CHAPTER 6
MANUFACTURING PROCESSES

Discussion Questions

1. What is meant by a process? Describe its important features.

   A process means a set of tasks that transform input into useful outputs. The important features of process are (a) tasks, (b) flow (of material and information), and (c) storage (of material and information).

2. What is a *customer order decoupling point*? Why is it important?

   Essentially it is where inventory is stored awaiting demand from the customer. It is important because it affects the lead time to fulfill the customer's order and the amount of inventory investment necessary.

3. What's the relationship between the design of a manufacturing process and the firm's strategic competitive dimensions (Chapter 2)?

   There is a natural relationship between the location of the customer order decoupling point, the level of customization the manufacturer provides its customers, and delivery speed of the product to the customer. At one end of the spectrum we have make-to-stock *processes which produce in anticipation of demand, allowing inventory to be stored close to the customer for often instantaneous delivery. However, there is virtually no customization available in make-to-stock products. On the other end of the spectrum are* engineer-to-order processes*, where the product is designed from the start to exactly satisfy the customer's unique needs. Customization is maximized in an engineered-to-order product, but lead time is quite extensive.*

4. What is meant by *manufacturing process flow*?

   In a manufacturing process, material and information must move throughout the facility between manufacturing points and storage locations. The path that both material and information take as they move through the facility defines the process flow.

5. Why is it that reducing moves, delays, and storages in a manufacturing process is a good thing? Can they be completed eliminated?

   While unavoidable to some extent, all three of these add time to the process while adding no value to the product. Reduction of these will reduce the time it takes to manufacture a product and thereby improve the process' flow.

6. What does the product-process matrix tell us? How should the kitchen of a Chinese restaurant be structured?

   The Chinese restaurant case might be debatable since it involves both high volume and high variety. Probably a work cell would be best.

7. It has been noted that during World War II Germany made a critical mistake by having its formidable Tiger tanks produced by locomotive manufacturers, while American car manufacturers produced the less formidable U.S. Sherman tank. Use the product-process matrix to explain that mistake and its likely result.

   The locomotive manufacturers likely used project technology and processes. This is low volume, high cost production. On the other hand, mass-producing automakers had the technology to make high volume at low per unit cost.

8. "How does the production volume affect the selection of a process and profitability?"

   A break-even analysis takes into account the production volume and the relevant cost of producing the volume by the available alternative processes. It calculates the relative profit or loss of the alternative processes, thus helping to decide which alternative to choose for a certain volume of production.

9. What is the objective of assembly-line balancing? How would you deal with the situation where one worker, although trying hard, is 20 percent slower than the other 10 people on the line?

   The objective of assembly line balancing is to assign all tasks needed to make an assembled item to the different workstations on an assembly line in a feasible manner considering precedence relationships between all of the tasks. Criteria for comparing alternative solutions would include minimizing the number of workstations needed to meet a specified cycle time, or minimizing the resultant cycle time given a fixed number of workstations.

   In the case of the relatively slow worker, there are several possible responses that might be appropriate given the situation. Additional training might help the employee perform faster. The employee could also be assigned to the workstation with the minimum total task time, although one could argue that this approach is simply hiding a problem employee. If the workstations have multiple workers assigned, the slow worker could be paired with the fastest workers on the line, which would have the dual benefit of balancing out the workstation speed and helping the slow worker learn how to be more efficient. As a last resort, the employee could be reassigned or fired.

Objective Questions

1. What is the first of the three simple steps in the high-level view of manufacturing?

    Sourcing the parts we need.

2. The customer order decoupling point determines the position of what in the supply chain?

    Inventory

3. Dell Computers' primary consumer business takes orders from customers for specific configurations of desktop and laptop computers. Customers must select from a certain model line of computer, and choose from available parts, but within those constraints may customize the computer as they desire. Once the order is received, Dell assembles the computer as ordered and delivers it to the customer. What type of manufacturing process is described here?

    Assemble-to-order

4. What term is used to mean manufacturing designed to achieve high customer satisfaction with minimum levels of inventory investment?

    Lean manufacturing

5. You are in a line at the bank drive-through and 10 cars are in front of you. You estimate that the clerk is taking about five minutes per car to serve. How long do you expect to wait in line?

    *Wait Time = 10 cars * 5 minutes each = 50 Minutes*

6. A firm has redesigned its production process so that it now takes 10 hours for a unit to be made. Using the old process, it took 15 hours to make a unit. If the process makes one unit each hour on average and each unit is worth $1,500, what is the reduction in work-in-process value?

    *Using Little's Law we know that Inventory = Throughput * Flowtime*
    *Before change: Inventory = 1 per hour * 15 hours = 15 * $1500 = $22,500*
    *After change: Inventory = 1 per hour * 10 hours = 10 * $1500 = $15,000*
    Reduction in WIP = $22,500 - $15,000 = $7,500

7. The Avis Company is a car rental company and is located three miles from the Los Angeles airport (LAX). Avis is dispatching a bus from its offices to the airport every 2 minutes. The average traveling time (a round trip) is 20 minutes.
    a. How many Avis buses are traveling to and from the airport?

        The throughput rate is 30 buses per hour. The throughput time is 20/60 =1/3 hours.
        *Inventory = Throughput * Flowtime = 30 * 1/3 = 10 buses are traveling to and from the airport at any one time.*

b. The branch manager wants to improve the service and suggests dispatching buses every 0.5 minutes. She argues that this will reduce the average traveling time from the airport to Avis's offices to 2.5 minutes. Is she correct? If your answer is negative, then what will the average traveling time be?

This reduces the average waiting time, but has no effect on the average traveling time. The average traveling time does not change and will remain 20 min. This would however result in 40 buses being in transit between the airport and the office at any given time. Does Avis have that many buses?

8. Safety regulations require that the time between airplane takeoffs (on the same runway) will be at least 3 minutes. When taking off, the run time of an airplane on the runway is 45 seconds. Planes are on average waiting 4 minutes and 15 seconds for take-off. On average there are 15 planes taking off per hour. How many planes are either on the runway or waiting to take off?

TR = 15 planes per hour. TT = (0.75 +4.25)/60 = 1/12 of an hour.
*WIP = TT * TR = 15 * 1/12 =* ***1.25*** *airplanes in line or taking off.*

9. In Children's Hospital in Seattle there are on average 60 births per week. Mothers and babies stay, on average, two days before they leave the hospital. In Swedish hospital (also in Seattle), the average number of births per week is 210. Mothers and children stay in the hospital two days on average.

a. How many new mothers are staying in Children's Hospital?

TR = 60 per week, TT = 2/7 weeks.
*WIP = TT *TR = 60*2/7 = 120/7 = 17.1*
On average there are 17.1 new mothers in the Children's Hospital.

b. How many new mothers are staying in Swedish Hospital?

TR = 210 per week, TT = 2/7 weeks.
*WIP = TT * TR = 210*2/7 = 60.*
On average there are 60 new mothers in Swedish Hospital.

c. The directors of the two hospitals are negotiating unifying the children wards of the two hospitals. They believe that by doing so they will be able to reduce the number of new mothers staying in the hospital. Are they correct? How many new mothers will stay, on average, in the unified ward?
You may assume that the average number of births and the lengths of stay of the new mothers will not change.

TR = 270 per week, TT = 2/7 weeks.
*WIP = TT * TR = 270*2/7 = 540/7 = 77.1*
On average there will be 77.1 new mothers in the unified hospital. No, it will not decrease the total number of mothers in the hospital.

10. A call center employs 1,000 agents. Every month 50 employees leave the company and 50 new employees are hired.
    a. How long on average does an agent work for this call center?

       Throughput Rate = 50 people/month. WIP = 1000 people.
       Average working time = Throughput Time = WIP/TR = 1000/50 = 20 months.

    Suppose the cost of hiring and training a new agent is $1,000. The manager of this call center believes that increasing agents' salaries would keep them working longer at the company. The manager wants to increase the average time that an agent works for the call center to 24 months, or two years.

    b. If an agent works for the call center for 24 months on average, how much can the company save on hiring and training costs over a year? Hint: first determine the current annual cost for hiring and training, then determine the new annual cost for hiring and training.

       Current annual cost for hiring and training:
       Throughput Rate = 50 people/month = 600 people/year
       *Annual hiring and training cost is 600*1000=$600,000*

       New annual cost for hiring and training:
       Average working time = Throughput Time = 24 months = 2 years
       Throughput Rate = WIP/TT = 1000 people/ 2 years = 500 people/ year
       *Annual hiring and training cost is 500*1000=$500,000.*
       Annual saving on hiring and training cost is $100,000

11. Money Laundry has 10 washers and 15 dryers. All orders are first sent to wash and then to dry. It takes on average 30 minutes to wash one order and 40 minutes to dry.
    a. What is the capacity of the washing stage?

       *10 * 60/30 = 20 orders / hour*

    b. What is the capacity of the drying stage?

       *15 * 60/40 = 22.5 orders/ hour*

    c. Identify the bottleneck(s). Briefly explain.

       Washers. That stage has the lowest processing rate.

    d. What is the capacity of Money laundry? Briefly explain.

       20 orders/hour. The bottleneck limits the output of the entire system.

    e. If Money laundry would like to increase the capacity by buying one more machine, should they buy a washer or a dryer? Why?

       Washer as that is the bottleneck.

    The manager, Mr. Money, decided not to buy a machine. He still has 10 washers and 15 dryers. The manager estimates that on average Money Laundry receives 8 orders every hour. The manager also finds that on average there are 5 orders in the washing stage and 7 orders in the drying stage.

    f. What is the utilization of washers, on average?

8 orders/hour / 20 orders/hour = 40%

g. What is the utilization of dryers, on average?

8 orders/hour / 22.5 orders/hour = 35.56%

h. On average, how long does it take an order to finish washing process, from the time the order is received?

WIP = 5, TR = 8 orders/hour. TT = WIP / TR = 5/8 = 0.625 hour or 37.5 minutes.

i. On average, how long does it take an order to finish drying process, from the time the order finishes the washing process?

WIP = 7, TR = 8 order/hour. TT = WIP / TR = 7/8 = 0.875 hour or 52.5 minutes.

j. On average, how long does an order stay in Money laundry?

0.625+0.875 = 1.5 hour.

Double check: WIP = 5+7=12, TR = 8 order/hour. TT = 12/8 = 1.5 hour.

12. How would you characterize the most important difference for the following issues when comparing a workcenter (job shop) and an assembly line?

Issue	***Workcenter (Job Shop)***	***Assembly Line***
Number of setups (job changeovers)	*Many*	*Few*
Labor content of product	*High*	*Low*
Flexibility	*High*	*Low*

13. The product–process matrix is a convenient way of characterizing the relationship between product volumes (one-of-a-kind to continuous) and the processing system employed by a firm at a particular location. In the boxes presented below, describe the nature of the intersection between the type of shop (column) and process dimension (row).

	Workcenter	***Assembly Line***
Engineering Emphasis	*Product variety and improvements*	*Process improvements*
General Workforce Skill	*Skilled workforce*	*Lower skill levels*
Facility Layout	*Process, functional*	*Product, line, flow*
WIP Inventory Level	*Depends on the product*	*Lower*

14. For each of the following variables, explain the differences (in general) as one moves from a workcenter to an assembly line environment.

    a. Throughput time (time to convert raw material into product).

    Throughput time decreases as you move from a work center to assembly line environment. This is due to a reduction in non-value-added movement time plus time waiting in queue in a workcenter setup.

    b. Capital/labor intensity.

    Capital intensity increases as you move to an assembly line (need for more machinery). Labor intensity (assuming you mean # of workers) would probably increase as well (depends on the level of automation). Ratio would increase in an assembly line because capital requirements are so much greater.

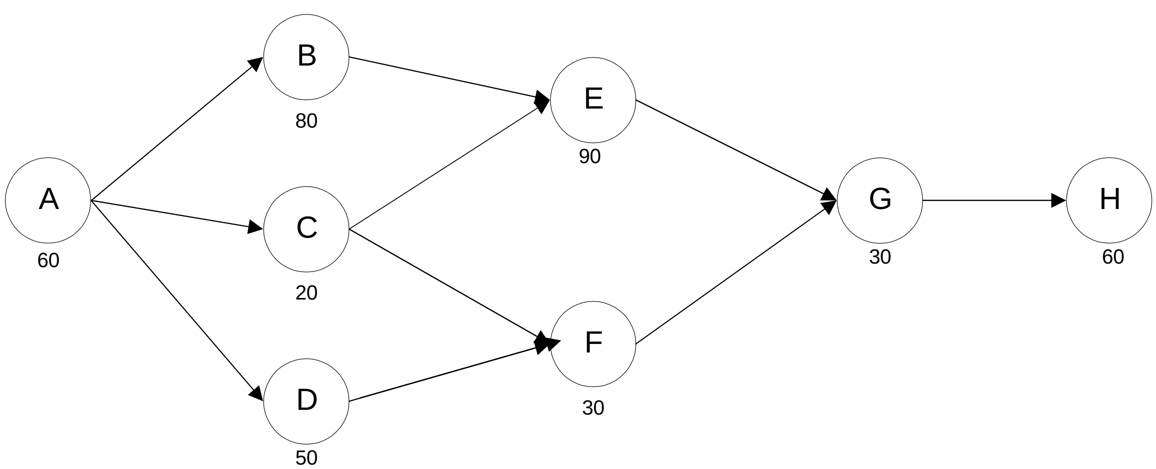
    c. Bottlenecks.

    Would probably decrease in an assembly line.

15. An assembly line is to operate eight hours per day with a desired output of 240 units per day. The following table contains information on this product's task times and precedence relationships:

Task	Task Time (Seconds)	Immediate Predecessor
A	60	—
B	80	A
C	20	A
D	50	A
E	90	B, C
F	30	C, D
G	30	E, F
H	60	G

a. Draw the precedence diagram.



b. What is the workstation cycle time required to produce 240 units per day?

C = production time per day/required output per day = (8 hour/day)(3600 seconds/hour)/240 units per day = 120 seconds per unit

c. Balance this line using the longest task time.

Work station	Task	Task time	Idle time
I	A	60	
	D	50	10
II	B	80	
	C	20	20
III	E	90	
	F	30	0
IV	G	30	
	H	60	30

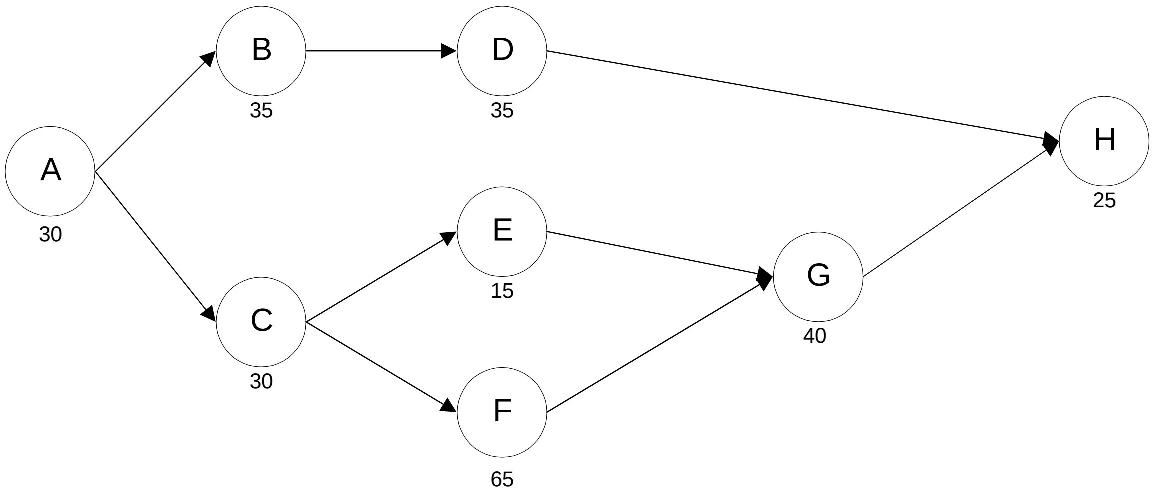
d. What is the efficiency of your line balance, assuming it is running at the cycle time from part (*b*)?

$$Efficiency = \frac{T}{N_a C} = \frac{420}{4(120)} = .875 \text{ or } 87.5\%$$

16. The desired daily output for an assembly line is 360 units. This assembly line will operate 450 minutes per day. The following table contains information on this product's task times and precedence relationships:

Task	Task Time (Seconds)	Immediate Predecessor
A	30	—
B	35	A
C	30	A
D	35	B
E	15	C
F	65	C
G	40	E, F
H	25	D, G

a. Draw the precedence diagram.



b. What is the workstation cycle time required to produce 360 units per day?

C = production time per day/required output per day = (450 minutes/day)/360units per day = 1.25 minutes per unit or 75 seconds per unit

c. Balance this line using the largest number of following tasks. Use the longest task time as a secondary criterion.

Work station	*Task*	*Task time*	*Idle time*
	A	*30*	
I	*C*	*30*	
	E	*15*	*0*
II	*F*	*65*	*10*
III	*B*	*35*	
	G	*40*	*0*
IV	*D*	*35*	
	H	*25*	*15*

d. What is the efficiency of your line balance, assuming it is running at the cycle time from part (b)?

$$Efficiency = \frac{T}{N_a C} = \frac{275}{4(75)} = .917 \text{ or } 91.7\%$$

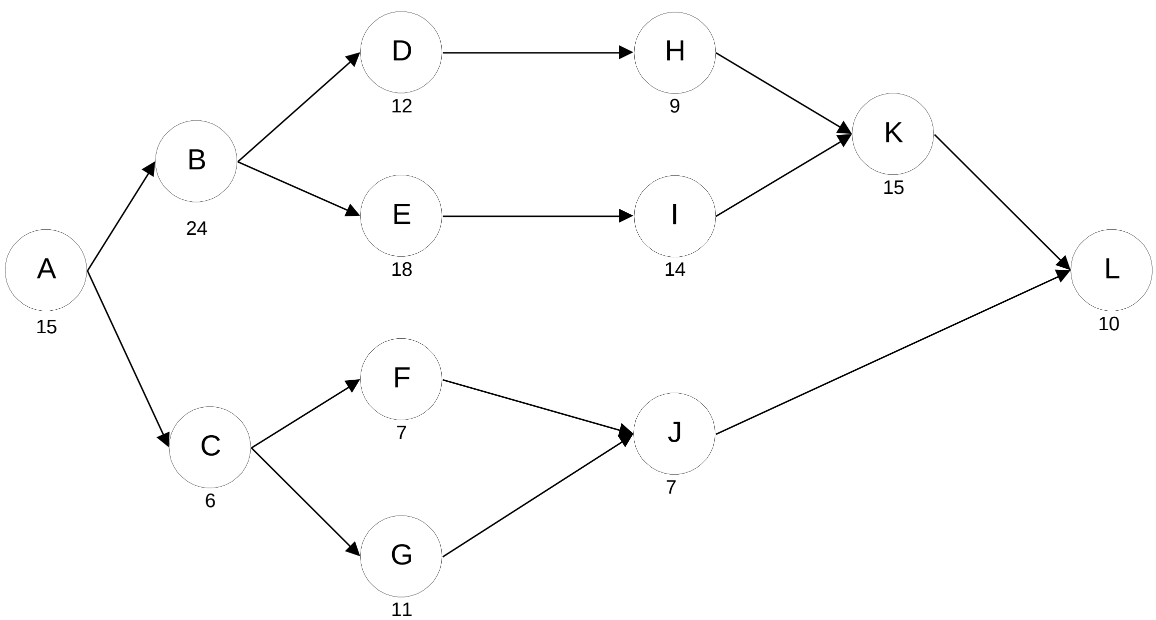
17. Some tasks and the order in which they must be performed according to their assembly requirements are shown in the following table. These are to be combined into workstations to create an assembly line. The assembly line operates 71⁄2 hours per day. The output requirement is 1,000 units per day.

Task	Preceding Tasks	Time (Seconds)	Task	Preceding Tasks	Time (Seconds)
A	—	15	G	C	11
B	A	24	H	D	9
C	A	6	I	E	14
D	B	12	J	F, G	7
E	B	18	K	H, I	15
F	C	7	L	J, K	10

a. What is the workstation cycle time required to produce 1,000 units per day?

C = production time per day/required output per day = (7.5 hour per day) (3600 seconds per hour)/1000units per day = 27 seconds per unit

b. Balance the line using the longest task time based on the 1,000-unit forecast, stating which tasks would be done in each workstation.



Work station	***Task***	***Task time***	***Idle time***
I	*A* *C*	*15* *6*	*6*
II	*B*	*24*	*3*
III	*E* *F*	*18* *7*	*2*
IV	*I* *D*	*14* *12*	*1*
V	*G* *H* *J*	*11* *9* *7*	*0*
VI	*K* *L*	*15* *10*	*2*

c. For (b), what is the efficiency of your line balance, assuming it is running at the cycle time from part (a)?

$$Efficiency = \frac{T}{N_a C} = \frac{148}{6(27)} = .914 \text{ or } 91.4\%$$

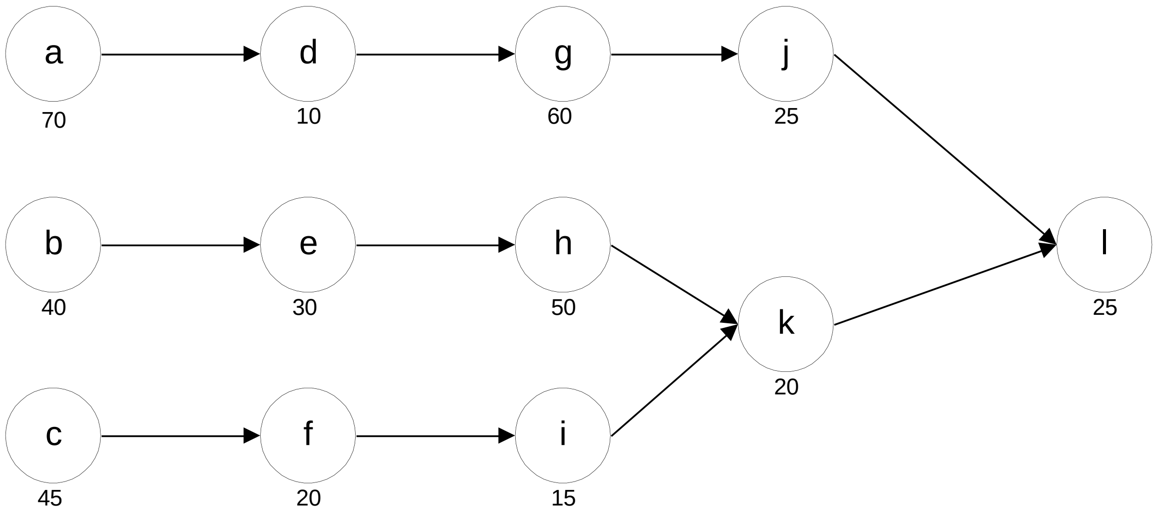
d. After production was started, Marketing realized that it understated demand and must increase output to 1,100 units. What action would you take? Be specific and quantitative in your answer.

*Reduce cycle time to 25 ((7.5*3600)/1100 = 24.54 seconds), which requires rebalancing the line or work overtime: (100 units) 27 seconds per unit = 2700 seconds or 45 minutes of overtime.*

18. An assembly line is to be designed to operate 71⁄2 hours per day and supply a steady demand of 300 units per day. Here are the tasks and their performance times:

Task	Preceding Tasks	Performance Time (Seconds)	Task	Preceding Tasks	Performance Time (Seconds)
a	—	70	g	d	60
b	—	40	h	e	50
c	—	45	i	f	15
d	a	10	j	g	25
e	b	30	k	h, i	20
f	c	20	l	j, k	25

a. Draw the precedence diagram.



b. What is the workstation cycle time required to produce 300 units per day?

C = production time per day/required output per day = (7.5 hour per day) (3600 seconds per hour)/300 units per day = 90 seconds per unit

c. What is the theoretical minimum number of workstations?

$$N_i = \frac{T}{C} = \frac{410}{90} = 4.56 \rightarrow 5 \text{ work stations}$$

d. Assign tasks to workstations using the longest operating time.

Workstation	Task	Task time	Idle time
I	*a*	*70*	
	d	*10*	*10*
II	*g*	*60*	
	j	*25*	*5*
III	*c*	*45*	
	b	*40*	*5*
IV	*e*	*30*	
	h	*50*	*10*
V	*f*	*20*	
	i	*15*	
	k	*20*	
	l	*25*	*10*

e. What is the efficiency of your line balance, assuming it is running at the cycle time from part (b)?

$$\textit{Efficiency} = \frac{T}{N_a C} = \frac{410}{5(90)} = .911 \text{ or } 91.1\%$$

f. Suppose demand increases by 10 percent. How would you react to this? Assume that you can operate only 71⁄2 hours per day.

Reduce cycle time, say, to 81 seconds per unit. This produces (7.5 hours)(3600 seconds per hour)/81 seconds per unit = 333.3 units. Another option is to work 45 minutes overtime (7.5 x 10% = .75 hour or 45 minutes). There are many other options possible that are combinations of these two options.

19. The following tasks are to be performed on an assembly line:

Task	Seconds	Tasks That Must Precede
A	20	—
B	7	A
C	20	B
D	22	B
E	15	C
F	10	D
G	16	E, F
H	8	G

The workday is seven hours long. Demand for completed product is 750 per day.

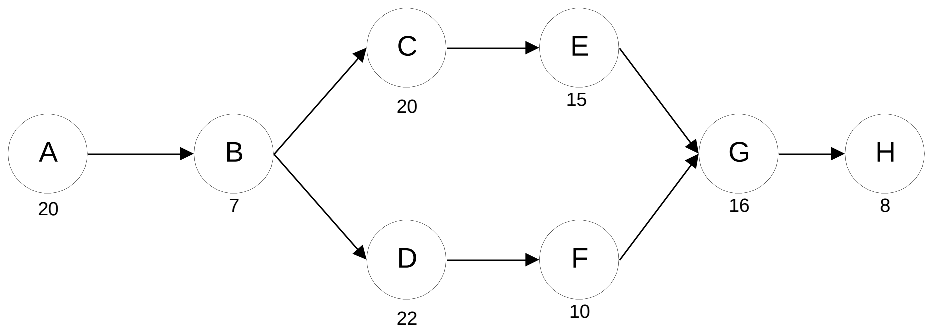
a. Find the cycle time required to produce 750 units per day.

C = production time per day/required output per day = (7 hour per day) (3600 seconds per hour)/750 units per day = 33.6 seconds per unit

b. What is the theoretical number of workstations?

$$N_i = \frac{T}{C} = \frac{118}{33.6} = 3.51 \rightarrow 4 \text{ work stations}$$

c. Draw the precedence diagram.



d. Balance the line using sequential restrictions and the longest-operating-time rule.

Workstation	*Task*	*Task time*	*Idle time*
I	*A* *B*	*20* *7*	 *6.6*
II	*D* *F*	*22* *10*	 *1.6*
III	*C*	*20*	*13.6*
IV	*E* *G*	*15* *16*	 *2.6*
V	*H*	*8*	*25.6*

e. What is the efficiency of the line balanced as in part (d), assuming it is running at the cycle time from part (a)?

$$\textit{Efficiency} = \frac{T}{N_a C} = \frac{118}{5(33.6)} = .702 \text{ or } 70.2\%$$

f. Suppose that demand rose from 750 to 800 units per day. What would you do? Show any amounts or calculations.

Reduce cycle time to 32. New production level is (7 hours/day)(3600 seconds per hour)/32 seconds per unit) = 787.5 units per day. Therefore, they are 800 – 787.5 = 12.5 units short. Work (12.5 units)(32 seconds per unit) = 400 seconds or 6.67 minutes overtime.*

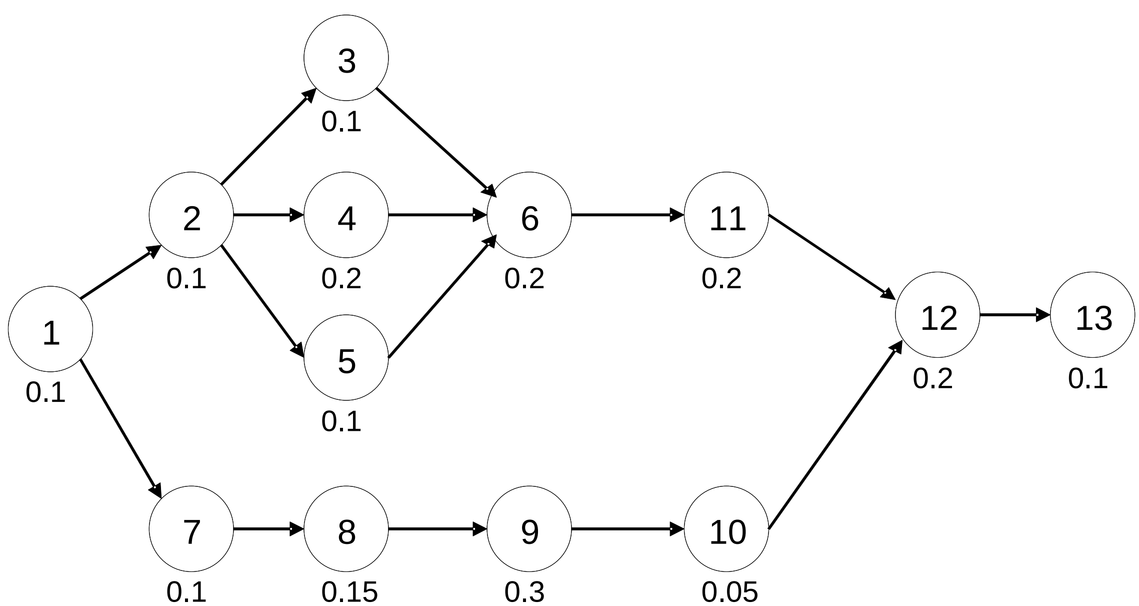
g. Suppose that demand rose from 750 to 1,000 units per day. What would you do? Show any amounts or calculations.

1000 – 787.5 = 212.5 units short, work (212.5 units)(32 seconds per unit) = 6800 seconds or 113.3 minutes or 1.89 hours of overtime. We may want to consider rebalancing the line.*

20. The Sun River beverage company is a regional producer of teas, exotic juices, and energy drinks. With an interest in healthier lifestyles, there has been an increase in demand for its sugar-free formulation.

The final packing operation requires 13 tasks. Sun River bottles its sugar-free product 5 hours a day, 5 days a week. Each week, there is a demand for 3,000 bottles of this product each week. Using the data below, solve the assembly-line balancing problem and calculate the efficiency of your solution, assuming the line runs at the cycle time required to meet demand. Use the longest task time for your decision criteria. Use the largest number of following tasks as a secondary criterion.

Task	Performance Time (Minutes)	Task Must Follow
1	0.1	—
2	0.1	1
3	0.1	2
4	0.2	2
5	0.1	2
6	0.2	3, 4, 5
7	0.1	1
8	0.15	7
9	0.3	8
10	0.5	9
11	0.2	6
12	0.2	10, 11
13	0.1	12



$$C = \frac{5\ hours\ x\ 5\ days\ x\ 60\ min/hr}{3000\ units/day} = 0.5\ min/unit$$

$$N_t = \frac{1.9\ min}{0.5\ min} = 3.8 \ldots round\ to\ 4$$

The solution is:

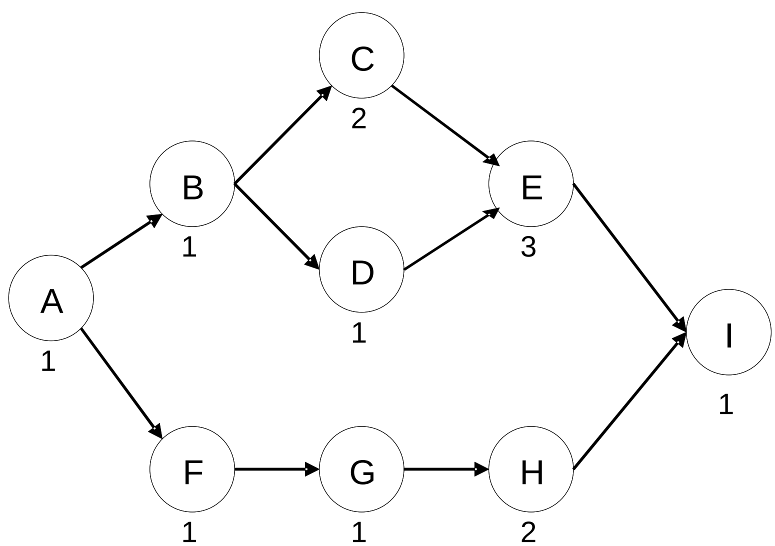
Station	*Tasks*
1	*1, 2, 7,4*
2	*8, 9, 10*
3	*3, 5, 6*
4	*11, 12, 13*

$$Efficiency = \frac{1.9}{(4\ x\ 0.5)} = 95\%$$

21. Consider the following tasks, times, and predecessors for an assembly of set-top cable converter boxes:

Task Element	Time (Minutes)	Element Predecessor
A	1	—
B	1	A
C	2	B
D	1	B
E	3	C, D
F	1	A
G	1	F
H	2	G
I	1	E, H

Given a cycle time of four minutes, develop two alternative layouts. Use the longest task time rule and the largest number of following tasks as a secondary criterion. What is the efficiency of your layouts, assuming the 4-minute cycle time?



Sum of task times = 13, Cycle time = 4 minutes

$$N_t = \frac{13}{4} = 3.25 \approx 4$$

There are two solutions:

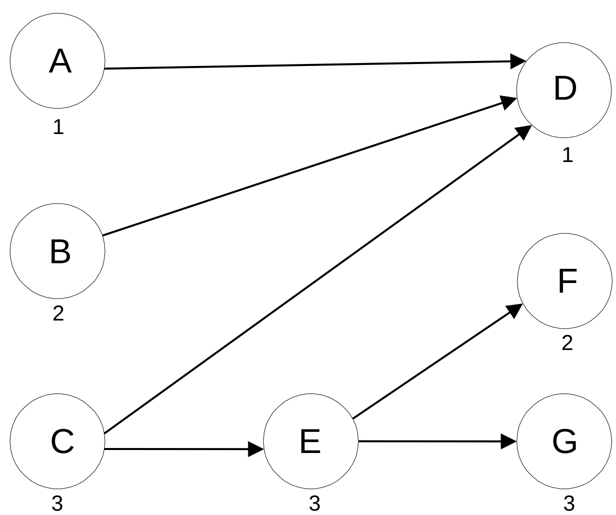
Station	***Solution 1***	***Solution 2***
1	*A, B, C*	*A, B, C*
2	*F, D, G*	*F, G, H*
3	*E*	*D, E*
4	*H, I*	*I*

$$Efficiency = \frac{13}{4 * 4.0} = 81.25\%$$

22. Francis Johnson's plant needs to design an efficient assembly line to make a new product. The assembly line needs to produce 15 units per hour, and there is room for only four workstations. The tasks and the order in which they must be performed are shown in the following table. Tasks cannot be split, and it would be too expensive to duplicate any task.

Task	Task Time (Minutes)	Immediate Predecessor
A	1	—
B	2	—
C	3	—
D	1	A, B, C
E	3	C
F	2	E
G	3	E

a. Draw the precedence diagram.



b. What is the workstation cycle time required to produce 15 units per hour?

(60 minutes/hr)/(15 units/hr) = 4 minutes per unit. C = 4.

c. Balance the line so that only four workstations are required. Use whatever method you feel is appropriate.

Workstation	***Task***	***Task time***	***Idle time***
I	*A*	*1*	
	C	*3*	*0*
II	*E*	*3*	*1*
III	*B*	*2*	
	F	*2*	*0*
IV	*D*	*1*	
	G	*3*	*0*

d. What is the efficiency of your line balance, assuming the cycle time from part (b)?

$$\textbf{Efficiency} = \frac{T}{N_a C} = \frac{15}{4(4)} = .9375 \textbf{ or 93.75\%}$$

ANALYTICS EXERCISE: Designing a Manufacturing Process

1. What is the daily capacity of the assembly line designed by the engineers?

   *The line operates for 7.5 hours per day. Workstation 9 is the bottleneck in the initial line balance, limiting the cycle time to 2 minutes, so output is limited to 30 units/ hours * 7.5 hours = 225 units per day.*

2. When the assembly line designed by the engineers is running at maximum capacity, what is the efficiency of the line relative to its use of labor? Assume that the "supporter" is not included in efficiency calculations.

   For this efficiency calculation, only consider the tasks that are performed at workstations using labor, not the 310 seconds for the software load. Therefore the sum of the task times for this calculation is 583 seconds.

$$\text{Efficiency} = \frac{T}{N_a C} = \frac{583}{6(120)} = .8097 \text{ or } 80.97\%$$

3. How should the line be redesigned to operate at the initial 250 units per day target, assuming that no overtime will be used? What is the efficiency of your new design?

   Without using overtime, the cycle time will have to be reduced. The maximum cycle time that will meet this production rate is:

$$C = \frac{\text{Production Time per Day (seconds)}}{\text{Required Output per Day}} = \frac{7.5 * 60 * 60}{250} = 108 \text{ seconds/unit}$$

   All current stations are under that cycle time except for station 6 (position 9). Because of the precedence relationships for tasks 16 and 17, they must be split across two stations to meet the new cycle time. A simple way to meet this cycle time is to just put task 17 into position 10 and add an additional worker. The efficiency of this solution is:

$$\text{Efficiency} = \frac{T}{N_a C} = \frac{583}{7(108)} = .7712 \text{ or } 77.12\%$$

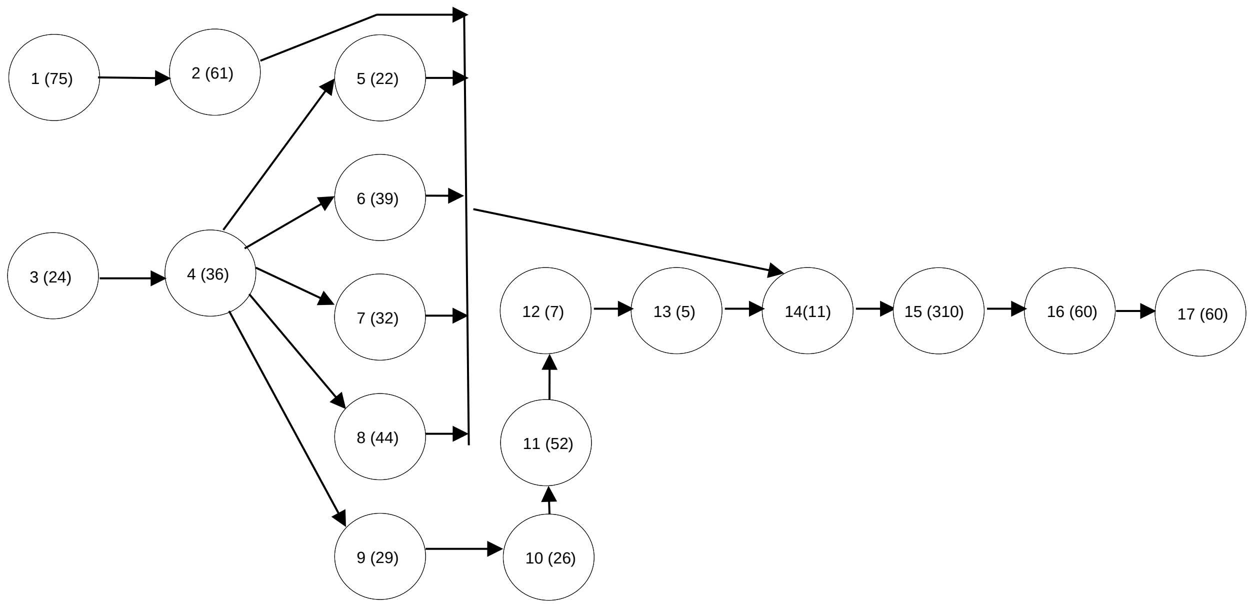
4. What about running the line at 300 units per day? If overtime were used with the engineer's initial design, how much time would need to be run each day?

   With the original design, output is 30 units per hour. To reach output of 300 units would require 2.5 hours of overtime per day.

5. Design a new assembly line that can produce 300 units per day without using overtime.

   The cycle time to meet this production rate without overtime is:

$$C = \frac{\text{Production Time per Day (seconds)}}{\text{Required Output per Day}} = \frac{7.5 * 60 * 60}{300} = 90 \text{ seconds/unit}$$



This may be possible with a redesigned line, but we might not have enough line positions to accommodate the new design. The following is a design that was constructed using the "longest task" priority run. This is actually a pretty good design and it would be possible to make 300 units per day. The labor efficiency of this line is 583/(8(90)) = .809 or 81%. [Since stations 7-9 are not staffed, they are not included in the efficiency calculation.]

Station	***Task***	***Task time***	***Labor Idle time***	***Station idle time***
1	*1*	*75*	*15*	*15*
2	*2* *3*	*61* *24*	*5*	*5*
3	*4* *8*	*36* *44*	*10*	*10*
4	*6* *7*	*39* *32*	*15*	*15*
5	*9* *5* *10*	*29* *22* *26*	*13*	*15*
6	*11* *12* *13* *14* *15*	*52* *7* *5* *11* *15*	*15*	*0*
7	*15*	*90*	*0*	*0*
8	*15*	*90*	*0*	*0*
9	*15*	*90*	*0*	*0*
10	*15* *16*	*25* *60*	*30*	*5*
11	*17*	*60*	*30*	*30*

6. What other issues might Toshihiro consider when bringing the new assembly line up to speed?

The total costs of the various options should be considered. For example, is it less expensive to work overtime to meet increased demand or to add another workstation requiring another full-time worker? Also, the quality of demand forecasts should be assessed. Redesigning the line to achieve higher output will be expensive, and should not be done unless there is strong confidence in demand forecasts. Finally, the cost of redesigning the line once it is operational and resultant downtime should be considered. A thorough analysis of demand and line design options should be performed to minimize the risk of having to redesign the line once operational in the near future. Perhaps the best option would be the balance from part 3, allowing maximum production of about 273 per day with no overtime, and the ability to reach 300 units per day with less than one hour overtime per day.