How to Add Capacity

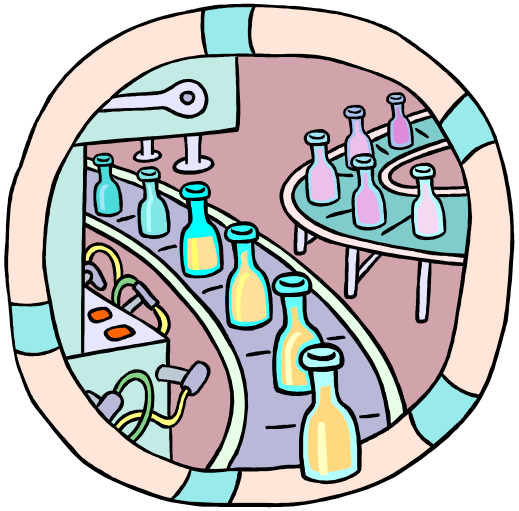
- 1. Add more workers
- 2. Add a second shift
- 3. Overtime ------- Probably the most frequently used method of adjusting capacity in the short term
- 4. Outsource also called Offloading

Capacity

• Industry	Primary Resource	Output
• Automobile	Hours	Cars
• Steel	Furnace Size	Tons of Steel
• Oil Refinery	Refinery Size	Barrels
• Wheat Farm	Acres	Bushels
• Dairy Farm	# of Cows	Pounds
• Restaurant	# of Seats	Meals
• Theater	Seats	Tickets
• Hospital	Beds	Occupied Beds

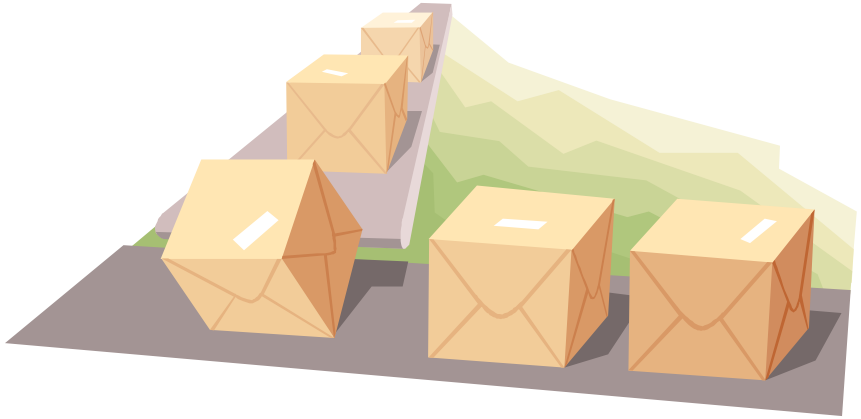
Concepts of Capacity

- Design Capacity
- Effective Capacity
- Actual Output

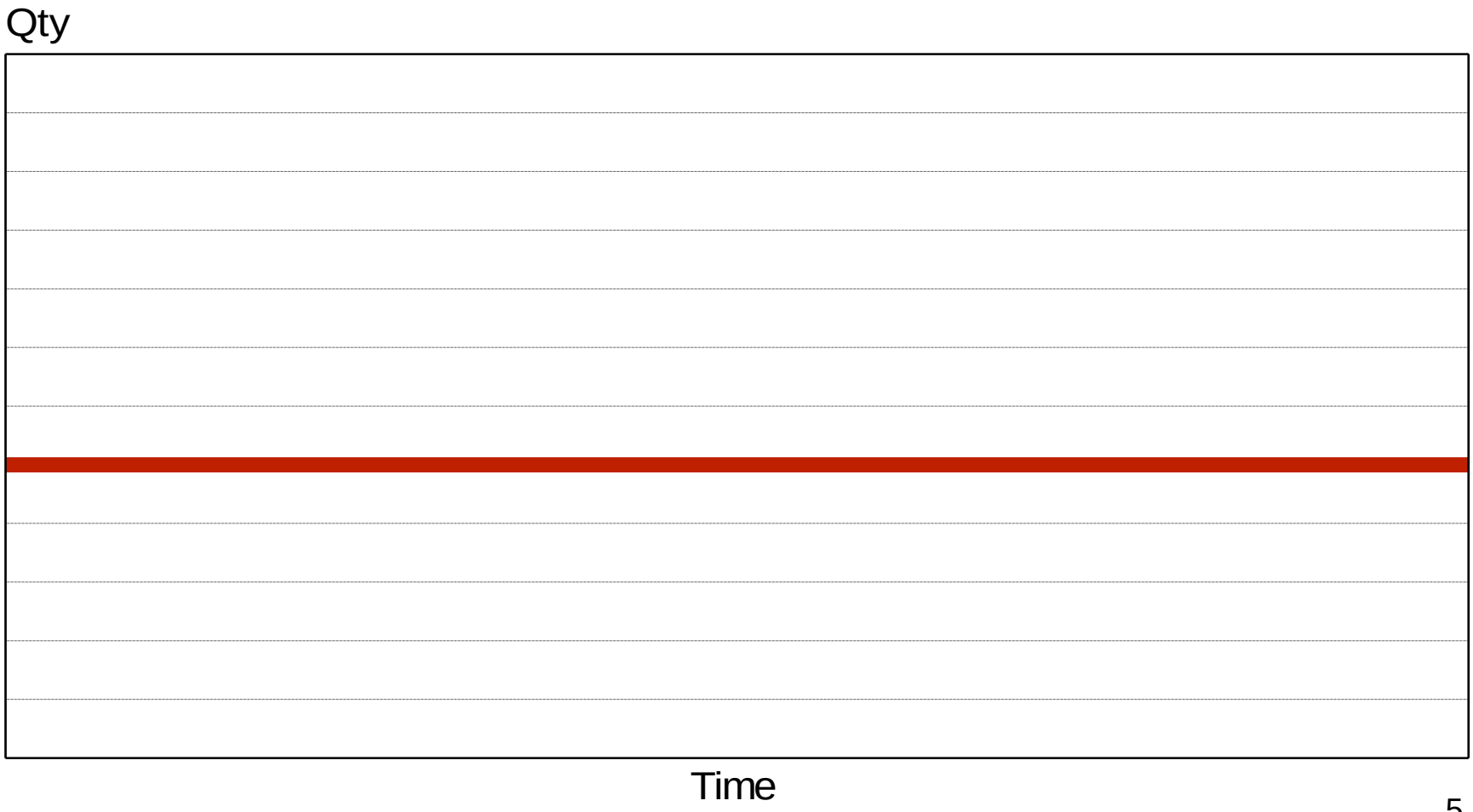


Measurements

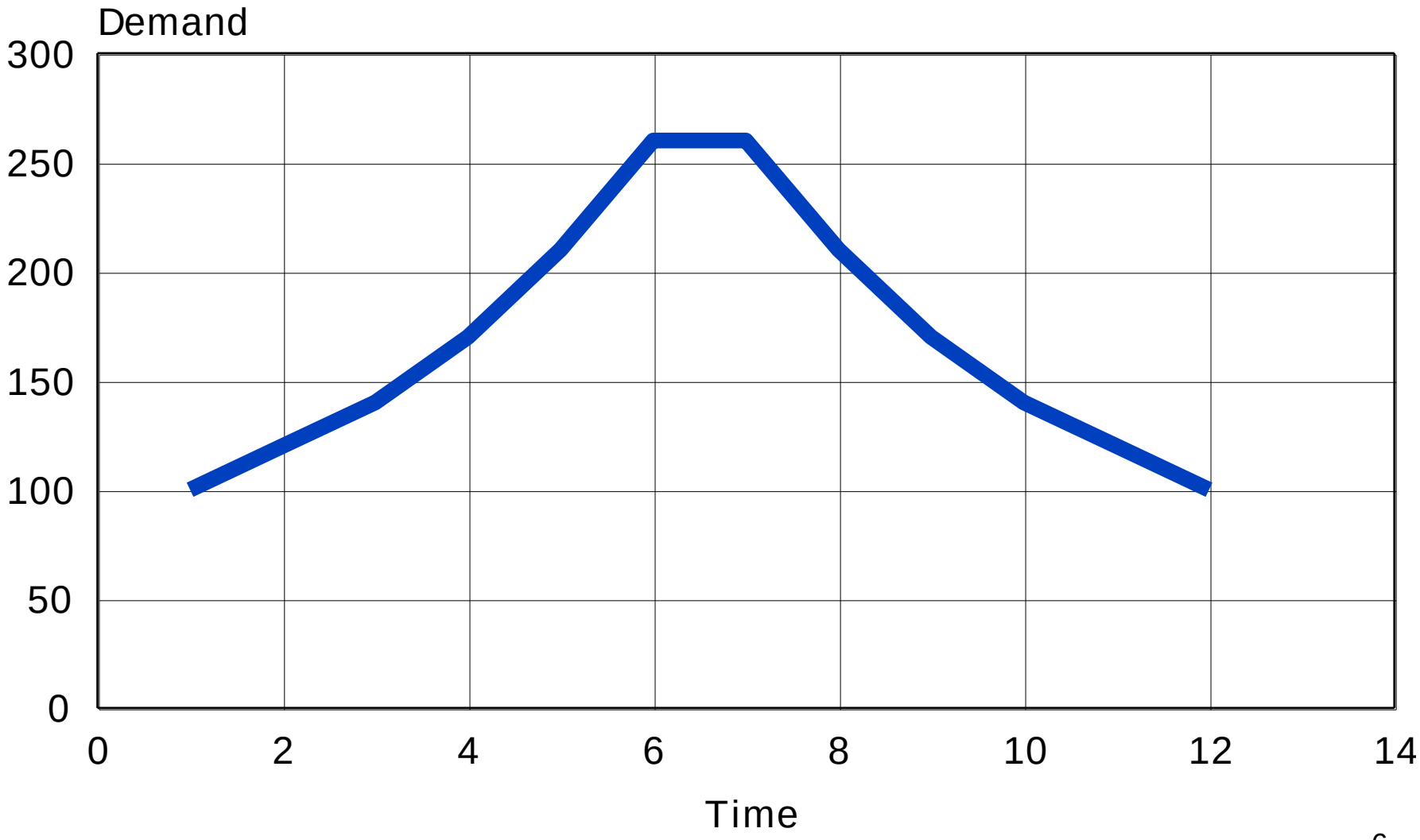
- **efficiency = actual output/effective capacity**
- **utilization = actual output/design capacity**

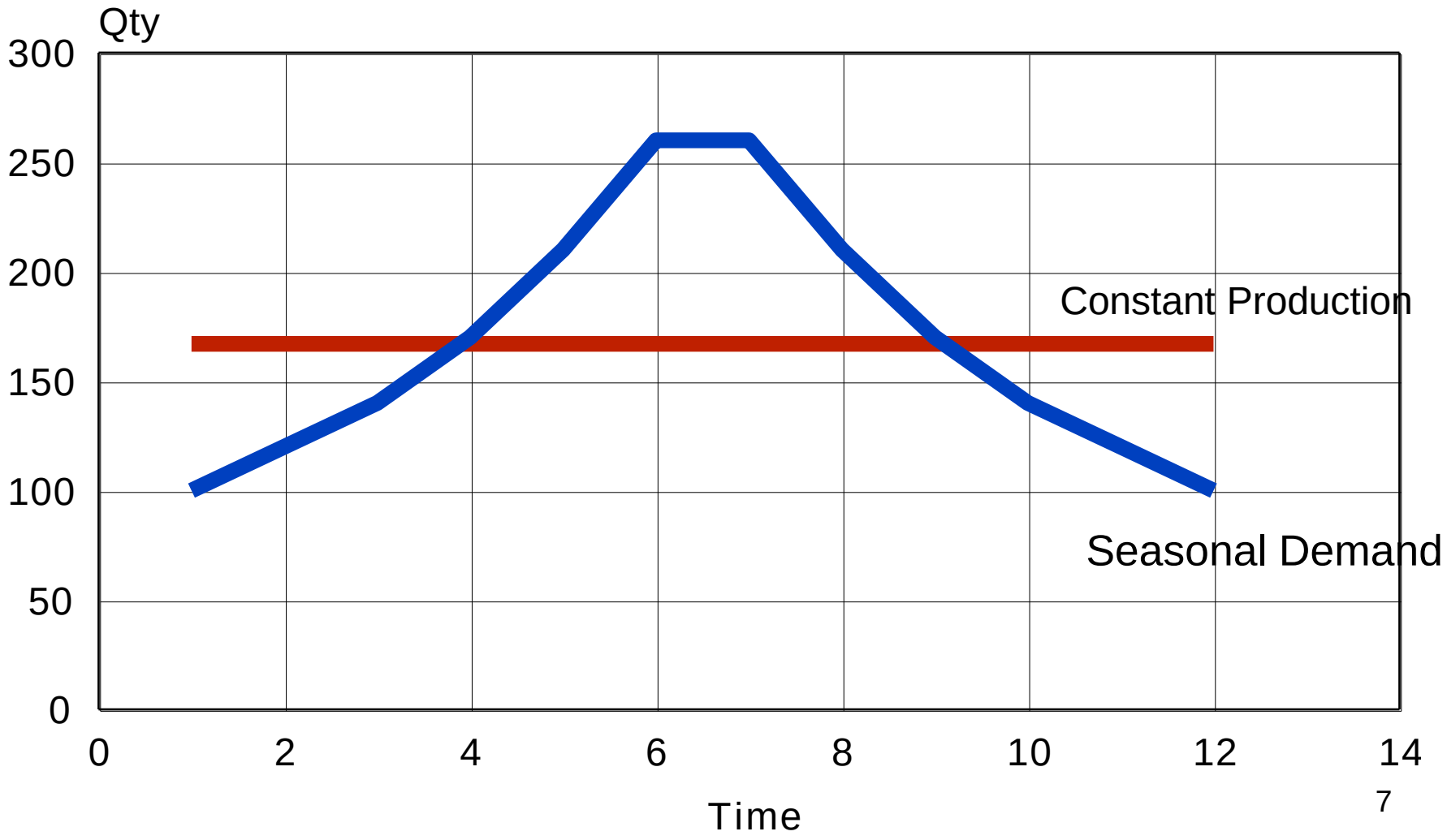


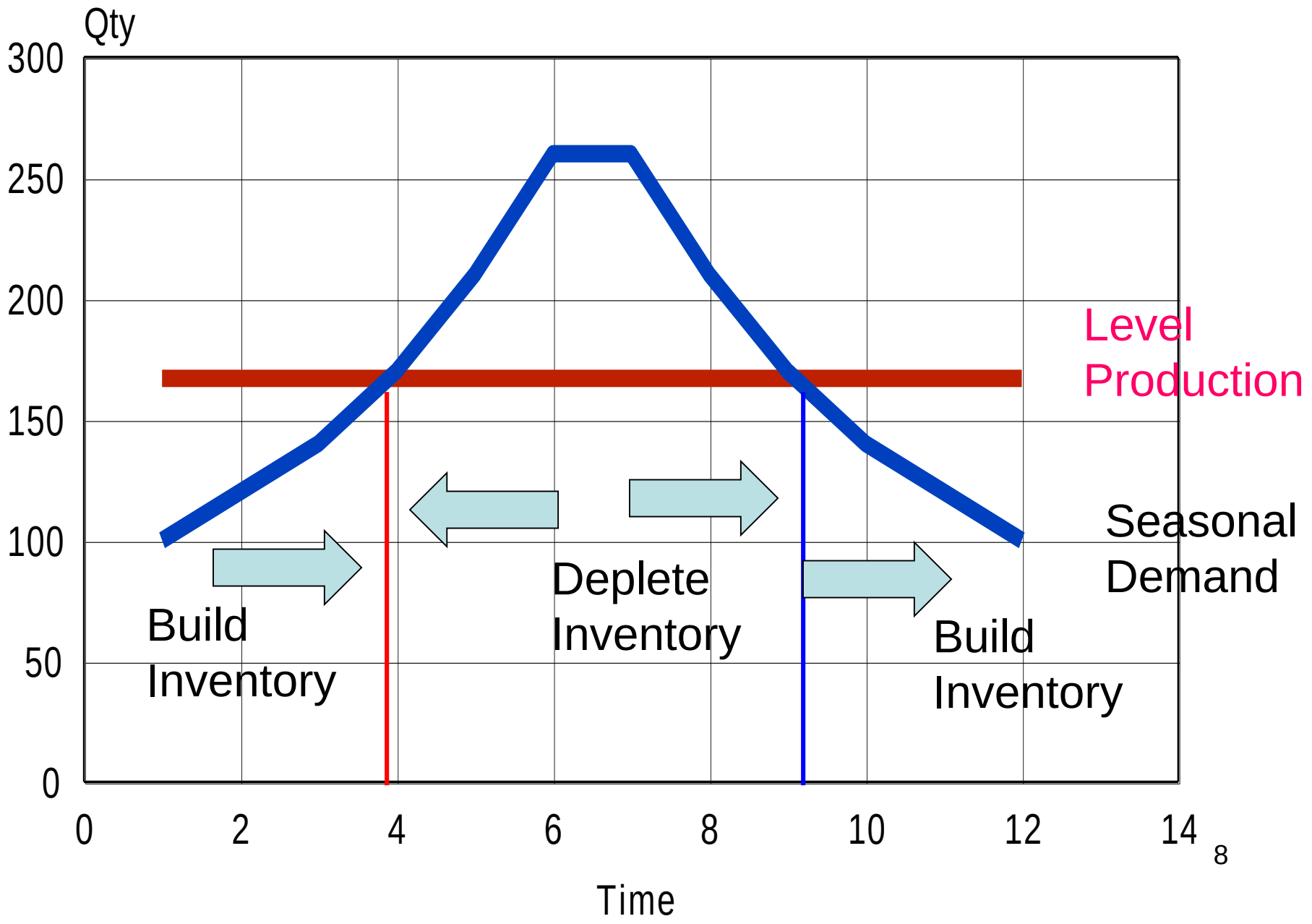
Constant Demand



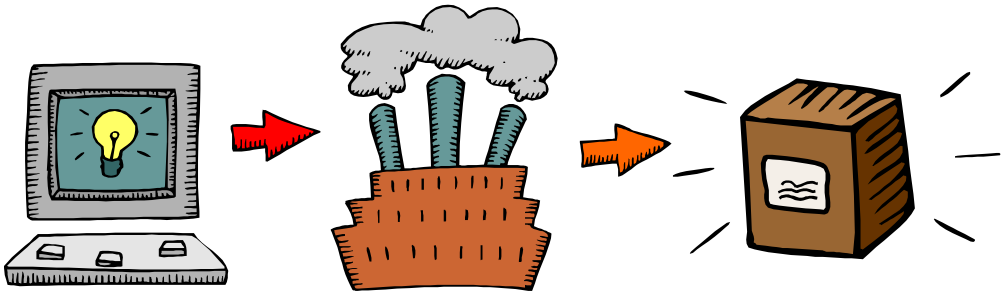
Seasonal Demand




Qty
300
250
200
150
100
50
0
0
2
4
6
8
10
12
14
Time
Constant Production
Seasonal Demand


Qty
300
250
200
150
100
50
0
0
2
4
6
8
10
12
14
Time
Level
Production
Seasonal
Demand
Build
Inventory
Deplete
Inventory
Build
Inventory

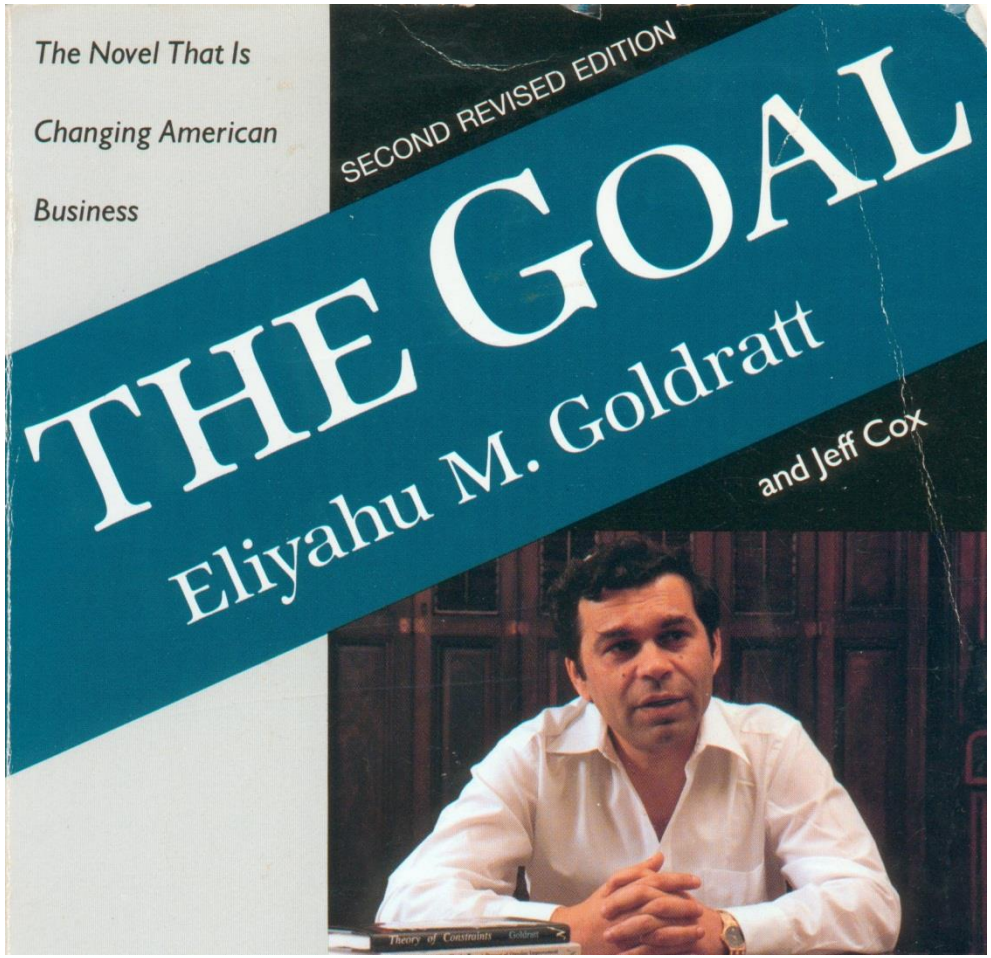
Capacity Planning → Aggregate Planning → Master Production Scheduling



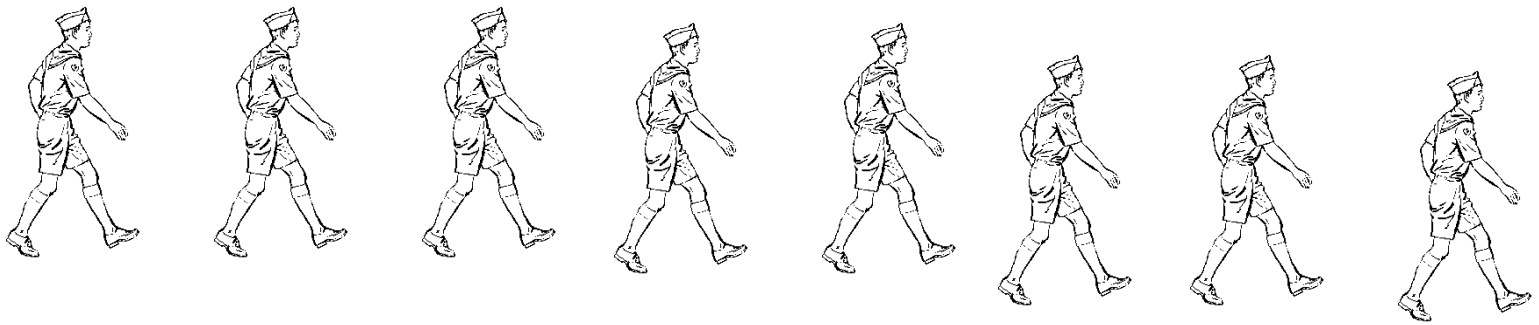
- Factors that Determine Capacity

- 1. Demand for Goods or Services
- 2. Facility Layout
- 3. Inputs----- material or customers
- 4. Resources ---- people machines etc.

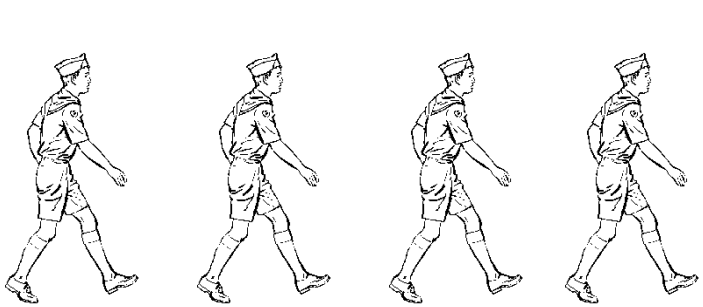
Dr. Eli Goldratt

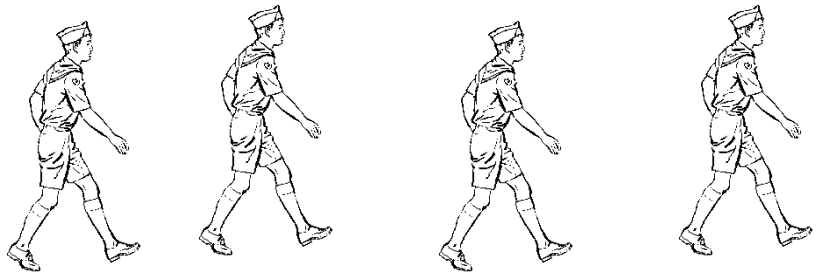


Hikers at 8:00 A.M.

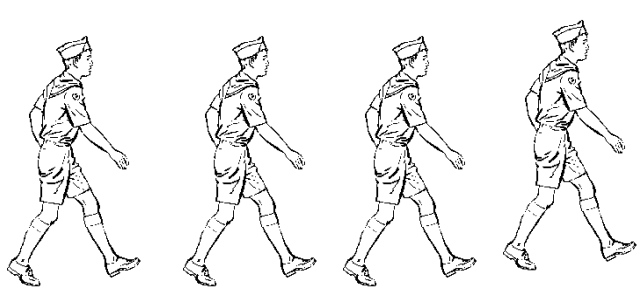


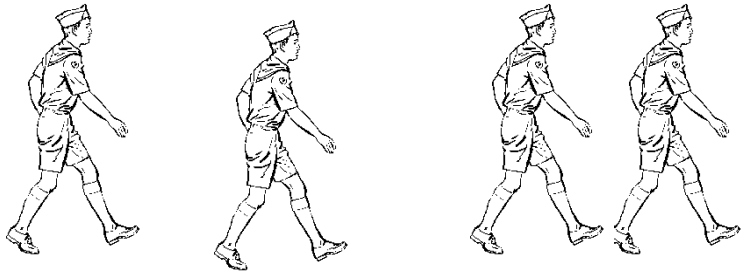
Hikers at 10:00 A.M.



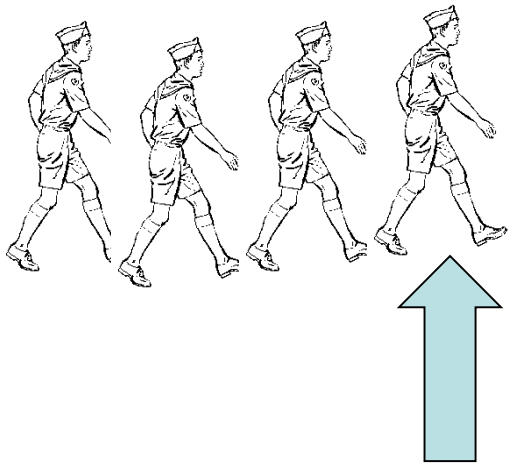


Hikers at Noon

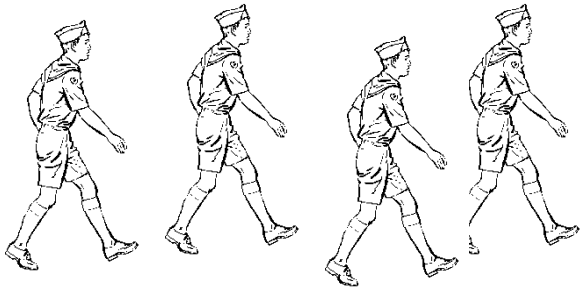




Hikers at 1:00 P.M.

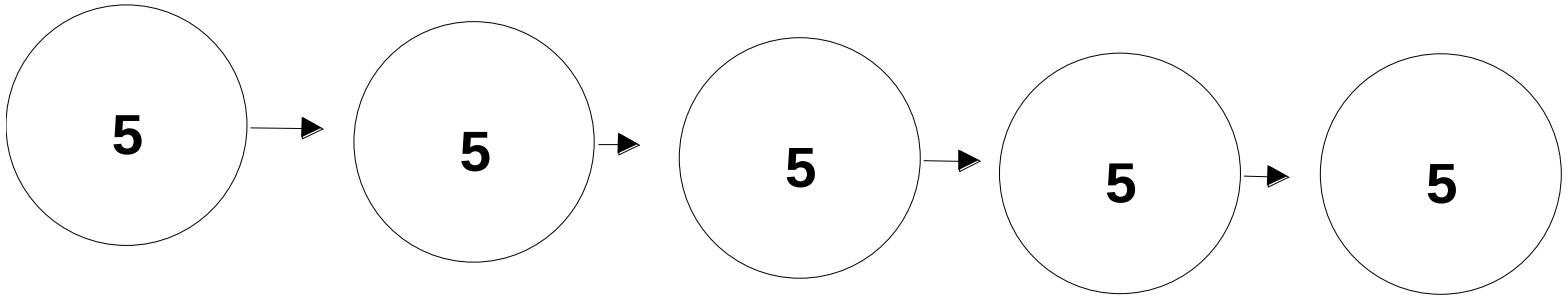


Herbie



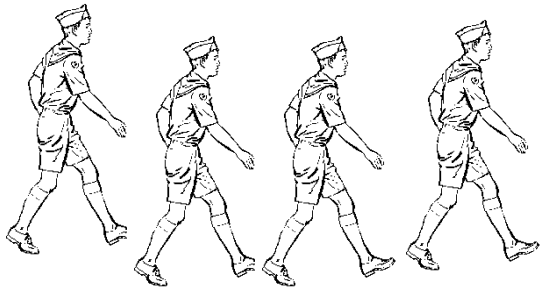
Where is the largest gap?

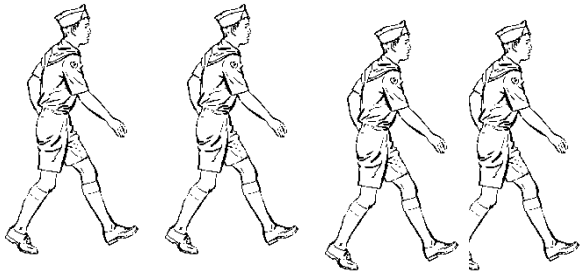
Balanced Line



Ground Covered=Finished Goods

Total WIP

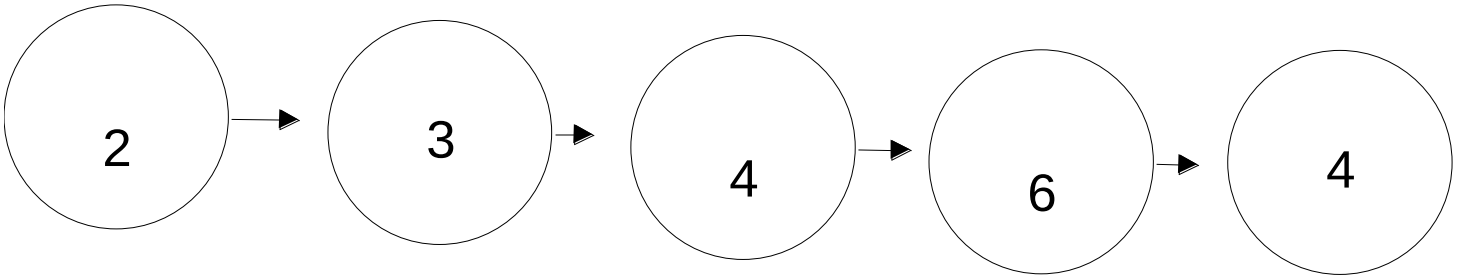




Large Pile
Of WIP

What is Happening to Total WIP Over Time?

Unbalanced Line



What to Do With Herbie

- **1. Put Herbie at the front of the pack**
- **2. Off-Load (Out-Source)**
- **3. Tie a rope around the waist of each scout**
- **4. Tie a rope from the first (lead) scout to Herbie**

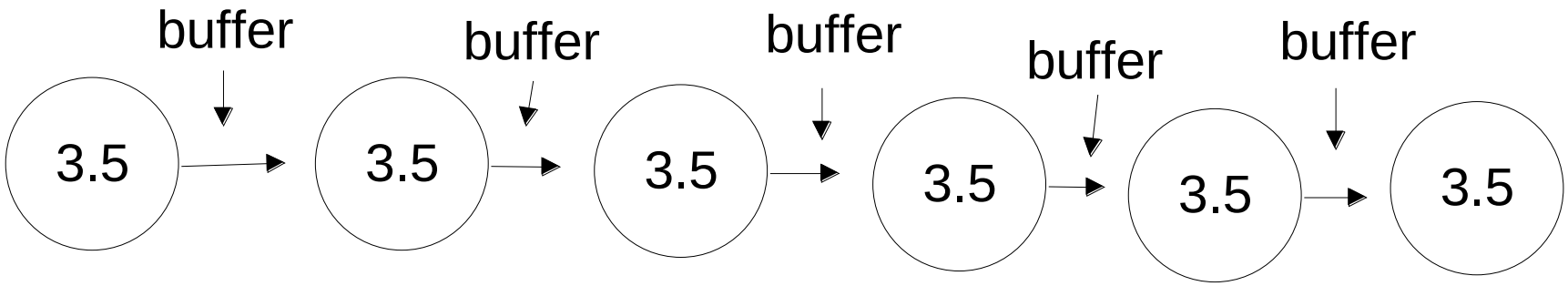
Tie a Rope from the Lead Scout to Herbie

- Drum-Buffer-Rope
- TOC approach to Scheduling

- Two Important Statistical Concepts
- Statistical Fluctuations
- Statistical Dependence

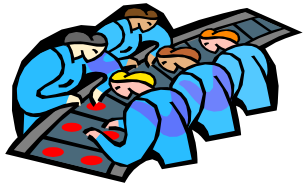
Statistics

Balanced Line



Plant Performance

Period	Qty Expected	Qty Actual	Cum. Late	Plant WIP	Qty Overtime
1	3.5	4	0	20	0
2	3.5	1	2.5	24	0
3	3.5	2	4	23	0
4	3.5	2	5.5	27	0
5	3.5	2	7	28	0
6	3.5	1	9.5	29	0
7	3.5	1	12	31	0
8	3.5	3	12.5	31	0
9	3.5	5	11	28	0
10	3.5	4	10.5	28	0
11	3.5	5	9	27	0
12	3.5	2	10.5	26	0
13	3.5	4	10	24	0
14	3.5	3	10.5	25	0
15	3.5	5	9	26	0
16	3.5	3	9.5	27	0
17	3.5	2	11	28	0
18	3.5	2	12.5	27	0
19	3.5	3	13	27	0
20	3.5	5	11.5	23	0
21	3.5	1	14	27	0
22	3.5	4	13.5	27	0
23	3.5	1	16	31	0
24	3.5	1	18.5	31	0
25	3.5	1	21	32	0



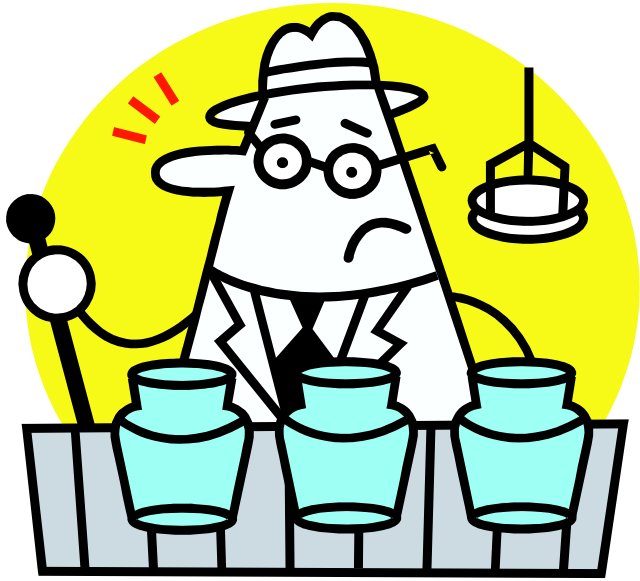
Balanced Line

Plant Performance

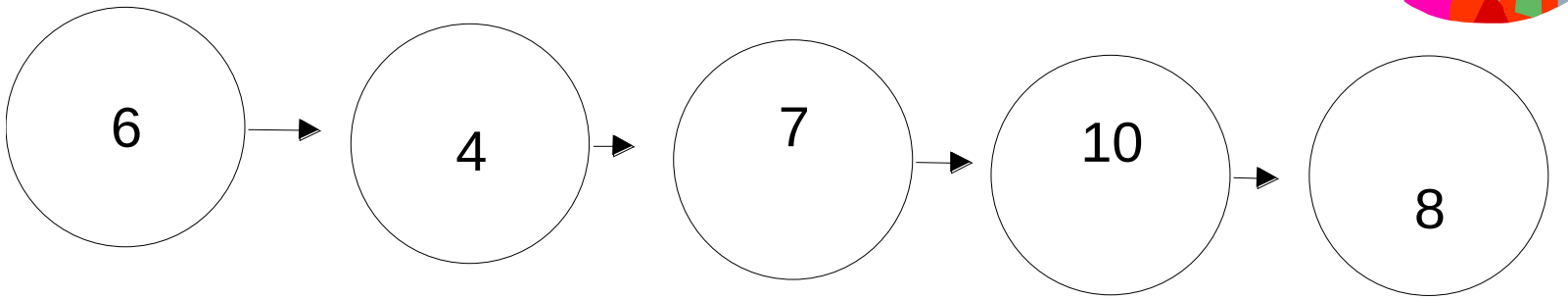
Period	Qty Expected	Qty Actual	Cum. Late	Plant WIP	Qty Overtime
26	3.5	3	21.5	31	0
27	3.5	1	24	31	0
28	3.5	4	23.5	33	0
29	3.5	5	22	33	0
30	3.5	3	22.5	34	0
31	3.5	2	24	36	0
32	3.5	5	22.5	32	0
33	3.5	2	24	36	0
34	3.5	6	21.5	33	0
35	3.5	2	23	32	0
36	3.5	3	23.5	31	0
37	3.5	1	26	31	0
38	3.5	5	24.5	29	0
39	3.5	2	26	28	0
40	3.5	6	23.5	24	0
41	3.5	5	22	22	0
42	3.5	1	24.5	25	0
43	3.5	1	27	29	0
44	3.5	1	29.5	32	0
45	3.5	3	30	35	0
46	3.5	1	32.5	36	0
47	3.5	4	32	37	0
48	3.5	2	33.5	38	0
49	3.5	6	31	34	0
50	3.5	3	31.5	35	0
Total	175	144			

Balanced Line?

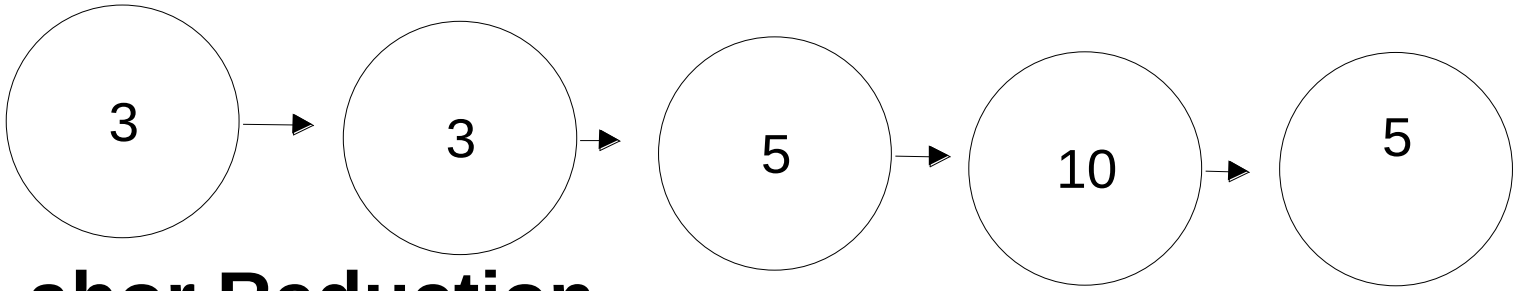
- What happens to WIP over time?
- Increases
- What happens to promised deliveries?
- Behind schedule



How to Improve this Process?



Proposal A

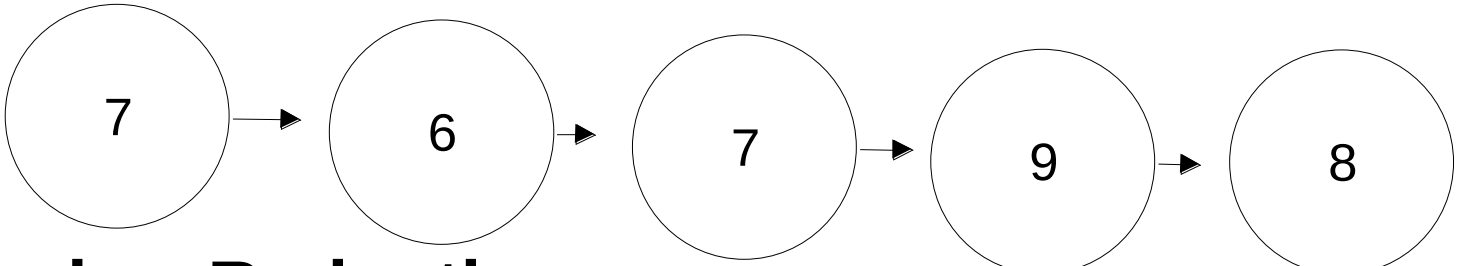


Labor Reduction

-3 **-1** **-2** **---** **-3**

Total Labor Saved
=9 minutes

Proposal B

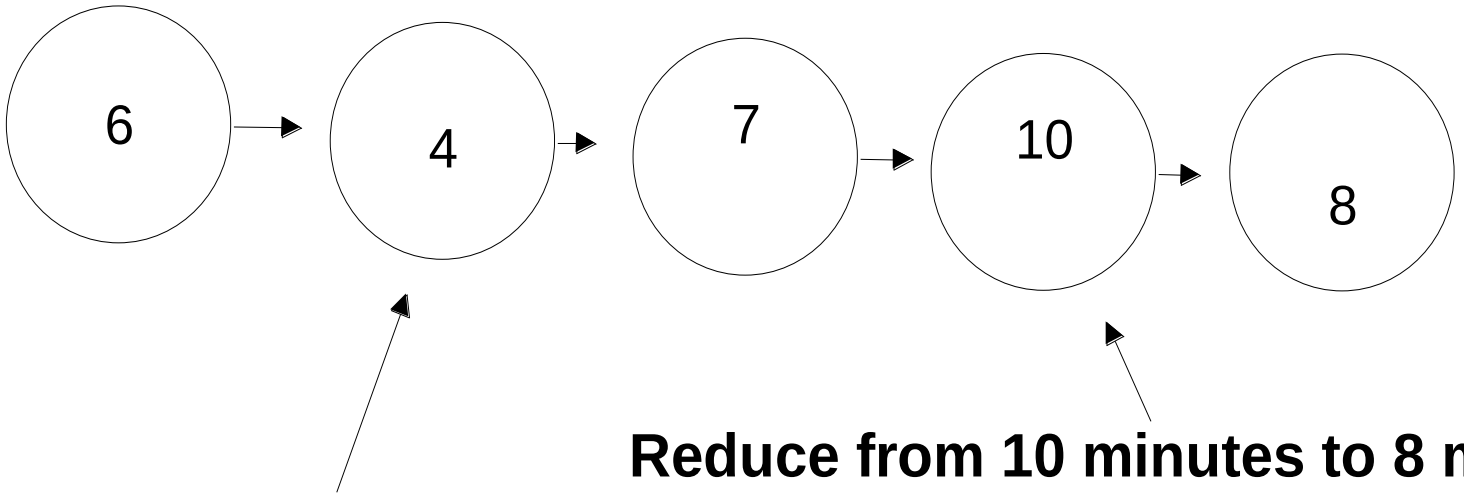


Labor Reduction

+1 **+2** **---** **-1** **---**

Total Labor Increase
=2 Minutes

Where Would You Try To Reduce Set-Up ?



Reduce from 10 minutes to 8 minutes

Reduce from 1 hour to 10 minutes

Product Cost

- **Traditional=**
- **Raw Material**
- **+Direct Labor**
- **+Variable Factory Overhead**
- ---
- **New Philosophies (TOC+JIT+TQM)**
- **=Raw Material**

Product Cost

- Company with a capacity of 1,000 units a month has fixed costs of $2,000 a month and labor costs of $6 a unit. Materials costs are $2 per unit. The company has been producing at 80 percent of capacity and selling its product for $12. What is its net income? What would it be at 100 percent of capacity?
- What would its net income be at 120 percent of capacity if it is assumed that 20 percent more products could be produced on overtime at an extra $3 labor cost per unit for all production above 100 percent? What would the net income be if production declines by 2 percent per hour because of the long hours? Should the company accept a contract which will call for 120 percent capacity for an extended period of time if the price is $12 and if the company could not otherwise operate at 100 percent of capacity?

Net Income

Net income at 80% capacity

Sales Revenue(800*12)		9,600
Fixed Costs	2,000	
Labor Costs (800*6)	4,800	
Material Costs (800*2)	1,600	
Total Costs		8,400
Net Income		1,200

Net Income

Net Income at 100 %

Sales Revenue	**(1,000 * 12)**		**12,000**
Fixed Costs		**2,000**	
Labor Costs	**(1,000 * 6)**	**6,000**	
Material Costs	**(1,000 * 2)**	**2,000**	
Total Costs			**10,000**
Net Income			**2,000**

Net Income

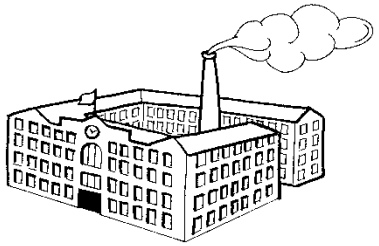
Net Income at 120 %

Sales Revenue (1,200 * 12)		**14,400**
Fixed Costs	**2,000**	
Labor Costs (1,000*6)	**7,800**	
+(200*9)		
Material (1,200*2)	**2,400**	
Total Costs		**12,200**
Net Income		**2,200**

Net Income at 120 % capacity with 2 % production decline
.98*1,200 = 1,176 units

Sales Revenue (1,176*12)			14,112
Fixed Costs		2,000	
Labor	(1,000*6)+(200*9)	7,800	
Material (1,176 * 2)		2,352	
Total costs			12,152
Net Income			1,960

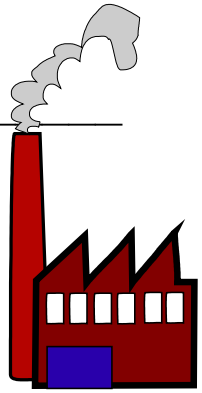
Net Income



- There are five products which are made on each of six types of equipment. The table on the next slide shows the operating times (in decimal hours) and the job setup times for each operation. In each block there are two times. The upper number is the job setup time and the lower number is the operating time per unit.

- How many of each kind of machine will be needed if the plant works at 170-hour month?

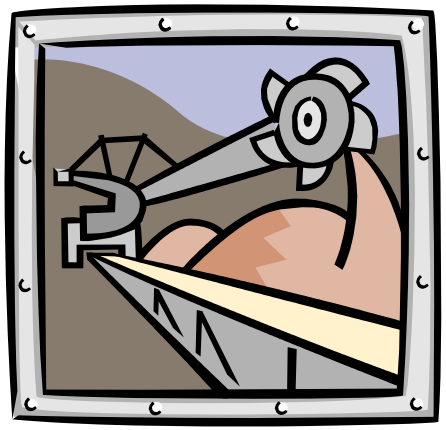
Product Equipment	1	2	3	4	5
Mult-Au-Matic	.670		.761		.073
	.036		.078		.097
Vertical mill		.543	.790		.870
		.097	.102		.105
Turret lathe		.732			.839
		.019			.021
Forging machine	.521	.434			.768
	.017	.049			.057
Centerless grinder			.087	.161	
			.036	.016	
Simplex mill	.617	.614	.911	.658	
	.053	.073	.081	.077	
Quantity needed per month	700	2,300	1,400	100	300
Manufacturing lot size for each production run	300	200	500	200	400



Job	Set-ups	Actual Set-ups
1	700/300=2.33	3
2	2300/200=11.5	12
3	1400/500=2.8	3
4	100/200=.5	1
5	300/400=.75	1

Machine	1	2	3	4	5	Tot	Tot/170
Multi-Aumatic	27.3		111.4		29.2	167.9	1
Vertical Mill		229.6	145.2		32.4	407.2	3
Turret Lathe		52.5			7.1	59.6	1
Forging Mch	13.5	118			17.9	149.4	1
Centerless Grd			50.7	1.8		52.3	1
Simplex Mill	38.9	175.3	116	8.4		338.6	2

Multi-Au-Matic



Product 1 set-ups = 3*.67 = 2.01
run (700*.036) = 25.2
total =27.2

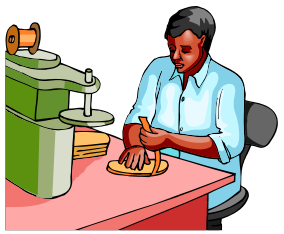
Product 3 set-ups=3*.761 = 2.283
run (1400*.078) =109.2
total =111.4

Product 5 set-ups= 1*.073 =.073
run (300*.097) =29.1
total = 29.2

Total Load = 167.9

Machine	1	2	3	4	5	Tot	Tot/170
Multi-Aumatic	27.3		111.4		29.2	167.9	1
Vertical Mill		229.6	145.2		32.4	407.2	3
Turret Lathe		52.5			7.1	59.6	1
Forging Mch	13.5	118			17.9	149.4	1
Centerless Grd			50.7	1.8		52.3	1
Simplex Mill	38.9	175.3	116	8.4		338.6	2

- Company XYZ needs to manufacture 3,000 pump housings a month, which requires grinding-machine time. The standard time for this operation is .17 hours per unit.
- A. How many machines will be needed if the company works 8 hours per day, 20 days per month at 100 % per cent efficiency with no scrap losses or lost machine time?
- B. What is the answer if the company realizes only 80% machine utilization from the machines and the operators are 105% efficient?
- C. How many housings should be started into production if the scrap rate is 7%? How many machines (using the production expectations calculated in B above) will be needed?



Pump Housing Problem

Required machines=load/available capacity

=(units*time required)/capacity (in hours)

a. (3,000*.17)/(8*20) = 3.2 (4 required)

b. (3,000*.17)/(160*.8*1.05)= 3.8 (4 required)

c. 3,000=1X-.07X

3,000=.93X

X=3,000/.93

X=3225.8 or 3,226 units

(.17*3,226)/(160*.8*1.05)= 4.08 (5 required)