Crosswind Learning

Version 6.1 Updated for the 2021
Project Management Professional (PMP)® Exam

Crosswind Success Series: PMP® Exam Bootcamp Manual

www.crosswindpm.com
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Version 6.1 aligned with the Project Management Institute, *A Guide to the Project Management Body of Knowledge, (PMBOK® Guide)* - Sixth Edition, Project Management Institute Inc., 2017

Slack (Float) Type	Description
Free Slack	Free slack (float) involves determining the latest that an activity can start without delaying the activities that follow it.
Total Slack	Total slack (float) is the latest an activity can start without delaying the project finish date.
Project Slack	Project slack (float) is the amount of time something can be delayed without delaying the published finish date. Most scheduling software will calculate these dates for you.

The concepts needed for the exam, which focus on total slack (float), follow.

11.5.5. Critical Path

Know the concepts of CPM (critical path method) estimation.

The critical path is the **longest path on the project network diagram.** It typically has no slack (float), yet the duration can change as the project evolves. The greatest project risk normally occurs on the critical path.

The project end date can be delayed if an activity on the critical path has a problem. The increase or slippage of an activity on the critical path can cause the overall finish date to slip.

A project has **negative slack (float) if it is behind schedule and a new finish date has not been authorized.**

A project can have multiple critical paths, but that would increase the risk of schedule slippage.

11.5.6. How to Calculate the Critical Path

The following table represents a data table typically found on the exam. It is used to create a network diagram and then determine the critical path.

Activity	Preceding Activities	Duration in Days
A	Start	4
B	Start	5
C	A	4
D	B	2
E	C, D	6
F	D	1
G	E, F	5

When the project starts, Activity A (4 days) and B (5 days) can begin. When Activity A is done, Activity C (4 days) can begin. When Activity B is done, Activity D (2 days) can begin. Activities C and D must finish before Activity E (6 days) can begin. Activity F (1 day) can begin when Activity D is complete. Activity G can begin when Activities E and F are complete. When Activity G (5 days) is complete, the project is complete.

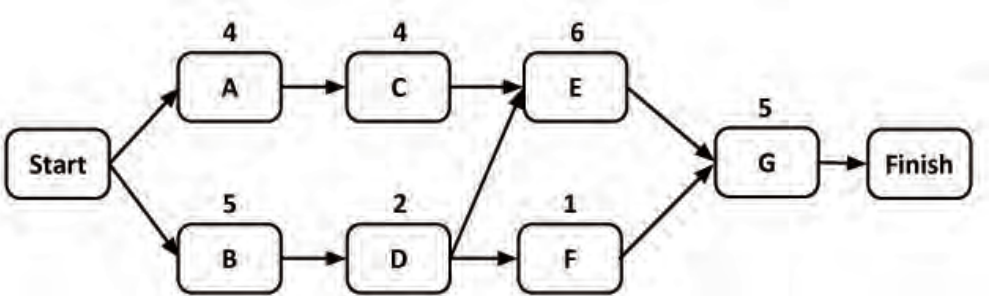

Figure 11-15: Network Diagram for Critical Path Analysis

The source for the above figure is the Project Management Institute, *A Guide to the Project Management Body of Knowledge*, (*PMBOK® Guide*) – Sixth Edition, Project Management Institute Inc., 2017, Figure 6-11, Page 193

Paths: ACEG = 19 BDEG =18 BDFG = 13

The critical path is the path that is the longest. That is path ACEG with a total of 19 days.

Note the following for the exam:

- For word problems related to network diagrams, draw the network diagram and then double check connections, activity labels, and activity durations
- List all paths and calculate the duration of each path using the top to bottom approach (list the paths as they start at the top of the diagram and work toward those on the bottom so you don't miss anything)
- Determine the critical path by selecting the longest (duration) path

11.5.7. Forward and Backward Pass Calculation

A forward and backward pass calculation is a standard calculation used to determine the critical path of the network diagram, the amount of slack (float) for each activity, and the amount of total slack (float).

- Slack (float) defines the amount of time an activity can slip before delaying the next activity
- Total slack (float) defines the amount of time an activity can slip before it delays the project finish date.

Mnemonics (memory tools) for the steps needed to perform a forward pass and a backward pass are **FIB** and **BDS**.

- **FIB** is the mnemonic for **Forward: Increment** (one day to another between activities) and choose the **Bigger** of all Early Finish (EF) dates feeding into an Early Start (ES) for the next activity
- **BDS** is the mnemonic for **Backward: Decrement** (one day to another between activities) and choose the **Smaller** of all Late Starts (LS) feeding into the Late Finish (LF) of the next activity

The **forward pass** starts at the start (left) of the network diagram and works through to the finish establishing the Early Start (ES) and Early Finish (EF) of the activities.

The **backward pass** starts at the finish and works backward to the left of the diagram establishing the Late Finish (LF) and Late Start (LS) of the activities.

Note that there are two approaches to a forward/backward pass: counting from day zero or counting from day one. Crosswind uses the day one approach, but either approach will work, so Crosswind has created a downloadable file that recreates sections 11.5.7 through 11.5.9 using the day zero approach. That file is located at http://www.crosswindpm.com/download/crosswindpmpday0.pdf.

Forward Pass Purpose	Provides the early start (ES) and early finish (EF) dates of each activity on the network diagram
Forward Pass Formula	ES + Duration - 1 = EF
Assumptions	A day starts at 8:00 a.m. and finishes at 5:00 p.m.
Starting Point	At the left of the network diagram, typically the start activity
Variables	**Early start (ES)** - The earliest an activity can start based on network diagram logic **Early finish (EF)** - The earliest an activity can finish based on network diagram logic **Duration** - The length of an activity **Convergence** - Where the output of more than one activity is a predecessor to an activity on the network diagram

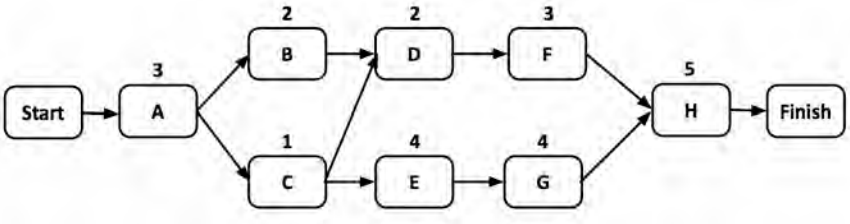

Figure 11-16: Network Diagram for Critical Path Analysis

The source for the above figure is the Project Management Institute, *A Guide to the Project Management Body of Knowledge*, (*PMBOK® Guide*) – Sixth Edition, Project Management Institute Inc., 2017, Figure 6-16, Page 211

Instructions for the Performance of a Forward Pass

Read the section below at least once, then perform the following steps referencing figure 11-16: Network Diagram for Critical Path Analysis.

1. Set the early start (ES) of Activity A to one (the first day of the project).
2. Apply the forward pass formula (EF = ES + Duration - 1) to the network diagram activity-by-activity from start to finish. As you move from one activity to another, increment the early finish (EF) of the current activity by one to give you the early start (ES) of the next activity. For example, Activity A has an early finish (EF) of 3; the early start (ES) of the following activity is 4.
   If you encounter a convergence (reference step 3), return to the beginning of the diagram and continue this step for all activities leading into the convergence.
3. Wherever you encounter a convergence, select the larger of the early finish (EF) values and continue applying the forward pass formula from start to finish on the network diagram.
4. Perform steps 2 and 3 until you have applied the forward pass formula to all activities. The forward pass is complete at this point. The network diagram should also be complete.

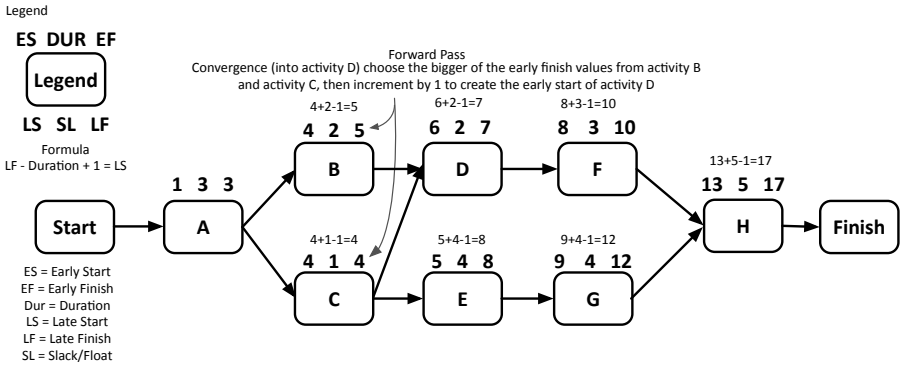

Figure 11-17: Forward Pass Calculation Description

The source for the above figure is the Project Management Institute, *A Guide to the Project Management Body of Knowledge*, (*PMBOK® Guide*) – Sixth Edition, Project Management Institute Inc., 2017, Figure 6-16, Page 211

Note that the calculations are not part of a typical diagram but are shown for clarification.

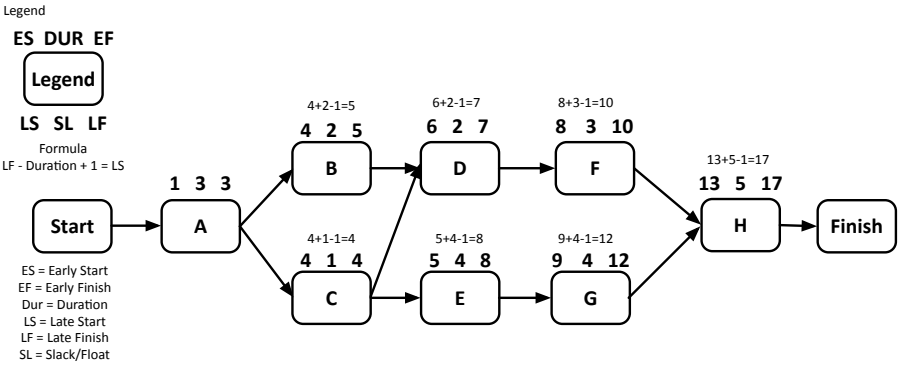

Figure 11-18: Forward Pass

The source for the above figure is the Project Management Institute, *A Guide to the Project Management Body of Knowledge*, (*PMBOK® Guide*) – Sixth Edition, Project Management Institute Inc., 2017, Figure 6-16, Page 211

Backward Pass Purpose	Provides the late start (LS) and late finish (LF) dates of each of the activities on the network diagram
Backward Pass Formula	LF - Duration + 1 = LS
Variables	**Late start (LS)** - The latest an activity can start based on the network diagram logic **Late finish (LF)** - The latest an activity can finish based on the network diagram logic **Duration** - The length of an activity **Burst** – Where an activity has multiple outputs that are predecessors to more than one activity
Assumptions	A day starts at 8:00 a.m. and finishes at 5:00 p.m.
Starting Point	At the right of the network diagram, typically the finish or end activity

Instructions for the Performance of a Backward Pass

1. The late finish (LF) is the same as the early finish (EF) on the last activity (also, the duration of the critical path). If the network diagram ends with multiple activities, the Late Finish (LF) for all is the greatest Early Finish (EF).
2. Apply the backward pass formula (LF - Duration + 1 = LS) from the finish (right) to the start (left) of the network diagram. As you move from one activity to another, decrease the late start (LS) by one to give you the late finish (LF) of the next activity. For example, Activity H has a late start (LS) of 13; the activity that precedes it has a late finish (LF) of 12.
   If you encounter a burst (see Backward Pass Calculation Description in this step), return to the finish (right) of the diagram and continue this step for all activities leading (from the right to the left) into the burst.

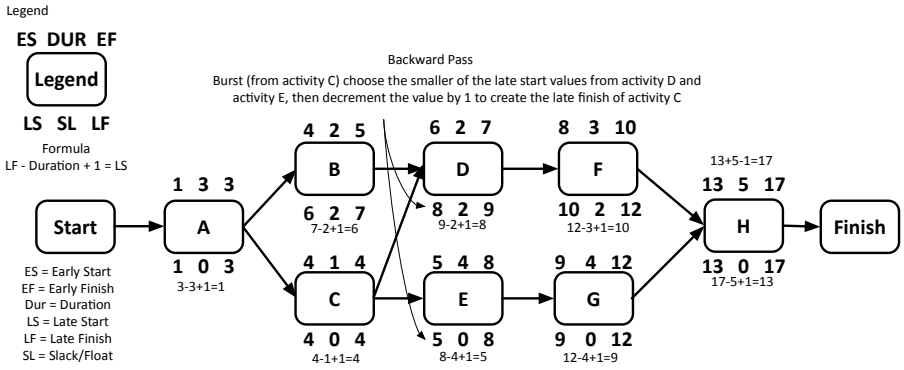

Figure 11-19: Backward Pass Calculation Description

The source for the above figure is the Project Management Institute, *A Guide to the Project Management Body of Knowledge*, (*PMBOK® Guide*) – Sixth Edition, Project Management Institute Inc., 2017, Figure 6-16, Page 211

3. At any burst on the network diagram, select the smaller of the late start (LS) values.
4. Perform steps 2 and 3 until all activities are done. At this point, the network diagram should resemble Figure 11-20: Backward Pass.

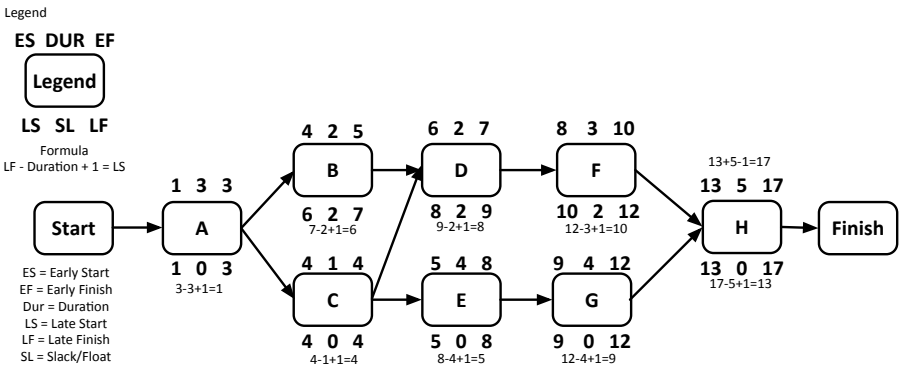

Figure 11-20: Backward Pass

The source for the above figure is the Project Management Institute, *A Guide to the Project Management Body of Knowledge*, (*PMBOK® Guide*) – Sixth Edition, Project Management Institute Inc., 2017, Figure 6-16, Page 211

Critical Path: The critical path is the longest path in the network diagram. Any activities on the critical path have an early start and late start that are the same value, as well as an early finish and late finish that are the same value. They have zero slack (float), meaning that if any of the activities slip, the overall project finish date slips as well.

11.5.8. Instructions for the Performance of a Forward and Backward Pass Substitute Technique

Know how to do a forward pass and a backward pass substitute technique on a network diagram.

To calculate the slack (float) of a path (or activity), without having to do the traditional forward/backward pass approach, do the following:

1. Add the durations of all paths and list them in the format "path name and total duration."
2. List each activity (A =, B=, etc.) to later list the slack of each activity after the equal sign.
3. Identify the critical path of the network diagram. This is the path with the longest duration.
4. Put 0 (zero) for slack (float) for each activity on the critical path.
5. On the next longest path, subtract that overall duration from the critical path duration (for example, 1-day difference).
6. Any activity from that path that does not already have a slack (float) number on it, put the difference (for example, 1 day) from step four as slack (float) for those activities.
7. Repeat steps five and six until all activities have slack (float) numbers.

If the path under review is not at the end of the diagram, you can still use this method. Other methods show subtracting all the activities one by one until you have the slack (float) value you are calculating for. You need to do that method only if you must calculate an early start or early finish of an activity. The next paragraph covers calculation of the early/late start and finishes.

11.5.9. Network Diagram Analysis

The Network Diagram (Figure 11-21: Network Diagram Analysis) contains the arrows and formulas necessary for the calculation of duration or slack (float). The relevant formulas are listed in the diagram and the diagram arrows point in the starting direction. Note that if an activity is on the critical path, the slack (float) is zero.

Instructions for Using the Alternative Method to Calculate the Slack (Float) of an Activity

Use the formula LF - EF (late finish - early finish) or LS - ES (late start - early start) to calculate the slack (float) of an activity by using the date provided in the exercise. If the difference is zero, the activity is on the critical path. If the value is negative, the activity has negative slack (float); if the value is positive, the activity has positive slack (float).

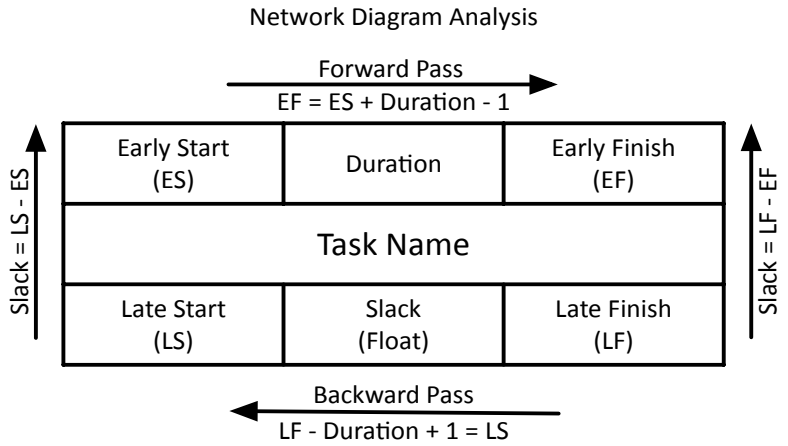

Figure 11-21: Network Diagram Analysis

The source for the above figure is the Project Management Institute, *A Guide to the Project Management Body of Knowledge*, (*PMBOK® Guide*) – Sixth Edition, Project Management Institute Inc., 2017, Figure 6-16, Page 211

11.5.10. Schedule Compression Techniques

If it is necessary to compress the schedule (usually to achieve a more aggressive time goal), the two main techniques are **crashing** and **fast tracking**. Schedule compression may employ either or both techniques.

Crashing is the application of additional resources (human) to the critical path items, excluding any resequencing activities.

Fast tracking is the analysis of the network diagram and activity sequencing to determine the sequencing adjustments that will accelerate the completion of work. Fast tracking does include the risk exposure associated with the resequencing.

Instructions for Fast Tracking

Figure 11-22: Network Diagram Pre-fast Tracking has two paths: the first path is A, B, D, E, F with a total duration of 13 and the second path is A, C, D, E, F with a total duration of 12. Path A, B, D, E, F is the critical path because it is the longer of the two paths.