

## Ch 9

### Problems

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- Draw a project network.
- What are the critical activities?
- What activity has the most slack time?
- Will the project be completed by September 1?

8. **Construction of an Athletic Complex.** Colonial State College is considering building a new multipurpose athletic complex on campus. The complex would provide a new gymnasium for intercollegiate basketball games, expanded office space, classrooms, and intramural facilities. The following activities would have to be undertaken before construction can begin. **LO 1, 2**

| Activity | Description            | Immediate Predecessor | Time (weeks) |
|----------|------------------------|-----------------------|--------------|
| A        | Survey building site   | —                     | 6            |
| B        | Develop initial design | —                     | 8            |
| C        | Obtain board approval  | A, B                  | 12           |
| D        | Select architect       | C                     | 4            |
| E        | Establish budget       | C                     | 6            |
| F        | Finalize design        | D, E                  | 15           |
| G        | Obtain financing       | E                     | 12           |
| H        | Hire contractor        | F, G                  | 8            |

- Draw a project network.
- Identify the critical path.
- Develop the activity schedule for the project.
- Does it appear reasonable that construction of the athletic complex could begin one year after the decision to begin the project with the site survey and initial design plans? What is the expected completion time for the project?

9. **Concert Planning.** At a local university, the Student Commission on Programming and Entertainment (SCOPE) is preparing to host its first concert of the school year. To successfully produce this concert, SCOPE has listed the requisite activities and related information in the following table (duration estimates measured in days). **LO 1, 2, 3, 4**

| Activity                                      | Immediate Predecessor(s) | Optimistic | Most Probable | Pessimistic |
|---|--------------------------|------------|---------------|-------------|
| A: Negotiate contract with selected musicians | —                        | 8          | 10            | 15          |
| B: Reserve site                               | —                        | 7          | 8             | 9           |
| C: Manage travel logistics for music group    | A                        | 5          | 6             | 10          |
| D: Screen & hire security personnel           | B                        | 3          | 3             | 3           |
| E: Arrange advertising & ticketing            | B, C                     | 1          | 5             | 9           |
| F: Hire parking staff                         | D                        | 4          | 7             | 10          |
| G: Arrange concession sales                   | E                        | 3          | 8             | 10          |

- Draw the project network.
- Compute the expected duration and variance of each activity.
- Determine the critical path in the project network.
- What is the expected duration and variance of the critical path?
- Based only on the critical path, what is the likelihood that the project will be completed within 30 days?
- If activity B is delayed by six days beyond its early start time, how does this affect the expected project duration?
- Using all paths through the project network, estimate the probability that the project will be completed within 30 days. Compare your answer to the answer in part e and explain.

10. **Habitat for Humanity.** Habitat for Humanity International is a nonprofit organization dedicated to eliminating poverty housing worldwide. The following table contains estimates of activity times (in days) involved in the construction of a house that Habitat for Humanity is building. **LO 3**

| Activity | Optimistic | Most Probable | Pessimistic |
|----------|------------|---------------|-------------|
| A        | 4          | 5.0           | 6           |
| B        | 8          | 9.0           | 10          |
| C        | 7          | 7.5           | 11          |
| D        | 7          | 9.0           | 10          |
| E        | 6          | 7.0           | 9           |
| F        | 5          | 6.0           | 7           |

- Compute the expected activity completion times and the variance for each activity.
  - An analyst determined that the critical path consists of activities B-D-F. Compute the expected project completion time and the variance of this path.
11. **Project Network for Blue Lagoon Pools.** Blue Lagoon is a contractor that installs residential swimming pools, projects that consist of nine major activities. The activities and their immediate predecessors are shown. Develop the project network. **LO 1**

| Activity              | A | B | C    | D    | E | F | G | H    | I       |
|-----------------------|---|---|------|------|---|---|---|------|---------|
| Immediate Predecessor | — | — | A, B | A, B | B | C | D | D, F | E, G, H |

12. **Critical Path for Blue Lagoon Pools.** The following table lists the activity time estimates (in days) for Blue Lagoon's swimming pool installation project in Problem 11. **LO 2, 3, 4**

| Activity | Optimistic | Most Probable | Pessimistic |
|----------|------------|---------------|-------------|
| A        | 3          | 5             | 6           |
| B        | 2          | 4             | 6           |
| C        | 5          | 6             | 7           |
| D        | 7          | 9             | 10          |
| E        | 2          | 4             | 6           |
| F        | 1          | 2             | 3           |
| G        | 5          | 8             | 10          |
| H        | 6          | 8             | 10          |
| I        | 3          | 4             | 5           |

- What are the critical activities?
  - What is the expected time to complete the project?
  - Based only on the critical path, what is the estimated probability that the project can be completed in 25 or fewer days?
13. **Probability of Wedding Plan Completion.** The following table lists the activity time estimates (in weeks) for the wedding planning project in Problem 6. **LO 3, 4**

| Activity | Optimistic | Most Probable | Pessimistic |
|----------|------------|---------------|-------------|
| A        | 4.0        | 5.0           | 6.0         |
| B        | 2.5        | 3.0           | 3.5         |
| C        | 6.0        | 7.0           | 8.0         |
| D        | 5.0        | 5.5           | 9.0         |
| E        | 5.0        | 7.0           | 9.0         |
| F        | 2.0        | 3.0           | 4.0         |
| G        | 8.0        | 10.0          | 12.0        |
| H        | 6.0        | 7.0           | 14.0        |

Jensen estimates that the parts needed to restore the body will cost \$3000 and that the parts needed to restore the engine will cost \$5000. His current labor costs are \$400 a day. **LO 1, 2, 3, 4**

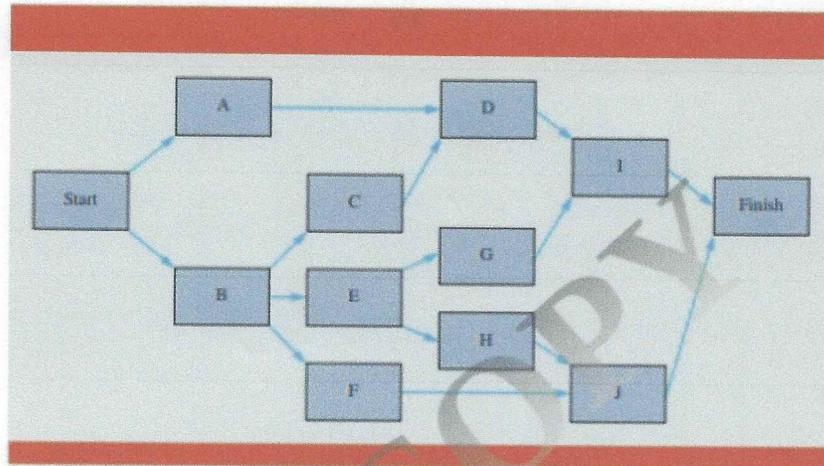
- Develop a project network.
- What is the expected project completion time?
- Jensen's business philosophy is based on making decisions using a best- and worst-case scenario. Develop cost estimates for completing the restoration based on both a best- and worst-case analysis. Assume that the total restoration cost is the sum of the labor cost plus the material cost.
- If Jensen obtains the job with a bid that is based on the costs associated with an expected completion time, what is the probability that he will lose money on the job? Base your calculation solely on the critical path.
- If Jensen obtains the job based on a bid of \$16,800, what is the probability that he will lose money on the job? Base your calculation solely on the critical path.

18. **Launching a New Track and Field Program.** Due to population growth in the area, the new Liberty High School has just opened in a local school district. The athletic director at Liberty High is planning the launch of the school's track and field team. The first team practice is scheduled for April 1. The activities, their immediate predecessors, and the activity time estimates (in weeks) are listed in the following table. **LO 1, 2, 3, 4**

| Activity | Description             | Immediate Predecessor | Time (weeks) |               |             |
|----------|-------------------------|-----------------------|--------------|---------------|-------------|
|          |                         |                       | Optimistic   | Most Probable | Pessimistic |
| A        | Meet with board         | —                     | 1            | 1             | 2           |
| B        | Hire coaches            | A                     | 4            | 6             | 8           |
| C        | Conduct fundraiser      | A                     | 2            | 4             | 6           |
| D        | Announce program        | B, C                  | 1            | 2             | 3           |
| E        | Meet with coaches       | B                     | 2            | 3             | 4           |
| F        | Order team equipment    | A                     | 1            | 2             | 3           |
| G        | Register athletes       | D                     | 1            | 2             | 3           |
| H        | Reserve buses for meets | G                     | 1            | 2             | 3           |
| I        | Plan first practice     | E, H, F               | 1            | 1             | 1           |

- Draw a project network.
  - Develop an activity schedule.
  - What are the critical activities, and what is the expected project completion time?
  - If the athletic director plans to start the project on January 1, calculate the probability the track and field team will be ready by the scheduled April 1 date (13 weeks) based solely on the critical path. Should the athletic director begin planning the track and field team before January 1?
19. **Software Development at Landon Corporation.** The product development group at Landon Corporation has been working on a new computer software product that has the potential to capture a large market share. Through outside sources, Landon's management learned that a competitor is working to introduce a similar product. As a result, Landon's top management increased its pressure on the product development group. The group's leader turned to PERT/CPM as an aid to scheduling the activities remaining before the new product can be brought to the market. **LO 2, 3, 4**

The project network is depicted in the following diagram.

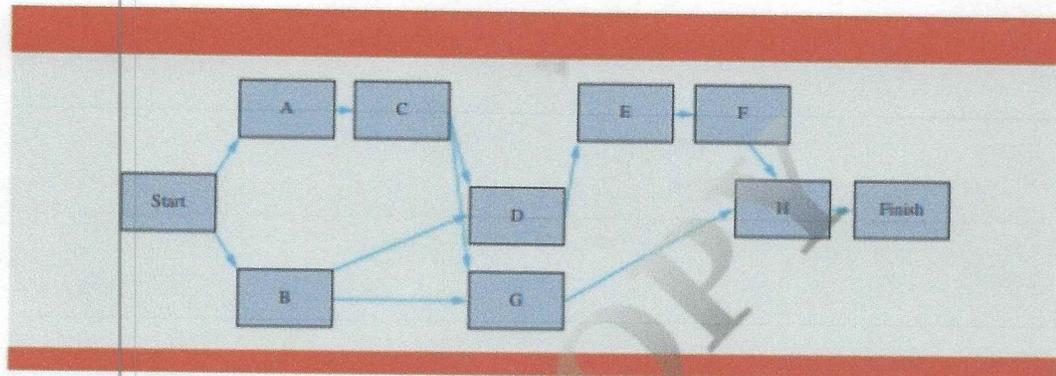


The activity time estimates (in weeks) are listed in the following table.

| Activity | Optimistic | Most Probable | Pessimistic |
|----------|------------|---------------|-------------|
| A        | 3.0        | 4.0           | 5.0         |
| B        | 3.0        | 3.5           | 7.0         |
| C        | 4.0        | 5.0           | 6.0         |
| D        | 2.0        | 3.0           | 4.0         |
| E        | 6.0        | 10.0          | 14.0        |
| F        | 7.5        | 8.5           | 12.5        |
| G        | 4.5        | 6.0           | 7.5         |
| H        | 5.0        | 6.0           | 13.0        |
| I        | 2.0        | 2.5           | 6.0         |
| J        | 4.0        | 5.0           | 6.0         |

- Develop an activity schedule for this project and identify the critical path activities.
  - Based solely on the critical path, what is the probability that the project will be completed so that Landon Corporation may introduce the new product within 25 weeks?
  - Based solely on the critical path, what is the probability that the project will be completed so that Landon Corporation may introduce the new product within 30 weeks?
20. **Antivirus Software.** Panda Security is a software company planning the release of the latest version of its antivirus software. The activities, activity times, and the project network follow. **LO 5**

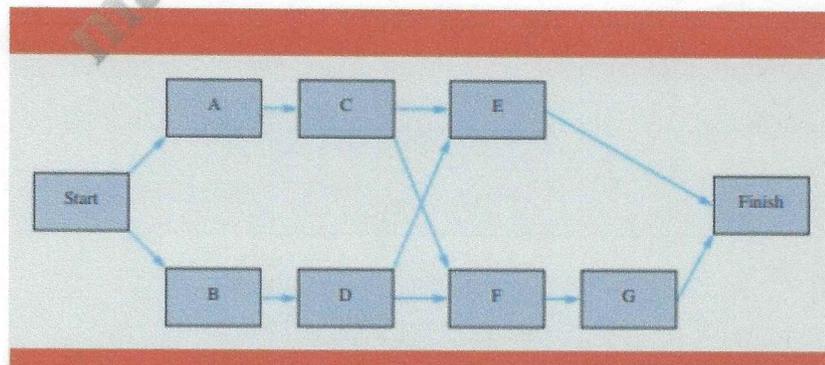
| Activity | Time | Activity | Time |
|----------|------|----------|------|
| A        | 3    | E        | 4    |
| B        | 6    | F        | 3    |
| C        | 2    | G        | 9    |
| D        | 5    | H        | 3    |



The critical path calculation shows B-D-E-F-H is the critical path, and the expected project completion time is 21 weeks. After viewing this information, management requested overtime be used to complete the project in 16 weeks. Thus, crashing of the project is necessary. The following table provides information on activity crashing.

| Activity | Time (weeks) |       | Cost (\$) |       |
|----------|--------------|-------|-----------|-------|
|          | Normal       | Crash | Normal    | Crash |
| A        | 3            | 1     | 900       | 1700  |
| B        | 6            | 3     | 2000      | 4000  |
| C        | 2            | 1     | 500       | 1000  |
| D        | 5            | 3     | 1800      | 2400  |
| E        | 4            | 3     | 1500      | 1850  |
| F        | 3            | 1     | 3000      | 3900  |
| G        | 9            | 4     | 8000      | 9800  |
| H        | 3            | 2     | 1000      | 2000  |

- Formulate a linear programming model that can be used to make the crashing decisions for this project.
  - Solve the linear programming model and make the minimum cost crashing decisions. What is the added cost of meeting the 16-week completion time?
  - Develop a complete activity schedule based on the crashed activity times.
21. **Process Improvement Project at Starbucks.** Starbucks management and employees have recently completed a kaizen event during which they identified ways to improve the store layout. To implement these changes, Starbucks has devised the following project network. **LO 2**





5. **Forecasting Weekly Motorcycle Helmet Sales.** Refer to the motorcycle helmet sales time series data in Problem 1. **LO 1, 2, 3, 4**
- Construct a time series plot. What type of pattern exists in the data?
  - Develop a three-week moving average for this time series. Compute MSE and a forecast for Week 7.
  - Use  $\alpha = 0.2$  to compute the exponential smoothing values for the time series. Compute MSE and a forecast for Week 7.
  - Compare the three-week moving average forecast with the exponential smoothing forecast using  $\alpha = 0.2$ . Which appears to provide the better forecast based on MSE? Explain.
  - Use trial and error to find a value of the exponential smoothing coefficient  $\alpha$  that results in a smaller MSE than what you calculated for  $\alpha = 0.2$ .
6. **Forecasting Monthly Lightning Strikes.** Refer to the lightning strike time series data in Problem 4. **LO 1, 2, 3, 4**
- Construct a time series plot. What type of pattern exists in the data?
  - Develop a three-month moving average for this time series. Compute MSE and a forecast for Month 8.
  - Use  $\alpha = 0.2$  to compute the exponential smoothing values for the time series. Compute MSE and a forecast for Month 8.
  - Compare the three-month moving average forecast with the exponential smoothing forecast using  $\alpha = 0.2$ . Which appears to provide the better forecast based on MSE?
  - Use trial and error to find a value of the exponential smoothing coefficient  $\alpha$  that results in a smaller MSE than what you calculated for  $\alpha = 0.2$ .
7. **Forecasting Gasoline Sales with Moving Averages.** Consider the data in Table 15.1 that show the number of gallons of gasoline (in 1000s) sold by a gasoline distributor in Bennington, Vermont, over the past 12 weeks. **LO 1, 2**
- Compute four-week and five-week moving averages for the time series.
  - Compute the MSE for the four-week and five-week moving average forecasts.
  - What appears to be the best number of weeks of past data (three, four, or five) to use in the moving average computation? Recall that MSE for the three-week moving average is 10.22.
8. **Forecasting Gasoline Sales with Weighted Moving Averages.** Refer again to the gasoline sales time series data in Table 15.1. **LO 1, 2**
- Using a weight of  $1/2$  for the most recent observation,  $1/3$  for the second most recent, and  $1/6$  for third most recent, compute a three-week weighted moving average for the time series.
  - Compute the MSE for the weighted moving average in part (a). Do you prefer this weighted moving average to the unweighted moving average? Remember that the MSE for the unweighted moving average is 10.22.
  - Suppose you are allowed to choose any weights as long as they sum to 1. Could you always find a set of weights that would make the MSE smaller for a weighted moving average than for an unweighted moving average? Why or why not?
9. **Forecasting Gasoline Sales with Exponential Smoothing.** With the gasoline time series data from Table 15.1, show the exponential smoothing forecasts using  $\alpha = 0.1$ . **LO 1, 3**
- Applying the MSE measure of forecast accuracy, would you prefer a smoothing constant of  $\alpha = 0.1$  or  $\alpha = 0.2$  for the gasoline sales time series?
  - Are the results the same if you apply MAE as the measure of accuracy?
  - What are the results if MAPE is used?
10. **Expanded Expression of the Forecasted Value from Exponential Smoothing.** With a smoothing constant of  $\alpha = 0.2$ , equation (15.8) shows that the forecast for Week 13 of the gasoline sales data from Table 15.1 is given by  $\hat{Y}_{13} = 0.2Y_{12} + 0.8\hat{Y}_{12}$ . However, the forecast for Week 12 is given by  $\hat{Y}_{12} = 0.2Y_{11} + 0.8\hat{Y}_{11}$ . Thus, we could combine these two results to show that the forecast for Week 13 can be expressed with the following equation. **LO 3**

$$\hat{Y}_{13} = 0.2Y_{12} + 0.8(0.2Y_{11} + 0.8\hat{Y}_{11}) = 0.2Y_{12} + 0.16Y_{11} + 0.64\hat{Y}_{11}$$