

Lecture 2

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

Process Flows (Lecture 1)

Little's Law: $I = R \times T$ I = Inventory, R = Flow Rate, T = Flow Time

Days of Supply = The "T" in Little's Law
 $I/R = 1/\text{Turns}$ (add def)

Inventory Turns = $1/T = R/I = \text{COGS}/I$

COGS = R , the flow rate

Gross Margin % = $(\text{Price} - \text{Cost}) / \text{Price}$

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 = $\text{Flow Rate good output} / \text{Flow rate bad output}$

Yield of Process = Product of resource yields

Implied Utilization Can be over 100% ,
 $= \text{Demand} / \text{Capacity}$ bottleneck has highest IU

Capacity = $1/\text{Processing Time}$

Processing Time = $1/\text{Capacity}$

Demand (in min of work) = $\text{Processing time} \times \text{Demand}$

Required input = $\text{Desired output} / \text{Process yield}$

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 = $T \times (\text{Demand} - \text{Capacity})$

Time to serve Qth person in queue = $Q / \text{Capacity}$

Time to serve customer arriving at time T = $T \times (\text{Demand} / \text{Capacity} - 1)$

Avg time to serve customers in the queue = $1/2 \times T \times (\text{Demand} / \text{Capacity} - 1)$

Variables to know a = inter arrival time, m = # of workers/kiosks, p = avg processing time

Demand = $1/a$

Capacity = $m \times (1/p)$

Utilization = $P / (a \times m)$

$m = P / (a \times \text{utilization})$

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 ($19 \times \text{Cycle Time}$)

Total ordering costs

$(K \times R) / Q$

Total holding costs

$1/2 \times Qh$

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

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

Setup Times and Batching

Capacity = Number of units produced/ Time to Produce units

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



Capacity

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

EOQ and Quantity Discounts

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

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

Ordering plus inventory holding cost per unit time

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

Time in Queue

$$\text{Time in queue} = \left(\frac{P}{m} \right) \left(\frac{\text{Utilization}^{m+1}}{1 - \text{Utilization}} \right) \left(\frac{CV_p^2 + CV_s^2}{2} \right)$$



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