Week 6

Project Scheduling (2)

457.307 Construction Planning and Management

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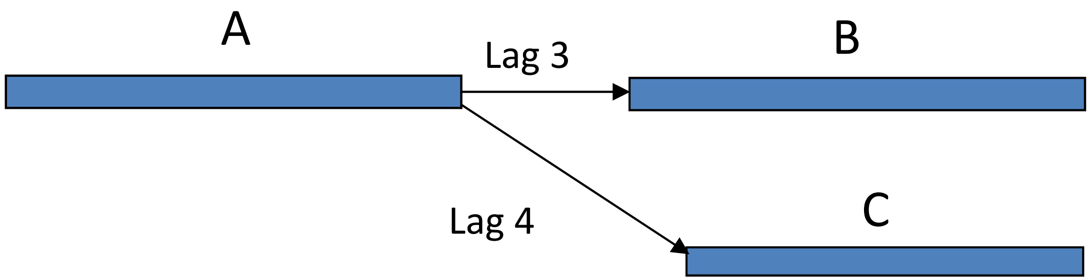
Total Float/Free Float

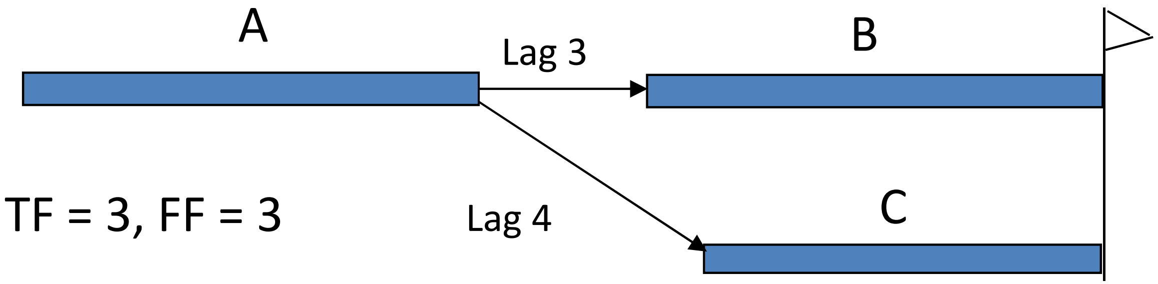
- **Total Float**
  - Most common
  - Amount of movement of an activity within a window before project completion delayed

    e.g., 3 days are okay to be delayed without causing a problem on a completion date
- **Free Float**
  - Amount of movement within window before start of any succeeding activity is delayed
  - ***e.g., 3 days are okay to be delayed without causing a problem on any succeeding activity***

Free Float/Total Float Comparison

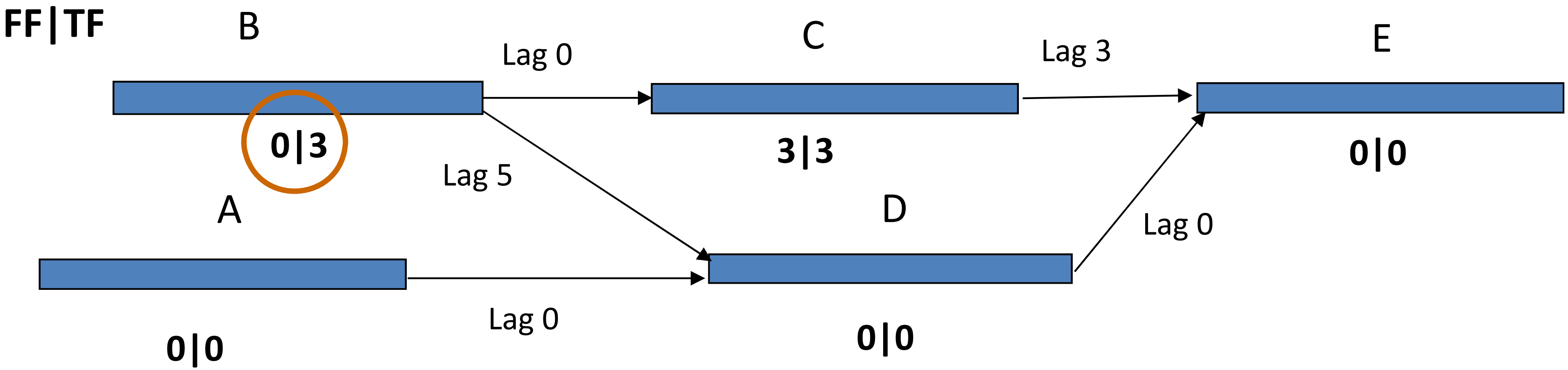


Free float = min lag = 3
Total float = ??? → why?



TF = 3, FF = 3

Free Float/Total Float Comparison



A, D, E on critical path

C has TF = FF = 3 → why?

B has TF = 3 when FF = 0 → why?

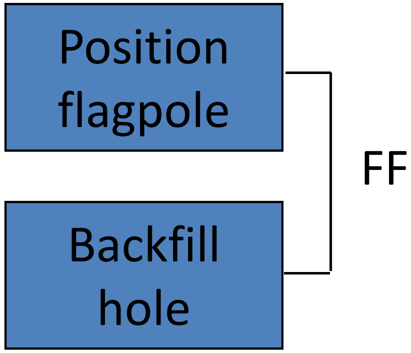
Activity Relationships

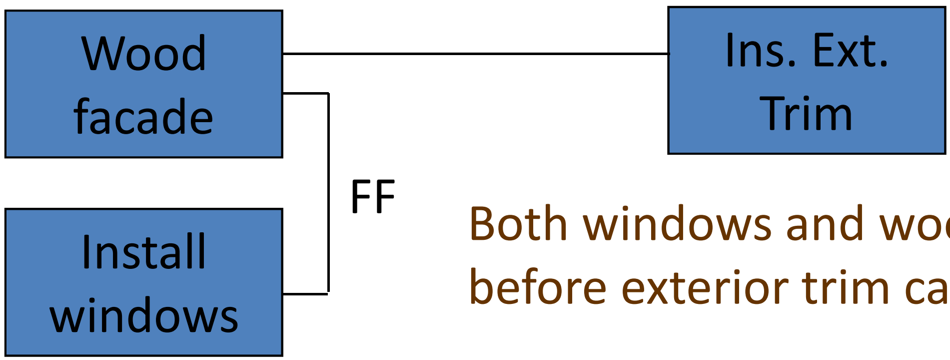
- **Logical connections in precedence networks**
  – Finish to Start (FS)
  – Start to Start (SS)
  – Finish to Finish (FF)
  – Start to Finish (SF)
- **FS by far most popular/used/understood**
- **Can include lags**
  – Lags are formal/required wait periods (e.g., concrete)

Finish to Finish

- **Two activities must finish at same time**

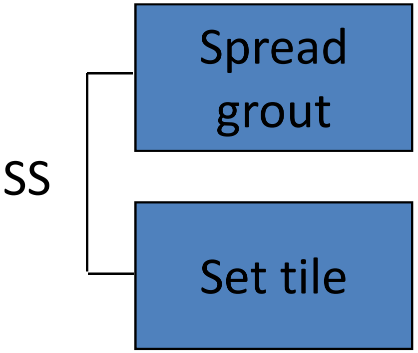
These two must finish
at same time.



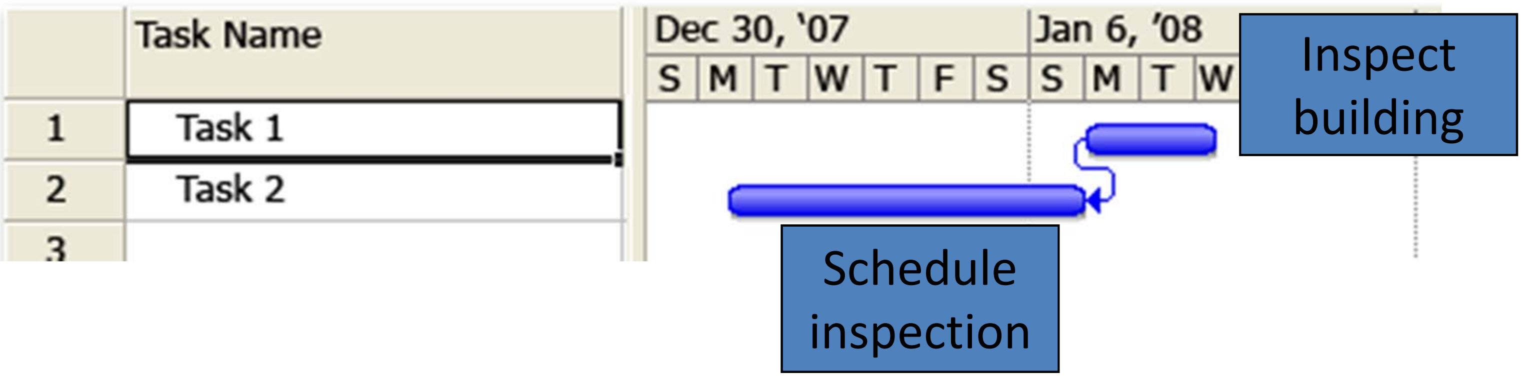


Both windows and wood must finish
before exterior trim can be installed.

Start to Start & Start to Finish



These two must start at same time.
(But why wouldn't you just model them as one activity?)



<u>SF is a tough one!</u> The start date of Task 1 determines the finish date of Task 2.
Usually used for procurement type activities.

Schedule Compression

- **Assumptions**
  - Direct costs
    - Are attached to activities
    - Increase with decreasing duration
  - Indirect costs
    - e.g., utilities, rent, audit and legal, administrative staffs, fuel, maintenance, security, telephone, etc.
    - Independent of activity duration
    - Decrease with project duration (linear costs)

Ignore indirect costs, so decrease duration by reducing Critical Path activities (why?)

Start with lowest cost/day activities (why?)

Schedule Compression

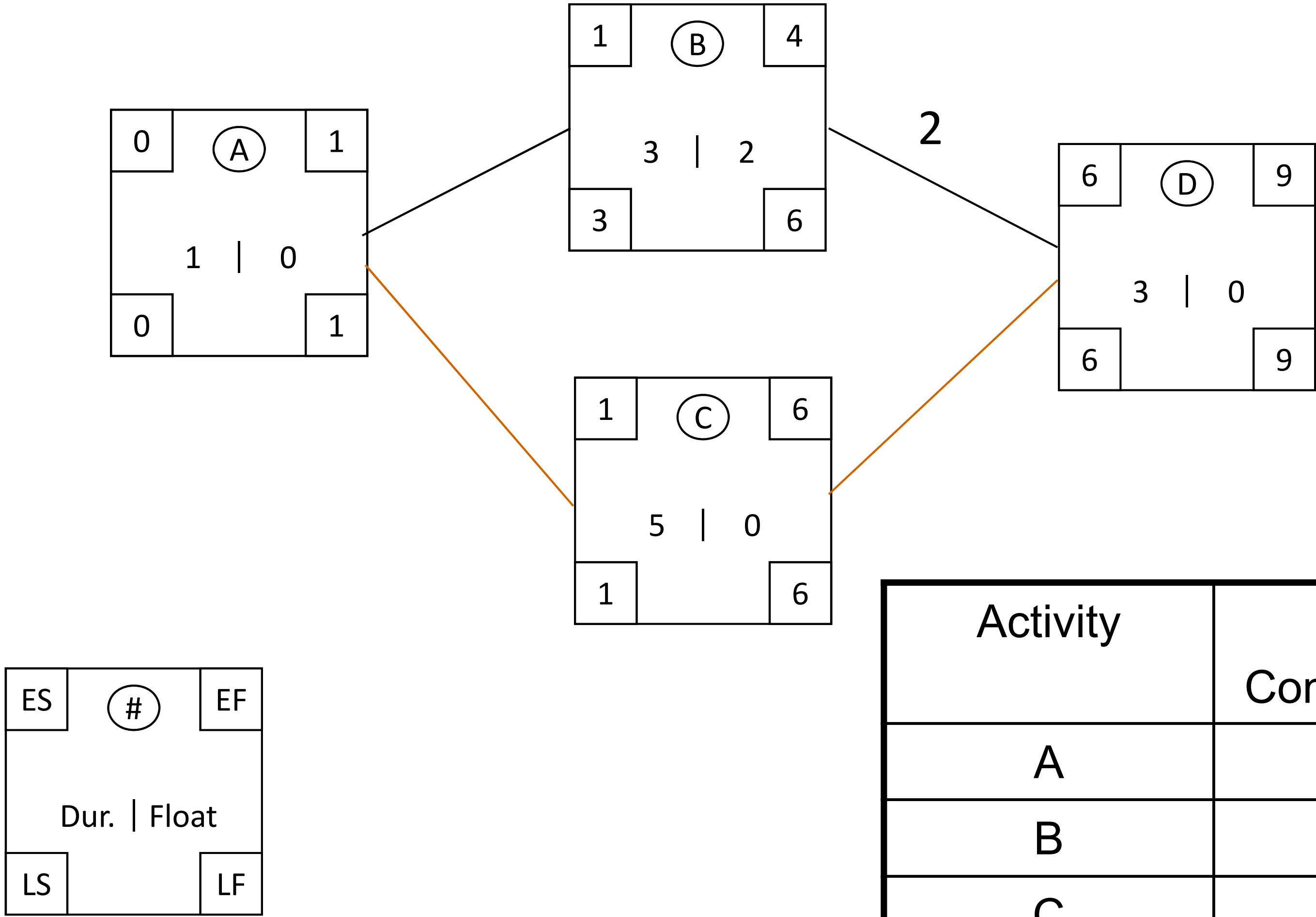
- **Some Terminology**
  - All normal: standard schedule, no compression
  - Least cost: compression where least amount of increase in cost
  - Least time: shortest possible project duration → reduce critical path activity
  - All crash: all activities shortened → cost is greater

Schedule Compression

- **Basic Steps in Compression**
  1. Compute schedule values for all normal schedule
  2. Select critical path activity with least slope for crash costs (Least amount of increase in cost per unit time)
  3. Reduce activity duration by minimum of following (= Network Interaction Limit, NIL):
     1. Max days activity can be compressed
     2. Min value of lags affected by activity compression

     NOTE: ***Min value of lags for the last activity is infinity!***
  4. Recalculate schedule (=new all normal) with compressed activity duration (= NIL)
  5. Schedule requirements met? Yes → End, No → Step 2

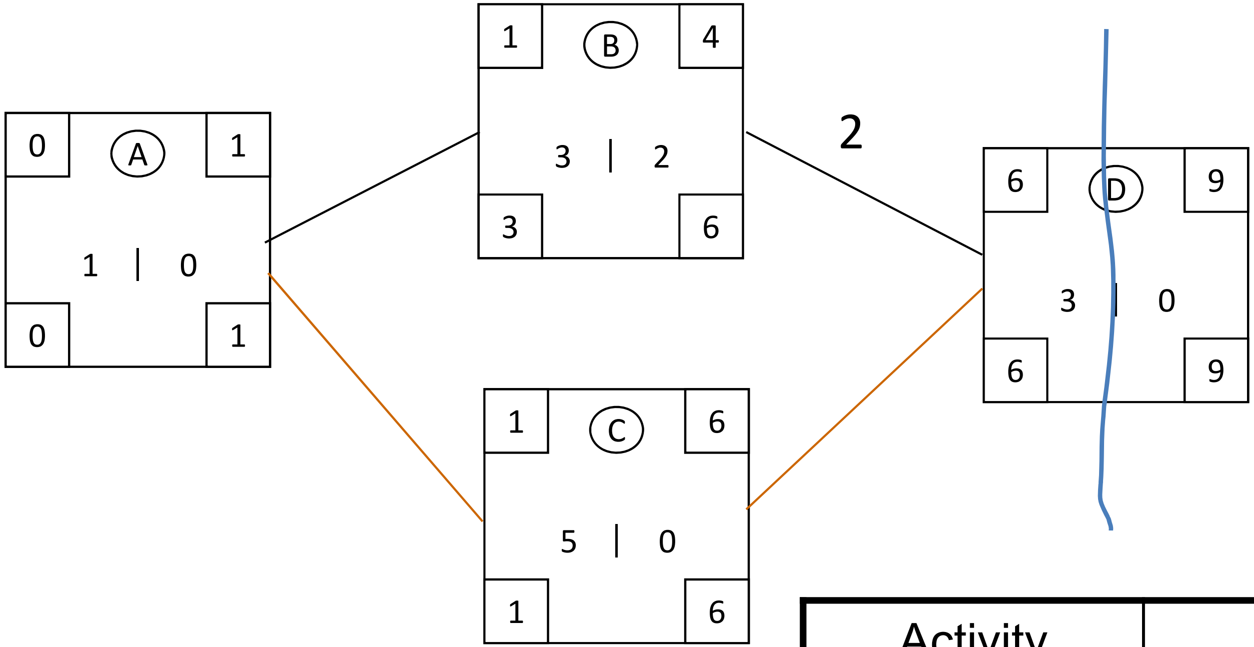
Schedule Compression Example (1)



Activity	Max Compression	Cost/Day
A	0	infinite
B	1	$400
C	3	$300
D	2	$150

Target: shortest possible schedule

Schedule Compression Example (1)



Activity	Max Compression	Cost/Day
A	0	infinite
B	1	$400
C	3	$300
D	2	$150

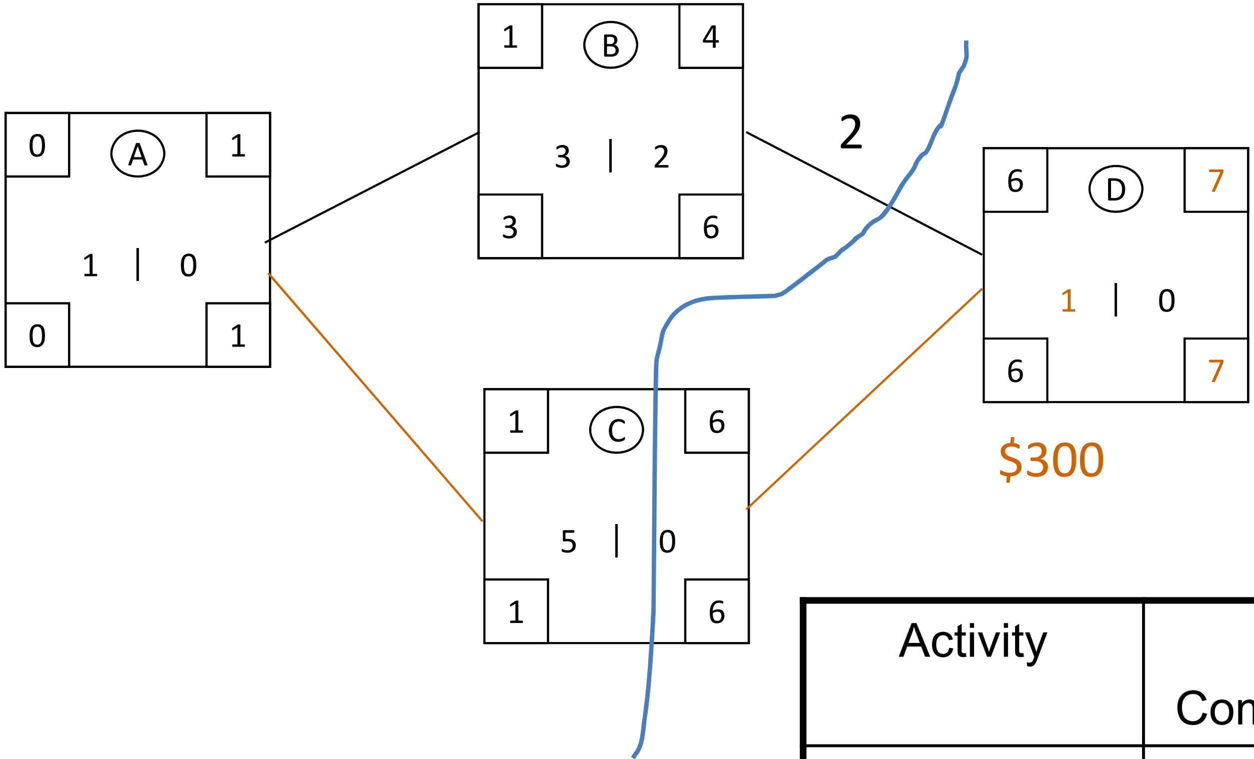
D has least slope (cost).

NIL(D) = min(2, Infinity) = 2

Min(Max days activity can be compressed,
Min value of lags affected by activity compression)

Recalculate

Schedule Compression Example (1)



C has least cost

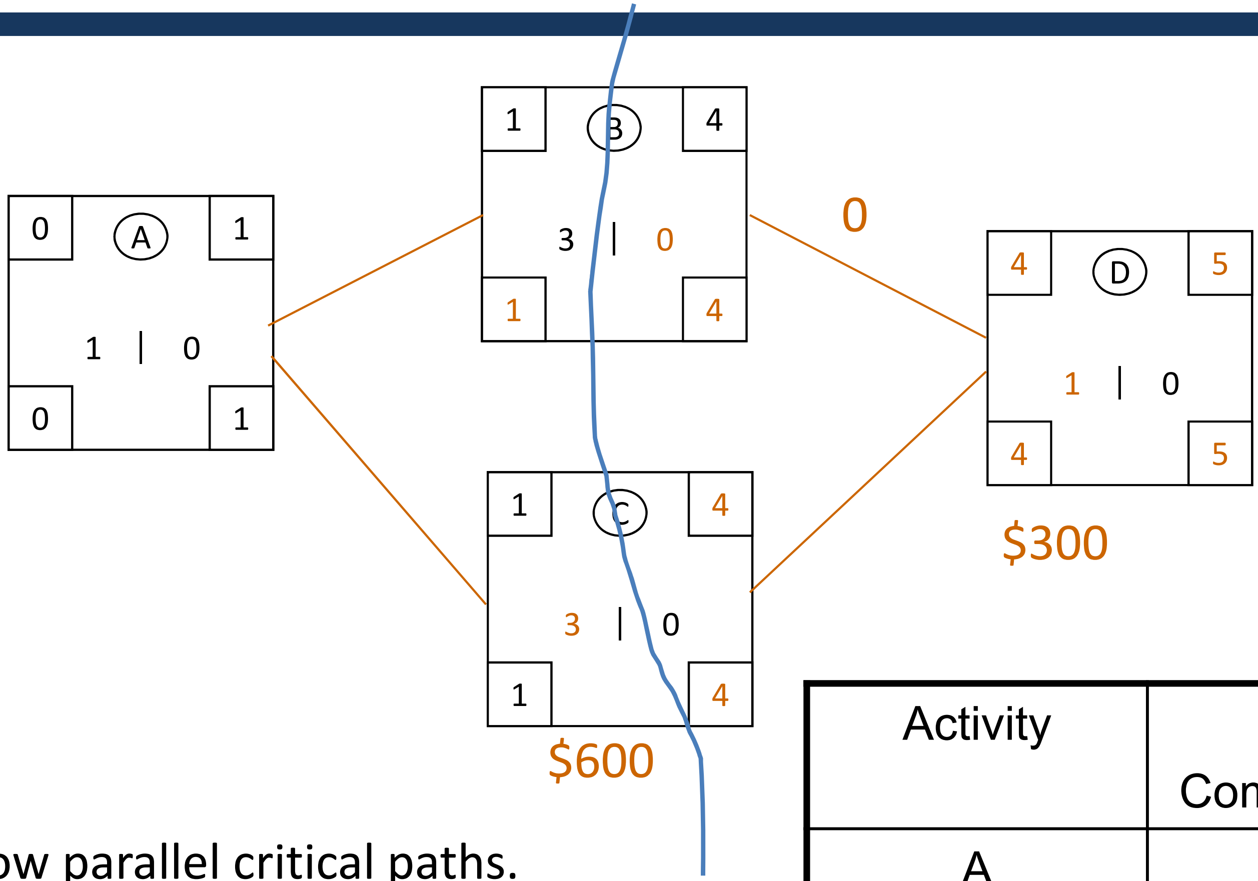
NIL(C) = min(3, 2) = 2

Min(Max days activity can be compressed,
Min value of lags affected by activity compression)

Recalculate

Activity	Max Compression	Cost/Day
A	0	infinite
B	1	$400
C	3	$300
√D	0	$150

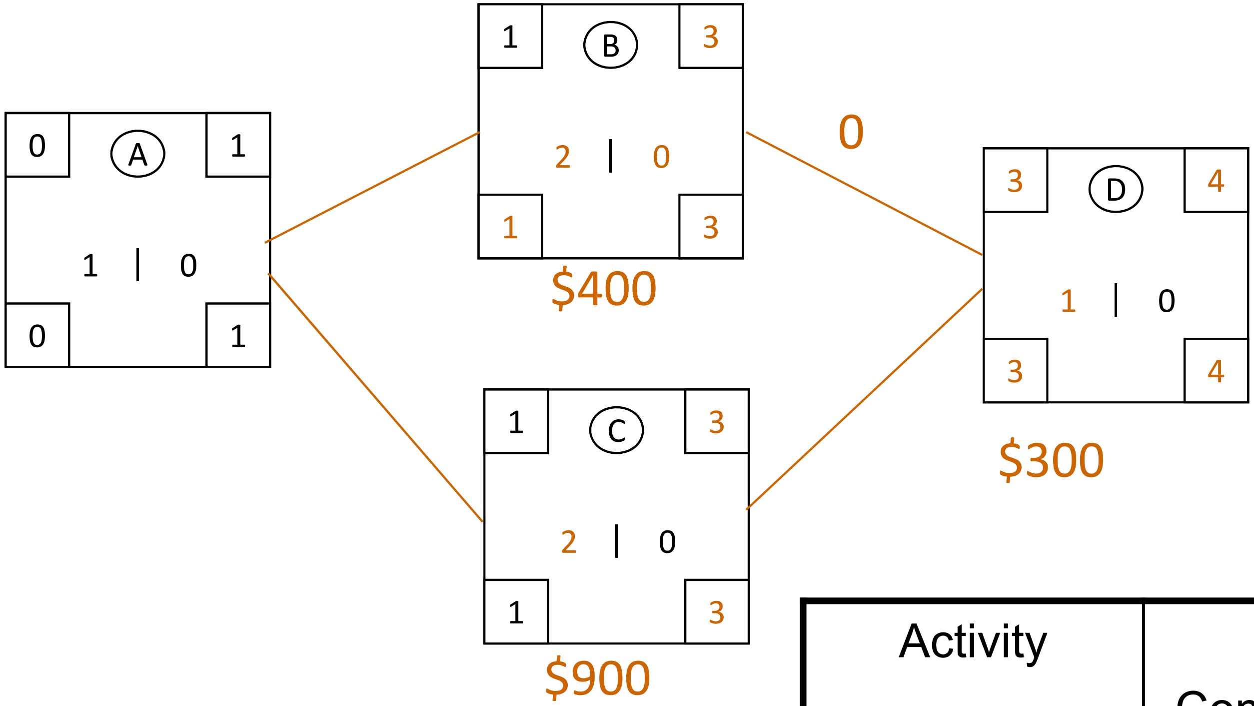
Schedule Compression Example (1)



B & C now parallel critical paths.
NIL (B,C) = min(1, infinite) = 1
Recalculate

Activity	Max Compression	Cost/Day
A	0	infinite
B	1	$400
√C	1	$300
√D	0	$150

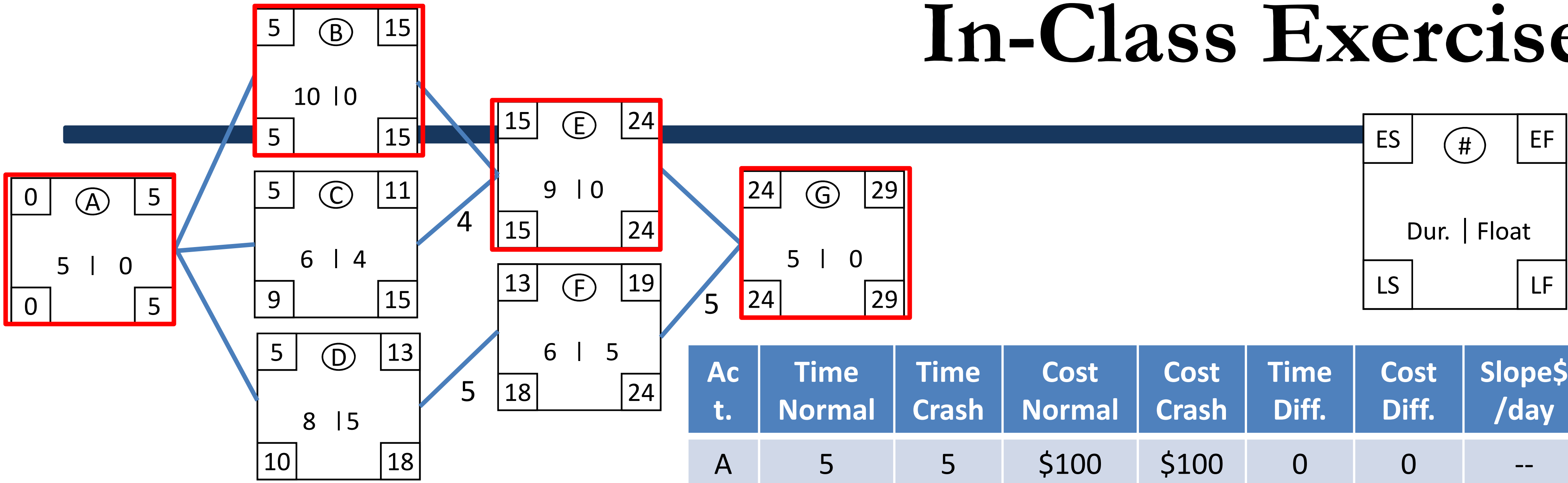
Schedule Compression Example (1)



Total cost = $1,600
Total compression = 5 days
Total duration = 4 days

Activity	Max Compression	Cost/Day
A	0	infinite
√B	0	$400
√C	0	$300
√D	0	$150

In-Class Exercise



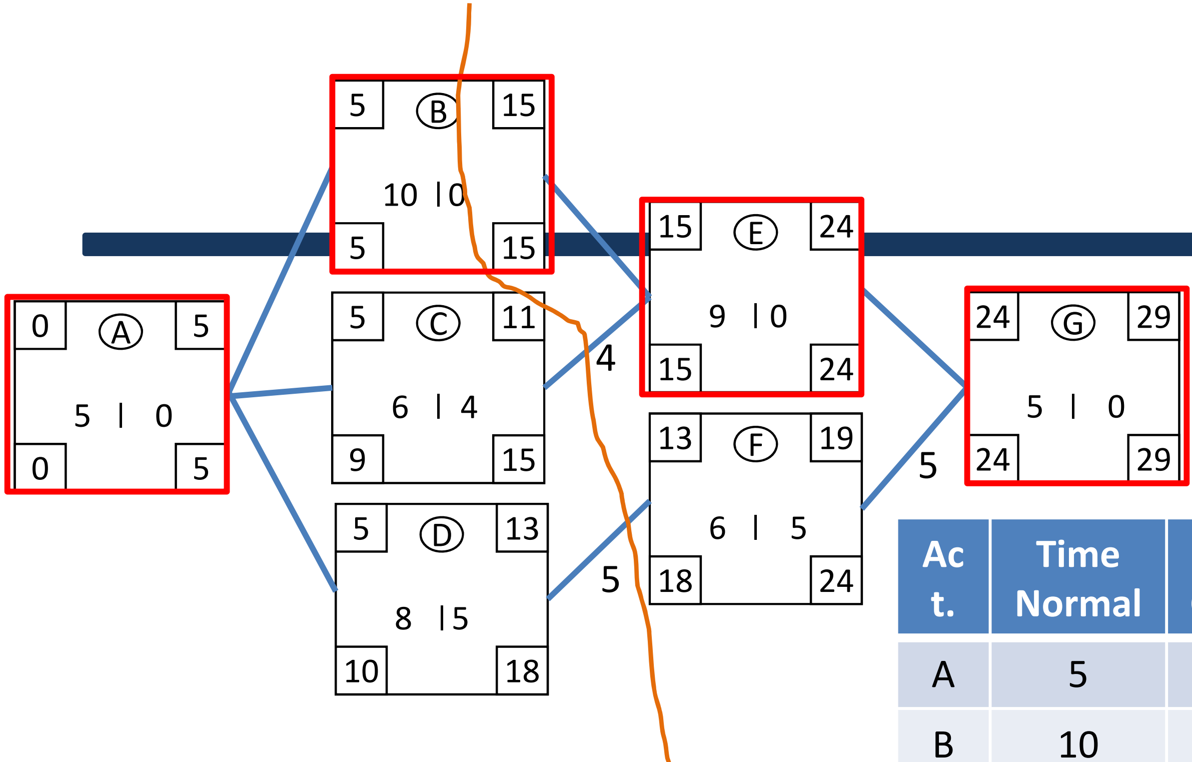
Act.	Time Normal	Time Crash	Cost Normal	Cost Crash	Time Diff.	Cost Diff.	Slope$/day
A	5	5	$100	$100	0	0	--
B	10	7	$500	$560	3	$60	$20
C	6	4	$300	$400	2	$100	$50
D	8	6	$400	$600	2	$200	$100
E	9	5	$200	$420	4	$220	$55
F	6	5	$100	$150	1	$50	$50
G	5	7	$320	$400	2	$80	$40

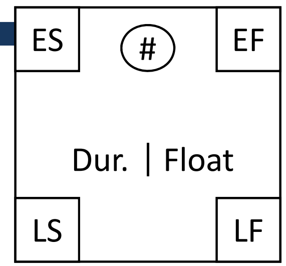
Target: shortest possible schedule

1. Critical Path
2. Fill out the table
3. For the activities on the critical path, pick the activity with least slope ($/day)
4. Reduce the duration by NIL

Cycle	Act	Can be shorten	NIL	Days shorten	Cost/day	Cost/cycle	Total	Project Duration
0							$1,920	29

In-Class Exercise



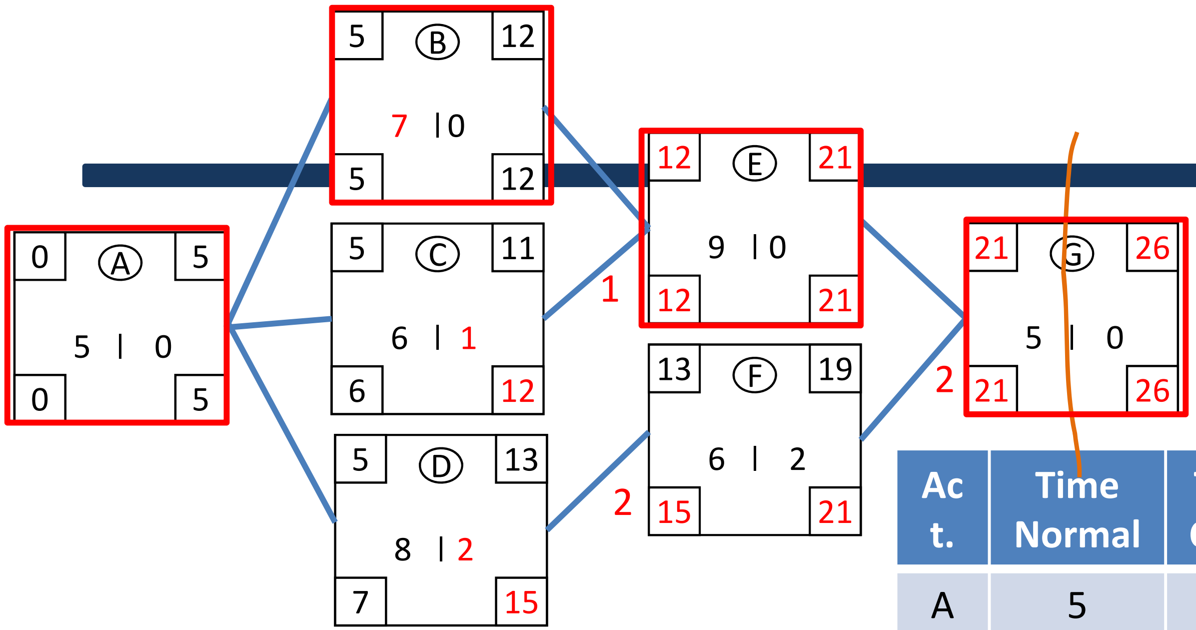


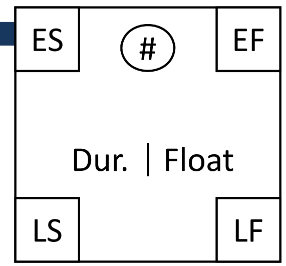
3. NIL(B) = min(3,4) = 3

Act.	Time Normal	Time Crash	Cost Normal	Cost Crash	Time Diff.	Cost Diff.	Slope $/day
A	5	5	$100	$100	0	0	--
B	10	7	$500	$560	3	$60	$20
C	6	4	$300	$400	2	$100	$50
D	8	6	$400	$600	2	$200	$100
E	9	5	$200	$420	4	$220	$55
F	6	5	$100	$150	1	$50	$50
G	5	7	$320	$400	2	$80	$40

Cycle	Act	Can be shorten	NIL	Days shorten	Cost/day	Cost/cycle	Total	Project Duration
0							$1,920	29
1	B	3	3	3	$20	$60	$1,980	26

In-Class Exercise





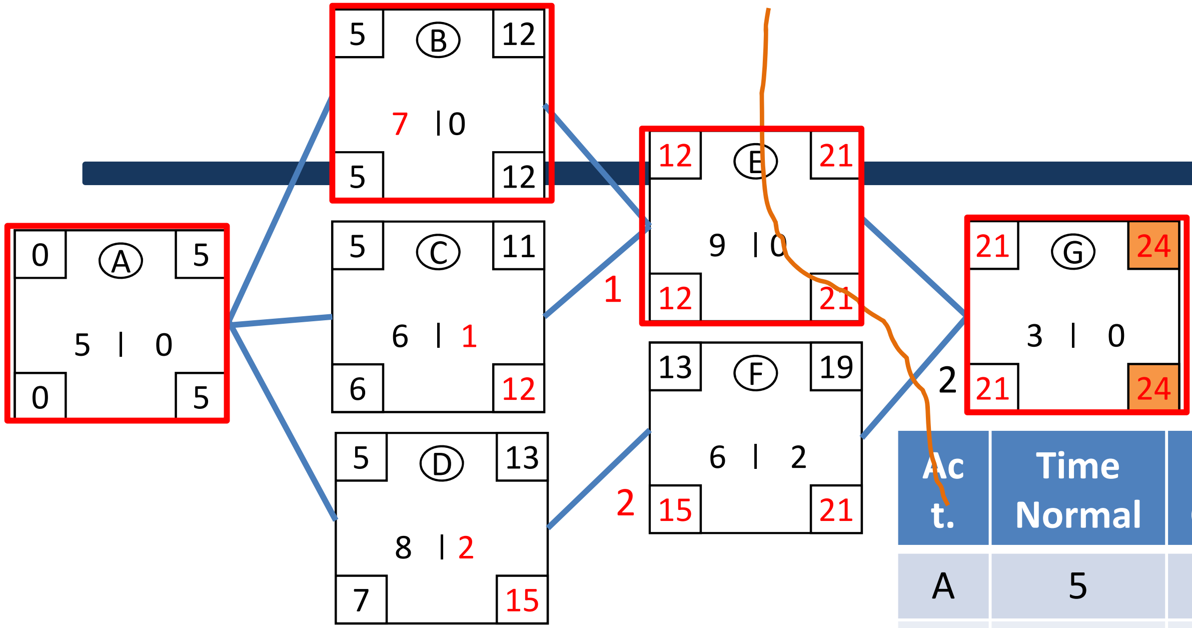
Act.	Time Normal	Time Crash	Cost Normal	Cost Crash	Time Diff.	Cost Diff.	Slope $/day
A	5	5	$100	$100	0	0	--
~~B~~	~~10~~	~~7~~	~~$500~~	~~$560~~	~~3~~	~~$60~~	~~$20~~
C	6	4	$300	$400	2	$100	$50
D	8	6	$400	$600	2	$200	$100
E	9	5	$200	$420	4	$220	$55
F	6	5	$100	$150	1	$50	$50
G	5	3	$320	$400	2	$80	$40

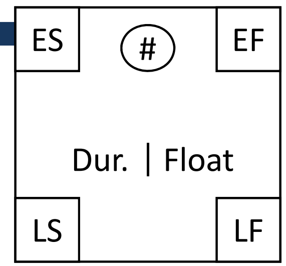
5. Recalculate the schedule
Go to Step 1…

NIL(G) = min(2, infinite) = 2

Cycle	Act	Can be shorten	NIL	Days shorten	Cost/day	Cost/cycle	Total	Project Duration
0							$1,920	29
1	B	3	3	3	$20	$60	$1,980	26
2	G	2	2	2	$40	$80	$2,060	24

In-Class Exercise



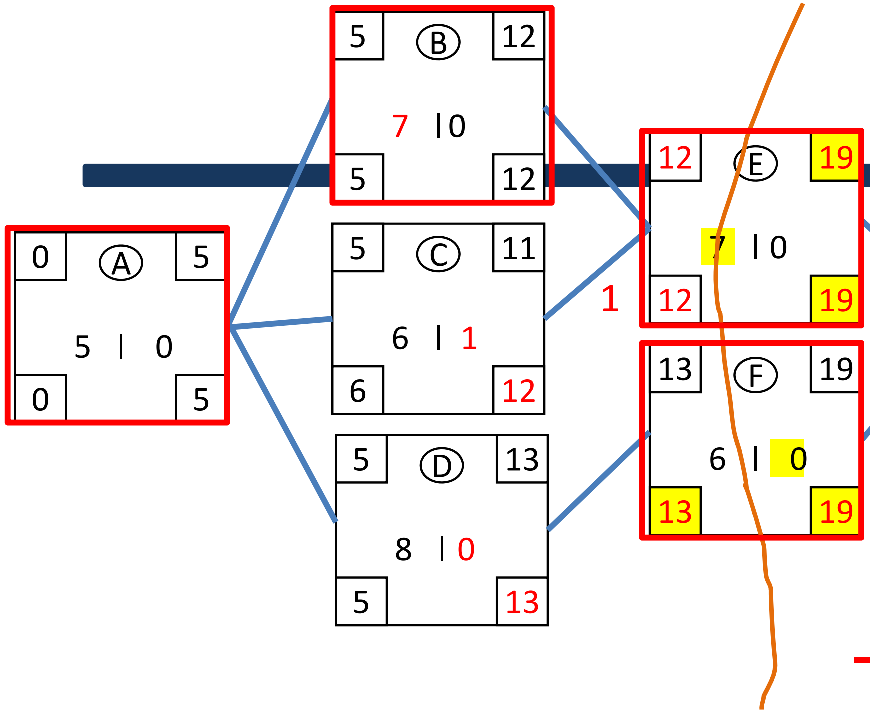


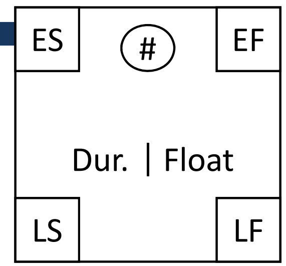
Act.	Time Normal	Time Crash	Cost Normal	Cost Crash	Time Diff.	Cost Diff.	Slope $/day
A	5	5	$100	$100	0	0	--
~~B~~	~~10~~	~~7~~	~~$500~~	~~$560~~	~~3~~	~~$60~~	~~$20~~
C	6	4	$300	$400	2	$100	$50
D	8	6	$400	$600	2	$200	$100
E	9	5	$200	$420	4	$220	$55
F	6	5	$100	$150	1	$50	$50
~~G~~	~~5~~	~~3~~	~~$320~~	~~$400~~	~~2~~	~~$80~~	~~$40~~

NIL(E) = min(4, 2) = 2

Cycle	Act	Can be shorten	NIL	Days shorten	Cost/day	Cost/cycle	Total	Project Duration
0							$1,920	29
1	B	3	3	3	$20	$60	$1,980	26
2	G	2	2	2	$40	$80	$2,060	24
3	E	4	2	2	$55	$110	$2,170	22

In-Class Exercise



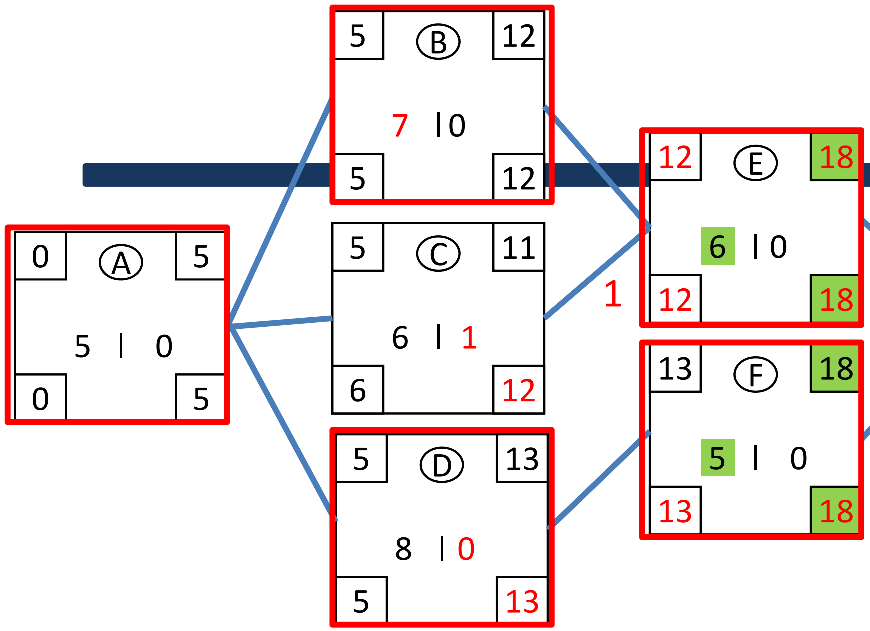


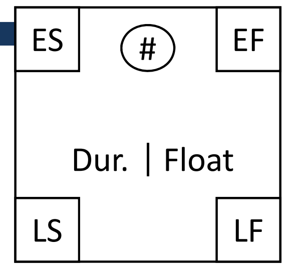
Act.	Time Normal	Time Crash	Cost Normal	Cost Crash	Time Diff.	Cost Diff.	Slope $/day
A	5	5	$100	$100	0	0	--
~~B~~	~~10~~	~~7~~	~~$500~~	~~$560~~	~~3~~	~~$60~~	~~$20~~
C	6	4	$300	$400	2	$100	$50
D	8	6	$400	$600	2	$200	$100
E	9	5	$200	$420	4	$220	$55
F	6	5	$100	$150	1	$50	$50
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

NIL(E, F) = min(1, infinite) = 1

Cycle	Act	Can be shorten	NIL	Days shorten	Cost/day	Cost/cycle	Total	Project Duration
0							$1,920	29
1	B	3	3	3	$20	$60	$1,980	26
2	G	2	2	2	$40	$80	$2,060	24
3	E	4	2	2	$55	$110	$2,170	22
4	E, F	1	1	1	$55+$50	$105	$2,275	21

In-Class Exercise





Act.	Time Normal	Time Crash	Cost Normal	Cost Crash	Time Diff.	Cost Diff.	Slope $/day
A	5	5	$100	$100	0	0	--
~~B~~	~~10~~	~~7~~	~~$500~~	~~$560~~	~~3~~	~~$60~~	~~$20~~
C	6	4	$300	$400	2	$100	$50
D	8	6	$400	$600	2	$200	$100
E	9	5	$200	$420	4	$220	$55
~~F~~	~~6~~	~~5~~	~~$100~~	~~$150~~	~~1~~	~~$50~~	~~$50~~

Total crash cost = $355 (8-day crash)
Total duration = 21 days

Cycle	Act	Can be shorten	NIL	Days shorten	Cost/day	Cost/cycle	Total	Project Duration
0							$1,920	29
1	B	3	3	3	$20	$60	$1,980	26
2	G	2	2	2	$40	$80	$2,060	24
3	E	4	2	2	$55	$110	$2,170	22
4	E, F	1	1	1	$55+$50	$105	$2,275	21