LEAST COST CALCULATIONS

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CONSTRUCTION COST

GENERALLY CONSTRCUTION COSTS ARE DIVIDED INTO TWO

- DIRECT COSTS
- INDIRECT COSTS

DIRECT COSTS

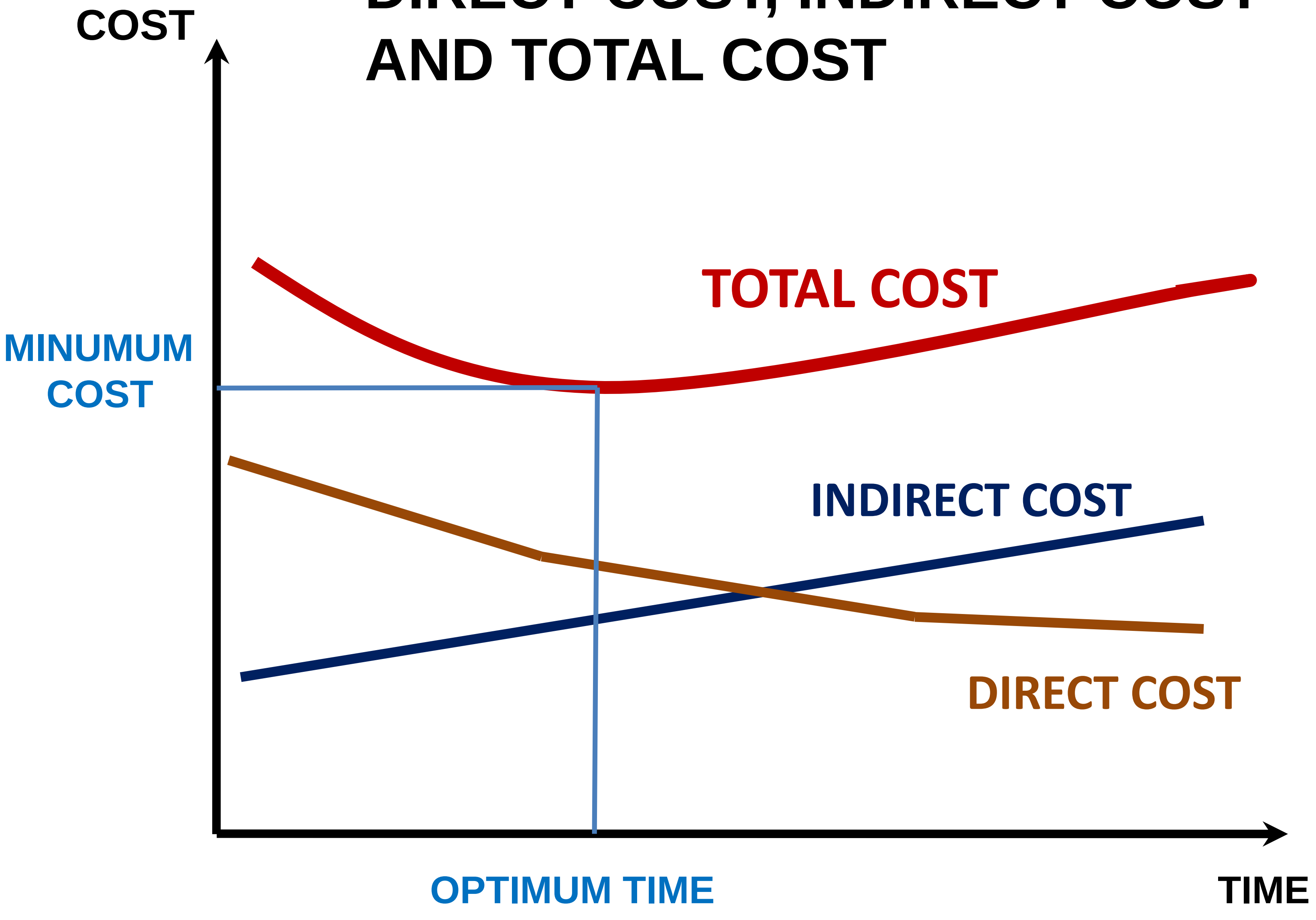
DIRECT COSTS ARE ASSOCIATED WITH THE PHYSICAL CONSTRUCTION OF THE PROJECT INCLUDING

- MATERIALS,
- EQUIPMENT AND
- LABOR AND
- SUBCONTRACTOR (IF EXISTS)

INDIRECT COSTS

- INDIRECT COSTS ARE NOT EASY TO VISUALIZE.
- THEY ARE GENERALLY BROKEN DOWN INTO TWO CATEGORIES:
  - HEAD OFFICE OVERHEAD AND
  - GENERAL CONDITIONS (PROJECT OR SITE OVERHEAD).

DIRECT COST, INDIRECT COST AND TOTAL COST



CRASHING COST CALCULATIONS (LEAST COST CALCULATIONS)

- **CRASHING A PROJECT MEANS THE PROCESS OF ACCELERATING AN ACTIVITY OR MULTIPLE ACTIVITIES TO SHORTEN THE OVERALL DURATION OF A PROJECT.**
- **BY ADDING ADDITIONAL PEOPLE, EQUIPMENT, OR MAN- HOURS, A PROJECT MANAGER CAN SHORTEN AN ACTIVITY'S DURATION.**
- **IF THE ACTIVITY AFFECTED IS CRITICAL, THE PROJECT WILL BE SHORTENED AS WELL.**
- **ACTIVITIES ARE CRASHED FOR DIFFERENT REASONS:**
- **AN ACTIVITY MAY NEED TO BE COMPLETED BY A SPECIFIC DATE FOR CONTRACTUAL REASONS.**
- **SOME ACTIVITIES CAN BE ACCOMPLISHED MORE ECONOMICALLY DURING A CERTAIN TIME OF THE YEAR, ENCOURAGING MANAGERS TO ACCELERATE PRECEDING ACTIVITIES.**

LEAST COST CALCULATIONS (continued)

- THE COST TO ACCELERATE AN ACTIVITY WHICH SHORTENS PROJECT'S DURATION MAY BE LESS EXPENSIVE THAN THE COST OF RUNNING THE PROJECT FOR THE SAME PERIOD.
- WHEN AN ACTIVITY IS CRASHED, IT'S DIRECT COSTS INCREASE DUE TO THE FOLLOWING REASONS.
  - THE INEFFICIENCIES CAUSED BY ACCELERATING THE WORK AT A RATE FASTER THAN NORMAL; **(overtime)**
  - PEOPLE MAY END UP WORKING IN TIGHTER QUARTERS, OR EQUIPMENT MAY SIT IDLE; **crowding effect**
- BUT THESE COSTS INCREASES MAY BE JUSTIFIED IF INDIRECT COSTS ARE DECREASED.
- ALTHOUGH THERE IS A CLEAR BENEFIT TO OPTIMIZING A PROJECT'S DURATION ON THE BASIS OF COST, CRASHING IS NOT A ROUTINE STEP IN PROJECT PLANNING. ;

LEAST COST CALCULATIONS (continued)

- **THE INTEGRATION OF SCHEDULING AND ESTIMATING INFORMATION CANNOT BE EASILY LINKED SINCE THE ACTIVITY UNITS ARE OFTEN NOT THE SAME.**
- **IT IS ALSO UNUSUAL TO CALCULATE CRASH COSTS FOR EACH ACTIVITY AND THEN FORMALLY ANALYZE AND COMPARE THOSE COSTS WITH INDIRECT COSTS.**
- **THIS PROCESS TAKES A CONSIDERABLE AMOUNT OF TIME AND IS DIFFICULT TO AUTOMATE.**
- **ANOTHER REAL CONCERN IS THAT, AS A PROJECT IS CRASHED, MULTIPLE CRITICAL PATHS ARE CREATED.**
- **AS MORE CRITICAL PATHS APPEAR, THERE IS A GREATER RISK OF DELAYING COMPLETION TIME.**

LEAST COST CALCULATIONS (continued)

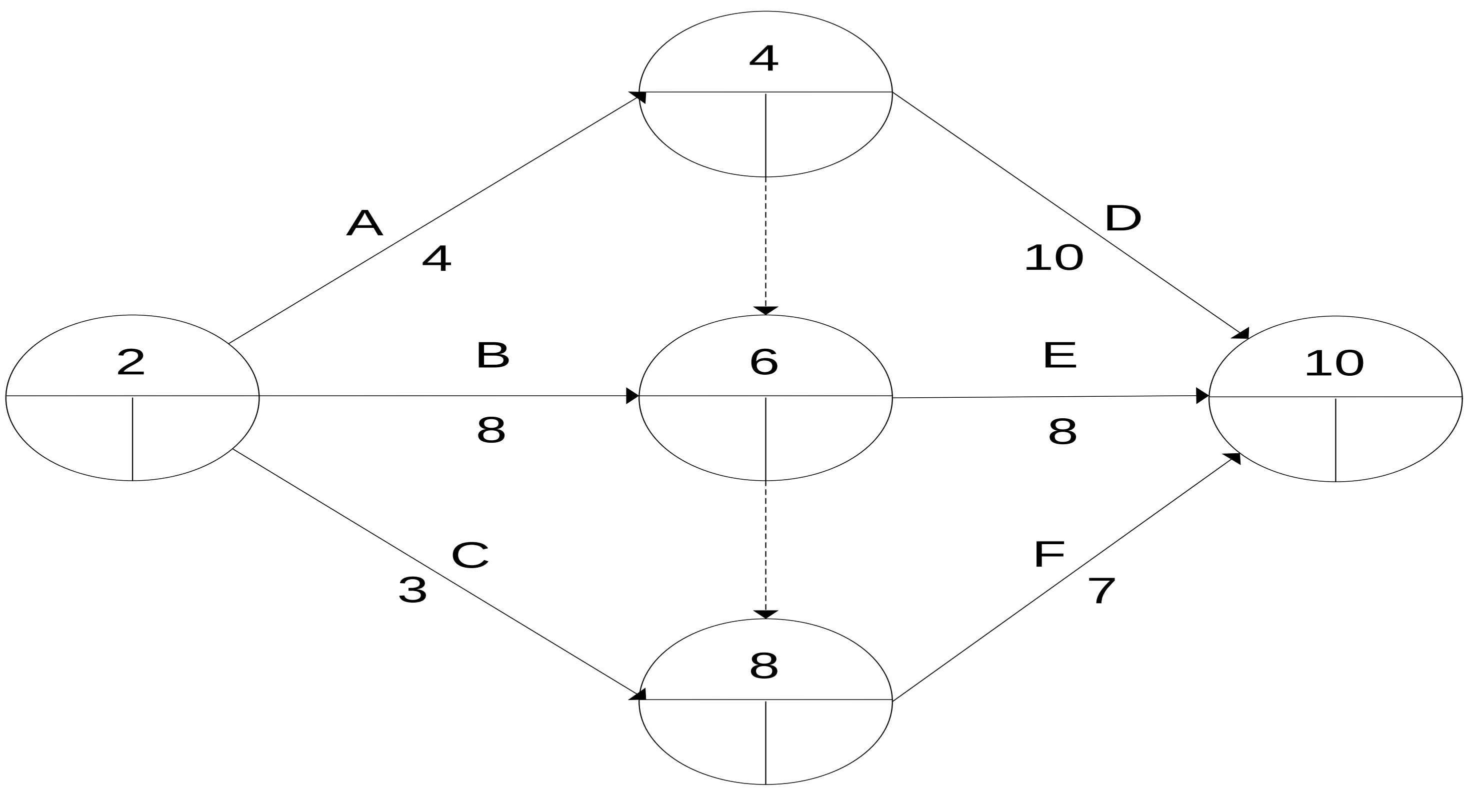
- **NEVERTHELESS, THE PROCESS OF DETERMINING THE OPTIMUM DURATION FOR A PROJECT IS AN IMPORTANT STEP IN PROPER PLANNING.**
- **PROPERLY ANALYZING COSTS AND THEN RUNNING THE PROJECT IN THE MOST COST- EFFECTIVE WAY CAN SAVE CONSIDERABLE TIME AND MONEY.**
- **AS EXPERT SYSTEM TECHNOLOGY IMPROVES AND COST AND SCHEDULE INFORMATION BECOMES MORE FULLY INTEGRATED, THIS KIND OF STUDY BECOMES MORE ROUTINE.**

Least Cost (Crash Time) Calculations

Example: 1

Find: Optimum time and least total cost for the project given below.

Overhead cost = £100/day



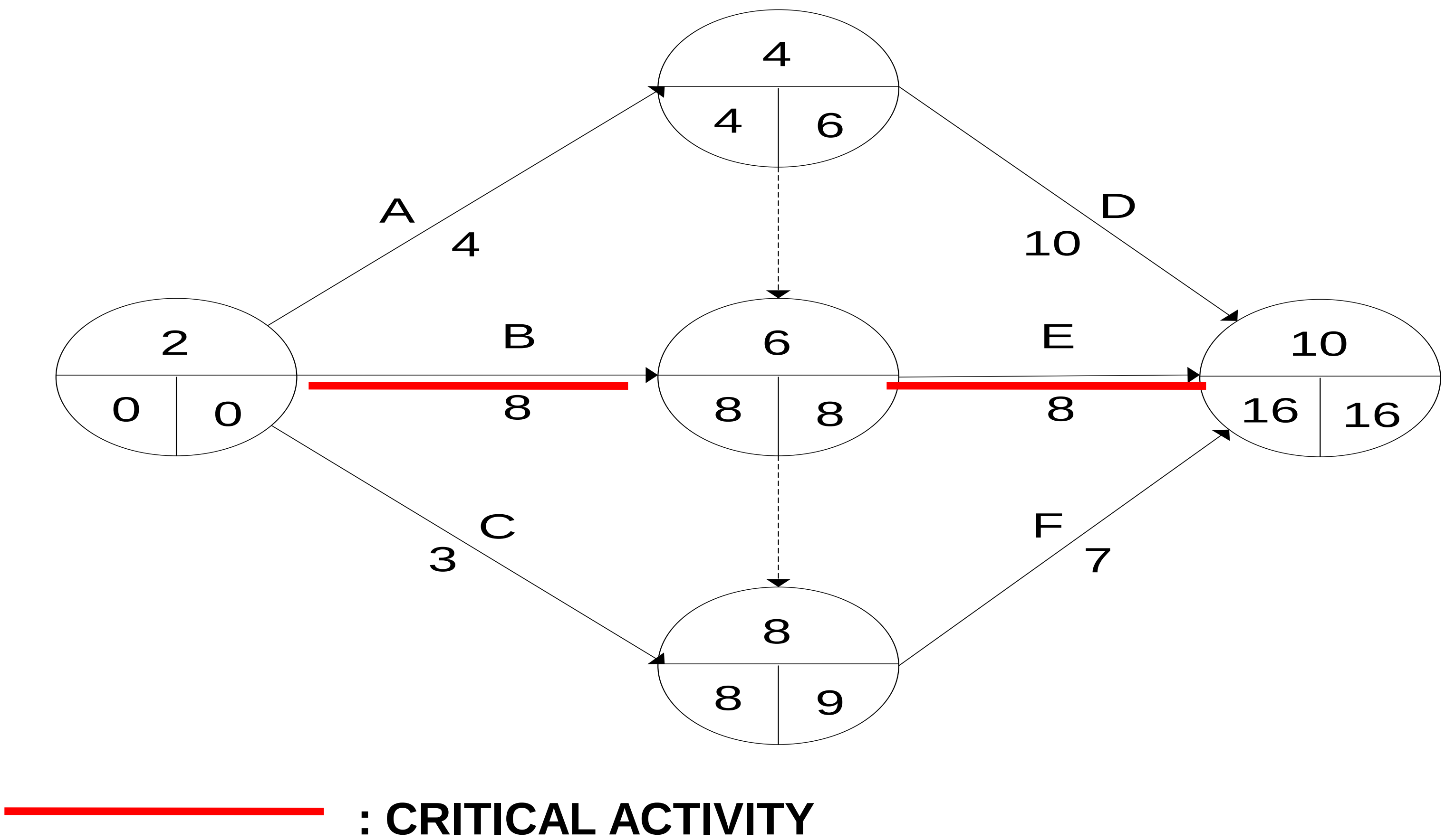
Least Cost (Crash Time) Calculations

Example: 1

Operation		Description	Duration (Days)		Direct Cost (£)	
i	j		Normal	Crash	Normal	Crash
2	4	A	4	2	400	500
2	6	B	8	5	800	980
2	8	C	3	2	600	700
4	10	D	10	6	500	600
6	10	E	8	6	800	950
8	10	F	7	4	700	1000

Least Cost (Crash Time) Calculations

Solution of Example: 1



Least Cost (Crash Time) Calculations

Step 1: Find normal duration of the project and normal cost for that normal duration.

Direct cost = 400+ 800+ 600+ 500+ 800+ 700 = **£**3800

Indirect cost = 16 days * **£**100/day = **£**1600

Total normal cost = **£5400**

Step 2: Calculate cost/day of activities by crashing duration.

Activities	Crashing Duration (Days)		Cost per day (£)	
A	4-2=	2	500-400=100	100/2=50
B	8-5=	3	980-800=180	180/3=60
C	3-2=	1	700-600=100	100/1=100
D	10-6=	4	600-500=100	100/4=25
E	8-6=	2	950-800=150	150/2=75
F	7-4=	3	1000-700=300	300/3=100

Least Cost (Crash Time) Calculations

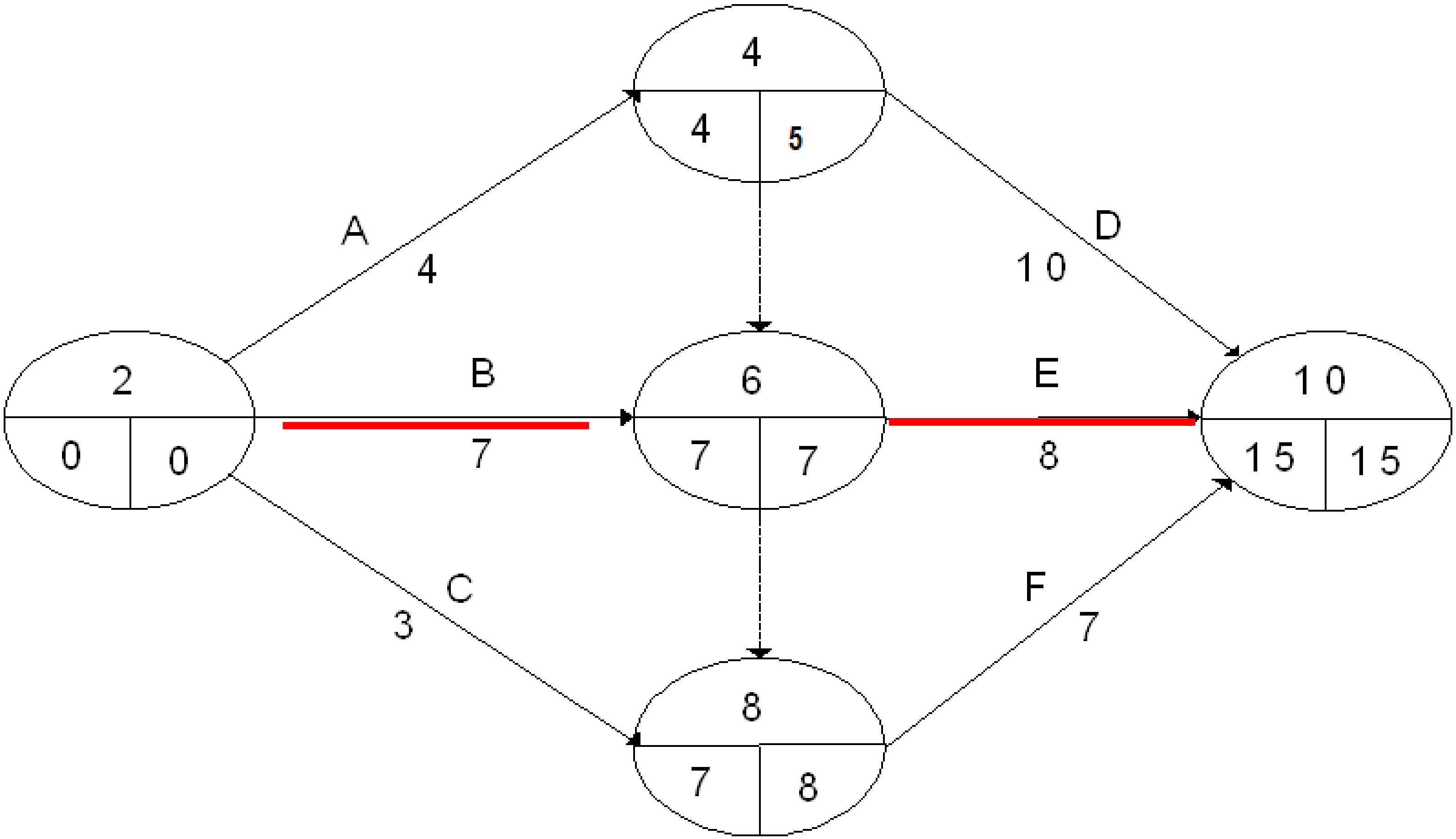
It is useful to use a worksheet such as shown below.

Activity	Duration		Cost (£)		Δ Cost	Δ Days	Δ Cost/Days	Days Shortened				
	Normal	Crash	Normal	Crash				Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5
A	4	2	400	500	100	2	50					
B	8	5	800	980	180	3	60	1	1	1		
C	3	2	600	700	100	1	100					
D	10	6	500	600	100	4	25			1	1	1
E	8	6	800	950	150	2	75				1	1
F	7	4	700	1000	300	3	100					1
					Days cut			1	2	3	4	5
					Project duration		16	15	14	13	12	11
					Increased cost/day			60	60	85	100	200
					Direct cost/day		3800	3860	3920	4005	4105	4305
					Overhead cost		1600	1500	1400	1300	1200	1100
					Total cost		5400	5360	5320	5305	5305	5405

Least Cost (Crash Time) Calculations

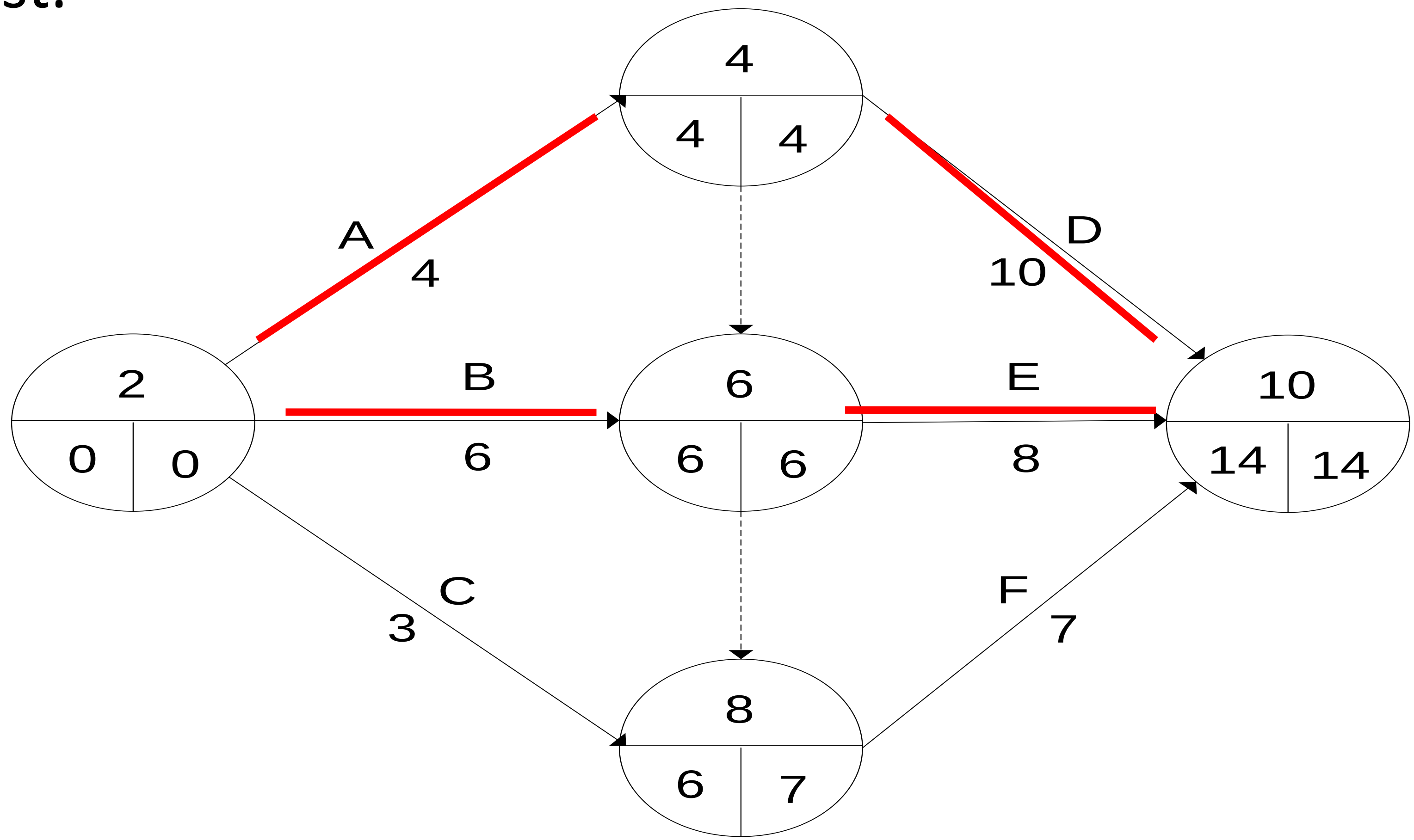
- **Cycle 1:** Activity which is on critical path and has the smallest cost/day is crashed by 1 day. Activities on critical paths are **B = £60/day** and E = **£75/day**. Therefore, B is crashed by 1 day.

Then calculate direct cost and overhead cost and total cost.



Least Cost (Crash Time) Calculations

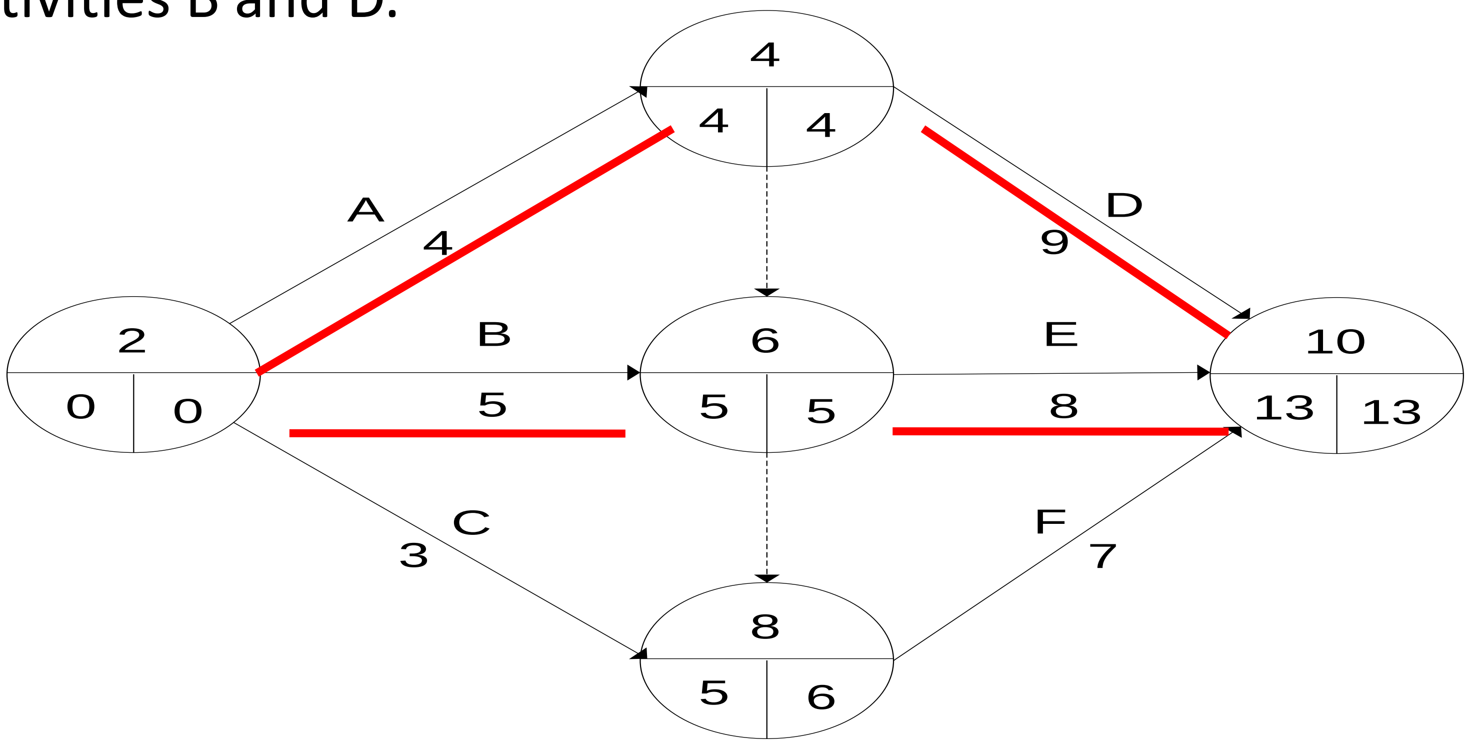
- **Cycle 2:** Critical activities are **B = £60/day** and **E = £75/day.** Therefore, activity B is crashed one more day.
- Then calculate direct cost and overhead cost and total cost.



Least Cost (Crash Time) Calculations

- **Cycle 3:** Two paths are critical. Critical activities are **A=£50/day, B = £60/day, D= £25/day** and **E = £75/day.** Crash one day from each path to reduce the project duration to 13.

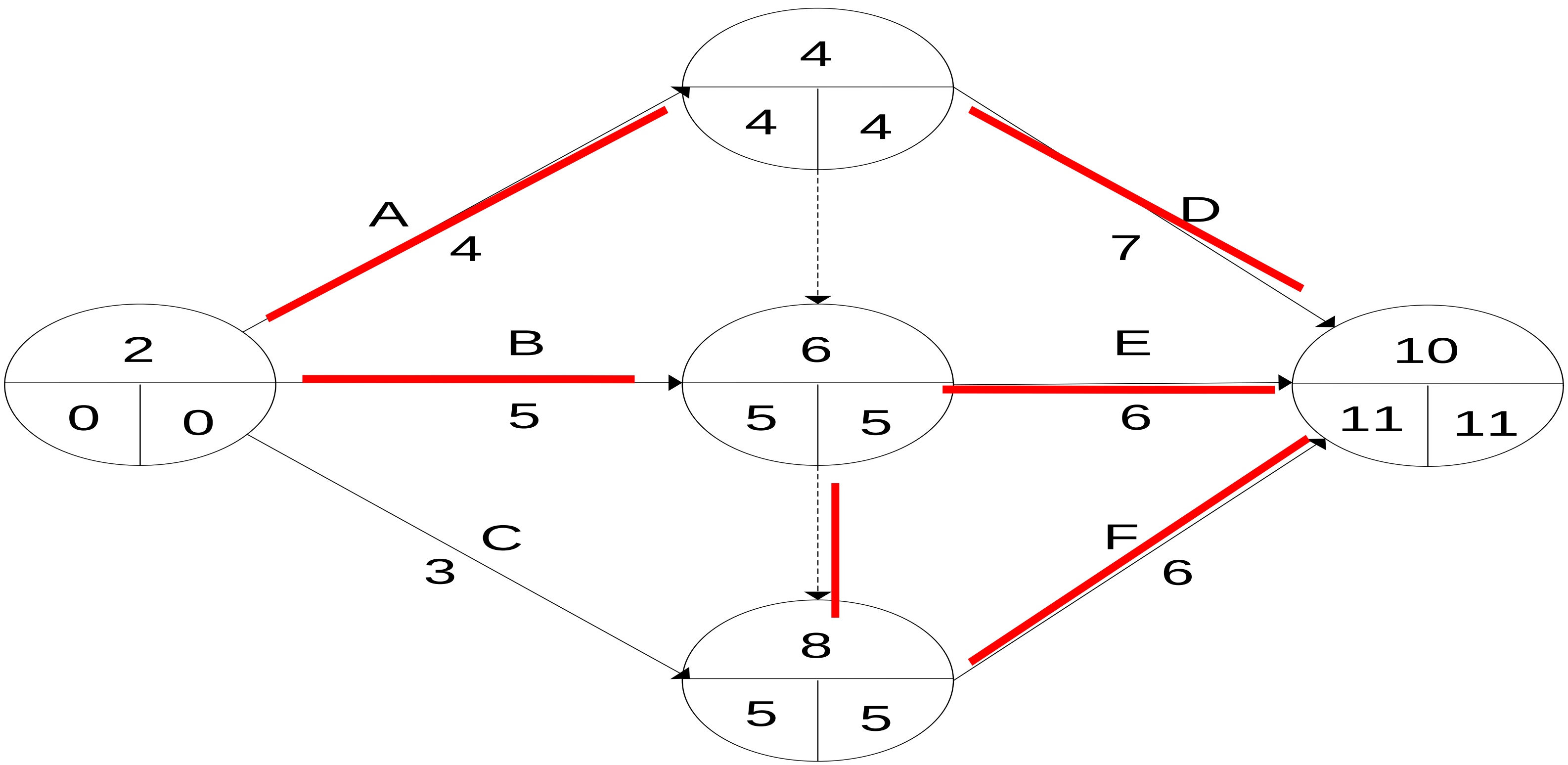
Activities to be crashed are A or D and B or E. Therefore, crash activities B and D.



Least Cost (Crash Time) Calculations

- **Cycle 5:** Critical activities are **A=£50/day, D= £25/day** and **E = £75/day.**

Two paths are critical as in cycle 3. Activities to be crashed are A or D and E. Therefore, crash activities D and E.



Cycle 5: Critical activities are D=£25/day, E= £50/day and F = £100/day. Therefore, crash activities D, E and F.

Least Cost (Crash Time) Calculations

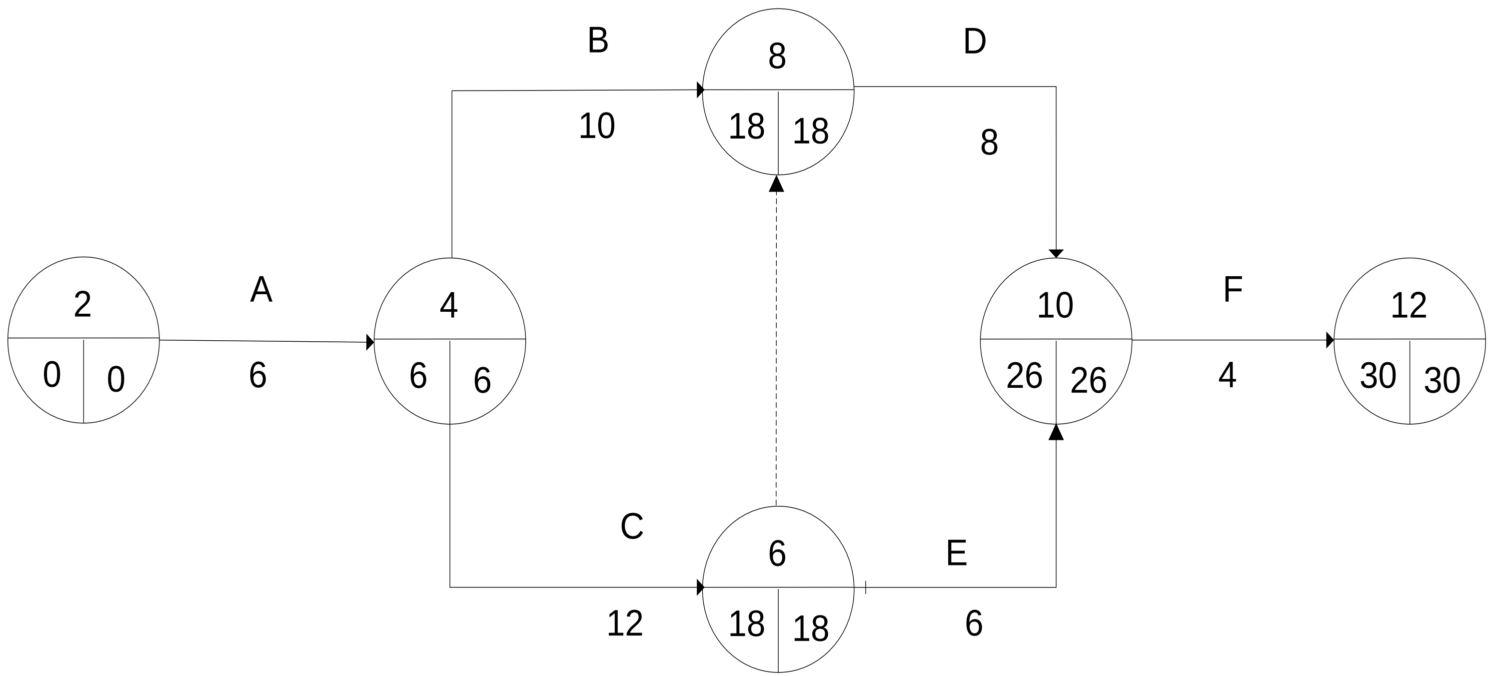
Example: 2

Crash the following network schedule (arrow diagram) and find the optimum time and least cost. Indirect cost = $100/day.

Activity Identity	Duration (Days)		Direct Cost (£)	
	Normal	Crash	Normal	Crash
A	6	4	600	780
B	10	7	500	875
C	12	8	600	900
D	8	4	800	940
E	6	3	600	795
F	4	2	800	850

Least Cost (Crash Time) Calculations

- Solution:



Least Cost (Crash Time) Calculations

Solution:

- Direct cost = 600+ 500+ 600+ 800+ 600+ 800 = $3900
- Indirect cost = 30 days * **$**100/day = $3000
- Total normal cost =**$6900**

Least Cost (Crash Time) Calculations

- Solution:

Activity Identity	Duration (Days)		Direct Cost (£)		Crash Cost per Day
	Normal	Crash	Normal	Crash	
A	6	4	600	780	90
B	10	7	500	875	125
C	12	8	600	900	75
D	8	4	800	940	35
E	6	3	600	795	65
F	4	2	800	850	25

Least Cost (Crash Time) Calculations

- Solution:

Cycle 1: Crash F and pay $25 extra.

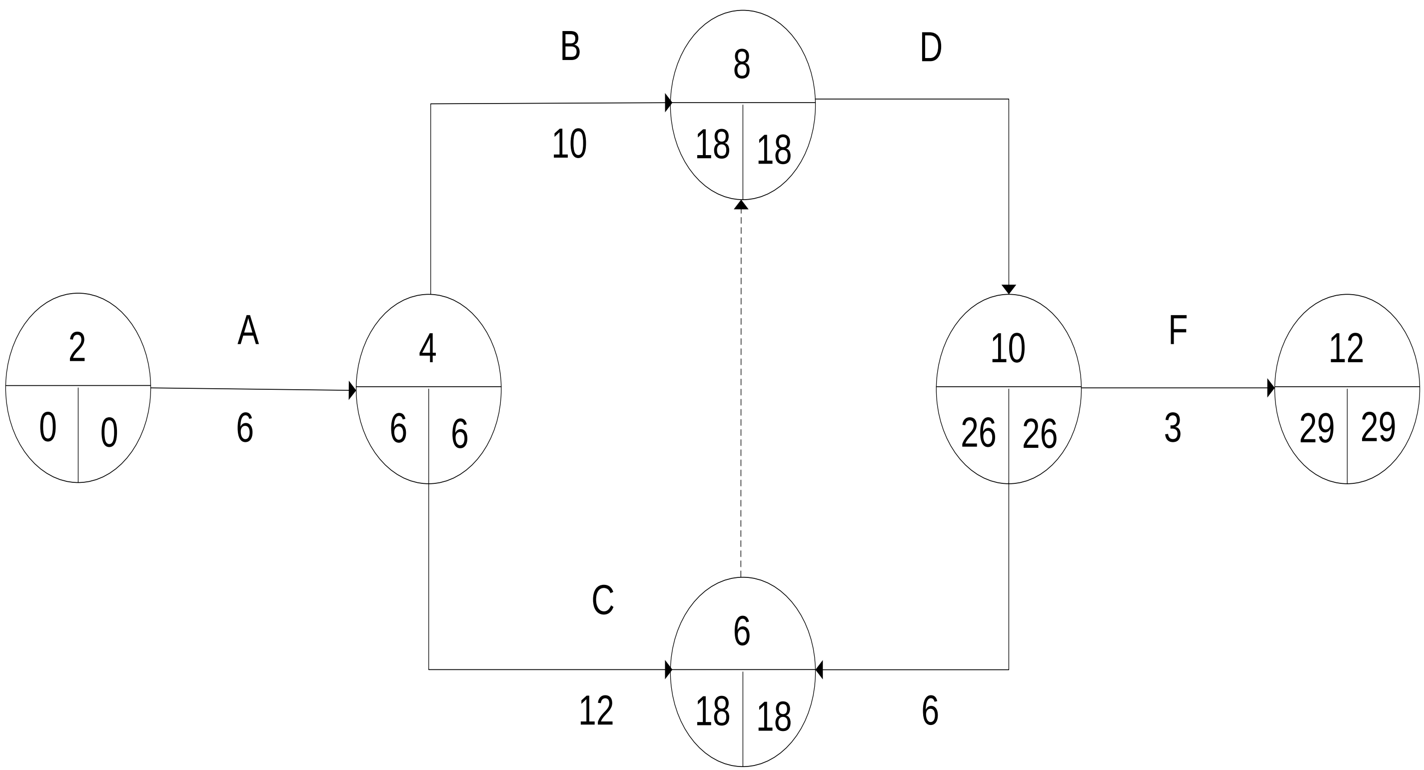
Direct cost = 600+ 500+ 600+ 800+ 600+ 825 = $3925

Indirect cost = 29 days * **$**100/day = $2900

Total normal cost =**$6825**

Least Cost (Crash Time) Calculations

- Solution:



Least Cost (Crash Time) Calculations

- Solution:
- **Cycle 2:** Crash F again and pay $25 extra.

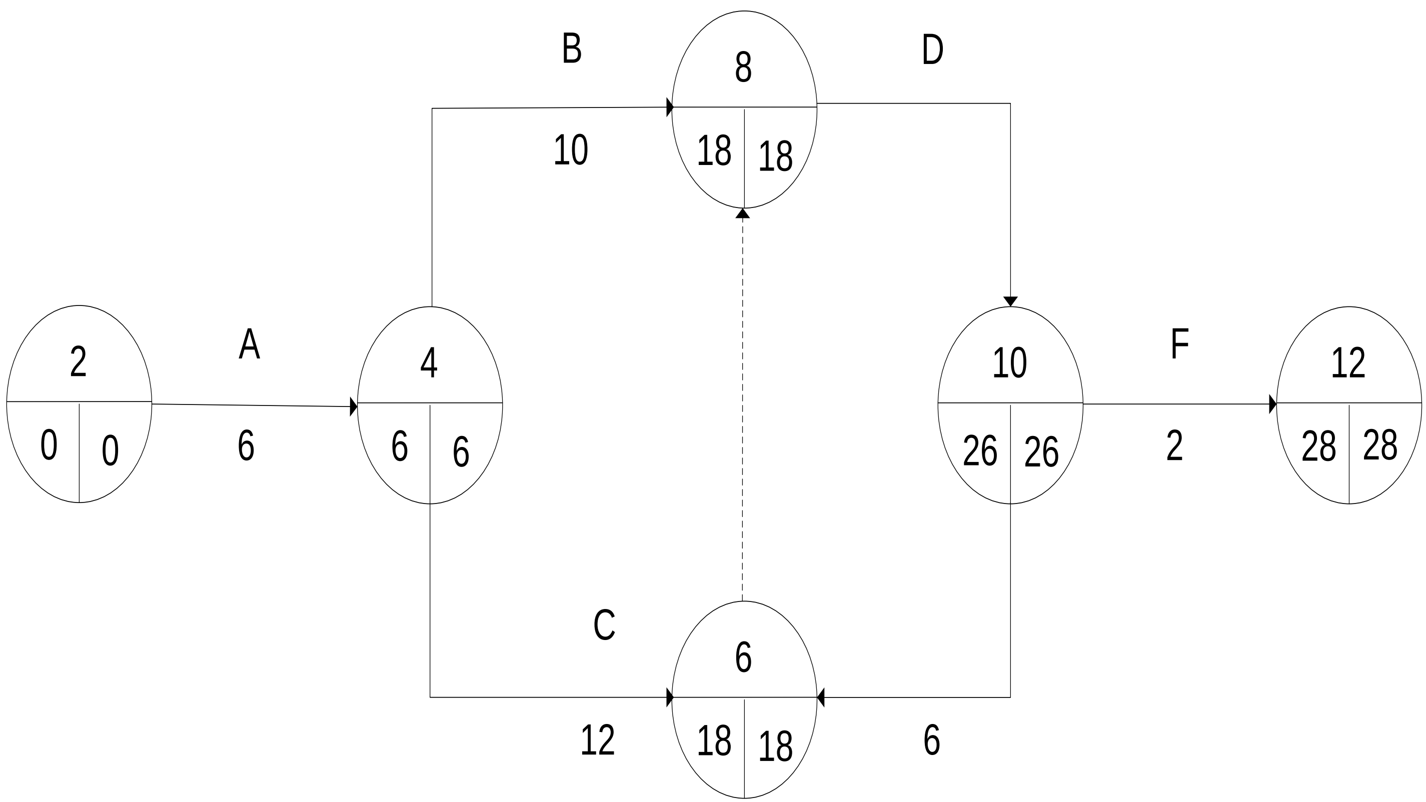
Direct cost = 600+ 500+ 600+ 800+ 600+ 850 = $3950

Indirect cost = 28 days * **$**100/day = $2800

Total normal cost =**$6750**

Least Cost (Crash Time) Calculations

- Solution:



Least Cost (Crash Time) Calculations

- Solution:
- **Cycle 3:** Crash D and pay $35 extra.

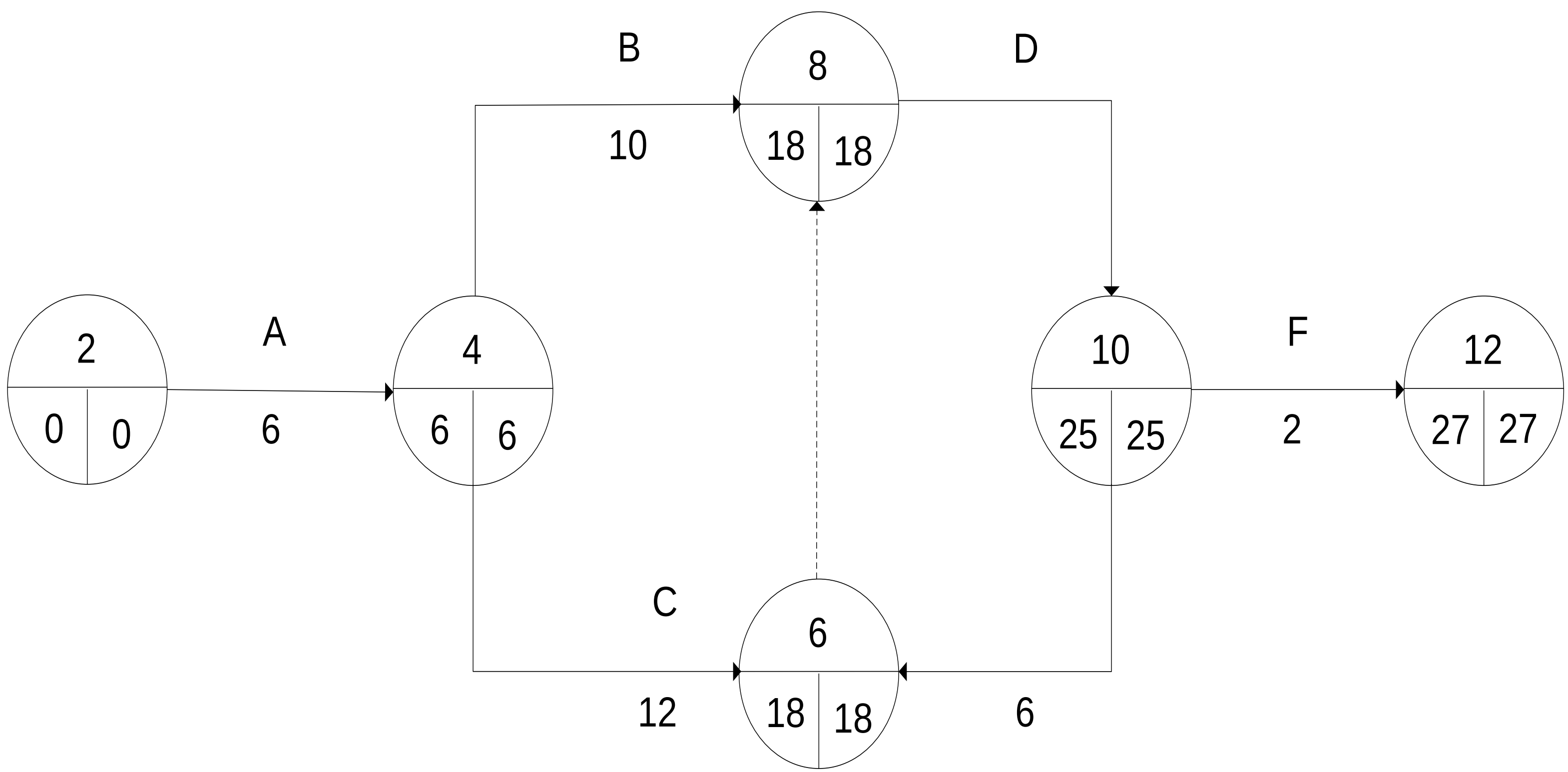
Direct cost = 600+ 500+ 600+ 835+ 600+ 850 = $3985

Indirect cost = 27 days * **$**100/day = $2700

Total normal cost =**$6685**

Least Cost (Crash Time) Calculations

- Solution:



Least Cost (Crash Time) Calculations

- Solution:
- **Cycle 4:** Crash D again and pay $35 extra.

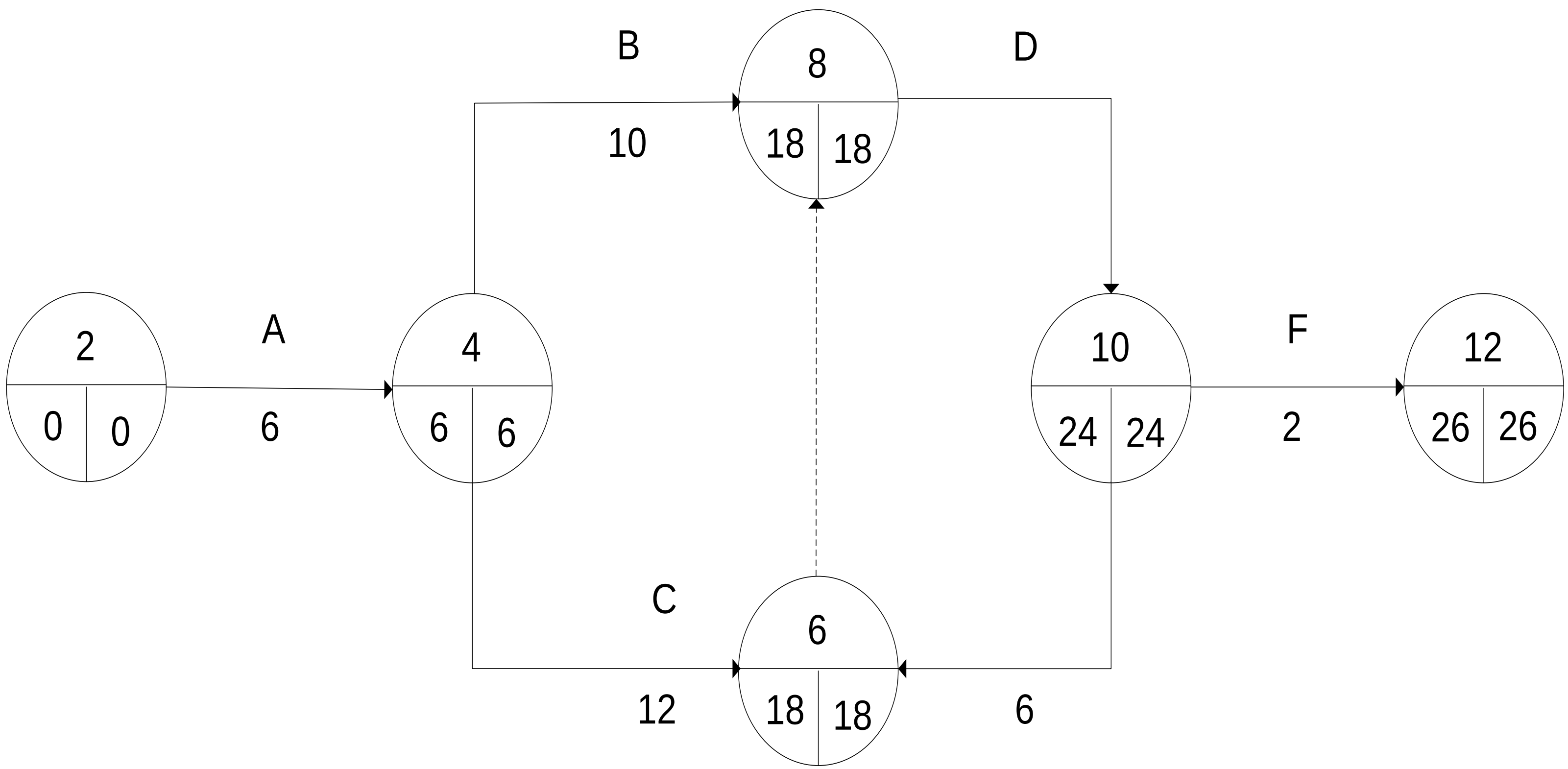
Direct cost = 600+ 500+ 600+ 870+ 600+ 850 = $4020

Indirect cost = 26 days * **$**100/day = $2600

Total normal cost =**$6620**

Least Cost (Crash Time) Calculations

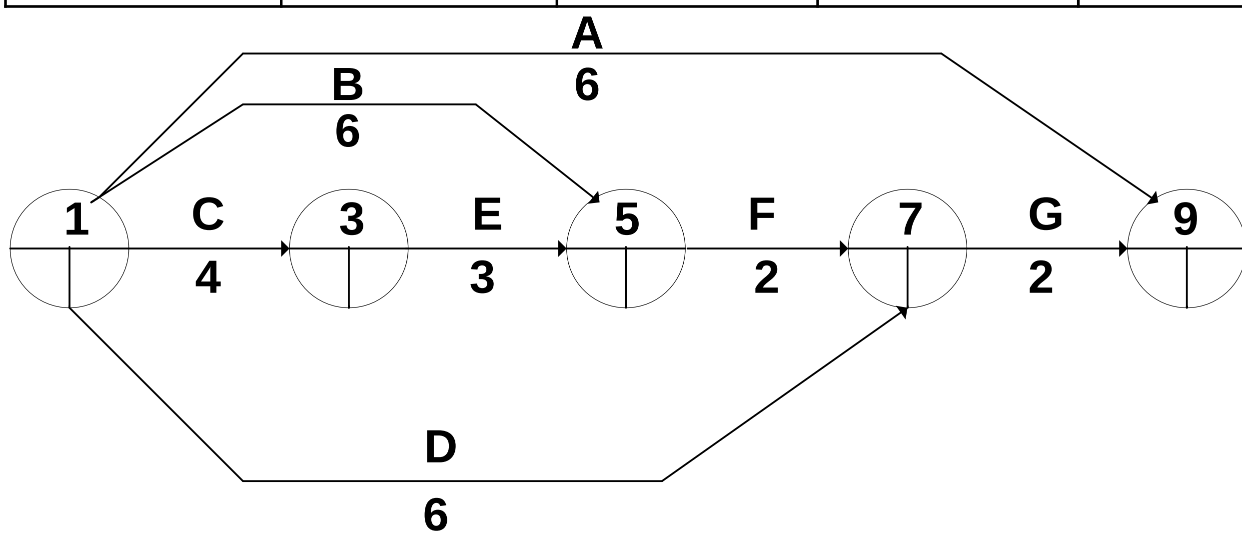
- Solution:



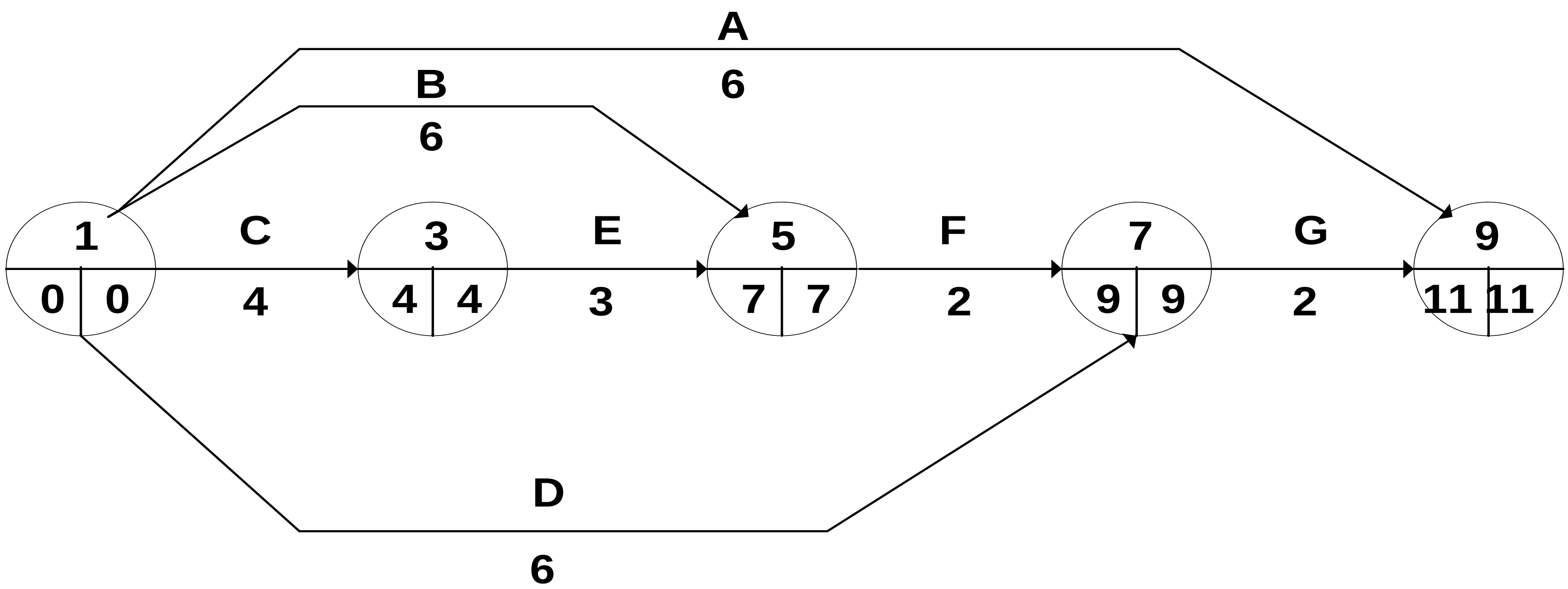
PROBLEM 8

Completely crash the following network schedules and find the optimum time and the least cost. Over head costs= $60 per day.

Activities	Duration		Cost $	
	Normal	Crash	Normal	Crash
A	6	3	300	360
B	6	4	450	500
C	4	2	360	420
D	6	3	600	675
E	3	2	325	350
F	2	1	250	285
G	2	1	310	350



SOLUTION OF PROBLEM 8



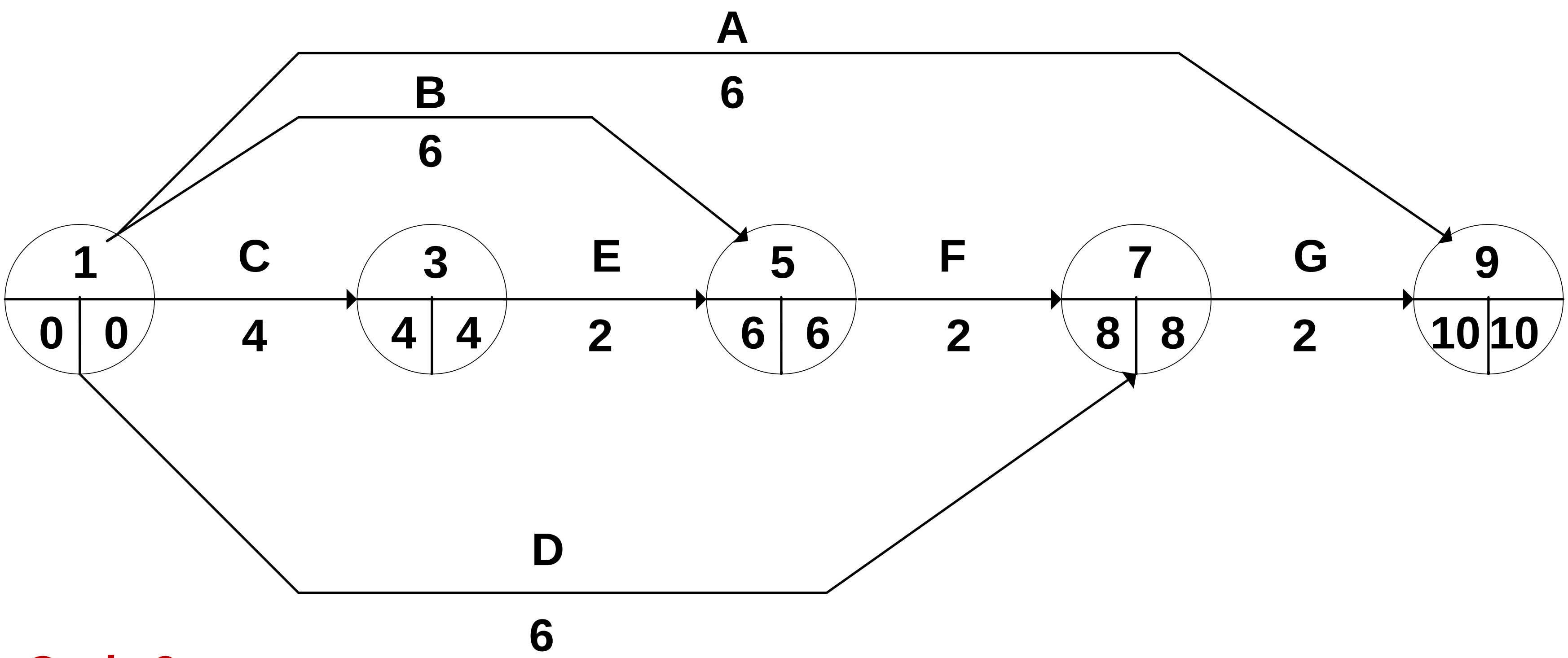
Critical path: 1-3-5-7-9
Normal project duration=11 days
Direct cost= 300+450+360+600+325+250+310= 2595
Overhead cost= (11*60) = 660
Normal project cost = (2595+660) = $3255

Cycle 1:
Among activities on critical path C-E-F-G, activity E has minimum cost per day.
Thus crash activity E by 1 day at $ 25.
New project duration: 11-1= 10 days
New project cost= 3255+25-60= $3220

SOLUTION OF PROBLEM 8

Activity	Duration		Cost ($)		Δ Cost	Δ Days	Δ Cost/ Day	Days Shortened				
	Normal	Crash	Normal	Crash				Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5
A	6	3	300	360	60	3	20					
B	6	4	450	500	50	2	25				1	1
C	4	2	360	420	60	2	30				1	1
D	6	3	600	675	75	3	25					1
E	3	2	325	350	25	1	25	1				
F	2	1	250	285	35	1	35		1			
G	2	1	310	350	40	1	40			1		
					Days cut			1	1	1	1	1
					Project duration		11	10	9	8	7	6
					Increased cost/day			25	35	40	55	80
					Direct cost		2595	2620	2655	2695	2750	2830
					Overhead cost		660	600	540	480	420	360
					Total cost		**3255**	**3220**	**3195**	**3175**	**3170**	**3190**

SOLUTION OF PROBLEM 8



Cycle 2:

Note that there are two critical paths to shorten at the same time, 1-3-5-7-9 and 1-5-7-9.

Crash cost for activities C (1-3) + B (1+5) = 25+30= $55

Crash cost for activity F (5-7) = $35

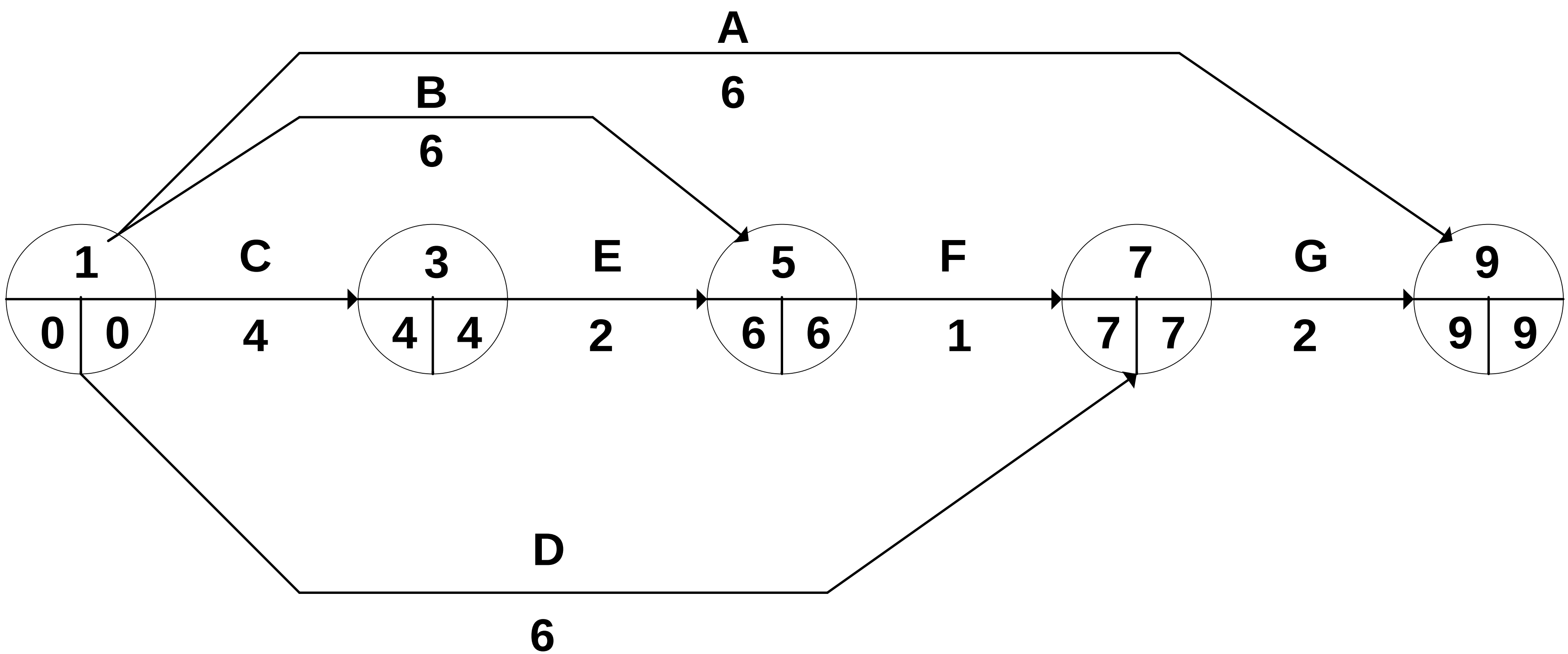
Crash cost for activity G (5-7) = $40

Activity (5-7) has the cheapest cost slope, potential 1 day. Therefore, crash activity F (5-7) by 1 day.

New project duration: 10-1= 9 days

New project cost= 3220+35-60= $3195

SOLUTION OF PROBLEM 8



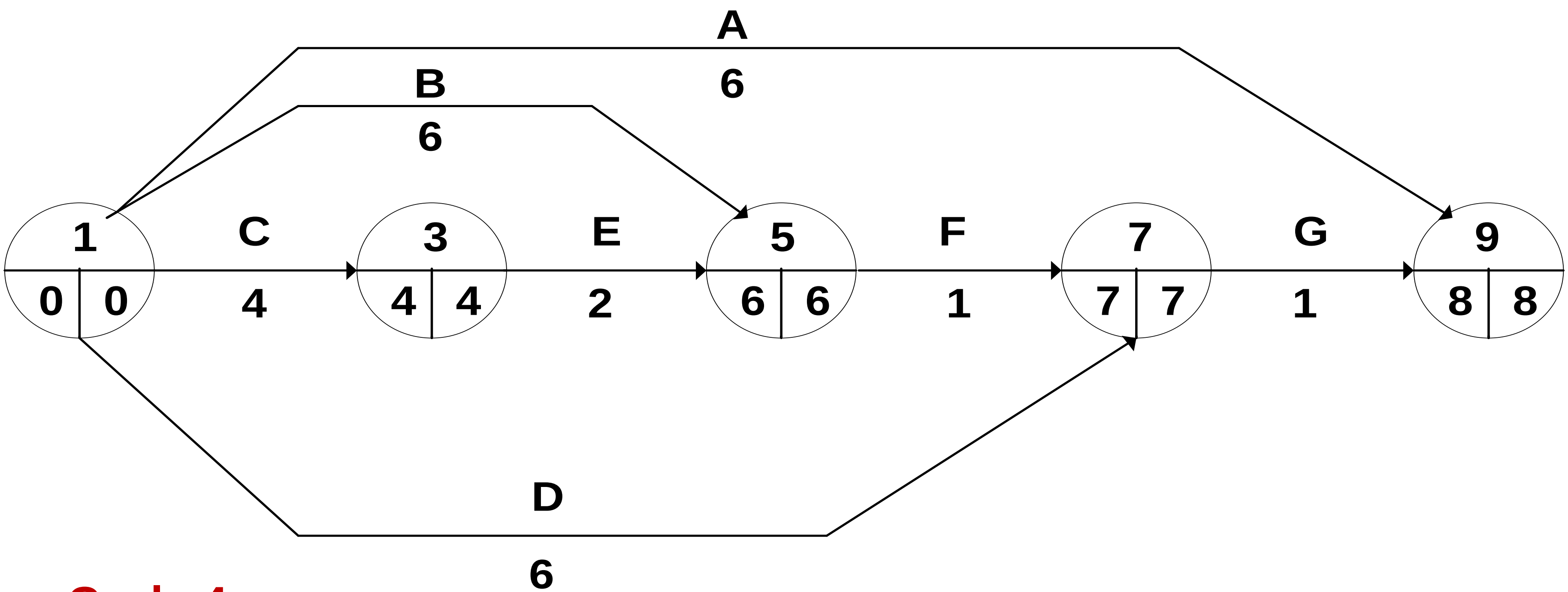
Cycle 3:

Among activities on critical path, activity G (7-9) has the cheapest cost slope $ 40 per day and potential 1 day. Compress activity G by 1 day.

New project duration: 9-1= 8 days

New project cost= 3195+40-60= $3175

SOLUTION OF PROBLEM 8



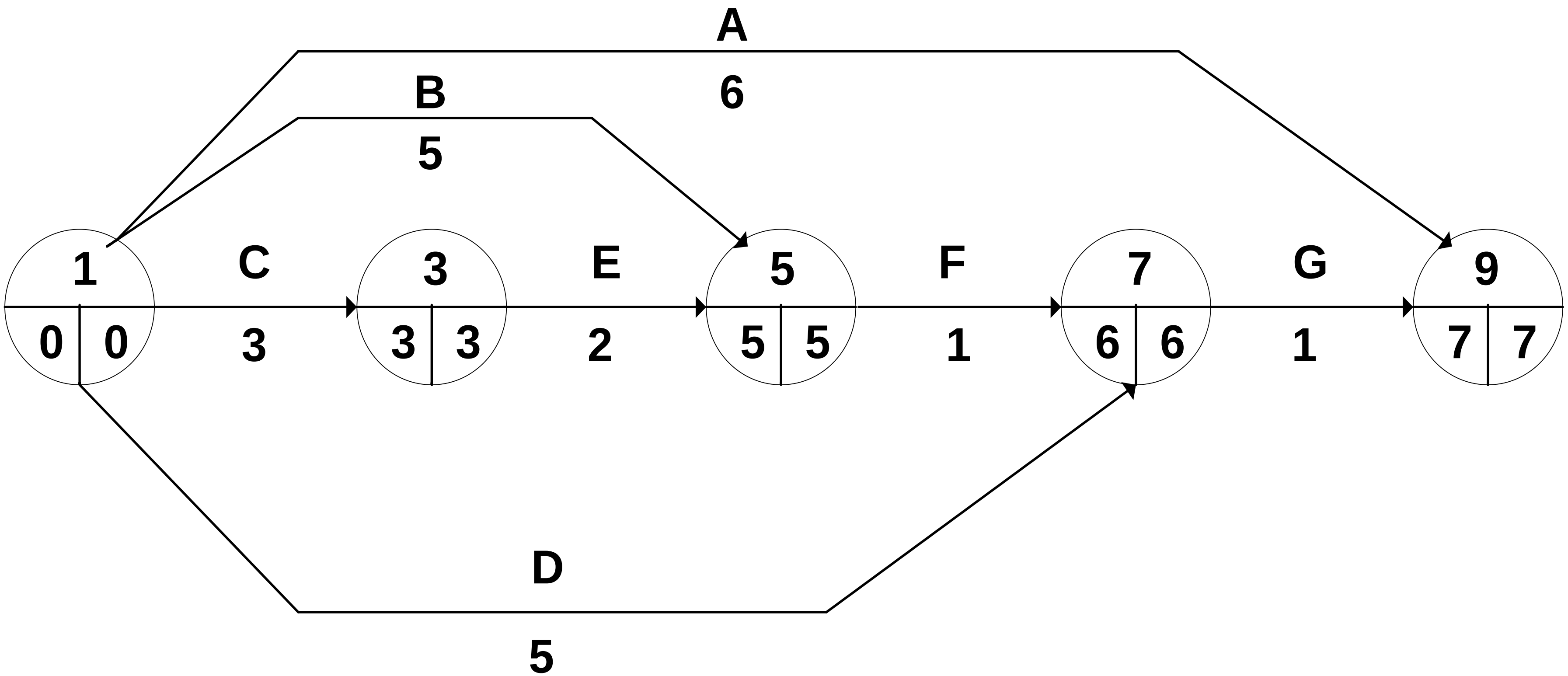
Cycle 4:

Simultaneous crash of activities C (1-3) and B (1-5) have the cheapest combined cost slope, with 2 days potential. Full compression (crash) is not possible since non critical activity D (1-7) terminating at 7 has only 1 day Free Float less than the potential available. Hence crash activities C and B by 1 day simultaneously.

New project duration: 8-1= 7 days

New project cost= 3195+ (30+25)-60= $3170

SOLUTION OF PROBLEM 8



Cycle 5:

Note that now there are multiple critical paths to shorten, 1-3-5-7-9, 1-5-7-9, 1-7-9.

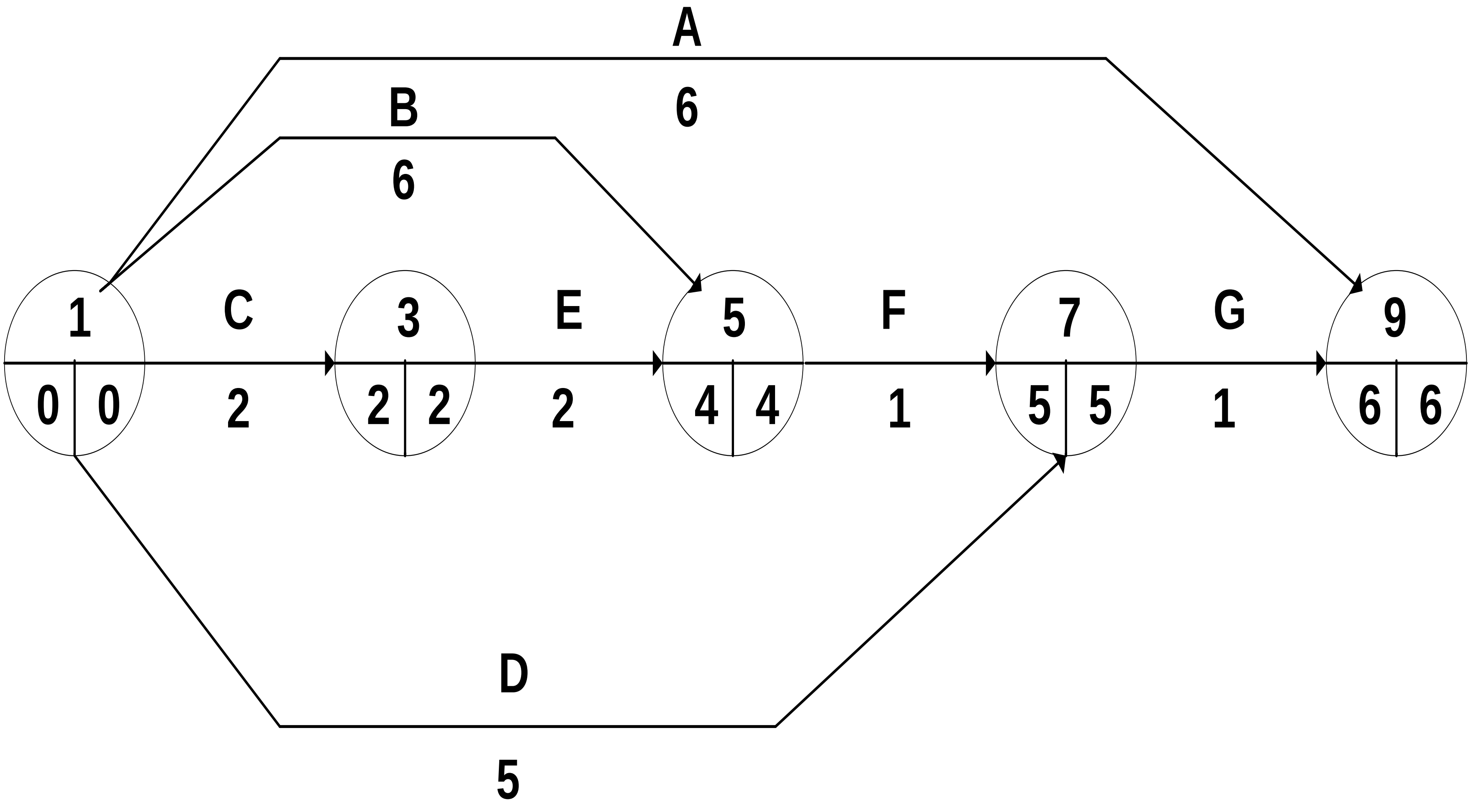
Crash activities B, C and D by 1 day simultaneously.

New project duration: 7-1= 6 days

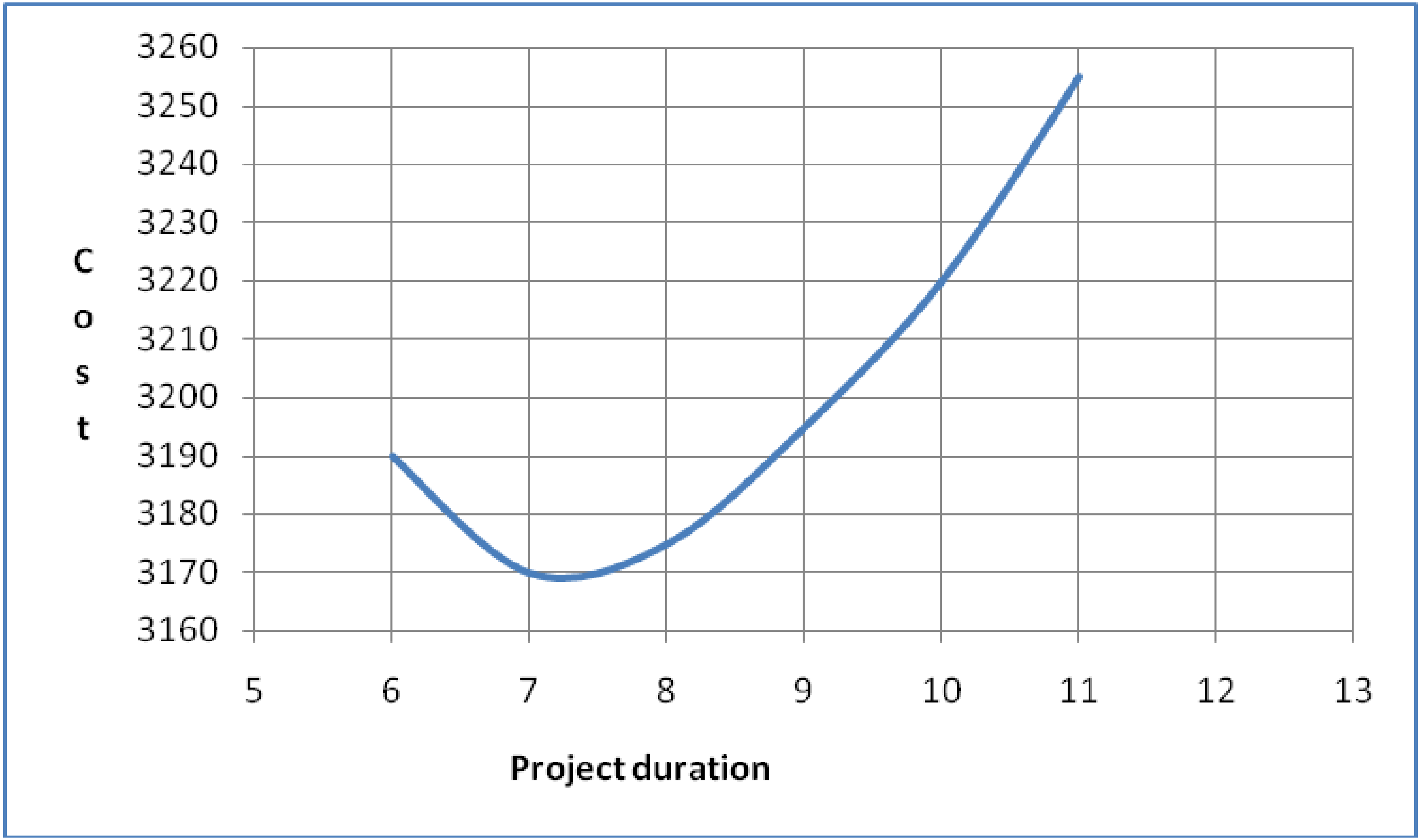
New project cost= 3170+ (25+30+25)-60= $3190

The potential available for critical paths (1-3-5-7-9) and (1-5-7-9) is completely crashed. Stop here.

SOLUTION OF PROBLEM 8



SOLUTION OF PROBLEM 8



Therefore, the optimum project duration is 7 days.
Least cost = $ 3170

THANKS FOR YOUR ATTENTION