TPPE74
Design and Development of Manufacturing Operations

ie3 Industrial Engineering and Management of European Higher Education

Seminar 1

System Relationships (Graphs)

Task A

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2021

Content

- The Project Tasks

- The Manufacturing System

  - Flow of products

  - Batched production

- Task A

  - Inspirational Relationships (Graphs)

  - Instructions

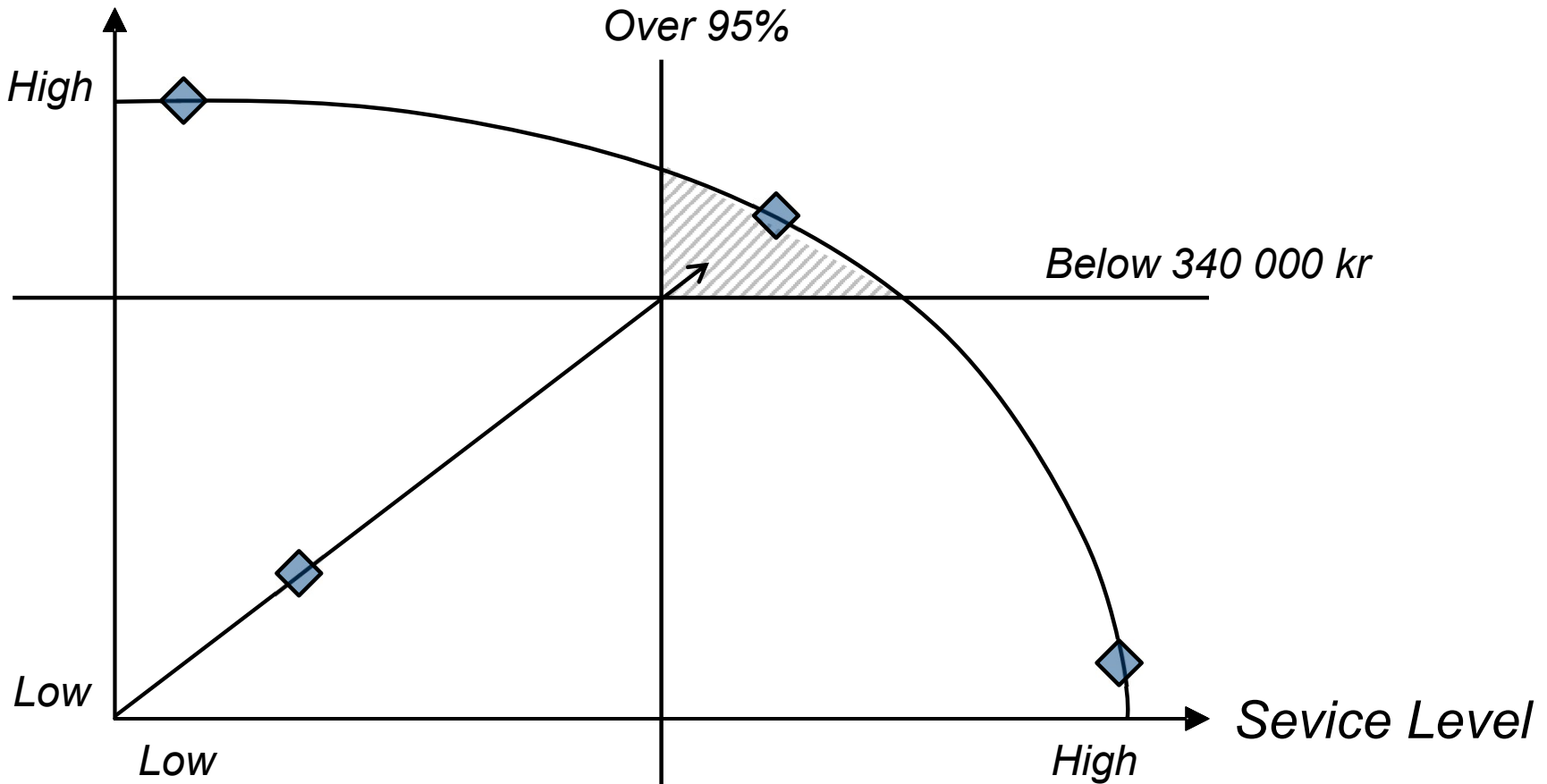- Usage of the Relationships

PicSim

- Production and Inventory Control Simulator (PicSim)

- Simulation model

    - 3 years of production

    - 1 year "Warm-up"

    - 2 years data collection

    - …takes apr. 0.1 second…

PicSim

Inventory cost efficiency
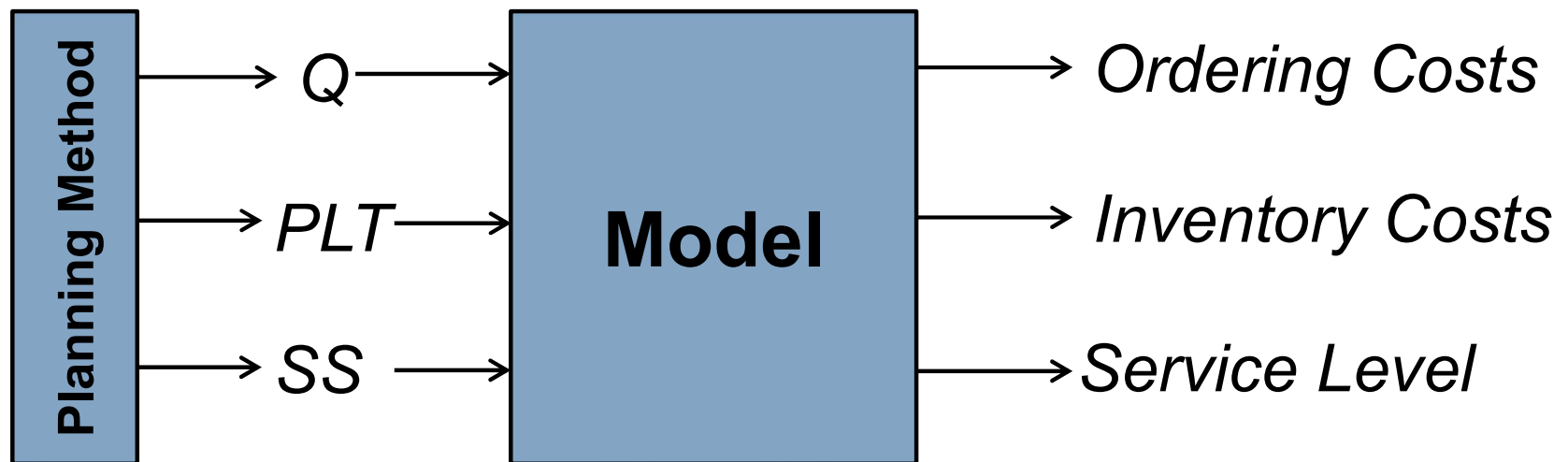
Also: Total Cost below 680 000 kr

Over 95%

High

Below 340 000 kr

Low

Low   High

Sevice Level

Simulation Result for the Case Company

Simulation Results

Simulation Results

Group No.	1									
Run No.	0									

Input data

Product/Item	A1	A2	A3	A4	A5	A6	A7	A8	A9
Lead time	3	4	3	4	4	3	3	3	3
Order quantity	495	632	692	1611	2619	2000	226	1732	1342
Safety stock	200	100	300	400	600	1400	100	1200	900

Costs

Ordering cost	158400	Total Ordering Cost	158400
Inventory of raw materials	94587	Total Inventory Cost	498498
Work in process	347459		
Semi-finished and finished goods inventory	56452		
Total	656898		

Max 680 000 (annotation pointing to Total 656898)

Max 340 000 (annotation pointing to Total Inventory Cost 498498)

Service levels (%)

Product 1	28.3
Product 2	72.8
Product 3	20.8
Overall	28.5

Min 95% (annotation pointing to Overall / service levels)

Statistics

	A1	A2	A3	A4	A5	A6	A7	A8	A9
Stockouts of finished products	3583.00	680.50	5940.00						
Average inventory level A1-A9	-434.00	186.00	-1149.00	721.50	975.00	2040.00	177.50	3103.00	4858.50
Average actual lead time A1-A5 (weeks)	7.09	8.69	7.36	11.20	15.25				
Average queueing time P1-P5 (hours)	51.34	37.77	44.98	88.66	53.36				
Average load P1-P5 (%)	82.46	67.13	66.21	78.77	73.03				

Inventory turnover rates

Raw material inventory	8.54
Work in process	5.89
Semi-finished and finished goods inventory	36.23
Total	5.72

Four Tasks in the Project

- Task A
  - Create graphs over nine different relationships.
  - Lisam Quiz to test conceptual shape.

- Task B
  - Run 10 simulations (we run the model) with the target to reach:
    Inventory cost: 340 000 kr
    Service level: 95 %
    Total Cost: 680 000 kr
  - Test all different planning methods
  - Lisam Quiz before simulations (at least one in each group needs to pass)

- Task C
  - Carry out a setup time reduction and study the effects.
  - Run 3 simulations (we run the model) to study the effects.

- Task D
  - Formulate system specific guidelines and rules that apply to the design parameters.
  - Run 3 simulations (we run the model) to "optimize" the system.
  - Competition!

Supervision

- Supervision in Teams, lists for booking
  - Week 14 to week 20, one day a week, see Time Edit
  - 08:30 -10:00 Booking in Sign Up (Lisam)
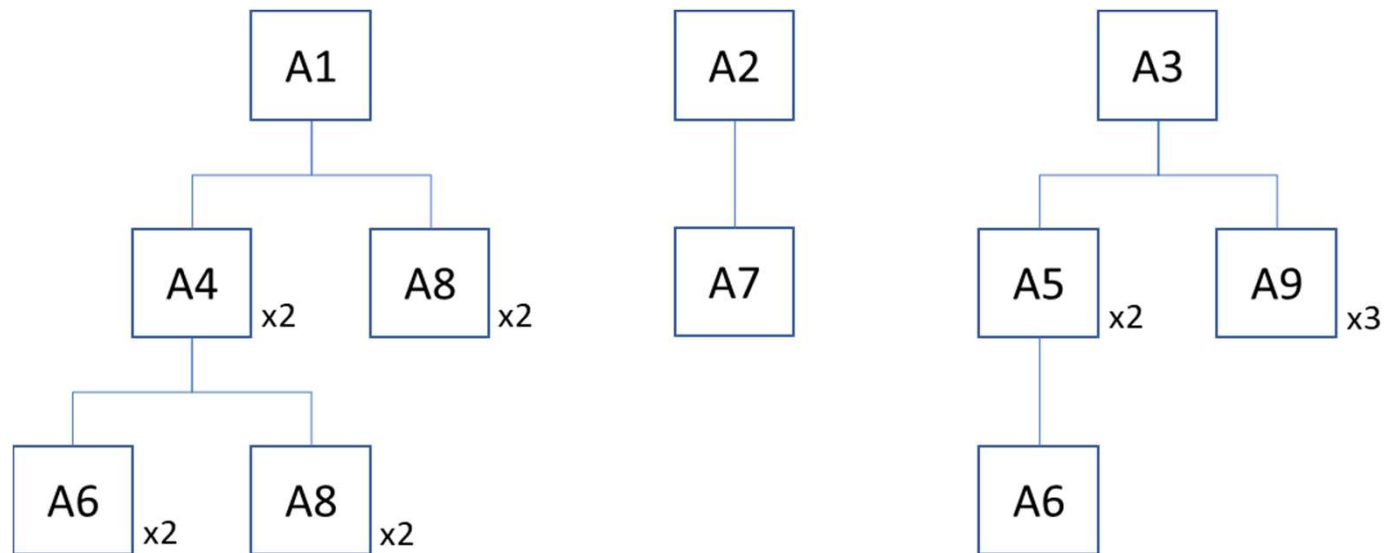 - 10:15 -11:30 Free supervision (Lisam)
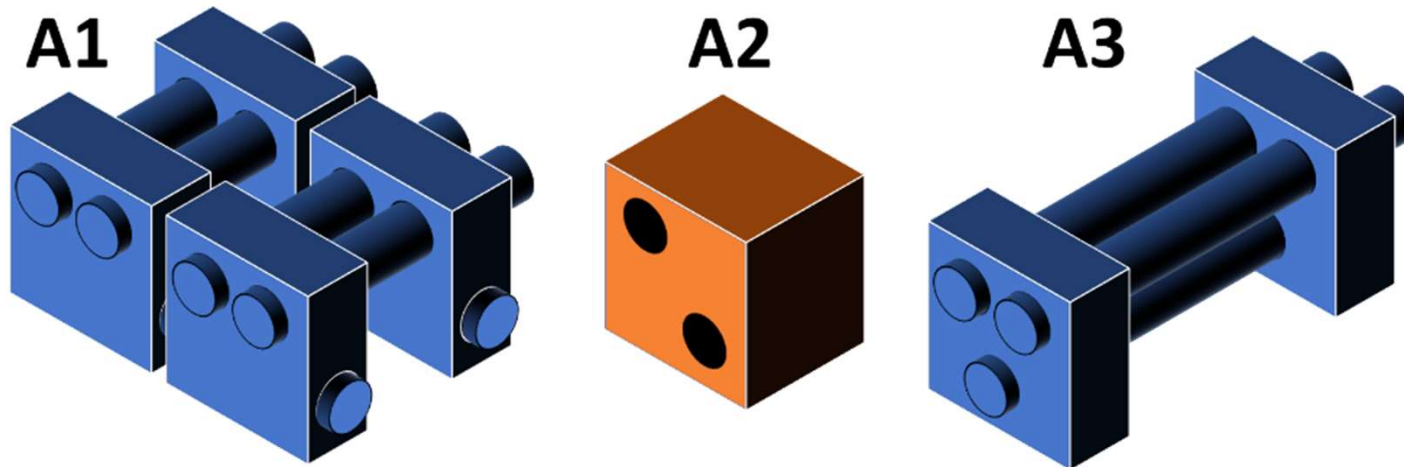
Project Task

- Manufacturing System
    - 9 products, 3 end-products, 2 manufactured components and 4 purchased components
    - 5 planning groups (resources)
    - 5 planning methods, Reorder point, MRP, Cyclic planning, Cyclic planning with base period, and Lean Production
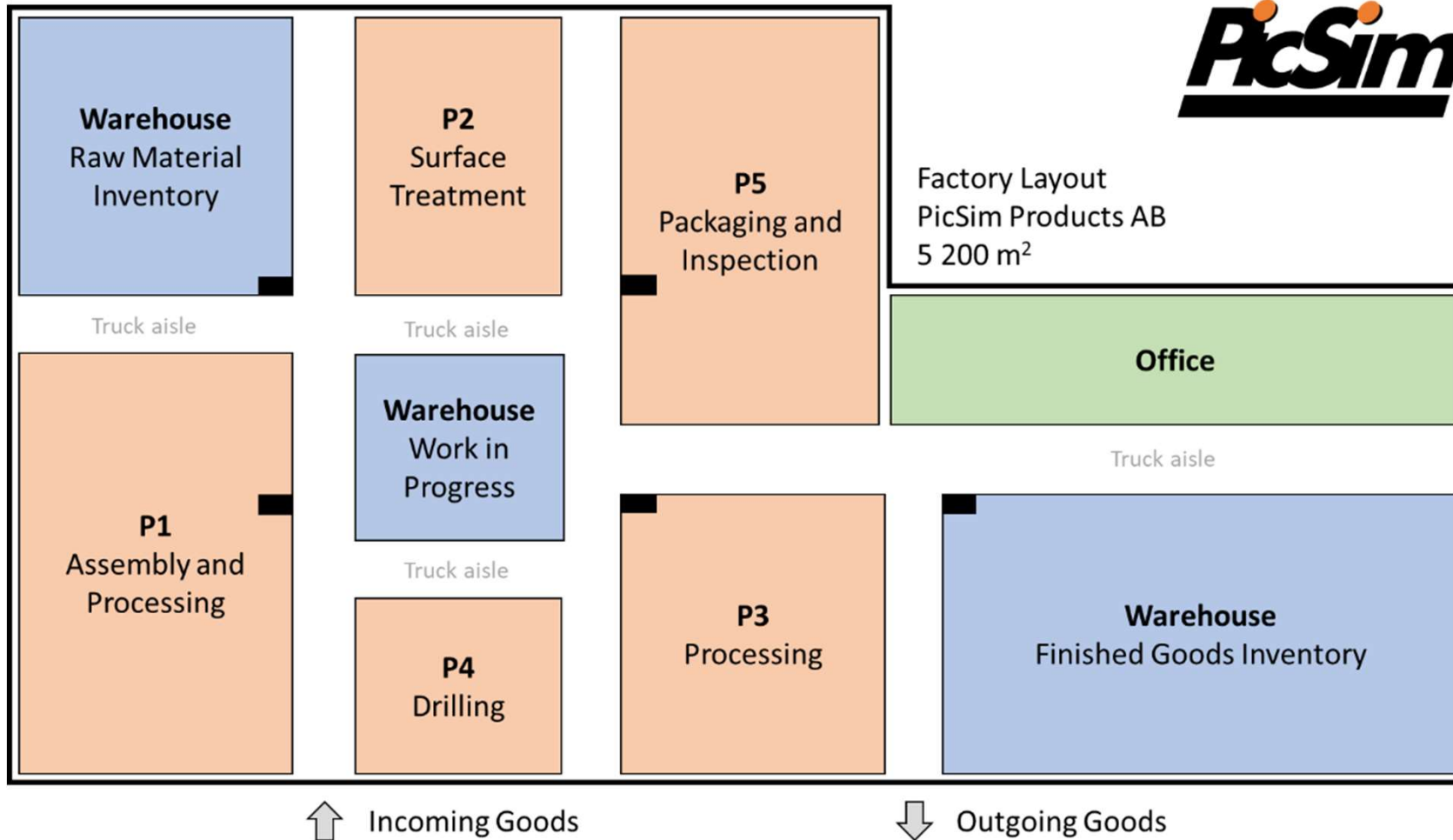
Project Task

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Project Task

Factory Layout
PicSim Products AB
5 200 m²

Warehouse Raw Material Inventory

P2 Surface Treatment

P5 Packaging and Inspection

Truck aisle

Truck aisle

Office

Truck aisle

P1 Assembly and Processing

Warehouse Work in Progress

Truck aisle

P4 Drilling

P3 Processing

Warehouse Finished Goods Inventory

⇧ Incoming Goods   ⇩ Outgoing Goods

Batched Production!

The Manufacturing System

Table 1. Means and standard deviations for weekly demand.

End product	Mean value	Standard Deviation
A1	100	12
A2	50	8
A3	150	15

Table 2. Product values in SEK per unit.

Products	Value
A1	1060
A2	500
A3	940
A4	370
A5	210
A6	70
A7	390
A8	80
A9	100

The Manufacturing System

Table 3. Processing times per unit (hours).

Planning Group \ Product		A1	A2	A3	A4	A5
P1	Assembly and Processing	0.03	0.05	0.07	0.02	0.04
P2	Surface treatment	0.06	0.08	-	0.02	0.04
P3	Processing	-	-	0.05	0.03	0.04
P4	Drilling	-	0.05	-	0.02	0.08
P5	Packing and Inspection	0.11	0.06	0.10	-	-

Table 4. Setup times and capacities for planning groups.

Planning Group \ Product		Setup time [hours]	Capacity [hours/week]
P1	Assembly and Processing	2	40
P2	Surface treatment	2	40
P3	Processing	3	40
P4	Drilling	3	40
P5	Packing and Inspection	1	40

Flow of A1

Factory Layout
PicSim Products AB
5 200 m²

Incoming Goods   Outgoing Goods

Table 3. Processing times per unit (hours)		A1	A2	A3	A4	A5
P1	Assembly and Processing	0.03	0.05	0.07	0.02	0.04
P2	Surface treatment	0.06	0.08	-	0.02	0.04
P3	Processing	-	-	0.05	0.03	0.04
P4	Drilling	-	0.05	-	0.02	0.08
P5	Packing and Inspection	0.11	0.06	0.10	-	-

Planning Group \ Product heading in first two columns of table.

Flow of A4

2 A6 and 2 A8

Table 3. Processing times per unit (hours).

Planning Group \ Product		A1	A2	A3	A4	A5
P1	Assembly and Processing	0.03	0.05	0.07	0.02	0.04
P2	Surface treatment	0.06	0.08	-	0.02	0.04
P3	Processing	-	-	0.05	0.03	0.04
P4	Drilling	-	0.05	-	0.02	0.08
P5	Packing and Inspection	0.11	0.06	0.10	-	-

Batched Production

Machine
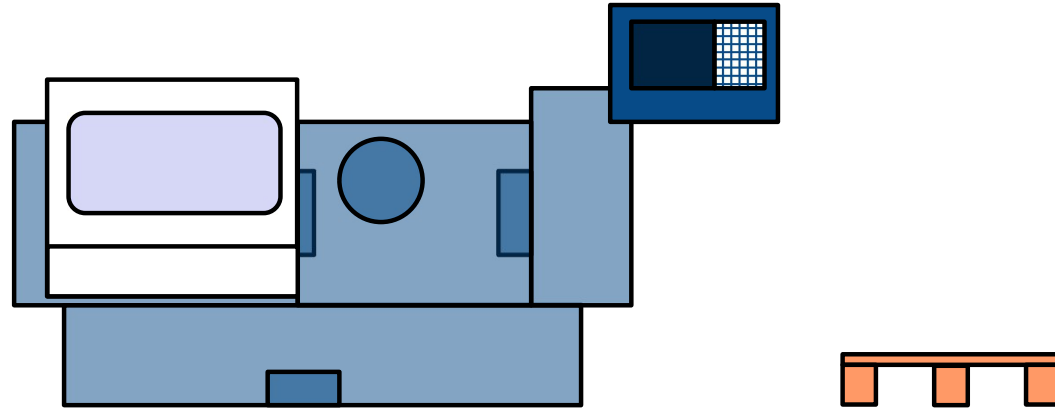
Q = 10

Batched Production
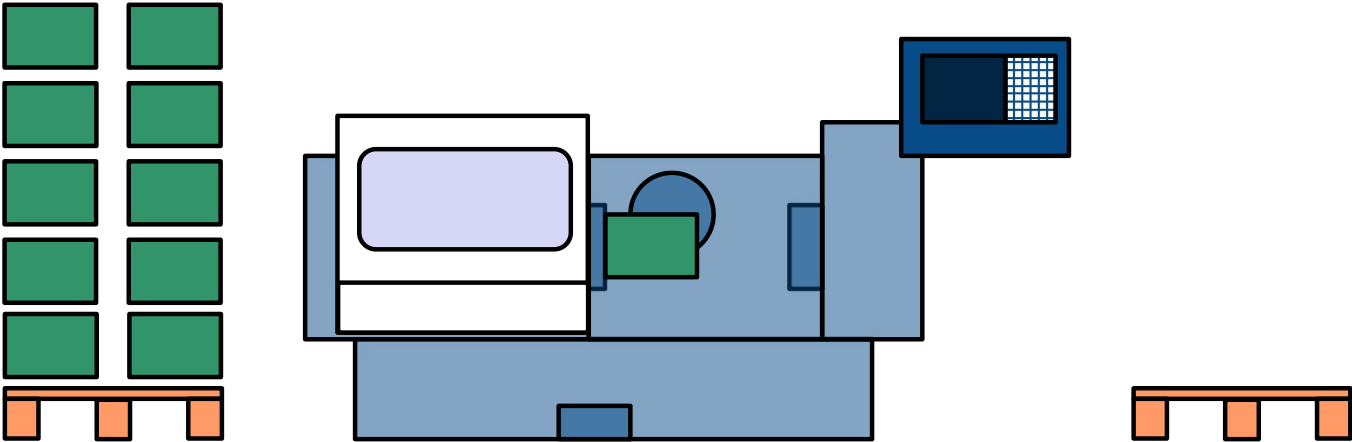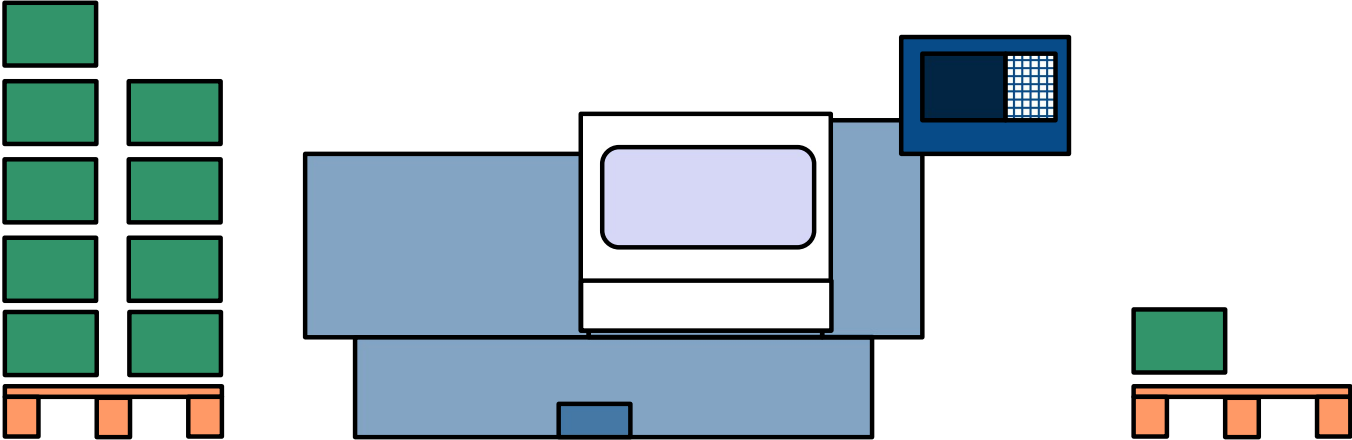
Processing

Batched Production

Processing
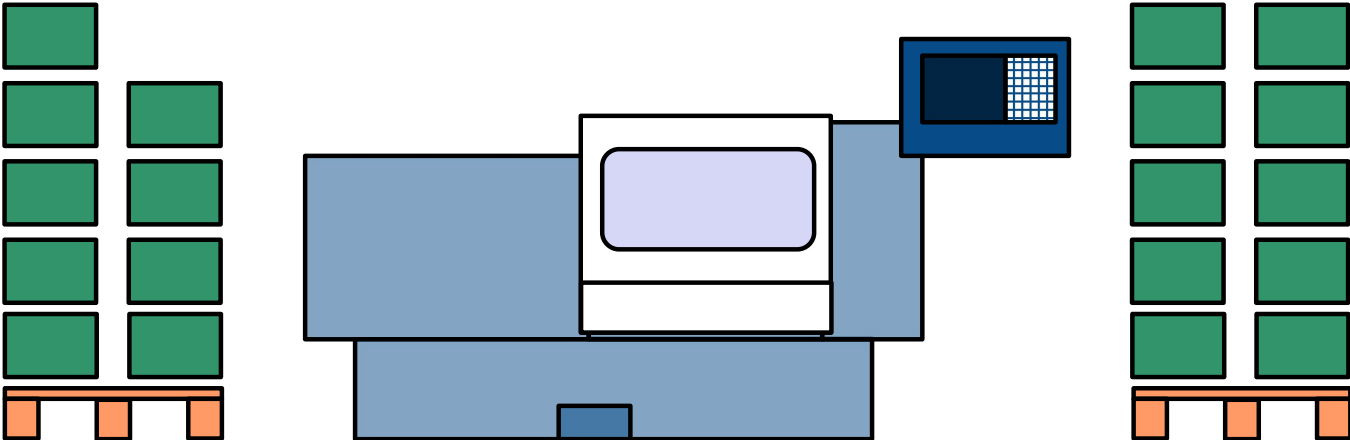
Batched Production
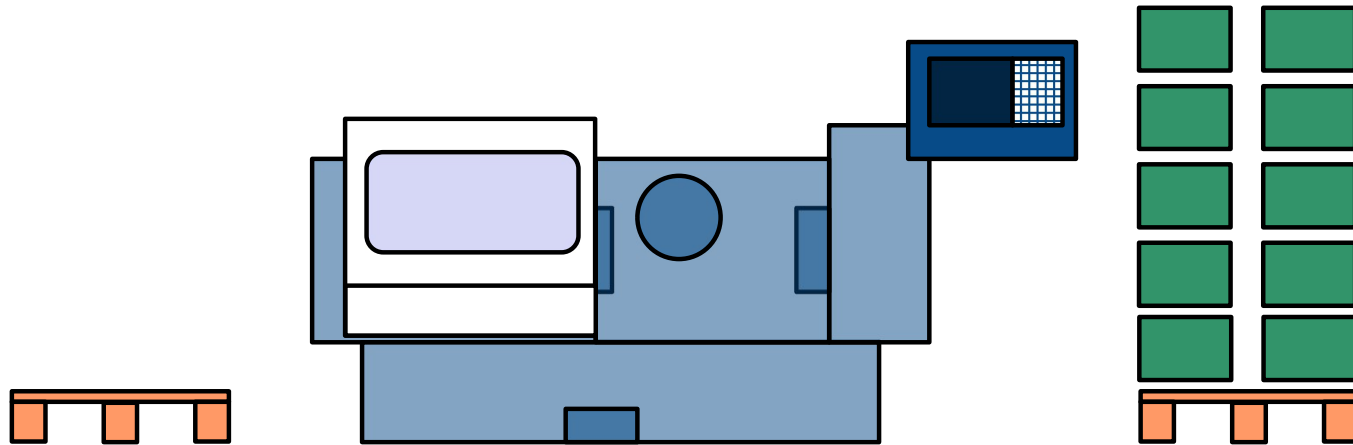
Q = 10

What happens to all other 9 parts when 1 part
is being machined?

Task A

- Task A
  - For task A, we test the pre-understanding by creating nine different conceptual shapes of graphs
  - The following nine graphs should be drawn:
    - Planned Lead Time's effect (x-axis) on Service Level (y-axis).
    - Planned Lead Time's effect (x-axis) on Inventory Level (y-axis).
    - Planned Lead Time's effect (x-axis) on Ordering Cost (y-axis).
    - Order Quantity's effect (x-axis) on Service Level (y-axis).
    - Order Quantity's effect (x-axis) on Inventory Level (y-axis).
    - Order Quantity's effect (x-axis) on Ordering Cost (y-axis).
    - Safety Stock's effect (x-axis) on Service Level (y-axis).
    - Safety Stock's effect (x-axis) on Inventory Level (y-axis).
    - Safety Stock's effect (x-axis) on Ordering Cost (y-axis).
  - The reasoning behind the shape of each graph should be clearly stated. Note that the graphs are only conceptual, there is no need to grade the axis more that from low to high.
  - To test the conceptual shape of each graph, there is a Lisam Quiz open where the correctness of the conceptual shape can be tested.
  - Passing the Quiz does not mean that Task A is passed but increases the probability to pass the submission.
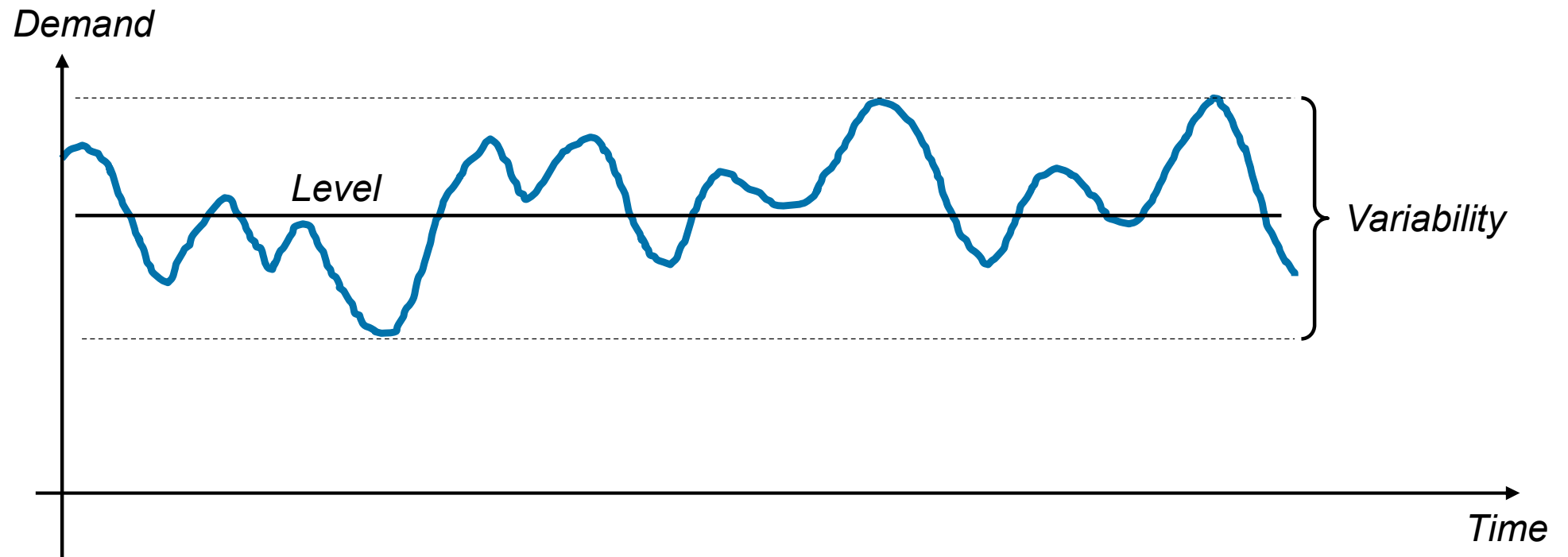
Examination – Grading Criteria

- Grade Pass requires the following:

- For Task A:
  - For each of the nine graphs, you need to draw the curve and motivate and explain the shape of the curve.
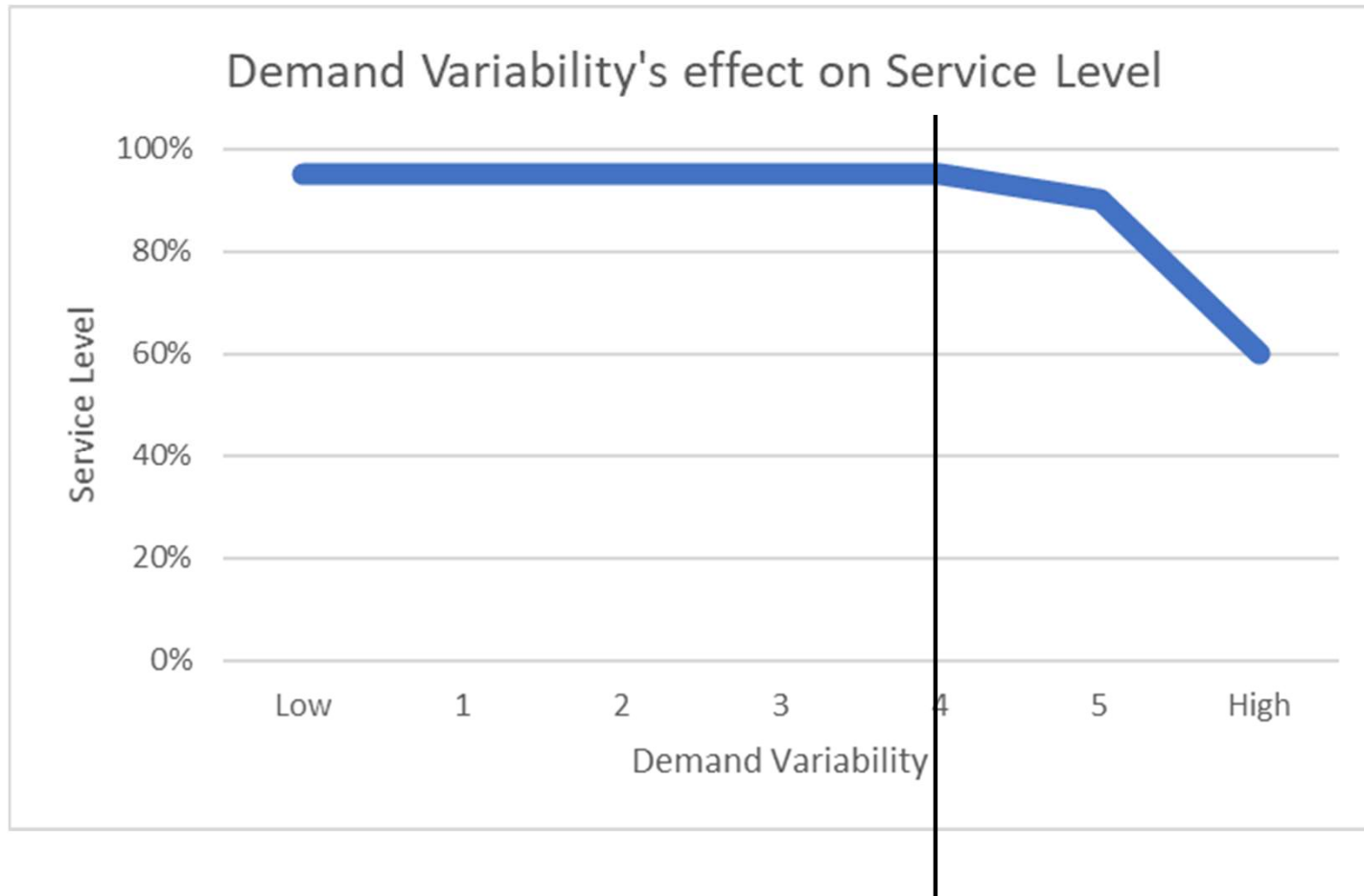
System Relationships

The Impact of Demand Variability
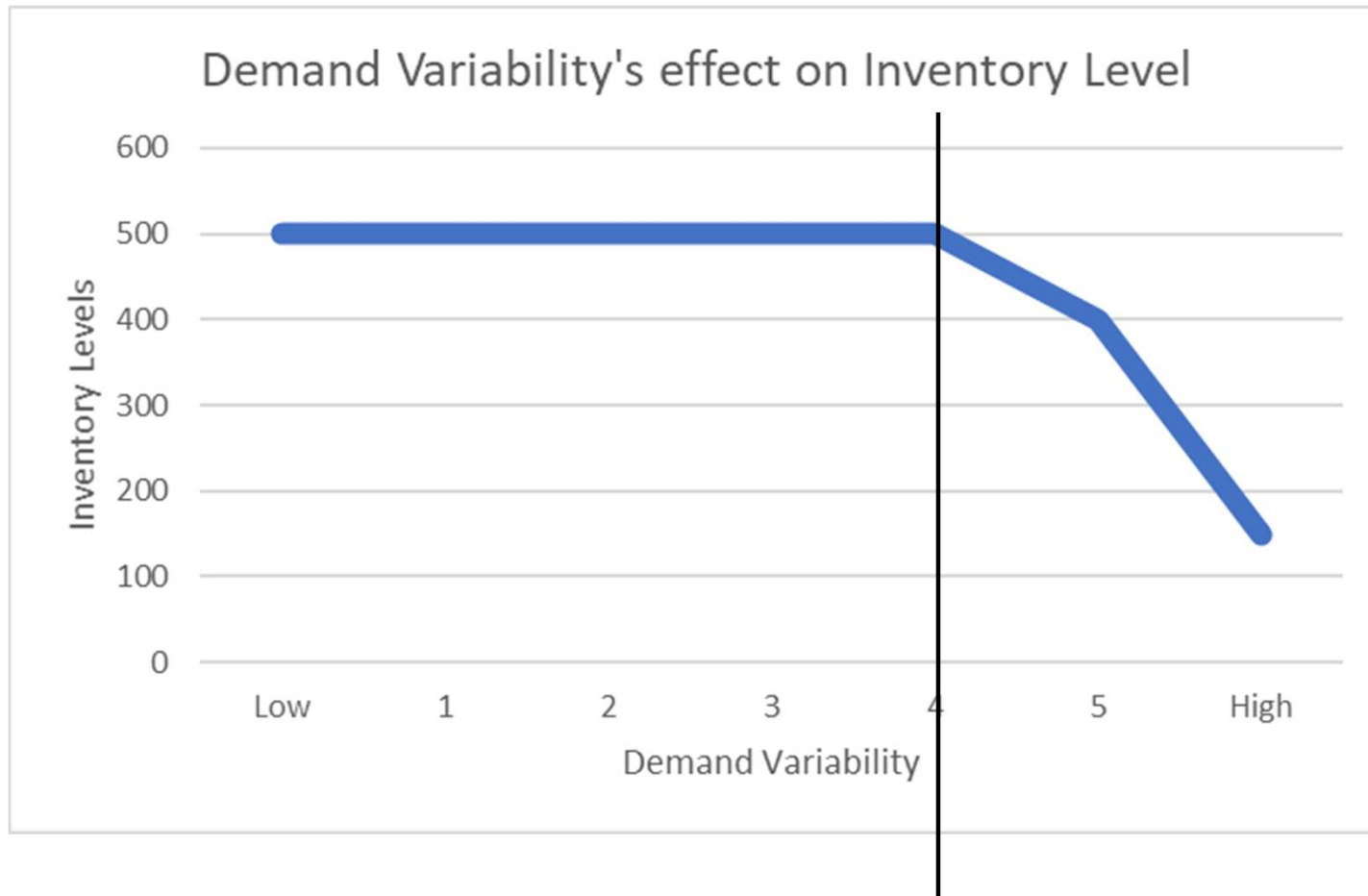
- Service Level

- Inventory Level

- Ordering Cost

System Relationships

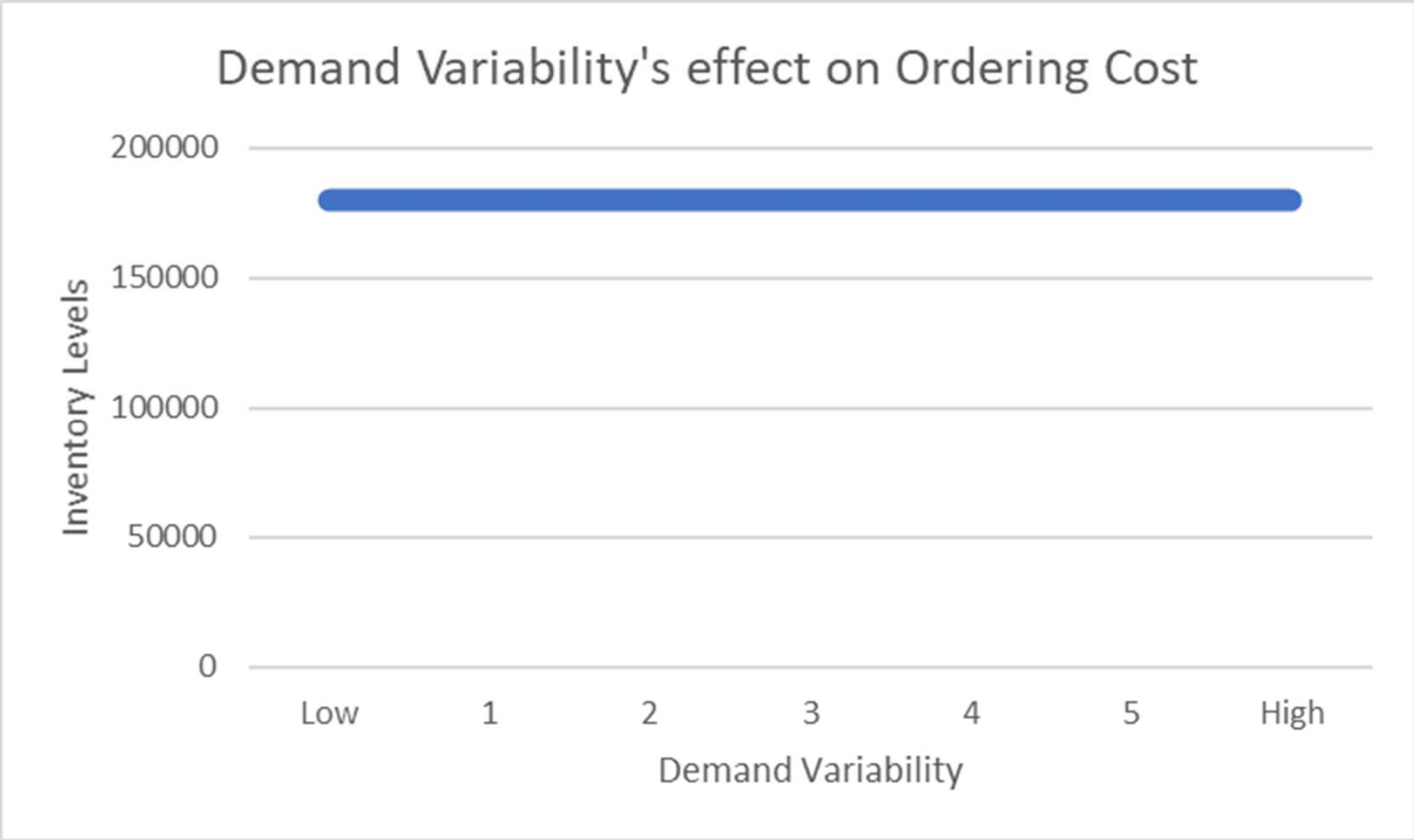Demand Variability's effect on Service Level

System Relationships

Demand Variability's effect on Inventory Level

System Relationships

Demand Variability's effect on Ordering Cost

Nine different relationships

Planned Lead Time

- Planned Lead Time's effect (x-axis) on Service Level (y-axis).

- Planned Lead Time's effect (x-axis) on Inventory Level (y-axis)

- Planned Lead Time's effect (x-axis) on Ordering Cost (y-axis)

Order Quantity

- Order Quantity's effect (x-axis) on Service Level (y-axis).

- Order Quantity's effect (x-axis) on Inventory Level (y-axis)

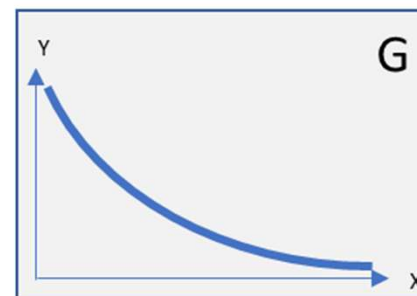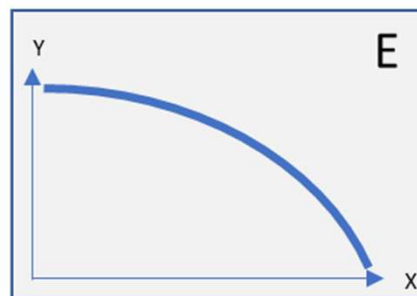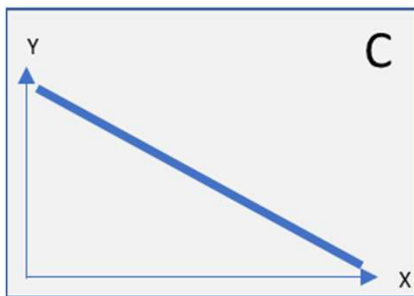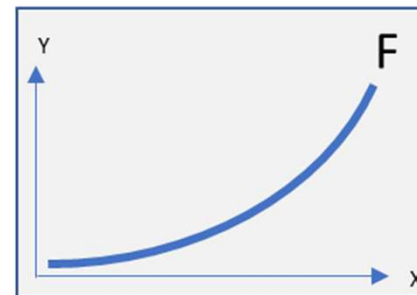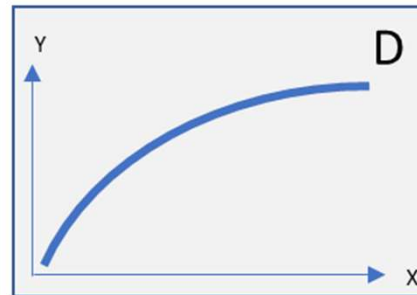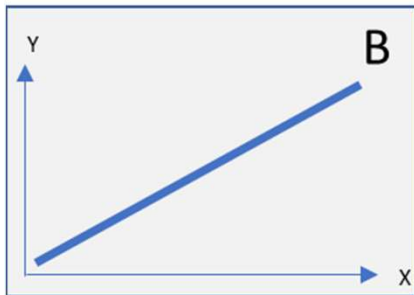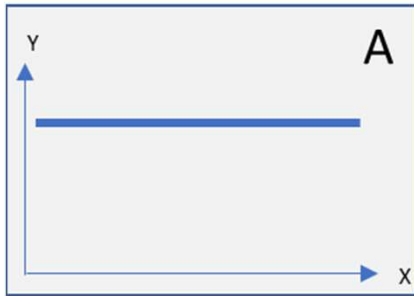- Order Quantity's effect (x-axis) on Ordering Cost (y-axis)

Safety Stock

- Safety Stock's effect (x-axis) on Service Level (y-axis).

- Safety Stock's effect (x-axis) on Inventory Level (y-axis)

- Safety Stock's effect (x-axis) on Ordering Cost (y-axis)

The Quiz

- Pick the closest conceptual graph

Instructions

- Think about long term effects

  - It is not the transition we are after, but the long term effect of a change

- If unclear, define

  - Inventory level? Which inventory – RMI, WIP, or FGI? Or all of them?

- One correct shape or several?

  - Are there any circumstances where several shapes are possible?

- Think about the motivation already now

  - You do not need to submit the motivation for each graph until the final submission, but it is a good idea to have the understanding ready
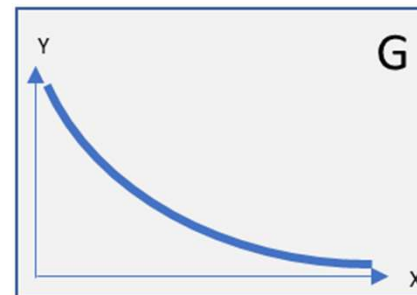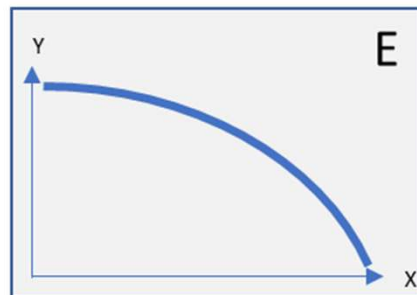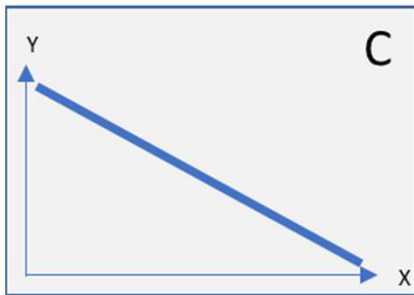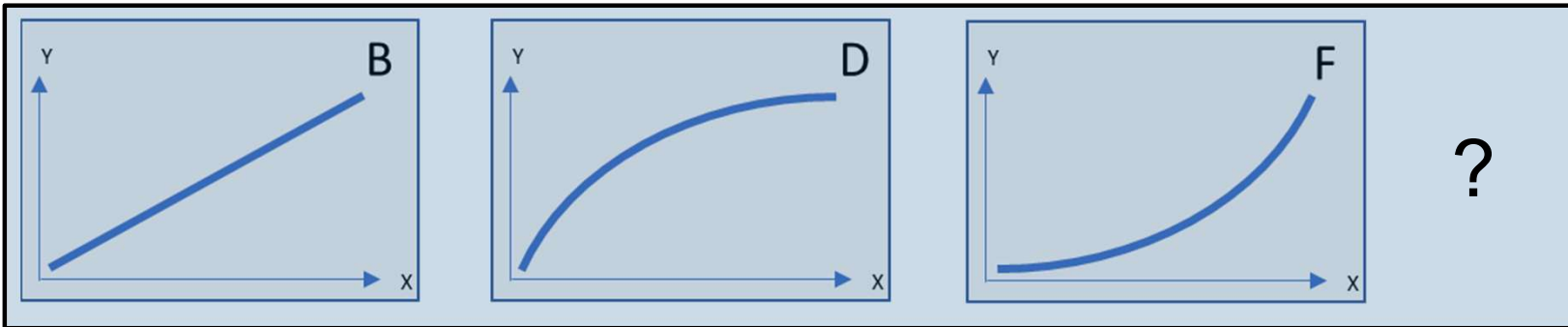
Usage of the Relationships

Simulation Results

Simulation Results

Group No.	1								
Run No.	0								

Input data

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Service levels (%)

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Product 2	72.8								
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Goal: Increased Service Level

Statistics

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Inventory turnover rates									
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Usage of the Relationships

Planned Lead Time's effect (x-axis) on Service Level (y-axis).
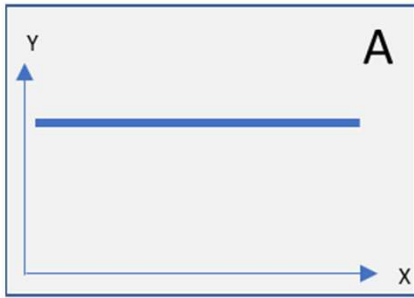
Increase Planned Lead Time!