Scheduling of Software
(Software Project Planning)

- Staffing estimation
- Scheduling
  - Activity Network
  - CPM (Critical Path Method)
  - Gantt Chart
  - PERT Chart (Program Evaluation & Review Technique)
- Monitoring and Control

Norden's ~~Method~~ Work (Only R&D Projects)

$$E = K/t_d^2 * t * e^{-t^2/2t_d^2}$$

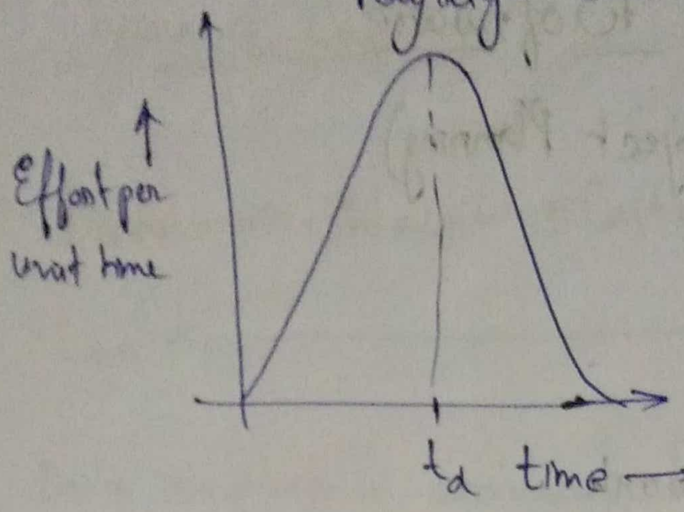
where E = effort required at time t i.e an indication of the no. of engineers needed at any particular time during the duration of the project.

K = area under the curve

t_d = time at which the curve attains the max value

t → time duration

Rayleigh Curve



Norden investigated the staffing pattern for R&D projects. This was later extended to software project by Putnam. Putnam studied the problem of staffing for software projects & found them to be very similar to the R&D projects studied by Norden, using Rayleigh-Norden curve.

Putnam's Work (Software Projects)

$$L = C_k K^{1/3} t_d^{4/3}$$

$$C_k = \begin{cases} 2 & \text{poor} \\ 8 & \text{good} \\ 11 & \text{excellent} \end{cases}$$

where K = Total effort in PM

L = product size in KLOC

t_d = time for software and integration testing

(Working environment) — C_k = state of technology constant that reflects the constraints that delay the progress of the programmer.

Putnam suggested that the optimal staff build it for a project should follow the rayleigh curve. Only a small no. of engineers are needed at the beginning of the project but as it progresses more detailed work is required but the number falls once the implementation & testing is done.

Effect of schedule change on cost

$$L = C_k * k^{1/3} * t_d^{4/3}$$

$$\Rightarrow L^3 = C_k^3 * k * t_d^4$$

$$\Rightarrow k = \frac{L^3}{C_k^3} * \frac{1}{t_d^4}$$

$$\Rightarrow K = \frac{C}{t_d^4} \quad \text{where} \quad C = \left(\frac{L}{C_k}\right)^3 \qquad \boxed{K \propto 1/t_d^4}$$

$$\frac{K_1}{K_2} = \frac{C_1/t_{d_1}^4}{C_2/t_{d_2}^4} \Rightarrow \frac{K_1}{K_2} = \frac{C_1}{C_2} * \left(\frac{t_{d_2}}{t_{d_1}}\right)^4$$

$$\Rightarrow \frac{K_1}{K_2} = C_3 * \left(\frac{t_{d_2}}{t_{d_1}}\right)^4 \quad \text{where } C_3 = \left(\frac{C_1}{C_2}\right)$$

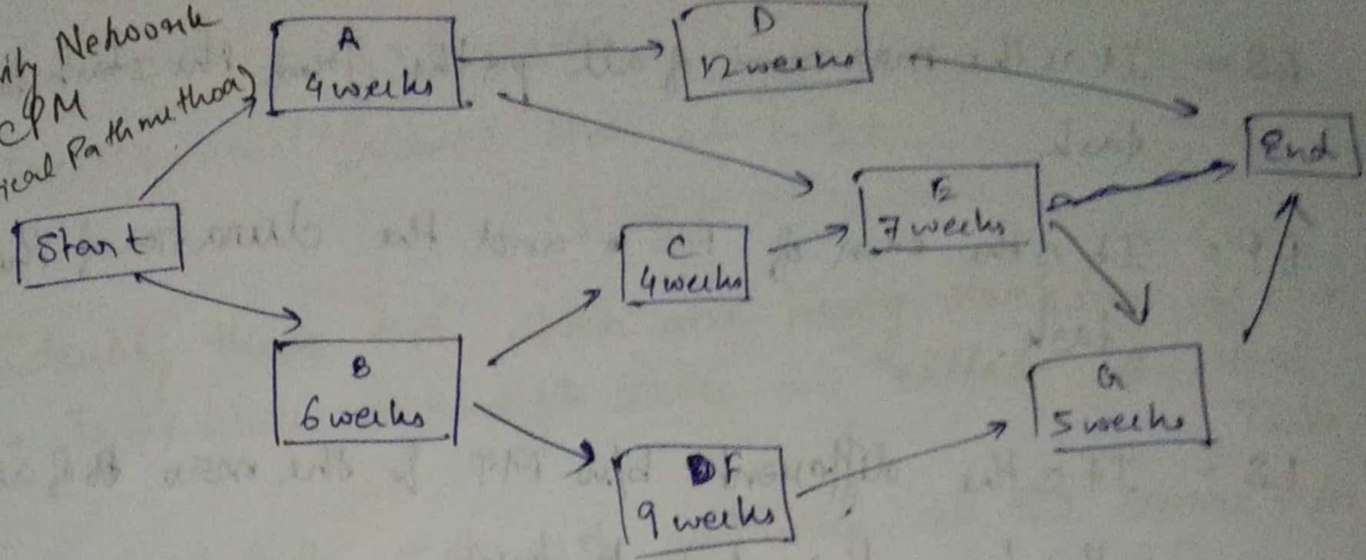
$$\boxed{\text{Cost} \propto \frac{1}{t_d^4}}$$

When the schedule is compressed ~~because~~ the required development effort as well as the project development cost increases in proportion to the 4^{th} power of the degree of compression.

Project Scheduling

1. Identify all tasks needed to complete the project.
2. Break down large tasks into smart activities.
3. Determine the dependency among different activities.
4. Establish the most likely estimates for the time durations necessary to compute the activities.
5. ~~Plan the~~ Allocate the resources to activities.
6. Plan the start and end dates for various activities.
7. Determine the critical path.

'Activity Network & CPM (Critical Path method)



Start → A → D → End 16 weeks

Start → ~~B~~A → E → G → End 16 weeks

Start → B → C → E → G → End 22 weeks (development time)

Start → B → F → G → End 20 weeks

MT = Minimum Time → minimum time to complete the projects is the max of all paths from start to end.

ES = Earliest Finish

EF = Earliest Start

LS = Latest Start

LF = Latest Finish

ST = Slack Time / Float

MT = 22 weeks

Task	ES	EF	LS	LF	ST
A	0 ~~weeks~~	4	6		
B	0 ~~weeks~~	6	0		
C	6 ~~weeks~~	10	6		
D	4	16	10		
E	10 (SBC)	17	10		
F	6	15	8		
G	17 (SBCE)	22	17		

ES = It is the maximum of all paths from the start to the task

EF = It is the sum of ES and the duration of the task.

LS = It is the different b/w MT & the max of all paths from this task to finish.

Activity networks

1. Precedessor & Successor of each task

2) Task duration

Task	ES	EF	LS	LF	ST
A	0	4	22-max{16,16} = 6	10	6
B	0	6	22-max{22,20} = 20	0	0
C	6	10	22-16 = 6	10	0
D	4	16	22-12 = 10	22	6
E	10	17	22-12 = 10	17	0
F	6	15	22-14 = 8	17	2
G	17	22	22-5 = 17	22	0

Latest Finish ⇒ LS + Duration

Slack Time = Difference b/w LF & EF

LF - EF

- Identify those task which are having slack time as Zero.
  - Tasks which are having ST=0 are called Critical Tasks.
  - Critical Path is the path containing all the critical tasks

- Slack Time is the total Time by which a task may be delayed before its effects the completion of the project.

- The slack time indicates the flexibility in starting & ending the task

- Critical tasks are tasks whose deadlines are to be met on the exact end date.

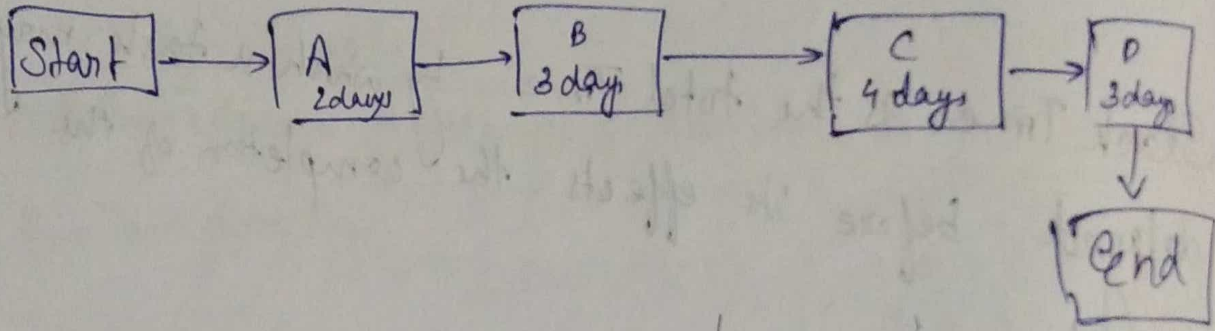
- Non-critical tasks are flexible.

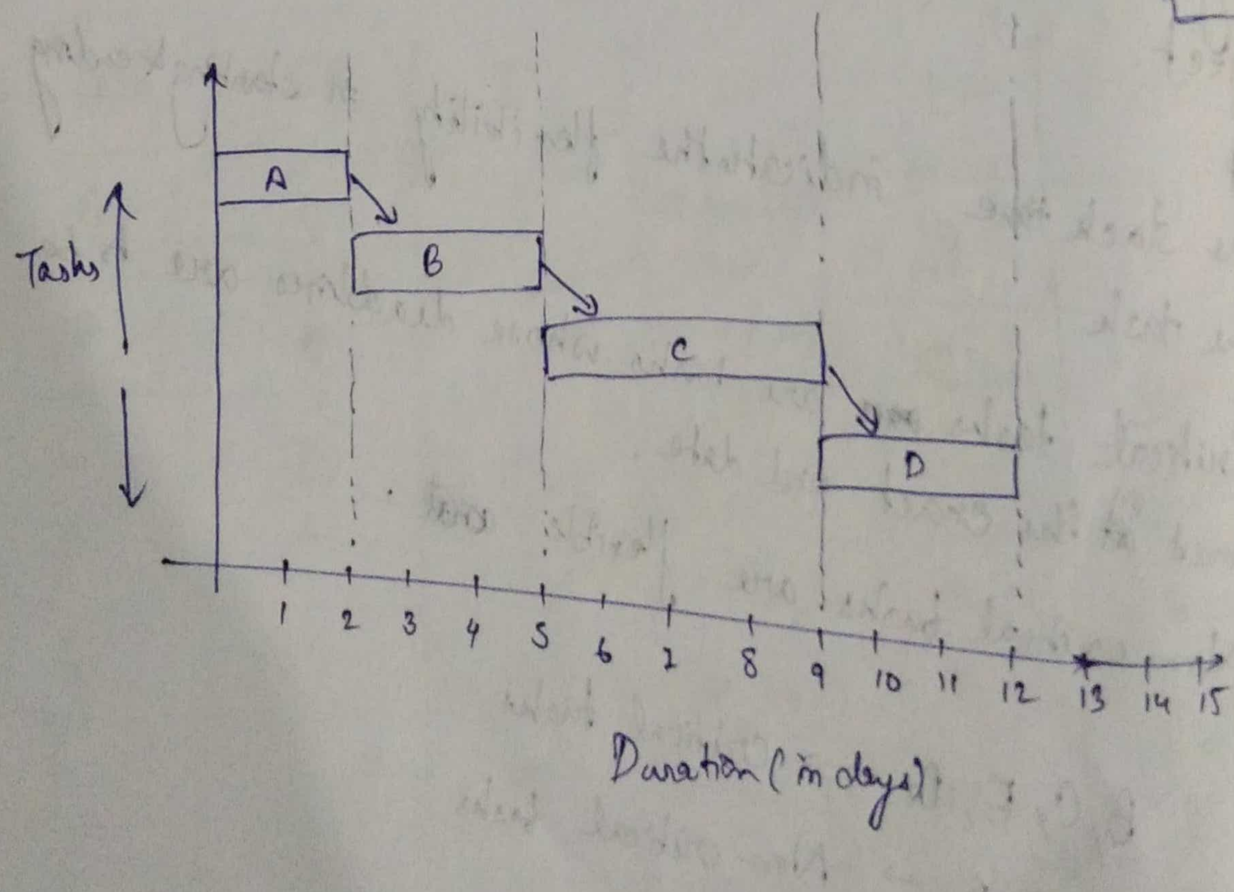
B, C, E, G → critical tasks

A, D, F → Non-critical tasks

Q)

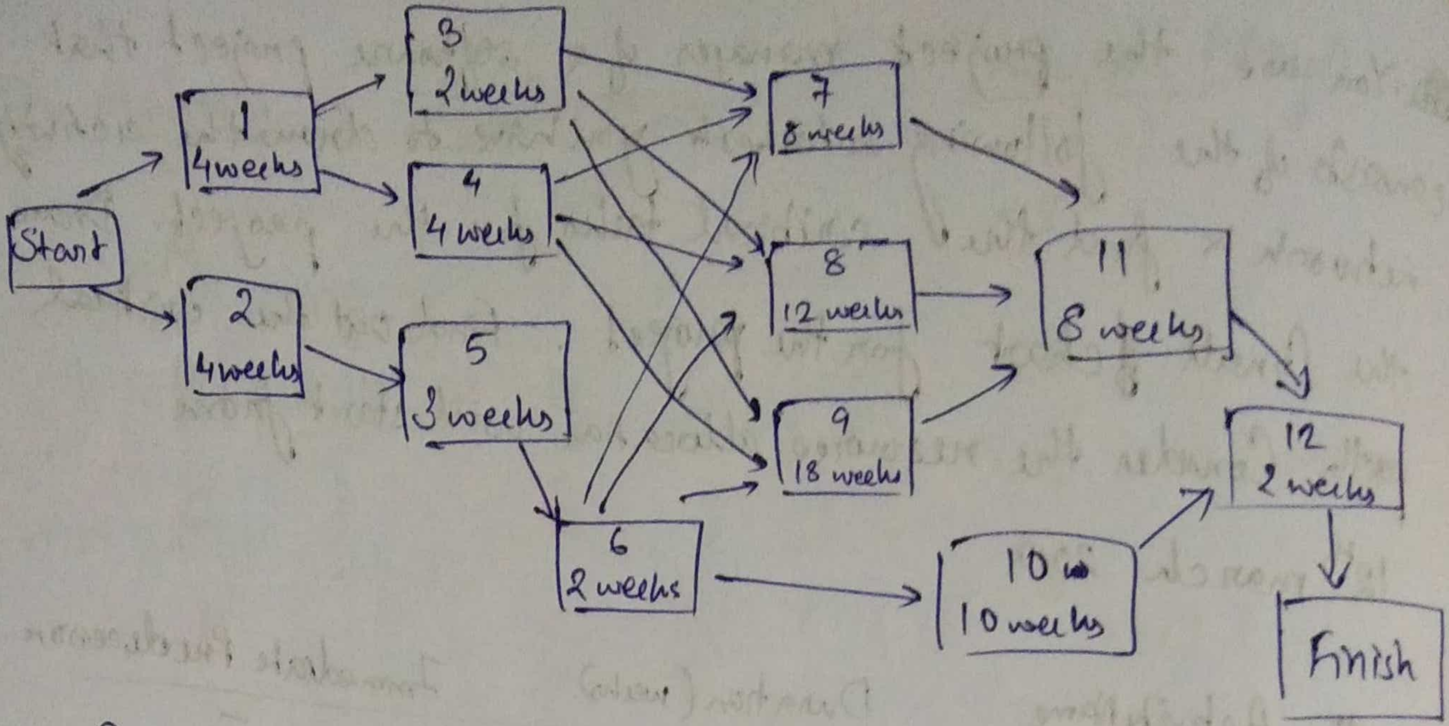
Activity	Predecessor	Duration (Days)
A	–	2
B	A	3
C	B	4
D	C	3





Q. You are the project manager of a software project that consists of the following activities & you have to draw the activity network & find the critical tasks for the project. Draw the Gnatt chart for the project. Find out the critical path. Consider the resource allocation will start from 12th march 2010.

Activity #	Activity Name	Duration (weeks)	Immediate Predecessor
1	Obtain Requirements	4	—
2	Analyze operations	4	1
3	Define subsystems	2	1
4	Develop database	4	2
5	Make decision analysis	3	5
6	Justify constraints	2	3,4,6
7	Build module 1	8	3,4,6
8	Build module 2	12	3,4,6
9	Build module 3	18	6
10	Write Report	10	7,8,9
11	Integration & Testing	8	10,11
12	Implementation	2	



Calculating MT

Start → 1 → 3 → 7 → 11 → 12 → Finish → 24 weeks
Start → 1 → 3 → 8 → 11 → 12 → Finish → 28 weeks
Start → 1 → 3 → 9 → 11 → 12 → Finish → 34 weeks
Start → 1 → 4 → 7 → 11 → 12 → Finish → 26 weeks
Start → 1 → 4 → 8 → 11 → 12 → Finish → 30 weeks
Start → 1 → 4 → 9 → 11 → 12 → Finish → 36 weeks
Start → 2 → 5 → 6 → 7 → 11 → 12 → Finish → 27 weeks
Start → 2 → 5 → 6 → 8 → 11 → 12 → Finish → 31 weeks
Start → 2 → 5 → 6 → 9 → 11 → 12 → Finish → 37 weeks
Start → 2 → 5 → 6 → 10 → 12 → Finish → 21 weeks

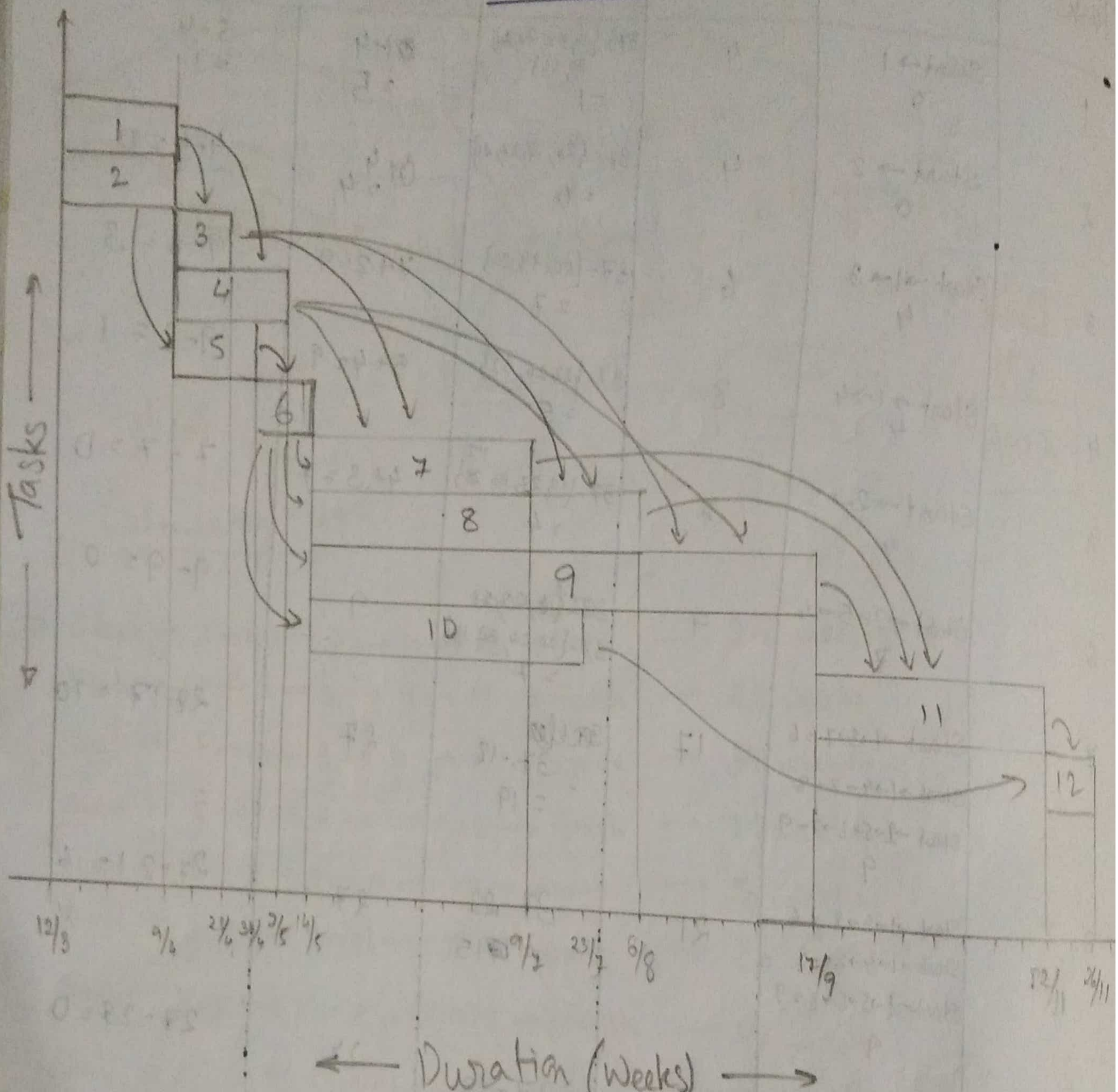
MT = 37 weeks

Critical Tasks - 2, 5, 6, 9, 11, 12

Critical Path - Start → 2 → 5 → 6 → 9 → 11 → 12 → Finish

Task	ES	EF	LS	LF	ST
1	Start → 1 0	4	37 - {24, 28, 34, 26, 30, 36} = 1	1+4 = 5	5 - 4 = 1
2	Start → 2 0	4	37 - {27, 31, 33, 29} = 0	0+4 = 4	4 - 4 = 0
3	Start → 1 → 3 4	6	37 - {20, 24, 30} = 7	7+2 = 9	9 - 6 = 3
4	Start → 1 → 4 4	8	37 - {23, 26, 32} = 5	5+4 = 9	9 - 8 = 1
5	Start → 2 → 5 4	7	37 - {23, 27, 30, 17} = 4	4+3 = 7	7 - 7 = 0
6	Start → 2 → 5 → 6 7	9	37 - {21, 24, 30, 14} = 7	9	9 - 9 = 0
7	Start → 1 → 3 → 7 = 6 Start → 1 → 4 → 7 = 8 Start → 2 → 5 → 6 → 7 = 9 9	17	37 - 18 = 19	27	27 - 17 = 10
8	Start → 1 → 3 → 8 = 6 Start → 1 → 4 → 8 = 8 Start → 2 → 5 → 6 → 8 = 9 9	21	37 - 22 = 15	27	27 - 21 = 6
9	Start → 1 → 3 → 9 = 6 Start → 1 → 4 → 9 = 8 Start → 2 → 5 → 6 → 9 = 9 9	27	37 - 28 = 9	27	27 - 27 = 0
10	Start → 2 → 5 → 6 → 10 9	19	37 - 12 = 25	35	35 - 19 = 16
11	Start → 2 → 5 → 6 → 7 → 11 = 17 Start → 2 → 5 → 6 → 8 → 11 = 21 Start → 2 → 5 → 6 → 9 → 11 = 27 27	35	37 - 10 = 27	35	35 - 35 = 0
12	Start → 2 → 5 → 6 → 9 → 11 → 12 35	37	37 - 2 = 35	37	37 - 37 = 0

Gnatt Chart



Tasks
1
2
3
4
5
6
7
8
9
10
11
12
12/3
9/4
21/4
30/4
7/5
14/5
9/7
23/7
6/8
17/9
12/11
26/11
Duration (Weeks)