Lecture 2

Flow Rate	Min between demand and capacity
Utilization = R/Capacity	fraction of time spent working
Cycle Time = 1/ Flow Rate	Time between when units exit process
Flow Time = I/R	Time unit spends in process
Cost of Direct Labor	=(wages per unit of time x #of workers) / Flow Rate
Labor Content	sum of processing times involving labor (don't multiply by #of workers)
Labor Utilization	= R / Labor Capacity
Labor Capacity	= N (# of workers) / Labor content
Takt Time =1/ Demand Rate	Time between when flow units are demanded
Target Manpower = Labor Content/ Takt Time	= Labor Content/ Takt Time
Goal of Line Balancing	Find min cycle time

Process Flows (Lecture 1)

Little's Law: I = R x T	I= Inventory, R= Flow Rate, T= Flow Time
Days of Supply = I/R = 1/Turns	The "T" in Little's Law (add def)
Inventory Turns = 1/T = R/I = COGS/ I	
COGS = R, the flow rate	
Gross Margin % = (Price - Cost) / Price	

Decision trees

Maximin Decision	Find the minimums of each branch, then choose the max of the mins
Maximax Decision	Find the max of each branch, then choose the max of the maxes
Expected value of Perfect info	= (expected value of decision w/ perfect info) - (expected value of decision w/o perfect info)

Baye's Rule

$$P(A|B) = \frac{P(A \cap B)}{P(B)} = \frac{P(B|A)\,P(A)}{P(B)}$$

Queues

Queues (cont)

Inventory in service = p/a

CVa= Standard deviation inter arrival time / avg inter arrival time

CVp= Standard deviation processing time/ avg processing time

Time in queue increases dramatically as utilization approaches 100%

Yield and Capacity of Process

Yield = Flow Rate goof output/ Flow rate bad output

Yield of Process = Product of resource yields

Implied Utilization = Demand/ Capacity	Can be over 100% , bottleneck has highest IU

Capacity = 1/Processing Time

Processing Time = 1/Capacity

Demand (in min of work) = Processing time x Demand

Required input = Desired output/ Process yield

Required resource capacity = Resource's demand with required input

Required resource capacity = Resource's demand with required input

Finding capacity of process	Find capacity of each step and find the bottleneck

Solving Questions

Solving Questions (cont)

Length of queue at time T = T x (Demand - Capacity)	
Time to serve Qth person in queue = Q/Capacity	
Time to serve customer arriving at time T = T x (Demand/Capacity-1)	
Avg time to serve customers in the queue = 1/2 x T x (Demand/Capacity -1)	
Variables to know	a= inter arrival time, m= # of workers/kiosks, p = avg processing time
Demand = 1/a	
Capacity= m x (1/p)	
Utilization = P / (a x m)	
m = P /(a x utilization)	
Time spent in system = Time in queue + Time in processing	
Inventory = Inventory in queue + Inventory in service	
Inventory in queue = Time in queue/ a	

What the question is asking	Approach to take
Inventory costs are what percent of purchasing costs?	Find Flow Time. Then multiply annual inventory cost percentage by flow time in years and by individual unit cost
Cost to hold inventory for a year	Cost of individual unit x annual holding cost percentage
What is the avg time...	Find flow time

Total time to process 20 customers	Time to process 1st customer (sum of processing times) + time to process other customers (19 x Cycle Time)
Total ordering costs	(K x R) / Q
Total holding costs	1/2 x Qh
How many individual units should they produce in each batch	Use desired capacity to find full batch size. Then multiply batch size by ratio of individual demand/capacity over total demand/capacity
If company ordered a specific number of cases at a time, what would be their holding and ordering costs	Find C(Q)
If company ordered a specific number of cases, what would be holding and ordering cost per case	Find C(Q)/ R
Quantity of cases per order	Find EOQ
How long will you wait if you are nth in line	Find the time to serve the number of people in front of you.

Avg Inventory

$$Average\ Inventory = \frac{1}{2} \times Batch\ size \times (1 - Flow\ rate \times Processing\ time)$$

Setup Times and Batching

Capacity = Number of units produced/ Time to Produce units

Utilization (with a setup time) = Flow rate x Processing Time

Capacity

$$Capacity = \frac{Batch\ size}{Setup\ time + Batch\ size \times Processing\ time}$$

EOQ and Quantity Discounts

Inventory Variables	**Q**= quantity in each order, **R**=Flow Rate, **h** = inventory holding cost per unit time, **K**= fixed vost per order

Time between shipments = Q/R

Avg inventory = Q/2

Number of orders placed per unit of time = R/Q

Capacity (in min of work/hr) = #of workers x 60

Quantity minimizing ordering and holding costs

$$Q^* = \sqrt{\frac{2 \times K \times R}{h}}$$

Batch Size

$$Batch\ size = \frac{Capacity \times Setup\ time}{1 - Capacity \times Processing\ time}$$

Ordering plus inventory holding cost per unit time

$$C(Q) = \frac{K \times R}{Q} + \frac{1}{2} h \times Q$$

Time in Queue

$$Time\ in\ queue = \left(\frac{p}{m}\right) \times \left(\frac{Utilization^{\sqrt{2(m+1)}-1}}{1\text{-}Utilization}\right) \times \left(\frac{CV_a^2 + CV_p^2}{2}\right)$$