DISCUSSION QUESTIONS AND PROBLEMS

Discussion Questions

12-1 What is the minimal-spanning tree technique? What types of problems can be solved using this quantitative analysis technique?

12-2 Describe the steps of the maximal-flow technique.

12-3 Give several examples of problems that can be solved using the maximal-flow technique.

12-4 What are the steps of the shortest-route technique?

12-5 Describe a problem that can be solved by the shortest-route technique.

12-6 Is it possible to get alternate optimal solutions with the shortest-route technique? Is there an automatic way of knowing if you have an alternate optimal solution?

Problems*

Q: 12-7 Bechtold Construction is in the process of installing power lines to a large housing development. Steve Bechtold wants to minimize the total length of wire used, which will minimize his costs. The housing development is shown as a network in Figure 12.21. Each house has been numbered, and the distances between houses are given in hundreds of feet. What do you recommend?

Q: 12-8 The city of New Berlin is considering making several of its streets one-way. What is the maximum number of cars per hour that can travel from east to west? The network is shown in Figure 12.22.

Q: 12-9 Transworld Moving has been hired to move the office furniture and equipment of Cohen Properties to their new headquarters. What route do you recommend? The network of roads is shown in Figure 12.23.

Q • 12-10 Because of a sluggish economy, Bechtold Construction has been forced to modify its plans for the housing development in Problem 12-7. The result is that the path from node 6 to 7 now has a distance of 7. What impact does this have on the total length of wire needed to install the power lines?

Q • 12-11 Due to increased property taxes and an aggressive road development plan, the city of New Berlin has been able to increase the road capacity of two of its roads (see Problem 12-8). The capacity along the road

FIGURE 12.21

Network for Problem 12-7

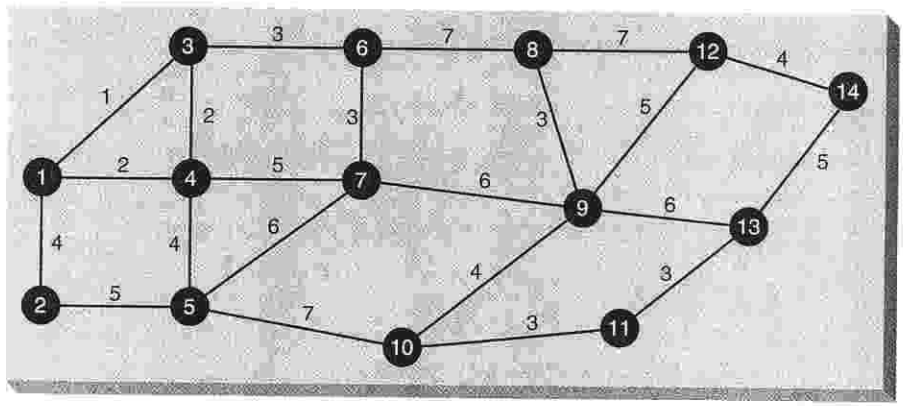
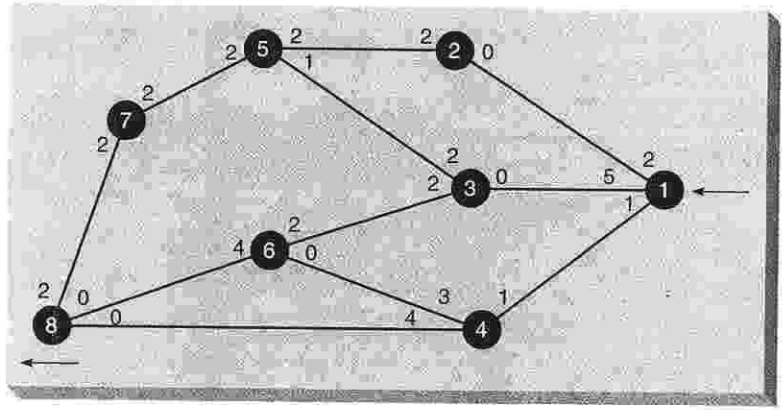


FIGURE 12.22

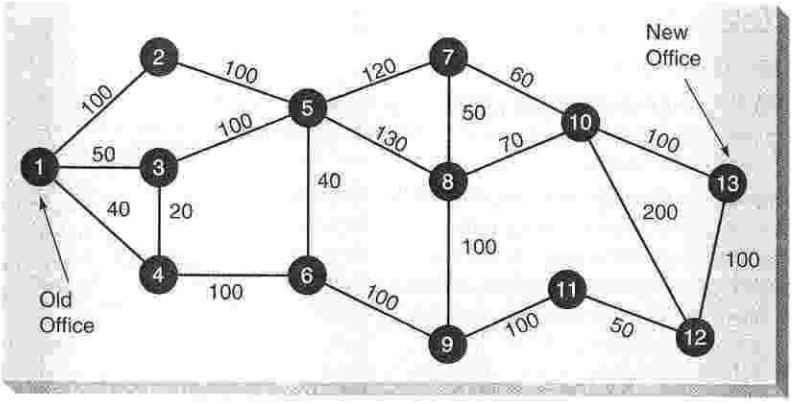
Network for Problem 12-8



* Note: Q means the problem may be solved with QM for Windows.

FIGURE 12.23

Network for Problem 12-9



represented by the path from node 1–2 has been increased from 2 to 5. In addition, the capacity from node 1–4 has been increased from 1 to 3. What impact do these changes have on the number of cars per hour that can travel from east to west?

Q: 12-12 The director of security wants to connect security video cameras to the main control site from five potential trouble locations. Ordinarily, cable would simply be run from each location to the main control site. However, because the environment is potentially explosive, the cable must be run in a special conduit that is continually air purged. This conduit is very expensive but large enough to handle five cables (the maximum that might be needed). Use the minimal-spanning tree technique to find a minimum distance route for the conduit between the locations noted in Figure 12.24. (Note that it makes no difference which one is the main control site.)

Q: 12-13 One of our best customers has had a major plant breakdown and wants us to make as many widgets for him as possible during the next few days, until he gets the necessary repairs done. With our general-purpose equipment there are several ways to make widgets (ignoring costs). Any sequence of activities that takes one from node 1 to node 6 in Figure 12.25 will

FIGURE 12.24

Network for Problem 12-12

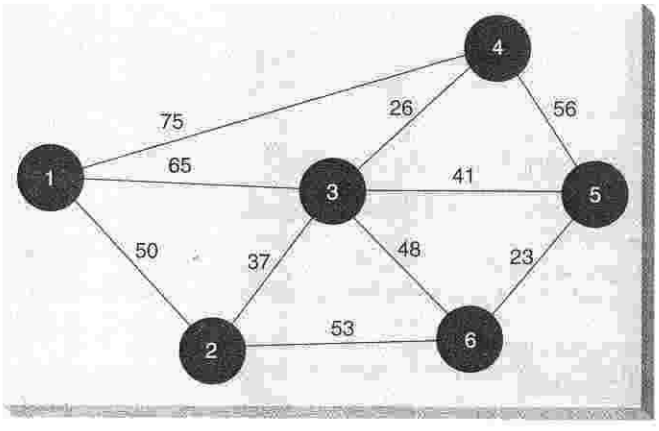
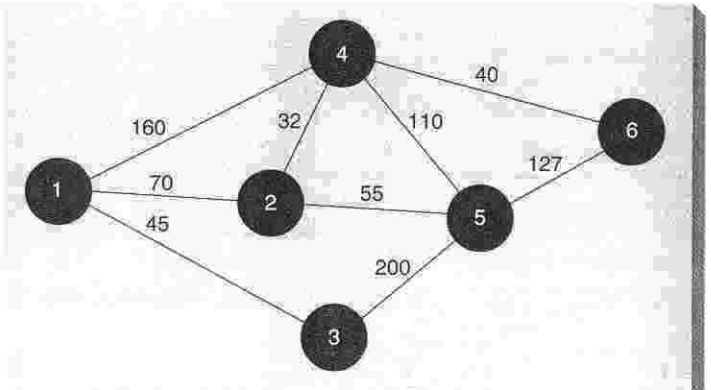


FIGURE 12.25

Network for Problem 12-13



produce a widget. How many widgets can we produce per day? Quantities given are number of widgets per day.

12-14 Transworld Moving, like other moving companies, closely follows the impact of road construction to make sure that its routes remain the most efficient. Unfortunately, there has been unexpected road construction due to a lack of planning for road repair around the town of New Haven, represented by node 9 in the network. (See Problem 12-9.) All roads leading to node 9, except the road from node 9 to node 11, can no longer be traveled. Does this have any impact on the route that should be used to ship the office furniture and equipment of Cohen Properties to their new headquarters?

12-15 Solve the minimal-spanning tree problem in the network shown in Figure 12.26. Assume that the numbers in the network represent distance in hundreds of yards.

12-16 Refer to Problem 12-15. What impact would changing the value for path 6–7 to 500 yards have on the solution to the problem and the total distance?

12-17 The road system around the hotel complex on International Drive (node 1) to Disney World (node 11) in Orlando, Florida, is shown in the network of Figure 12.27. The numbers by the nodes represent the traffic flow in hundreds of cars per hour. What is the maximum flow of cars from the hotel complex to Disney World?

12-18 A road construction project would increase the road capacity around the outside roads from International Drive to Disney World by 200 cars per hour (see Problem 12-17). The two paths affected would be 1–2–6–9–11 and 1–5–8–10–11. What impact would this have on the total flow of cars? Would the total flow of cars increase by 400 cars per hour?

12-19 Solve the maximal-flow problem presented in the network of Figure 12.28 on the next page. The numbers in the network represent thousands of gallons per hour as they flow through a chemical processing plant.

12-20 Two terminals in the chemical processing plant, represented by nodes 6 and 7, require emergency repair (see Problem 12-19). No material can flow into or out of these nodes. What impact does this have on the capacity of the network?

12-21 Solve the shortest-route problem presented in the network of Figure 12.29 on the next page, going from node 1 to node 16. All numbers represent kilometers between German towns near the Black Forest.

12-22 Due to bad weather, the roads represented by nodes 7 and 8 have been closed (see Problem 12-21). No traffic can get onto or off of these roads. Describe the impact that this will have (if any) on the shortest route through this network.

12-23 Grey Construction would like to determine the least expensive way of connecting houses it is building with

FIGURE 12.26

Network for Problem 12-15

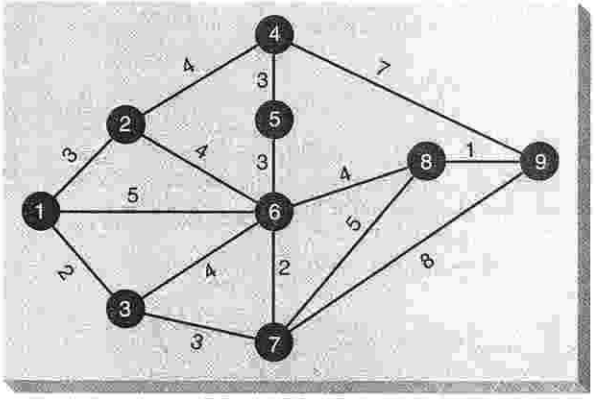


FIGURE 12.27

Network for Problem 12-17

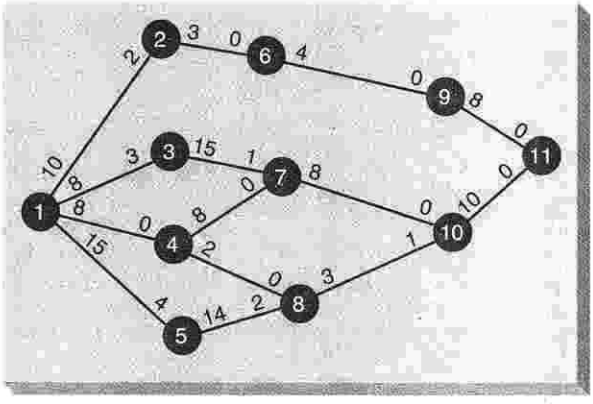


FIGURE 12.28

Network for Problem 12-19

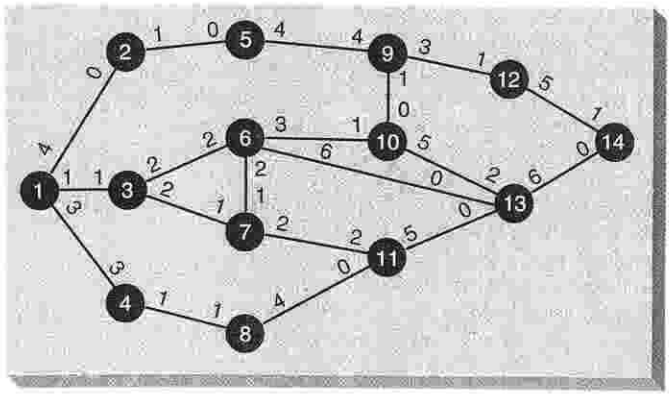
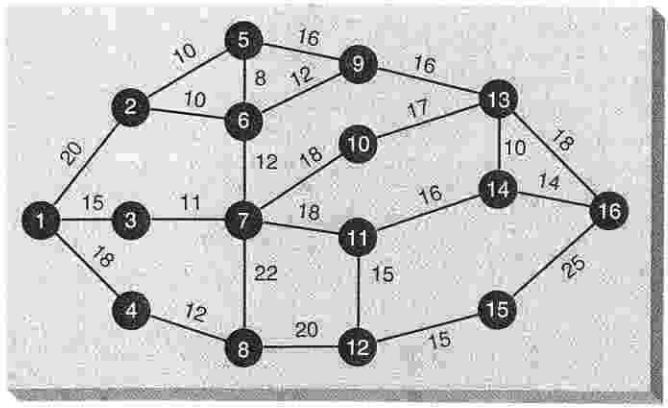


FIGURE 12.29

Network for Problem 12-21



cable TV. It has identified 11 possible branches or routes that could be used to connect the houses. The cost in hundreds of dollars and the branches are summarized in the following table.

(a) What is the least expensive way to run cable to the houses?

Branch	Start Node	End Node	Cost ($100)
Branch 1	1	2	5
Branch 2	1	3	6
Branch 3	1	4	6
Branch 4	1	5	5
Branch 5	2	6	7
Branch 6	3	7	5
Branch 7	4	7	7
Branch 8	5	8	4
Branch 9	6	7	1
Branch 10	7	9	6
Branch 11	8	9	2

(b) After reviewing cable and installation costs, Grey Construction would like to alter the costs for installing cable TV between its houses. The first branches need to be changed. The changes are summarized in the following table. What is the impact on total costs?

Branch	Start Node	End Node	Cost ($100)
Branch 1	1	2	5
Branch 2	1	3	1
Branch 3	1	4	1
Branch 4	1	5	1
Branch 5	2	6	7
Branch 6	3	7	5
Branch 7	4	7	7
Branch 8	5	8	4
Branch 9	6	7	1
Branch 10	7	9	6
Branch 11	8	9	2

Q: 12-24 In going from Quincy to Old Bainbridge, there are 10 possible roads that George Olin can take. Each road can be considered a branch in the shortest-route problem.

(a) Determine the best way to get from Quincy (node 1) to Old Bainbridge (node 8) that will minimize total distance traveled. All distances are in hundreds of miles.

Branch	Start Node	End Node	Distance (in Hundreds of Miles)
Branch 1	1	2	3
Branch 2	1	3	2
Branch 3	2	4	3
Branch 4	3	5	3
Branch 5	4	5	1
Branch 6	4	6	4
Branch 7	5	7	2
Branch 8	6	7	2
Branch 9	6	8	3
Branch 10	7	8	6

(b) George Olin made a mistake in estimating the distances from Quincy to Old Bainbridge. The new distances are in the following table. What impact does this have on the shortest route from Quincy to Old Bainbridge?

Branch	Start Node	End Node	Distance (in Hundreds of Miles)
Branch 1	1	2	3
Branch 2	1	3	2
Branch 3	2	4	3
Branch 4	3	5	1
Branch 5	4	5	1
Branch 6	4	6	4
Branch 7	5	7	2
Branch 8	6	7	2
Branch 9	6	8	3
Branch 10	7	8	6

Q: 12-25 South Side Oil and Gas, a new venture in Texas, has developed an oil pipeline network to transport oil from exploration fields to the refinery and other locations. There are 10 pipelines (branches) in the network. The oil flow in hundreds of gallons and the network of pipelines is given in the following table.

(a) What is the maximum that can flow through the network?

Branch	Start Node	End Node	Capacity	Reverse Capacity	Flow
Branch 1	1	2	10	4	10
Branch 2	1	3	8	2	5
Branch 3	2	4	12	1	10
Branch 4	2	5	6	6	0
Branch 5	3	5	8	1	5
Branch 6	4	6	10	2	10
Branch 7	5	6	10	10	0
Branch 8	5	7	5	5	5
Branch 9	6	8	10	1	10
Branch 10	7	8	10	1	5

(b) South Side Oil and Gas needs to modify its pipeline network flow patterns. The new data is in the following table. What impact does this have on the maximum flow through the network?

Branch	Start Node	End Node	Capacity	Reverse Capacity	Flow
Branch 1	1	2	10	4	10
Branch 2	1	3	8	2	5
Branch 3	2	4	12	1	10
Branch 4	2	5	0	0	0
Branch 5	3	5	8	1	5
Branch 6	4	6	10	2	10
Branch 7	5	6	10	10	0
Branch 8	5	7	5	5	5
Branch 9	6	8	10	1	10
Branch 10	7	8	10	1	5

Q: 12-26 The following table represents a network with the arcs identified by their starting and ending nodes. Draw the network and use the minimal spanning tree to find the minimum distance required to connect these nodes.

Arc	Distance
1–2	12
1–3	8
2–3	7
2–4	10
3–4	9
3–5	8
4–5	8
4–6	11
5–6	9

12-27 The network in Figure 12.30 represents streets of a city with the indicated number of cars per hour that can travel these streets. Find the maximum number of cars that could travel per hour through this system. How many cars would travel on each street (arc) to allow this maximum flow?

12-28 Refer to Problem 12-27. How would the maximum number of cars be affected if the street from node 3 to node 6 were temporarily closed?

12-29 Use the shortest route algorithm to determine the minimum distance from node 1 to node 7 in Figure 12.31. Which nodes are included in this route?

12-30 Northwest University is in the process of completing a computer bus network that will connect computer facilities throughout the university. The prime objective is to string a main cable from one end of the campus to the other (nodes 1–25) through underground conduits. These conduits are shown in the network of Figure 12.32; the distance between them is in hundreds of feet. Fortunately, these underground conduits have remaining capacity through which the bus cable can be placed.

(a) Given the network for this problem, how far (in hundreds of feet) is the shortest route from node 1 to node 25?

(b) In addition to the computer bus network, a new phone system is also being planned. The phone system would use the same underground conduits. If the phone system were installed, the following paths along the conduit would be at capacity and would not be available for the computer bus network: 6–11, 7–12, and 17–20. What changes (if any) would you have to make to the path used for the computer bus if the phone system were installed?

(c) The university *did* decide to install the new phone system before the cable for the computer network. Because of unexpected demand for computer networking facilities, an additional cable is needed for node 1 to node 25. Unfortunately, the cable for the first or original network has completely used up the capacity along its path. Given this situation, what is the best path for the second network cable?

FIGURE 12.30
Network for Problem 12-27

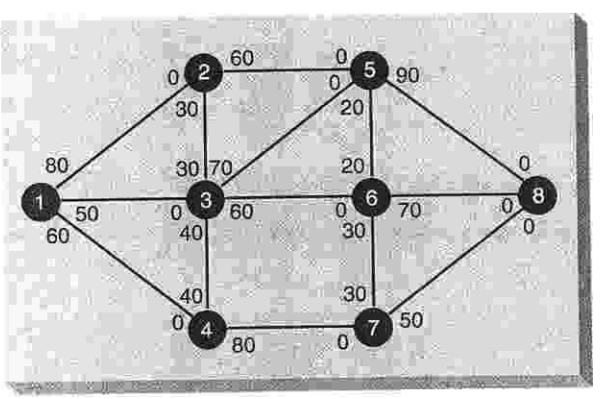


FIGURE 12.31
Network for Problem 12-29

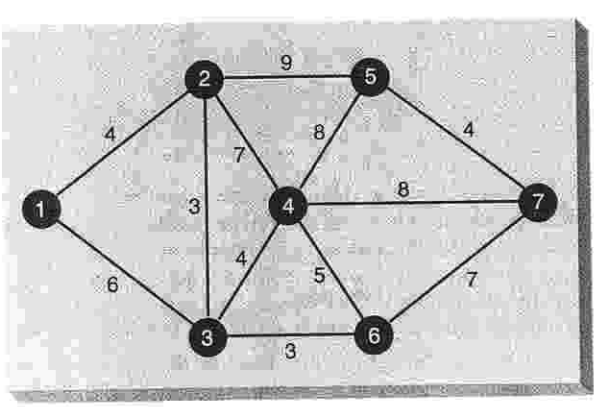
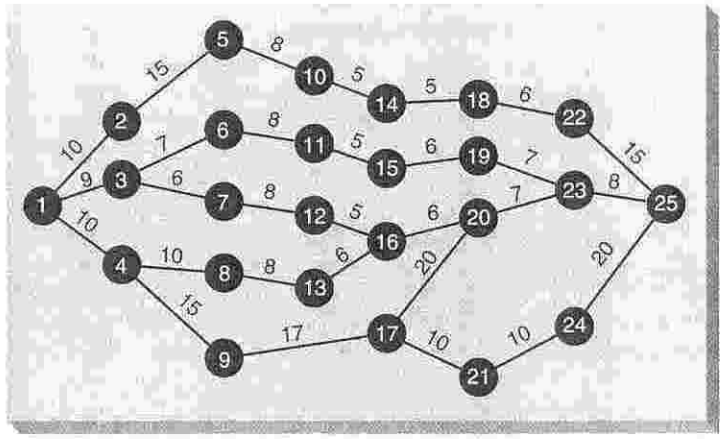


FIGURE 12.32
Network for Problem 12-30



INTERNET HOMEWORK PROBLEMS

See our Internet home page at **www.prenhall.com/render** for additional homework problems 12-31 through 12-35.

CASE STUDY

Binder's Beverage

Bill Binder's business nearly went under when Colorado almost passed the bottle bill. Binder's Beverage produced soft drinks for many of the large grocery stores in the area. After the bottle bill failed, Binder's Beverage flourished. In a few short years, the company had a major plant in Denver with a warehouse in east Denver. The problem was getting the finished product to the warehouse. Although Bill was not good with distances, he was good with times. Denver is a big city with numerous roads that could be taken from the plant to the warehouse, as shown in Figure 12.33.

The soft drink plant is located at the corner of North Street and Columbine Street. High Street also intersects North and Columbine Street at the plant. Twenty minutes due north of the

FIGURE 12.33
Street Map for Binder's Beverage Case