# University of Pretoria Yearbook 2025

# BScHons in Applied Science specialising in Industrial Systems (12243051)

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|---|---|
| **Department** | Industrial and Systems Engineering |
| **Minimum duration of study** | 1 year |
| **Total credits** | 128 |
| **NQF level** | 08 |

## Programme information

The curriculum is determined in consultation with the relevant heads of departments. A student is required to pass modules to the value of at least 128 credits.

The degree is awarded on the basis of examinations only.

The BScHons (Applied Science) degree is conferred by the following academic departments:

- Chemical Engineering
- Civil Engineering
- Industrial and Systems Engineering
- Materials Science and Metallurgical Engineering
- Mechanical and Aeronautical Engineering
- Mining Engineering

Any specific module is offered on the condition that a minimum number of students are registered for the module, as determined by the relevant head of department and the Dean. Students must consult the relevant head of department in order to compile a meaningful programme, as well as on the syllabi of the modules. The relevant departmental postgraduate brochures must also be consulted.

## Admission requirements

1. Three-year Bachelor of Science (or equivalent) degree (in Natural Sciences) with a cumulative weighted average of at least 60% for the degree
   or
   relevant BTech qualification excluding the National Diploma; i.e. one offered by a department of civil engineering at a university of technology in South Africa, with a cumulative weighted average of at least 75% for the degree
   and
   no modules failed in the BTech degree
   or
   a relevant Advanced Diploma qualification (NQF Level 7), excluding the National Diploma; i.e. one

offered by a department of industrial engineering at a university of technology in South Africa, with a cumulative weighted average of at least 70% for the diploma
and
no modules failed in the Advanced Diploma
or
a four-year engineering-based university degree not recognised by ECSA for registration as a professional engineer
or
Bachelor of Engineering degree awarded by the University of Pretoria
or
relevant four-year bachelor's degree in engineering that the Engineering Council of South Africa (ECSA) regards as acceptable for registration as a candidate engineer and for eventual registration as a professional engineer

2. Comprehensive intellectual CV
3. An entrance examination may be required

## Other programme-specific information

The programme consists of three compulsory modules (64 credits) with any relevant core module as prerequisite and the remainder of credits either core and/or non-core modules.

Please refer to the Programme Guide for further information, available here.

## Examinations and pass requirements

Refer also to G18 and G26.

i. The examination in each module for which a student is registered, takes place during the normal examination period after the conclusion of lectures (i.e. October/November or May/June).
ii. G18(1) applies with the understanding that under exceptional circumstances an extension of a maximum of three years may be approved: provided that the Dean, on reccommendation of the relevant head of department, may approve a stipulated limited extension of this period.
iii. A student must obtain at least 50% in an examination for each module where no semester or year mark is required. A module may only be repeated once.
iv. In modules where semester or year marks are awarded, a minimum examination mark of 40% and a final mark of 50% is required.
v. No supplementary or special examinations are granted at postgraduate level.

## Pass with distinction

A student passes with distinction if he or she obtains a weighted average of at least 75% (not rounded) in the first 128 credits for which he or she has registered (excluding modules which were discontinued timeously). The degree is not awarded with distinction if a student fails any one module (excluding modules which were discontinued timeously). The degree must be completed within the prescribed study period.

# Curriculum: Final year

**Minimum credits: 128**

BAN 780, BCS 780 and BLK 781 are compulsory modules.

Please note that not all modules listed are presented each year. Please consult the departmental postgraduate brochure.

## Core modules

### Industrial analysis 780 (BAN 780)

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|---|---|
| **Module credits** | 16.00 |
| **NQF Level** | 08 |
| **Service modules** | Faculty of Natural and Agricultural Sciences |
| **Prerequisites** | Industrial Engineering students may not register for this module |
| **Contact time** | 24 contact hours per semester |
| **Language of tuition** | Module is presented in English |
| **Department** | Industrial and Systems Engineering |
| **Period of presentation** | Semester 1 or Semester 2 |

**Module content**

Descriptive models are used to describe how systems or processes operate, and the outputs of these models are used as inputs for prescriptive and predictive models. Therefore, the first part of this module focuses on descriptive modelling and covers the basic approaches to data and statistical analysis.

In cases with numerous design or redesign options, mathematical programming is a powerful modelling tool that can be used to find the best design to implement. Therefore, the second part of this module covers the basics of mathematical programming and optimisation, and teaches students how to formulate, solve, and interpret results of Linear Programming (LP) and Mixed Integer Linear Programming (MILP) models.

After the best design is identified, predictive models are used to predict whether a new design or improvement will have the desired effect, before its implementation. Therefore, the final theme of this module introduces students to discrete-event simulation modelling, a popular predictive modelling approach.

### Enterprise engineering and research methods 781 (BBA 781)

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|---|---|
| **Module credits** | 32.00 |
| **NQF Level** | 08 |
| **Prerequisites** | Knowledge about database design, using entity relationship diagrams to represent data requirements |
| **Contact time** | 36 contact hours per semester |
| **Language of tuition** | Module is presented in English |
| **Department** | Industrial and Systems Engineering |
| **Period of presentation** | Semester 1 |

**Module content**

Enterprise Engineering can be defined as the body of knowledge, principles, and practices to design an enterprise. Due to their complexity and the continuously changing environment, enterprises need new approaches, tools and techniques to deliver innovative products and services to new markets in competitive environments. This module offers an introduction to the engineering design process applied to the enterprise as a system, and present existing approaches for designing, aligning and governing the enterprise. Within the design paradigm, the module also offers research methods (e.g. case study research, design science research, action research and action design research) that are relevant for doing research within the enterprise engineering discipline.

The module covers:

- Background on systems thinking
- The basic system design process
- Prominent approaches for creating an enterprise engineering capability (e.g. Dietz/Hoogervorst, Zachman, The Open Group).
- Mechanisms and practices associated with different phases of enterprise design (e.g. enterprise modelling, languages, road maps, maturity assessment).
- Research methodologies, methods and techniques to validate and extend the EE knowledge base
- Case studies

## Industrial and systems engineering research 780 (BCS 780)

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|---|---|
| **Module credits** | 32.00 |
| **NQF Level** | 08 |
| **Prerequisites** | No prerequisites. |
| **Contact time** | 36 contact hours per semester |
| **Language of tuition** | Module is presented in English |
| **Department** | Industrial and Systems Engineering |
| **Period of presentation** | Semester 2 |

**Module content**

*This is a compulsory research module.

The module affords an individual student the opportunity of studying a designated area of coherent advanced knowledge under the tutorship of a senior staff member of the Department of Industrial and Systems Engineering. Eligibility, topic and scope of the intended project must be determined in consultation with the proposed supervisor.

## Supply chain processes 781 (BLK 781)

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|---|---|
| **Module credits** | 16.00 |
| **NQF Level** | 08 |
| **Prerequisites** | Industrial Engineering students may not register for this module. |
| **Contact time** | 24 contact hours |
| **Language of tuition** | Module is presented in English |

| | |
|---|---|
| **Department** | Industrial and Systems Engineering |
| **Period of presentation** | Semester 1 |

**Module content**

Supply chain engineering is an area in which Industrial Engineering is often applied to execute, manage, or improve elements of product and service supply chains. This module introduces students to an integrated supply chain and exposes them to strategic supply chain planning and management decisions. It also introduces key activities, business processes and business decisions related to demand- and supply-side supply chain and operations management.

Module outline:

- Supply chain foundations
  - o Supply chain management overview
  - o Global dimensions of supply chains
  - o Introduction to supply chain reference models
  - o Aligning and integrating the supply chain
  - o Supply chain performance management
  - o Supply chain sustainability and reverse logistics
- Operations management
  - o Manufacturing planning and control framework
  - o Aggregate planning and master production scheduling
  - o Material requirement planning
  - o Inventory management and risk pooling
  - o Process selection and design
  - o Product and service design
  - o Strategic and operational capacity planning
  - o Production activity control
  - o Basic pull-based manufacturing flow control techniques (Introduction to lean and Theory of Constraints).
- Introduction to procurement principles.
- Demand-side supply chain management
  - o Demand management
  - o Order management and customer service
  - o Transportation management
  - o Warehousing operations

## Operations research 780 (BOZ 780)

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|---|---|
| **Module credits** | 32.00 |
| **NQF Level** | 08 |
| **Prerequisites** | BOZ 312 or BAN 780 |
| **Contact time** | 36 contact hours per semester |
| **Language of tuition** | Module is presented in English |
| **Department** | Industrial and Systems Engineering |

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|---|---|
| **Period of presentation** | Semester 1 or Semester 2 |

**Module content**

Building on undergraduate modules in Operations Research, the module aims to extend the mathematical programming and optimisation capabilities by introducing uncertainty. Many decision makers are confronted with complex environments in which data is not known with certainty, or in which the decision constraints are uncertain. For cases where one knows the shape, or can assume that the uncertainty follows a known probabilistic distribution, stochastic programming can be used. In the module both chance-constrained programming and fixed recourse are introduced. The module also addresses the uncertainty when a decision maker is confronted with multiple, competing objectives. Finally, deterministic and probabilistic dynamic programming are introduced for to solve recursive problems.

## Manufacturing planning and control systems 782 (BPZ 782)

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|---|---|
| **Module credits** | 32.00 |
| **NQF Level** | 08 |
| **Prerequisites** | Operations Management and Operations Research (advisable but not mandatorily required) |
| **Contact time** | 36 contact hours per semester |
| **Language of tuition** | Module is presented in English |
| **Department** | Industrial and Systems Engineering |
| **Period of presentation** | Semester 1 or Semester 2 |

**Module content**

1. Review of the general framework for the planning and control of manufacturing and service systems
2. Deterministic Lot Sizing Models of Inventory Management
   a. Basic single item EOQ/EPQ, shortage, all unit and marginal discount models
   b. Discrete time and quantity models and their solution approaches
   c. Multi item models including shared resource with constraints, common cycle, basic cycle, power of two and Economic Lot Scheduling models
   d. Multi echelon and foundational supply chain inventory models
   e. Models with building blocks for contemporary research areas in deterministic inventory models: deterioration, delayed payment, recoverable stock, non-linear demand rate, non-linear production rate, growing items, demand-, time-, stock and price- dependent models and other emerging lot sizing model block areas
3. Finite Job Scheduling Models and their Solution Techniques
   a. Scheduling notation, dispatch rules and their solution characteristics
   b. Flow shop models, job shop models, selected variants and their solution algorithms
   c. Formulation of basic mathematical programming models for scheduling problems
   d. Solution techniques for scheduling LP models and analysis of solution heuristics: review of general mathematical proof techniques; growth functions and asymptotic bounds of solution algorithms; NPcompleteness, orst- and average-case behaviour of algorithms and illustration with some basic problems; analysis of selected exact scheduling solution algorithms; discussion of selected heuristic and meta heuristic alternatives and their time complexity; design and analysis of hybrid-solutions for NP-hard scheduling problems; scheduling solution/result analysis
4. Structural Models of Supply Chain Factors and their Relationships
   a. Review of descriptive statistics, statistical inference, estimation and hypothesis testing principles
   b. Multivariate statistical problems and foundational regression analysis
   c. Foundations of Structural Equation Modelling (SEM) and its representations
   d. Foundational Principal Component Analysis (PCA) and Factor Analysis (FA)
   e. Introduction to Covariance Based (CB) and Partial Least Square (PLS) SEM approaches
   f. Procedure for implementing PLS SEM and interpretation of solution output
   g. Cases of Supply Chain SEM models and their analysis with PLS SEM using Smart PLS

At the beginning of the contact sessions, students may be allowed, based on the class composition, to suggest one additional area they may want us to discuss. This may include assembly line balancing, aggregate planning, forecasting or some areas of modern manufacturing flow control like Lean/JIT, Synchronous manufacturing/TOC, CONWIP, POLCA, COBACABANA, or DDMRP. This is not examinable, but may help students with such needs, if they are sizable and the need is identified.

## Simulation modelling 780 (BUY 780)

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|---|---|
| **Module credits** | 16.00 |
| **NQF Level** | 08 |
| **Prerequisites** | BUY 321 or BAN 780 |
| **Contact time** | 24 contact hours |
| **Language of tuition** | Module is presented in English |
| **Department** | Industrial and Systems Engineering |

**Period of presentation** Semester 1 or Semester 2

**Module content**

In recent years, the boundaries between different simulation paradigms such as discrete event simulation, system dynamics and agent-based models have become less distinct. Improvements in computational efficiency also allow much richer and complex models to be built. This module introduces system dynamics (SD) and agent-based models (ABM) as a class of computational models. While SD is concerned with understanding the dynamical interactions amongst the elements of a system covering (man, machine, materials, methods, money and management) in a bid to gain a measurable insight into a system's local and/or global behaviour over a given horizon time for effective decision making, ABS on the other hand is concerned with deploying a collection of autonomous decision-making entities called agents. Inhere, each agent, individually assesses its situation and makes decisions on the basis of a set of rules. ABS addresses autonomous agents and their interactions with other agents, and their surrounding environments. The module content covers basic theoretical foundations of ABM and then focuses on a few specific application areas where ABM is used for decision-making covering: pedestrian and transport models; production and logistics; as well as biology.

Theme 1: **System Dynamics Modelling**

**Block Week1:**

1. **System Behavioural Patterns*:*** Exponential growth, goal seeking, s-shaped growth, oscillatory growth.
2. **Delays, Smoothing and Averaging:** Pipeline material flow delays, third order exponential delays, information averaging (moving average, exponential smoothing, information delays).
3. **Representing Decision Processes:** Modelling Decision Processes (Types of Decision Models)-- weighted-average decision models, floating goals, multiplicative decision rules
4. **Nonlinearities***:* Nonlinear responses.
5. **Initial Conditions:** Initialising a model to equilibrium, Simultaneous initial conditions.
6. **Vensim Software Hands-on Demo**: Creating and converting causal loop diagrams to stock and flow diagrams, and conduct of simulations.

Theme 2: **Agent-Based Simulation**

**Block Week 2:**

1. Discrete event simulation overview.
2. Introduction to agent-based simulation and modelling philosophy premised on (routine deployment of human interaction).
3. Agent-based simulation modelling as a decision support tool (based on the principle presented in Macal (2016)).
4. Research in agent-based modelling covering (Design Research Methodology- (as an appropriate methodology for simulation).

**Block Week 3:**

1. Java for AnyLogic
2. Agent-based modelling in AnyLogic

## Supply chain design 780 (BVK 780)

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|---|---|
| **Module credits** | 16.00 |
| **NQF Level** | 08 |

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|---|---|
| **Prerequisites** | BLK 781 or BLK 320 |
| **Contact time** | 24 contact hours |
| **Language of tuition** | Module is presented in English |
| **Department** | Industrial and Systems Engineering |
| **Period of presentation** | Semester 2 |

**Module content**

This module builds on the foundational supply chain knowledge gained in prerequisite modules and aims to provide students with insight into the various elements of supply chain design, enabling them to participate in strategic and tactical supply chain mapping, (re)design and improvement projects.

**Main topics covered:**

Supply chain reference models (SCOR and GSCF models)

Supply chain network planning and design

Global supply chain and risk management

Supply chain technology and integration

## Elective modules

### Quality management 780 (BGH 780)

| | |
|---|---|
| **Module credits** | 16.00 |
| **NQF Level** | 08 |
| **Prerequisites** | No prerequisites. |
| **Contact time** | 24 contact hours |
| **Language of tuition** | Module is presented in English |
| **Department** | Industrial and Systems Engineering |
| **Period of presentation** | Semester 1 or Semester 2 |

**Module content**

Professionally, engineers are confronted with issues related to product quality and performance or organisational excellence. The intention of this course is to provide an overview of the domain of modern quality management and to equip the student with theory, methodologies and tools and techniques to improve and achieve product quality and performance excellence.
The course covers the following topics;
• Contextualisation: The History, Guru's, Principles, Industrial setting and the Domain of Quality Management
• Practices of improving and achieving product quality: Role in Industrial Engineering, On-line and Off-line Quality Control Practices
• Frameworks of improving organisational excellence: National Quality Awards, ISO 9000 and other frameworks
• Practices of improving performance excellence: Quality and Competitive advantage, Customer and Supplier relationships, People Empowerment and Motivation, Quality Leadership and Organisational change.

## Systems engineering 780 (BSS 780)

| | |
|---|---|
| **Module credits** | 24.00 |
| **NQF Level** | 08 |
| **Prerequisites** | BBA 781 |
| **Contact time** | 24 contact hours |
| **Language of tuition** | Module is presented in English |
| **Department** | Industrial and Systems Engineering |
| **Period of presentation** | Semester 1 or Semester 2 |

**Module content**

Systems engineering is a multidisciplinary engineering profession that focuses on the conception, design, development, architecting, integration and management of complex systems over their life cycle. It does this by creating, executing and coordinating an interactive platform for all stakeholders viz: clients, consumers, design team/technical crew and management team amongst others. Complexity of systems hinges on diversity, multiplicity and intricacy of intra and interconnectivity of system entities. This module will commence briefly with some introductory knowledge prior to diverting to intermediate and advanced concepts with specific attention given to case studies, software applications and emergence of research opportunities. Artificial Intelligence (AI) systems covering robotics systems modelling amongst others would be addressed and given a special preference.

[Block Week One]: Design, Operations and Performance of Systems
Systems Design, Architecting, verification, Analysis and validation
Model-Based Systems Engineering
Matlab Demo of Requirements Deployment-Modelling of case study systems.
Operation of systems-covering: Reliability of systems; Maintenance-Time and Condition based
Fuzzy Logic/Biomimicry Maintenance.

[Block Week Two]:Complexity of interaction in Systems
Understanding and modelling system complexity, IoT (Internet of Things), RoTs (Relationship of Things), System of Systems, System of System of Systems, Life Cycle Analysis of interacting systems.

[Block Week Three]: Understanding and Modelling AI Systems
Robotic Arm and Vehicle, Design, Dynamics (Kinematics and Kinetics), Static analysis and joint stiffness; Sensors and Actuators.

## Reliability engineering 780 (BTH 780)

| | |
|---|---|
| **Module credits** | 16.00 |
| **NQF Level** | 08 |
| **Prerequisites** | No prerequisites. |
| **Contact time** | 24 contact hours |
| **Language of tuition** | Module is presented in English |
| **Department** | Industrial and Systems Engineering |

**Period of presentation** Semester 1 or Semester 2

**Module content**

To make students conversant with the concepts, tools and techniques of reliability engineering.
Capita selecta from:
• Introduction to Reliability Engineering
• Reliability Mathematics
• Probability Plotting
• Reliability Prediction for Design
• Reliability Testing
• Reliability Growth
• Maintainability
• Reliability Management

### General Academic Regulations and Student Rules

The General Academic Regulations (G Regulations) and General Student Rules apply to all faculties and registered students of the University, as well as all prospective students who have accepted an offer of a place at the University of Pretoria. On registering for a programme, the student bears the responsibility of ensuring that they familiarise themselves with the General Academic Regulations applicable to their registration, as well as the relevant faculty-specific and programme-specific regulations and information as stipulated in the relevant yearbook. Ignorance concerning these regulations will not be accepted as an excuse for any transgression, or basis for an exception to any of the aforementioned regulations. The G Regulations are updated annually and may be amended after the publication of this information.

### Regulations, degree requirements and information

The faculty regulations, information on and requirements for the degrees published here are subject to change and may be amended after the publication of this information.

### University of Pretoria Programme Qualification Mix (PQM) verification project

The higher education sector has undergone an extensive alignment to the Higher Education Qualification Sub-Framework (HEQSF) across all institutions in South Africa. In order to comply with the HEQSF, all institutions are legally required to participate in a national initiative led by regulatory bodies such as the Department of Higher Education and Training (DHET), the Council on Higher Education (CHE), and the South African Qualifications Authority (SAQA). The University of Pretoria is presently engaged in an ongoing effort to align its qualifications and programmes with the HEQSF criteria. Current and prospective students should take note that changes to UP qualification and programme names, may occur as a result of the HEQSF initiative. Students are advised to contact their faculties if they have any questions.