

Postgraduate modules

Department of Civil Engineering

This document summarises the postgraduate modules presented by the Department of Civil Engineering of Stellenbosch University. Modules are presented annually or biannually. An indication of the year in which a module is anticipated to be presented is indicated in this document (* indicates the planned year of presentation, however, this is subject to change). Draft module presentation dates are updated regularly, please refer to <https://civeng.sun.ac.za/current-postgraduates/> or email civilcourses@sun.ac.za.

Engineering Faculty modules

Faculty modules are presented annually. These five modules form the core of all MEng(Structured) programmes throughout the Faculty of Engineering. MEng(S) students take three of these five core modules, as well as an additional five modules specific to their discipline. MEng(Research) and PGDip students may take faculty modules, however, this is not mandatory.

Advanced Topics in Engineering Management - 812/773

Years presented: Annually

Host department: Industrial Engineering

The purpose of the module is to present principles of general management within the context of technical disciplines. The module 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. The module will include a significant focus on tools and techniques for technology and innovation management, exploring the link between technology management and business management taking a capabilities approach. These capabilities include acquisition, protection, exploitation, identification and selection. We relate traditional approaches to technology management to what it means for the context of the fourth industrial revolution, platform economies and innovation platforms. The functions of engineering management, namely planning, organising, leading and controlling will also be discussed. This includes a focus on human resource management, insofar as managing projects, people and groups is concerned, as well as aspects of labour relations and specifically the labour law and contractual requirements in South Africa.

Data Science - 874/774

Years presented: Annually

Host department: Industrial Engineering

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. Each of these steps will be studied with the main purpose to gain an understanding of the requirements, complexities, and tools to apply to each of these life cycle steps. Students will understand the process of constructing a data pipeline, from raw data to knowledge. Case studies from the engineering domain will be used to explore each of these steps.

Numerical Methods - 876/776

Years presented: Annually

Host department: Applied Mathematics, Faculty of Science

The module focuses on matrix computations. We study the effective solution of linear systems, involving both square and rectangular matrices (least-squares). Direct as well as iterative methods are considered, with the emphasis on sparse matrices and matrices with structure. Numerical methods for the eigenvalue problem are also considered. Pitfalls such as numerical instability and ill-conditioning are pointed out. Model problems are taken from partial differential equations, data analysis and image processing. Theory, algorithmic aspects, and applications are emphasized in equal parts

Project Economics and Finance 874/711

Years presented: Annually

Host department: Civil Engineering

The module focuses on how to finance a business opportunity (project) that can be isolated from the rest of a company's business activities. Financing through a combination of debt and equity are discussed, based on the future profitability of the project where project cash flow is the main source of capital recovery, and the project assets are the only collateral. The concepts of construction loans and public- private partnerships are discussed. A number of case studies will be covered in the module, including projects to construct a bridge, a satellite and a wind turbine farm. Current module content includes: infrastructure and development finance, time value of money, basic accounting statements, ratio analysis, economic analysis of investment decisions, market valuation (EVA and MVA), the national accounts and economic growth, feasibility studies and techno economic analysis, risk and uncertainty in infrastructure finance and project development.

Project Management 812/713

Years presented: Annually

Host department: Industrial Engineering

The module focuses on advanced topics in project management, and it is expected that participants have either attended a project management module or have experience in managing projects. The module builds on the traditional project scheduling by addressing critical chain management and looks at managing project risks through the identification and assessment of risk potentials and mitigating strategies, including resource / cost management and contingency planning. The selection of appropriate teams and structures to facilitate contract management are discussed, along with executing project leadership through proper communication channels. The importance of procurement, from tender procedures through to supplier selection will be highlighted. The different nuances between commercial and research projects will be explained.

Fire Engineering

Package coordinator: Prof Richard Walls

Fire Engineering I -874/774

Years presented: 2024, 2026*

This is a module designed to put the fundamentals of fire science into practice. Students will develop and demonstrate an understanding of topics from first principles and apply them to real-world scenarios. This module focuses on the design of systems that ensure safe conditions for people during a fire incident. Specific topics covered include:

- Fire safety design
- Fire detection and alarm systems
- Smoke management
- Evacuation and human movement principles

Fire Engineering II -874/774

Years presented: 2025*, 2027*

This is a module designed for students to develop and demonstrate an understanding of topics such material and product behaviour in fire, hazard and risk analysis, suppression systems and design and performance-based design, following on from Fire Engineering I. This module focuses on understanding different risks and the design of suppression systems that ensure safe conditions during a fire incident. Specific topics covered include:

- Material and product behaviour in fire
- Hazard and risk analysis
- Suppression systems and design
- Performance-based design

Techniques in Fire Engineering - 874/774

Years presented: 2025*, 2027*

This module is designed to provide and assess an understanding of techniques in fire engineering. Experimental and numerical techniques will be covered to ensure that students (a) have a sound knowledge and experimental understanding regarding fire safety systems, their operations, fire behaviour, and fire tests; (b) can understand and apply numerical techniques to solve fire dynamic problems with the use of tools such as zonal models and computational fluid dynamics (CFD). Specific topics covered include:

- Fire behaviour laboratory
- Detection system laboratory
- Suppression system laboratory
- Zonal modelling
- CFD modelling

Fire Behaviour - 874/774

Years presented: Annually

This is a module designed to provide and assess an understanding of the physics and engineering aspects of fire and fire protection engineering. This module serves as the foundation for students wishing to go into structural fire engineering design or traditional fire engineering. Specific topics addressed are:

- Thermochemistry
- Heat transfer
- Fire plumes and smoke behaviour
- Steady burning of liquids
- Ignition and initiation of burning
- Spread of flame
- Pre-and post-flashover compartments

Structural Fire Engineering - 874/774

Years presented: 2024, 2026*

This is a structural design module in which students develop the ability to understand the complex nature of fire and how structures respond in the event of a fire. The module has been designed to be suitable for engineers from a variety of backgrounds, and not only structural engineers. The ultimate aim is to ensure that engineers can ensure structural safety, by analysing how materials and systems respond to elevated temperatures. Specific topics covered include:

- Fires and heat
- Fire severity and fire resistance
- Design of structures for fire
- Steel, concrete and timber structures
- General structures (composite, facades, etc.)

Geotechnical Engineering

Package coordinator: Prof Charles MacRobert

Advanced Geotechnics -812

Years presented: 2023, 2025*, 2027*

This course covers sources of uncertainty in geotechnical engineering including stratigraphy, soil properties, calculation model and other uncertainties. Means to account for uncertainty in design such as basic statistics, limit states design including the selection of characteristic and design values, reliability analysis and risk assessments are then presented. These tools are applied to the design of shallow foundations, pile foundations, retaining walls and slopes.

Applied Geomechanics - 873/711

Years presented: 2024, 2026*

This course covers the prediction of shear strength of granular soils, silts, clays, and municipal waste for use in slope stability analysis with an emphasis on in-situ testing. Calculation methods including hand calculations, limit equilibrium methods and finite element methods are presented along with an introduction to seepage modelling. Slope stabilisation, factors of safety and reliability are also covered. The module also includes a series of guest lectures focusing on case studies showing how taught theories are applied in practical geomechanics.

Advanced Foundation Design -812/711

Years presented: Annually

This course covers geotechnical investigations including requirements for problem soils, parameter selection, loads and load combinations, damage and limiting settlements, bearing capacity and settlement of shallow foundations, load capacity and settlement of piles, pile groups, raft foundations and large-scale load tests. This is a practical course that is aligned with current industry practice. It is suitable for post-graduate students and practitioners of structural and geotechnical engineering.

Soil Behaviour - 812/741

Years presented: 2024, 2026*

What makes soil behave the way it does? Soil is a particulate material and the interaction between individual particles and the voids between them results in the behaviour of soil being a function of the stresses and void ratio. Critical state soil mechanics provides a framework that unifies shear and consolidation behaviour of soils and allows prediction of soil strength and deformation as a function of initial state, loading and drainage conditions. In this course participants will learn the theory defining the critical state line and constitutive models based on this theory, namely Cam-Clay and NorSand. Practical

application will focus on the use of the state parameter in predicting dilative and contractive behaviour, particularly in assessing static liquefaction potential and stability of tailings storage facilities.

Pavement Engineering

Package coordinator: Prof Kim Jenkins

Advanced Bitumen Technology - 812/772

Years presented: 2024, 2026*

Module contents to be announced or enquire at Course Division (civilcourses@sun.ac.za)

Pavement Evaluation and Rehabilitation (PERD) - 812/711

Years presented: 2024 ,2026*

Pavement materials, design principles and methods refresher. Functional/structural: pavement distress approach (including roughness and friction). Performance of pavement types. The rehabilitation process (TRH12). Functional/structural evaluation. Network and project level evaluation. Condition surveys: visual inspection and use instruments. Condition assessment (TMH9): performance criteria for the evaluation of pavements. Drainage evaluation. Sub grade and pavement materials evaluation. Traffic loading evaluation. Structural evaluation using non- destructive testing. Deflection measurement, analysis, interpretation and application. Rehabilitation design of flexible pavements. Pavement overlay design. Recycling. Empirically and theoretically derived rehabilitation approaches used in SA. Economic Analysis. Accelerated Pavement Testing. Surface rehabilitation techniques for flexible pavements, including construction aspects.

Pavement Management Systems (PMS) 842/772

Years presented: 2024 , 2026*

Pavement systems, monitoring of distress and deterioration, establishment of appropriate performance models and limiting criteria. Validation of design methods, diagnostic methods. Rehabilitation design. Pavement Management systems, tools and methods for data acquisition, visual inspections, use of functional and structural measurements, maintenance and rehabilitation strategies, economic analysis including road user costs, prioritisation and optimisation procedures, programming and case studies. In addition, specifically for Gravel Road Management: Structural capacity; Basic material properties and gravel performance modelling; Soil stabilizers; Visual condition assessment; Pavement condition description; Appropriate maintenance measures; HDM for unsurfaced Road Management; Borrow pits and environmental issues.

Pavement Materials I - Granular and Cemented - 812

Years presented: 2023, 2025*

Pavement systems, monitoring of distress and deterioration, establishment of appropriate performance models and limiting criteria. Validation of design methods, diagnostic methods. Rehabilitation design. Pavement Management systems, tools and methods for data acquisition, visual inspections, use of functional and structural measurements, maintenance and rehabilitation strategies, economic analysis including road user costs, prioritisation and optimisation procedures, programming and case studies. In addition, specifically for Gravel Road Management: Structural capacity; Basic material properties and gravel performance modelling; Soil stabilizers; Visual condition assessment; Pavement condition description; Appropriate maintenance measures; HDM for unsurfaced Road Management; Borrow pits and environmental issues.

Pavement Materials II - Asphalt - 812

Years presented: 2023, 2025*

Rheology of bituminous binders and mixes related to performance. Bitumen refining and chemical properties, tests and specifications (standard and modified binders). Emulsion and foamed bitumen. Aggregate production, sampling, composition (mineralogy), physical properties. Asphalt composition for base and surfacing, thin and ultra-thin mixes, hot and cold mixes, spatial considerations and volumetrics, mix design (with examples), special mixes. Material properties important for structural and functional design. Factors influencing the performance of seals, selection of binder, seal design and material specifications. Thin layer technology.

Pavement Materials III: Bitumen Stabilised Materials (PMIII) -842/722

Years presented: 2024 ,2026*

Base bitumen binders and characteristics; Foamed bitumen characteristics; Bitumen emulsion characteristics; Emulsifiers; Aggregate selection and suitability; Marginal materials; Mix design of cold bituminous mixes; Curing; Compaction; Mix volumetrics and spatial composition; Performance of cold mix; (laboratory, APT, LTPP); Pavement Design with BSMs (CIPR); Construction issues; Slurries.

Rigid Pavement Design - 812

Years presented: 2023, 2025*

Fundamentals of Concrete Pavement Types and Behaviour, Concrete Mix Proportioning and Design Modes of Failure, supporting layer behaviour, Westergaard Subgrade, Slab Analysis, Slab Support Theory, Environmentally Induced Behavioural Characteristics, Curling and Warping Stresses, Concrete Specifications, Durability, Traffic Characterisation, AASHTO Design Procedure, Mechanistic Design including FEM, South African Mechanistic Design, Reliability, Concrete Pavement Rehabilitation.

Structural Engineering

Package coordinator: Prof John Babafemi

Seismic Design of Buildings - 812/813

Years presented: 2024 ,2026*

Module contents to be announced or enquire at Course Division (civilcourses@sun.ac.za)

Advanced Structural Steel Design - 812

Years presented: 2024 ,2026*

Design of industrial and commercial steel structures to SANS 10162-2005; design of plate girders, crane girders and overhead travelling crane support structures subjected to fatigue loading.

Continuum Mechanics and finite Element Methods -842

Years presented: To be announced, enquire at Course Division (civilcourses@sun.ac.za)

This module presents computational methods for the static analysis of structures, using finite elements. Preliminary basic knowledge of the finite element method would be useful but is not required. A good foundation in matrix and vector algebra and mathematics in general is crucial. Programming exercises in MATLAB allow the student to explore the concepts presented and test their understanding. Basic understanding of programming (not necessarily in MATLAB) will help. The following themes will be treated in this module:

- Tensor algebra
- Strain and stress measures
- Linear elasticity
- Discretisation of differential equations using Galerkin's method
- Displacement based beams, membranes and volume elements
- Introduction to plates and shells
- Gauss-quadrature and Iso-parametric elements
- Contragrediently transformations
- Introduction to non-linear analysis (Newton-Raphson)
- Analysis failure and sources of errors

Structural Dynamics -812

Years presented: 2023, 2025*

This module presents computational methods for the dynamic analysis of structures. A basic understanding of static analysis of structures is necessary. Knowledge of finite element methods is not a prerequisite but will be helpful. Students can take MT11 in one year and MT04 in the following year. Complex and Fourier analysis are introduced in the module, but a good foundation in matrix and vector algebra and mathematics in general is crucial. Programming exercises in MATLAB allow the student to explore the concepts

presented and test their understanding. Basic understanding of programming (not necessarily in MATLAB) will help. Some of the theory and applications covered in this module is:

- Dynamic equilibrium equations for linear discrete systems
- Complex numbers
- Steady state harmonic response
- The single degree of freedom oscillator, resonance
- Multiple degrees of freedom, transfer function
- Modal analysis
- Simplified models for low damping, diagonalisation
- Systems with high damping or non-proportional damping
- Fourier analysis, continuous and discrete (Continues on next page)
- Frequency domain analysis
- Introduction to stochastic analysis
- Time domain analysis: Newmark's method
- Applications in machine vibration and codified earthquake analysis

Probability and Risk Analysis in Civil Engineering - 812

Years presented: To be announced, enquire at Course Division (civilcourses@sun.ac.za)

The following themes will be treated in this module:

- Overview of fundamental probability theorems
- Probability models including extreme value distributions
- Joint variables, functions of variables, Markov chains
- Decision analysis, utility criteria, design choices
- Reliability and risk analysis of engineering elements and systems
- Regression analysis, hypothesis tests
- Simulation
- Analysis of variation, experimental design
- Bayesian decision theory:
- Bayes' formula
- Parameter estimation
- Bayesian probabilities and decision theory.

Transportation Engineering

Package coordinator: Prof Marion Sinclair

Geometric Road Design - 812/714

Years presented: 2024 ,2026*

Traffic and capacity, design criteria, safety systems design, sight distance, horizontal alignment, vertical alignment, cross- section elements, roadside restraint systems, designing for automated driving, drainage, intersections, interchanges, pedestrians and cyclists.

Intelligent Transport Systems - 841

Years presented: 2023, 2025*

Basic ITS elements, Systems engineering approach for ITS, Technology and communications overview, Overview of application areas including Freeway Management Systems, Public Transport Systems and Arterial Management Systems, New developments such as Connected and Autonomous Vehicles as well as Smart Cities, Big Data in Transportation overview and Applications.

Public Transport - 842

Years presented: 2023, 2025*

The role of public transport in the community, system components, integration and co-ordination of different modes, technological status, liaison problems, terminal requirements, costs, effect on the environment and the economy, legislation, management, operation and control.

Traffic Flow theory - 812

Years presented:2023, 2025*

This course considers the theory of traffic movement required by traffic engineers. Traffic flow theory is the mathematical description of traffic movement, specifically considering the interaction between drivers and vehicles on a road. This provides input to the analysis of traffic state on all types of roadway infrastructure, including uninterrupted flow on roadways, and interrupted flow at intersections. In this course, students will consider the mathematical descriptions of traffic state: flow, speed and density on the macroscopic and microscopic levels. The first three days of the course focus on the core theories related to traffic description. The last two days of the course relate more to the application of traffic flow theory for the analysis of traffic movements on roadways.

Transportation Planning -812/714

Years presented: 2023, 2026*

Overview of the process, demand estimation, surveys for transportation studies, trip models: trip generation, trip distribution, modal split, trip assignment, road networks, public transport networks, public participation, land use forecasts.

Transportation Safety Engineering - 812

Years presented: 2023, 2025*

This module presents the current thinking on safe road design, looking specifically at the emergence of the Safe System Approach to traffic safety and at how the principles of SSA can be applied in the South African context. It begins with an overview of the factors that undermine the safety of road users globally as well as in SA and looks at the role that traffic engineering plays as one of the constituents of the SSA - and how it relates to Safe Road Users, Safe Speeds, and Safe Vehicles. Road safety issues that are prevalent in the SA context are highlighted, including safety issues around NMT users (and particularly pedestrians) and public transport safety. Students are exposed to the techniques of safety analyses, the identification and assessment of engineering countermeasures, and the economic and socioeconomic evaluation of road safety interventions.

Water Engineering

Package coordinator: Dr Adèle Bosman

Hydraulic Structures -812

Years presented: 2023, 2025*

Project planning and site selection, foundation and construction materials, embankment dams: earth fill, embankment dams: rock fill, concrete & rollcrete dams, masonry dams, hydraulic design of flow gauging weirs, SANCOLD Dam design floods and freeboard requirements, hydraulic design of spillways and outlet works, Hydraulic design of stilling basins and energy dissipators, reservoir sedimentation, dam safety and monitoring, dam rehabilitation, construction of small dams, dam management; Hydropower project and Environmental aspects.

Flood Hydrology - 812

Years presented: To be announced, enquire at Course Division (civilcourses@sun.ac.za)

The general themes covered includes:

- Monitoring the processes of the hydrological cycle
- Catchments as impacted systems
- Philosophy of hydrological design
 - Design Flood Determination includes:
 - Empirical methods
 - Probabilistic analysis
 - Deterministic methods
 - Flood routing
 - Problems of large catchments
 - Dam safety procedures
 - Urban storm water modelling
 - Environmental water requirements
 - River system planning concepts

Water Services and Pipeline Hydraulics - 841

Years presented: To be announced, enquire at Course Division (civilcourses@sun.ac.za)

- The following themes will be treated in this module:
- Pipe flow theory, pipe material & hydraulic roughness, secondary losses and pipe ageing
- Municipal water demand, peak flows, guidelines and the impact of Water Demand Management
- Pipe material selection: PVC, HDPE, concrete, steel pipes, etc.
- Hydraulic Pressure Transients in pipelines
- Pipeline design considerations
- Air valves & design principles

- Pipeline corrosion causes & mitigation
- Design of river abstraction works: Theory and case studies
- Pump selection and high lift pump station design
- CFD modelling to inform pump station design
- Environmental considerations during pipeline design and construction
- Control Valves: pressure, flow rate, water level, etc.
- Pipeline surveillance & rehabilitation

River and Stormwater Hydraulics - 842

Years presented: 2024 , 2026*

The following themes will be treated in this module:

- Urban drainage and sustainable designs
- Storm water modelling and management
- Flood-lines and flood hazards• Road drainage
- Riverbank erosion protection
- Culverts and bridge hydraulics
- Hydrodynamic modelling of flood levels and routing

Special Hydraulics - 842

Years presented: To be announced, enquire at Course Division (civilcourses@sun.ac.za)

Module contents to be announced or enquire at Course Division (civilcourses@sun.ac.za)

Water Network Analysis - 811

Years presented: To be announced, enquire at Course Division (civilcourses@sun.ac.za)

The objective of this module is to provide the latest information regarding water network planning and modelling, incorporating the hydraulics, design, construction and maintenance of all piped water networks. The focus of the module is on urban services, demand estimation and hydraulic analysis. The module is presented biennially. This module also provides the latest information regarding sewer systems, their planning and design. The objective is to move Participants towards more effective planning, design, construction and maintenance of sewer systems. The focus of the module is on waterborne sewer systems and the latest technology with regards to this component of urban drainage. Topics addressed include pipes, modelling, hydraulics, pumps and practical challenges pertaining to sewers and sewer flow in pipes. Most of the sessions cover municipal sewers, although bulk sewers and general topics such as management are also addressed.

Water Resource Management - 842

Years presented: To be announced, enquire at Course Division (civilcourses@sun.ac.za)

The following themes will be treated in this module:

- Water balance in catchments
- Demand projection in catchments
- Modelling runoff generation in catchments
- Estimation of impacts of stream flow reduction activities
- Storage/yield/reliability concepts
- System analysis modelling
- Water quality

Environment, water quality and modelling -811

Years presented: 2023 , 2025*

To provide the introduction to the latest and most relevant theory on Water & Wastewater treatment. Application of the theory in practise, the latest technology, as well as practical application of the theory in the maintenance and operation of water & wastewater treatment works. The module format for lecturers and assignments is fully online. The following themes will be treated in this module:

- Pollution and the importance of Water Quality in Natural Water System
- Theory of Water and Wastewater Treatment
- Plant Operation and Maintenance Considerations