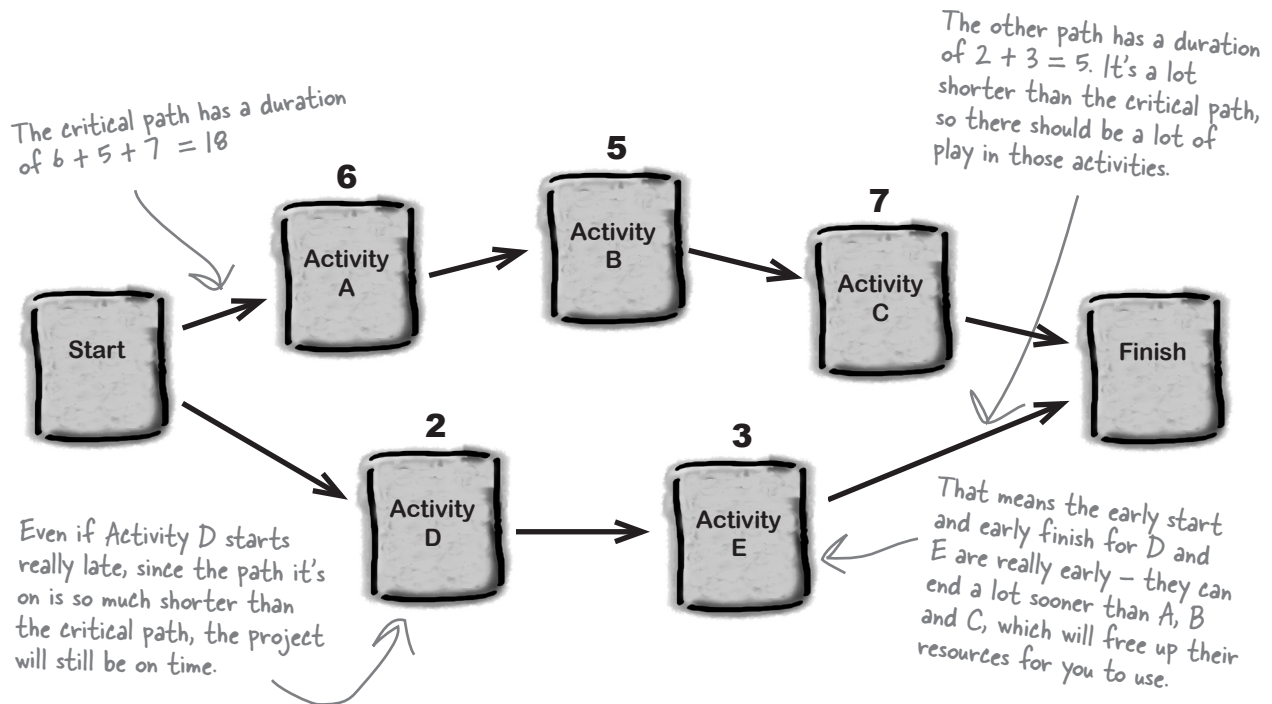


Figure out the early start and early finish

Coming up with the float for each activity is useful, but you can actually do better! When you have a long critical path, but the other paths in your network diagram are short, then you have a lot of freedom in when you can start and finish each of the activities that are not on the critical path. You can use **early start** and **early finish** to get a handle on exactly how much freedom you have in your schedule.



Early start

Is the earliest time that an activity can start. An activity near the end of the path will only start early if all of the previous activities in the path also started early. If one of the previous activities in the path slips, that will push it out.

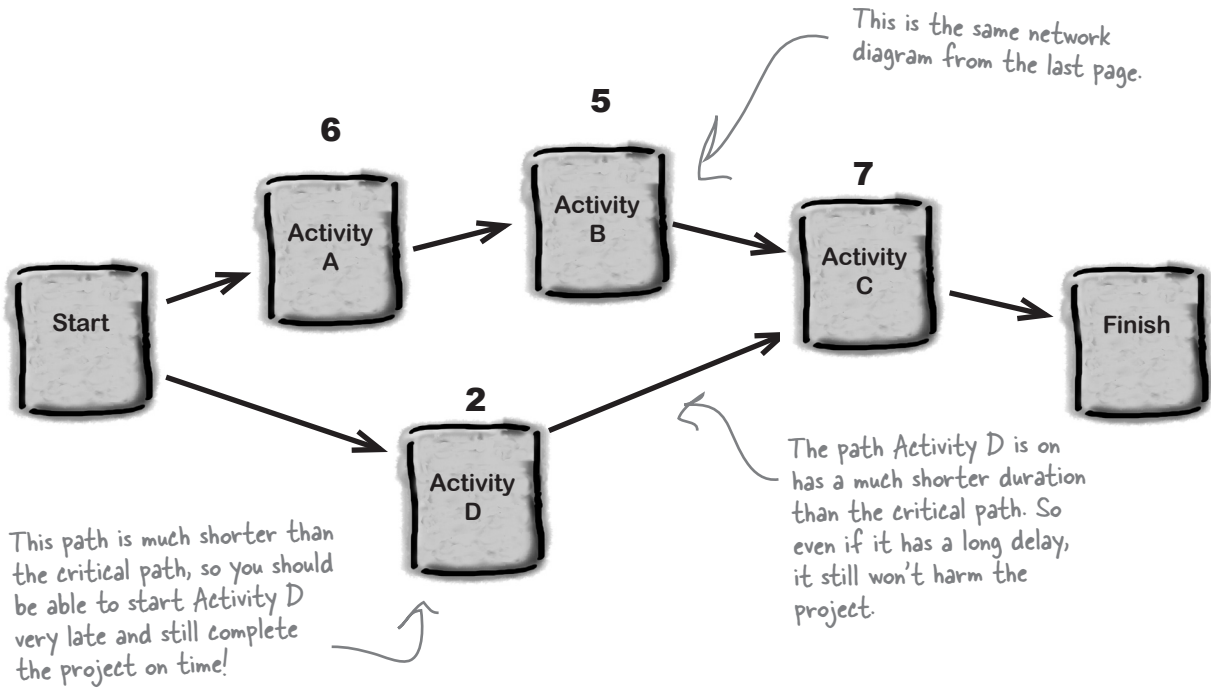
Early finish

Is the earliest time that an activity can finish. It's the date that an activity will finish if all of the previous activities started early and none of them slipped.

When you find the early start and early finish for each task, you know exactly how much freedom you have to move the start dates for those activities around without causing problems.

Figure out the latest possible start and finish

It's also important to know how late any activity can run before it delays the project. That's what **late start** and **late finish** are for! They let you figure out how late you can start a certain task and how much it can slip before it delays your project.



Late start

Is the latest time that an activity can start. If an activity is on a path that's much shorter than the critical path, then it can start very late without delaying the project – but those delays will add up quickly if other activities on its path also slip!

Late finish

Is the latest time that an activity can finish. If an activity is on a short path and all of the other activities on that path start and finish early, then it can finish very late without causing the project to be late.

Figuring out the late start and late finish will help you see how much “play” you have in your schedule. An activity with a large late start or late finish means you have more options.

Add early and late durations to your diagrams

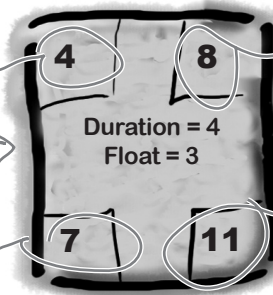
You can use a method called **forward pass** to add the early start and finish to each path in your network diagram. Once you've done that, you can use **backward pass** to add the late start and finish. It makes your network diagrams look a little more complicated, but it gives you a lot of valuable information.

You can use this special node in your network diagram to write down the early and late start and finish.

The early start for this activity is 4.

Write the late start in the lower-left hand corner. As long as the invitation design starts by day 7, it won't delay the critical path.

Design Invitations



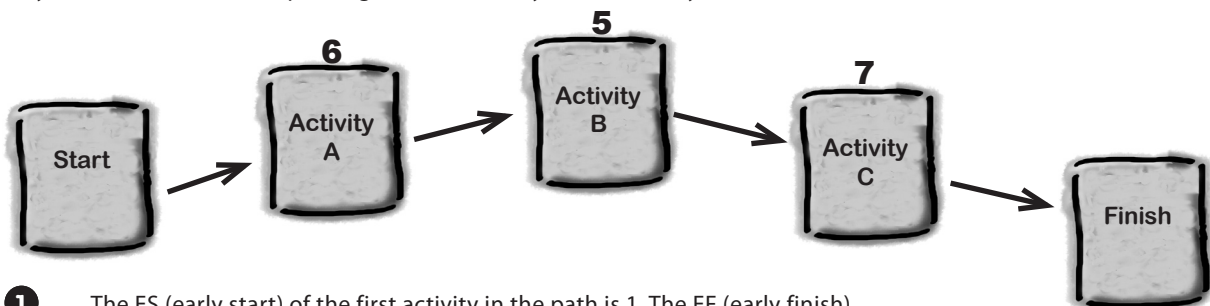
Early start and finish go in the upper corners. Write the name of the activity above it, and the duration and float inside the box.

The early finish for this activity is 8. There's no way it can end before day 8.

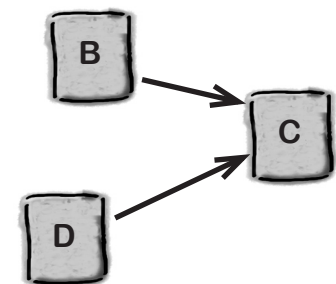
The late finish for the Design Invitations activity is 11, which means the latest it can finish without delaying the schedule is on day #11. If it hasn't finished by then, Kathleen should worry!

Take a forward pass through the network diagram.

Start at the beginning of the critical path and move forward through each activity. Follow these three steps to figure out the early start and early finish!



- 1 The ES (early start) of the first activity in the path is 1. The EF (early finish) of any task is its ES plus its duration minus one. So start with Activity A. It's the first in the path, so $ES = 1$, and $EF = 1 + 6 - 1 = 6$.
- 2 Now move forward to the next activity in the path, which is Activity B in this diagram. To figure out ES, take the EF of the previous task and add one. So for Activity B, you can calculate $ES = 6 + 1 = 7$, and $EF = 7 + 5 - 1 = 11$.
- 3 **Uh-oh! Activity C has two predecessors.** Which one do you use to calculate EF? Since C can't start until both B and D are done, use **the one with the latest EF**. That means you need to figure out the EF of activity D (its ES is 1, so its EF is $1 + 2 = 3$). Now you can move forward to Activity C and calculate its EF. The EF of Activity D is 2, which is smaller than B's EF of 11, so for Activity C the $ES = 11 + 1 = 12$, and $EF = 12 + 7 - 1 = 18$.

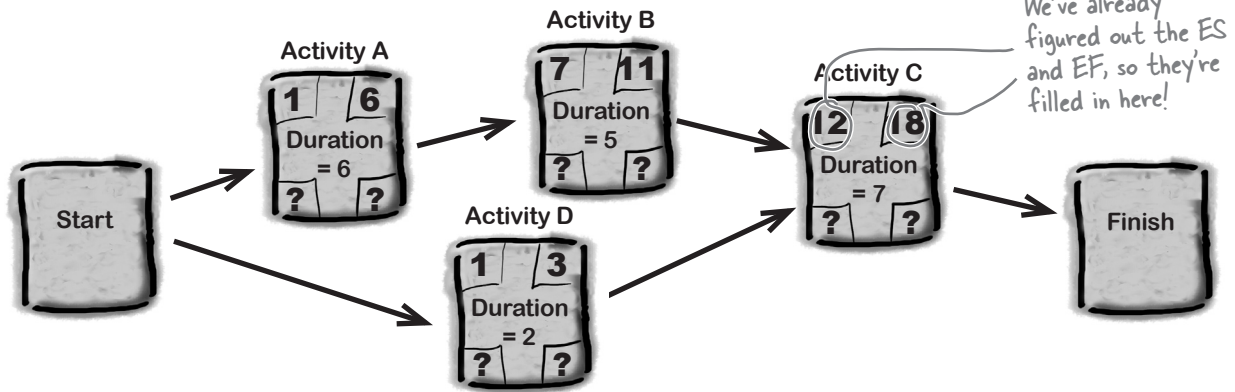


Take a backward pass to find late start and finish

You can use a **backward pass** to figure out the late finish and start for each activity.

Now take a backward pass through the same network diagram.

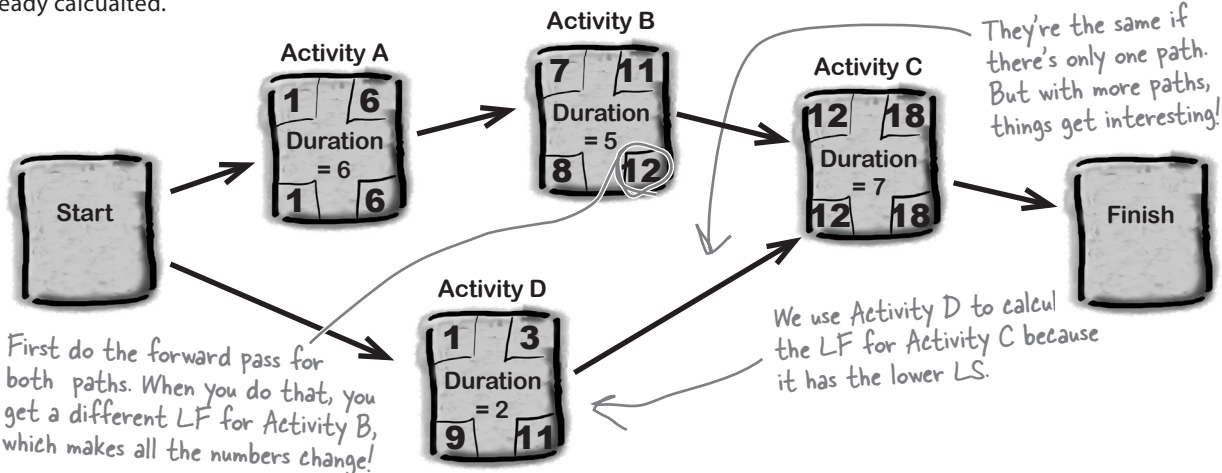
The backward pass is just as easy as the forward pass. Start at the end of the path you just took a pass through and work your way backward to figure out the late start and finish.



Start with the critical path.

You're calculating the latest any activity can start and finish, so it makes sense that you need to start at the end of the project and work backwards – and the last activity on the critical path is always the last one in the project. Then do these three steps, working backwards to the next-longest path, then the next-longest, etc., until you've filled in the LS and LF for all of the activities. Fill in the LF and LS for the activities on each path, but **don't replace** any LF or LS you've already calculated.

- 1 Start at the end of the path, with Activity C. The LF (late finish) of the last activity is the same as the EF. Calculate its LS (late start) by subtracting its duration from the LF and adding one. $LS = 18 - 7 + 1 = 12$
- 2 Now move backwards to the previous activity in the path—in this case, Activity B. Its LF is the LS of Activity C minus one, so $LF = 12 - 1 = 11$. Calculate its LS in the same way as step 1: $LS = 11 - 5 + 1 = 7$.
- 3 Now do the same for Activity A. LF is the LS for Activity B minus one, so $LF = 7 - 1 = 6$. And LS is LF minus duration plus one, so $LS = 6 - 6 + 1 = 1$.
- 4 Now you can move onto the next-longest path, Start-D-C-Finish. If there were more paths, you'd then move on to the next-longest one, etc., filling in LF and LS for any nodes that **haven't already been filled in**.



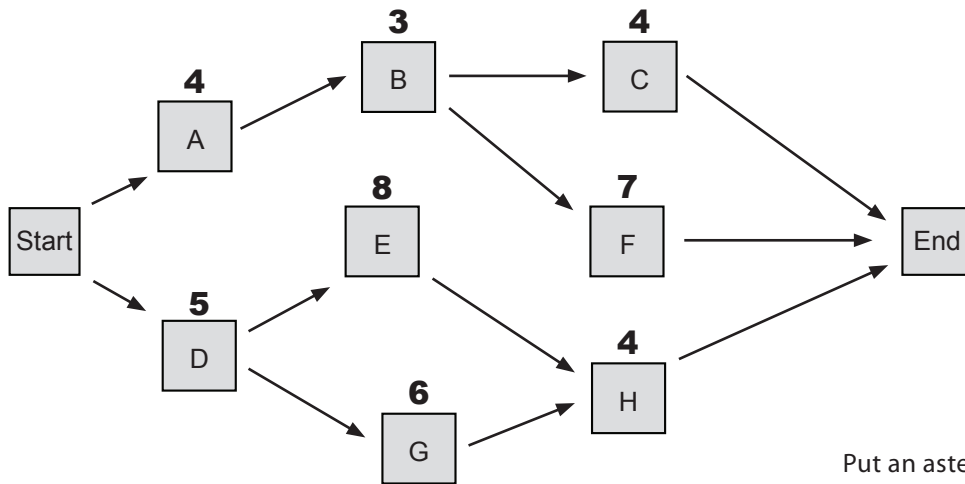
Let's take some time out to walk through this!

All of this critical path stuff seems pretty serious, right? It's one of the toughest concepts on the exam. But don't sweat it, because it's actually not hard! It just takes a little practice. Once you do it yourself, you'll see that there's really nothing to worry about.

Calculating the ES, EF, LS, and LF may seem complicated, but it only takes a little practice to get the hang of it. Once you walk through it step by step, you'll see that it's actually pretty easy!



There are four paths in this network diagram. Fill in each of the activity names and durations for each of the paths.



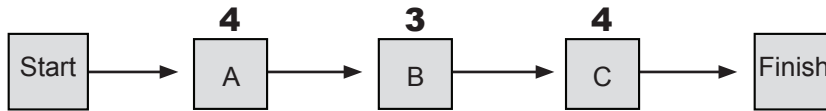
Put an asterisk (*) next to the critical path.

Start	→	<input type="text"/>	→	<input type="text"/>	→	<input type="text"/>	→	Finish
Start	→	<input type="text"/>	→	<input type="text"/>	→	<input type="text"/>	→	Finish
Start	→	<input type="text"/>	→	<input type="text"/>	→	<input type="text"/>	→	Finish
Start	→	<input type="text"/>	→	<input type="text"/>	→	<input type="text"/>	→	Finish

We're not done yet! There's more on the next page...

Sharpen your pencil

Take a forward pass through each of the four paths in the diagram and fill in the early starts and early finishes for each activity. Start with the first one.



Remember, the early start of the first activity in a path is one.

ES= __
EF= __

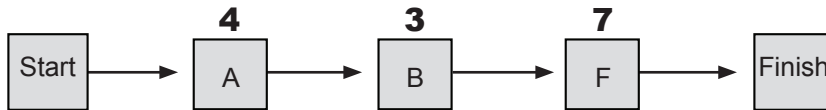
ES= __
EF= __

ES= __
EF= __

The early finish of an activity is its ES plus its duration minus one.

The early start of an activity is the early finish of the previous activity plus one.

Let's move on to the second path.

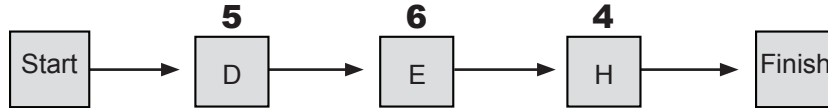


ES= __
EF= __

ES= __
EF= __

ES= __
EF= __

The next path isn't as straightforward as it looks. Start by filling in its values.



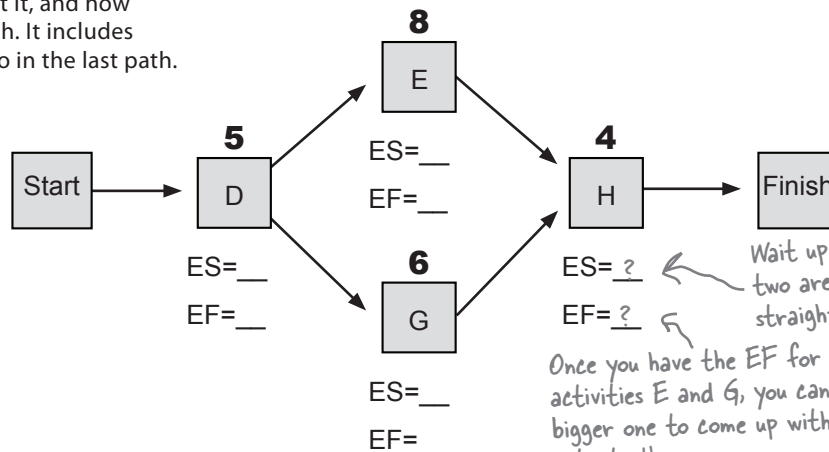
ES= __
EF= __

ES= __
EF= __

ES= __
EF= __

Now take another look at it, and how it mixes with the last path. It includes activity H, which was also in the last path.

H will have a different ES depending on which path you use! So which predecessor do you use - E or G? The idea here is that you **use the predecessor with the larger EF value** when you calculate the ES for activity H (because you want the **latest possible** start date).



ES= __
EF= __

ES= __
EF= __

ES= __
EF= __

ES= ?
EF= ?

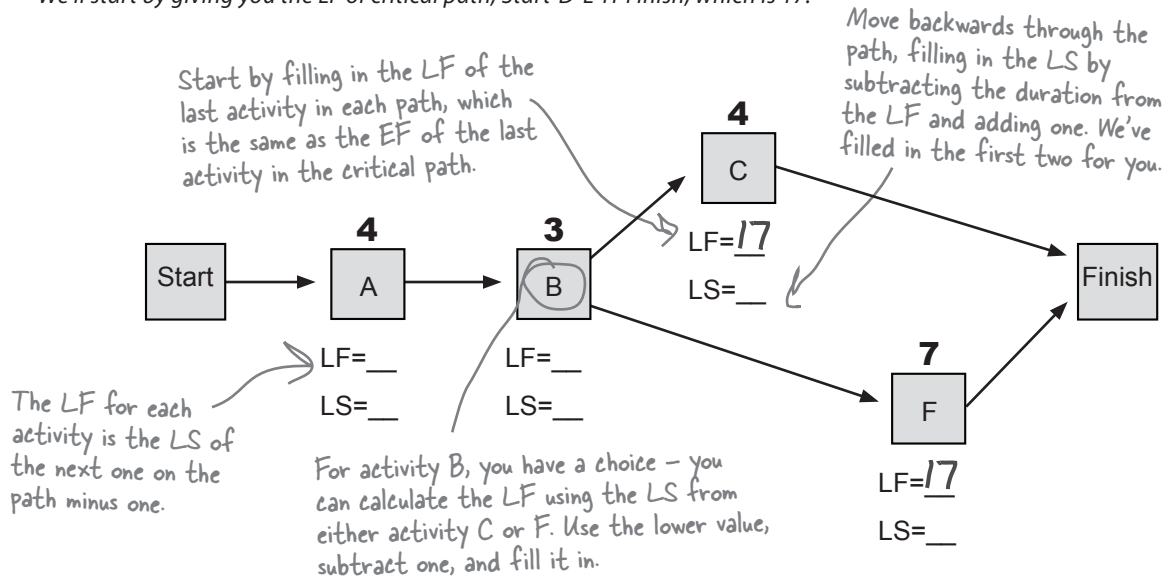
Wait up! These two aren't so straightforward.

Once you have the EF for both activities E and G, you can use the bigger one to come up with the ES for activity H.

You've calculated the ES for each activity. Use that information and take a backward pass through the paths, starting with the first two paths.

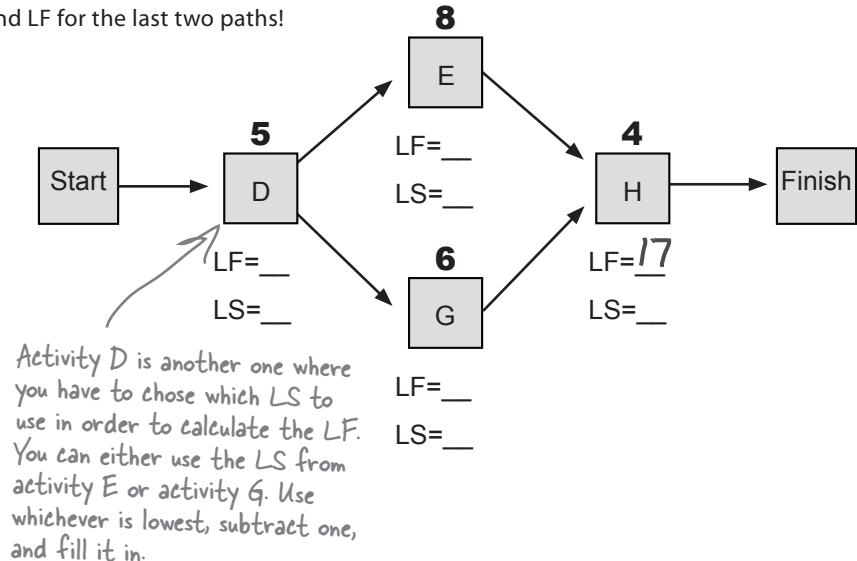
First start with the critical path. Take the EF of the last activity in the critical path and use it as the LF for the last activity in **every** path. If you take a minute to think about it, it makes sense to do that. The point of LF is to figure out the absolute latest that the activity can end without making the project late. And as long as every non-critical-path activity ends before the last activity in the critical path, then they won't be late.

We'll start by giving you the LF of critical path, Start-D-E-H-Finish, which is 17.



Finish up by calculating the LS and LF for the last two paths!

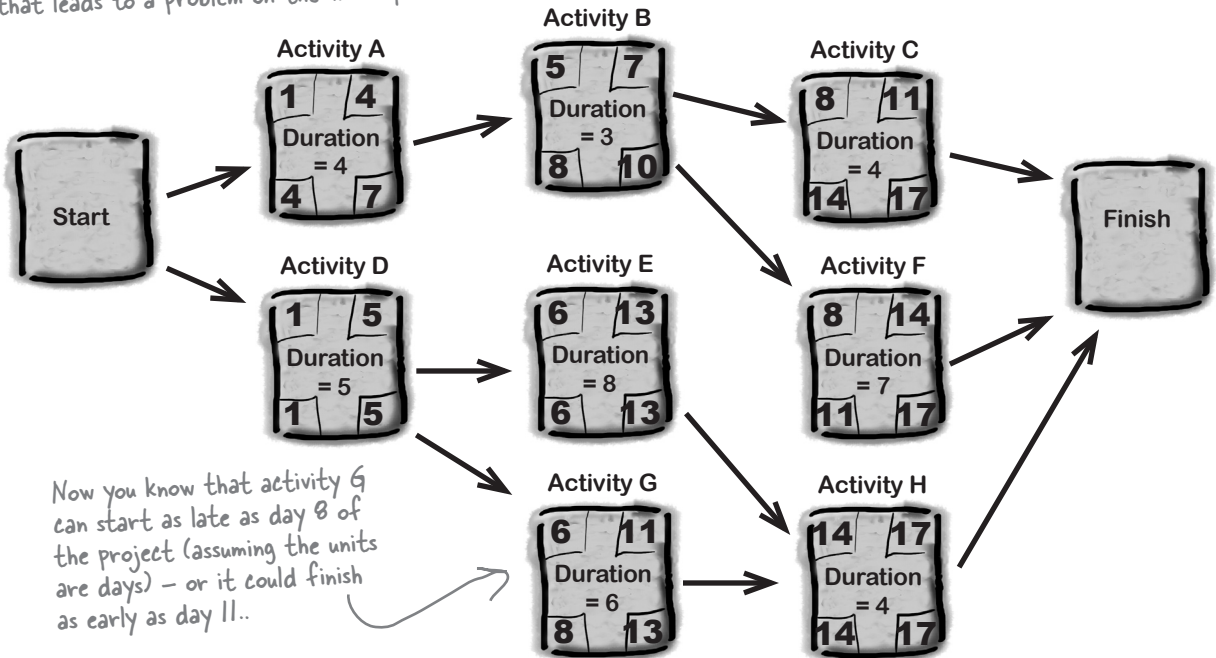
Activities B and D have two possible choices for which LS to use for the calculation. For activity B, do you use the LS of C or the LS of F? And for activity D, do you use the activity E or G? The answer is that you always **use the lowest value of LS to calculate the LF**. The reason is that you're trying to find the latest possible start date that *won't make the project late*. If you use an activity with a later LS, and the activity really is delayed by that much, then it'll cause a delay in both following activities. And that will make the one with the lower LS start too late.



Sharpen your pencil Solution

If you got a few of these wrong, don't worry. It's easy to miss one calculation, and that leads to a problem on the whole path.

For the exam, you'll only have to do one or two of these calculations, not a whole string of them like this. You'll definitely be able to handle the exam questions now!



Now you know that activity G can start as late as day 8 of the project (assuming the units are days) – or it could finish as early as day 12..



Wait a minute... I've never had to do this for my projects at work! I've got projects with dozens of activities, and this would take all day!

You won't have to do this kind of thing on the job... that's what computers are for!

Project management software like Microsoft Project will do these calculations for you. But you need to know how to do it yourself, because when the computer is doing critical path analysis, this is exactly how it figures it out!

there are no Dumb Questions

Q: Would I really use this critical path stuff in real life, or is it just something I need to memorize for the PMP exam?

A: Yes, critical path analysis really is important in real life! Sure, for a small project with a dozen or so activities, it's pretty easy to figure out which activities are critical and which can slip by a little bit. But what happens if you've got a project with dozens of team members and hundreds of activities? That's where critical path analysis can come in very handy. For a project like that, you'd probably be using project management software rather than calculating the critical path yourself, and the software will be able to highlight that path for you. Pay special attention to all of the activities that are on the critical path—those are the ones that could potentially delay the project.

Q: What about the other numbers? How do I use float?

A: Float is a very powerful planning tool that you can use to figure out how well your

project is going, and to predict where your trouble spots might be. Any activity with a low or zero float absolutely must come in on time, while the people performing an activity with a larger float have more freedom to slip without delaying the project. So you might want to assign your “superstar” resources to the low-float activities, and those people who need a little more mentoring to the ones with higher float.

Q: Okay, but what about late start, early finish, and those other numbers? Do those do me any good?

Early and late start and finish numbers are also very useful. How many times have you been in a situation where you've been asked, “If we absolutely had to have this in two months, can we do it?” Or, “How late can this project realistically be?” Now you can use these numbers to give you real answers, with actual evidence to back them up.

Here's an example. Let's say you've got an activity in the middle of your project, and one of your team members wants to plan a vacation right at the time that the activity will

start. Do you need to find someone to fill in for him? If he'll be back before the late start date, then your project won't be late! But that comes at a cost – you'll have used up the extra slack in the schedule.

Q: I can see how the critical path is useful on its own, but what does it have to do with the rest of time management?

A: If you start putting together your schedule but the activities are in the wrong order, that's really going to cause serious problems... and sometimes doing critical path analysis is the only way you'll really figure out that you've made that particular mistake. That's why you need to pay a lot of attention to the Activity Sequencing tools and techniques. If you've come up with an inefficient or inaccurate sequence, with too many or incorrect predecessors and dependencies, then your entire critical path analysis will be useless.



BULLET POINTS: AIMING FOR THE EXAM

- The **critical path** is the path that has the longest duration.
- You should be able to figure out the number of paths in a **network diagram**, and the duration of each path.
- The **float** for an activity is the amount that its duration can slip without causing the project to be delayed. The float for any activity on the critical path is zero.
- You'll need to know how to calculate the **early start, late start, early finish, and late finish** for an activity in a network diagram using the forward pass and backward pass. This is the core of critical path analysis.
- You may see a **PDM** (or **activity-on-node**) diagram with special nodes that have extra boxes in the corners for the ES, EF, LF and LS. You may see an **ADM** (or **activity-on-arrow**) diagram too, but that's much less common.
- Don't forget that when two paths intersect, you have to decide which ES or LF value to take for the calculation in the next node. For the **forward pass**, use the larger value; for the **backward pass**, use the smaller one.