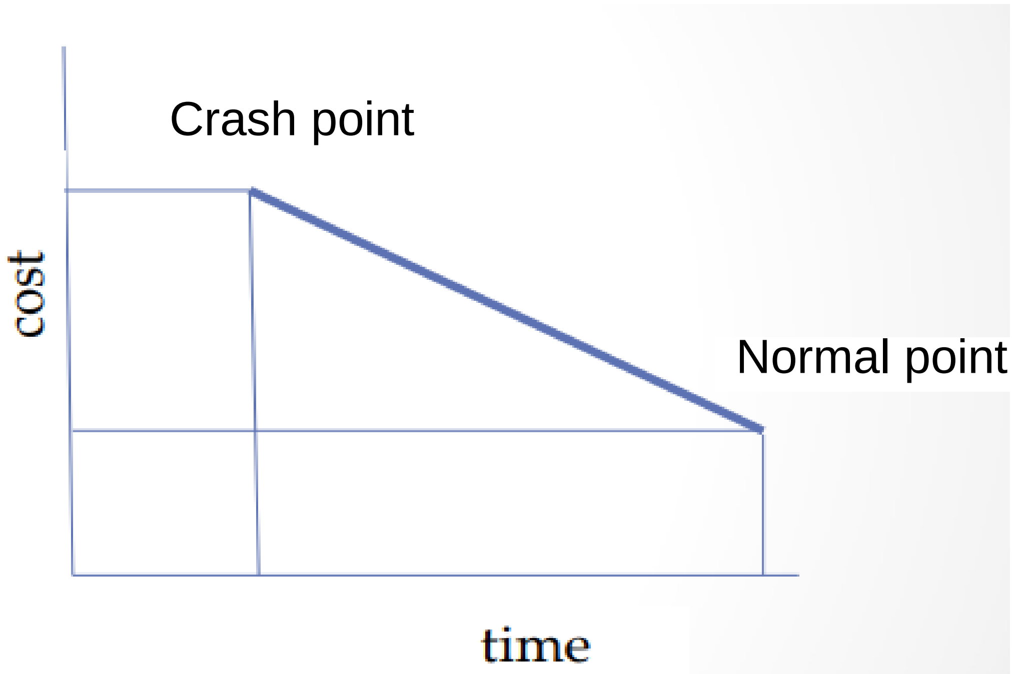
Solution:



- We can only reduce total time for path 1-2-3 = path 1-3, that is 8 weeks
- If the cost for path 1-2 and path 2-3 is the same then we can random pick them to crash so that its completion time is 8 weeks

TIME-COST TRADE-OFF

$$\text{Slope} = \frac{\text{crash cost} - \text{normal cost}}{\text{normal time} - \text{crash time}}$$



Where: slope = cost per day of crashing a project

Calculating the Cost of Crashing

Suppose that for activity X, the normal activity duration is 5 weeks and the budgeted cost is $12,000. The crash time for this activity is 3 weeks and the expected cost is $32,000. Using the above formula, we can calculate the cost slope for activity X as:

Solution

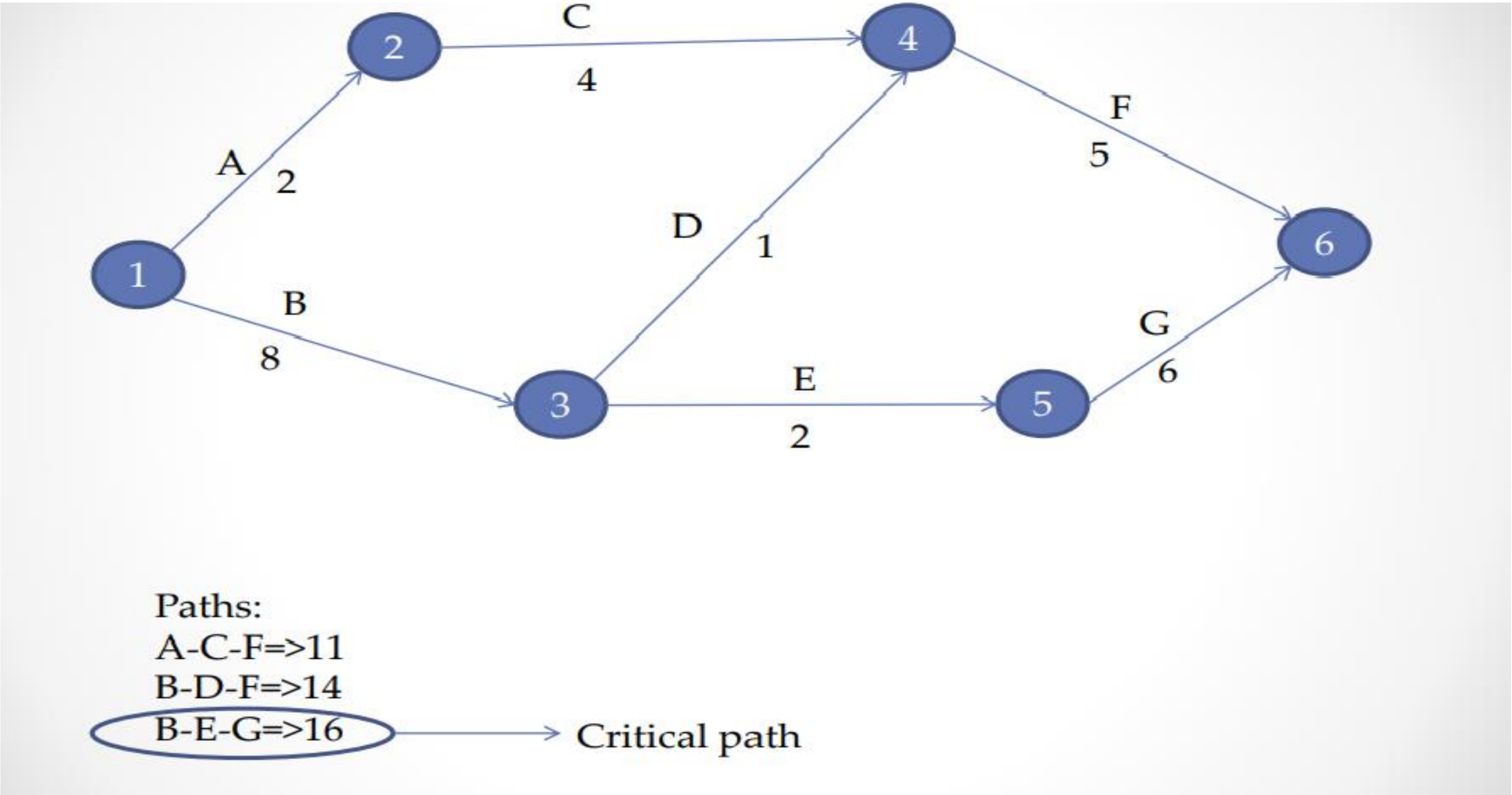
$$\frac{32{,}000 - 12{,}000}{5 - 3} \text{ or } \frac{20{,}000}{2} = 10{,}000 \text{ per week}$$

Example

Activity	Predecessor activity	Normal time	Crash time	Normal cost	Crash cost
A	-	2	1	10000	15000
B	-	8	5	15000	21000
C	A	4	3	20000	24000
D	B	1	1	7000	7000
E	B	2	1	8000	15000
F	C,D	5	3	10000	16000
G	E	6	2	12000	36000

Find the minimum possible time of the project and the cost associated with this.

Solution


1
2
3
4
5
6
A
2
B
8
C
4
D
1
E
2
F
5
G
6
Paths:
A-C-F=>11
B-D-F=>14
B-E-G=>16
Critical path

Solution

Activity	Predecessor activity	Normal time	Crash time	Normal cost	Crash cost	Time can be Decreased	Increased cost	Cost slope	Crashed time
A	-	2	1	10000	15000	1	5000	5000	
B	-	8	5	15000	21000	3	6000	2000(1st)	3
C	A	4	3	20000	24000	1	4000	4000	
D	B	1	1	7000	7000	-	-	-	
E	B	2	1	8000	15000	1	7000	7000	
F	C,D	5	3	10000	16000	2	6000	3000(3rd)	2
G	E	6	2	12000	36000	4	24000	6000(2nd,3rd)	2,2

1.Comparing cost slope of B,E,G=>B minimum so crash B.(next page)

2. Next critical path also B-E-G .=> G next minimum. (next page)
3.Comparing between A,C,D,E,F,G=> F is the minimum cost slope. Crash F. Again Crashing F alone will leave B-E-G path with value 11(project not benefited by crashing).So crashing G by 2 days to reach at 9 as in BD

Solution

path	Normal time	Crashing B by 3 days	Crashing G by 2 days	Crashing F by 2 days and G by 2 days
B-E-G	16	13 B*-E-G	11 B*-E-G′	9 B*-E-G*
B-D-F	14	11 B*-D′′-F	11 B*-D′′-F	9 $\boxed{\text{B*-D′′-F*}}$ crashed complete
A-C-F	11	11 A-C-F	11 A-C-F	9 A-C-F*
Cost added	-	+6000	+12000	12000+ 6000
Total cost	82000	88000	100000	118000

Crashing G completely result in reducing below11.So to attain 11 days G is crashed for 2days only. Now 3 critical paths. Go to Previous page.