Structured MEng (Chemical Engineering)

Focus area: Data Analytics

at the Department of Chemical Engineering, Stellenbosch University

Preparing engineers to critically analyse and leverage dynamic data in chemical- and minerals-processing

Who is the programme for?

The structured Master's programme will equip engineers with the fundamentals of data science — specifically machine learning — and enable them to apply newly developed methods in the context of large, integrated industrial processes.

The course is specific to the process industry, considering topics such as plantwide dynamics and advanced process monitoring and control. Focussing on the fundamentals of machine learning, we encourage engineers to understand the methods they employ rather than implementing black-box solutions.

What are the admission requirements?

All applicants must meet the minimum admission requirements as detailed in section 3.6 in the Engineering Calendar, Part II. The minimum selection criteria for the Data Analytics focus area is a BEng or BSc (Eng) degree in a discipline that has provided previous exposure to control systems (typically chemical, mechanical or electronic engineering). All applicants who meet the criteria undergo a selection process and are approved by a departmental committee that considers applicants' academic record as well as relevant industry experience.

Stellenbosch
UNIVERSITY
IYUNIVESITHI
UNIVERSITEIT

Course details continued

How is the programme structured?
Students register for 180 credits over the duration of the programme, including eight taught modules and one research project module. Each taught module is 15 credits, amounting to 150 notional hours of work. A typical module consists of two weeks of pre-reading, followed by a block week which may be attended online or on campus. The final part of each module is a six-week post-block period where students will work on assignments (collaboratively and individually). Most assessments take the form of an assignment and do not require students to be on campus.

The block week provides an opportunity for students to critically engage with their lecturers and peers on fundamental concepts as well as applied problems. Students are not required to attend the block week in person on Stellenbosch campus: it is offered in a hybrid mode, serving students attending in person or remotely. However, the block week is a synchronous session. Students are thus required to actively participate in real-time, whether on campus or online. As such, students will be required to attend the full block week during normal working hours; part-time students will likely have to apply for study leave to do so. This is opposed to the pre-reading and post-block sessions, which are asynchronous: students engage with the content and work on assignments in their own time.

Lastly, students undertake a 60-credit research project (i.e., 600 notional hours of work) as the final step towards earning their degree. During this time, students will work on a complex, relevant problem in the field of process data analytics. They are supported in their research through individualised supervision from experts in the field.

An outline of the programme and individual modules are provided on the following pages.

When do classes take place?
The exact schedule is subject to change from year to year. However, an overview of a typical programme is shown below, both for full-time students aiming to complete the degree in two years and part-time students extending their studies over three years.

What does the application process involve?
Interested candidates must complete a departmental application form, which can be downloaded via the department's website under the application procedure tab, and submit it to the Postgraduate Manager with the necessary supporting documentation. The Postgraduate Manager will communicate the process from thereon and keep applicants updated with the selection process. The admission outcome will be communicated by mid-December at the latest of the year prior to first registration.

Programme overview

The programme overview for both full-time and part-time registering students are given below. Due to pre-requisite requirements, the module structure is fixed and students will be required to enroll for the specific modules per academic year as indicated below.

The scheduling of the modules for the following academic year are subject to change (as decided by the host department) and communicated to students well in advance, allowing sufficient time to plan and manage schedules.

Part-time students	Term 1	Term 2	Term 3	Term 4	*Full-time students*
Year 1	Data Science	Applied Machine Learning	Plantwide Dynamics andControl		Year 1
Year 2	Numerical Methods	Optimisation		Data Analysis for Dynamic Processes	
Year 3	Advanced Topics in Eng. Management Integrated Process Data Analysis Research project →				Year 2

For more information about the Structured Master's Degree in Chemical Engineering at SU, please contact:

Prof Tobi Louw
tmlouw@sun.ac.za

Mrs Mieke de Jager
miekedup@sun.ac.za

Detailed course outline

Data Science (Eng) 874 [15 credits]

Data science is the application of computational, statistical, and machine-learning techniques to gain insight into real-world problems. The focus of this module is on the data science project life cycle, specifically to gain a clear understanding of the five steps in the data science process, namely obtain, scrub/wrangling, explore, model, and interpret.

Pre-requisites: A working knowledge of an appropriate coding language (e.g., Python).

Applied Machine Learning 874 [15 credits]

Understanding the theoretical underpinnings of several machine learning techniques is essential for data analysis. This module emphasises an understanding of the requirements, inductive bias, advantages and disadvantages of these techniques to real-world problems, and provides exposure to various machine-learning methods. Pre-requisites: Data Science (Eng) 874

Pre-requisites: Data Science (Eng) 874

Optimisation (Eng) 874 [15 credits]

Different classes of optimisation problems occur in the engineering domain, each characterised by various complexities. A wide range of advanced meta-heuristics and hyper-heuristics can be used to solve these different classes of optimisation problems. Students will gain experience in implementing advanced optimisation algorithms to solve real-world engineering problems.

Pre-requisites: Applied Machine Learning 874

Numerical Methods TW876 [15 credits]

Matrix computations are required for almost all machine learning techniques. This module investigates the effective solution of linear systems involving both square and rectangular matrices. Direct as well as iterative methods are considered, with an emphasis on sparse matrices and matrices with structure. Numerical methods for the eigenvalue problem are also considered.

Advanced Topics in Engineering Management 873 [15 credits]

The purpose of the module is to present principles of general management within the context of technical disciplines. The course themes include the business environment and strategic management on a firm level, touching on the role of innovation and technology for competitiveness on a systems level from international and national perspectives.

Data Analysis for Dynamic Processes [15 credits]

The analysis of dynamic time-series data presents a variety of challenges but is well supported by classical control theory as well as new developments in machine learning. This module will require students to develop a practical understanding of traditional approaches to analyse and leverage data produced by measurements of dynamic processes specific to the chemical and minerals processing industries, including systems identification, data reconciliation, and state estimation. Students will also be required to use contemporary statistical and machine learning tools for time series analysis.

Pre-requisites: Applied Machine Learning 874, Data Science (Eng) 874

Plant-wide process control [15 credits]

Process engineers must understand the effects of plant dynamics and control to successfully implement any form of intervention. This module provides an overview of plant-wide control and advanced process control, with a focus on understanding cause-and-effect relationships in systems with multiple unit operations, the effects of process integration on dynamics, and advanced control strategies specific to integrated systems.

Pre-requisites: Relevant undergraduate modules in process dynamics and control, control systems, or similar.

Integrated Data Analysis for Process Engineers [15 credits]

Combining and applying knowledge and methods from various knowledge domains to real-world problems remains a significant challenge. This module will require students to critically evaluate a selection of case studies from industrial chemical and mineral-processing plants, allowing them to apply the methods developed in other modules to complex problems. The case studies will also serve as a framework to prepare students for the 60-credit research project required for the chemical engineering programme.

Pre-requisites: Optimisation 874, Dynamic Process Data Analysis 872, Plantwide Dynamics and Control 872

Research Project [60 credits]

Students apply methods and concepts developed throughout the course to investigate an industrial case study in the form of a short research project.