# INVENTORY *(What is it?)*

## TYPES OF INVENTORY *(Where is it at in the system?)*

Raw Materials

Work-in-process

Finished Goods

## PURPOSES OF INVENTORY *(Why do we keep it?)*

Smoothing Production...

Economies of Scale...

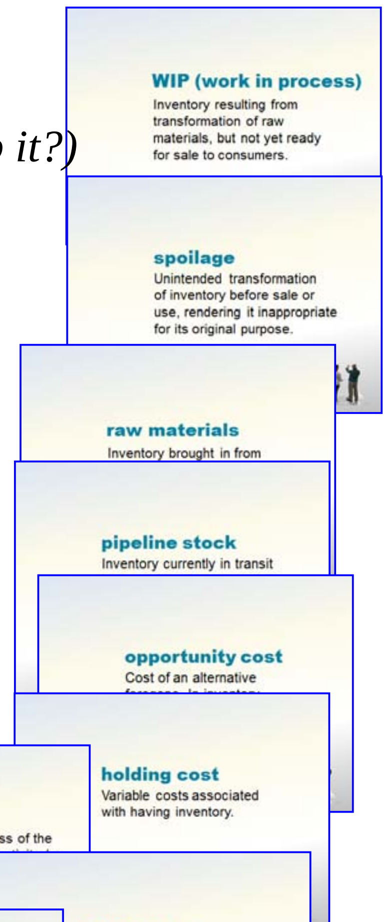
Protection against Uncertainty...

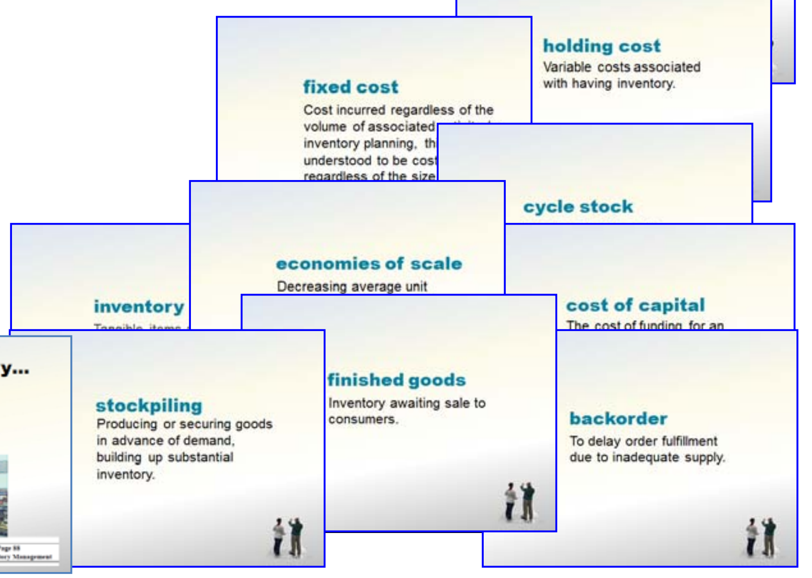
## COSTS OF INVENTORY *(Why do we care?)*

Holding Costs:

Stockout Costs:

Ordering/Set-up Costs:



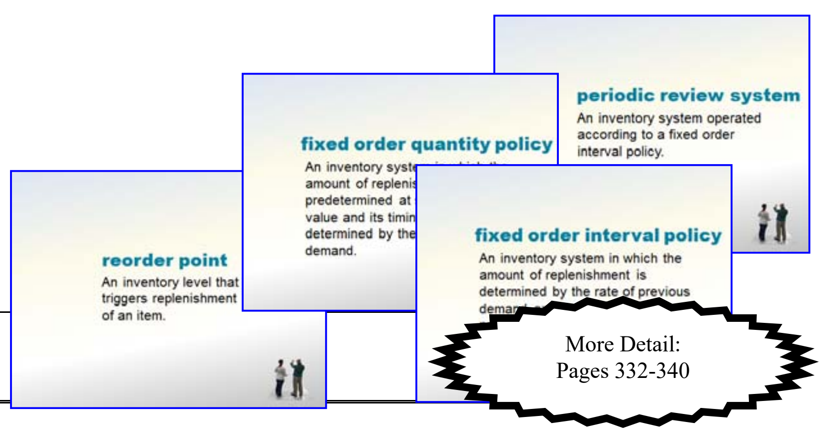




# INVENTORY MANAGEMENT:

1. HOW MUCH should I order?
2. WHEN should I order it?

| | HOW MUCH? | WHEN? |
|---|---|---|
| Fixed Order Quantity Systems | | |
| Fixed Order Interval Systems | | |

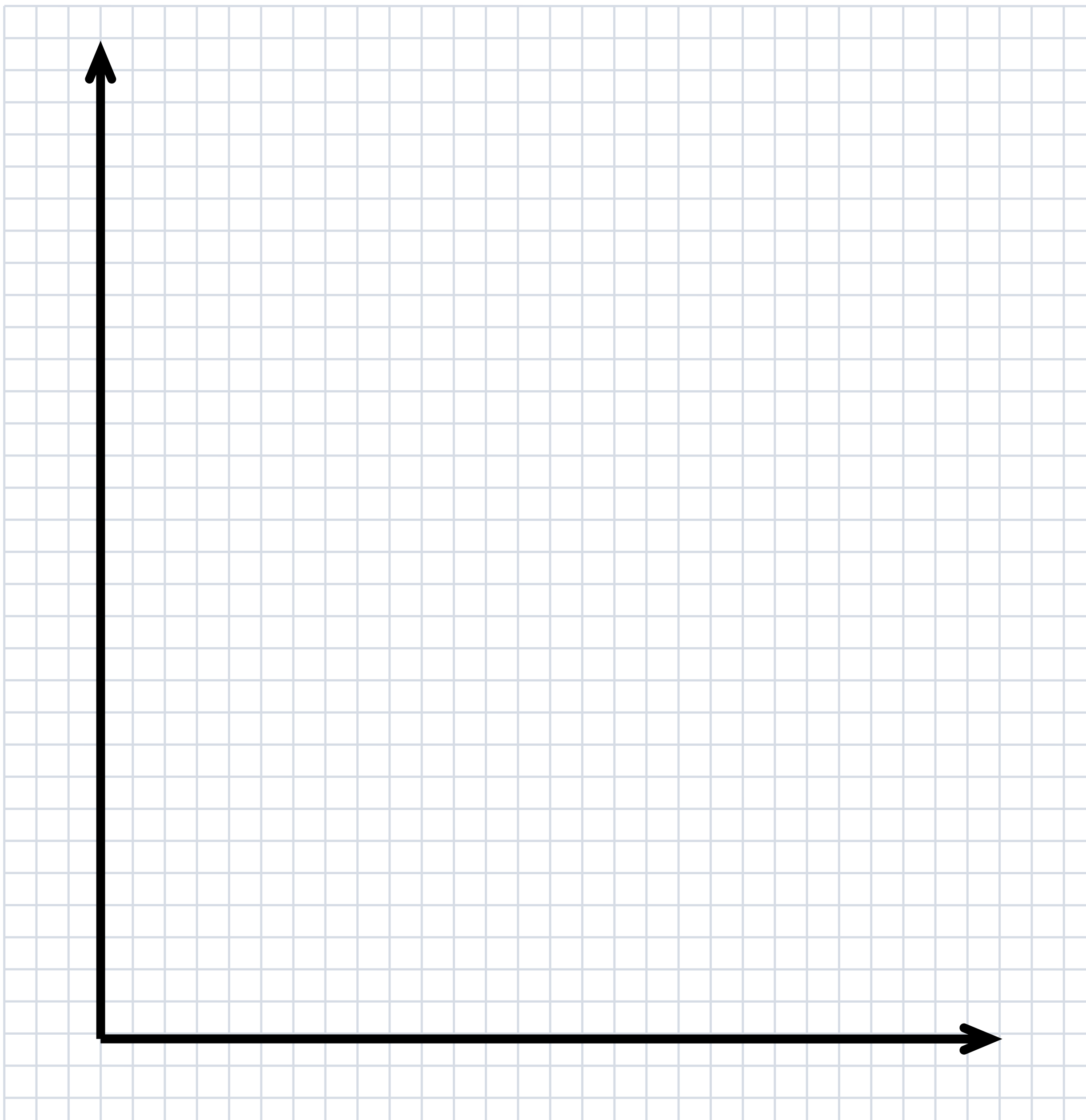
ABC Analysis:



# "SAWTOOTH DIAGRAMS"

Suppose we need 8000 of some item a year

***Illustrating inventory levels over time.***




# An EOQ Problem

Suppose we must secure 8000 of some SKU annually, at a cost of $10 a unit. There are 250 working days in the year and costs us $30 to place an order, regardless of its size. We estimate our inventory holding cost to be 30% annually.

* Should we order 8000 immediately?

* Should we order these one at a time?

* Generally speaking, what is the annual cost of a particular order size "Q"?

* So, how do we identify the "best" order size?

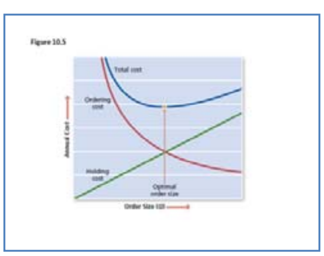
* Suppose we make this optimal order size our policy. What is the annual cost of this policy?

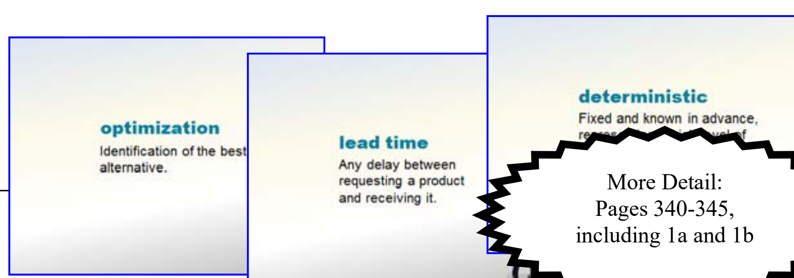
* How many times a year will we order?

* How much time will pass between placing one order and placing the next? (Or, what is the length of the "order cycle"?)

* What is the most we would ever have in inventory?

* On average, how much would we have in inventory?



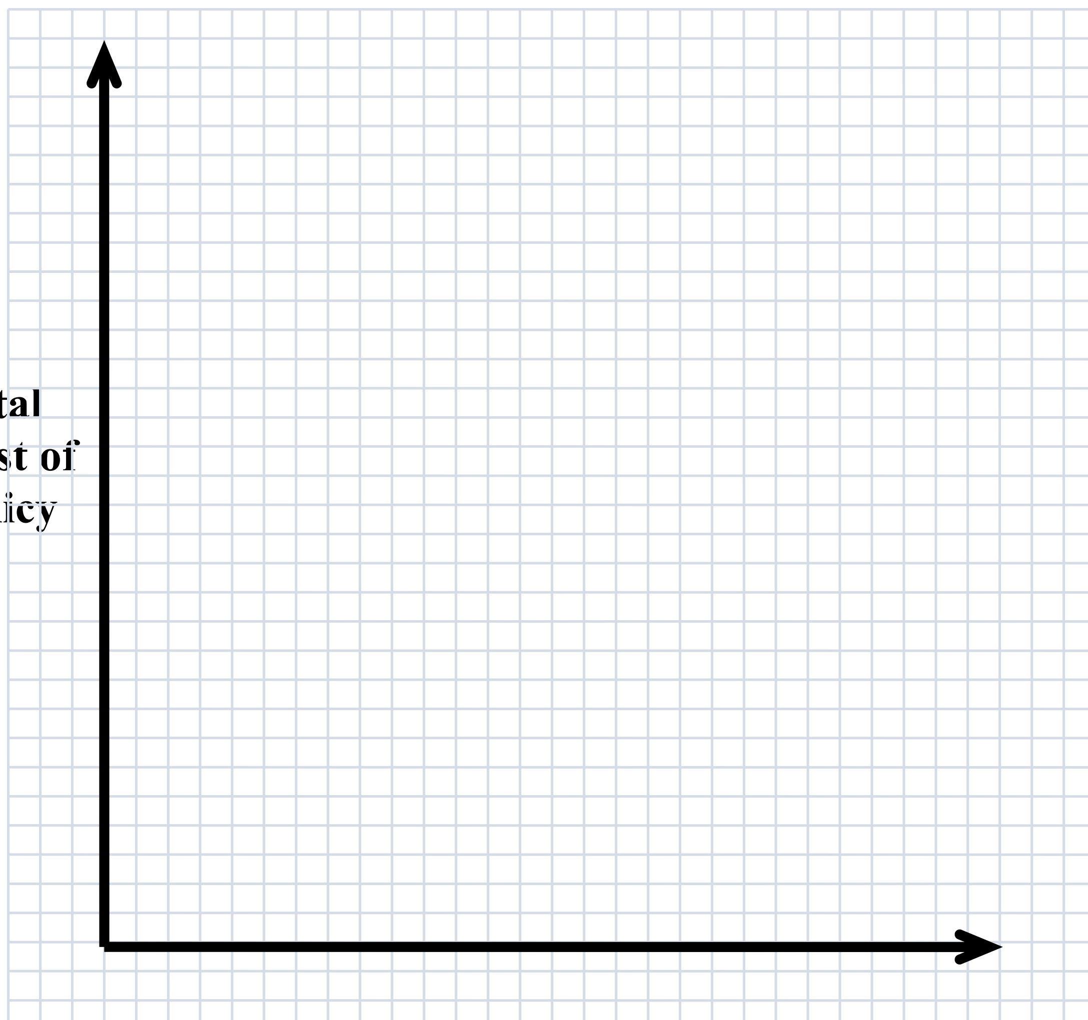




More Detail:
Pages 340-345,
including 1a and 1b

# The EOQ Problem with Price Breaks

Sometimes, an item's price is dependent on how <u>much you</u> order. What now? What actually changes in the EOQ model when the item's cost to you changes?

**Total Cost of Policy**



**Order Quantity**

Take our first EOQ example, but suppose the item costs us $9.00 each if we place an order for 500 to 999 units, and $8.00 each if we order 1000 or more.

STEP ONE: Compute the EOQ for each possible item price.

STEP TWO: Only one of these EOQ's will be "valid". Find the valid one. If the valid EOQ corresponds to the lowest unit price, we are finished - order that amount. If not, go to Step Three.

# The EOQ Problem with Price Breaks Cont'd...

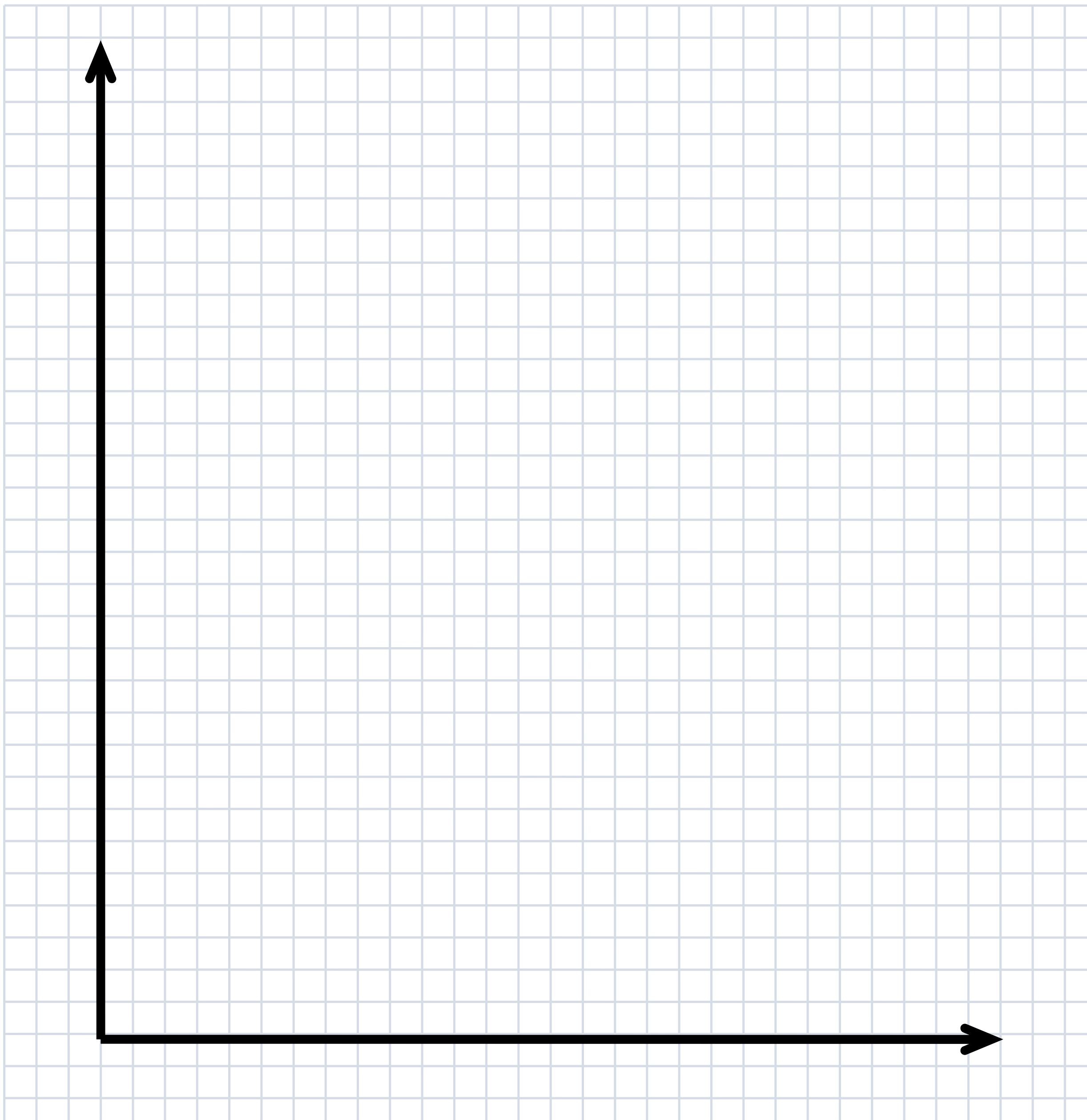
STEP THREE: Calculate the total annual costs associated with the valid EOQ and *with any price break quantity that qualifies you for a lower price*. Remember to include purchase costs in these calculations, in addition to the annual ordering and holding costs.

STEP FOUR: Compare and identify the order quantity with the lowest annual cost.

More Detail:
Pages 345-348,
including Scenario 1c

# SAWTOOTH DIAGRAM:

***The case of "Non- instantaneous Replenishment"***



# An EPQ Problem

Suppose we must produce 500 of some SKU annually. There are 250 working days in the year and we can produce 50 units a day. It costs us $10 to set up production, regardless of the size of the batch we produce, and it costs us $1.25 to hold one unit in inventory for an entire year.

* What is the total annual cost of any order size (or batch size) under these conditions?

* What order size minimizes total cost?

* How much time will pass between production set ups? (Or, what is the length of the "order cycle"?)

* What is the most we would ever have in inventory?

* On average, how much would we have in inventory?

* What is the "run time" of our ordering policy? That is, how long do we spend producing a single order?

More Detail:
Pages 348-352,
including 2a and 2b

# WHEN SHOULD WE ORDER?
## SERVICE LEVEL AND SAFETY STOCK
*Taking chances by making choices...* (look for **reorder point**.xls on UBlearns)

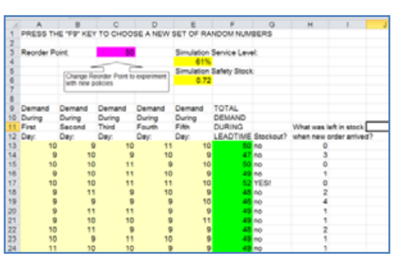
Example: Suppose demand is constant at 10 units a day, and the lead time on an order is always 5 days. When is it time to order?

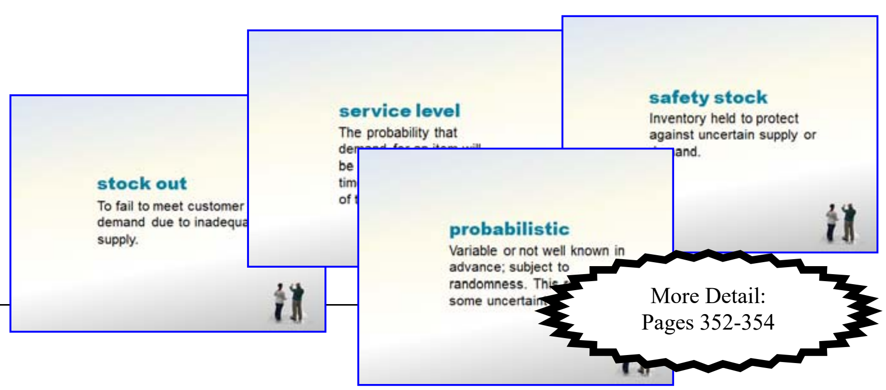
Suppose demand varies a little bit. Sometimes it is 9 units a day, sometimes 10, and sometimes it is 11 units a day. When would you order?

This brings up the issues of:

Service Level-

Safety Stock-



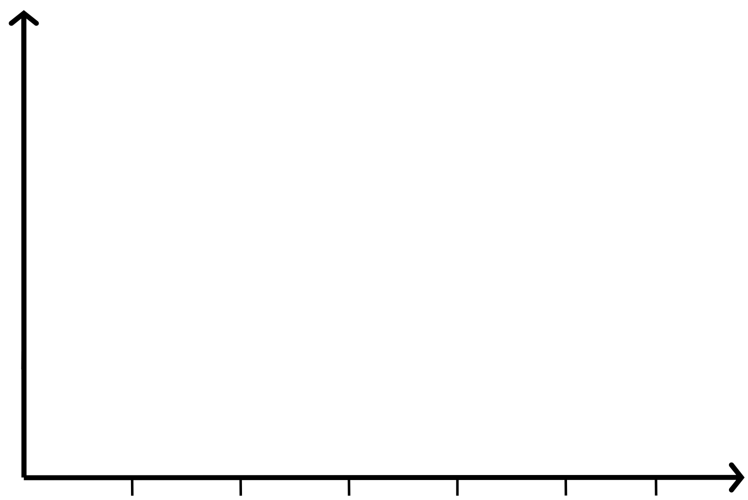



More Detail:
Pages 352-354

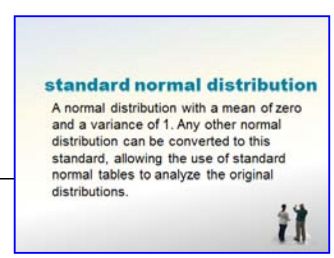
To illustrate a ***random variable***, we need an appropriate ***probability distribution*** describes its behavior...

What is random in this situation? (What don't we know in advance?)

Probability
of the
each of the possible
levels of demand
during lead time.



Possible Levels of Demand During
Lead Time



# EXAMPLE:

Suppose we have a lead time of 5 working days on some item. Demand during lead time for this item is normally distributed with a mean of 500 and a variance of 50.

Suppose we declare a reorder point of 510. What is our service level?

Suppose we want a service level of 80%. When should we reorder?

More Detail:
Pages 355-357, including
Scenario 3a and 3b

# SIX OLD EXAM QUESTIONS ON *INVENTORY MANAGEMENT*:

60 * 200
= 12,000 Days

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

Video tutorials explaining each of these questions are available on UBlearns.

D = 60
S = 100
p = 150
h = .80

The Happy Postage Company sells pre-stamped envelopes. The demand for pre-stamped envelopes is always 60 a day, and there are 200 working days annually at the Happy Postage Co. It costs the Happy Postage Company $100.00 to set-up the production process each time it wants to make a batch of pre-stamped envelopes. The Happy Postage Company can produce 150 pre-stamped envelopes in a working day, and it costs the company $0.80 to keep one pre-stamped envelope in inventory for one year. The Happy Postage Company also does all of its inventory planning according the "Economic Production Quantity" formula.

Sqrt(2*d*s / h) * sqrt( p / p-d) sqrt(2*12,000*100) * sqrt(150-150-60) = 2,236

Similar EPQ problem:
Chapter 10 Scenario #29

**1.** How many pre-stamped envelopes does the Happy Postage Company produce each time it sets up to produce pre-stamped envelopes? (Round to the nearest whole number.)

a) 122 b) 158 c) 1,732 d) 2,236 e) 2,556

EPQ = 2236

TC = 12,0000/2236 * (100) + 2236(150-120000) / 2(150) * (.80)

TC = d/q * (s) + q(p-d) / 2p * (h)

**2.** What is the total annual cost of the Happy Postage Company's inventory policy for pre-stamped envelopes?

a) $967 b) $1,073 c) $1,386 d) $1,431 e) $1,637

**3.** How many times a year does the Happy Postage Company produce pre-stamped envelopes?

a) 2.0361 b) 4.6948 c) 5.3667 d) 6.9284 e) 8.4320

D/Q
= 12,000 /2236
=

**4.** Lead time for some stock keeping unit (SKU) is always four days, and demand for that SKU is always 40 per day. What is the reorder point for this SKU?

a) 4 units b) 40 units c) 50 units d) 160 units e) 200 units

LT = 4
D = 40
4 * 40 = 160

Re order point = 102

Expected Demand = 97

102 - 97 = 5

**5.** The reorder point for SKU #303 is 102 units, while average demand during the lead time on an order for SKU #303 is 97 units. How much safety stock is implied by SKU #303's reorder point policy?

a) none b) 3 units c) 5 units d) 15 units e) 97 units

**6.** A certain company reorders envelopes when it stock drops to 12 boxes, although demand for envelopes during lead time is normally distributed with a mean of 10 boxes and a standard deviation of 3 boxes. Which of the following is closest to the probability of this company stocking out before a new order of envelopes arrives?

a) 5% b) 25% c) 50% d) 75% e) 95%

X = 12
MU = 10
Q = 3

x - mu / q

Z = (12-10) / 3 = 0.67

Look at z chart is 75%

Similar problems:
Quick Start #20 and
Ramp Up #23

Aggregate planning- devising a strategy to meet *changing* demands on the system.

We begin with a forecast of demand...

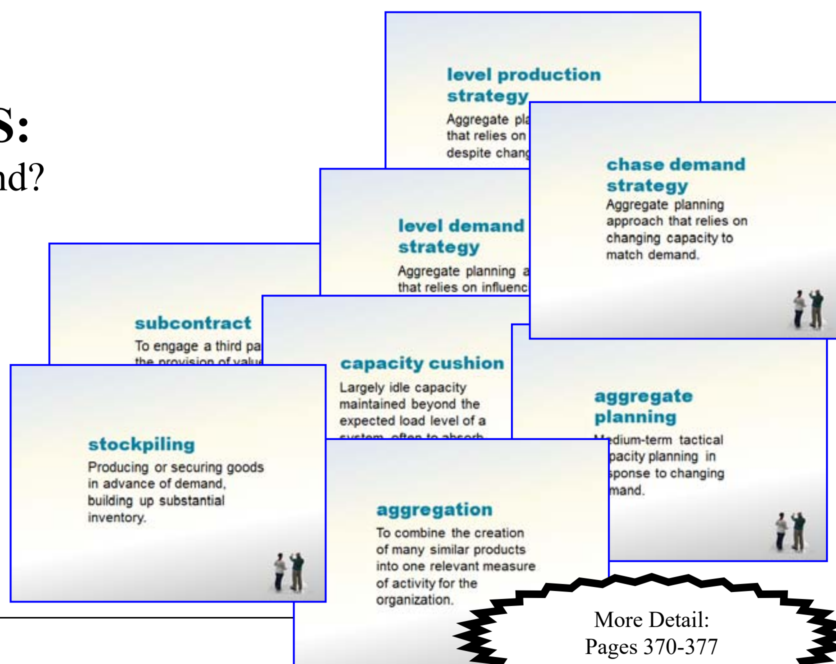
# CAPACITY OPTIONS:

1. How can you change your production capacity to reflect changing demand conditions?

2. How can you not change your production capacity, despite demand conditions?

# DEMAND OPTIONS:

How can you change demand?


More Detail:
Pages 370-377

# AGGREGATE PLANNING METHOD ONE: CHARTING

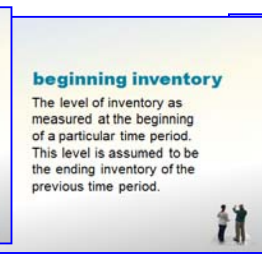
Create and interpret an illustration of your proposed strategy...

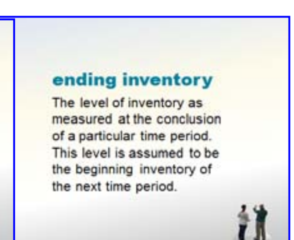
Example:

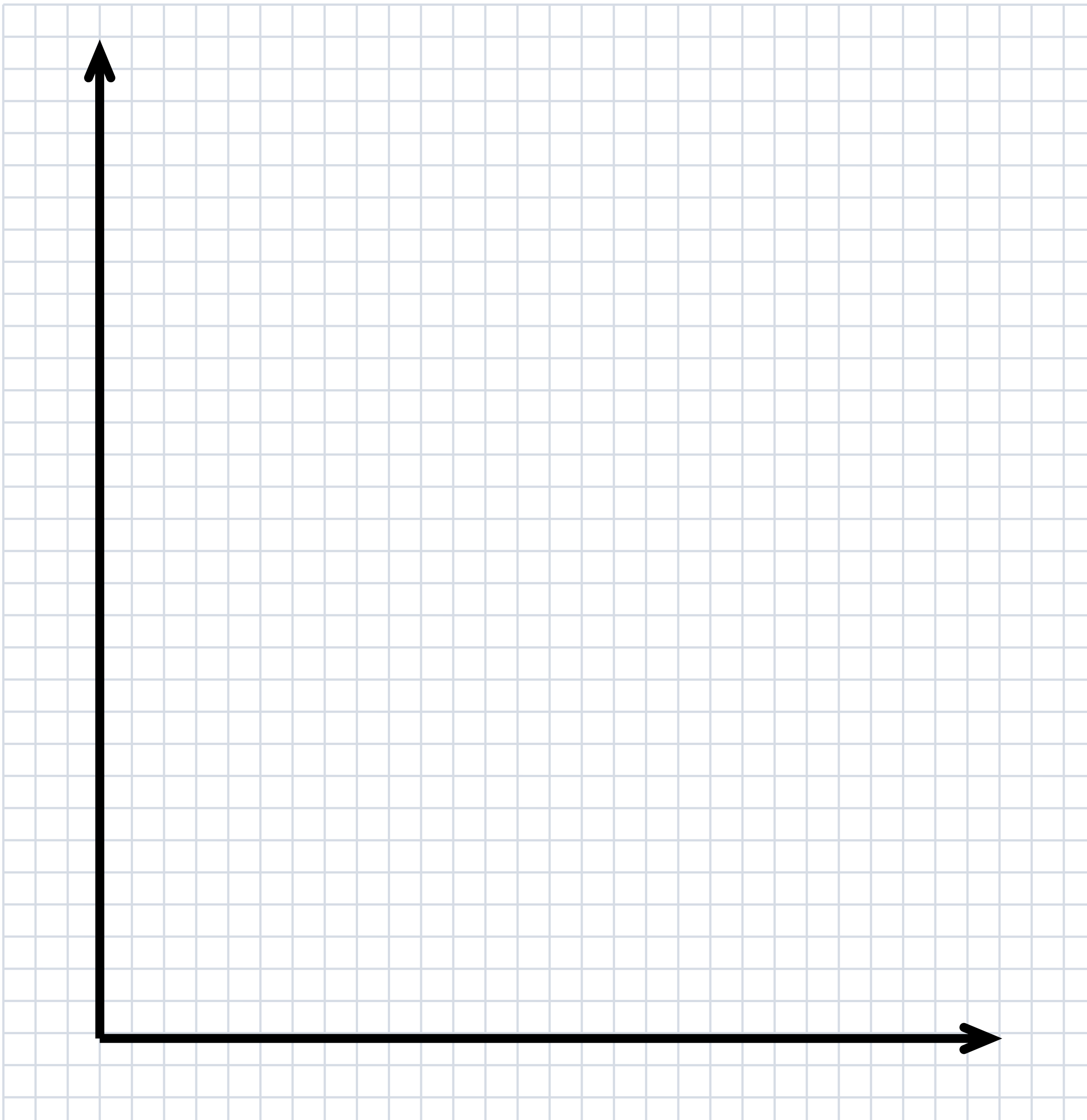
| Month | Demand Forecast | Chase Strategy | Level Strategy |
|---|---|---|---|
| 1 | 100 | 100 | 200 |
| 2 | 350 | 400 | 200 |
| 3 | 150 | 100 | 200 |
| 4 | 50 | 100 | 200 |
| 5 | 50 | 0 | 200 |
| 6 | 500 | 500 | 200 |

How can we illustrate this?

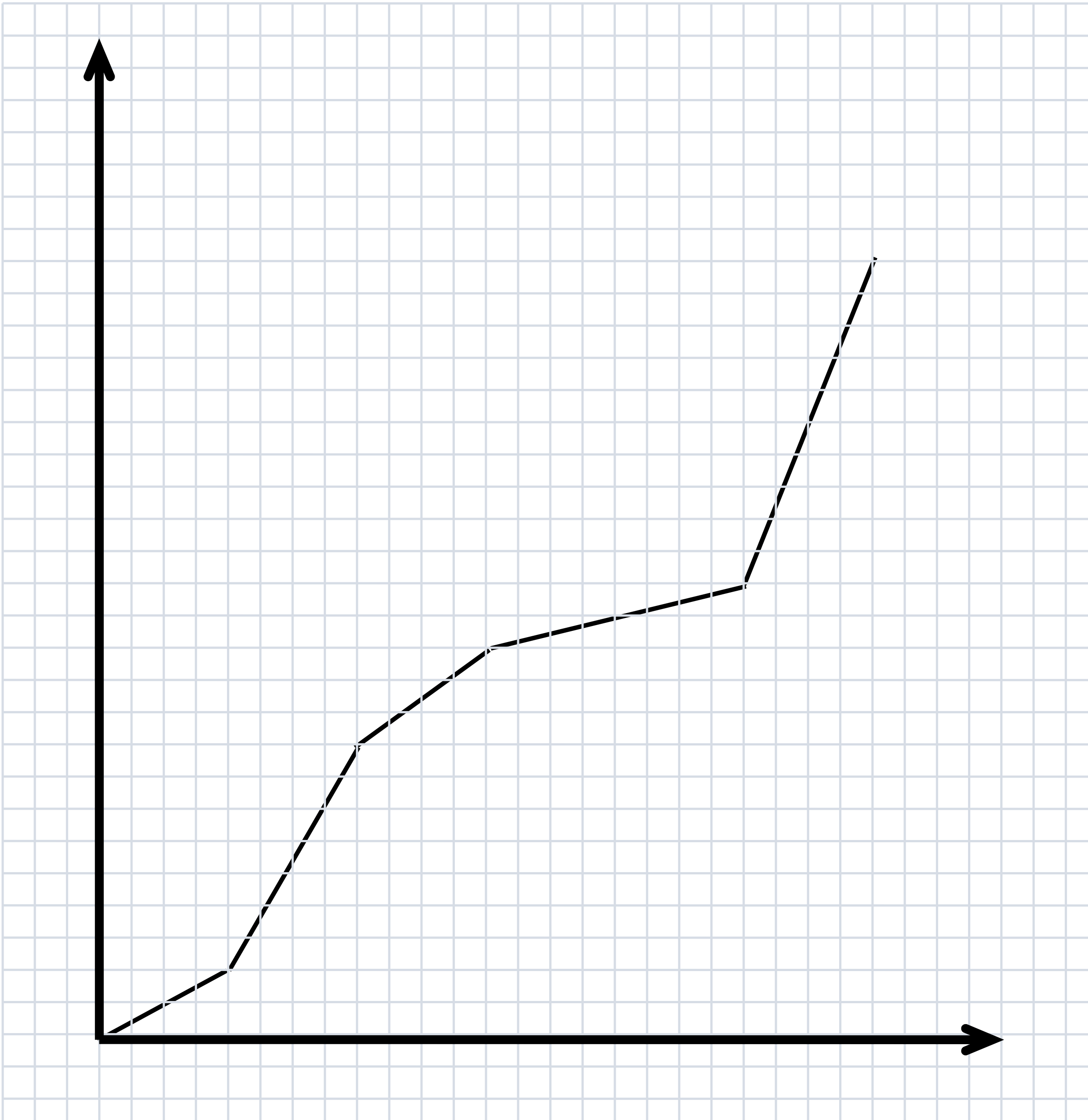
| Month | Cumulative Demand | Cumulative Chase Strategy | Cumulative Level Strategy |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |

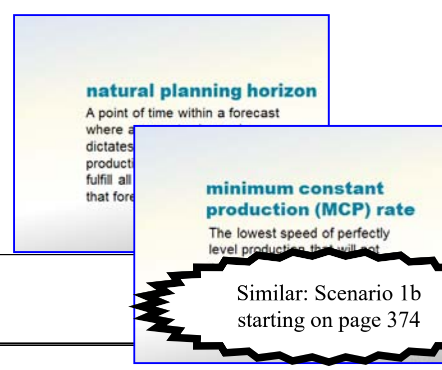






Similar: Scenario 1a
starting on page 372






Similar: Scenario 1b starting on page 374

# General Aggregate Planning Tips

***Step One:*** Identify a Strategy
***Step Two:*** Implement it, given your data and options
***Step Three:*** Determine its total cost
***Step Four:*** Go back to step one, pick another strategy, and see if it is less expensive by the time you get to step three

EXAMPLE:

| | | | | | |
|---|---|---|---|---|---|
| Month: | 1 | 2 | 3 | 4 | 5 |
| Demand: | 200 | 1000 | 300 | 1200 | 600 |

Cost of Increasing the Workforce by One = $500
Cost of Decreasing the Workforce by One = $700
Cost of Producing One Unit in Regular Time = $15
Cost of Producing One Unit in Overtime = $25
Cost of Carrying One Unit in Inventory for One Month = $10
Each person can work 160 hours of Regular Time in a month.
Each person can work 80 hours of Overtime in a month.
It takes one person one hour to produce one unit.
Current size of workforce: 7 people.

**Try this Strategy-**

| Month: | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Demand: | 200 | 1000 | 300 | 1200 | 600 |
| Produced: | | | | | |
| Resulting Size of Workforce: | | | | | |



More Detail:
Pages 377-387, including
Scenario 1c and 1d

Same problem as on SN 108 but using an Optimization Technique:

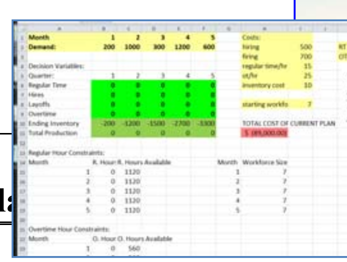
| Month: | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Demand: | 200 | 1000 | 300 | 1200 | 600 |

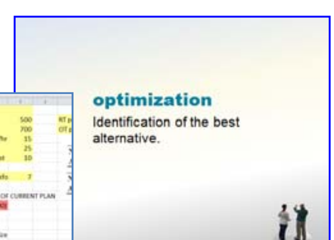
Cost of Increasing the Workforce by One = $500
Cost of Decreasing the Workforce by One = $700
Cost of Producing One Unit in Regular Time = $15
Cost of Producing One Unit in Overtime = $25
Cost of Carrying One Unit in Inventory for One Month = $10
Each person can work 160 hours of Regular Time in a month.
Each person can work 80 hours of Overtime in a month.
It takes one person one hour to produce one unit.
Current size of workforce: 7 people.

## AGGREGATE PRODUCTION PLAN:

| Month: | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Regular Production: | | | | | |
| Overtime Production: | | | | | |
| Ending Inventory: | | | | | |
| New Hires: | | | | | |
| Layoffs: | | | | | |
| TOTAL COST OF PLAN: | | | | | |

(look for **aggregate math program**.xls on UBlearns…)





AGGREGATE PLANNING EXAMPLE (AGAIN):

| | | | | | |
|---|---|---|---|---|---|
| Month: | 1 | 2 | 3 | 4 | 5 |
| Demand: | 200 | 1000 | 300 | 1200 | 600 |

Cost of Increasing the Workforce by One = $500
Cost of Decreasing the Workforce by One = $700
Cost of Producing One Unit in Regular Time = $15
Cost of Producing One Unit in Overtime = $25
Cost of Carrying One Unit in Inventory for One Month = $10
Each person can work 160 hours of Regular Time in a month.
Each person can work 80 hours of Overtime in a month.
It takes one person one hour to produce one unit.
Current size of workforce: 7 people.

***But suppose you pay $10 per hour of idle regular time (Each person is promised 160 hours of regular time)...***

## AGGREGATE PRODUCTION PLAN:

| Month: | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Regular Production: | | | | | |
| Overtime Production: | | | | | |
| Ending Inventory: | | | | | |
| New Hires: | | | | | |
| Layoffs: | | | | | |
| TOTAL COST OF PLAN: | | | | | |

# SIX OLD EXAM QUESTIONS ON *AGGREGATE PLANNING*:

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

Video tutorials explaining each of these questions are available on UBlearns.

Livingston Fabrication has created the following aggregate plan for the next five months:

| | August | September | October | November | December |
|---|---|---|---|---|---|
| Forecasted Demand (units of finished goods): | 1,500,000 | 1,500,000 | 2,000,000 | 3,000,000 | 500,000 |
| Production Plan: | 2,000,000 | 2,000,000 | 2,000,000 | 2,000,000 | 2,000,000 |

August Production
---------------------
2,000,000

Ending Inventory 500,000 1,000,000 1,000,000 0 1,500,000

12 Units / Hr
1000 Workers
150 Hours

= 1,800,000 Units 2,000,000 - 180,000,000 = 200,000 200,000 / (12*150) = 111.11

Assume that Livingston will have nothing in inventory at the end of July. Livingston employs 1,000 production assembly workers and it takes one production assembly worker 5 minutes to assemble one unit of finished good. (The unit is complete at that point.) Each production assembly worker can provide 150 hours of assembly time a month without requiring overtime pay. Please answer the following four questions, based on this information

We have 1000
6*60 = 12 Units/ hr

**1.** Livingston wants to complete this plan without working any overtime in assembly. Logically, how many <u>additional</u> production assembly workers should Livingston hire to start in August?

a) none b) 64 c) 112 d) 145 e) 224

Similar: Chapter 11
Scenarios #29 and #30

**2.** What will the <u>ending</u> inventory level during the month of October?

a) 0 b) 125,000 c) 250,000 d) 750,000 e) 1,000,000

**3.** What will the <u>average</u> inventory level during the month of September?

a) 0 b) 125,000 c) 250,000 d) 750,000 e) 1,000,000

500,000 + 1,000,000 / 2 =

**4.** If it costs Livingston $2 to hold one unit of finished good in inventory for one month, what is the total holding cost of this five month plan?

a) $1,000,000 b) $2,000,000 c) $4,000,000 d) $5,000,000 e) $8,000,000

(500,000 + 1,000,000 + 1,000,000 + 0 + 1,500,000) * 2.00 = 8,000,000

# SIX OLD EXAM QUESTIONS ON *AGGREGATE PLANNING* CONT'D:

**5.** A warehouse began the month of October with 300 tons of goods, but its inventory had fallen to 100 tons at the beginning of November, before increasing again to 200 tons at the beginning of December. Which of the following best describes the change in average monthly inventory from October to November?

a) -45% b) -25% c) 0% d) 100% e) 400%

October 300
November 100
December 200

Average Inventory October
300 + 100 / 2 = 200

Average Inventory for november
100 + 200 / 2 = 150

Newer - older / older

150 - 200 / 200 = -.25%

Similar: Chapter 11 Quick Start #15 and #16; Ramp Up # 21- #23

**6.** Customer demand for some finished good is forecasted at 1000 units for January, 2000 units for February, and 3000 units for March. If the company that produces this finished good has nothing in inventory at the beginning of January, how much should it plan to produce during the month of March, if it wants to follow a level production schedule that leaves it with nothing in inventory at the end of March?

a) 1000 units b) 2000 units c) 3000 units d) 4000 units e) 6000 units

January 1000 Units
Feburary 2000 Units
March 3000 Units

Total = 6,000 Units for 3 months

6000 / 3 = 2,000 Units a month to break even on inventory

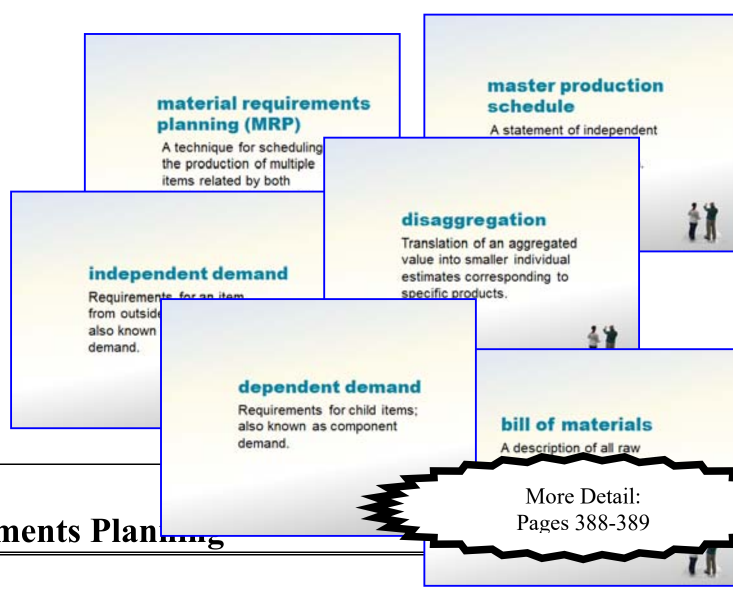
# Material Requirements Planning
## "The Right Part at the Right Time"

## THE THREE INPUTS OF MRP

1. A Bill of Materials

2. A Master Production Schedule

3. Current Inventory Records




More Detail:
Pages 388-389

# INPUT ONE: BILL OF MATERIALS

## Example Product Structures:

Your company assembles two product lines: ***transaxles*** and ***turnstiles***. A typical transaxle consists of three yellow wheels, a red rod, a blue rod, and a green bearing. Two yellow wheels and the green bearing are joined with the red rod to create an "axle subassembly." The third yellow wheel is welded to the end of the blue rod to create the "transmission subassembly." When these two subassemblies are linked, the finished product looks like this:

A typical turnstile consists of a blue wheel, a yellow wheel, four red rods, an orange washer and one blue rod. The yellow wheel and blue rod are welded together to create the same "transmission subassembly" used in the transaxle. The four red rods are fixed to blue wheel to create a "top subassembly." When these two subassemblies are linked with the addition of an orange washer, they look like this:

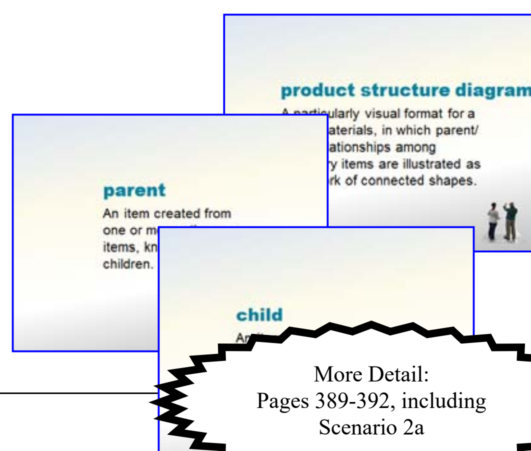
# INPUT ONE: BILL OF MATERIALS

*Describing Product Structures*: The Product Structure Tree

Level 0

Level 1

Level 2




More Detail:
Pages 389-392, including
Scenario 2a

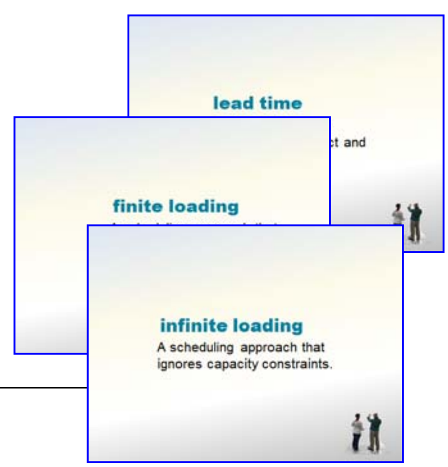
# Additional Bill of Material Issue...

***Time Phasing***. How do you add the dimension of time to your illustration of the product's structure? For example:

| **Item:** | **Leadtime:** |
|---|---|
| Transaxle | 1 day |
| Turnstile | 1 day |
| Axle SA | 5 days |
| Transmission SA | 2 days |
| Top SA | 3 days |
| Red Rod | 1 day |
| Blue Rod | 1 day |
| Yellow Wheel | 5 days |
| Blue Wheel | 2 days |
| Orange Washer | 1 day |
| Green Bearing | 5 days |

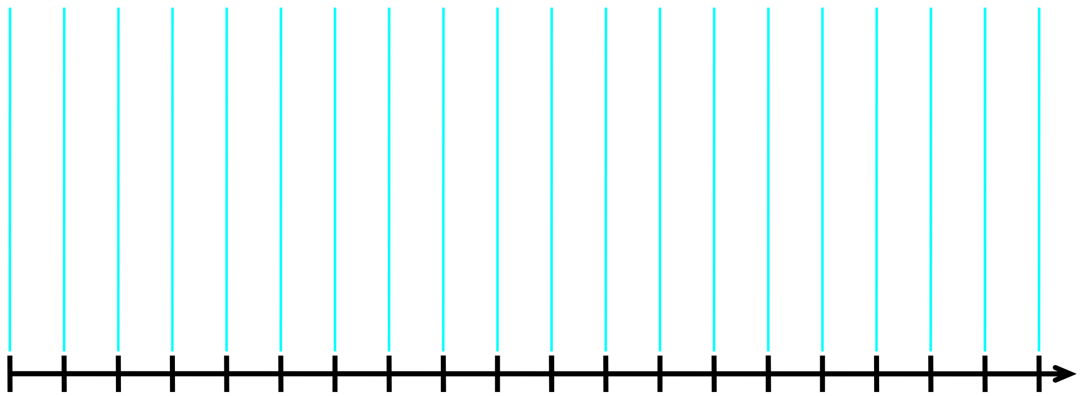
How long would it take to produce a transaxle?

How long would it take to produce a turnstile?



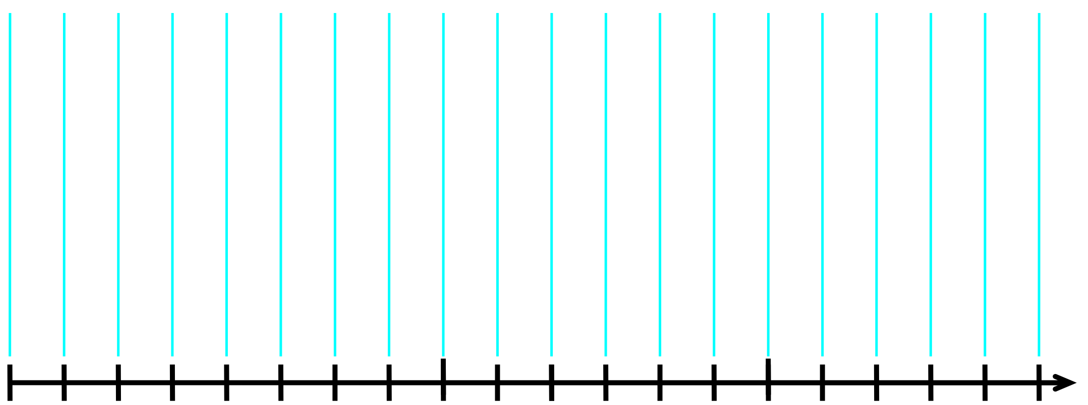
“TIME PHASED PRODUCT STRUCTURE TREES”

Transaxle:



Time...

Turnstile:



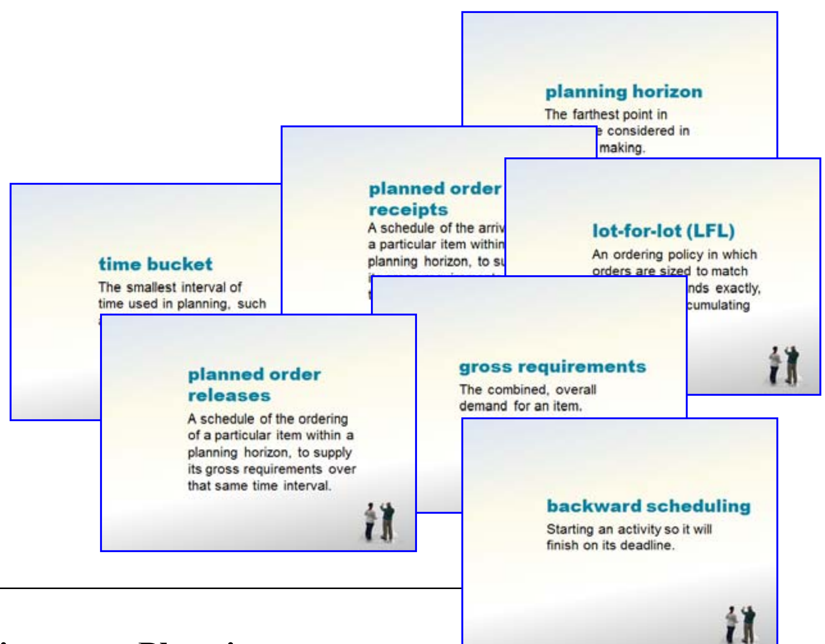
Time...


More Detail:
Pages 392-395, including
Scenario 2b

# THE BASIC MRP RECORD

PART: LEADTIME: LOTSIZE:

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| Gross Requirements: | | | | | | | | | | |
| Planned Order Receipts: | | | | | | | | | | |
| Available Balance: | | | | | | | | | | |
| Planned Order Releases: | | | | | | | | | | |



# THE STEPS OF MRP

1. Enter what you know.

2. Calculate the Planned Order Releases for all LEVEL 0 items.

3. Enter the Planned Order Releases of each parent into the Gross Requirements line of each child's record, multiplied by the number of that child item required by the parent.

4. Go to the next level and repeat this process for all items on that level. Go to the next level and keep repeating this process until you've done it for all levels.


More Detail:
Pages 397-399

# Material Requirements Planning
# EXAMPLE PROBLEM

# THE INPUTS OF MRP

1. A Bill of Materials
For example, our transaxles and turnstiles...

2. A Master Production Schedule
For example,

| Day: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Transaxles Req.: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **42** |
| Turnstiles Req.: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **23** | 0 |

3. Current Inventory Records
For example,

| Item: | Leadtime: | Current On-hand Inventory: |
|---|---|---|
| Transaxle | 1 day | 20 |
| Turnstile | 1 day | 20 |
| Axle SA | 5 days | 10 |
| Transmission SA | 2 days | 0 |
| Top SA | 3 days | 0 |
| Red Rod | 1 day | 0 |
| Blue Rod | 1 day | 0 |
| Yellow Wheel | 5 days | 80 |
| Blue Wheel | 2 days | 75 |
| Orange Washer | 1 day | 0 |
| Green Bearing | 5 days | 30 |

# MRP RECORDS (LEVEL 0)

PART: Transaxle LEADTIME: 1 day

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Gross Requirements: | | | | | | | | | |
| Planned Order Receipts: | | | | | | | | | |
| Available Balance: | | | | | | | | | |
| Planned Order Releases: | | | | | | | | | |

PART: Turnstile LEADTIME: 1 day

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Gross Requirements: | | | | | | | | | |
| Planned Order Receipts: | | | | | | | | | |
| Available Balance: | | | | | | | | | |
| Planned Order Releases: | | | | | | | | | |

# MRP RECORDS (LEVEL 1)

PART: Axle Sub-assembly LEADTIME: 5 days

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| Gross Requirements: | | | | | | | | | | |
| Planned Order Receipts: | | | | | | | | | | |
| Available Balance: | | | | | | | | | | |
| Planned Order Releases: | | | | | | | | | | |

PART: Transmission Sub-Assembly LEADTIME: 2 days

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| Gross Requirements: | | | | | | | | | | |
| Planned Order Receipts: | | | | | | | | | | |
| Available Balance: | | | | | | | | | | |
| Planned Order Releases: | | | | | | | | | | |

PART: Top Sub-Assembly LEADTIME: 3 days

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| Gross Requirements: | | | | | | | | | | |
| Planned Order Receipts: | | | | | | | | | | |
| Available Balance: | | | | | | | | | | |
| Planned Order Releases: | | | | | | | | | | |

PART: Orange Washer LEADTIME: 1 day

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| Gross Requirements: | | | | | | | | | | |
| Planned Order Receipts: | | | | | | | | | | |
| Available Balance: | | | | | | | | | | |
| Planned Order Releases: | | | | | | | | | | |

# MRP RECORDS (LEVEL 2)

PART: Red Rod LEADTIME: 1 day

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Gross Requirements: | | | | | | | | | |
| Planned Order Receipts: | | | | | | | | | |
| Available Balance: | | | | | | | | | |
| Planned Order Releases: | | | | | | | | | |

PART: Blue Rod LEADTIME: 1 day

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Gross Requirements: | | | | | | | | | |
| Planned Order Receipts: | | | | | | | | | |
| Available Balance: | | | | | | | | | |
| Planned Order Releases: | | | | | | | | | |

PART: Yellow Wheel LEADTIME: 5 days

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Gross Requirements: | | | | | | | | | |
| Planned Order Receipts: | | | | | | | | | |
| Available Balance: | | | | | | | | | |
| Planned Order Releases: | | | | | | | | | |

PART: Blue Wheel LEADTIME: 2 days

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Gross Requirements: | | | | | | | | | |
| Planned Order Receipts: | | | | | | | | | |
| Available Balance: | | | | | | | | | |
| Planned Order Releases: | | | | | | | | | |

## MRP RECORDS (MORE LEVEL 2)

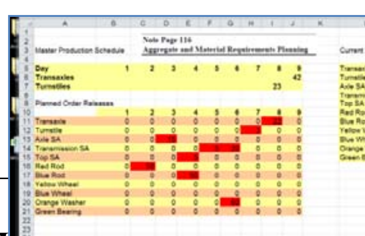
PART: Green Bearing LEADTIME: 5 days

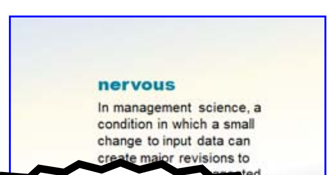
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| Gross Requirements: | | | | | | | | | | |
| Planned Order Receipts: | | | | | | | | | | |
| Available Balance: | | | | | | | | | | |
| Planned Order Releases: | | | | | | | | | | |

(look for **mrp.xls** on UBlearns…)

## SUMMARY OF PLANNED ORDER RELEASES:

| Item | Level | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 | Day 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Transaxle** | 0 | | | | | | | | | |
| **Turnstile** | 0 | | | | | | | | | |
| **Axle SA** | 1 | | | | | | | | | |
| **Transmission SA** | 1 | | | | | | | | | |
| **Top SA** | 1 | | | | | | | | | |
| **Red Rod** | 2 | | | | | | | | | |
| **Blue Rod** | 2 | | | | | | | | | |
| **Yellow Wheel** | 2 | | | | | | | | | |
| **Blue Wheel** | 2 | | | | | | | | | |
| **Orange Washer** | 1 | | | | | | | | | |
| **Green Bearing** | 2 | | | | | | | | | |






More Detail:
Pages 399-407, including
similar Scenario 2c

# SIX OLD EXAM QUESTIONS ON *MATERIAL REQUIREMENTS PLANNING*:

Video tutorials explaining each of these questions are available on UBlearns.

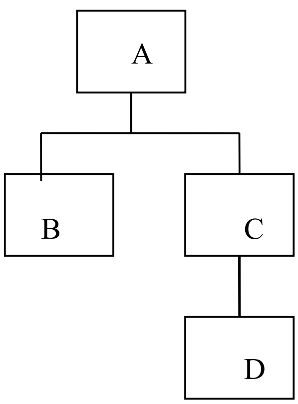
**1.** Consider the following product structure: Each A consists of 2 B's and 1 C. Each B consists of 3 D's and 2 E's. Each C consists of 4 D's and 2 E's. How many D's are necessary to produce 400 A's?

a) 1600 b) 2400 c) 4000 d) 2000 e) 400

Similar problems:
Quick Start #13

The XYZ Company has just hired you as Production Manager of their Nort h American Fabrication Facility. Your first job is to use the MRP methodology to schedule production for the next nine weeks. The XYZ Company has given you the following information to work with:

Bill of Materials:
(Product Structure Diagram)




Similar MRP problem:
Chapter 11 Scenarios #32 and #33

Current Inventory Records:

| Part | Leadtime (in weeks) | Lotsize | Inventory Currently On-hand |
|---|---|---|---|
| A | 1 | Lot-for-Lot | 125 |
| B | 3 | 100 | 875 |
| C | 2 | Lot-for-Lot | 55 |
| D | 1 | 50 | 900 |

Master Production Schedule:

| | -Weeks- | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Part | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| A | 100 | 0 | 0 | 500 | 0 | 500 | 100 | 0 | 95 |

# SIX OLD EXAM QUESTIONS ON *MATERIAL REQUIREMENTS PLANNING* CONT'D:

**2.** Using your MRP schedule for the next nine weeks, how much of Part C will be in inventory at the end of Week 3?

a) 0 b) 25 c) 55 d) 80 e) 100

**3.** Using your MRP schedule for the next nine weeks, how much of Part B will be in inventory at the end of Week 9?

a) 0 b) 5 c) 25 d) 55 e) 80

**4.** Which of the following best describes some of the events taking place in Week 4 at your facility?

I. An order for 475 A's will be completed (planned order receipts).
II. An order for 100 D's will be completed (planned order receipts).
III. An order for 100 C's will be placed (planned order releases).

a) I only. b) II only. c) III only. d) I and III. e) I, II, and III.

**5.** Bartran Company assembles ink cartridges. Each finished cartridge has three child items: a plastic case, a label and several ounces of ink. Lead time on assembling a finished cartridge is 1 day, while the lead time for procuring new plastic cases is also 1 day, although the lead time is 5 days for procuring new labels and 2 days for procuring more ink. Assuming that all the assumptions of an MRP bill of materials is true, how long would it take Bartran to create at least one finished ink cartridge if it started with nothing in stock?

a) 6 days b) 7 days c) 4 days d) 5 days e) 9 days

**6.** Suppose you made a sandwich from two slices of bread and one slice of American cheese. Suppose a friend of yours drew a product structure diagram to describe what you just did. Which of the following statements is true about this diagram?

I. The slice of American cheese is a "Level Zero" item.
II. The slice of American cheese is a "child" of your finished sandwich, which means the finished sandwich is its "parent" item.
III. This diagram has a total of three levels.

a) I only. b) II only. c) I and III. d) II and III. e) I, II, and III.

# MRP RECORDS FOR EXAMPLE EXAM PROBLEM:

PART: LEADTIME: LOTSIZE:

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Gross Requirements: | | | | | | | | | |
| Planned Order Receipts: | | | | | | | | | |
| Available Balance: | | | | | | | | | |
| Planned Order Releases: | | | | | | | | | |

PART: LEADTIME: LOTSIZE:

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Gross Requirements: | | | | | | | | | |
| Planned Order Receipts: | | | | | | | | | |
| Available Balance: | | | | | | | | | |
| Planned Order Releases: | | | | | | | | | |

PART: LEADTIME: LOTSIZE:

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Gross Requirements: | | | | | | | | | |
| Planned Order Receipts: | | | | | | | | | |
| Available Balance: | | | | | | | | | |
| Planned Order Releases: | | | | | | | | | |

PART: LEADTIME: LOTSIZE:

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Gross Requirements: | | | | | | | | | |
| Planned Order Receipts: | | | | | | | | | |
| Available Balance: | | | | | | | | | |
| Planned Order Releases: | | | | | | | | | |

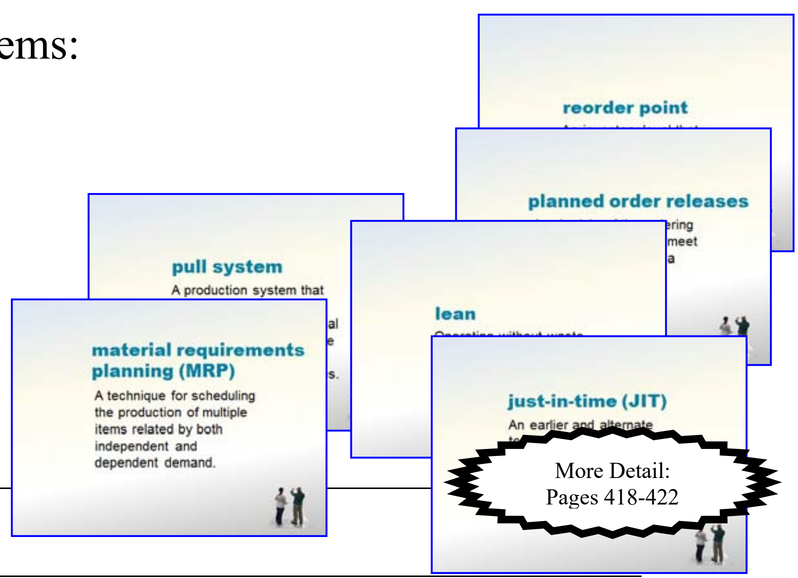
# LEAN OPERATION

*How do you know when it's time to place an order for some item?*

* Reorder Point Systems:

* MRP Systems:

* Lean (Just in Time) Systems:



# LEAN SYSTEMS

*Making this work...*

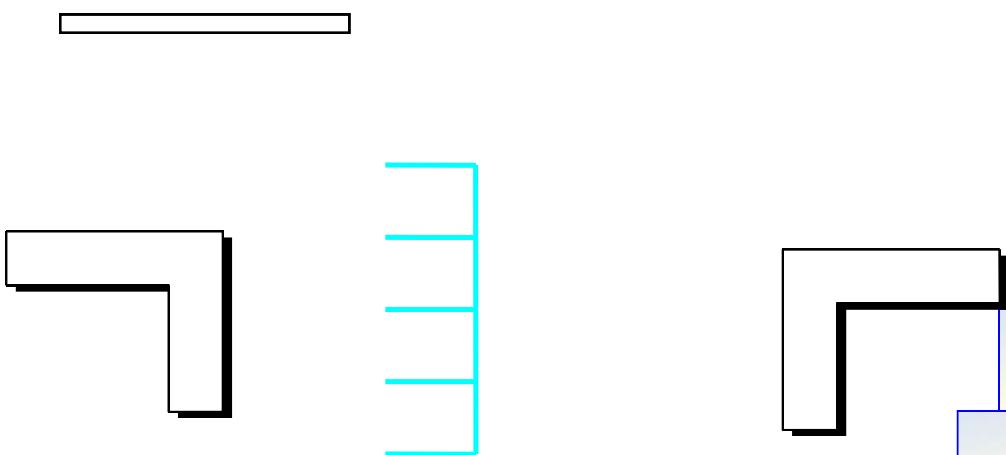
In a lean system, we don't order or produce until we receive a signal that the system "needs some more"...

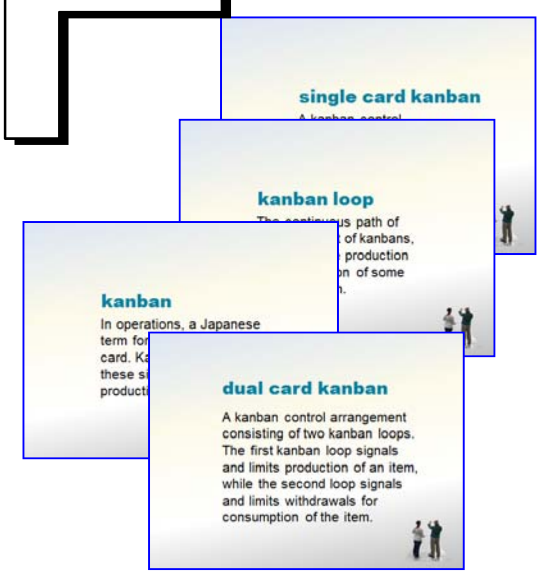
Possible signals...

Single card Kanban system...

Producing Workcenter

Consuming Workcenter





BUT, HOW MANY KANBAN CARDS SHOULD YOU HAVE FOR EACH ITEM?

YOU COULD USE TOYOTA'S FORMULA...

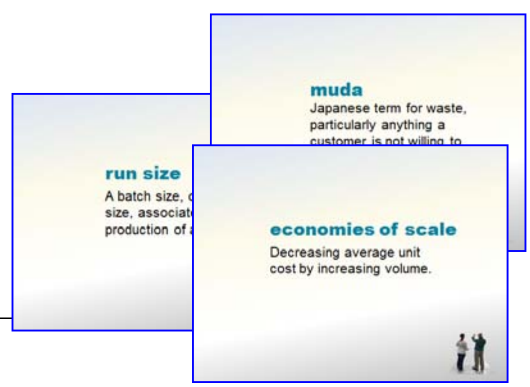


More Detail:
Pages 422-427, including
Scenario 1

# GENERAL MECHANICS AND PHILOSOPHY OF LEAN

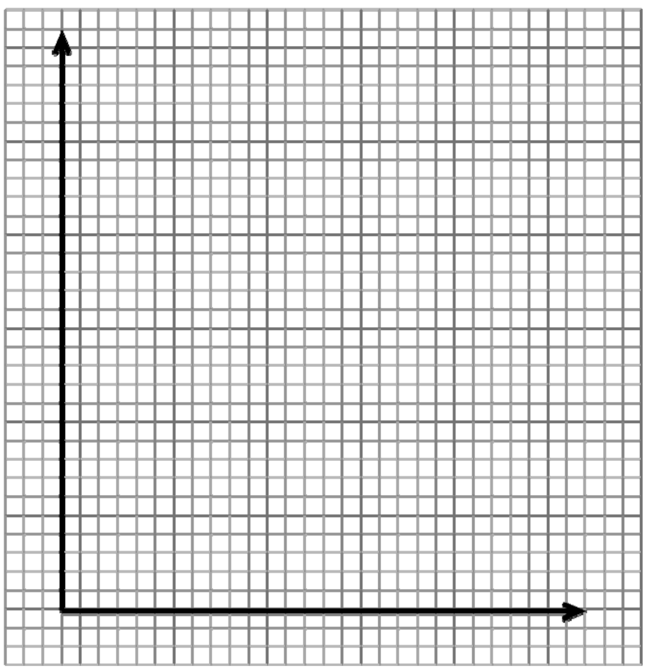
1. Reduce lot sizes and ordering costs.

2. Improve material handling and facility layout

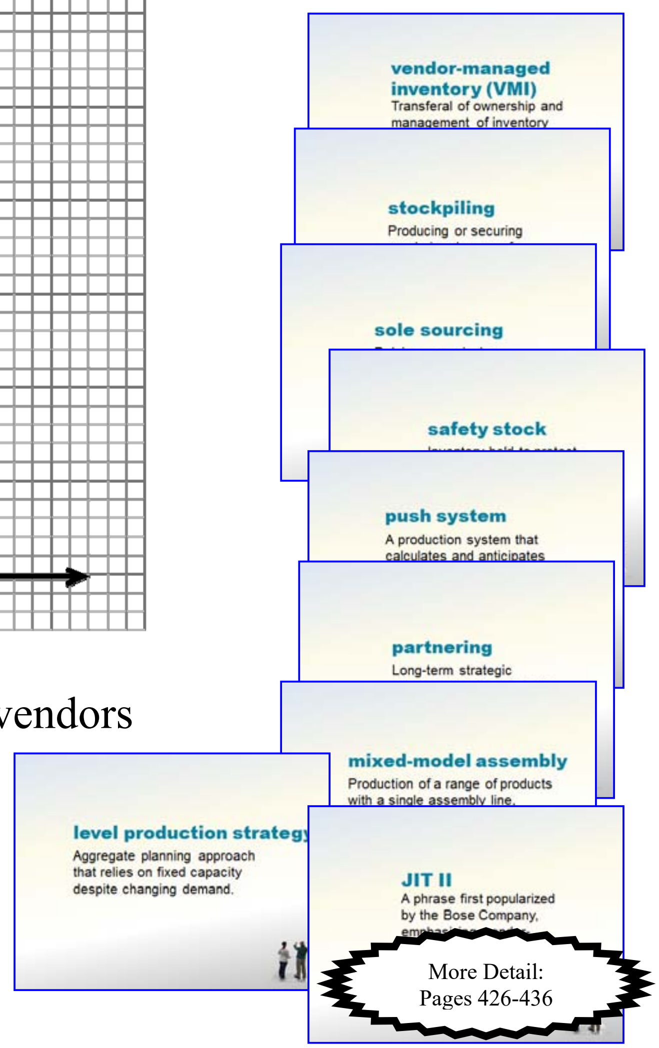


3. No more safety stock!

4. "Smooth production"



5. Reduce the number of outside vendors you deal with.



# SIX OLD EXAM QUESTIONS ON *LEAN OPERATIONS*:

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

Video tutorials explaining each of these questions are available on UBlearns.

**1.** One common illustration used to demonstrate the philosophy of Just in Time inventory management shows a lake in which sharp rocks are hiding beneath the water's surface. Which of the following is true about that illustration?

Similar problems:
Chapter 12 Ramp Up
#20-#21

~~I.~~ The sharp rocks represent safety stock.
~~II.~~ The water represents mistakes and defects produced by your manufacturing system.
III. Water hiding the rocks illustrates how high inventory levels can hide production problems.

a) II only. b) III only. c) II and III. d) I and III. e) I, II, and III.

**2.** Suppose you are visiting a friend who works in a factory with a Kanban system in place to control production. Three Kanban cards are hanging on a board next to your friend's workstation, while another identical Kanban card is attached to the container he is busy filling with the parts that he makes at that workstation. Five more matching Kanban cards are already attached to full containers which he has placed in a convenient "parking" area in front of his workstation. Even as he works, a supervisor walks over, removes two of the Kanban cards from his board, and puts them in her pocket. The supervisor then walks away. Which of the following is the <u>**best**</u> explanation for why the supervisor did that?

a) The supervisor wants to increase the level of work-in-process inventory in the system.
~~b) The super~~visor is worried about your friend making defective parts.
~~c) The~~ supervisor doesn't think your friend has enough work to do.
~~d) The~~ supervisor needed those two Kanban cards to pick a lock on the employee bathroom.
e) The supervisor wants to decrease the level of work-in-process inventory in the system.

Similar problems:
Ramp Up #23-

**3.** Your department provides a component for the Assembly Department. Their usage of the component is 4800 units per (8 hour) day. Your department can usually fill each container with 60 units in about 40 minutes. Management has built a 20% "efficiency factor" ( 0.20 ) into the system. How many containers (or Kanban cards) should be used for this component?

a) 6 b) 7 c) 8 d) 32 e) 64

Similar problems:
Quick Start #13-#15

D = 4800
L = 40 Minutes
C = 60
X = .20

N = DL(1+X) / C
N = (4800/8)*.66(1+.20)/60 = 8

# SIX OLD EXAM QUESTIONS ON *LEAN OPERATIONS* CONT'D:

**4.** Which of the following are general principles associated with lean operations?

I. Reduce fixed ordering and set-up costs associated with your system.
II. Improve the material handling and facility layout within your system.
III. Increase the number of outside vendors (suppliers) you deal with.

a) I only. b) II and III. c) I and II. d) I, II and III e) II only

**5.** You have introduced a kanban system into a machine shop to control the production of a common part used by many different sub-assemblies at many different workstations. The kanban system has been operating for two weeks, and you have received many complaints about it. These complaints are coming from people who build the sub-assemblies, because now they cannot always find that part in stock exactly when they need it. Which of the following best describes how you should address these complaints?

a) Increase the number of kanban cards in the loop, forcing the system to circulate more cards in the production "loop."
b) Tell the complainers to be quiet.
c) Confiscate a few of the kanban cards, forcing the system to circulate fewer cards in the production "loop."
d) Create a bigger stocking area, with better marking on the containers that hold this part.
e) Cancel the kanban system project, and go back to the methods that were in place before you introduced it.

**6.** Which of the following is true?

I. 'Muda' is another term for waste.
II. Lean operations are considered 'push' style inventory planning.
III. Lean operations rely on reaction to signals when operating, as opposed to following precisely calculated plans for inventory replenishment.

Kanbans

a) I only b) II only c) I and III d) II and III e) I, II and III

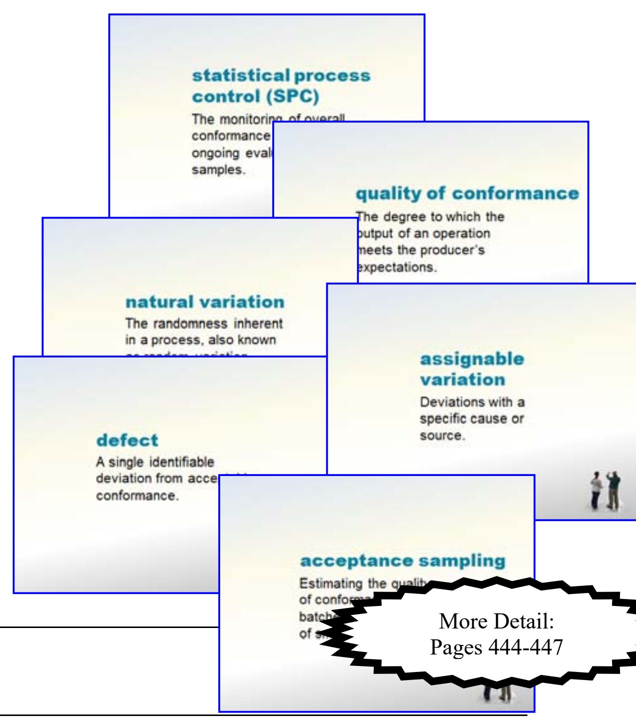
# CONTROL CHARTS:

*Is it possible to produce two items that are exactly alike?*
*We expect some variation ...*

* Random Variation-

* Assignable Variation-

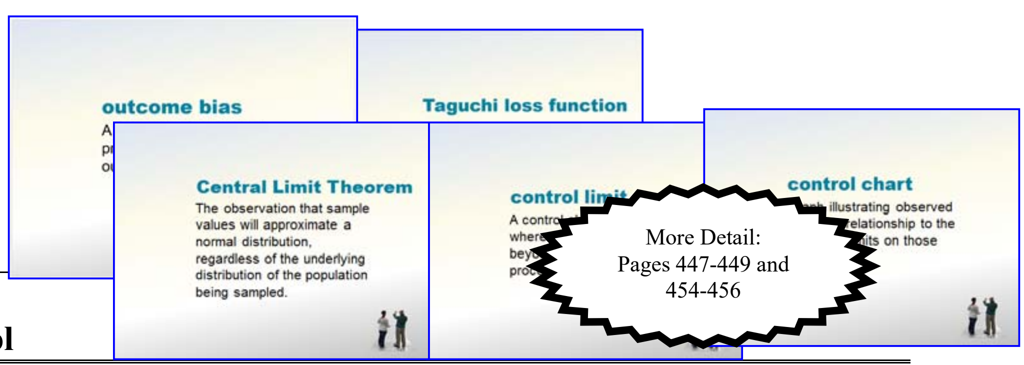
Why do we care?




More Detail:
Pages 444-447

CONTROL CHARTS:
How can we know the difference between random and assignable variation?

BEFORE WE GO FURTHER: What are the major limitations of this approach?



MEAN CHARTS WITH KNOWN VARIATION (X-bar Charts)

We are monitoring the central tendency of a process. We assume we know σ, the standard deviation of random process variability.

Step One: Gather several samples of size "n". Calculate the average of each sample.

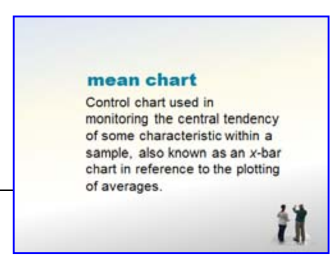
Example: Filling 12 ounce cans.

Sample size = 16 cans.
Standard deviation of the process: $\sigma = 0.05$

| SAMPLE | AVERAGE WEIGHT |
|---|---|
| #1 | 12.010 |
| #2 | 12.025 |
| #3 | 11.995 |
| #4 | 11.985 |

Step Two: Calculate the mean of the sample means.

Step Three: Calculate the standard deviation of the sample means.



Step Four:  Select a "Z" and draw the chart!

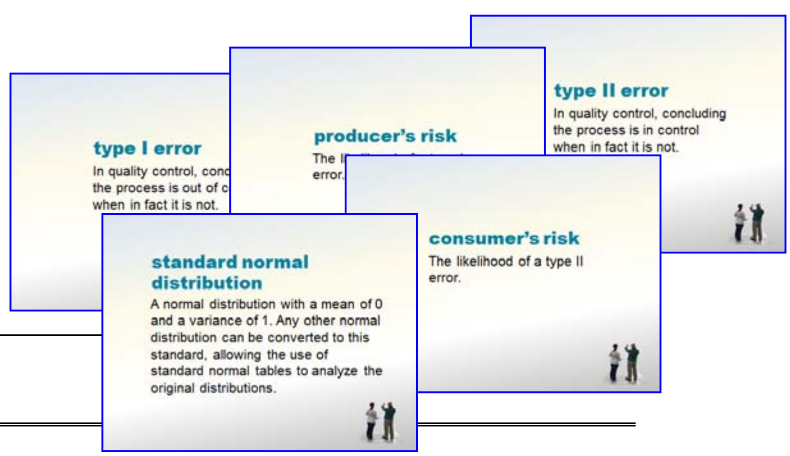
More Detail:
Pages 457-460 including
Scenario 2a

By the way...  CHOOSING Z
There is always the possibility that a sample mean will fall outside the control limits, even though the process is in control.  What is that possibility?

1. Look up your Z on the Z table.

2. Double the area you get from the table.  That is the probability that a sample mean will fall inside the control limits, given that the process is in control.

EXAMPLE:  Z = 3.00



ANOTHER EXAMPLE: Suppose we want sample means to fall within the limits 90.1% of the time, given the process is in control. Where do we put the limits?

YET ANOTHER EXAMPLE: Suppose we will only stop the process if a sample mean falls outside the control limits. We are willing to accidentally stop (stop when nothing is wrong) 3% of the time. What Z should we use for the control limits?

# MEAN CHARTS WITH UNKNOWN VARIATION (R-charts)

We are monitoring the central tendency of a process, but we don't know $\sigma$, the standard deviation of random process variability. When you don't know the random variation, you must estimate it.

Step One: When gathering your samples, also record the range of each sample.

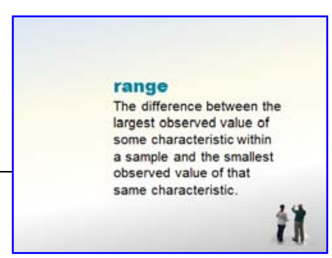
Example: Filling 12 ounce cans.

Sample size = 16 cans.

| SAMPLE | SAMPLE RANGE | AVERAGE WEIGHT |
|---|---|---|
| #1 | 0.10 | 12.010 |
| #2 | 0.15 | 12.025 |
| #3 | 0.05 | 11.995 |
| #4 | 0.10 | 11.985 |

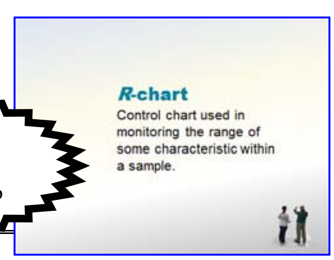
Step Two: Calculate the average range.

Step Three: Look up the factor "$A_2$" from table.



Step Four: Draw your charts! Now we should maintain two charts because it is a good idea to track sample ranges as well as sample means.

More Detail:
Pages 460-464,
including Scenario 2b



p- CHARTS

What if you don't measure each item in a sample, but just answer a "yes" or "no" question about it? This is an attribute. The "P" in P charts is short for "proportion."

Example: The results of an inspection of DNA samples taken over the past 10 days are given in the table below. The sample size is 100.

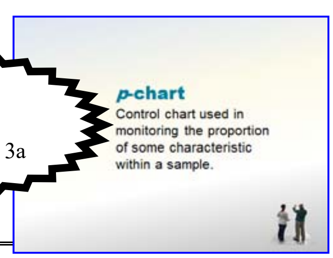
| Day | # of Defectives | Proportion of Defectives |
|---|---|---|
| 1 | 7 | |
| 2 | 6 | |
| 3 | 6 | |
| 4 | 9 | |
| 5 | 5 | |
| 6 | 6 | |
| 7 | 0 | |
| 8 | 8 | |
| 9 | 9 | |
| 10 | 1 | |

Step One: Calculate the average proportion of defective samples.

Step Two: Calculate the standard deviation in the proportion of defective samples.

Step Three: Draw your chart!

More Detail:
Pages 464-467,
including Scenario 3a



# c- CHARTS

What if there is something you want to track, but you can't sample for it exactly? What do you do if you are counting the number of times something happens?

Example: A random sample of 100 Modern Art dining room tables that came off the firm's assembly line is examined. Careful inspection reveals a total of 2000 blemishes. What are the 99.73% upper and lower control limits for the number of blemishes? If one table had 42 blemishes, should any special action be taken?

Step One: Calculate the average number of incidents (occurrences).

Step Two: Draw your chart!

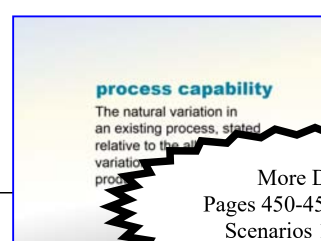

More Detail:
Pages 467-468,
including Scenario 3b

PROCESS CAPABILITY:
Given we have a control chart can we know if we have any hope of staying between the lines?

$$C_p = \frac{\text{design specification width}}{\text{natural width of the process}} \quad \text{or} \quad \frac{\text{design specification width}}{6\sigma}$$

But would that catch the problem if we were drifting toward one of the limits in particular?

$$C_{pk} = \min \frac{\text{USL} - \mu}{3\sigma}, \frac{\mu - \text{LSL}}{3\sigma}$$




More Detail:
Pages 450-453 including
Scenarios 1a and 1b

# SIX OLD EXAM QUESTIONS ON *QUALITY CONTROL*:

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

Video tutorials explaining each of these questions are available on UBlearns.

**1.** Which of the following is (are) true?

I. A production process that exhibits only random variability would be considered "out of control".
II. If a point on a control chart falls outside one of the control limits, this suggests that assignable variation is present in the production process.
III. Assignable variation in a production process is completely random, and cannot be prevented.

a) I only. b) II only. c) III only. d) I and II. e) I and III.

Tobi Skinner, a Quality Analyst, wants to construct a sample mean chart (or "x-bar" chart) for monitoring and controlling a packaging process. She knows from past experience that whenever this process is under control, package weight is normally distributed with a standard deviation of two ounces. While the process was in control, Tobi took several samples, each sample consisting of four packages.

Similar mean chart problem: Chapter 13 Scenario #28

N =4

Q = 2

2 / sqrt(4)

| Sample | Average weight (ounces) |
|---|---|
| #1 | 23 |
| #2 | 21 |
| #3 | 20 |
| #4 | 19 |
| #5 | 20 |

= 1 Ounce

**2.** What is the standard deviation of the sample means whenever this process is under control?
a) 0.1 ounces. b) 0.4 ounces. c) 0.5 ounces. d) 1 ounce. e) 2 ounces.

**3.** If Tobi uses z = 3 for her upper and lower control limit formulas, what will be the upper and lower control limits of her chart?

a) UCL =23.6 and LCL =17.6 b) UCL =26.6 and LCL =14.6 c) UCL =23 and LCL =17
d) UCL = 26 and LCL = 14 e) UCL = 100 and LCL = 0

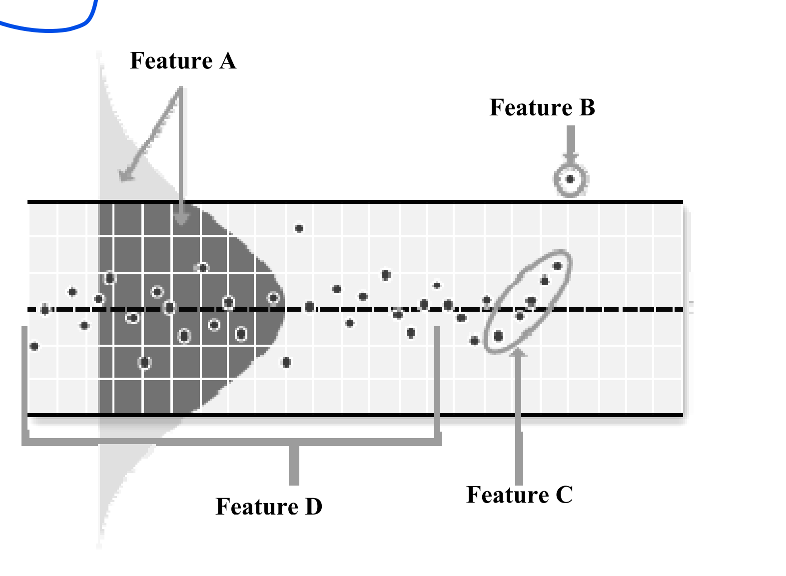
N = 5 Mean X = 20.6 Average Range = 23 - 19 = 4 Ounces A2 = 0.577

UCL = 20.6+(0.577*4) = 22.908
UCL = 20.6-(0.577*4) = 22.908

# SIX OLD EXAM QUESTIONS ON *QUALITY CONTROL* CONT'D:

**4.** Suppose the packaging process will only be stopped if a sample mean falls outside of the control limits. Consider a chart Tobi constructed using z = 1.5. What is the probability that a sample mean will fall <u>outside</u> of the control limits, given the process is in control?

a) 0.00% b) 13.36% c) 43.32% d) 86.64% e) 100.00




Consider the illustration above, in which a control chart is super-imposed on a normal distribution labeled Feature A, representing the distribution of the natural variation in samples from the process that the control chart is designed to monitor. Various samples from that process have been plotted on the chart, visible within Features B, C, and D. Please answer the following two questions, based on this illustration.

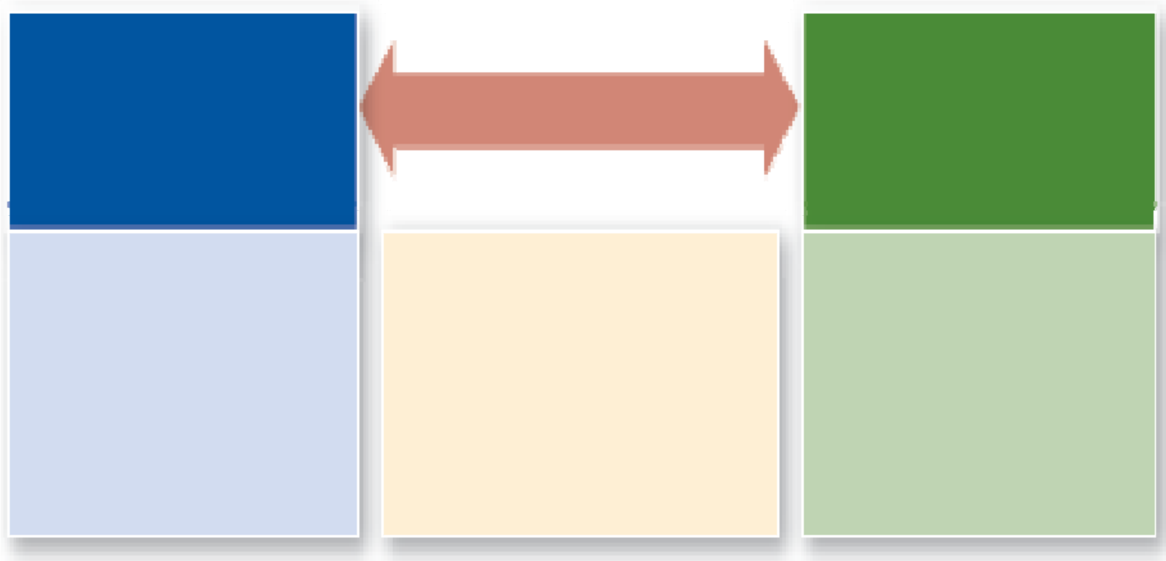
**5.** Which of the following is/are true?
I. The samples charted within the horizontal bracket of Feature D (and Feature D only) would suggest that this process is in control.
II. Both Features B and C can be interpreted as signals that assignable variation is present.
III. Only Feature B suggests the process is out of control.

a) I only b) III only c) I and II d) II and III e) I, II and III

**6.** The area of the Feature A 'tails' located outside of the upper and lower control limits represent what?
a) assignable variation b) group think c) consumer's risk
d) producer's risk e) Taguchi loss function

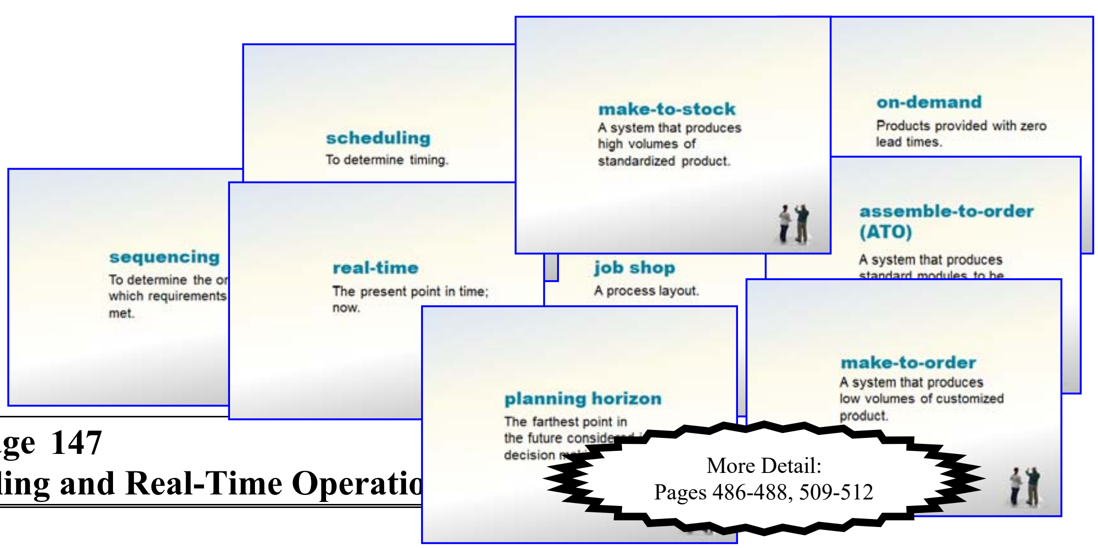
**<u>Scheduling</u>** - establishing the *timing* of the use of equipment, facilities, and employees in an organization.

| **High Volume** | **Medium Volume** | **Low Volume** |
|---|---|---|



**So when is *planning* called *scheduling* and *scheduling* called *planning*?**

**Where does *real-time* fit?**



# Scheduling a Single Workcenter: Priority Rules

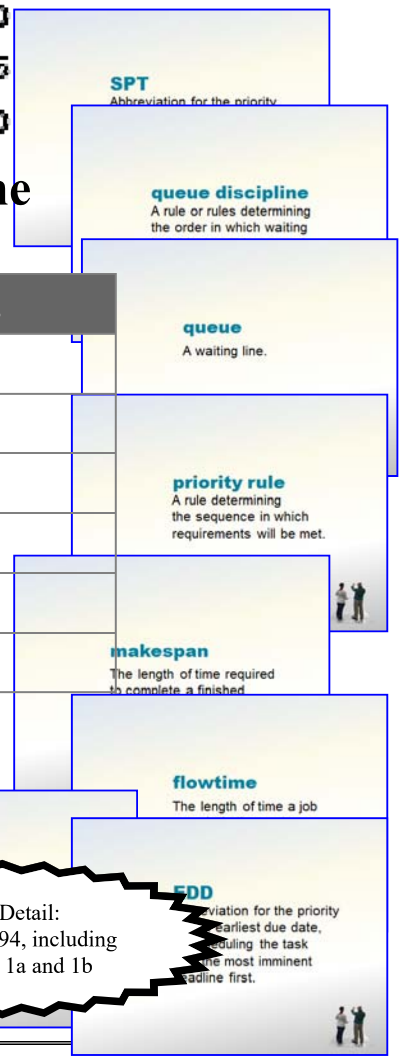
*How do you choose which job to schedule next?*

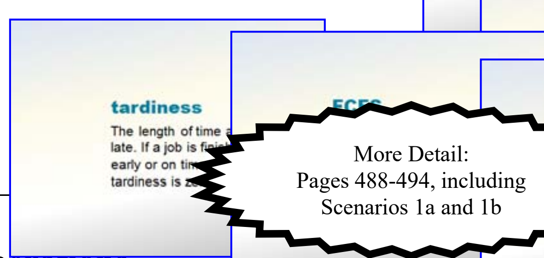
Global Freightways operates a small satellite center in Edinburgh, Scotland. Each day, a large plane from Amsterdam lands at Edinburgh, bringing inbound freight. As this plane is unloaded, five small jets arrive in Edinburgh, bringing outbound freight. Once the large plane is unloaded, each of the small jets is unloaded and then reloaded with its portion of the newly arrived inbound freight. These small jets then leave, while the large plane is reloaded with the outbound freight. The five jets vary somewhat in the time required to unload and then reload them:

| Jet | Processing Time (hrs.) | Scheduled Departure (hrs.) |
|---|---|---|
| Belfast | 0.50 hr. | 1.0 hr. |
| Birmingham | 0.25 | 2.6 |
| Dublin | 0.65 | 2.0 |
| Manchester | 0.75 | 1.5 |
| London | 1.50 | 3.0 |

## Example Rule: Shortest Processing Time

| Sequence | Flowtime | Tardiness |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| Average: | | |




More Detail:
Pages 488-494, including
Scenarios 1a and 1b

# *Dynamic* Rule: Critical Ratio

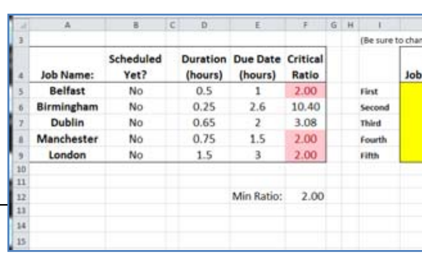
The cargo manager at Global Freightways' Edinburgh satellite center feels that a good sequence for all five jets cannot be developed without considering both the processing requirements and planned departure times of the jets, and wonders if critical ratio would be a better priority rule in this situation.

If the Edinburgh center uses critical ratio to select courier jets for processing, what sequence would result?

| Job Name: | Duration (hours) | Due Date (hours) | | | | |
|---|---|---|---|---|---|---|
| Belfast | 0.5 | 1.0 | | | | |
| Birmingham | 0.25 | 2.6 | | | | |
| Dublin | 0.65 | 2.0 | | | | |
| Manchester | 0.75 | 1.5 | | | | |
| London | 1.5 | 3.0 | | | | |

| Sequence | Flowtime | Tardiness |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| Average: | | |

(look for **critical ratio model.xls** on UBlearns…)

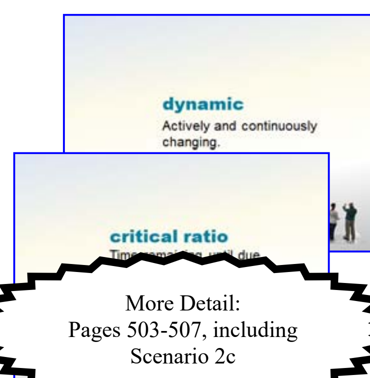


| Job Name: | Scheduled Yet? | Duration (hours) | Due Date (hours) | Critical Ratio |
|---|---|---|---|---|
| Belfast | No | 0.5 | 1 | 2.00 |
| Birmingham | No | 0.25 | 2.6 | 10.40 |
| Dublin | No | 0.65 | 2 | 3.08 |
| Manchester | No | 0.75 | 1.5 | 2.00 |
| London | No | 1.5 | 3 | 2.00 |

Min Ratio: 2.00

(Be sure to chan

| Job |
|---|
| First |
| Second |
| Third |
| Fourth |
| Fifth |




More Detail:
Pages 503-507, including Scenario 2c

# Scheduling Two Workcenters: Johnson's Rule

*Suppose each job requires some amount of time at two workcenters. Johnson's rule minimizes the makespan of the schedule.*

How do you get a group of jobs done "ASAP"?

1. Select the job with the shortest time any workcenter. If that time refers to the first workcenter, schedule that job <u>first</u>. If that job refers to the second workcenter, schedule that job <u>last</u>.

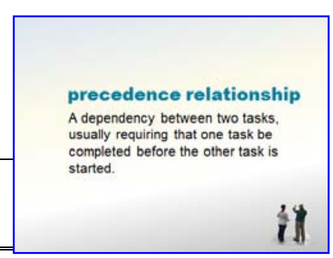
2. Cross that job off your list.

3. Repeat steps 1 and 2 with the remaining data, until all jobs are scheduled.

| Jet | Total Duration (hrs.) | = | Unloading Time (hrs.) | + | Loading Time (hrs.) |
|---|---|---|---|---|---|
| Belfast | 0.50 hr. | | 0.20 hr. | | 0.30 hr. |
| Birmingham | 0.25 | | 0.15 | | 0.10 |
| Dublin | 0.65 | | 0.30 | | 0.35 |
| Manchester | 0.75 | | 0.50 | | 0.25 |
| London | 1.50 | | 1.00 | | 0.50 |

One crew unloads a jet while another crew loads a previously unloaded jet, a detail missing from the earlier analysis.

How should the cargo manager schedule these five jets, to minimize the total amount of time required to accomplish all loading and unloading?



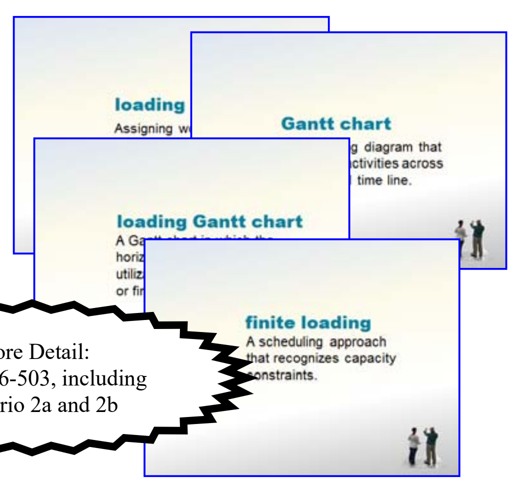
## Schedule:

| 1st | 2nd | 3rd | 4th | 5th |
|---|---|---|---|---|
| | | | | |

## But what is the makespan of this schedule?

## Gantt Chart!

| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UNLOAD | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| LOAD | | | | | | | | | | | | | | | | | | | | | | | | | | | |




More Detail:
Pages 496-503, including
Scenario 2a and 2b

# SIX OLD EXAM QUESTIONS ON *SCHEDULING*:

Video tutorials explaining each of these questions are available on UBlearns.

The operations manager of a body and paint shop has five cars to schedule for repair. He would like to minimize the time needed to compete all work on these cars. Each car requires body work prior to painting. The estimates of the times required to do the body and paint work on each car are as follows:

| CAR | BODY WORK (hours) | PAINT (hours) |
|---|---|---|
| A | 10 | 2 |
| B | 5 | 4 |
| C | 7 | 5 |
| D | 3 | 6 |
| E | 1 | 7 |

Similar problems:
Chapter 14 Scenarios #27
and #28

**1.** Using Johnson's Rule, where should car E be scheduled?
a) first. b) second. c) third. d) fourth. e) fifth.

**2.** Using Johnson's Rule, where should car A be scheduled?
a) first. b) second. c) third. d) fourth. e) fifth.

The owner/operator of the local franchise of Handyman, Inc. has four jobs to do today, ***shown in the order in which they were received:***

| JOB | PROCESSING TIME (hours) | DUE (hours) |
|---|---|---|
| W | 4 | 4 |
| X | 3 | 5 |
| Y | 2 | 2 |
| Z | 1 | 1 |

**3.** Suppose he uses the first come, first served (FCFS) priority rule to schedule these jobs. How long, on average, will be required before each job is finished (also known as the "average flowtime" of his schedule)?
a) 7.5 hours. b) 5 hours. c) 3 hours. d) 2.5 hours. e) 2 hours.

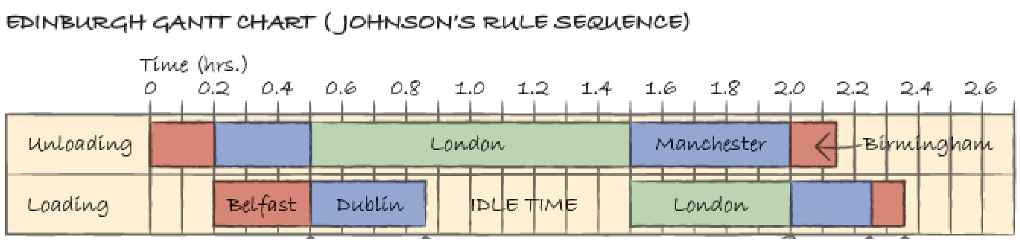
**4.** If he uses the shortest processing time first (SPT) priority rule to schedule these jobs, what will be the average job tardiness?
a) 0 hours. b) 1.5 hours. c) 1.75 hours. d) 2 hours. e) 2.25 hours.

Similar problems:
Chapter 14 Scenarios #29
and #30

# SIX OLD EXAM QUESTIONS ON *SCHEDULING* CONT'D:

Global Freightways, an international air freight company, operates a small 'satellite center' in Edinburgh, Scotland. Each day, five planes arrive in Edinburgh, bringing out-bound freight collected from across the United Kingdom and Ireland. Outbound freight is unloaded from each plane, and then the plane is re-loaded with its portion that day's newly arrived in-bound freight. When unloading and then loading is complete, each plane leaves immediately, returning to its city of origin.

Only one plane can be unloaded and loaded at any time, although unloading and loading are done by two different crews, so these two processes can happen simultaneously. The planes do vary in the amount of time required to 'turn them around', or unload and then re-load them again. To coordinate this, the manager at the Edinburgh satellite center has found the best sequence with Johnson's rule, and drawn up a Gantt Chart of this sequence, in which each of the five planes is labeled with its city of origin.




In this Gantt Chart, Time 0 is actually 4:00 AM at the satellite center, and 0.1 hours is the same as 6 minutes, so the chart is marked at 6 minute intervals. Please answer the following two questions, based on this information.

**5.** Which of the following is (are) true in this schedule?

I. The Johnson's rule sequence is apparently Belfast-London-Dublin-Manchester-Birmingham.

II. All five planes will be unloaded, loaded, and returning to their cities of origin by 6:00 AM.

III. The plane from Belfast will be ready to return to Belfast by 4:30 AM.

a) I only b) III only c) I and II d) II and III e) I, II and III

**6.** Which of the following is the best expression of the flow time of the plane from London?

a) 0.5 hours b) 1.0 hours c) 1.5 hours d) 2.0 hours e) 2.5 hour