Build a PDM Network Schedule

Introduction
This job aid addresses how to build a network schedule using the Precedence Diagram Method (PDM), including the following:

- Determine early start and finish dates (forward pass)
- Determine late start and finish dates (backward pass)
- Calculate float days
- Identify the critical path

Things to Know Before You Begin
This job aid uses the following base schedule; task durations have been pre-determined:

See the How to Read a Schedule job aid for more information about PDM network schedules.
Forward Pass: Determine Early Start and Finish Dates

Once task durations have been identified, the first step in completing a PDM network schedule is conducting a forward pass to determine each task's early start and finish dates. A forward pass starts with the first task in the project, works through the network according to task relationships and durations, and concludes with the final task.

质押 Note: Instead of calendar dates (e.g., January 1, 2020), this PDM network schedule will use number of days, starting with Day 1.

The first task in the project is Task A. Because it is the first task, it starts on Day 1; this is Task A's early start date.

To determine a task's early finish date, use the following formula:

\[
\text{Early Finish Date} = \text{Early Start Date} + \text{Task Duration} - 1
\]

The reason that you subtract 1 in the formula is that the task’s duration includes the task’s start date. Consider the following example:

A task starts on Monday. If it has a duration of 4 days, then it would be complete on Thursday: Monday is Day 1, Tuesday is Day 2, Wednesday is Day 3, and Thursday is Day 4.

If you simply add 4 days to Day 1, without subtracting 1, then you would incorrectly determine that the task completes on Day 5.

To calculate Task A's early finish date, insert the early start date and duration values into the formula:

\[
\begin{align*}
\text{Early Finish Date}_{\text{Task A}} &= \text{Early Start Date}_{\text{Task A}} + \text{Task Duration}_{\text{Task A}} - 1 \\
&= 1 + 5 - 1 \\
&= 5
\end{align*}
\]

Continue with the forward pass by moving to the next task (successor) in the sequence, in this case, Task B:
Tasks A and B have a *finish-to-start* relationship, which means that Task B cannot start until Task A finishes. By default, successor tasks that have finish-to-start relationships with their predecessors start the day after the predecessor task finishes. To determine the early start date for the successor task in this type of relationship, use the following formula:

\[ \text{Early Start Date Successor Task} = \text{Early Finish Date Predecessor Task} + 1 \]

However, there is also a 2-day lag between Task A and Task B. This means Task B cannot start until 2 days after Task A finishes. Task B has to wait out day 6 and day 7 (2 lag days) and start at the beginning of day 8. In this case, the formula to calculate Task B's early start date must include the lag time:

\[ \text{Early Start Date Successor Task} = \text{Early Finish Date Predecessor Task} + \text{Lag Time} + 1 \]

To calculate Task B's early start date, insert Task A's early finish date and the lag time into the formula:

\[
\text{Early Start Date } \text{Task B} = \text{Early Finish Date } \text{Task A} + \text{Lag Time} + 1 \\
= 5 + 2 + 1 \\
= 8
\]

To calculate Task B's early finish date, use the same Early Finish Date formula as for Task A:

\[
\text{Early Finish Date } \text{Task B} = \text{Early Start Date } \text{Task B} + \text{Task Duration } \text{Task B} - 1 \\
= 8 + 15 - 1 \\
= 22
\]
Continue with the forward pass by moving to the next task (successor) in the sequence. In this case, Task B has three successors, Tasks C, D, and E, all of which have finish-to-start relationships with Task B. Task B may be referred to as having *diverging* successor tasks.

![Diagram showing tasks B, C, D, and E with their respective dates and connections]

Note that there is no lag time for any of these successor tasks. Because of the finish-to-start relationships, the early start date for these successor tasks is 1 day after Task B’s early finish date. Use the previous Early Finish Date formula to calculate each task’s finish date.

![Diagram showing tasks B, C, D, and E with their respective dates and connections]

Task C has a finish-to-start relationship with only one successor task, Task G. The early start and finish dates for this successor task are determined in the same manner as with the previously described finish-to-start task relationships.

![Diagram showing tasks C and G with their respective dates and connections]
Like Task B, Task E has a finish-to-start relationship with multiple successor tasks, Tasks F and I. Once again, the early start and finish dates for Task F are determined in the same manner as with the previously described finish-to-start task relationships. However, Task I has two predecessor tasks, Tasks E and F, so you must consider both relationships with Task I before determining its early start and finish dates.

Notice that Task F has a *finish-to-finish* relationship with task I, which means Task I cannot finish any earlier than Task F finishes. Recall that because of its finish-to-start relationship with Task E, Task I also cannot start until Task E has finished.

*Note:* In a finish-to-finish relationship, the successor task cannot finish *earlier* than the predecessor task, but it can finish on the *same day*.

Considering only the finish-to-start relationship with Task E, the early start date for the Task I is Day 37, 1 day after Task E finishes. Using the Early Finish Date formula, if Task I starts on Day 37, with a duration of 14 days, its early finish date would be Day 50. If task I had a duration of 13 days, its early finish would be on day 49. But task I cannot finish any sooner than task F, so we would have had to change the early finish of task I to 50 days. This scenario represents a situation that clearly demonstrates why a forward and backward pass are conducted: the objective is to determine the absolute earliest and absolute latest a task can start and finish. The scheduler must ensure that no logic violations exist after calculating the early start and early finish dates. I

Like Task I, Task H has two predecessor tasks, Tasks D and F, so you must consider both relationships with Task H before determining its early start date. Task D has a finish-to-start relationship with Task H, and Task F has a *start-to-start* relationship with Task H.
Task F's start-to-start relationship with Task H means Task H cannot start until Task F has started. Because of its finish-to-start relationship with Task D, Task H also cannot start until Task D has finished.

**Note:** In a start-to-start relationship, the successor task cannot start *earlier* than the predecessor task, but it can start on the *same day.*

To determine Task H's early start date, you must compare Task D's early finish date to Task F's early start date. Even if Task H meets the start-to-start constraint with Task F on Day 37, it will not meet the finish-to-start constraint with Task D. This means that Task H cannot start any earlier than Day 40.

To determine Task H's early finish date, use the standard formula of adding the task's duration (10 days) to its early start date (Day 40) and subtracting 1 day.

Task J has finish-to-start relationships with three predecessor tasks, Tasks G, H, and I.

To determine Task J's early start date, you must consider the early finish dates for all three predecessor tasks. Task J cannot start until the task with the latest finish date finishes. In this case Task G has the latest finish date at Day 55, so Task J cannot start until Day 56. To
determine Task J’s early finish date, use the standard formula of adding the task’s duration (12 days) to its early start date (Day 56) and subtracting 1 day.

Task K is the final task in the project. It has a finish-to-start relationship with Task J, and has no other predecessors. The early start and finish dates for this final task are determined in the same manner as with the previously described finish-to-start task relationships.

The forward pass is complete, and the early start and finish dates have been determined for all tasks in the project.
Backward Pass: Determine Late Start and Finish Dates

Once the early start and finish dates have been determined for all tasks, the next step in completing a PDM network schedule is conducting a **backward pass** to determine each task's late start and finish dates. A backward pass starts with the last task in the project, works through the network according to task relationships and durations, and concludes with the first task.

The last task in the project is Task K. Because it is the last task, unless otherwise decided for the project, its late finish date is the same as its early finish date.

To determine a task's late start date, use the following formula:

\[
\text{Late Start Date} = \text{Late Finish Date} - \text{Task Duration} + 1
\]

You add 1 in the formula for a reason similar to why you subtract 1 in the Early Finish Date formula: the task's duration includes the task's start date.

To calculate Task K's late start date, insert the late finish date and duration values into the formula:

\[
\begin{align*}
\text{Late Start Date Task K} & = \text{Late Finish Date Task K} - \text{Task Duration Task K} + 1 \\
& = 72 - 5 + 1 \\
& = 68
\end{align*}
\]

Continue with the backward pass by moving to the previous task (predecessor) in the sequence, in this case, Task J:

Tasks K and J have a **finish-to-start** relationship, which means that Task K cannot start until Task J finishes. To determine the late finish date for the predecessor task in this type of relationship, use the following formula:

\[
\text{Late Finish Date Predecessor Task} = \text{Late Start Date Successor Task} - 1
\]

To calculate Task J's late finish date, insert Task K's late start date into the formula:

\[
\begin{align*}
\text{Late Finish Date Task J} & = \text{Late Start Date Task K} - 1 \\
& = 68 - 1 \\
& = 67
\end{align*}
\]
Basically, because of the finish-to-start relationship, Task J’s late finish date is 1 day before Task K’s late start date.

To calculate Task J’s late start date, use the same Late Start Date formula as for Task K:

\[
\text{Late Start Date}_{\text{Task J}} = \text{Late Finish Date}_{\text{Task J}} - \text{Task Duration}_{\text{Task J}} + 1
\]
\[
= 67 - 12 + 1
\]
\[
= 56
\]

Continue with the backward pass by moving to the previous task (predecessor) in the sequence. In this case, Task J has three predecessors, Tasks G, H, and I, all of which have finish-to-start relationships with Task J. Task J may be referred to as having converging predecessor tasks.
As with Tasks J and K, because of the finish-to-start relationships, the late finish date for these predecessor tasks is 1 day before Task J's late start date. And, as before, calculate their late dates using the previous Late Start Date formula.

Both Tasks I and H have a non-standard relationship with the same predecessor task, Task F. Task I has a finish-to-finish relationship with Task F, which means Task I cannot finish any earlier than Task F finishes. Task H has a start-to-start relationship with Task F, which means Task H cannot start until Task F has started.
Task F's late finish date is only constrained by its finish-to-finish relationship with Task I. Recall that in a finish-to-finish relationship, the successor task cannot finish earlier than the predecessor task, but it can finish on the same day. So, Task F's late finish date will be the same as Task I's, Day 55.

To determine Task F's late start date, you must consider both the Late Start Date formula and Task F's start-to-start relationship with Task H. Using the Late Start Date formula, when you subtract Task F's duration (14 days) from its late finish date (Day 55) and add 1 day, you get a late start date of Day 42.

Now consider Task F's start-to-start relationship with Task H. Recall that in a start-to-start relationship, the successor task cannot start earlier than the predecessor task, but it can start on the same day. Based on this relationship, Task F cannot start any later than Task H's late start date, Day 46.

Since the late start date of Day 42 meets the Day 46 latest start date constraint, this is Task F's late start date.
Tasks I and F have a finish-to-start relationship with the same predecessor task, Task E.

You must consider both relationships with Task E before determining its late finish date. Task E cannot finish any later than the task with the earlier late start date. Both tasks I and F have late start dates of day 42, so Task E cannot finish any later than Day 41. To determine Task E's late start date, use the standard formula of subtracting the task's duration (14 days) from its late finish date (Day 41) and adding 1 day.

Task H has a finish-to-start relationship with Task D, and Task G has a finish-to-start relationship with Task C. The late finish and start dates for both of these predecessor tasks are determined in the same manner as with the previously described finish-to-start task relationships.

Tasks C, D, and E share a finish-to-start relationship with the same predecessor task, Task B. To determine Task E's late finish date, you must consider all three relationships.
Recall that a finish-to-start relationship means that a successor task cannot start before the predecessor task finishes. Task B’s late finish date cannot be any later than the earliest late start date of the three successor tasks. In this case, Task C has the earliest late start date at Day 23, so Task B’s late finish date is Day 22. To determine Task B’s late start date, use the standard formula of subtracting the task’s duration (15 days) from its late finish date (Day 22) and adding 1 day.

Task A is the first task in the project. It has a finish-to-start relationship with Task B, and has no other successors. Recall that there is also a 2-day lag between Tasks A and B, which means Task B cannot start until 2 days after Task A finishes. In this case, the formula to calculate Task A’s late finish date must include the lag time:

**Late Finish Date Predecessor Task = Late Start Date Successor Task - Lag time - 1**
To calculate Task A’s late finish date, insert Task B’s late start date and the lag time into the formula:

\[
\text{Late Finish Date}_{\text{Task A}} = \text{Late Start Date}_{\text{Task B}} - \text{Lag Time} - 1
\]

\[
= 8 - 2 - 1
\]

\[
= 5
\]

The late start date for this final task is determined in the same manner as with the previously described tasks.

The backward pass is complete, and the late start and finish dates have been determined for all tasks in the project.
Calculate Float Days

Once the late start and finish dates have been determined for all tasks, the next step in completing a PDM network schedule is calculating each task's float days. To determine the total float for a task, you must perform two calculations:

1. Subtract the task's earliest start time from its latest start time.
   \[ \text{Float}_{\text{START}} = \text{Latest Start Time} - \text{Early Start Time} \]

2. Subtract the task's earliest finish time from its latest finish time.
   \[ \text{Float}_{\text{FINISH}} = \text{Latest Finish Time} - \text{Early Finish Time} \]

If there is a difference between the two calculations, then the float is the lesser of the two values.

To calculate Task A's float days, insert its applicable start and finish times into each formula.

\[
\begin{array}{c|c|c}
1 & 5 & 5 \\
A & & \\
\hline
1 & 5 & 
\end{array}
\]

1. \[
\text{Float}_{\text{TASK A-START}} = \text{Latest Start Time}_{\text{TASK A}} - \text{Early Start Time}_{\text{TASK A}} = 5 - 5 = 0
\]

2. \[
\text{Float}_{\text{TASK A-FINISH}} = \text{Latest Finish Time}_{\text{TASK A}} - \text{Early Finish Time}_{\text{TASK A}} = 1 - 1 = 0
\]

Since the values are the same for both calculations, Task A has zero float days.

\[
\begin{array}{c|c|c}
1 & 5 & 5 \\
A & & \\
\hline
1 & 0 & 5 
\end{array}
\]

Continue through the network schedule, performing these calculations and comparisons to calculate the float for each task.
Identify the Critical Path

The critical path is the sequence of tasks through the network schedule that has the longest total duration with the least amount of float. Tasks on the critical path typically have zero float, or very little float. Tasks on the critical path cannot be delayed without delaying the project's finish time.

In this PDM network schedule, the critical path is across the top of the diagram and includes Tasks, A, B, C, G, J, and K. Notice that each of these tasks has zero float.