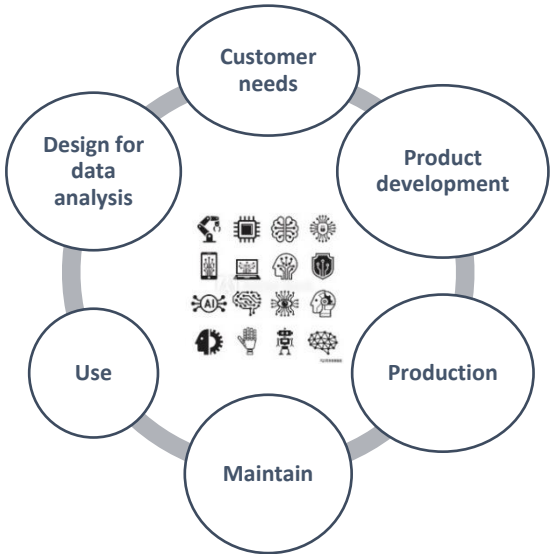
# IMS065 - Data Science in Product Realization

5,0 Credits, ETC 7,5

**Elective course in Master Programs**

- Production Engineering
- Product Development

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## Course aim

The course aims to enable data-driven and facts-based decisions in mechanical engineering, specifically in the industrial product realization process. Therefore, the course aims to provide the students with fundamental knowledge about data science (including elements of Artificial Intelligence - AI and Machine Learning - ML) and abilities to apply data science techniques for improving production systems and product development. This course provides well understanding of AI systems through the appropriate formulation of the problem and the choice/application of suitable ML algorithms in order to assess the effectiveness of such algorithms using industrial case studies from product realization life cycle steps shown as in the above figure.

## Learning objectives of the course

On successful completion of the course, the student should be able to:

LO1. Describe the fundamentals of data science, its applications (AI/ML), data-driven modelling and big data analytics.
LO2. Apply the basics of well-known libraries of the toolboxes for data scientists.
LO3. Describe steps of the data mining process.
LO4. Describe and apply visualization techniques with respect to the data mining process.
LO5. Describe and perform data pre-processing methods to ensure multi-dimensional measure of data quality.
LO6. Explain and interpret utilization of data and applicability of AI/ML algorithms for improving production systems and product development.
LO7. Interpret and discuss state-of-the-art knowledge from scientific papers related with data science in mechanical engineering.
LO8. Implement commonly used AI/ML algorithms, analyze their performance, and discuss their application using industrial applications from product realization life cycle.
LO9. Critically analyze and argue key ethical principles and potential impacts of AI on people and society and evaluate social and human requirements of systems and scenarios.

## Course content and organization

The course is divided four modules and each module covers the following topics:

*Module 1 - Introduction to Data Science*

- Fundamentals of data science (AI/ML)
- An overview of data-driven modelling
- Introducing toolboxes for data scientists

*Module 2 - Data Mining & Visualization*

- Introduction to the data mining process and work procedures
- Plotting for exploratory data analysis (EDA)
- An overview of data quality dimensions
- Methods for data pre-processing

*Module 3 - AI and ML*

- A general introduction to AI and ML
- Examples of ML algorithms to understand in what situations they can be used
- Examples of deep learning
- Analysis of different industrial applications from product realization life cycle using AL/ML
- The ethics of AI (will be covered by reading scientific papers and discussion in literature seminar presentation)

*Module 4 - How to drive AI in your business - Project work*

- Practicing with group work project for understanding AI/ML systems through the appropriate formulation of the selected industrial cases from product realization life cycle

*Different learning activities will be used during the course summarized as below:*

- *Lectures* – Basis for theoretical understanding of the concepts of data science.
- *Guest lectures* – Basis for understanding different industrial applications of data science.
- *Workshops* – To reinforce the learning via more engagement with the students related to data utilization and analytics of the selected industrial cases from product realization life cycle.
- *MATLAB seminars* – To support learning of the necessary toolboxes, which will be expected to use in examination project work.
- *Self-paced hands-on exercises* – Training in an interactive tutorial in MATLAB called Machine Learning Onramp course, which introduces practical ML methods, preparation for MATLAB seminars and examination project work.
- *Project work,* which is mandatory for examination, and it aims to practice skills learned throughout the course based on a structured project methodology.
- *Presentation and discussion of scientific papers* related to applications of data science in the product realization process.

*The following table also shows a summary of above learning activities for each module.*

| Module no | Lecture | Guest lecture | Workshop | MATLAB seminar | Project work | Presentation | Hands-on exercises |
|---|---|---|---|---|---|---|---|
| 1 | √ | √ | √ | | | | |
| 2 | √ | √ | √ | √ | | | √ |
| 3 | √ | √ | | √ | √ | √ (Literature seminar) | √ |
| 4 | | | | | √ | √ (Project work) | |

## Examination including compulsory elements

Grading is based on the examination project work including a technical report and recorded oral presentation. Students must be approved on all assessment tasks individually (project work, hands-on exercises, mandatory knowledge test, and literature seminar presentation) to pass the course. The grading scale are Failed, 3, 4, and 5.

## Literature

- Course PM
- Lecture materials (power-point presentations) will be available at the course Canvas homepage
- Scientific papers
- Recommended resources to support learning

Literature for reading during the course as summarized below:

| **Book information** | **Chapter to read** |
|---|---|
| Skiena S.S. (2017). The Data Science Design Manual. Texts in Computer Science. Springer, Cham.<br><br>Here is the link to access some lectures slides for this book!<br><br>https://www3.cs.stonybrook.edu/~skiena/data-manual/lectures/ | Chapter 1 – What is Data Science? (pages 1-25)<br><br>Chapter 6 – Visualizing Data (6.1 Exploratory data analysis, pages 155-162)<br><br>Chapter 11 – Machine Learning (pages 351-390) |
| Han, J., Kamber, M., & Pei, J. (2011). Data mining concepts and techniques third edition. The Morgan Kaufmann Series in Data Management Systems. | Chapter 3 – Data Preprocessing (pages 83-124) |
| **Scientific papers to read** | |
| 1. Cao, L. (2017). Data science: a comprehensive overview. ACM Computing Surveys (CSUR), 50(3), 1-42.<br><br>2. Tao, F., Qi, Q., Liu, A., & Kusiak, A. (2018). Data-driven smart manufacturing. Journal of Manufacturing Systems, 48, 157-169.<br><br>3. Lee, J., Davari, H., Singh, J., & Pandhare, V. (2018). Industrial Artificial Intelligence for industry 4.0-based manufacturing systems. Manufacturing letters, 18, 20-23.<br><br>4. Wuest, T., Weimer, D., Irgens, C., & Thoben, K. D. (2016). Machine learning in manufacturing: advantages, challenges, and applications. Production & Manufacturing Research, 4(1), 23-45. | |
| **Recommended link for machine learning algorithm examples i.e., classification, regression, clustering, etc.** | |
| https://scikit-learn.org/stable/ | |
| **Some helpful resources for machine learning in MATLAB :** | |
| https://www.mathworks.com/help/stats/machine-learning-in-matlab.html<br><br>Some interactive apps used during the course:<br>Diagnostic feature designer app link:<br>https://www.mathworks.com/help/predmaint/gs/import-and-visualize-data-in-diagnostic-feature-designer.html<br><br>Classification learner app video:<br>https://www.mathworks.com/videos/classify-data-using-the-classification-learner-app-106171.html | |

## Course staff

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## Schedule of the course

| W | Time | Room | Activity | Content | Responsible |
|---|---|---|---|---|---|
| **45** | ***Module 1 - Introduction to Data Science*** | | | | |
| 45 | 201103 13:15-15:00 Tuesday | Zoom | Lecture | Course introduction | AS |
| 45 | 201103 15:15-17:00 Tuesday | Zoom | Lecture | Introduction to data science | ETB |
| 45 | 201105 13:15-15:00 Thursday | Zoom | Lecture | Specification of ML solutions in manufacturing | JB |
| 45 | 201105 15:15-17:00 Thursday | Zoom | Workshop | Data-driven analytics in production | JB |
| 45 | 201106 13:15-15:00 Friday | Zoom | Lecture | General introduction toolboxes for data scientists<br>Information about MATLAB | ETB + PN |
| **46** | ***Module 2 - Data Mining & Visualization - Part 1*** | | | | |
| 46 | 201110 13:15-15:00 Tuesday | Zoom | Lecture | Guest lecture - A view of data science /exploratory data analysis (EDA)<br>Introduction to data mining & visualization | AK + ETB |
| 46 | 201110 15:15-17:00 Tuesday | Zoom | Lecture | Basic methodologies and applications in data mining | ETB |
| 46 | 201112 13:15-15:00 Thursday | Zoom | Lecture | A general overview of the selected case study from product development | MS |
| 46 | 201112 15:15-17:00 Thursday | Zoom | Lecture | A demonstration of the application of EDA & data visualization in MATLAB by using the case at hand | MS |
| 46 | 201113 13:15-15:00 Friday | Zoom | Workshop | Data utilization in product development | KB + GA |
| **47** | ***Module 2 - Data Mining & Visualization - Part 2*** | | | | |
| 47 | 201117 13:15-15:00 Tuesday | Zoom | Lecture | Data quality & Information about project methodology | AS |
| 47 | 201117 15:15-17:00 Tuesday | Zoom | Lecture | Methods of data pre-processing | ETB |
| 47 | 201119 13:15-15:00 Thursday | Zoom | Self-study & First part of self-paced activity in MATLAB* | | ETB + Own work |
| 47 | 201119 15:15-17:00 Thursday | | | | |
| 47 | 201120 13:15-15:00 Friday | Zoom | MATLAB Seminar 1 | A demonstration of data pre-processing & feature selection with MATLAB | RA + ETB |
| *More information will be available on CANVAS page! | | | | | |
| **48** | ***Module 3 - AL and ML - Part 1*** | | | | |
| 48 | 201124 13:15-15:00 Tuesday | Zoom | Lecture | Introduction and practical use cases of deep learning | KA |
| 48 | 201124 15:15-17:00 Tuesday | Zoom | Guest lecture | External case – Computer vision for improved manufacturing processes | A.Syberfeldt |
| 48 | 201126 13:15-15:00 Thursday | Zoom | Literature seminar | AI in industry from different perspectives* | AS + ETB |
| 48 | 201126 15:15-17:00 Thursday | Zoom | Literature seminar | AI in industry from different perspectives* | AS + ETB |
| 48 | 201127 13:15-15:00 Friday | Zoom | Project work | Project plan discussion with groups - Q & A | AS + ETB |
| *Literature seminar contains group presentation and discussion of the selected scientific papers!<br>**-Deadline for uploading project plan – 20/12/03!** | | | | | |
| **49** | ***Module 3 - AL and ML - Part 2*** | | | | |
| 49 | 201201 13:15-15:00 Tuesday | Zoom | Self-study & Second part of self-paced activity in MATLAB* | | ETB + Own work |
| 49 | 201201 15:15-17:00 Tuesday | | | | |
| 49 | 201203 13:15-15:00 Thursday | Zoom | MATLAB Seminar 2 | A demonstration of modeling & evaluation with MATLAB | RA + ETB |
| 49 | 201203 15:15-17:00 Thursday | - | Self-study | | Own work |
| 49 | 201204 13:15-15:00 Friday | Zoom | Guest lecture | Use cases in industry analytics | CL |
| *More information will be available on CANVAS page! | | | | | |

| W | Time | Room | Activity | Content | Responsible |
|---|---|---|---|---|---|
| **50** | ***Summary of all modules*** | | | | |
| 50 | 201208 13:15-15:00 Tuesday | Canvas/ On line | - | Knowledge test* | ETB |
| 50 | 201208 15:15-17:00 Tuesday | Zoom | Project work | Supervision on project work | ETB + Groups |
| 50 | 201210 13:15-14:00 Thursday | Zoom | Lecture | Summary - Recap | AS + ETB |
| 50 | 201210 14:15-17:00 Thursday | Zoom | Project work | Supervision on project work | ETB + Groups |
| 50 | 201211 13:15-15:00 Friday | - | Project work | Self-study | Own work |
| ***The knowledge test is mandatory to attend!**<br>**-Deadline for uploading project progress report – 20/12/16!** | | | | | |
| **51** | ***Module 5 - How to drive AI in your business – Project work*** | | | | |
| 51 | 201215 13:15-15:00 Tuesday | - | Project work | Self-study | Own work |
| 51 | 201215 15:15-17:00 Tuesday | - | Project work | Self-study | Own work |
| 51 | 201217 13:15-15:00 Thursday | Zoom | Project work | Supervision on project work | ETB + Groups |
| 51 | 201217 15:15-17:00 Thursday | Zoom | Project work | Supervision on project work | ETB + Groups |
| 51 | 201218 13:15-15:00 Friday | - | Project work | Self-study | Own work |
| **52** | **Holiday / Project work** – **The final project report and presentation must be submitted latest on Friday January 15, 23:55.** | | | | |

## Zoom information for the course

All teaching activities will be held on line via Zoom. Please check the course calendar and join the meeting by using your Chalmers login. If you are asked for a password to join the meeting, the password is IMS065.

Here is the general information regarding with the zoom.

*How to install the zoom:* https://it.portal.chalmers.se/itportal/CDAWindows/InstallZoom

*How to login via web:*

1. Go to https://chalmers.zoom.us
2. Click on Sign In
3. You will be directed to Chalmers IDP-login page
4. Log in with your "CID"

*How to login via Zoom app:*

1. Start Zoom
2. Click on Sign In
3. Click on Sign In with SSO
4. Write "**chalmers**" so it looks like "chalmers. zoom.us".
5. Click on Continue
6. You will be directed to Chalmers IDP-login page
7. Log in with your "CID"