29. Where does an MRP system work best?
30. Where does a Kanban system work best?
31. Where does a drum-buffer-rope system work best?
32. Can MRP and Kanban be used at the same time and if so how?

PROBLEMS

15.1. A company carries 10 items in stock, each with an economic-order quantity of $20,000. Through a program of component standardization, the 10 items are reduced to 5. The total annual demand is the same, but the annual demand for each item is twice what it was before. In Chapter 10, we learned that the economic-order quantity varies as the square root of the annual demand. Since the annual demand for each item is now doubled, calculate:

a. The new EOQ.

b. The total average inventory before standardization.

c. The total average inventory after standardization.

15.2. In problem 15.1, if the annual carrying cost is 20% per unit, what will be the annual savings in carrying cost?

15.3. A company has an annual demand for a product of 1000 units, a carrying cost of $20 per unit per year, and a setup cost of $100. Through a program of setup reduction, the setup cost is reduced to $10. Run costs are $2 per unit. Calculate:

a. The EOQ before setup reduction.

b. The EOQ after setup reduction.

c. The total and unit cost before and after setup reduction.

15.4. A company produces a line of golf putters composed of three models. The demand for model A is 500 per month, for B is 400, and for C is 300. What would be the mixed-model sequence if some of each were made each day?

Answer. ABC, ABC, ABC, ABA

15.5. The following MPS summary schedule is leveled for capacity. Using the following table, level the schedule for material as well.

Week	1	2	3	4	5
Model A			800	1600	1600
Model B	600	1600	800		
Model C	1000				
Total					

Answer.

Week	1	2	3	4	5
Model A	800	800	800	800	800
Model B	600	600	600	600	600
Model C	200	200	200	200	200
Total					

15.6. Bill builds benches in a small shop and he plans to operate five 8-hour days per week. Each bench has two ends and a top. It takes 5 minutes to cut and sand each end and 3 minutes to make each top. Assembly requires 10 minutes per bench, and painting requires 5 minutes per bench. Bill has one employee who makes the tops and ends. Bill will do the final assembly and painting. He also plans 1 hour per day for setup and teardown for each department.

a. How many benches should he plan to build per week?

b. How many hours per week are required for each person?

c. Suggest ways to increase the number of benches produced per week.

15.7. Parent W requires one of component B and two of component C. Both B and C are run on work center 10. Setup time for B is 2 hours, and run time is 0.1 hour per piece. For component C, setup time is 2 hours, and run time is 0.15 hour per piece. If the rated capacity of the work center is 80 hours, how many Ws should be produced in a week?

Answer. 190 Ws

15.8. Parent S requires three of component T and two of component U. Both T and U are run on work center 30. Setup time for T is 7 hours, and run time is 0.1 hour per piece. For component U, setup time is 8 hours, and run time is 0.2 hour per piece. If the rated capacity of the work center is 120 hours, how many Ts and Us should be produced in a week?

Answer. 450 Ts and 300 Us a week

CASE STUDY 15.1

Murphy Manufacturing

When Joe Vollbrach, vice president of operations for Murphy Manufacturing, was given the CEO's directive to investigate the lean production concepts and to implement them if appropriate; he was slightly apprehensive. Everyone knew, he thought, that MRP was the best way to run a manufacturing operation, and they had been pretty successful with their MRP system. Once he read a couple of books and a magazine article or two about JIT and lean production, however, he thought maybe there was something to it and it sure seemed simple enough. Dozens of companies had reported great reductions in inventory cost and other forms of waste, and with Murphy Manufacturing having only five to six inventory turns per year, the prospect of significant inventory reductions was very appealing.

Encouraged with the success stories and very mindful of the CEO directive, Joe wasted no time. He put out the directive to all his people to implement lean production the way it was working in the book examples he had read. A few months later, however, he was beginning to wonder about the truth of the success stories in those books. The following are some of the examples of the complaints he was getting and the problems he was facing.

KAREN, THE PURCHASING MANAGER: "Joe, this JIT and lean production are a disaster for us. It's not only costing us a lot more money, but the suppliers are getting real angry with us. Since our raw material inventory had typically been high, you said we should order smaller quantities and have it delivered just in time for its need. Sure, that cut down on the raw material inventory, but that cost saving has been more than made up for with all the increased cost. First, purchase orders are not cost free, and we're making a lot more of them. That's also taking up a lot more of our buyer's time. Then there's the transportation cost. Since most of the trucking companies charge a lot more for less-than-full truckloads, our costs are going sky-high with more frequent deliveries of smaller loads. Combine that with expediting costs, and it gets really bad. Our schedules are changing even more frequently, and without the raw material the production people are often asking for next-day delivery of material they need for a schedule change. We're flying more parts in, and you know how much that costs!

3. Name and describe the eight dimensions to quality.
4. What is total quality management, and what are its objectives?
5. What are the six basic concepts of TQM?
6. What does *customer focus* mean? Who is the customer?
7. What is empowerment, and why is it important in TQM?
8. What are the three key factors in supplier partnerships?
9. What is the purpose of performance measurement?
10. Quality costs fall under two categories. Name each category and think of an example to illustrate the category.
11. What is chance variation? What are its causes? How can it be altered?
12. What is assignable variation?
13. What is a normal distribution? Why is it important in quality control?
14. What is the arithmetic mean or average?
15. What is meant by *process spread*? What are the two measures of it?
16. What percentage of the observations will fall within 1, 2, and 3 standard deviations of the mean?
17. In which two ways can a process create defects?
18. What is tolerance, and how does it relate to the USL and LSL?
19. What is the purpose of the process capability index C_p and the C_{pk}? How do they differ?
20. What is the purpose of process control? What kind of variation does it try to detect?
21. What is a run chart?
22. What is an $\overline{X}$ and R chart?
23. What are upper and lower control limits?
24. What is the difference between variables and attributes?
25. When is it appropriate to use 100% inspection?
26. What is acceptance sampling? When is it appropriate to use?
27. What are the consumer's risk and the producer's risk?
28. Why was the third-party registration system established for ISO 9000 certification?
29. What is benchmarking, and how is it different from continuous improvement?
30. What is the first step in Quality Function Deployment? What is the output from QFD?
31. List three similarities and three differences between Lean Production and TQM.
32. What does the acronym *VOC* stand for?
33. What technique is used to organize the VOC?

PROBLEMS

16.1. The specification for the length of a shaft is 12 inches ± 0.001 inch. If the process standard deviation is 0.00033, approximately what percentage of the shafts will be within tolerance?

Answer. There are approximately 99.7% of shafts within tolerance.

16.2. In problem 16.1, if the tolerance changes to +0.0007 inch, approximately what percentage of the shafts will be within tolerance?

16.3. The specification for the thickness of a piece of steel is 0.5 inch ± 0.05 inch. The standard deviation of the band saw is 0.015. Using C_p, calculate whether the process is capable or not.

Answer. $C_p = 1.11$. Process is marginally capable.

16.4. The specification for the weight of a chemical in a compound is ±0.05. If the standard deviation of the weighing scales is 0.02, is the process considered capable?

16.5. The specification for the diameter of a hole is 0.75 inch ± 0.015 inch. The standard deviation of the drill press is 0.007 inch. Using C_p, calculate whether the process is capable or not.

16.6. If, in problem 16.5, the process is improved so the standard deviation is 0.0035, is the process capable now?

Answer. Process is capable.

16.7. In problem 16.6, what is the C_{pk} when

a. The process is centered on 0.75? Is the process capable?

b. The process is centered on 0.74? Is the process capable?

Answer. a. $C_{pk} = 1.43$. Process centered on 0.75. The process is capable.

b. $C_{pk} = 0.24$. Process centered on 0.74. The process is not capable

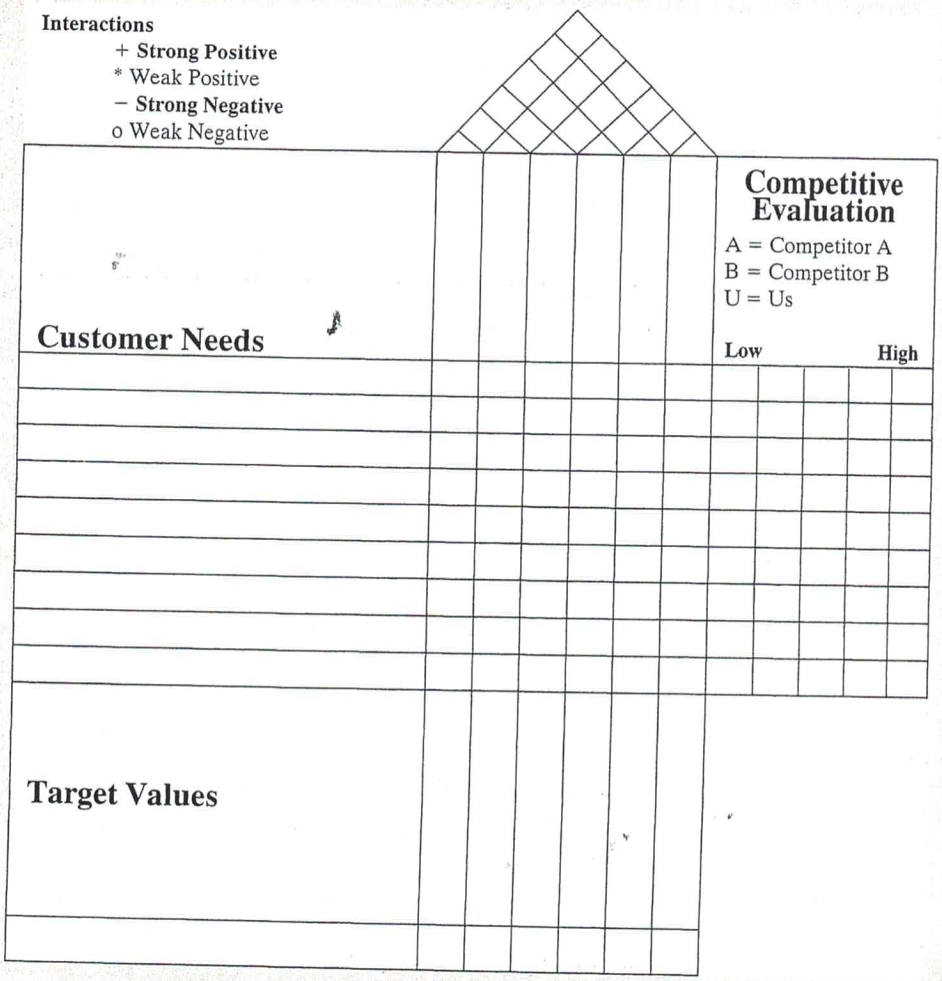
16.8 A company fills plastic bottles with 8 ounces of shampoo. The tolerance is ±0.1 ounce. The process has a standard deviation of 0.02 ounce. For the following situations, calculate the C_{pk} and evaluate the process capability.

a. A sample has an average of quantity of 7.93 ounces.

b. A sample has an average of quantity of 7.98 ounces.

c. A sample has an average of quantity of 8.04 ounces.

16.9. Create a House of Quality for a product familiar to you and complete the House of Quality form. Pick at least three different brands of the product to make the competitive comparison. List at least three customer needs inherent in the products and three features that deliver these needs. Identify the interactions among the features and establish target values for your new and improved product.



d. Process components.
e. Suppliers.
f. Environment.

28. What are the six symbols used in method analysis? Are there other symbols that can be used?
29. Describe each of the following:
    a. Operations process chart.
    b. Process flow diagram.
30. What is the purpose of the analysis step in continuous process improvement? What is the basic question?
31. What are the four approaches that should be taken when developing a better method?
32. What are the four principles of motion economy?
33. Describe job design.
34. What is the learning curve?
35. What might be some of the advantages and disadvantages of self-directed work teams?
36. How might the learning curve impact standard production times used for planning? How would you possibly deal with this impact?
37. How might an application of Little's Law prove useful?
38. What is meant by the term "business environment"?
39. Select a product with which you are familiar. How do you think it might be redesigned to make it easier to manufacture and possibly more useful to the user?

PROBLEMS

14.1. Given the following fixed and variable costs and the volumes, calculate the total and unit costs.

Fixed cost	Variable cost	Volume (units)	Total cost	Unit cost
$200.00	$10.00	100		
$200.00	$7.00	1000		
$50.00	$15.00	20		
$1,000.00	$1.00	2000		
$500.00	$20.00	500		

14.2. A process costs $200 to set up. The run time is 5 minutes per piece and the run cost is $30 per hour. Determine the following:

a. The fixed cost.
b. The variable cost.
c. The total cost and unit cost for a lot of 600.
d. The total cost and unit cost for a lot of 1200.

Answer. a. Fixed cost = $200.00
b. Variable cost = $2.50
c. Total cost = $1450.00
   Unit cost = $2.90
d. Total cost = $2700.00
   Unit cost = $2.70

14.3. A manufacturer has a choice of purchasing and installing a heat-treating oven or having the heat treating done by an outside supplier. The manufacturer has developed the following cost estimates:

	Heat Treat In-house	Purchase Services
Fixed cost	$28,000.00	$0.00
Variable cost	$10.00	$17.00

a. What is the cost equalization point?

b. Should the company have the heat treating done outside if the annual volume is 3000 units? 5000 units?

c. What would be the unit (average) cost for the selected process for each of the volumes in b above?

Answer. a. CEP = 4000 units

b. Volume 3000 units purchase services;
Volume 5000 units heat treat in-house

c. Unit cost for 3000 units is $17.00; for 5000 units is $15.60

14.4. Bananas are on sale at the Cross Towne store for 79¢ per pound. They normally sell for 99¢ per pound at your corner store. If round-trip bus fare costs $3.60 to the Cross Towne store, is it worth going? Discuss other ways of taking advantage of this bargain.

14.5. Given the following costs, which process should be used for an order of 400 pieces of a given part? What will be the unit cost for the process selected?

	Buy	Process A	Process B
Setup		$40.00	$180.00
Tooling		$10.00	$20.00
Labor/unit		$4.10	$3.80
Material/unit		$2.00	$2.00
Purchase cost	$6.10		

14.6. The Light Company is planning on producing a new type of light shade, the parts for which may be made or bought. If purchased, they will cost $2 per unit. Making the parts on a semiautomatic machine will involve a $5000 fixed cost for tooling and $1.30 per unit variable cost. The alternative is to make the parts on an automatic machine. The tooling costs are $15,000, but the variable cost is reduced to 60¢ per unit.

a. Calculate the cost equalization point between buying and the semiautomatic machine.

b. Calculate the cost equalization point between the semiautomatic and automatic machines.

c. Which method should be used for expected sales of the following?
   i. 5000 units
   ii. 6000 units
   iii. 8000 units
   iv. 10,000 units
   v. 25,000 units

d. What is the unit cost for the selected process for each of the sales in c above?

Answer. i. Unit cost = $2.00
ii. Unit cost = $2.00
iii. Unit cost = $1.925
iv. Unit cost = $1.80
v. Unit cost = $1.20

Operation	1	attach clip to upper barrel
	2	insert button into upper barrel
	3	insert rotor into upper barrel
	4	press ball into tip of cartridge
	5	insert tip into cartridge
	6	fill cartridge with ink
Inspection	1	test cartridge
Operation	7	insert cartridge into upper barrel
	8	slip spring over cartridge
	9	screw lower barrel and upper barrel together
Inspection	2	test operation of pen
	3	final inspection

14.12. Draw a process flow diagram for your activities from the time you wake up until you arrive at work. Can you think of ways to improve the process?

14.13. A process can produce a final product at the rate of 2 products per minute. If an individual product takes 30 minutes to pass through the process, what is the inventory of products in the process at any time?

14.14. A university registration process can register a person every 4 minutes. If there are an average of 10 people in line for the registration, how long will each person have to wait in line?

CASE STYDY 14.1

Cheryl Franklin, Production Manager

Cheryl Franklin had been production manager at Cooper Toy Company for only a week when she started to wonder if her promotion had really been a good thing. Her boss was concerned that production was falling behind on one of their newest toys. The company had spent a lot to advertise the toy and the demand that had been created was not being met by production.

Cheryl decided to try to investigate to discover the problem and try to get the production volume back on track. Unfortunately, she found that almost everyone involved was blaming someone else.

The toy in question was one of those plastic water guns popular at beaches and swimming pools. Water is held in a reservoir and then air is pumped into the gun, allowing a fairly large stream of water to be shot about 10 meters.

Cheryl knew that the slowest part of the production line that she was using to produce the toy should be able to produce one every 3 minutes, and she also knew that the demand averaged only about one toy every 5 minutes. When she started her investigation at the assembly area, however, she found that assembly was averaging only one toy every 10 minutes. The assembly supervisor had a good explanation, however. He said that they didn't have enough inventory to work on. They were getting the water tanks being released from inspection on average only one every 8 minutes, so they were assembling the toys as fast as they could.

When Cheryl went to the inspection area, she discovered that there were lots of tanks waiting there to be inspected. The inspector assigned to the tanks appeared to be working hard, but obviously that was the problem.

Cheryl talked to the quality manager and got quite a bit more information. To quote the quality manager, "Look, we need to put those tanks through some important testing. If a child pumps too much air into the tank they are designed to let some of the air out through a relief valve. Unfortunately, a lot of the tanks have improperly glued seams. If one of those bad tanks gets on a toy then the tank is liable to rupture before the relief value activates. That rupture could send pieces of plastic flying. The last thing we need is to have some child get injured with flying plastic. We find that we have to inspect every tank since the reject rate on the gluing of the seams has been running close to 20 percent!"