Production Management (ME-419)

Module 3 – Supply Management

Material Requirement Planning (MRP)

Amin Kaboli

Week 10 – Session 1 – Nov 15h, 2024

Course Framework

Business plan
Strategic plan
Financial plan

Production Management (ME-419)

Module 1	Module 2	Module 3	Module 4	
Introduction to PM	Demand Management	Supply Management	Digital Transformation	Final Presentation
Sep	**Sep-Oct**	**Nov**	**Dec**	**Dec 18th & 20th**
Value Adding Network Production Process Flows, Bill of materials, Production procedures, Value adding activities	Demand disruptions Forecasting Methods Qualitative methods Quantitative methods Demand plan	Supply disruptions Production Planning AP, MPS, MRP, Inventory Management Supply Plan	Digital technologies for PM, Demand and Supply Analytics, From Products to Ecosystems	Final presentation & solid understanding of the course

Planning a Dinner Party

- Required activities:

MPS

1. Plan the menu
2. Determine the number of guests

BOM

3. Review the recipes for each item on the menu

Stock

4. Check the kitchen for what you already have

MRP

5. Purchase required materials
6. Dinner is ready, let's party

The Main Objectives of MRP

1. Determining the quantity and timing of material requirements

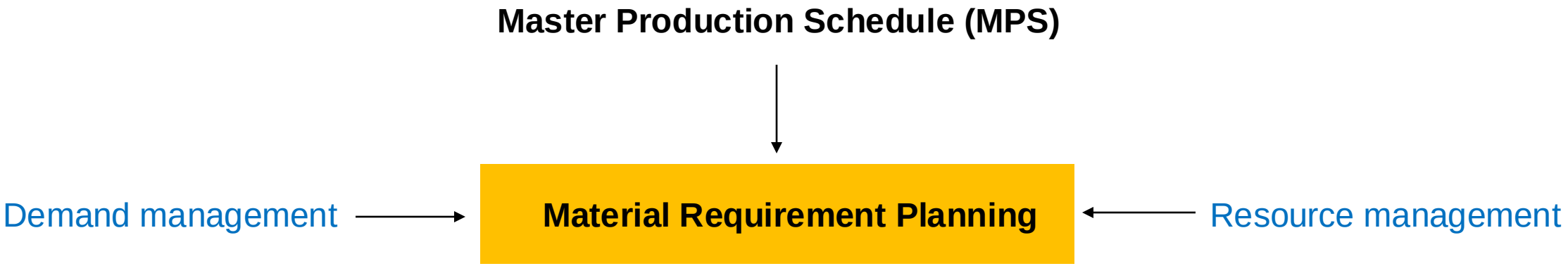
   - What to order
   - How much to order
   - When to place the order
   - When to schedule delivery

2. Keeping priorities updated and ensuring the inventory level is optimized.

   - Disruptions
   - Order cancelations
   - Order quantity/time changes
   - Unexpected scrap in production line
   - Production delay
   - …

Disaggregation

Overview of MRP Process



MRP calculates the materials needed to meet the authorized MPS.

The Process of Developing MRP

Step 1. Define the gross requirements of the finished good for each period (look at authorized MPS).

Step 2. Compare the gross requirements with the available inventory (Projected available).

Step 3. Check whether there is shipment on the way (Scheduled receipt).

Step 4. If the gross requirements exceeds the available inventory, an order must be schedule to arrive in that period.

Step 5. Calculate the timing of the replenishment order by subtracting the lead time (in weeks) from the period the material is needed to satisfy the gross requirements.

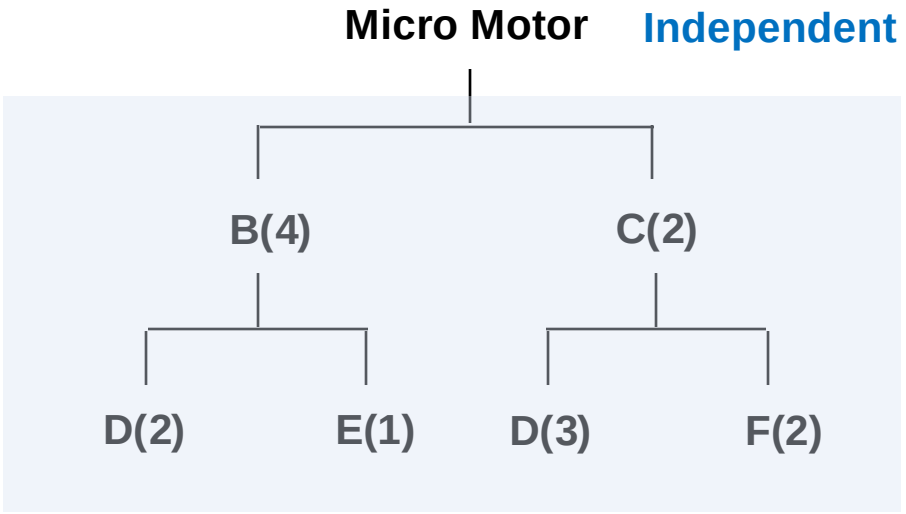
Step 6. Calculate the quantity of the replenishment order by the lot size policy for the given item.

Two Concepts Within MRP

1. Backward scheduling

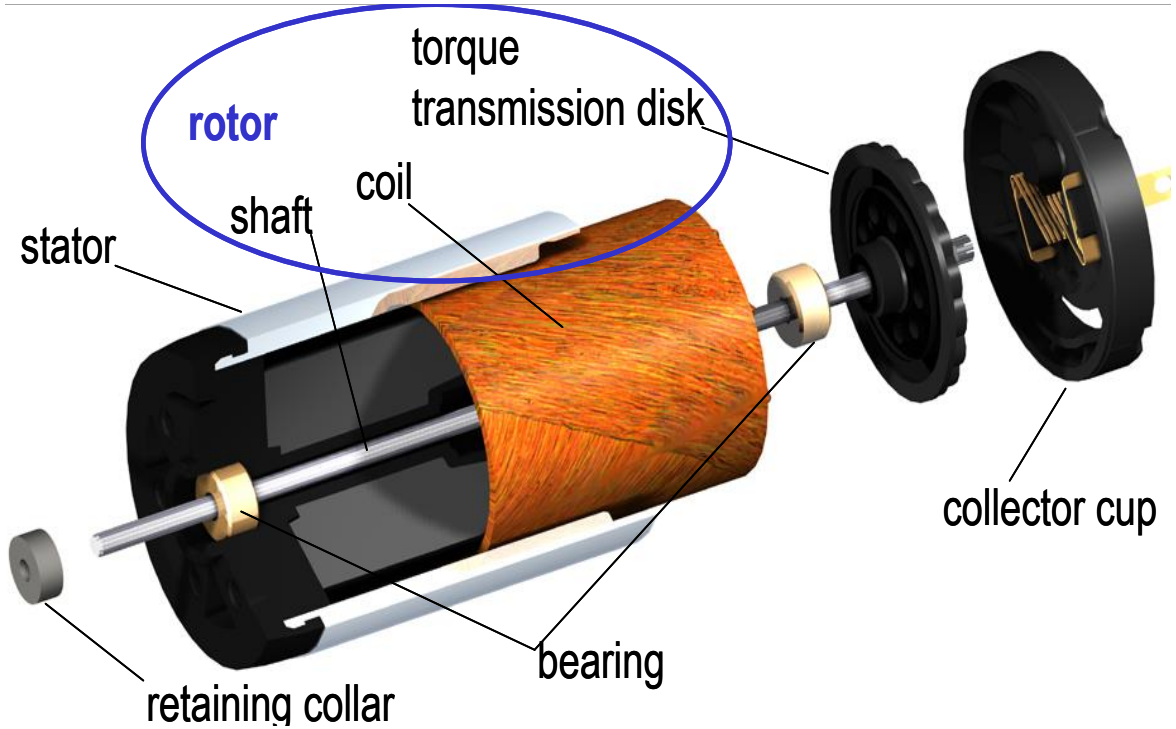
Week	1	2	3	4	5	6	7
Gross Requirements				100			100
Projected Available (0)	0	0	0	0	0	0	0
Planned Orders	0	0	100	0	0	100	0

2. Dependent demand planning



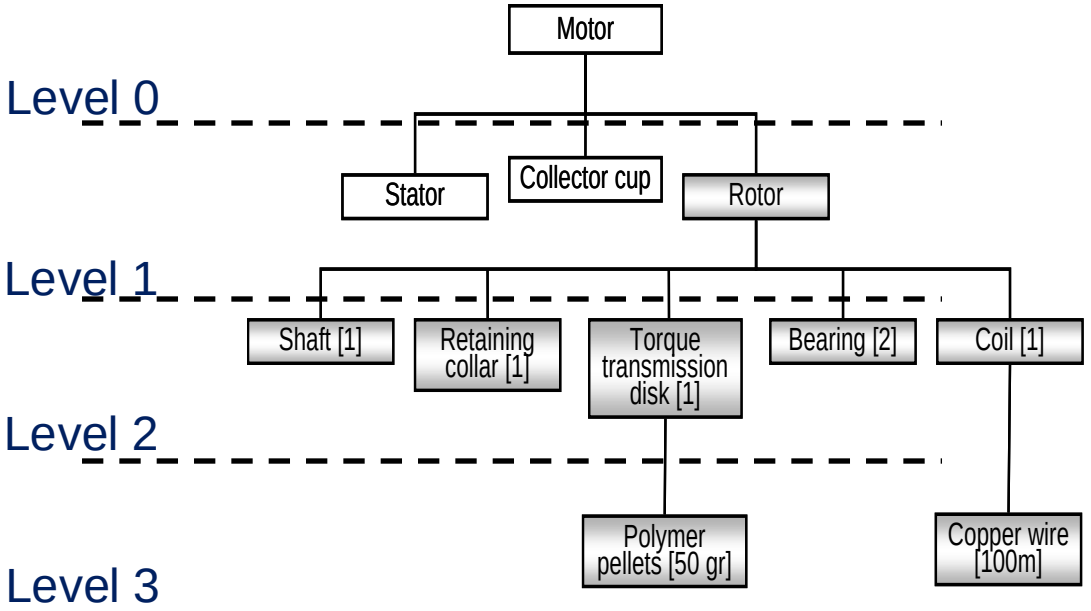
Example: Micro-motor

Example: Micro-motor



Electrical ironless micro-motor

(Parent & Children)



Electrical ironless micro-motor

MPS Record

Item: Micro-Motor Lead time: 1 week

Lot size policy: FOQ* = 100 Beginning inventory: 80

Week	1	2	3	4	5	6	7	8	9	10	11	12
Gross Requirements	25	25	25	25	30	30	30	30	35	35	35	35
Projected Available (80)	55	30	5	80	50	20	90	60	25	90	55	20
MPS	0	0	0	**100**	0	0	**100**	0	0	**100**	0	0

* **Fixed Order Quantity (**FOQ) = 100 OR 2x, 3x, …

Inventory Record

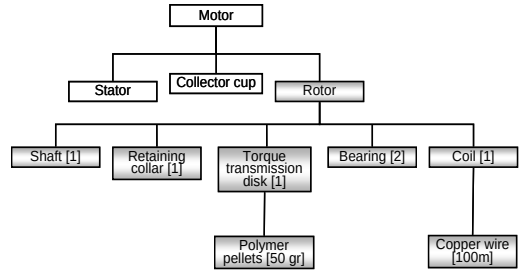
Item: Micro-Motor Lead time: 1 week

Lot size policy: L4L* = 100 Beginning inventory: 0

Week	1	2	3	4	5	6	7	8	9	10	11	12
Gross Requirements				**100**			**100**			**100**		
Projected Available (0)	0	0	0	0	0	0	0	0	0	0	0	0
Planned Orders	0	0	**100**	0	0	**100**	0	0	**100**	0	0	0

* **Lot-for-Lot (**L4L) = the company orders exactly what is needed.

Inventory Record (Micro-Motor)

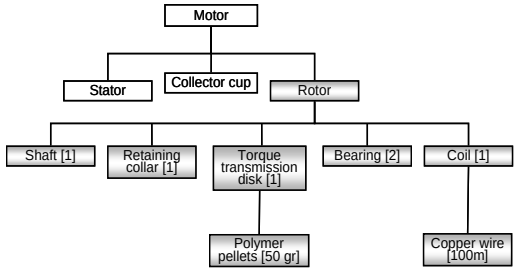


Item: Micro-Motor Lead time: 1 week

Lot size policy: L4L* = 100 Beginning inventory: 0

Week	1	2	3	4	5	6	7	8	9	10	11	12
Gross Requirements				**100**			**100**			**100**		
Projected Available (0)	0	0	0	0	0	0	0	0	0	0	0	0
Planned Orders	0	0	**100**	0	0	**100**	0	0	**100**	0	0	0

Inventory Record – Rotor (I)



Item: Rotor

Parent: Micro-Motor

Lot size policy: FOQ= 144

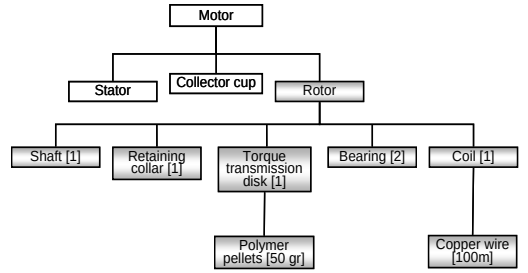
Children: Shaft, Retaining collar, torque transmission disk, bearing, coil

Lead time: 3 weeks

Beginning inventory: 20

Week	1	2	3	4	5	6	7	8	9	10	11	12
Gross Requirements			**100**			**100**			**100**			
Projected Available (20)	20	20	-80	-80	-80	-36	-36	-36	-136	-136	-136	-136
Planned Orders			144									

Inventory Record – Rotor (II)



Item: Rotor

Parent: Micro-Motor

Lot size policy: FOQ= 144

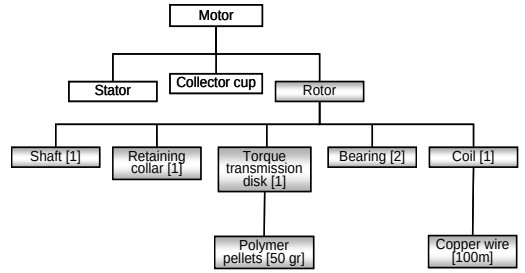
Children: Shaft, Retaining collar, torque transmission disk, bearing, coil

Lead time: 3 weeks

Beginning inventory: 20

Week	1	2	3	4	5	6	7	8	9	10	11	12
Gross Requirements			**100**			**100**			**100**			
Scheduled Receipts			144									
Projected Available (20)	20	20	64	64	64	108	108	108	8	8	8	8
Planned Orders			144									

Inventory Record – Bearing



Item: Bearing

Parent: Rotor

Lot size policy: L4L

Children: none

Lead time: 4 weeks

Beginning inventory: 0

Week	1	2	3	4	5	6	7	8	9	10	11	12
Gross Requirements	0	0	**288**	0	0	0	0	0	0	0	0	0
Scheduled Receipts			288									
Projected Available (0)	0	0	0	0	0	0	0	0	0	0	0	0
Planned Orders												

Lot Size Policies

Fixed Order Quantity (FOQ): Fixed number of units (or multiple) to order whenever an order is placed.

Lot-for-Lot (L4L): The company orders exactly what is needed.

Period Order Quantity (POQ): Order placement for defined period of time.

Inventory Records – Comparing Lot Size Policies

Item: Micro Motor

Lead time: 1 week

Lot size policy: FOQ = 144

Beginning inventory: 0

Week	1	2	3	4	5	6	7	8	9	10	11	12	13
Gross Requirements	0	25	25	40	40	0	60	60	60	0	60	60	60
Scheduled Receipts													
Projected Available (0)	0	119	94	54	14	14	98	38	122	122	62	2	86
Planned Orders	144					144		144				144	

Inventory Records – Comparing Lot Size Policies (II)

Item: Micro Motor

Lead time: 1 week

Lot size policy: L4L

Beginning inventory: 0

Week	1	2	3	4	5	6	7	8	9	10	11	12	13
Gross Requirements	0	25	25	40	40	0	60	60	60	0	60	60	60
Scheduled Receipts													
Projected Available (0)	0	0	0	0	0	0	0	0	0	0	0	0	0
Planned Orders	25	25	40	40		60	60	60		60	60	60	

Inventory Records – Comparing Lot Size Policies (III)

Item: Micro Motor **Lead time: 1** week

Lot size policy: POQ = 4 periods **Beginning inventory:** 0

Week	1	2	3	4	5	6	7	8	9	10	11	12	13
Gross Requirements	0	25	25	40	40	0	60	60	60	0	60	60	60
Scheduled Receipts													
Projected Available (0)	0	105	80	40	0	0	120	60	0	0	120	60	0
Planned Orders	130					180				180			

Exercise – Apple Airpods

Exercise – Material Requirement Planning (MRP)

Ear bud

Battery - 93mWh (2x)

Microphone

Audio Codec

Battery – 1.52mWh(1x)

USB Cable

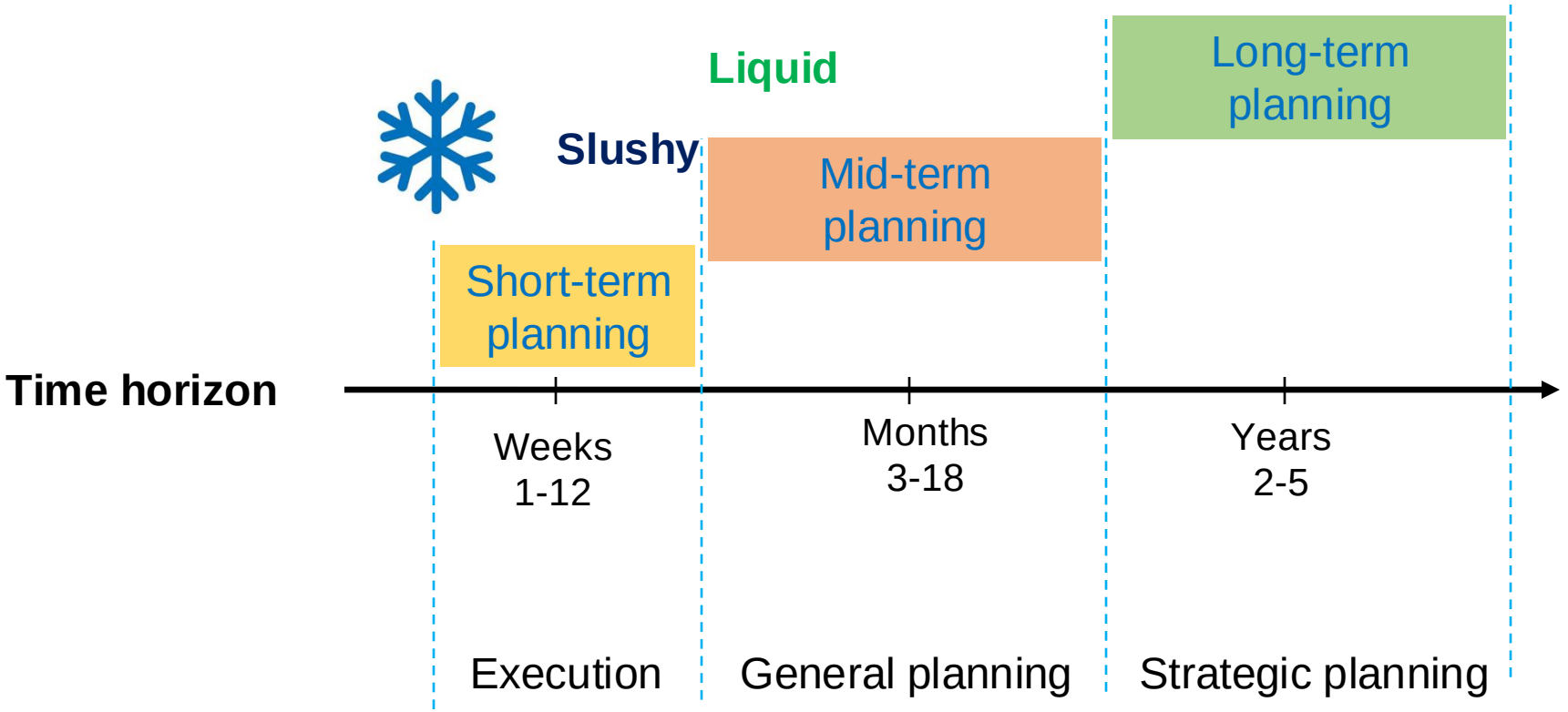
Charging case

Antenna

The complete list of the items that are required to build a product.

Exercise – Develop MRP for Apple AirPods

Time Fence and Plan Horizon



Production Management (ME-419)

Play & Practice

Amin Kaboli

Week 10 – Session 2 – Nov 15h, 2024

Production Management (ME-419)

Module 3 – Supply Management

Inventory Management (ABC, EOQ)

Amin Kaboli

Week 10 – Session 3 – Nov 15h, 2024

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The Pain: Cashier Scans & Line Up Experience

When Somebody Walks in Limited-items-line With +50 Items!

Inventory Management – Goals

- Understanding the basic principles of inventory management
- Learn inventory management methods
- Implementing apply inventory management methods

Types of Inventory

Raw materials

Components

Work in progress
(WIP)

Finished Goods
(FG)

Why Inventory?

Stock build-up (Anticipation inventory)

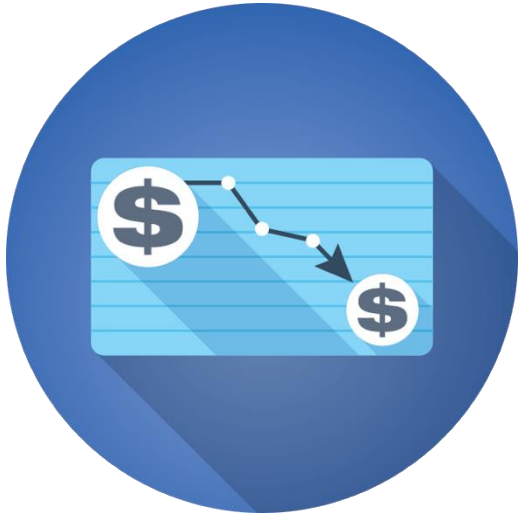
Safety stock (Fluctuation inventory)

Cycle stock (Lot-size inventory)

Transportation inventory (Supply line)

The Objectives – Why Shall We Hold Inventory?

Customer Satisfaction



Minimize Total Costs

Relevant Inventory Costs

1. **Ordering costs:** Fixed costs associated with placing an order or set up costs for inhouse production.

2. **Holding costs:** Include the variable costs incurred by the plant related to the volume of inventory held.

3. **Shortage costs:** Incurred when demand exceeds supply.

4. **Backorder costs:** Delaying delivery to the customer until the item becomes available.

5. **Lost sales:** Occurs when the customer is not willing to wait for delivery.

Objective Function: Minimize Total Costs

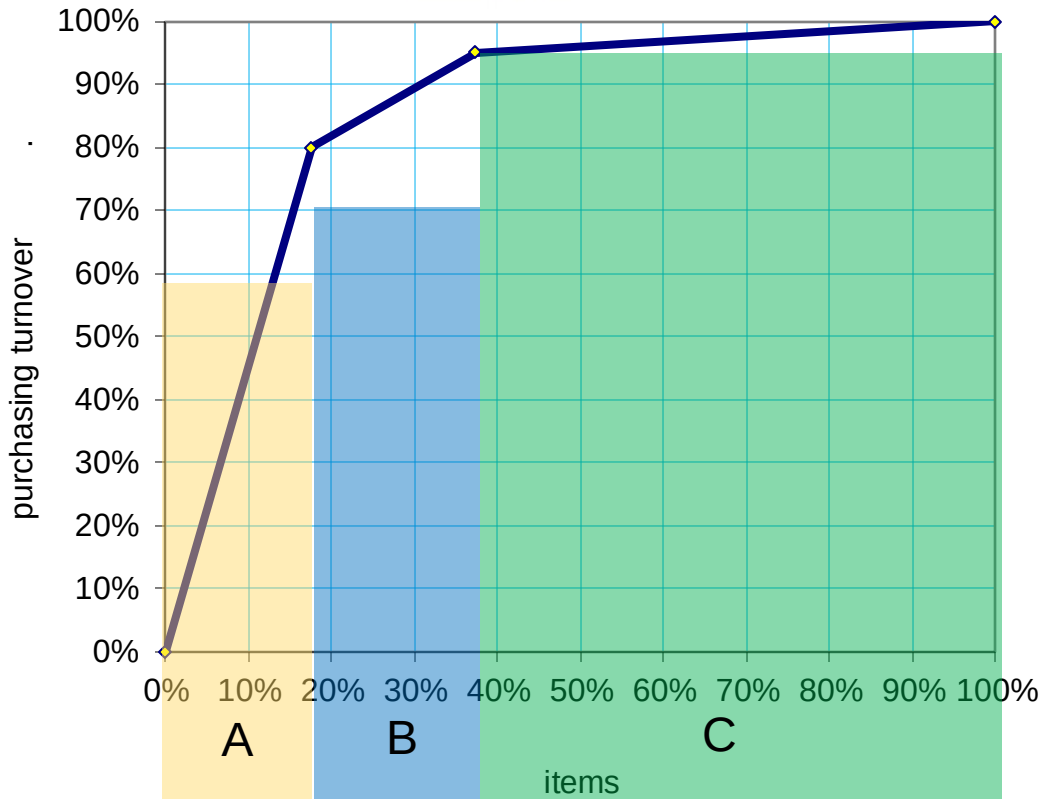
ABC Classification of Items

Pareto rule: 80-20 rule

Example:

Financial volume of the purchased items

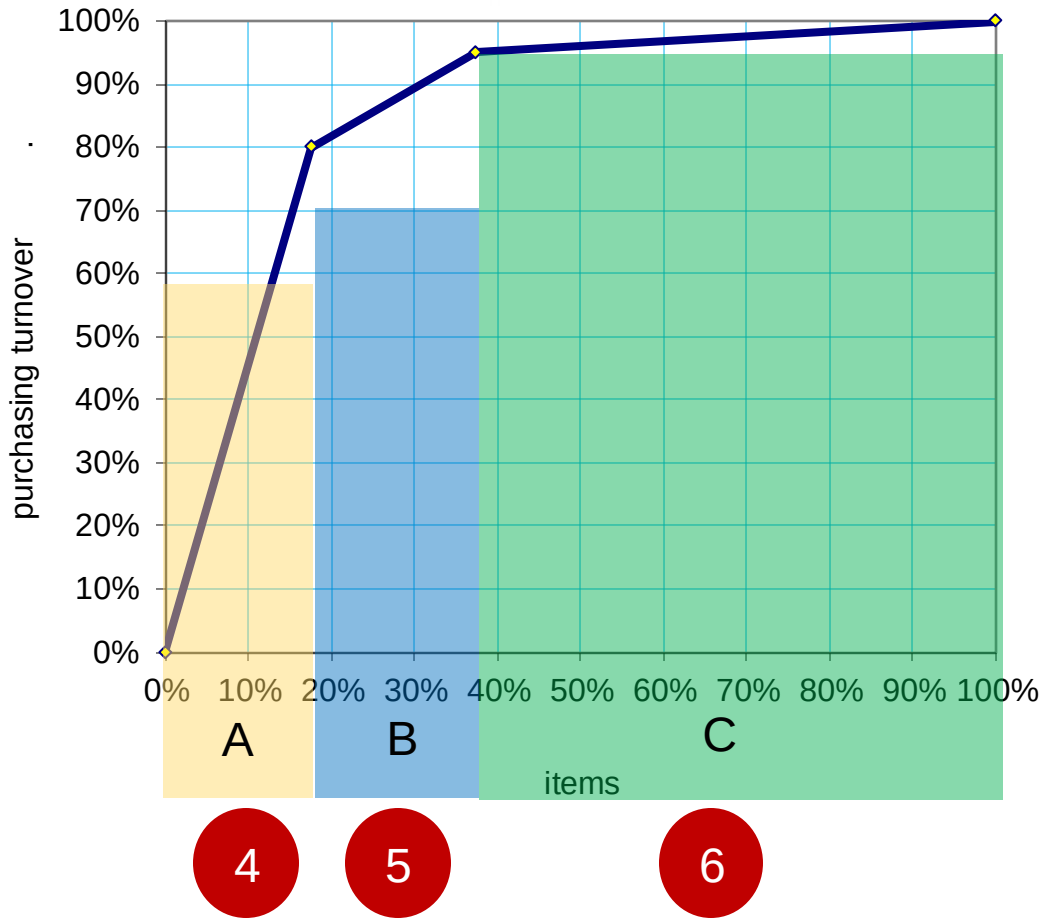
- Class A = 0 to 80%
- Class B = 80 to 95%
- Class C = 95 to 100%



ABC Classification of Items

item	volume in inventory	% volume in inventory	cumulative % volume in inventory	class
1003	1000	38.73%	38.73%	A
1004	600	23.24%	61.97%	A
1002	300	11.62%	73.59%	A
1001	200	7.75%	81.33%	A
1005	100	3.87%	85.21%	B
1015	77	2.98%	88.19%	B
1013	56	2.17%	90.36%	B
1008	40	1.55%	91.91%	B
1011	36	1.39%	93.30%	B
1009	35	1.36%	94.66%	B
1014	34	1.32%	95.97%	C
1010	24	0.93%	96.90%	C
1016	23	0.89%	97.79%	C
1012	13	0.50%	98.30%	C
1017	11	0.43%	98.72%	C
1006	10	0.39%	99.11%	C
1021	7	0.27%	99.38%	C
1020	6	0.23%	99.61%	C
1007	5	0.19%	99.81%	C
1019	5	0.19%	100.00%	C
sum	2582			

1 2 3 4 5 6



Exercise 1: ABC Classification

5 min

A company is interested to evaluate their internal consumption (unit);

a) What are their most and least consumed items?
b) What would be their A class, B class, and C class items ?

Item	Consumption (unit)
1	827
2	345
3	71
4	590
5	425
6	263
7	322
8	73

Inventory Management – Decision Variables

How much to buy?

When to buy?

Order Quantity (Q)

Order Time (T)

Companies make replenishment decisions to manage inventory.

Common Policies for Order Quantity (Q)

1. Fixed Order Quantity (FOQ): Order a predetermined inventory units each time an order is placed.

2. Lot-for-Lot (L4L): Orders exactly what is needed.

3. Period Order Quantity (POQ): Order enough to satisfy demand for the next *n* periods.

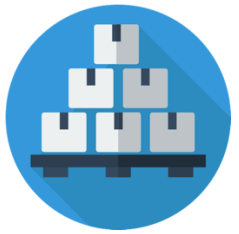
4. Min-Max system: When on-hand inventory falls below a predetermined minimum level, order a quantity that will take the inventory back up to its predetermined maximum level.

Inventory Management Models

Economic Order Quantity (EOQ)

Safety Stock

Economic Production Quantity (EPQ)



Periodic Review System

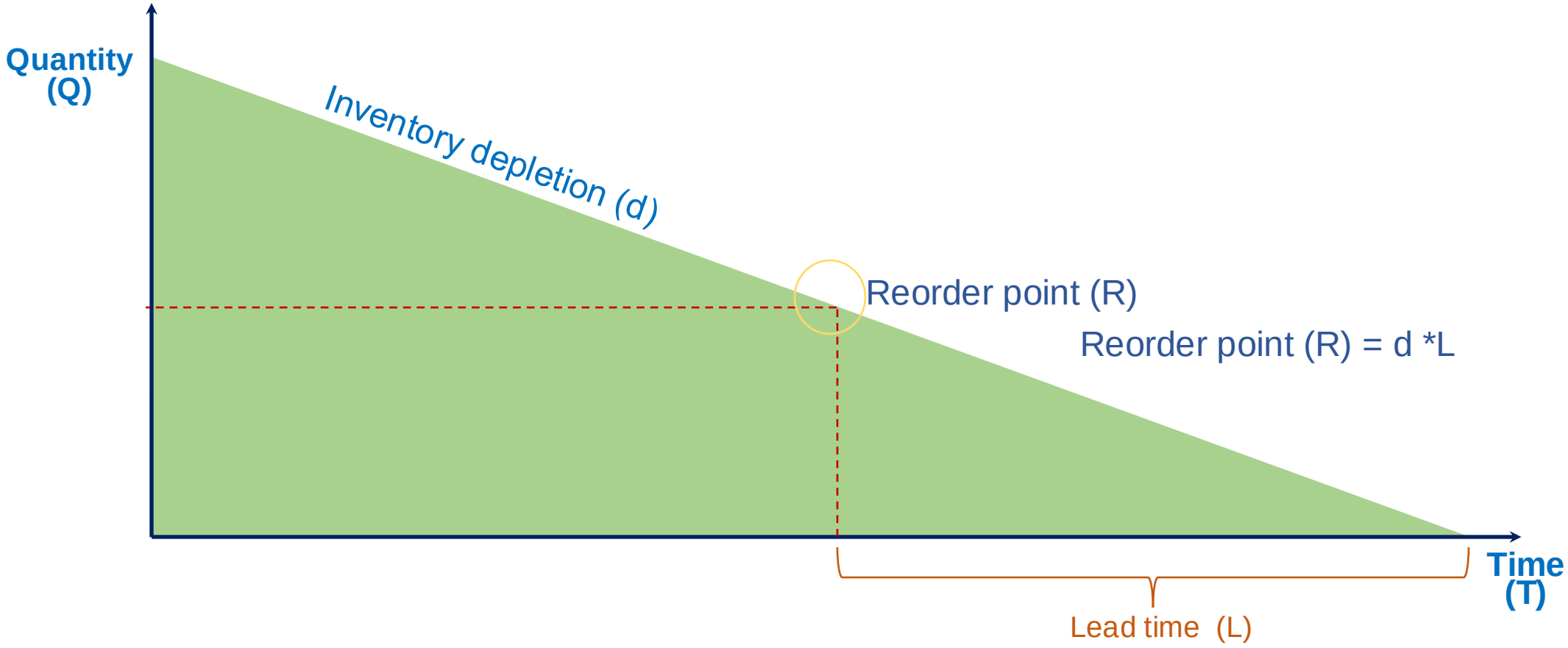
Discount Model

Single Period Inventory Model (Chromas Tree)

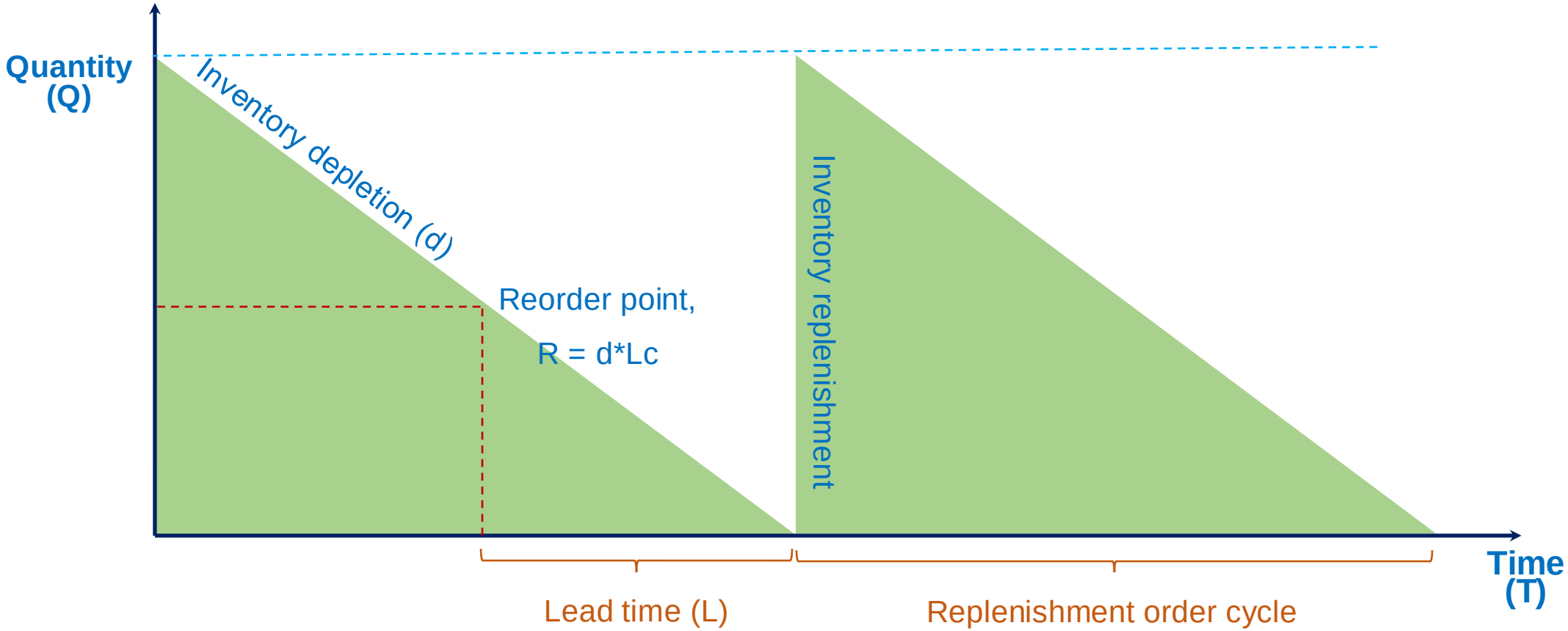
Economic Order Quantity (EOQ) - Assumption

- Demand is known and constant.
- Lead time is known and constant.
- Ordering (and set up) costs are fixed and constant.
- Unlimited capacity.
- Full (NOT partial) shipment.
- Price is fixed and constant.

Replenishment Decision – Dynamic (I)



Replenishment Decision – Dynamic (II)



Total Costs in EOQ

Total costs (TC) = Ordering costs + Holding costs

Ordering costs = Number of orders placed * cost to place an order

= (Demand/Quantity ordered) * S

= (D/Q) * S

Holding costs = Average inventory level * holding cost per unit

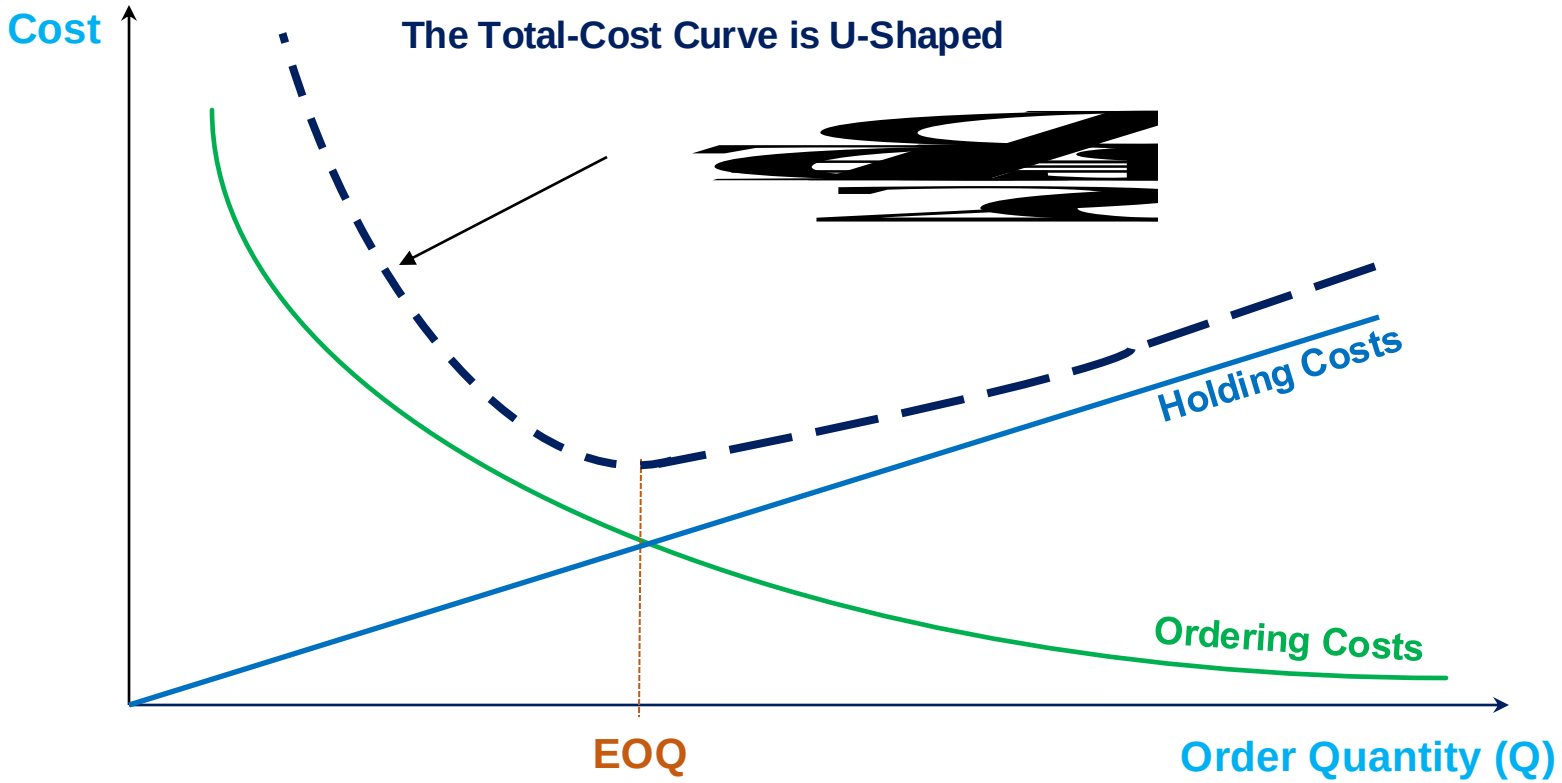
= (Max-Min)/2 * H

= (Q-0)/2 * H

Total costs (TC) = (D/Q) * S + (Q)/2 * H

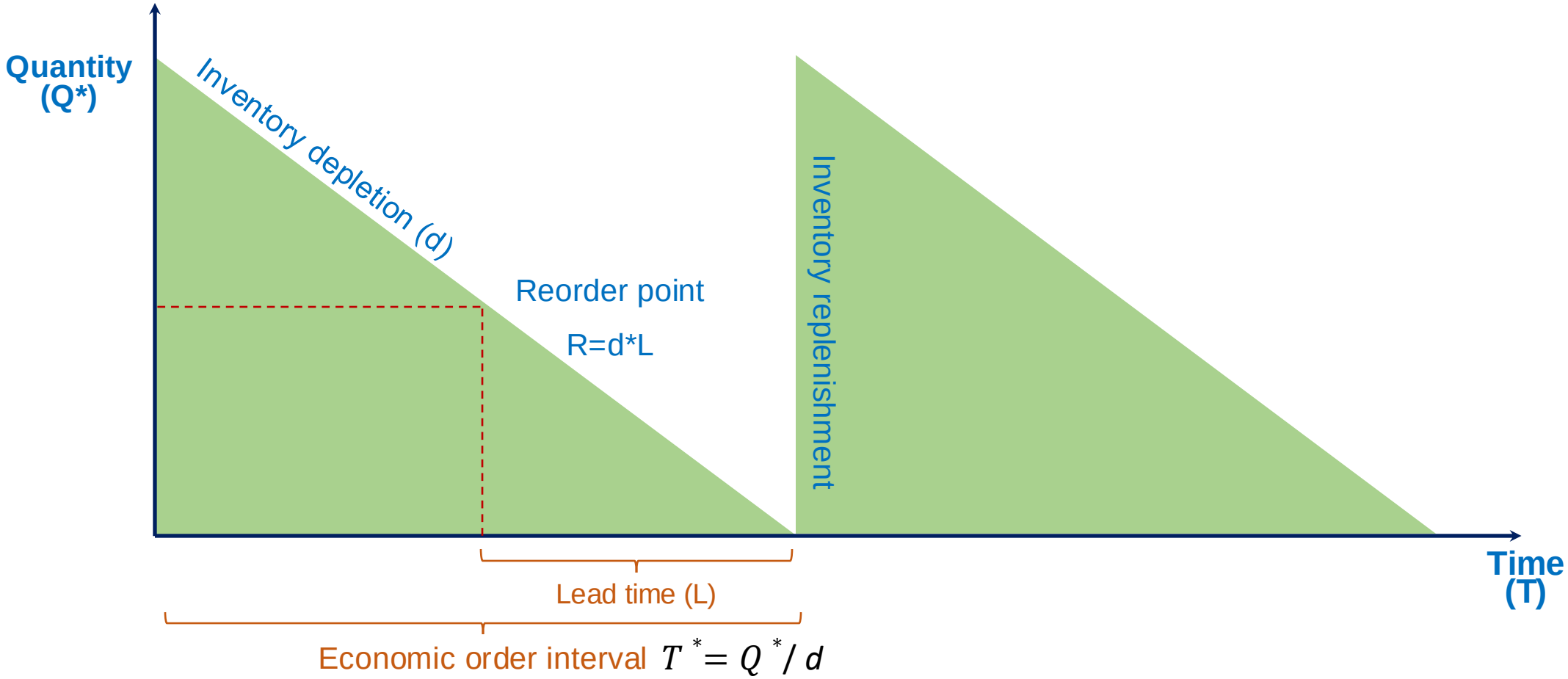
Economic Order Quantity – Q*

The objective is to find the order quantity that minimizes total costs. This order quantity is called EOQ or **Q***.

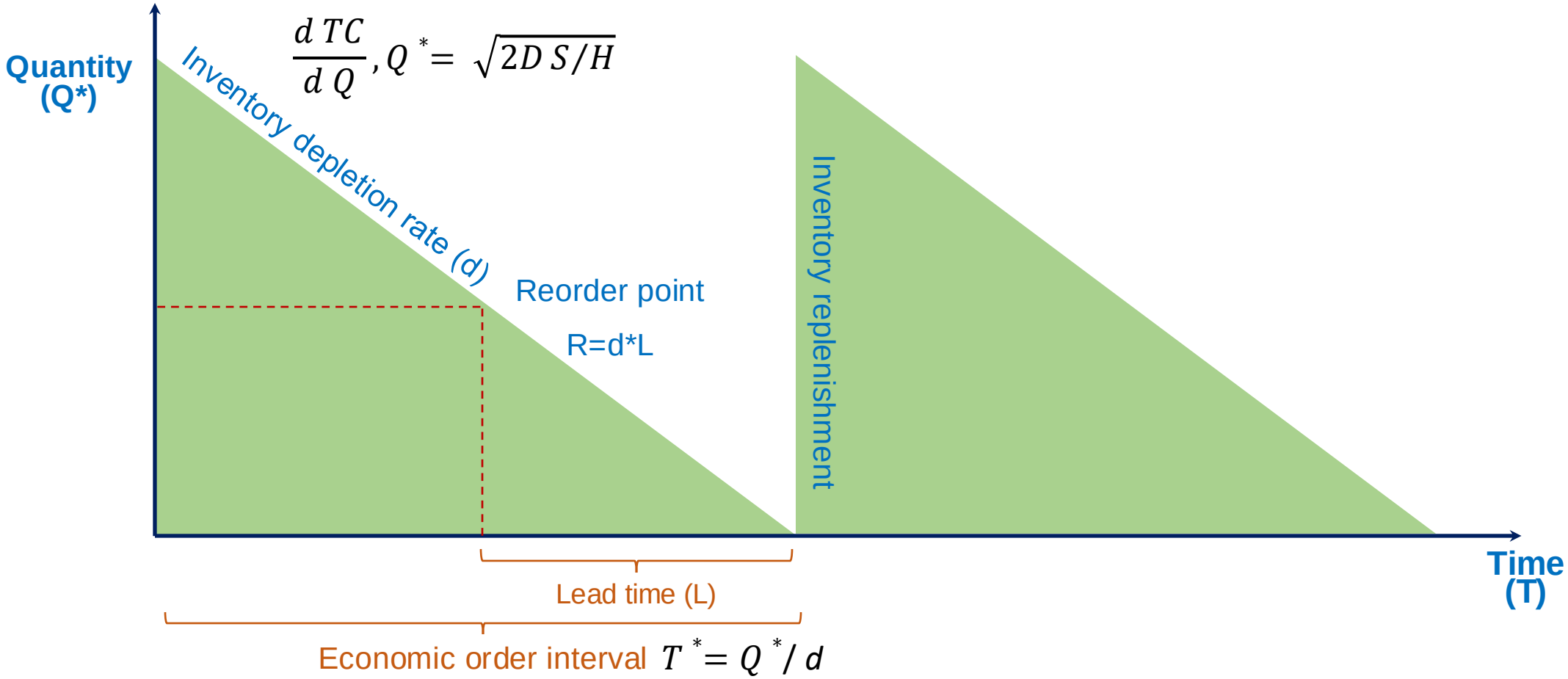


$$\frac{d\,TC}{d\,Q}, Q^{*} = \sqrt{2D\,S/H}$$

Economic Order Interval – T*



Economic Order Quantity and Order Interval



Exercise 2: EOQ, Reorder Point, Economic Order Interval

3 min

Annual demand (D): 10’000 units

Lead time (L): 5 days

Ordering cost (S): CHF 75 per order

Annual holding cost (H): CHF 6 per unit

Company operations: 250 days per year

Solution: Find EOQ, Reorder Point, Economic Order Interval

Annual demand (D): 10’000 units

Lead time (L): 5 days

Company operations: 250 days per year

Ordering cost (S): CHF 75 per order

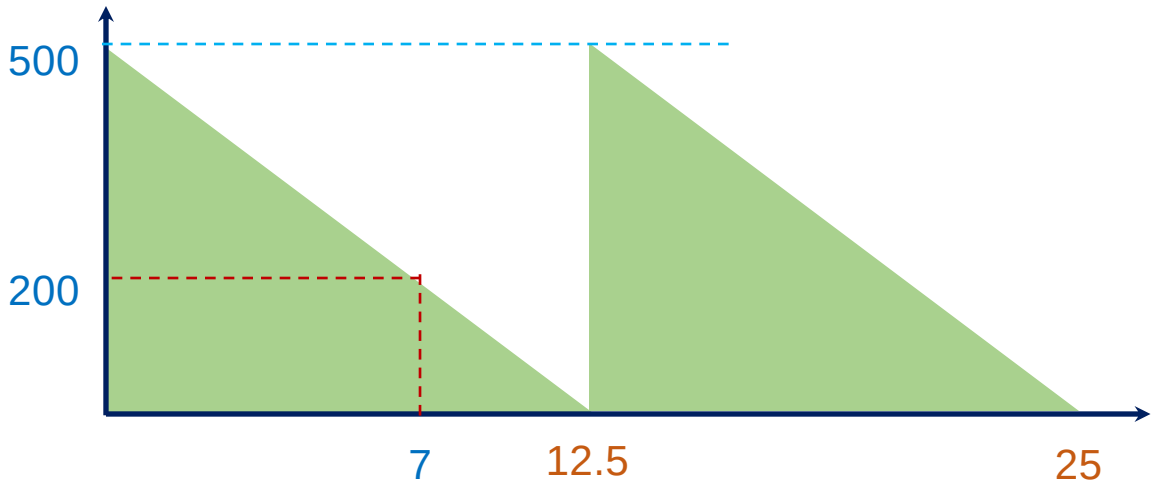
Annual holding cost (H): CHF 6 per unit

$$Q^* = \sqrt{2D\,S/H}$$

$$Q^* = \sqrt{2 * 10000 * \text{CHF } 75/6} = 500 \text{ units}$$

$$R = \text{d} * \text{L} = 40 \text{ units} * 5 \text{ days} = 200 \text{ units}$$

$$T^* = Q^* / d = 500 / 40 = 12.5 \text{ days}$$



Production Management (ME-419)

Coaching Rooms

Amin Kaboli

Week 10 – Session 4 – Nov 15h, 2024

Please Follow Your coaches to Your Designated Rooms

Coaches

Saria

GCA 330

Joao

GCA 331

Xavier

GRA 332

The Art of Giving and Receiving Effective Feedback

Feedback is a gift

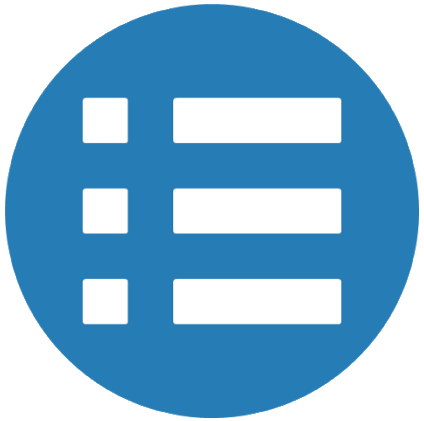
Feedback/comments are always welcome

Giving Effective Feedback

Respectful

Ask for permission

May I share my observation



Fact-based

Share facts/ your feelings

What I observed/felt is that …

Constructive

Stay focused on growth

What I suggest is that …

Concise

Be to-the-point and short

Max three key points

Open

Be open to any reaction

I respect your feeling …

Receiving Effective Feedback

Receive the gift

Be open and receptive

I appreciate your feedback

Listen

Listen to listen!

The goal is to listen not to answer, no interruption (zip it)

Understand

Focus on THE message

The goal is to understand, ask questions, clarify, repeat key points, …

Decide

You always have a choice

Thank you, I have never seen it this way

OR

Thank you, let me reflect and get back to you?

Follow up

Reach a common understanding

There are many ways to follow up: revise the work, set up a meeting, …