Unit 3 Effective Project Planning

Learning Outcomes

By the end of this unit the learner will be able to:

- ✓ Calculate the critical path of a project
- ✓ Use the Program Evaluation and Review Technique (PERT) to create estimates
- ✓ Plan for risks
- ✓ Create a communication plan

Unit 3

Effective Project Planning

Network Diagrams

Types of Network Diagrams

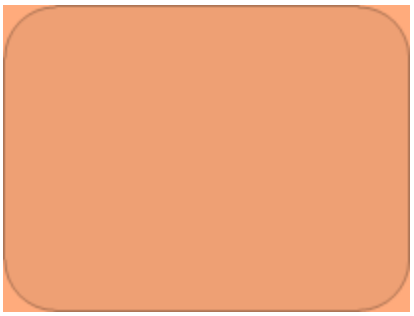
Network diagrams are drawings that display activities, their associated precedence relationships, and the order (series or parallel) in which the tasks can be completed. The precedence relationships are illustrated by the use of nodes and arrows.

There are two different kinds of network diagrams: activity on node (AoN) and activity on arrow (AoA).

About Activity on Node Diagrams

Activity on Node diagrams place the importance on the tasks by displaying the activity on the node. Tasks are represented by boxes while the arrows show the task dependency. With the AoN diagram, the node is used to house information about the task.

A rounded edge rectangle shows the start and end points of the diagram. This represents time zero.



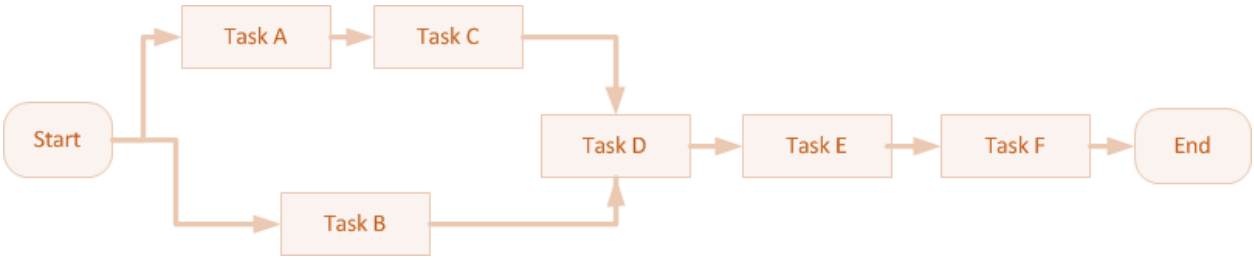
A rectangle represents the activities.

A solid arrow shows precedence between tasks.

Sample Activity on Node Diagram
The table below describes activities and task relationships for a project.

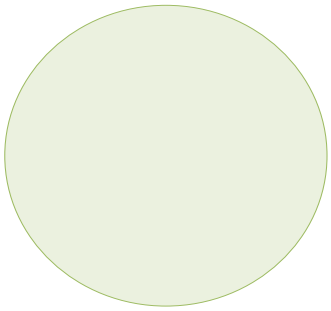
Activity	Predecessor
A	None
B	None
C	A
D	B, C
E	D
F	D, E

Below is the network diagram for the above table.



About Activity on Arrow Diagrams
Activity on arrow diagrams place importance on milestones. When constructing an activity on arrow diagram, all tasks lead to nodes (milestones). The tail of an arrow is the start of the activity, and the head of the arrow is the completion of the activity. Tasks are written on top of or below the solid arrows. At the start node of AoA diagrams, the time is always zero.

A circle represents a node (milestone) and is used to show the connection between activities. The starting node is always time zero.



A solid arrow represents an activity.

A dashed arrow represents a dummy activity. Dummy activities are used to show precedence relationships and have a duration of zero (0). Dummy activities are only used in AoA diagrams.

In AoA diagrams the nodes are typically numbered, but this number does not indicate precedence or duration. Activities are usually written as a letter, such as A, B, or C, because there is limited space available above/below the arrows for each written task description.

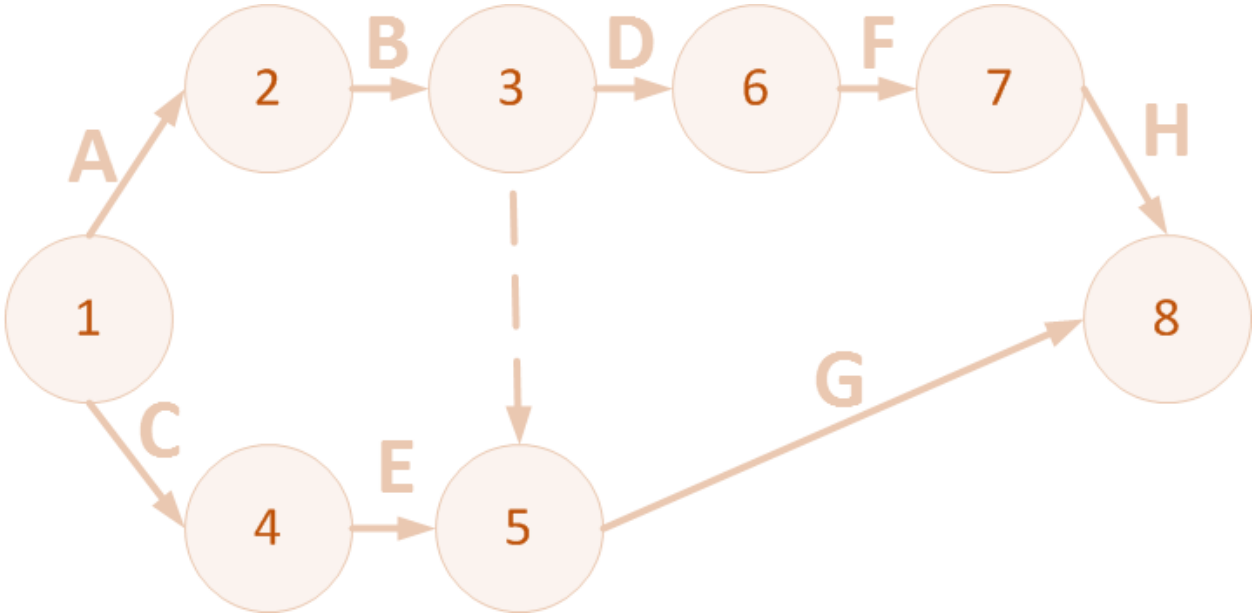
Sample Activity on Arrow Diagram

The table below describes activities and task relationships for another example project.

Activity	Predecessor
A	None
B	A
C	None
D	B
E	C
F	D

G	B, E
H	F

Below is the network diagram for the above table.



Critical Path Method

What is the Critical Path Method?

The term “critical path” is very important in the world of project management. A critical path identifies the total duration of a project and identifies the tasks that must be completed, in order and on time, to complete the project on schedule.

CPM is a systematic approach to finding the critical path of a project. It uses the work breakdown structure to create network diagrams and is calculated by examining task relationships, activity durations, and activities.

An activity is said to be on the critical path if there is no slack to push the activity date out without affecting the overall duration of the project. Slack is the amount of time an activity can be delayed before the overall duration of the project is delayed.

Once a project is represented by a network diagram, the critical path can be found. For smaller projects, you will sometimes be able to quickly identify the critical path from the network diagram. However, for

larger projects it would be impossible to determine the critical path by looking at the network diagram. Once you have activities, task relationships, and time estimates, you are ready to create your CPM network diagram.

Sample Project

We will now walk through an example using the critical path method and the project listed below.

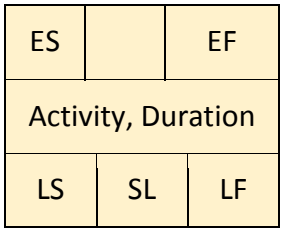
- A and B are performed concurrently at the start of the project
- C can begin on the completion of A
- F is completed in parallel to D, upon B's completion
- D follows B
- C precedes E
- G can begin when D and F are complete, and marks the end of the project

The estimates for the activity durations are as follows.

- A: 8 days
- B: 20 days
- C: 18 days
- D: 23 days
- E: 9 days
- F: 10 days
- G: 4 days

Creating a Network Diagram

When creating network diagrams to perform CPM, you must include more detail at the node level. Below is a sample CPM node that shows the layout and description for each required field.



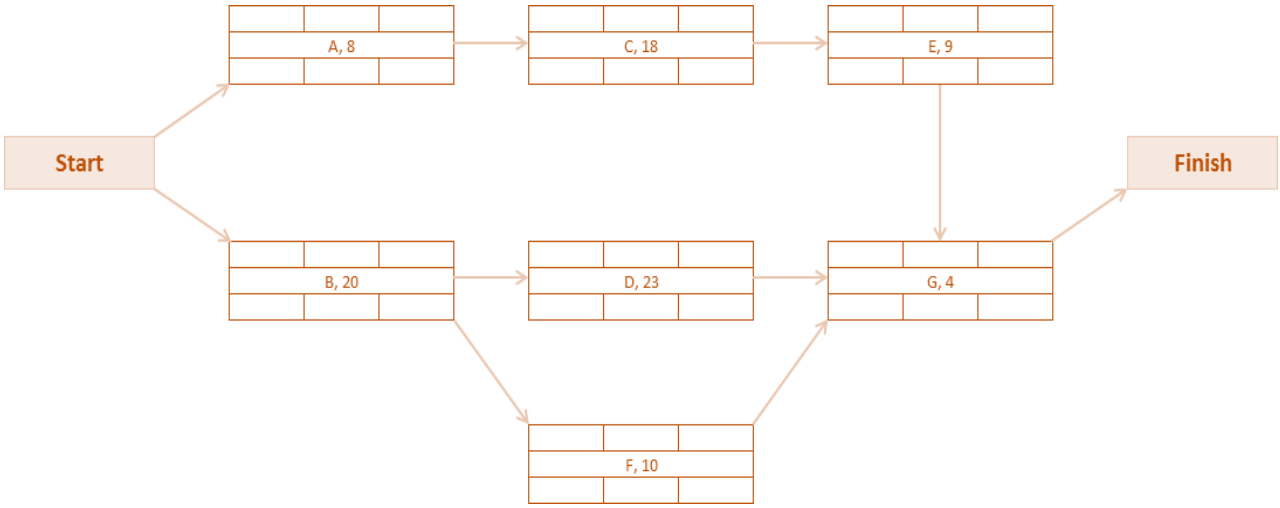
Where:

- ES = Earliest Start, the earliest time that this activity will begin
- EF = Earliest Finish, the earliest point at which this activity will end
- LS = Latest Start, the latest time that this activity will begin

- LF = Latest Finish, the latest point at which this activity will end
- SL = Slack, the amount of delay available for an activity

Starting Network Diagram

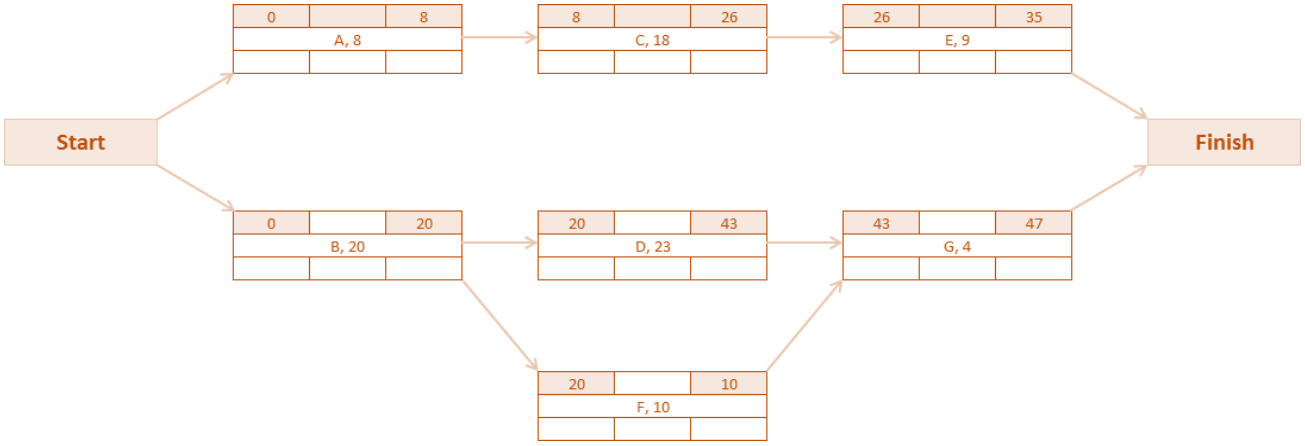
Here is the network diagram for the project listed above. As you can see, all precedence relationships have been identified, and the activities and durations are labeled.



Perform Forward Pass through Network

The forward pass through the network provides details on the earliest start and finish times for each activity. Start with the first activity (or activities) and step through each activity on each path of the network. The start node is always time zero. Successive tasks begin as soon as their predecessor(s) are complete. If two or more arrows enter one node, you must use the highest completion time for the previous task. This means that if one task finishes at 12 days and the other at 17 days, you would use 17 days as the starting point in the next node.

Now we'll step through the forward pass. An updated network diagram is below and depicts the results of the forward pass.



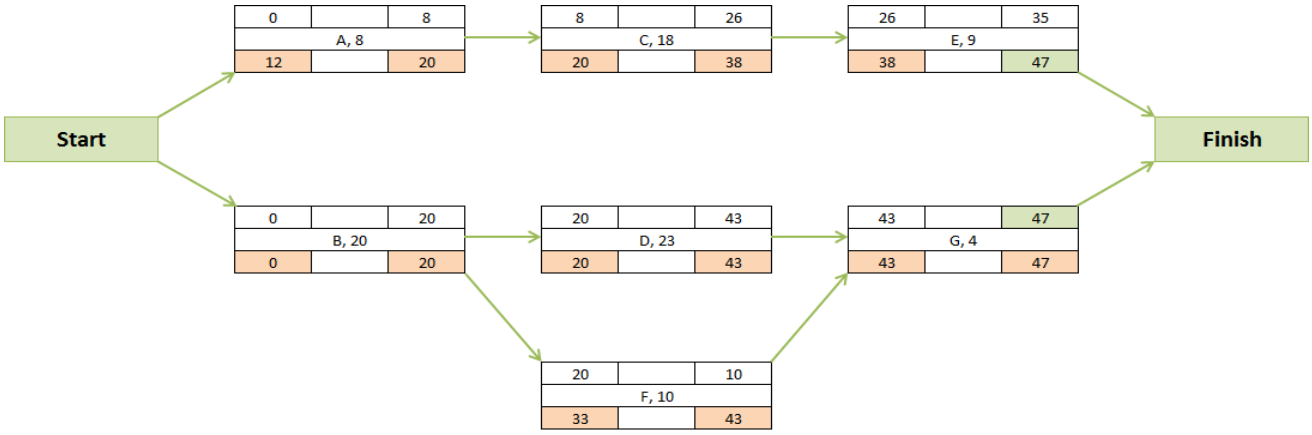
The total duration of the project will be 47 days – the longer of the last two tasks.

Perform Backward Pass through Network

The backward pass through the network provides details on the latest start and latest finish times for each activity. The backward pass method through the network is identical to the forward pass, except instead of working from the front to the back through the diagram, you will now work from the back to the front.

The ending point (latest finish) for the backward pass is the earliest finish time of the final activity, G in our example, which was 47 days. The latest finish time for an activity is the latest start time of its successor. If two arrows lead to one activity, the latest finish for that task is the smaller of the latest start times of each successor.

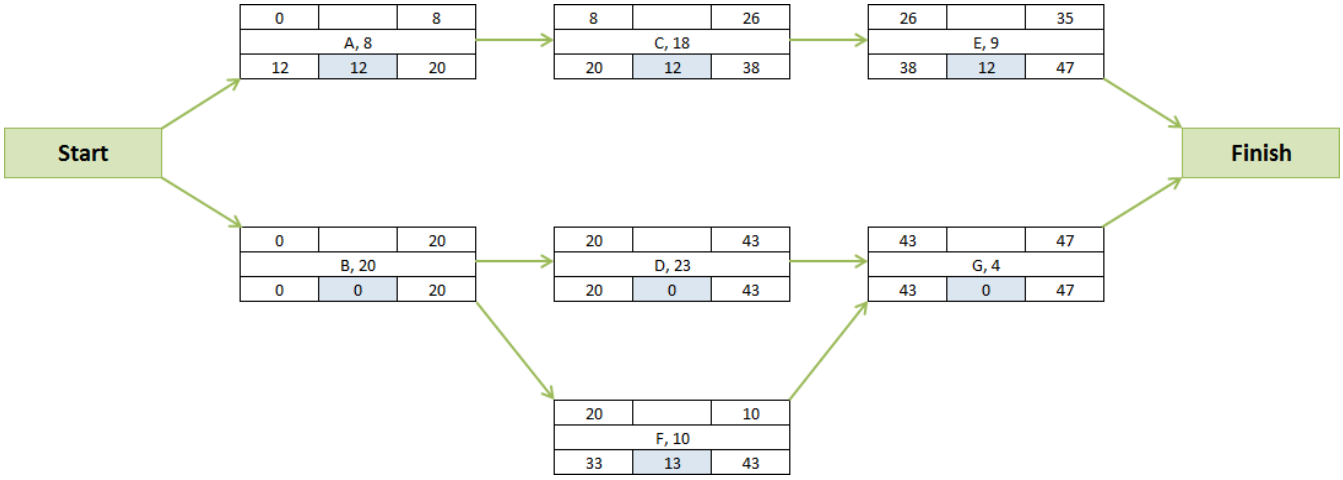
The earliest finish for our example at activity G is 47. Plug the number 47 in for the latest finish time and begin the backward pass.



Determine Slack

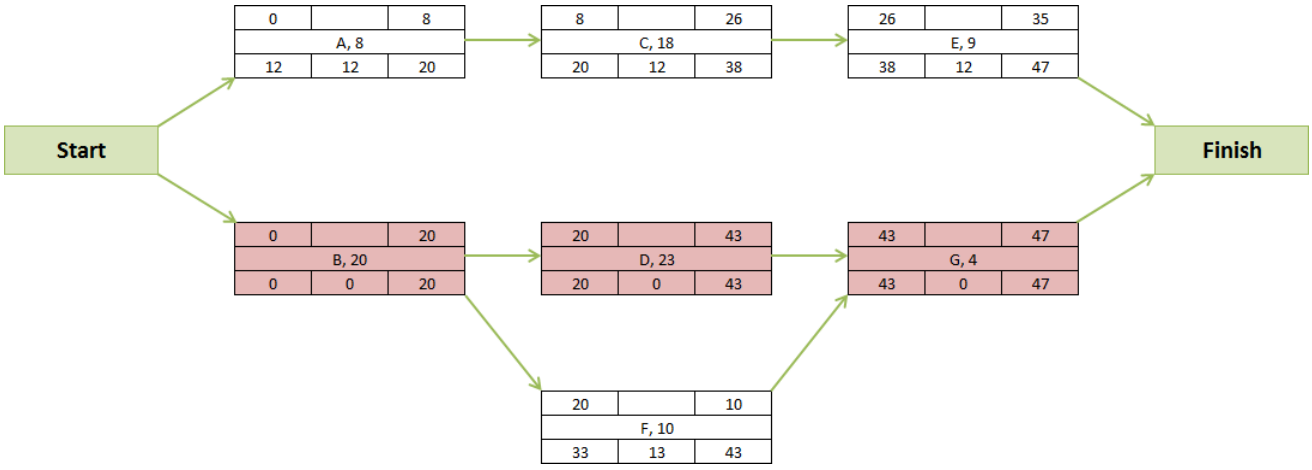
Now, determine the slack associated with each activity by subtracting the earliest start time from the latest start time, or the earliest finish time from the latest finish time. The network diagram is now populated with slack, as seen below.

When slack exists in an activity, it means there is extra time available in the schedule during which you can complete said activity. For example, task E above has a slack of nine days. Task E can therefore start anytime between time 26 and time 47, and still be on time.



Establish the Critical Path

Now that the amount of slack in each activity is identified, we can determine the critical path. The critical path is the path where there is no slack. It is important to identify the critical path on your network diagram, as this provides full visibility to everyone. You can identify via highlighting the nodes, inserting double-arrows, etc. In our example, the critical path is highlighted in red and is B, D, and G.



Break

Critical Path Exercise
Perform critical path analysis on the following example.

Task	Predecessor	Duration (days)
A	None	3
B	A	7
C	None	4
D	B	8
E	C	2
F	D	3
G	C, F	5

In the space below, draw the network diagram using the activity-on-node method.

Program Evaluation and Review Technique (PERT)

PERT vs. CPM
PERT and CPM are identical in the way you create a network diagram, perform backward and forward passes, determine slack, and find the critical path. Why are there two methods? It's because they were created by two different people around the same time in the late 1950's.

The main difference between PERT and CPM is the way the activity estimation is performed. Rather than using one time estimate for each activity, PERT uses three. The three time estimates are: most likely time, optimistic time, and pessimistic time.

- **Most likely** time is the most common result when a task is completed multiple times in the same manner.
- **Optimistic** time is the shortest reasonable amount of time during which the activity can be completed if all goes as expected.
- **Pessimistic** time is the longest amount of time required to complete the activity, given that if anything can go wrong, it will.

PERT is valuable if there is a large portion of uncertainty in your project. It assumes that the uncertainty present in each of the three time estimates can be modeled by a probability distribution (the beta distribution).

The PERT Formula

To combine the three estimates into one expected time estimate, the values must be plugged into a formula. The formula calculates the average estimated time (T_e) to complete the task. The formula is written as follows:

$$T_e = \frac{T_o+4T_m+T_p}{6}$$

Where:

T_m= most likely time	T_o= optimistic time
T_p=pessimistic time	T_e= expected (average) time

Creating Time Estimates

The first step in using the PERT method starts during the estimation phase of the project. During this phase you assign the three time estimates to each activity. This will allow you use the formula above for PERT purposes and will provide you with a better idea of time durations for each task, when there is a great amount of uncertainty. Remember, you want to use the best estimates possible, so be sure to check with subject matter experts and your resource team when estimating.

Test your knowledge

Perform PERT on the previously discussed Trip to New York project. Plug the values for T_o, T_m, and T_p into the expected time formula above to get the value for T_e. (Time is represented in hours.)

Task No.	Task Name	T_o	T_m	T_p	T_e
A	Determine budget	1	4	8	
B	Select dates	1	2	6	
C	Renew passports	1	2	6	

D	Book flight	1	1	2	
E	Research hotels	2	4	6	
F	Book hotel	1	1	2	
G	Book car	1	1	2	
H	Plan activities	2	8	16	
I	Pack suitcases	1	2	4	
J	Go to airport	1	1	2	

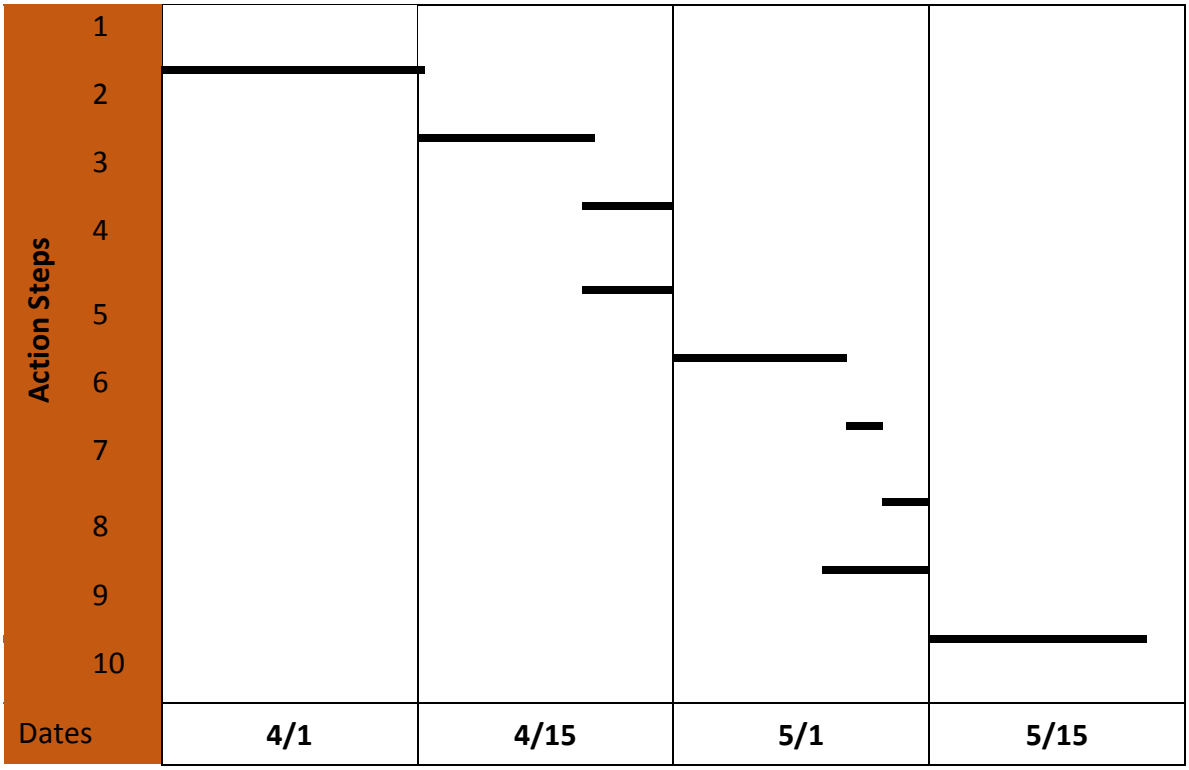
The Value of PERT

If there are a lot of questions surrounding tasks and milestones, or if the project is entirely new to you and your project team, it may be best to use PERT to determine the critical path, in which case you would need three estimates as opposed to one per activity. Knowing you are going to use the PERT method will help you avoid duplication of effort. Instead of creating one estimate in the beginning and then going back to create three estimates, simply knowing that you will perform PERT will set you on the right estimation path from the beginning.

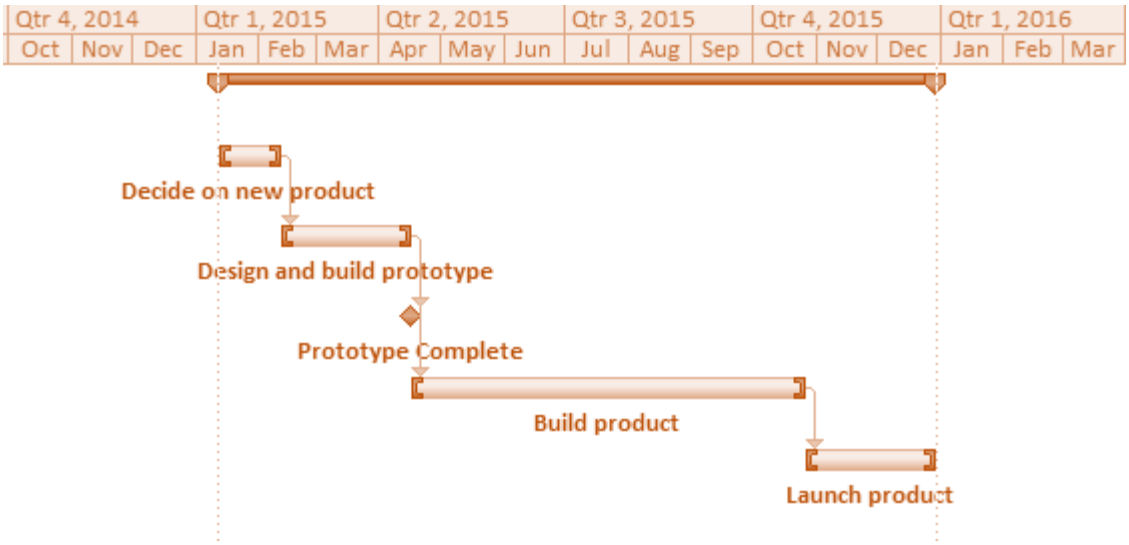
About Gantt Charts

Gantt charts are bar charts that provide a graphical representation of milestones, activities, and time. Once you know the estimated duration of your project, you should complete a Gantt chart. They are a valuable tool when scheduling work, allocating resources, and communicating project progress.

Although milestones have no standalone duration, it is common to add them to a Gantt chart for tracking purposes. Having milestones on your Gantt chart allows your project team and sponsor(s) to immediately focus in on and see high-level progress. In Microsoft Project, milestones are displayed as solid-colored diamonds. Here is a sample Gantt chart drawn by hand.



The image below is a simple Gantt chart created by a software program. Notice the milestone (diamond) in the image.



Computer-generated Gantt charts are capable of showing task relationships. This allows the project manager and resources to step through all of the project milestones and activities in order.

Gantt Chart Exercise

Review the task relationships and durations in the table below. (Task durations are expressed in days.)

Task No.	Task Name	Depends On	Dependency (SS, FS, SF, FF)	T_o	T_m	T_p	T_e
A	Determine budget	N/A	N/A	1	4	8	4
B	Select dates	N/A	N/A	1	2	6	3
C	Renew passports	N/A	N/A	1	2	6	3
D	Book flight	Select dates	Finish-to-start	1	1	2	1
E	Research hotels	N/A	Finish-to-start	2	4	6	4
F	Book hotel	Research hotels	Finish-to-start	1	1	2	1
G	Book car	Book flight	Finish-to-start	1	1	2	1
H	Plan activities	Book flight	Finish-to-start	2	8	16	8
I	Pack suitcases	Book flight	Finish-to-start	1	2	4	2
J	Go to airport	Pack suitcases	Finish-to-start	1	1	2	1

Draw a Gantt chart that depicts the task relationships and the durations.

Action Steps								
	A							
	B							
	C							
	D							
	E							
	F							
	G							
	H							
	I							
	J							
Dates		1	5	10	15	20	25	30

Scheduling Software

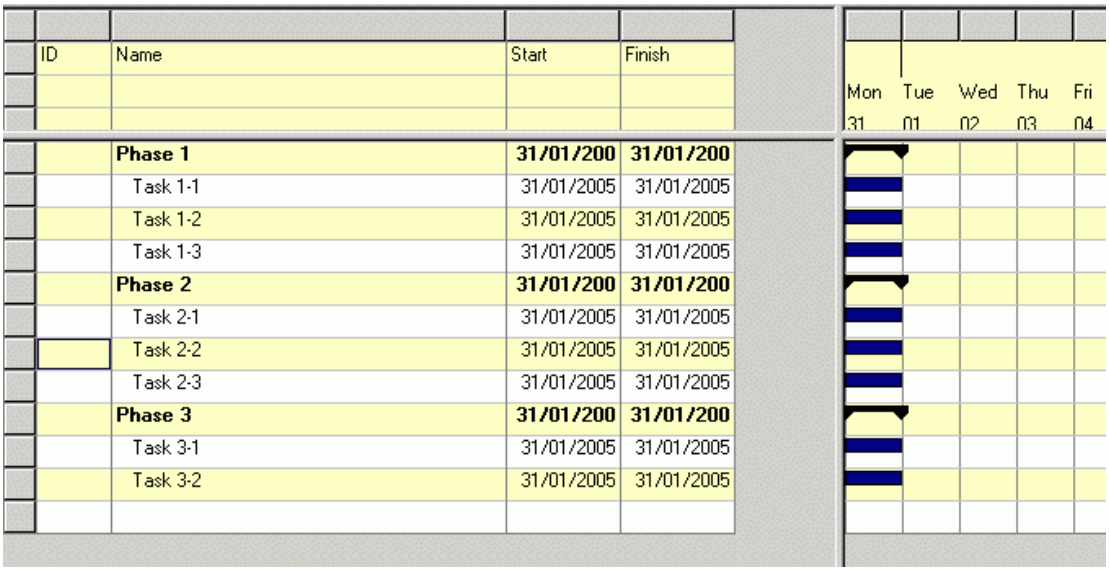
When creating a schedule, the size of your project tends to dictate the software required. If the project is small and manageable, an Excel spreadsheet will likely suffice for creating the schedule, tracking action items and deliverables, and for managing resources. If the project is large, you may need more formal software such as Microsoft Project, Open Workbench (freeware), Agile, Clarion, etc.

How do you know what software is best for you?
Does your company have a preferred scheduling software program? If so, there could be a spare license floating around, or an additional license may need to be purchased. If there is no preferred program, it is at the discretion of the project manager.

When you are using a new piece of software, you should receive some form of training (in class, online, or in a book) before delving into using the program. It takes times to understand how to properly enter tasks, assign resources, and create dependencies.

As previously mentioned, a Gantt chart provides a graphical representation of activities. Gantt charts can be created by hand in Microsoft Word and Excel, or automatically in specialized programs like Microsoft Project and other scheduling software. Activities, duration estimates, and task relationships come together to form the Gantt charts in software applications.

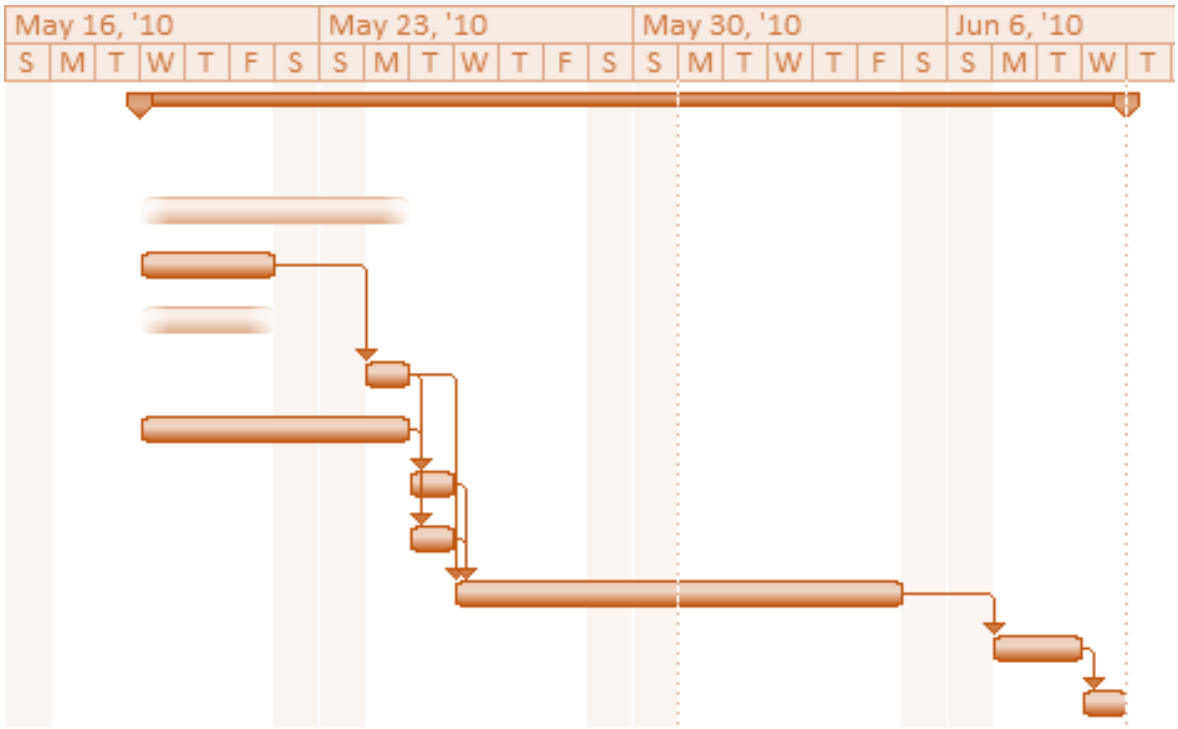
Below is a Gantt chart as displayed in Open Workbench.



ID	Name	Start	Finish
	Phase 1	**31/01/200**	**31/01/200**
	Task 1-1	31/01/2005	31/01/2005
	Task 1-2	31/01/2005	31/01/2005
	Task 1-3	31/01/2005	31/01/2005
	Phase 2	**31/01/200**	**31/01/200**
	Task 2-1	31/01/2005	31/01/2005
	Task 2-2	31/01/2005	31/01/2005
	Task 2-3	31/01/2005	31/01/2005
	Phase 3	**31/01/200**	**31/01/200**
	Task 3-1	31/01/2005	31/01/2005
	Task 3-2	31/01/2005	31/01/2005

Mon 31 Tue 01 Wed 02 Thu 03 Fri 04

Below is a Gantt chart as displayed in Microsoft Project.



As you can see, Gantt charts between software programs are similar. They all require the input of tasks, task durations, task relationships, resources, and working time/days.