General Information

You will work on the case study exercise and term paper in groups of up to 5 students. Please limit the length of the main part of your term paper to 5 pages. You may use an appendix for additional information.

The deadline for submitting the term paper is 17/12/2025 (inclusive) by email to mina.amiri@om.rwth-aachen.de. Please send your file in a ZIP folder, including the term paper with the number of the group and the names of the participants as a PDF document, and the Python code you used as the basis of the analyses of your group work, so it can be evaluated. It is sufficient if one member submits the term paper on behalf of the group.

You will find instructions for installing Python and Gurobi in the Moodle room. In addition, we provided links to video tutorials on working with Python and Gurobi.

Passing the assignment will improve the exam grade by one grade increment. However, this only applies on the condition that the written exam is graded with at least 4.0.

Assignment

VeloMotion GmbH is a leading German producer of high-quality electric bicycles. The company is preparing its supply and demand plans for the upcoming year. The expected monthly demand over the next year is shown in Table 1 below. VeloMotion's production capacity depends on its workforce. The company operates 22 days per month with a single 8-hour shift. Any hours beyond this are paid as overtime. The standard hourly wage is €19, with €24 per overtime hour. Each employee can work up to 12 overtime hours per month. VeloMotion currently employs 160 production workers and may hire or lay off employees. The hiring cost is €950 per employee, and the layoff cost is €1,600 per employee. Due to managerial policy, no more than 50 employees may be hired per month. Each e-bike requires 3.5 labor hours to produce. Unsold units can be stored at a monthly cost of €12 per unit, and warehouse capacity is limited to 8,000 units. Each unit of raw material and components costs €620, while the finished e-bike sells for €1,250 per unit. VeloMotion also cooperates with an external assembler that can produce units at a cost of €710 per unit. The current plan estimates an initial inventory of 600 e-bikes. If VeloMotion cannot meet distributor demand within a month, it can fulfill it later (backorders) at a penalty cost of €35 per delayed unit per month due to potential dealer dissatisfaction and lost sales reputation. All orders must be fulfilled by the end of the planning period.

Notes

- In the case of multiple promotions, assume that promotions do not overlap and only pull forward demand from months without a promotion. In other words, promotions cannot occur in consecutive months. Please state all assumptions made regarding this behavior.

- There is no restriction on the inventory level in the final period; it may be fully consumed or remain positive, depending on your results.

- Clearly document any additional assumptions you make where information is missing or requires interpretation for your solution.

Questions to be answered:

Implement a mathematical optimization model for production planning at Plasticon in Python and determine the optimal production plan using Gurobi.

1. What is the annual profit of the optimal plan? And what is the structure of costs (labor, overtime, hiring/layoff, inventory, backorder, outsourcing, materials, etc.)?

2. How does VeloMotion use flexibility options (overtime, hiring/layoff, inventory, outsourcing) to adjust supply?

3. What is the number of employees per month? And what is the inventory level each month?

4. Why might VeloMotion use the external assembler even though its per-unit cost is higher than average in-house production (including regular and overtime)?

5. If the inventory cost rises to €18 per unit per month, what happens to the optimal production schedule of the base case, and why?

6. If the supplier increases component prices by €50 per unit, what is the impact on the cost structure and production plan of the base case?

7. How would the production schedule and cost structure change if VeloMotion faced a 10% increase in demand for three consecutive months of the base case? What would be the best strategy to manage this temporary surge?

8. Market research indicates that a one-month 5% price reduction increases sales by 35% in that month and brings forward 6% of the following two months' demand. In which month should VeloMotion launch a price promotion to the base case? What is the impact on annual profit and total cost?

9. Evaluate the effect of having more than one price promotion (non-consecutive months only). Is it better to have multiple promotions? What is the best number and timing of promotions?

10. How would you include setup costs of 5000€ and minimum batch sizes of 50 units in the production-planning model of the base case?

11. Which supply chain drivers could impact VeloMotion's profitability?

12. How can supply chain partnerships (e.g., external assemblers or logistics providers) be designed to improve responsiveness to demand changes without significantly increasing costs?

13. How could postponement or modular design affect the supply chain's flexibility?

14. What are the limitations of linear optimization models in representing real-world supply chains?

Table 1: Plasticon Manufacturing Demand Forecast for the Year

Month	*Demand*
January	2800
February	3200
March	4000
April	4500
May	5500
June	5200
July	4800
August	4300
September	4700
October	5400
November	6000
December	6800

Adapted from: Chopra, S.; Meindl, P. (2016): Supply Chain Management - Strategy, Planning and Operation