Planning and Scheduling ISE410
SESSION 6
September 9, 2021

## OUTLINE

- Questions?
- Roll
- Quiz Results
- Next quiz 09/14/21
- Go over homework and Quiz
- Objectives for this session
  - Inventory concepts of when and how many to order and when do you need it
- Introduction to inventory
- Basic  Equation and derivation, Safety stock
- New Homework

## What kind of inventory have you managed?

- **We talked about:**
  - **Groceries**
  - **Gasoline**
  - **?**

## How can we tell that we need something?

- When we are about to run out
- When we think we are going to run out in the future

## How much or how many should we order?

- How much or how many we can afford
- How much or how many we can store in our available space
- The most economical quantity

## How long will it take to get here?

- **This is how soon we have to order it**

- **The contributors to the cost of inventory**
  - **What are they?**
  - **Let's make a list**

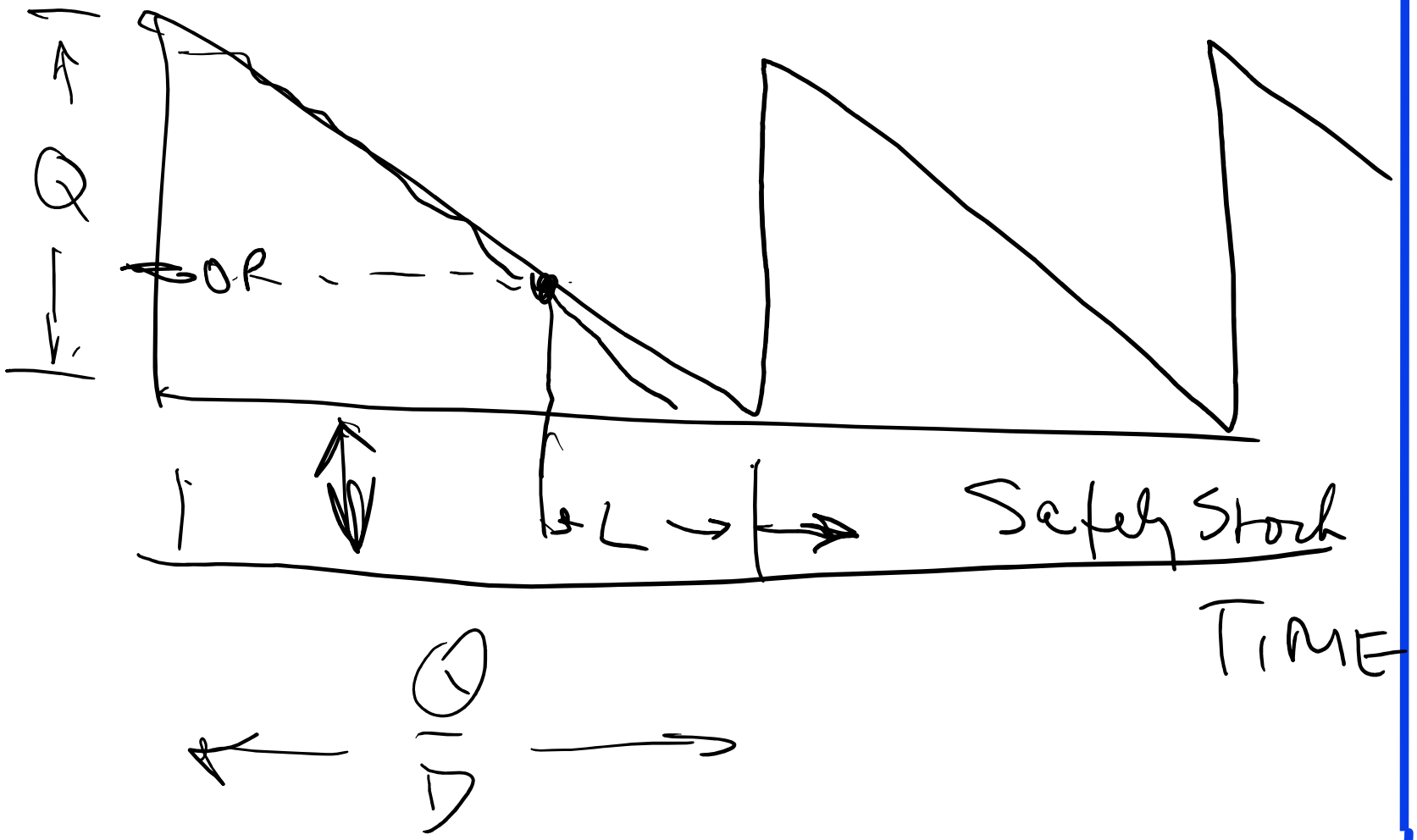
HOLDING
SPACE
TRANSPORTATION SPOILAGE
INSURANCE, SAFETY, PILFERAGE
INTEREST RATE

$\Sigma \sim 20\% - 25\%$

## Inventory

- **Definitions:**
  - **D = Annual demand for an item (units/Year), sometimes other time periods**
  - **A = Cost of ordering ($)**
  - **v = Value of an Item ($), sometime c**
  - **k = cost of carrying inventory (%/$/Year), sometimes i or r**
  - **Q = Quantity ordered at any given time (units/order)**
  - **L = Lead time – the time from ordering an item until it arrives (could be any time unit, but needs to be consistent with the other units in an equation)**

- **Definitions:**
  - **OP or s = Order point, The remaining quantity at which we place an order**
  - **SS = Safety Stock – the amount held in inventory to protect against uncertainty**
  - **S = order up to level – the amount to which we raise the inventory position every time that we order**
  - **R = Review period – the time between checking inventory and ordering or not (could be any time unit, but needs to be consistent with the other units in an equation)**


Q
OR
L
Safety Stock
TIME
Q
D

## Inventory

- **Equations:**

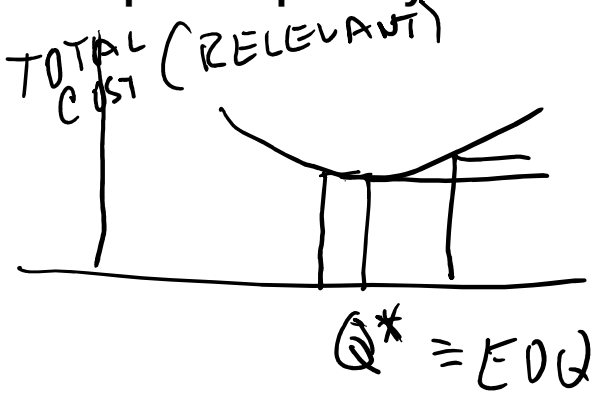
**Orders/Year = D/Q = Annual demand divided by quantity ordered each time**

**Average Inventory for constant demand and constant Q, Q/2**

**Annual Cost = Ordering cost + Inventory Carrying cost + Acquisition cost**

**Total cost = A(D/Q) + Qkc/2 + DV (Note that acquisition cost does not depend on the quantity ordered so we generally do not include it. It is a constant for the year)**

**Optimal quantity to order to minimize cost (EOQ)**




$$EOQ = \sqrt{\frac{2AD}{kc}}$$

## EOQ Example

- Let's say that an Apple store cells 2000 iPhones a year. It costs them $75 to order a batch of phones. Assume that the demand is spread pretty evenly across the year. Each phone costs them $350. Their inventory carrying rate is 20% per year per dollar.
- How many phones should they order each time?
- How often will they be ordering?
- What is their total annual cost (not counting what they pay directly for the phones)?
- Should they use these numbers?

## Kinds of inventory

- **Transit**
- **Cycle**
- **Anticipation**
- **Safety Stock**

## Where do find inventory?

## Order point calculations

- The order point is determined by the length of the lead time and the rate of consumption (Demand) during lead time
- Theoretically the rate of consumption is constant and as far as the order point is concerned, only matters during lead time
- $OP = s = DL$
- For example, if the annual demand D is 2600 and the lead time L is two weeks, which is 2/56, then the order point is 100.

## Safety stock (1 of 3 )

- Unfortunately, both demand and lead time can very and we are exposed to running out of our item before the shipment arrives, hence we keep safety stock.
- We usually assume that demand will vary with a normal distribution and that the variance of the annual demand is given.
- However, we are only concerned with the variance during lead time:
- $Var_L = LVar_D$
- Note that since D is usually per year, L must be expressed in years as well

## Safety stock (2 of 3)

- $Var_L = LVar_D$
- **However, to perform statistical calculations, we need the standard deviation:**
- $SD_L = \sqrt{Var_L} = \sqrt{Var_D}\sqrt{L}$
- **Example:**
- **In the preceding example the annual demand was 2600 and the lead time 2 weeks. If the variance of the annual demand is 67,600 then the standard deviation during lead time**
- $SD_L = \sqrt{67200 * \frac{2}{52}}$ **= 50.99**

## Safety stock (3 of 3)

- $SD_L = \sqrt{67200 * \frac{2}{52}}$= 50.99
- To be 100% sure that we never run out, we would have to hold an infinite number of units for safety stock or know the maximum demand rate. So we have to decide how sure we want to be not to run out in any given cycle.
- Let's assume 90%. The z value (remember we assumed a normal distribution) is 1.28
- $Safety\ Stock = SS = zSD_L = 1.28 * 50.99 = 65.34 \sim 66$
- If we hold this amount in reserve, we will stock out only in 10% of the cycles. The number of cycles per year would be determined from the EOQ

## Example

- D= 5000 with Var = 160,000
- Ordering cost = $100
- Carrying percentage 25%
- Value = $230
- Lead time = 1 week
- Maximum % of stock outs 5%