Answers to Problems

1. The system capacity is 4,650 units per hour and B is the bottleneck department. The bottleneck department restricts the flow of product from up-stream departments and starves downstream departments.

3. a. The system capacity can be increased by 100 tons per hour to 2,500 by adding capacity to the bottleneck department, which is department C. When sufficient capacity is added to department C, the bottleneck will shift to department D.

   b. To increase the input to department D by 100 tons per hour, the following increase in capacity for department C must occur.

   Capacity increase for dept. C = 2/3(100 tons/hr.)
   = 66.67 tons/hr.

   Because two parts of the input to department D must come from department C, 2/3 of the 100 tons per hour must come from department C.

   c. D is now the bottleneck department.

5. a. Calculate the production rate in square feet per hour for each width. Then determine the production rate based on the mix.

Width	**Calculation**	**Production Rate**
36	((36 in.)/(12 in./ft.))(200 ft./min.)(60 min./hr.)	36,000 s.f./hr.
50	((50 in.)/(12 in./ft.))(200 ft./min.)(60 min./hr.)	50,000 s.f./hr.
60	((60 in.)/(12 in./ft.))(200 ft./min.)(60 min./hr.)	60,000 s.f./hr.

PR = (36,000 s.f./hr.)(.3) + (50,000 s.f./hr.)(.25) + (60,000 s.f./hr.)(.45)
= 50,300 s.f./hr.

Capacity = (50,300 s.f./hr.)(80 hr./wk.)
= 4,024,000 s.f./wk.

   b. The capacity based on the new mix is:

PR = (36,000 s.f./hr.)(.4) + (50,000 s.f./hr.)(.4) + (60,000 s.f./hr.)(.2)
= 46,400 s.f./hr.

Capacity = (46,400 s.f./hr.)(80 hr./wk.)
= 3,712,000 s.f./wk.

   c. The capacity would increase by 10 percent, because the number of hours worked per week increased by 10 percent.

Capacity = (50,300 s.f./hr.)(80 hr./wk.)(1.10)
= 4,426,400 s.f./wk.

   d. The capacity would decline by 5 percent because the number of hours worked per week would decline.

Capacity = (50,300 s.f./hr.)(80 hr./wk.)(.95)
= 3,822,800 s.f./wk.

e. The production rate would increase because the machine speed has increased. This would cause the capacity to increase. Students who understand the impact may go directly to the capacity and increase it by 10 percent. Otherwise, they must recalculate the production rates for each size.

Width	**Calculation**	**Production Rate**
36	((36 in.)/(12 in./ft.))(220 ft./min.)(60 min./hr.)	39,600 s.f./hr.
50	((50 in.)/(12 in./ft.))(220 ft./min.)(60 min./hr.)	55,000 s.f./hr.
60	((60 in.)/(12 in./ft.))(220 ft./min.)(60 min./hr.)	66,000 s.f./hr.

PR = (39,600 s.f./hr.)(.3) + (55,000 s.f./hr.)(.25) + (66,000 s.f./hr.)(.45)
= 55,330 s.f./hr.

Capacity = (55,330 s.f./hr.)(80 hr./wk.)
= 4,426,400 s.f./wk.

7. a. To find the bottleneck department, first convert the capacity of each operation from units per week to bicycles per week. This requires that any component with more than one unit per finished bicycle to adjust its capacity to reflect the requirement per bicycle. For example, there are two wheels on each bicycle so the capacity of the wheel operation would be 375 bicycles per week rather than 750 wheels per week.

Component	**Quantity/ Finished Bicycle**	**Capacity (units/week)**	**Capacity (bicycles/week)**
Wheels	2	750	375
Tires	2	900	450
Frames	1	400	400
Brakes	2	950	475
Handle bars	1	600	600
Pedal and drive sprocket subassembly	1	500	500

The capacity of the system is 350 bicycles per week and the bottleneck department is assembly.

b. If 10 percent overtime is applied to assembly, its capacity will be (350 bicycles/wk.)(1.1) = 385 bicycles/wk. The bottleneck department will be the wheel-making department and the capacity will be 375 units per week.

c. The capacity of assembly, wheel-making, and frame-making would have to be increased. For assembly, the capacity must go from 350 to 450 bicycles per week unless the organization plans to consistently work overtime in assembly, which brings capacity to 385 bicycles/week. If that is the case, then the capacity must go from 385 to 450 bicycles per week. For wheel-making, the capacity in bicycles must go from 375 to 450 bicycles per week, but in individual units the capacity must go from 750 to 900 units per week. For frame-making, the capacity must go from 400 to 450 bicycles per week.

9. Department A can deliver 100 gallons/hour, but department B can process only 60 gal./hr. So far, department B is the bottleneck. At the next step, outputs from departments B and C must be combined 1:1 so the most they can deliver is 100 gal./hr. Department D has sufficient capacity to process the 100 gal./hr. so it cannot be the bottleneck. Next, departments E and F combine in a ratio of 2 to 1 to deliver a maximum of 120 gal./hr. to department G. Department F limits the capacity of the system because it can only deliver 40 gals./hr. to mix with 80 gal./hr. from department E. Department G has sufficient capacity to process the entire 120 gal./hr. As a result, the system capacity is 120 gal./hr. and department F is the bottleneck.

a. The system's capacity is 120 gallons/hour.

b. The bottleneck is department F.

c.

Department	**Capacity (gal./hr.)**	**Production Rate to Achieve a System Capacity of 120 (gal./hr.)**	**Slack (gal./hr.)**
A	100	40	60
B	60	40	20
C	50	40	10
D	120	80	40
E	100	80	20
F	40	40	0
G	140	120	20

d. Set the capacity of the bottleneck department to infinity and rework the problem. Department G is the bottleneck and the system capacity is 140 gal./hr. Therefore, the capacity of department F = (1/3)(140 gal./hr.) = 46.7 gal./hr.

11. a. At capacity, the company can produce 1,600,000 integrate circuits that meet specifications (2,000,000 units)(.80).

b. The unit variable cost declines by $.278 per unit from $2.50 at 80% yield to 2.22 at 90% yield. The unit cost equations indicate that total cost is driven by what is produced (2,000,000) both good and bad, but unit cost is determined by the number of “good” units that can be sold. These “good” units must absorb all of the cost.

Unit Variable cost @80% = (2,000,000 units)($2.00)/1,600,000 units
= $2.50
Unit Variable cost @90% = (2,000,000 units)($2.00)/1,800,000 units
= $2.222

c. Profit increases by $2,400,000. The unlimited demand means that the company can sell everything that it produces. At 80% yield, the profit is $5,200,000. The company can sell only the good units, but it must absorb the cost to produce all of the units. As yield increases to 90%, the production costs do not increase. The company is still making 2,000,000 units, but the process has been improved so that 200,000 units are good rather than not good. This brings us to a potential short cut. Because the 200,000 units are produced at no cost, the revenue for these units actually represent profit (200,000)($12)= $2,400,000.

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Profit @80% = (1,600,000)($12)-((2,000,000)($2)+10,000,000))
            = $5,200,000
Profit @90  = (1,800,000)($12)-((2,000,000)($2)+10,000,000))
            = $7,600,000
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d. Profit increases by $444,444. In this version, demand is limited to 1,600,000 units so the company can only sell 1,600,000 units even though it can produce 1,800,000 good units if the yield increases to 90%. However, there is still a benefit to the increase in yield. As the yield increases to 90%, fewer than 2,000,000 units must be produced to make 1,600,000 good units. In fact only 1,777,777 units must be produced if the yield is 90% ((1,600,000 units)/(.90)=1,777,778 units). This profit increase is driven by the $.278 unit variable cost reduction achieved when the yield increased from 80% to 90% as shown in part a of this problem (($.278/unit)(1,600,000 units)= $444,800). The difference is caused by rounding the unit cost.

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Profit @80% = (1,600,000)($12)-((2,000,000)($2)+10,000,000))
            = $5,200,000
Profit @90  = (1,600,000)($12)-((1,777,778)($2)+10,000,000))
            = $5,644,444
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e. The difference is caused by demand, which limits sales in part d to 1,600,000 units.