a. How long do you estimate the time required to install the second pool?

b. How long do you estimate the time required to install the fourth pool?

19. Return to Problem 18. Using OM Explorer's *Learning Curves* Solver, how long do you estimate the time required to install the fifth pool? What is your estimate of the total time for all five pools?

20. The manager of Perrotti's Pizza collects data concerning customer complaints about pizza delivery. Either the pizza arrives late, or the wrong pizza is delivered.

Problem	Frequency
Topping is stuck to box lid	17
Pizza arrives late	35
Wrong topping or combination	9
Wrong style of crust	6
Wrong size	4
Pizza is partially eaten	3
Pizza never arrives	6

a. Use a Pareto chart to identify the "vital few" delivery problems. Comment on potential root causes of these problems and identify any especially egregious quality failures.

b. The manager of Perrotti's Pizza is attempting to understand the root causes of late pizza delivery and has asked each driver to keep a log of specific difficulties that create late deliveries. After one week, the logs included the following entries:

delivery vehicle broke down, couldn't make it across town to deliver second pizza in time, couldn't deliver four pizzas to four different customers in time, kitchen was late in producing order, got lost, order ticket was lost in production, couldn't read address on ticket and went to wrong house.

Organize these causes into a cause-and-effect diagram.

21. Smith, Schroeder, and Torn (SST) is a short-haul household furniture moving company. SST's labor force, selected from the local community college football team, is temporary and part-time. SST is concerned with recent complaints, as tabulated on the following tally sheet:

Complaint	Tally
Broken glass	𝍸 𝍸 III
Delivered to wrong address	𝍸 IIII
Furniture rubbed together while on truck	𝍸 𝍸 𝍸 𝍸
Late delivery	𝍸
Late arrival for pickup	𝍸 𝍸 𝍸 III
Missing items	𝍸 𝍸 𝍸 𝍸 𝍸 I
Nicks and scratches from rough handling	𝍸 𝍸
Soiled upholstery	𝍸 III

a. Draw a bar chart and a Pareto chart using OM Explorer to identify the most serious moving problems.

b. The manager of Smith, Schroeder, and Torn is attempting to understand the root causes of complaints. He has compiled the following list of issues that occurred during problem deliveries.

truck broke down, ran out of packing boxes, multiple deliveries in one day caused truck to be late, no furniture pads, employee dropped several items, drive got lost on route to address, ramp into truck was bent, no packing tape, new employee doesn't know how to pack, moving dolly has broken wheel, employee late to work

Organize these causes into a cause-and-effect diagram.

22. Rick DeNeefe, manager of the Golden Valley Bank credit authorization department, recently noticed that a major competitor was advertising that applications for equity loans could be approved within two working days. Because fast credit approval was a competitive priority, DeNeefe wanted to see how well his department was doing relative to the competitor's. Golden Valley stamps each application with the date and time it is received and again when a decision is made. A total of 104 applications were received in March. The time required for each decision, rounded to the nearest hour, is shown in the following table. Golden Valley's employees work 8 hours per day.

Decision Process Time (hours)	Frequency
8	8
11	19
14	28
17	10
20	25
23	4
26	10
Total	104

a. Draw a bar chart for these data.

b. Analyze the data. How is Golden Valley Bank doing with regard to this competitive priority?

23. Last year, the manager of the service department at East Woods Ford instituted a customer opinion program to find out how to improve service. One week after service on a vehicle was performed, an assistant would call the customer to find out whether the work had been done satisfactorily and how service could be improved. After one year of gathering data, the assistant discovered that the complaints could be grouped into the following five categories:

Complaint	Frequency
Unfriendly atmosphere	5
Long wait for service	17
Price too high	20
Incorrect bill	8
Needed to return to correct problem	50
Total	100

a. Use OM Explorer to draw a bar chart and a Pareto chart to identify the significant service problems.

b. Categorize the following causes of complaints into a cause-and-effect diagram: tools, scheduling, defective parts, training, billing system, performance measures, diagnostic equipment, and communications.

24. Oregon Fiber Board makes roof liners for the automotive industry. The manufacturing manager is concerned about product quality. She suspects that one particular failure, tears in the fabric, is related to production-run size. An assistant gathers the following data from production records:

Run	Size	Failures (%)	Run	Size	Failures (%)
1	1,000	3.5	11	6,500	1.5
2	4,100	3.8	12	1,000	5.5
3	2,000	5.5	13	7,000	1.0
4	6,000	1.9	14	3,000	4.5
5	6,800	2.0	15	2,200	4.2
6	3,000	3.2	16	1,800	6.0
7	2,000	3.8	17	5,400	2.0
8	1,200	4.2	18	5,800	2.0
9	5,000	3.8	19	1,000	6.2
10	3,800	3.0	20	1,500	7.0

a. Draw a scatter diagram for these data.

b. Does there appear to be a relationship between run size and percent failures? What implications does this data have for Oregon Fiber Board's business?

25. Grindwell, Inc., a manufacturer of grinding tools, is concerned about the durability of its products, which depends on the permeability of the sinter mixtures used in production. Suspecting that the carbon content might be the source of the problem, the plant manager collected the following data:

Carbon Content (%)	Permeability Index
5.5	16
3.0	31
4.5	21
4.8	19
4.2	16
4.7	23
5.1	20
4.4	11
3.6	20

a. Draw a scatter diagram for these data.

b. Is there a relationship between permeability and carbon content?

c. If low permeability is desirable, what does the scatter diagram suggest with regard to the carbon content?

26. The operations manager for Superfast Airlines at Chicago's O'Hare Airport noticed an increase in the number of delayed flight departures. She brainstormed possible causes with her staff:

- Aircraft late to gate
- Acceptance of late passengers
- Passengers arriving late at gate
- Passenger processing delays at gate
- Late baggage to aircraft
- Other late personnel or unavailable items
- Mechanical failures

Draw a cause-and-effect diagram to organize the possible causes of delayed flight departures into the following major categories: equipment, personnel, material, procedures, and "other factors" beyond managerial control. Provide a detailed set of causes for each major cause identified by the operations manager, and incorporate them in your cause-and-effect diagram.

27. Plastomer, Inc. specializes in the manufacture of high-grade plastic film used to wrap food products. Film is rejected and scrapped for a variety of reasons (e.g., opacity, high carbon content, incorrect thickness or gauge, scratches, and so on). During the past month, management collected data on the types of rejects and the amount of scrap generated by each type. The following table presents the results:

Type of Failure	Amount of Scrap (lbs.)
Air bubbles	500
Bubble breaks	19,650
Carbon content	150
Unevenness	3,810
Thickness or gauge	27,600
Opacity	450
Scratches	3,840
Trim	500
Wrinkles	10,650

Draw a Pareto chart to identify which type of failure management should attempt to eliminate first.

28. Management of a shampoo bottling company introduced a new 13.5-ounce pack and used an existing machine, with some modifications, to fill it. To measure filling consistency by the modified machine (set to fill 13.85 ounces), an analyst collected the following data (volume in ounces) for a random sample of 100 bottles:

a. Draw a histogram for these data.

b. Bottles with less than 12.85 ounces or more than 14.85 ounces are considered to be out of specification. Based on the sample data, what percentage of the bottles filled by the machine will be out of specification?