# Lecture 18 – Project Scheduling

Karl R. Wilcox
K.R.Wilcox@reading.ac.uk

# Objectives

- To move on from task estimates to “nominal” project duration
- To add in “reality” in the form of resource calendars
- To understand resource levelling and schedule adjustment options

# Our Project Now Has:

- A Documented and signed off Statement Of Work (SOW)
- A task list or work breakdown structure
- A network diagram showing task precedence
- Next stage:
  - Task effort estimates

# Task Estimates

- We need estimates of the effort required for each of the tasks in the list / WBS
- Estimation was covered last year
  - Will not be covered (or examined!) this year
- At this stage also indicate who / what resources are required on each task
  - Sometimes named individuals
  - Sometimes by role
- This will give us the task duration

# Scheduling Vs Planning

- Everything so far has been about Project Planning
  - What needs to be done?
  - How will it be done?
  - Who will do it?
  - Where it will be done?
  - Why will it be done?

- With the information we now have we can start Project Scheduling
  - When will it be done?

# Review

- We have completed the following steps:

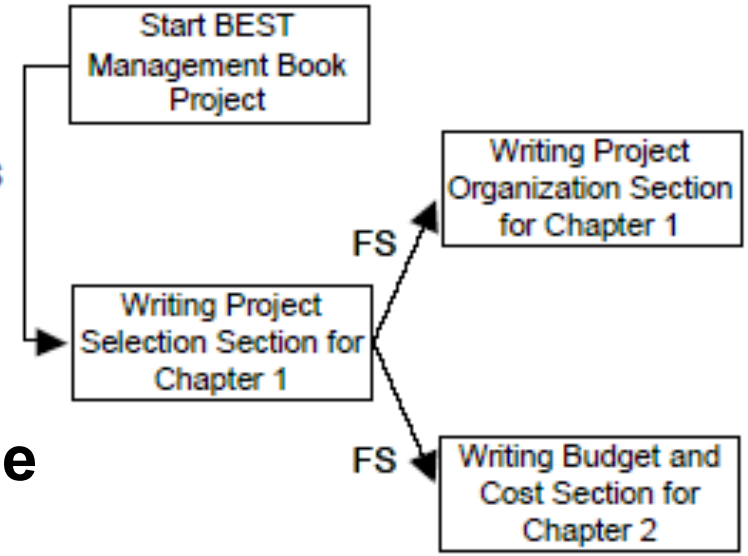
1. Developing the list of project activities
2. Sequencing the list of project activities
3. Determining the relationship between each activity
4. Establishing the duration for each activity

# Project Duration

- We now need to determine the project duration
  - i.e. Start calendar time to finish calendar time
- The process will also tell us
  - The critical path
  - The float available for each task
- Process involves a forward pass & a backward pass
  - Usually automated by project planning tool

# The Forward Pass

- **The Forward Pass calculates the earliest date that each activity can start and finish according to the logical sequence of work and the duration of each activity.**
- **The Forward Pass gives us the project duration.**




| WBS | Activity | Duration | ES | EF | LS | LF |
|---|---|---|---|---|---|---|
| 1.1 | Start Development of Project Management Book | 0 wks | 1/1 | 1/1 | | |
| 1.1.1.1.1 | Writing Project Selection section for Chapter 1 | 8 wks | 1/1 | 2/25 | | |
| 1.1.1.1.2 | Writing Project Organization section for Chapter 1 | 10 wks | 2/26 | 5/6 | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

# Project End Date

- **Completing the forward pass provides the end date**

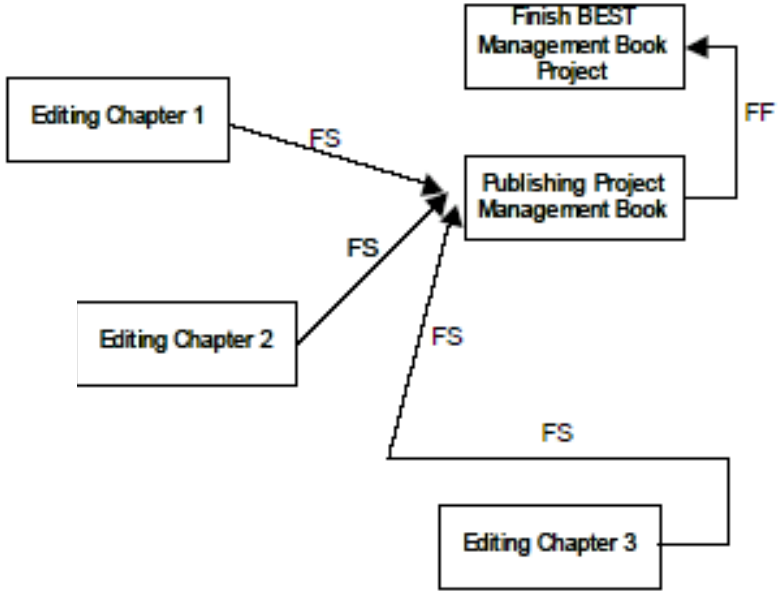
| WBS | Activity | Duration | ES | EF | LS | LF |
|---|---|---|---|---|---|---|
| 1.1 | Start Development of Project Management Book | 0 wks | 1/1 | 1/1 | | |
| 1.1.1.1.1 | Writing Project Selection section for Chapter 1 | 8 wks | 1/1 | 2/25 | | |
| 1.1.1.1.2 | Writing Project Organization section for Chapter 1 | 10 wks | 2/26 | 5/6 | | |
| 1.1.1.2.1 | Writing Budget and Cost section for Chapter 2 | 9 wks | 2/26 | 4/29 | | |
| 1.1.1.1.3 | Writing Project Planning section for Chapter 1 | 9 wks | 5/7 | 7/8 | | |
| 1.1.1.2.2 | Writing Scheduling section for Chapter 2 | 5 wks | 4/30 | 6/3 | | |
| 1.1.1.2.3 | Writing Project Controls section for Chapter 2 | 7 wks | 6/4 | 7/22 | | |
| 1.1.1.3.1. | Writing Auditing section for Chapter 3 | 2 wks | 7/23 | 8/5 | | |
| 1.1.1.3.2 | Writing Administrative Closeout section for Chapter 3 | 1 wk | 8/6 | 8/12 | | |
| 1.1.2.1 | Editing Chapter 1 | 8 wks | 7/9 | 9/2 | | |
| 1.1.2.2 | Editing Chapter 2 | 8 wks | 7/23 | 9/16 | | |
| 1.1.2.3 | Editing Chapter 3 | 4 wks | 8/13 | 9/9 | | |
| 1.1.3 | Publishing Project Management Book | 4 wks | 9/17 | 10/14 | | |
| 1.1 | Finish Development of the Project Management Book | 0 wks | 10/14 | 10/14 | | |

- **Total duration 41 weeks**

# The Backward Pass

- The Backward Pass calculates the latest date that each activity can start and finish in order to meet the project end date
- Start at the bottom of the chart with the last activity and work backwards
- With the end date fixed, determine the latest end date and hence the latest start date

# Backward Pass Example




| WBS | Activity | | | | | |
|---|---|---|---|---|---|---|
| 1.1 | Start Development of Project Management Book | | | | | |
| 1.1.1.1.1 | Writing Project Selection section for Chapter 1 | | | | | |
| 1.1.1.1.2 | Writing Project Organization section for Chapter 1 | | | | | |
| 1.1.1.2.1 | Writing Budget and Cost section for Chapter 2 | | | | | |
| 1.1.1.1.3 | Writing Project Planning section for Chapter 1 | | | | | |
| 1.1.1.2.2 | Writing Scheduling section for Chapter 2 | 5 wks | 4/30 | 6/3 | | |
| 1.1.1.2.3 | Writing Project Controls section for Chapter 2 | 7 wks | 6/4 | 7/22 | | |
| 1.1.1.3.1. | Writing Auditing section for Chapter 3 | 2 wks | 7/23 | 8/5 | | |
| 1.1.1.3.2 | Writing Administrative Closeout section for Chapter 3 | 1 wk | 8/6 | 8/12 | | |
| 1.1.2.1 | Editing Chapter 1 | 8 wks | 7/9 | 9/2 | 7/23 | 9/16 |
| 1.1.2.2 | Editing Chapter 2 | 8 wks | 7/23 | 9/16 | 7/23 | 9/16 |
| 1.1.2.3 | Editing Chapter 3 | 4 wks | 8/13 | 9/9 | 8/20 | 9/16 |
| 1.1.3 | Publishing Project Management Book | 4 wks | 9/17 | 10/14 | 9/17 | 10/14 |
| 1.1 | Finish Development of the Project Management Book | 0 wks | 10/14 | 10/14 | 10/14 | 10/14 |

# Completed Activity List

| WBS | Activity | Duration | ES | EF | LS | LF |
|---|---|---|---|---|---|---|
| 1.1 | Start Development of Project Management Book | 0 wks | 1/1 | 1/1 | 1/1 | 1/1 |
| 1.1.1.1.1 | Writing Project Selection section for Chapter 1 | 8 wks | 1/1 | 2/25 | 1/1 | 2/25 |
| 1.1.1.1.2 | Writing Project Organization section for Chapter 1 | 10 wks | 2/26 | 5/6 | 3/12 | 5/20 |
| 1.1.1.2.1 | Writing Budget and Cost section for Chapter 2 | 9 wks | 2/26 | 4/29 | 2/26 | 4/29 |
| 1.1.1.1.3 | Writing Project Planning section for Chapter 1 | 9 wks | 5/7 | 7/8 | 5/21 | 7/22 |
| 1.1.1.2.2 | Writing Scheduling section for Chapter 2 | 5 wks | 4/30 | 6/3 | 4/30 | 6/3 |
| 1.1.1.2.3 | Writing Project Controls section for Chapter 2 | 7 wks | 6/4 | 7/22 | 6/4 | 7/22 |
| 1.1.1.3.1. | Writing Auditing section for Chapter 3 | 2 wks | 7/23 | 8/5 | 7/30 | 8/12 |
| 1.1.1.3.2 | Writing Administrative Closeout section for Chapter 3 | 1 wk | 8/6 | 8/12 | 8/13 | 8/19 |
| 1.1.2.1 | Editing Chapter 1 | 8 wks | 7/9 | 9/2 | 7/23 | 9/16 |
| 1.1.2.2 | Editing Chapter 2 | 8 wks | 7/23 | 9/16 | 7/23 | 9/16 |
| 1.1.2.3 | Editing Chapter 3 | 4 wks | 8/13 | 9/9 | 8/20 | 9/16 |
| 1.1.3 | Publishing Project Management Book | 4 wks | 9/17 | 10/14 | 9/17 | 10/14 |
| 1.1 | Finish Development of the Project Management Book | 0 wks | 10/14 | 10/14 | 10/14 | 10/14 |

# The Critical Path

- The Critical Path tells you the activities that cannot slip a day without increasing the total duration of the project or moving the project completion date
- The critical path is the longest path of logically related activities through the network which cannot slip without impacting the total project duration
- Tasks are on the critical path if the Latest Finish is the same as the Earliest Finish

# Critical Path Example

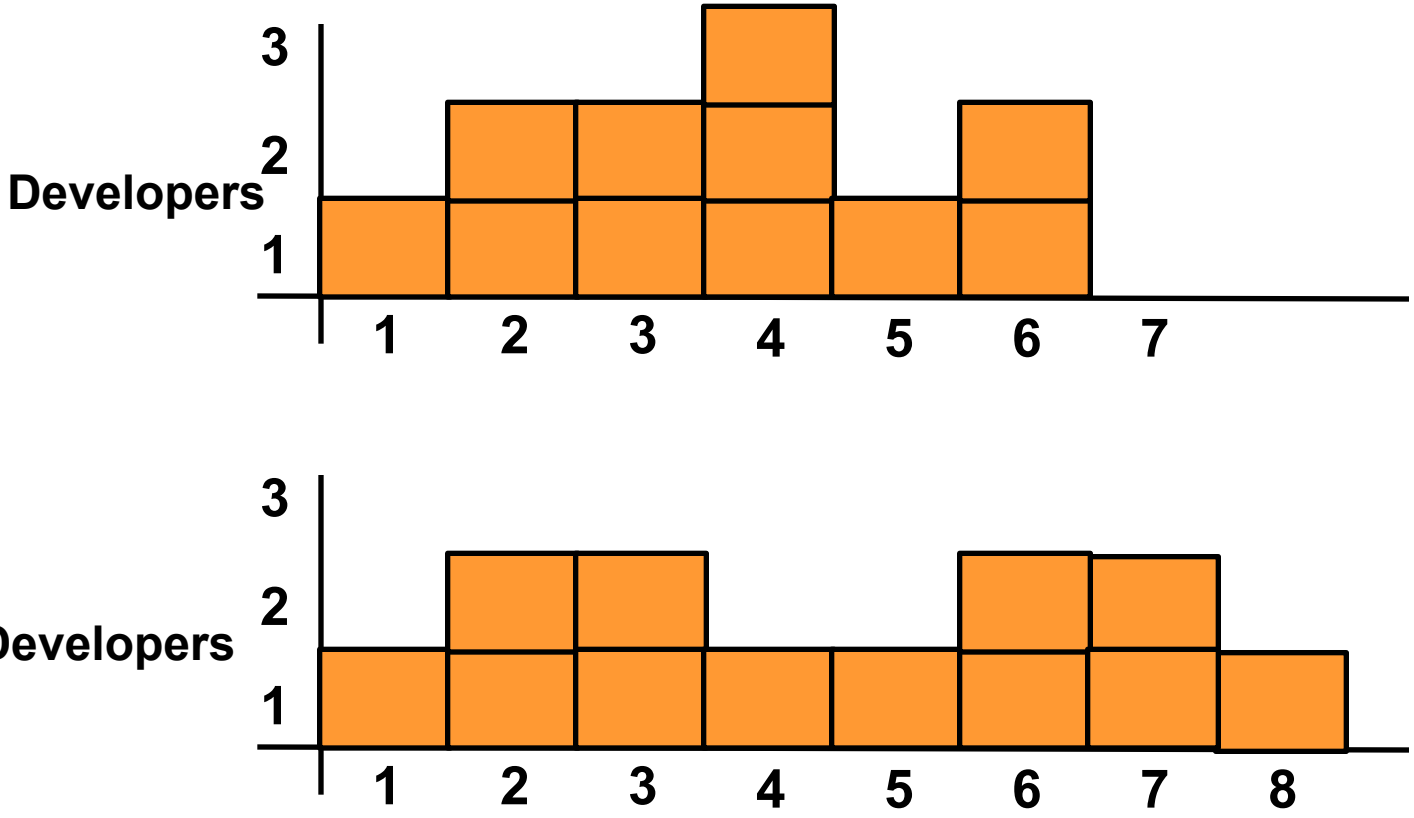
| WBS | Activity | Duration | ES | EF | LS | LF | Float |
|---|---|---|---|---|---|---|---|
| 1.1 | Start Development of Project Management Book | 0 wks | 1/1 | 1/1 | 1/1 | 1/1 | 0 |
| 1.1.1.1.1 | Writing Project Selection section for Chapter 1 | 8 wks | 1/1 | 2/25 | 1/1 | 2/25 | 0 |
| 1.1.1.1.2 | Writing Project Organization section for Chapter 1 | 10 wks | 2/26 | 5/6 | 3/12 | 5/20 | 14 |
| 1.1.1.2.1 | Writing Budget and Cost section for Chapter 2 | 9 wks | 2/26 | 4/29 | 2/26 | 4/29 | 0 |
| 1.1.1.1.3 | Writing Project Planning section for Chapter 1 | 9 wks | 5/7 | 7/8 | 5/21 | 7/22 | 14 |
| 1.1.1.2.2 | Writing Scheduling section for Chapter 2 | 5 wks | 4/30 | 6/3 | 4/30 | 6/3 | 0 |
| 1.1.1.2.3 | Writing Project Controls section for Chapter 2 | 7 wks | 6/4 | 7/22 | 6/4 | 7/22 | 0 |
| 1.1.1.3.1. | Writing Auditing section for Chapter 3 | 2 wks | 7/23 | 8/5 | 7/30 | 8/12 | 7 |
| 1.1.1.3.2 | Writing Administrative Closeout section for Chapter 3 | 1 wk | 8/6 | 8/12 | 8/13 | 8/19 | 7 |
| 1.1.2.1 | Editing Chapter 1 | 8 wks | 7/9 | 9/2 | 7/23 | 9/16 | 14 |
| 1.1.2.2 | Editing Chapter 2 | 8 wks | 7/23 | 9/16 | 7/23 | 9/16 | 0 |
| 1.1.2.3 | Editing Chapter 3 | 4 wks | 8/13 | 9/9 | 8/20 | 9/16 | 7 |
| 1.1.3 | Publishing Project Management Book | 4 wks | 9/17 | 10/14 | 9/17 | 10/14 | 0 |
| 1.1 | Finish Development of the Project Management Book | 0 wks | 10/14 | 10/14 | 10/14 | 10/14 | 0 |

- **We calculate Latest Finish – Earliest Finish for each task**
- **Result is the Float**
  - **If float = 0, task is on critical Path**

# Resource Constraints

- All scheduling activity to date has assumed that resources are available when required
- This may not be the case due to
  - Commitments to other projects
  - Leave, training or other non-project activities
  - The resource may be over-committed
- We need to examine the loading on each resource
  - Typically by using a resource histogram
  - Generated by the project planning tool

# Resource Histograms



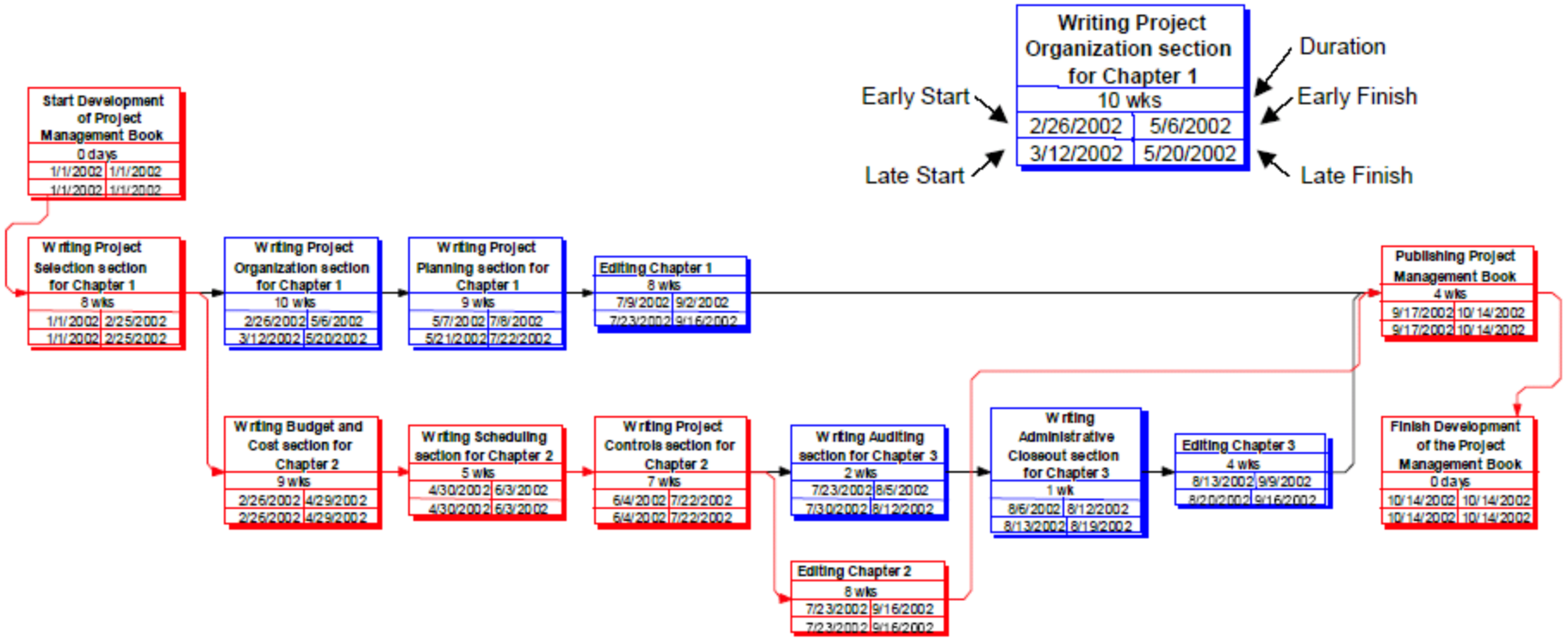
# Options for Resource Levelling

- Move the task within its float
- Obtain additional (or different?) resources
- Reduce the scope of the project
  - Will require re-planning
- Negotiate a change of end date
  - May change the critical path
- Use your imagination!

# Schedule Representations

- The final schedule can be represented in several ways
  - As a table (as on previous pages)
  - As a PERT Chart
  - As a Gantt Chart
  - It is possible to combine some PERT information on a Gantt chart

# The PERT Chart

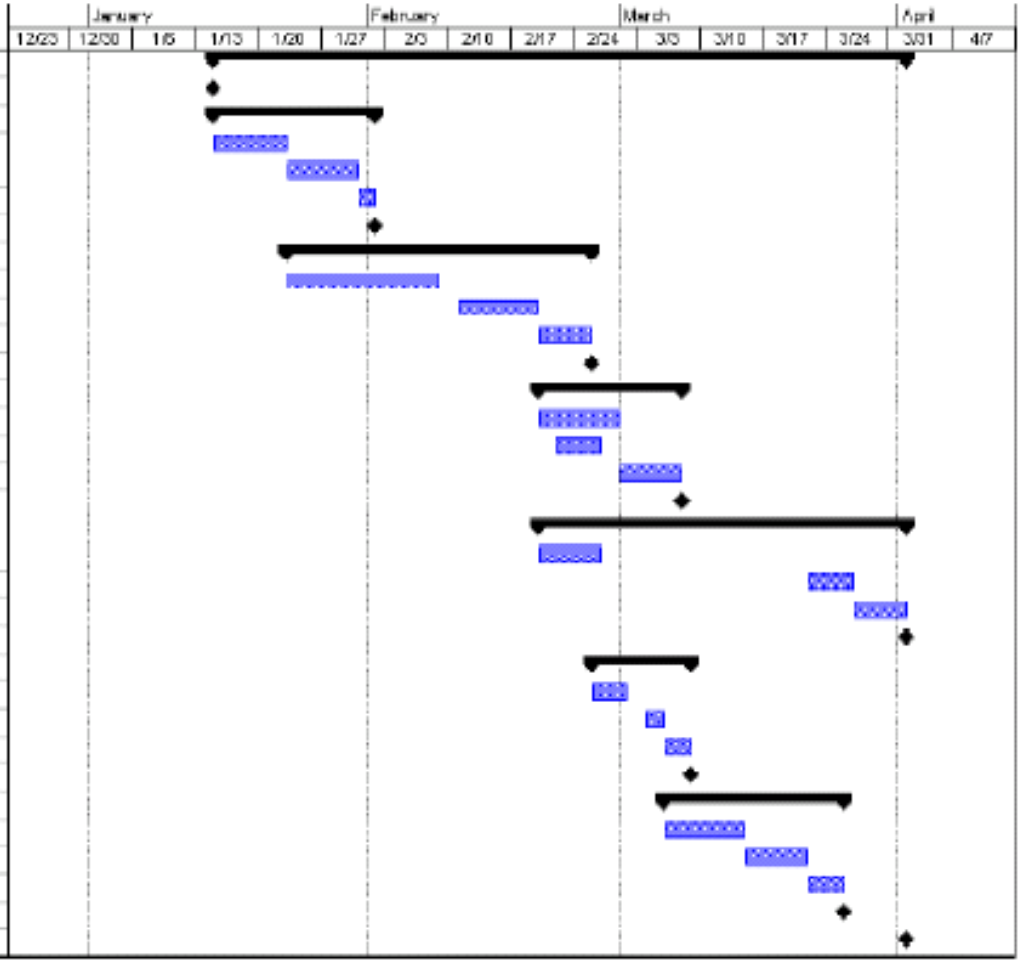


# GANNT Charts

- Show activities along a timeline / calendar
- Clearly shows parallel tasks
- Can be used to show progress
  - Bar “internal” to a task bar
- Can be used to show “float”
  - “T bar” lines outside task bar
- Can be used to show precedence
  - Arrows between task bars
- Can be used to show allocated resource
  - In additional columns

# Example Gantt Chart

| ID | Task Name | Duration | Start | Finish |
|---|---|---|---|---|
| 1 | **1 House** | **55 days** | **1/15/02** | **4/1/02** |
| 2 | 1.1 Start House Construction | 0 days | 1/15/02 | 1/15/02 |
| 3 | **1.1.1 Concrete** | **14 days** | **1/15/02** | **2/1/02** |
| 4 | 1.1.1.1 Pour foundation | 6 days | 1/15/02 | 1/22/02 |
| 5 | 1.1.1.2 Install Patio | 6 days | 1/23/02 | 1/30/02 |
| 6 | 1.1.1.3 Pour stairway | 2 days | 1/31/02 | 2/1/02 |
| 7 | 1.1.1 Concrete Complete | 0 days | 2/1/02 | 2/1/02 |
| 8 | **1.1.2 Framing** | **21 days** | **1/23/02** | **2/25/02** |
| 9 | 1.1.2.1 Frame exterior walls | 13 days | 1/23/02 | 2/8/02 |
| 10 | 1.1.2.2 Frame interior walls | 7 days | 2/11/02 | 2/19/02 |
| 11 | 1.1.2.3 Install roofing trusse | 4 days | 2/20/02 | 2/25/02 |
| 12 | 1.1.2 Framing Complete | 0 days | 2/25/02 | 2/25/02 |
| 13 | **1.1.3 Plumbing** | **12 days** | **2/20/02** | **3/7/02** |
| 14 | 1.1.3.1 Install water lines | 7 days | 2/20/02 | 2/28/02 |
| 15 | 1.1.3.2 Install gas lines | 3 days | 2/22/02 | 2/26/02 |
| 16 | 1.1.3.3 Install DW fixtures | 5 days | 3/1/02 | 3/7/02 |
| 17 | 1.1.3 Plumbing Complete | 0 days | 3/7/02 | 3/7/02 |
| 18 | **1.1.4 Electrical** | **29 days** | **2/20/02** | **4/1/02** |
| 19 | 1.1.4.1 Install wiring | 5 days | 2/20/02 | 2/26/02 |
| 20 | 1.1.4.2 Install outlets/switches | 3 days | 3/22/02 | 3/26/02 |
| 21 | 1.1.4.3 Install fixtures | 4 days | 3/27/02 | 4/1/02 |
| 22 | 1.1.4 Electrical Complete | 0 days | 4/1/02 | 4/1/02 |
| 28 | **1.1.6 Roofing** | **9 days** | **2/26/02** | **3/8/02** |
| 29 | 1.1.6.1 Install felt | 4 days | 2/26/02 | 3/1/02 |
| 30 | 1.1.6.2 Install shingles | 2 days | 3/4/02 | 3/5/02 |
| 31 | 1.1.6.3 Install vents | 3 days | 3/6/02 | 3/8/02 |
| 32 | 1.1.6 Roofing Complete | 0 days | 3/8/02 | 3/8/02 |
| 23 | **1.1.5 Interior** | **14 days** | **3/6/02** | **3/25/02** |
| 24 | 1.1.5.1 Install drywall | 7 days | 3/6/02 | 3/14/02 |
| 25 | 1.1.5.3 Painting | 5 days | 3/15/02 | 3/21/02 |
| 26 | 1.1.5.2 Install Carpeting | 2 days | 3/22/02 | 3/25/02 |
| 27 | 1.1.5.4 Interior Complete | 0 days | 3/25/02 | 3/25/02 |
| 33 | 1.1 House Complete | 0 days | 4/1/02 | 4/1/02 |



# Key points

- Need effort + resource estimates for each task
  - To give duration
- Task durations + precedence
  - Provides project duration
- Forward & backward scheduling passes
  - Provide float & critical path
- May need to make further adjustments
  - To take account of resource constraints