ways to make things feasible

# MRP & CRP

### 1) Determining Gross and Net Requirements

Units Available = Units on Hand - Safety Stock
Total Demand = Known Demand + Forcasted Demand
Available at week 1 = Initial Inventory
Available at week t (where t >= 2): Max(Available(t-1) – Gross Req.(t-1), 0)
Net Req.(t) = Max(Gross Req.(t)- Scheduled Receipts (t) - Available(t), 0)
Order Receipts(t) = Net Req.(t) [applies to lot-for-lot method only]

### 2) Lot Sizing Techniques

Lot-for-lot - Orders will be placed in the exact order quantities needed.
Lot size (example: 500) - Orders must be places in multiples of 500.
Minimums - Order size must be over the minimum order size required
EOQ - Orders will be placed in quatities that are equal to EOQ, where:

$$EOQ = Q = \sqrt{\frac{2DS}{H}}$$

POQ - Order are placed for a certain number of periods that can be calculated as follows:
Interval = EOQ / average demand per period

### 2) Constructing Production Plan

**Need:** - Gross Requirements (Given or Calculated)
- Schedule receipts get added to available (like inventory)
- # Units Available for each Component
- Net Requirement for each Component
- Order Receipts for each period for each Component
- Order Releases for each period for each Component
- Lead time for each step in production

### 4) Sample Production Chart

| | | Lead Time | t = 1 | t = 2 |
|---|---|---|---|---|
| A | Gross Req.<br>Scheduled Rec.<br>Available = ____<br>Net Req.<br>Order Receipts<br>Order Releases | | | |
| B | Gross Req.<br>Scheduled Rec.<br>Available = ____<br>Net Req.<br>Order Receipts<br>Order Releases | | | |

# QUALITY CONTROL

**Control Charts:** A Time ordered graph of sample statistics, used to distinguish between common causes (Natural variations/random variations) and assignable causes (nonrandom variations). Points outside control limits suggests process is out of control.

z-score = 2 tailed

**1) Attribute Charts:** Used when the process characteristic is counted rather than measured (qualitative)

**P-Chart (% defective):** Determines whether the population proportion of defectives is in control

**Variables:** p = average percent defectives in a population
$\bar{p}$ = percent defective in a sample (one)
$\bar{\bar{p}}$ = percent defective across all samples

**Center Line:** $\bar{\bar{p}}$ = (total defects in all samples)/(n*m)
**UCL:** $\bar{\bar{p}}$ + z x SQRT[($\bar{\bar{p}}$ x (1-$\bar{\bar{p}}$))/n]
**LCL:** $\bar{\bar{p}}$ - z x SQRT[($\bar{\bar{p}}$ x (1-$\bar{\bar{p}}$))/n] cannot be negative

**C-Chart (# defective):** Determines whether the number of defects per unit is in control

**Variables:** c = average number of defects per unit in a ~~population~~ sample
$\bar{c}$ = average number of defects across all samples

**Center Line:** $\bar{c}$ = (total defects in all samples)/(m)
**UCL:** $\bar{c}$ + z x SQRT[ $\bar{c}$ ]
**LCL:** $\bar{c}$ - z x SQRT[ $\bar{c}$ ]

**2) Variables Charts:** Based on quality characteristics that are measurable on continuous scale (quantitative)

**R-Chart (range):** Range control charts, monitor the dispersion of a process (is variability in control?)
major problems

**Variables:** R = sample range (one) = Max value - Min Value
$\bar{R}$= average of all sample ranges = SUM(R)/m

**Center Line:** $\bar{R}$ -> Parameters Unknown (Mean & SD)
K*SD -> Parameters Known

**UCL:** $\bar{R}$ x D4 (Para. Unknown) **UCL:** (K*SD) x D4 (Para. Known)
**LCL:** $\bar{R}$ x D3 (Para. Unknown) **LCL:** (K*SD) x D3 (Para. Known)

**x̄-Chart (mean):** mean control charts, monitor the central tendency of a process. (is process average in control?)
minor problems

**Variables:** mu = population mean
$\bar{x}$ = sample average (one)
$\bar{\bar{x}}$ = average of all samples

A2 = 3/(K*SQRT[ n ])

**Center Line:** $\bar{\bar{x}}$ = SUM( $\bar{x}$ )/m
**UCL:** $\bar{\bar{x}}$ + A2 x $\bar{R}$
**LCL:** $\bar{\bar{x}}$ - A2 x $\bar{R}$
(Para. Unknown)

Centerline = mu $\mu$
**UCL:** mu + z x (SD/SQRT[ n ])
**LCL:** mu - z x (SD/SQRT[ n ])
(Para. Known)

**Other Variables:**
m = number of samples taken
n = number of observations per sample
z = z-value based on confidence level
SD = population standard deviation
s = sample standard deviation
A2, D3, D4, K = variables from chart using "n"

**Natural Variation** occurs within the control limts,
**Abnormal Variation** occurs outside the control limits.

Sign of problems in all charts:
- Points outside of the upper or lower CL
- 5 Points in a row increasing or decraesing
- 2 Points very close to upper or lower CL
- 5 Points in a row above or below the centerline
- Any pattern present in the data

& check! why there is a pattern

**Process Cabability:** A process should be in control and within specifications before production begins. Measure how well the process is capable of producing relative to the design tolerances.

**A Test for randomness**

Cp = tolerance/(6*SD)
$= \frac{\text{Upper Spec - Lower Spec}}{6*SD}$

assumes avg in centre of 2 limits

$$Cpk = MIN\left(\frac{\text{Upper Spec} - \bar{x}}{3*SD}, \frac{\bar{x} - \text{Lower Spec}}{3*SD}\right)$$

Cp or Cpk > 1 -> process can more then satisfy
Cp or Cpk = 1 -> process can satisfy specifications
Cp or Cpk < 1 -> process cannot satisfy

What % satisfies? $z = \frac{\text{spec} - \mu}{\sigma}$

# INVENTORY CONTROL

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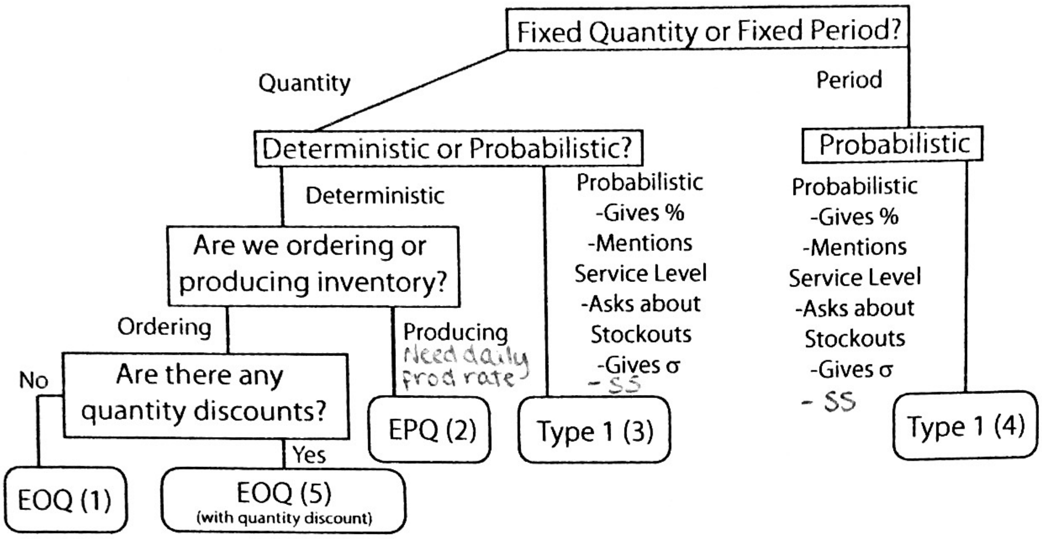



**Getting through the Tree:**

1) **Fixed period** - orders are placed on regular intervals
   **Fixed quantity** - the same size order is placed each time
2) If there is any mention of a service level or if you see a probability in the question, (99%, 99.74%, etc) then it must be **probabilistic**. If no prob. it is **deterministic**.
3) **Type 1** question will be worded like: "management wants to ensure a 99% chance of not stocking out". (you either have a stockout or you do not)

### 1) FOQ Model - Deterministic - EOQ

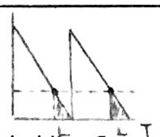
$EOQ = Q = \sqrt{\frac{2DS}{H}}$ — if C not given ignore

Total Cost = TC(Q) = $D^*C + (D/Q)^*S + (Q/2)^*H$
= material C + ordering C + holding C

# Orders per year = D/Q    Avg Inventory = Q/2

Interval Between Orders (Year) = Q/D
Interval Between Orders (Month) = 12 x Q/D
Interval Between Orders (Week) = 52 x Q/D
Interval Between Orders (Days) = 250 x Q/D
Reorder Point = R = d * L

Be consistent with time periods (↑ changes)




HC always / year!! x12 if it is given by mo

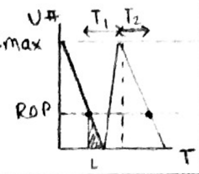
### 2) FOQ Model - Deterministic - EPQ

★ If Q* > Imax, use Imax in the HC total calc

$EPQ = Q = \sqrt{\left(\frac{2DS}{H}\right)*\left(\frac{p}{(p-d)}\right)}$    RoP = d × L ensure unit consistency

Total Cost = TC(Q) = $D^*C + (D/Q)^*S + [(p-d)/p]^*(Q/2)^*H$
= material C + ordering C + holding C

# production runs per year = D/Q
$T_1 = Q/p$ (length of time you produce)
$T_2 = I_{max}/d$ (length of demand)
$T = T_1 + T_2$
$I_{max} = (p-d)^*(Q/p)$
Average I = $I_{max}/2$




### 3) FOQ Model - Probabilistic - EOQ - TYPE 1

$EOQ = Q = \sqrt{\frac{2DS}{H}}$
$R = \mu_L + z^*(\sigma_L)$
$SS = R - \mu_L$
$\mu_L = d^*L$
$SS = z^*(\sigma_L)$
$\sigma_L = \sqrt{\sigma_d{}^2 * L}$

To get z:
1) Look up service level in Z-table

$TC(Q) = D^*C + (D/Q)^*S + (Q/2)^*H$

If SL > 0.5 (50%), look up SL-0.5 in z-table
If SL < 0.5, look up 0.5-SL in z table. Make z score neg.

### 4) FOP Model - Probabilistic - EOQ - TYPE 1

$EOQ = Q = S^* - I_i$
$S^* = \mu_{T+L} + z^*(\sigma_{T+L})$ (Max inv)
$SS = S^* - \mu_{T+L}$
$\mu_{T+L} = d^*(T+L)$
$SS = z^*(\sigma_{T+L})$

$\sigma_{T+L} = \sqrt{\sigma_d{}^2 * (T+L)}$

To get z:
1) Look up service level in Z-table

prob of stockout: $z = \frac{R - \mu_L}{\sigma_L}$    complex formula: $z = \frac{S^* - \mu_L}{\sigma_L}$

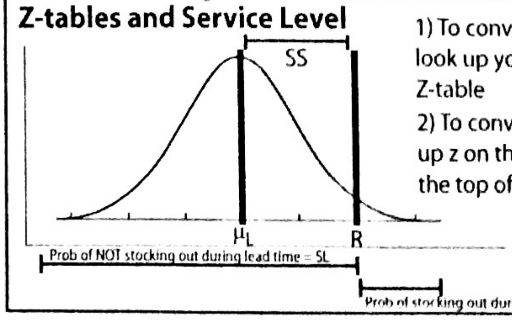
### 5) Quantity Discounts

1) Calculate EOQ for each quatity interval
2) If EOQ is above the upper end of the interval, you can ignore this interval. ★
3) If EOQ is in the interval, then Q=EOQ
4) if EOQ is below the lower end of the interval, then Q = lower end of the interval
5) Calculate the total invertory cost for each value of Q.
6) Select the value of Q that has the lowest total inventory cost.

*** You will be using formulas from box #1

| Discount | D | Units Purch (Range) | C | H | S | Q* | Order Size | TC |
|---|---|---|---|---|---|---|---|---|

### Z-tables and Service Level




1) To convert SL to z, look up your SL in the Z-table (SL-0.5)
2) To convert z to SL, look up z on the side and the top of the Z-table, then add 0.5
3) These are 1-tailed z-scores

### VARIABLES

Q = Order Quantity
Q* = Q at EOQ
D = Annual Demand
S = Setup/Ordering Cost
H = Holding Cost per unit per year
TC= Total Annual Cost
C = Cost per unit
d = average daily demand
L = lead time
p = daily production rate
$I_{max}$ = maximum inventory level
$T_1$ = length of production part of cycle
$T_2$ = lengh of demand part of cycle
z = # of standard dev. for service level
$\mu_L$ = demand during lead time
$\sigma_L$ = standard dev. of lead time
SS = safety stock
R = reorder point
stockout = 1-SL
service level = prob of not stock out
$\sigma_d$ = standard dev. per day (week)
$\mu_{T+L}$ = demand during T and L
$\sigma_{T+L}$ = standard dev. of T and L
S* = maximum inventory level
$I_i$ = inventory level at reorder time
T = time between orders