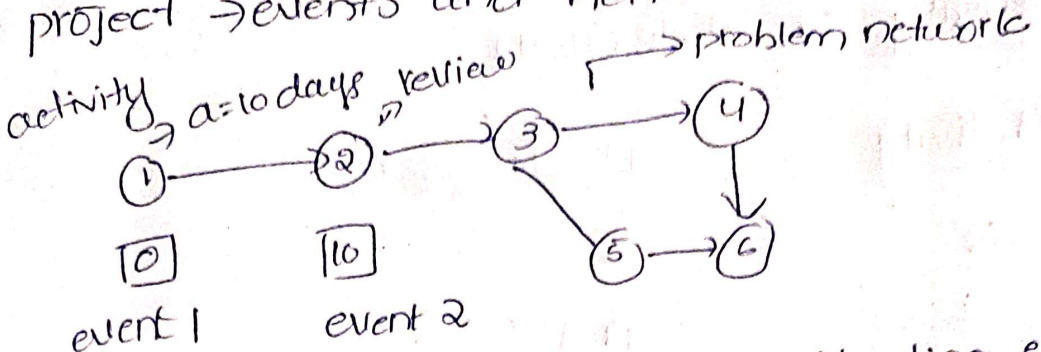
Unit-6

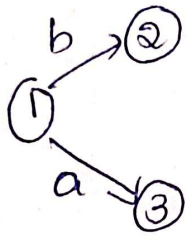
Network models (Project management)

* project → events and Activities



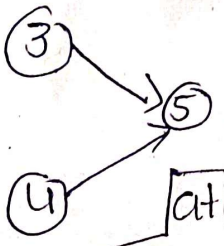
* only one ending event and one starting event

Burst event



3 events
2 activities

Merge event

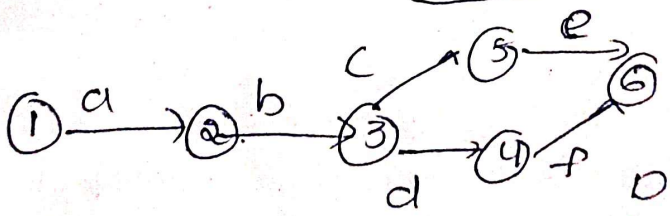


atleast 1 predecessor & 1 successor

Dual event

event	pred	succ
1	-	2
2	1	3
3	2	4,5
4	3	6
5	3	6
6	4,5	-

n events
n-2 dual event



→ dummy activity (DA)
Duration = 0
DA's wont have any duration
≤ 6 → no. of DA's

* Each activity and event must have different sign
* It should only from left to right (→)
* we should use only one arrow, Should not use multiple arrows. It should be straight
* Arrows should not intersect.

Network Diagram

① Activity on Arrow (AOA)

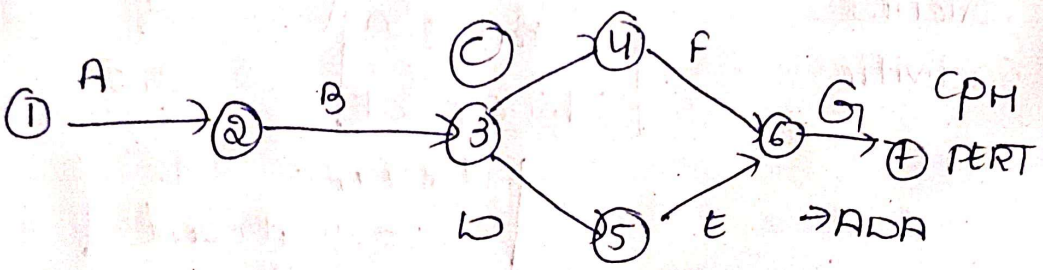
② Activity on Node (AON)

①

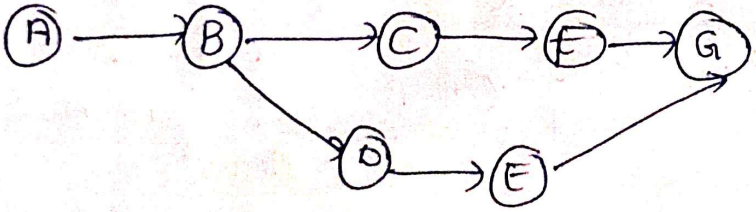
Activity	Predecessor
A	-
B	A
C	B
D	B
E	D
F	C
G	E, F

Network diagram

①



②



→ AON

*We can draw in different structures ↓ don't have

EST, LFT can't found them

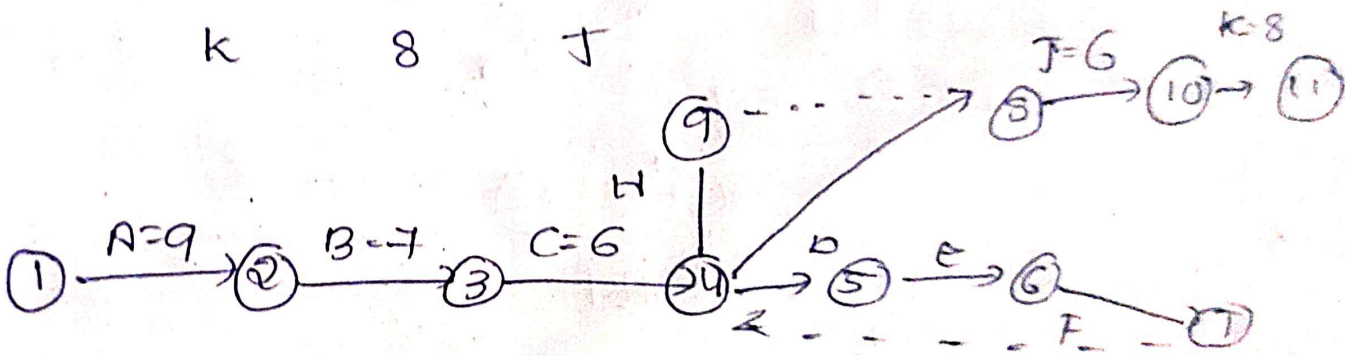
(P1) Activity Duration Predecessor

A	9	-
B	7	A
C	6	B
D	4	C
E	2	D
F	3	E
G	2	E
H	1	C
I	5	C, F
J	6	G, H, I
K	8	J

Burst

Burst

Merge



events = 11

Activities = 11

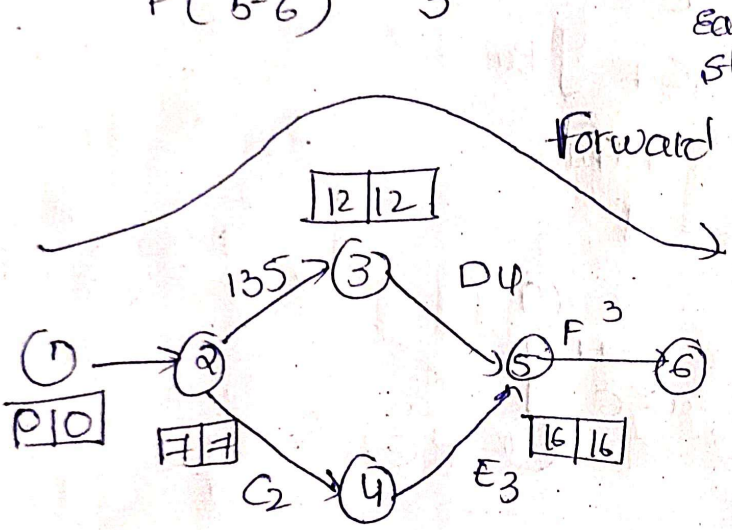
Dummy Activities = 2

* only one starting & one ending event

Critical path method (CPM) (or) Deterministic model

(P1) Activity duration (weeks)

A(1-2)	7
B(2-3)	5
C(2-4)	2
D(3-5)	4
E(4-5)	3
F(5-6)	3



Backward pass (LST, LFT)

↓ later standing time

↳ latest finishing time

* EFT = EST + D

* LST = LFT - D

* Float = LFT - EFT (or) LST - EST

↓

float = 0 → No duration → critical activity (or) job (or) task

↓

highest duration

→ No Freedom to reschedule

Paths	Duration
① $1 \xrightarrow{A} 2 \xrightarrow{B} B \xrightarrow{D} 5 \xrightarrow{F} 6$ (→ critical path)	19 weeks
② $1-2-4-5-6$	15 weeks

① EST for ② = EST of ① + Activity ① Duration

② EST for ⑤ = max { EST of ③ + 'D' Duration ; EST of ④ + 'E' Duration }

③ LFT of ⑤ = LFT of ⑥ − 'F' Duration

④ LFT of ② = min { LFT of ③ − 'B' Duration ; LFT of ④ − 'C' Duration }

For starting path EST = LFT

ending path. EST = LFT

LST − EST (or) LFT − EFT

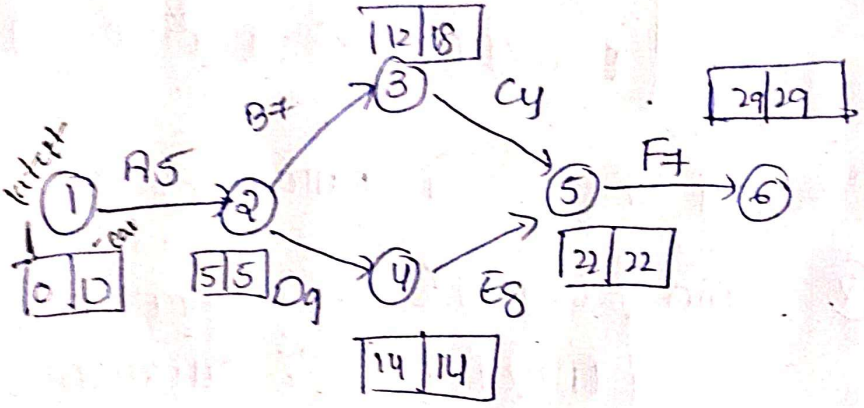
Activity	Duration	EST	EFT	LST	LFT	float
A(1-2)	7	0	7	0	7	A 0
B(2-3)	5	7	12	7	12	B 0
C(2-4)	2	7	9	11	13	4
D(3-5)	4	12	16	12	16	D 0
E(4-5)	3	9	12	13	16	4
F(5-6)	3	16	19	16	19	F 0

For A, B, D, F float = 0 → No freedom

C, E float = 4 → have '4' freedom

(Pg) Activity — Duration (days)

A(1-2)	5
B(2-3)	7
C(3-5)	4
D(2-4)	9
E(4-5)	8
F(5-6)	7



Paths		Duration
(1)	1 —A→ 2 —B→ 3 —C→ 5 —F→ 6	23 days
(2)	1 —A→ 2 —D→ 4 —E→ 5 —F→ 6	29 days

Activity	Duration	EST	EFT	LST	LFT	Float	
A(1-2)	5	0	5	0	5	0	A
B(2-3)	7	5	12	11	18	6	
C(3-5)	4	12	16	18	22	6	
D(2-4)	9	5	14	5	14	0	D
E(4-5)	8	14	22	14	22	0	E
F(5-6)	7	22	29	22	29	0	F

A, D, E, F → Float = 0, B, C → Float = 6

CPM PERT

① Deterministic probabimodel

② Float Slack

= LFT - LFT = LFT - EPT

(or) (or)

LST - EST LST - EST

③ Activity based Event based

* probability of completing the project in D days

$$Z = \frac{D - te}{s.d}$$

$$te = \frac{tot\ u(ln) + tp}{6}$$

Z = 0.00 Z = 1.11

Z	0.00	0.01	0.02	0.03	0.04
0.00	0.500				
0.01					
0.02					
⋮					
1.00	0.8413				
1.10					
1.12					

→ Z distribution

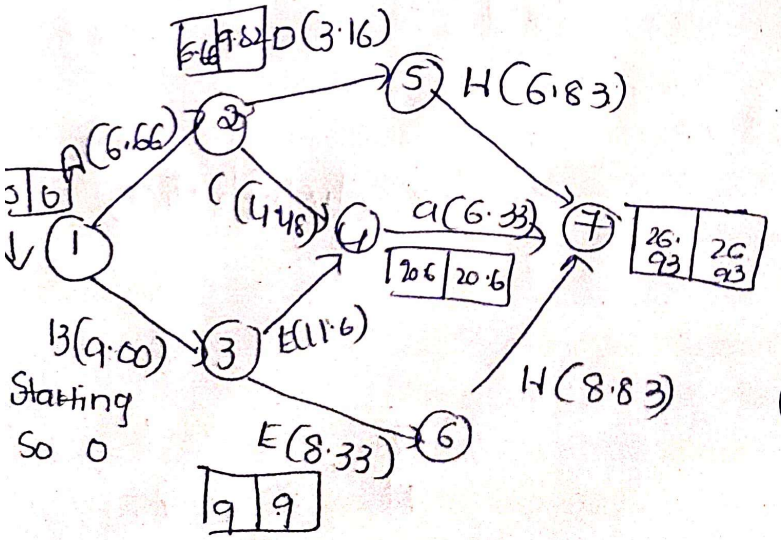
-1	1	1
14	20	95
250'/.	50'/.	750'/.

PERT

Activity	t_o	t_m	t_p	t_e
A(1→2)	3	2	9	(3+4(4)+9)/6 = 6.66
B(1→3)	5	9	13	(5+36+13/6) = 9
C(2→4)	2	5	2	4.48
D(2→5)	1	3	6	3.16
E(3→4)	8	12	14	11.6
F(3→6)	6	9	8	8.33
G(4→7)	3	6	11	6.33
H(5→7)	4	2	9	6.83
I(6→7)	6	9	11	8.83

Probability in 30 days → D value

Probability in estimated time Prob = 50 !



Paths	Duration (days)
① 1-2-5-7	16.65
② 1-2-4-7	14.4
③ 1-3-4-7	26.93
④ 1-3-6-7	26.16

B, E, Φ → Slack = 0

↓

Critical activities

	EST	EFT	LST	LFT	Slack
A(1-2)	0	6.66	9.46	16.12	9.46
B(1-3)	0	9.00	0	9.00	0 — B
C(2-4)	6.66	11.14	16.12	20.6	9.46
D(2-5)	6.66	9.82	16.94	20.1	10.28
E(3-4)	9	20.6	9.0	20.6	0 — E
F(3-6)	9	17.33	9.77	18.1	0.77
G(4-7)	20.6	26.93	20.6	26.93	0 — G
H(5-7)	98	16.65	20.1	26.93	10.28
I(6-7)	17.33	26.16	18.1	26.93	0.77

B, E, G → slack = 0

No freedom to reschedule

A, C, D, F, H, I have freedom to reschedule

Variance $\left(\frac{tp - Po}{6}\right)^2$

$B = (8/6)^2 = 1.77$

$E = (6/6)^2 = 1$

$G = (8/6)^2 = 1.77$

total variance 4.54

$STD = \sqrt{4.54} = 2.13$

Probability = $\frac{D - Le}{std} = \frac{30 - 26.93}{2.13}$

$= 1.44$

Z table

0.425 + 0.5

0.925 1.

Crashing of a project:- to reduce cost & reduce time

* Normal → time
  → cost
* crash — time
  — cost

→ Activities direct cost

Crash cost > Normal cost
Normal time > Crash time

* slope = $\frac{\text{Crash cost} - \text{Normal cost}}{\text{Normal time} - \text{crash time}}$
  ↓
  if is same
* crash limit = normal time - crash time
  ↓
  it will be changing

In problem they will mention. changes for every iteration

* Indirect cost = Rs 20
* Total cost = Direct cost + Indirect cost
* 1-2-4-5-6

	Slope	crash limit
1-2 A	50	9 → cant crash
2-4 C	60	3 → crash
4-5 E	65	2
5-6 F	100	1

↓
we will select with less slope

Iteration

① Total cost = previous cost + slope - Indirect cost

→ 2500

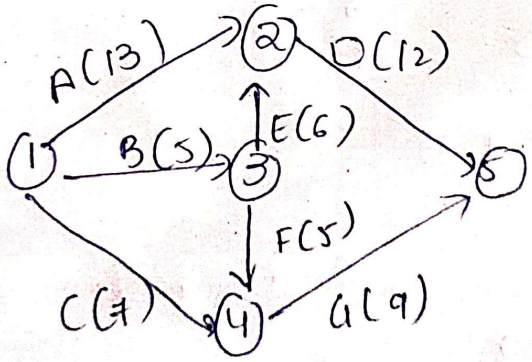
→ we have to stop iterations

2423
2470
2460
2465 ×

it must be less than previous

(8) Activity		weeks Normal time	(Rs) Normal cost	weeks crash time	(Rs) crash cost	slope
A	1-2	13	400	9	900	50
B	1-3	5	400	4	460	60
C	1-4	4	600	4	810	70
D	2-5	12	800	11	865	65
E	3-2	6	900	4	1130	115
F	3-4	5	1000	3	1150	90
G	4-5	9	1500	6	1800	100
			5900			

* Indirect cost is Rs 160 per week crash it by 1 week each time. Find the project cost & time after crashing



1-2-5 = 25

1-3-2-5 = 23

1-3-4-5 = 19

1-4-5 = 16

Indirect cost = 25 * 160 = Rs 4000

Total cost = Direct + Indirect cost

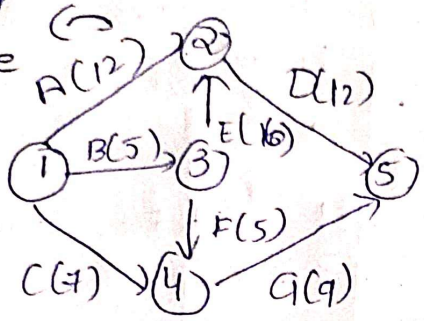
= 5900 + 4000

= Rs. 9900.

Iteration

	Slope	Crash limit (NT - CT)
1-2-5 A(1-2)	50	4 (13-9 = 4)
D(2-5)	65	1

Crashed decrease



Circle Critical path

1-2-5 = 24

1-3-2-5 = 23

1-3-4-5 = 19

1-4-5 = 16

Total cost = 9900 + 50 - 160

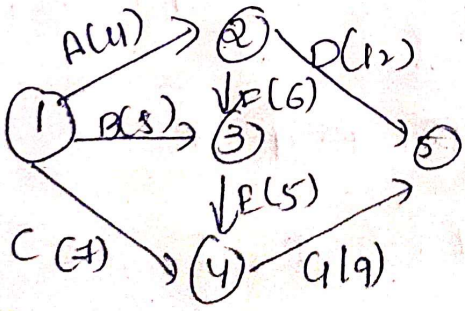
= 9790

Iteration 2

	Slope	Crash limit
1-2-5 A(1-2)	50	3
D(2-5)	65	1

Total cost = 9790 + 50 - 160

= 9680



Critical path

1-2-5 = 23 ✓

1-3-2-5 = 23 ✓

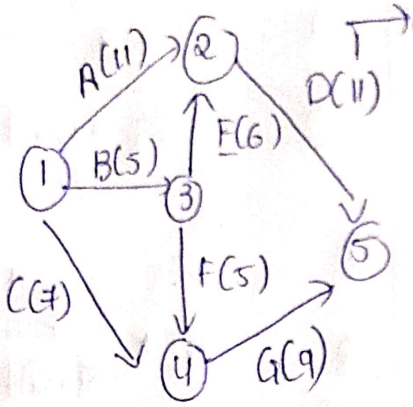
1-3-4-5 = 19

1-4-5 = 16

Iteration 3

		Slope	CL	
① 1-2-5	A(1-2)	50	2	To avoid simultaneously creating we take '65' as slope
	D(2-5)	65*	1	
② 1-3-2-5	B(1-3)	60	1	
	E(3-2)	115	2	
	D(2-5)	65*	1	

Total cost = 9680 + 65 - 160 = Rs 9585



Critical path

1-2-5 = 22 ✓
1-3-2-5 = 22 ✓
1-3-4-5 = 19
1-4-5 = 16

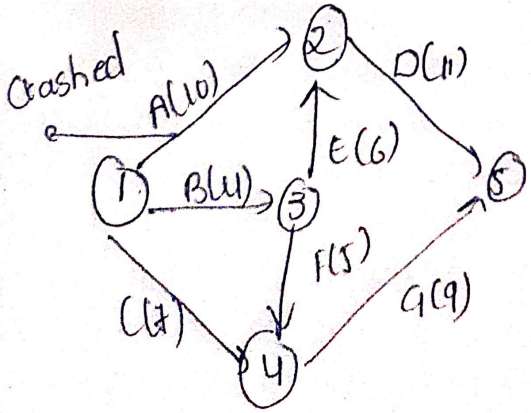
Iteration 4

			slope	CL
①	1-2-5	A(1-2)	50*	2
		D(2-5)	65	0
②	1-3-2-5	B(1-3)	60*	1
		E(3-2)	115	2
		D(2-5)	65	0

By crashing 'A', 'B' is crashed simultaneously

Total cost = 9585 + 50 + 60 - 160

= Rs 9535



Critical path

1-2-5 = 21 ✓
1-3-2-5 = 21 ✓
1-3-4-5 = 18
1-4-5 = 16

Iteration-5

		CL	Slope
1-2-5	A(1-2)	1	50
	D(2-5)	0	65 → cant crash
1-3-2-5	B(1-3)	0	60 → cant crash because CL=0
	E(3-2)	2	115* → simultaneous crash
	D(2-5)	0	65

Total cost = 9535 + 50 + 115 - 160

= Rs 9540 → it increases when compared to previous

So, here iteration stops

* project cost - Rs. 9535

* Project time = 21 weeks (10+11=21)