2025 Postgraduate Guide

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Engineering, Built Environment and Information Technology

Fakulteit Ingenieurswese, Bou-omgewing en Inligtingtegnologie / Lefapha la Boetšenere, Tikologo ya Kago le Theknolotši ya Tshedimošo

Make today matter

www.up.ac.za

Department of Industrial & Systems Engineering

Contents

Introduction to Department of Industrial and Systems Engineering

Industrial Engineering is an extensive field of study since it consists of many diverse scientific disciplines with interfaces to various fields of study from the sciences, engineering and management. If one characteristic of Industrial Engineering has to be isolated then it may be the capability of the Industrial Engineer to integrate the contributions of all the other engineering disciplines into a final, functional and marketable product, at the lowest possible cost, by using system knowledge and understanding.

The Department of Industrial and Systems Engineering at the University of Pretoria is the oldest and biggest Industrial Engineering department in South Africa. The first Industrial Engineers graduated from the University of Pretoria in 1963. Up to 1974 Industrial Engineering was offered as a programme in the Department of Mechanical Engineering. In 1975 the Department of Industrial Engineering was established as an independent academic department.

Research Focus Streams

The following research streams exist within the Department of Industrial and Systems Engineering, providing a suggested combination of modules, based on the modules offered in 2024.

For additional guidance on selecting additional modules outside the Department within the selected stream, please consult with the lecturers assigned within a particular stream.

Data analytics and data science ("analysing the mill")

- BAN 780: Industrial Analysis
- BOZ 780: Operations Research
- BUY 780: Simulation Modelling

Systems Design, Optimization and Digitization ("changing the mill")

- BBA 781: Enterprise Engineering and Research Methods
- BSS 780: Systems Engineering
- BLK 781: Supply Chain Processes
- BVK 780: Supply Chain Design

Management and Control of Systems ("running the mill")

- BPZ 782: Manufacturing Planning and Control Systems

Postgraduate Academic Programmes

Post-graduate programs offered consist of Honours, Masters and PhD. The admission requirements are stipulated in this brochure.

Honours Programmes

Important Information: Electives & Modules outside IE Department

Students who completed **BEng (Industrial Engineering)** are allowed 32 relevant credits from outside the department, whereas students *without* a BEng (Industrial Engineering) degree are not allowed to take electives outside the department.

To pursue these external elective options, please follow the outlined procedure:

1. Obtain approval from the Head of Department/Postgraduate Coordinator where you plan to take the elective module.
2. Once you have received approval, send an email to **Mrs Hanli Helm, hanli.helm@up.ac.za**, seeking approval from the Head of Department (Industrial Engineering Department).
3. If your request is approved by the IE Department Head, Mrs Helm will provide you with a module change form to complete, which is necessary for processing your request. Please return the completed form to her.
4. The completed form will be signed, stamped, and forwarded to Student Administration for processing.
5. Kindly refrain from submitting forms directly to Mr Roy Mashiloane, Student Administration or the Head of Department (IE), as your request will not be considered.

Please ensure that you adhere to these steps and obtain the required approvals and documentation for your desired outside electives.

BEngHons Industrial Engineering (Plan code: 12240012)

A student is required to pass modules to the total value of 128 credits. The minimum duration of study is 1 year. The programme consists of one compulsory module (32 credits) with core and elective modules. Students are allowed 32 relevant credits from outside the department. Students are advised to select modules in line with their desired research stream.

NOTE: Since BCS 780 is a research-based module, students are strongly advised to enrol for a 32-credit module, i.e. a module with research methods, prior to enrolling for BCS 780.

Presentation Mode

The class schedules in the appendices, indicate that classes are presented in 3 block weeks per semester.
The 1st block week will have in-person on-campus classes, whereas the 2nd and 3rd block week will be presented in an online format.

Course Curriculum

Semester 1	Semester 2
Compulsory module	
BAN 780 (16 credits) Industrial Analysis **(Not for students that completed BEng (Industrial)** BLK 781 (16 credits) Supply Chain Processes **(Not for students that completed BEng (Industrial)**	BCS 780 (32 credits) Industrial & Systems Engineering Research
Core modules (IE Department)	
BBA 781 (32 credits) Enterprise Engineering and Research Methods	BOZ 780 (32 credits) Operations Research
BPZ 782 (32 credits) Manufacturing Planning & Control Systems	BUY 780 (16 Credits) Simulation Modelling
	BVK 780 (16 credits) Supply Chain Design
-	BSS 780 (24 credits) Systems Engineering
Non-core Modules (Outside IE Department)	
Elective module/s worth 32 credits allowed (NOTE: Please send email for approval to hanli.helm@up.ac.za)	

Minimum Admission Requirements

A BEng degree awarded by the University of Pretoria

or

A relevant four-year bachelor's degree in engineering that the Engineering Council of South-Africa (ECSA) regards acceptable for registration as a Candidate Engineer and for eventual registration as a Professional Engineer.

Selection Process

The departmental postgraduate committee reserves the right to make a thorough assessment of the applicant's academic transcript and Curriculum Vitae (CV), to decide if the applicant is suitable for postgraduate studies.

Applications and Registration

Students may Apply Online via the University of Pretoria website - https://www.up.ac.za/online-application. Once a student has been admitted he/she may register for modules. Online registrations open in January 2025.

Closing Dates

South-African citizens: 30 November 2024
International applicants: 30 June 2024

BScHons AplSci Industrial Systems (Plan code: 12243051)

A student is required to pass modules to the total value of 128 credits. The minimum duration of study is 1 year. The programme consists of three compulsory modules (64 credits) with core modules.

NOTE: Since BCS 780 is a research-based module, students are strongly advised to enrol for a 32-credit module, i.e. a module with research methods, prior to enrolling for BCS 780.

Presentation Mode

The class schedules in the appendices, indicate that classes are presented in 3 block weeks per semester.
The 1st block week will have in-person on-campus classes, whereas the 2nd and 3rd block week will be presented in an online format.

Course Curriculum

Semester 1	Semester 2
Compulsory module	
BAN 780 (16 credits) Industrial Analysis	BCS 780 (32 credits) Industrial & Systems Engineering Research
BLK 781 (16 credits) Supply Chain Processes	
Core module (IE Department)	
BBA 781 (32 credits) Enterprise Engineering and Research Methods	BOZ 780 (32 credits) Operations Research
BPZ 782 (32 credits) Manufacturing Planning & Control Systems	BUY 780 (16 Credits) Simulation Modelling
-	BSS 780 (24 credits) Systems Engineering
	BVK 780 (16 credits) Supply Chain Design

Minimum Admission Requirements

A three-year BSc degree in Natural Sciences with a weighted average of at least 60%, including required mathematical component.
or

An equivalent degree with a weighted average of at least 60%, including a required mathematical component.
or

An appropriate BTech/BEng Tech qualification, excluding the National Diploma, e.g. one offered by a department of industrial engineering at a university of technology in South Africa with a weighted average of at least 75% and no modules failed in the BTech degree.
or

A four-year engineering-based university degree not recognised by ECSA for registration as a Professional Engineer, according to Washington Accord.
or

A relevant Advanced Diploma qualification (NQF Level 7), excluding the National Diploma, for example, one offered by a department of Civil 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.

Selection Process

The departmental postgraduate committee reserves the right to make a thorough assessment of the applicant's academic transcript and Curriculum Vitae (CV), to decide if the applicant is considered suitable for postgraduate studies.

Applications and Registration

Students may Apply Online via the University of Pretoria website - https://www.up.ac.za/online-application

Once a student has been admitted he/she may register for modules. Online registrations open in January 2025.

Closing Dates

South-African citizens:	30 November 2024
International applicants:	30 June 2024

Master's Programmes (Plan code: 12250012, Module code: BIR 890)

A dissertation is required as deliverable. The dissertation must prove the student's ability to undertake scientific research and to report thereon. The minimum duration of study is 1 year.

A dissertation is acceptable if it proves that a student:
- is conversant with the nature and aim of the research,
- has a satisfactory knowledge of the literature concerned and can interpret it,
- has mastered the techniques relevant to his/her research,
- has sound knowledge of both the theory and the practice of scientific methodology,
- is able to evaluate the scientific relevance of his/her findings and
- can structure the report on the research scientifically with accountability

The student may not have previously submitted the dissertation for graduation purposes at another tertiary institution.

Research Topic

A prospective student should select a research topic in collaboration with the staff of the Department of Industrial and Systems Engineering. Research topics may be chosen within the three research focus streams (presented in the introductory section) and other topics may be considered in consultation with the Head of Department.

Please consult with the concerned lecturer as indicated. Students may also provide their own research topic that should first be approved by the lecturer that will act as the study leader.

Minimum Admission Requirements

- **Degree Prerequisites (weighted averages):** 65% for B.Eng (Industrial Engineering) OR minimum 65% for B.Eng.Hons OR 65% for relevant 4-year degree (e.g. B.EngTech.Hons / PG.Diploma / BSc.Hons.Appl.Sc with adequate mathematical component).
- **Topic-related Prerequisites:** M.Eng topic approved by the person that will act as the supervisor for the Masters study i.e. a lecturer with a PhD degree. The approved **topic concept document** (TCD) should be attached to the application, as well as a **letter/e-mail** from the supervisor: (1) *stating the agreed-upon topic* and (2) *confirming the commitment to lead the study*.
- Prior to applying for a Masters, students need to obtain guidance from their potential study leader on whether

registering for a Masters degree during the preparation phase OR **registering for an Honours** degree during the preparation phase, if the student did not complete a relevant Honours degree before. One of the advantages of registering for an Honours during the *preparation phase*, is that a student completes (and passes) the modules prescribed by the **potential study leader** with an option to exit with an Honours degree during the subsequent year, rather than continuing with the Masters in the subsequent year.

Process for Masters Studies

Also refer to the section "Research Process" for additional guidance.

Preparation phase

- Students need to consult with the **allocated study leader** (i.e. a lecturer with PhD degree) to receive instruction from the study leader regarding the required **core** modules (if any) and **other prerequisite honours modules** (if any) that should be taken during a Masters *preparation phase.*
- Agreement regarding the agreed-upon pathway for conducting the Masters study should be finalized within at most 3 months after registration, in a **Memorandum of Agreement** (MoA).

Completion Phase

- The student continues with the Master's degree in accordance with the approved MoA.

Additional Conditions for Students with *Not-engineering-related* 4-year Degrees

- The departmental postgraduate committee may request evidence of research methodology knowledge and its application, since it is possible that the student did not complete an appropriate research methodology module as part of their previous studies.
- The departmental postgraduate committee reserves the right to make a thorough assessment of the applicant's academic transcript and Curriculum Vitae (CV), to decide if the applicant is considered suitable for postgraduate studies. This assessment may include an oral or written examination.

Doctorate Programmes (Plan code: 12263002, Module code: BIR 990)

It requires the preparation of a thesis by the student based on his/her own independent and original research as a positive contribution towards the development of science and the existing body of knowledge of the area/knowledge domain. The requirements for the thesis are based on, but not limited to, the requirements for a dissertation, with the important addition of the student's ability to prove that he/she can plan, initiate, and execute independent and original research. The minimum duration of study is 2 years. The student may not have previously submitted the thesis for graduation purposes at another tertiary institution.

Research Topic

A prospective student should select a research topic in collaboration with the staff of the Department of Industrial and Systems Engineering. Research topics may be chosen within the three research focus streams (presented in the introductory section) and other topics may be considered in consultation with the Head of Department.

Please consult with the concerned lecturer as indicated. Students may also provide their own research topic.

Also refer to the section "Research Process" for additional guidance.

Minimum Admission Requirements

An MEng degree awarded by the University of Pretoria.

or

A research-based Master's degree in engineering awarded by another university.

The applicant must also meet the admission requirements for the BEng Hons degree.

or

An appropriate research-based Master's degree.

The applicant must also meet the admission requirements for the BScHons AplSci degree if not meeting with the requirements for the BEng Hons degree.

Selection process

The departmental postgraduate committee may request evidence of knowledge of research methodology, a copy of the Master's dissertation and a list of published journal articles (if any).

The departmental postgraduate committee may require additional honours modules for non-degree purposes where background is considered insufficient. The departmental postgraduate committee reserves the right to make a thorough assessment of the applicant's academic transcript and Curriculum Vitae (CV), to decide if the applicant is considered suitable for postgraduate studies. This assessment may include an oral or written examination.

Research Process

The following section is applicable mainly to students enrolling for Master's and Doctorate studies.

Research phases

An overview of the different research phases and required documents are given on the EBIT Lifecycle Website: https://www.up.ac.za/ebit-postgraduate-lifecycle

Proposal document

When a student enrols for BCS 780 as part of an Honours, a student already completes a proposal document that needs to be approved for Masters studies by a study leader, where the study leader should be a permanent employer at the Department of Industrial Engineering with a PhD degree.

A student may also start afresh with a new topic, especially if enrolling for a PhD degree. Requirements regrading a formal proposal should be stipulated as part of the Memorandum of Agreement, signed by the student, study leader and HOD.

Library Resources

Students who have already consulted with a supervisor in the department and who have been advised to utilize the University of Pretoria's library resources may apply and register for the following programme and gain access to the library with a student card (issued by the Student Service Centre 'SSC'):

Engineering Postgraduate (Non-degree purposes) (Plan code: 12290001)

- Master's students will be registered for the following module: ZZZ 777
- Doctorate students will be registered for the following module: ZZZ 888

Policies, professional and ethical conduct

It is expected of students and lecturers to follow the University's policies and to display professional conduct in all activities related to post graduate studies, including matters such as: class conduct, plagiarism, copyright, referencing and students with special needs apply. Please visit the EBIT Faculty webpage on Research Ethics and Integrity:

(https://www.up.ac.za/faculty-of-engineering-built-environment-it/article/15815/faculty-committee-for-research-ethics-integrity)

Application forms, *declaration by researcher* and *informed consent* forms should be submitted as part of an ethical clearance process. All Masters and PhD students, intending to obtain data from informants via interviews, surveys, group discussions or observations, must apply for ethical clearance before they start with data gathering.

General

Fees and funding

Please refer to the "Fees and Funding webpage" (http://www.up.ac.za/fees-and-funding) which gives details regarding tuition fees, scholarships and loans. Student may contact Student Accounts at the Student Service Centre (SSC) for queries on the various fees such as application-, registration- and tuition fees. Contact detail:

Tel: 012 420 3111/4111, E-mail: ssc@up.ac.za

ClickUP

ClickUP is the online learning management system of the University of Pretoria that acts as a virtual classroom. All Postgraduate students (including Masters and PhD students) will have access to ClickUP once registered. Students will be able to login via "MyTUKS Login" from the Homepage on the University of Pretoria's website. Students will then be navigated to the "UP Student Portal" where his/her registered modules (ClickUP courses for each subject and the departmental ClickUP course) will be listed. Each module has a unique site that contains lecturer details, study guide, course structure, prescribed material, and announcements. It also hosts facilities to conduct online discussions and e-mail communication(s). Since ClickUP is the official means through which lecturers communicate to all students, students must visit ClickUP regularly and ensure that their latest e-mail addresses are registered in ClickUP.
Additional information may be obtained from the Student Help Desk at:

- E-mail: studenthelp@it.up.ac.za
- Tel: +27 12 420 3837

***Note:**

The most recent version of the brochure will be published on the departmental website as stated above. All matters pertaining to the administration of postgraduate activities is the responsibility of the Head of the Department IE
Although every attempt has been made to ensure that this brochure is correct and up to date at the time of publishing, the Department reserves the right to make any changes without prior notice and without prejudice. Due to the unavailability of lecturing staff, some modules may be discontinued or changed.

Appendices

Contact Details

Department of Industrial and Systems Engineering

Honours, Master's and PhD enquiries: Curriculum and Class Timetables

Contact person	Mrs Hanli Helm
Office	Engineering II, Room 3-10
Contact details	Tel: +27(0)12 420 5230
	Fax: +27(0)12 362 5103
	E-mail: hanli.helm@up.ac.za
Webpage:	https://www.up.ac.za/industrial-and-systems-engineering
Office hours	Monday - Friday 07:30-16:00

Engineering Student Administration (EBIT)

Honours Programmes: Applications, Administration and Registration

Contact person	Mr Roy Mashiloane
Office	Engineering I, Room 6-9
Contact details	Tel: +27(0)12 420 3656
	Fax: +27(0)86 544 4640
	E-mail: roy.mashiloane@up.ac.za

Master's & Doctorate Programmes: Administration, Applications and Registration

Contact person	Mr Edward Masemola
Office	Engineering I, Room 6-8.1
Contact details	Tel: +27(0)12 420 3619
	Fax: +27(0)86 544 4640
	E-mail: te.masemola@up.ac.za.
Webpage	http://www.up.ac.za/faculty-of-engineering-built-environment-it
Office hours	Monday - Friday 07:30-16:00

Student Service Centre (SSC)

Enquiries on Applications student accounts, fees & funding and Bursaries & Loans

Contact details	Tel: +27(0)12 420 3111
	Fax: +27(0)12 420 4555
	E-mail: ssc@up.ac.za
Webpage	http://www.up.ac.za/enquiry
Office hours	Monday - Friday 08:00 - 16:00

Module Descriptions

BAN 780 Industrial analysis (Compulsory module, BSc Hons) – Credits: 16

Module credits	16.00
NQF Level	08
Prerequisite	Industrial Engineering students may not register for this module
Contact time	24 contact hours per semester
Language of tuition	Module is presented in English
Academic organisation	Industrial and Systems Engineering
Period of presentation	Semester 1 or Semester 2

**Compulsory only for BSc(Hons) AplSci students. Can be taken as elective module by Engineering students who did not complete an Industrial Engineering undergraduate degree. It CANNOT be taken by students who completed an Industrial Engineering undergraduate degree **

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

BAO 780 Advanced aspects of Operations Research (Elective module) - Credits: 16

Academic organisation: Industrial and Systems Engineering
Contact time: 24 contact hours per semester
Period of presentation: Semester 1 or 2
Language of instruction: English

Module content:

Decision makers are frequently faced with complex problem environments. The module introduces two advanced topics in the field of Operations Research that can assist in the development of more relevant decision support models. The first topic deals with multi objectivity and introduces a variety of interventions to incorporate the competing objectives into mathematical programming models. Secondly, the topic of Data Envelopment Analysis (DEA) is introduced, a non-parametric method used to empirically measure the productive efficiency of decision-making units. This linear programming methodology allows the decision maker to measure the productivity in complex environments with multiple inputs and outputs; uncover often-overlooked relationships between in- and outputs; and analyse and quantify the inefficiencies of every unit evaluated.

BAR 780 Solution Algorithms in Operations Research[1] (Core elective module) - Credits: 32

Academic organisation: Industrial and Systems Engineering
*Prerequisite: BAN 313 or BAN 780
Contact time: 36 contact hours per semester
Period of presentation: Semester 1 or 2
Language of instruction: English

Module content:

When developing decision-support models using optimisation, the computational burden is often so great that exact optimal solutions are not attainable, or not efficiently found, especially in combinatorial and discrete optimisation problems. Often approximate solutions are adequate and can provide superior solutions to the current state-of-practice decision approaches. The module introduces a selection of heuristics and metaheuristics applied to a variety of problems frequently faced by Industrial Engineers. The module also introduces a methodology to test and validate heuristics to ensure robust and reliable application. The module will focus on exact, heuristic and meta-heuristic optimisation algorithms, and introducing research methodologies specifically applicable to the field of operations research.

[1]Students are encouraged to take this module in conjunction with BDE 780 and BOZ 780

BBA 781 Enterprise engineering & research methods (Core prerequisite module) – Credits: 32

Module credits	32.00
NQF Level	08
Prerequisite	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
- Representing systems behaviour graphically
- 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

* A prerequisite-knowledge test will be conducted at the start of the semester to evaluate whether the student has sufficient prerequisite knowledge to continue with the module.

BCI 780 Supply chain information & decision technology (Elective module) - Credits: 16

Academic organisation: Industrial and Systems Engineering
Contact time: 24 contact hours per semester
Period of presentation: Semester 1 or 2
Language of instruction: English

Module content:

Information technology is an important enabler of effective supply chain management, typically spanning the extended value chain from suppliers to customers. The timeliness and availability of relevant information are critical when applying supply chain strategies that increase service levels of and reduce cost and lead times. Value-added IT-based services are increasingly used to differentiate and develop relationships with customers.

The objective of the course is:

- To develop a sound understanding of components and priorities
- IT investment to enable supply chain integration and efficiency
- The impact of business process change on IT implementation and selection of decision support systems
- The value of information
- Leveraging financial information
- Advanced supply chain planning and execution
- Decision support systems
- IT capabilities for supply chain excellence
- Enterprise resource planning
- Systems advanced planning and scheduling systems
- Identification technology
- Integrating supply chain IT

BCS 780 Industrial and systems engineering research (Compulsory module) - Credits: 32

Module credits	32.00
NQF Level	08
Prerequisite	We **strongly recommend** that students **complete a 32-credit module during the first semester**, so that they use the research methods, offered by the 32-credit module, in BCS 780.
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:

The module affords an individual student the opportunity of studying a designated area of coherent 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.

BDE 780 Design and analysis of experiments (Elective module) - Credits: 16

Academic organisation: Industrial and Systems Engineering
*Prerequisites: BES 220 or BAN 780 or equivalent as approved by the Head of the Department. Students who have completed another statistical course must apply for acceptance to this module by writing a letter, which demonstrates equivalence of courses.
Contact time: 24 contact hours per semester
Period of presentation: Semester 1 or 2
Language of instruction: English

Module content:

The design of an experiment may be defined as 'the logical construction of an experiment in which the degree of uncertainty with which the inferences are drawn may be well defined'.

The module covers:

- Principles of experimental design (randomisation, replication and blocking, local control)
- One-Factor-Two-level factorial designs
- One-Factor-Multi-level factorial designs
- Completely Randomised Design (CRD) and introduction to ANOVA
- Randomised Complete Block Design (RBD)
- Latin Square Design (LSD)
- Balanced Incomplete Block Design (BIBD)
- Factorial experiments (2^{nd} and 3^{rd} factorial experiments)
- Blocking and confounding in factorial designs
- Overview of fractional factorial designs

BEE 780 Inventory modelling (Elective module) - Credits: 16

Academic organisation: Industrial and Systems Engineering
Contact time: 24 contact hours per semester
Period of presentation: Semester 1 or 2
Language of instruction: English

Module content:

- Theory of Inventory Systems: Inventory models and modelling including time and certainty complexities, linear and non-linear systems and feedback systems
- Review of inventory models: Types and representations (classic, shortage, capacity constraint, time
- Review of important inventory papers, their approaches and their focus
- Modelling and solution techniques: characterisation and assumptions, mathematical modelling, mathematical programming, heuristics, simulation models, Control Theory and other approaches
- State of the art of modelling: current challenges and research trends
- Technological solutions of inventory modelling and management: algorithms and software, integration to MRP, ERP and scheduling modules, integration to WMS modules, and demonstrations

BES 780 Applied engineering statistics (Elective module) - Credits: 16

Academic organisation: Industrial and Systems Engineering
Contact time: 24 contact hours per semester
Period of presentation: Semester 1 or 2

Language of instruction: English

Module content:

This module presents an applied approach to solve real-world engineering problems. The premise of the course is that data analysis, and thus, applied statistics, is an inseparable part of conducting research and solving engineering problems. The module presents the elements of different types of statistical studies as they relate to different industrial settings. The aim of the module is to promote inductive reasoning through the gathering, analysing and interpreting of diverse types of observational data. The outcome of the module is an engineer equipped to select and apply statistical methods appropriate to an industrial setting.

The module covers:

- Contextualisation: different types of industrial processes and research settings, related types of statistical studies and a framework for understanding and applying statistics, principles of probabilistic and rational data gathering
- The use of common and specialised probability distributions (such as the Gamma, Exponential and Weibull distributions) in solving real-life problems, conducting scientific research and analysing stochastic and deterministic processes
- Data transformations: when and how to transform data
- Bridging the gap between technology and statistical analysis: The use of EXCEL in resolving basic and advanced statistical problems

BGH 780 Quality management (Core elective module) - Credits: 16

Academic organisation: Industrial and Systems Engineering
Contact time: 24 contact hours per semester
Period of presentation: Semester 1 or 2
Language of instruction: English

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 module covers:

- 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, online and offline 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

BHM 780 Probability models (Elective module) - Credits: 16

Academic organisation: Industrial and Systems Engineering
Contact time: 24 contact hours per semester
Period of presentation: Semester 1 or 2
Language of instruction: English

Module content:

The objective of the module is that students be exposed to probability theory, learn the ability to follow fairly involved theoretical reasoning, continue to learn how to reason mathematically, and solve problems of a more practical nature.

The module covers:

- Probability theory: random variables and random vectors, Sequence of random variables, transformation of probability distributions, stochastic processes: examples of stochastic processes; various types of stochastic processes
- Poisson processes: homogeneous and non-homogeneous stochastic processes with examples
- Renewal processes: renewal functions; ordinary and delayed renewal processes; regenerative stochastic processes
- Discrete-time Markov chains: continuous time Markov chains with focus on examples in reliability, queuing and inventory models

BIS 780 Information systems (Elective module) - Credits: 16

Academic organisation: Industrial and Systems Engineering
*Prerequisites: Information systems design BID 320, Production BPZ 410 – for Industrial Engineering students prior to 2003. Similar course presented by Information Technology
Contact time: 24 contact hours per semester
Period of presentation: Semester 1 or 2
Language of instruction: English

Module content:

To introduce the student with a background in transactional application software development to a variety of aspects in the wider field of information technology. Emphasis is on the functional design of Business Intelligence systems from an Industrial Engineering perspective. The aim is to enable the student to appreciate the scope of management challenges in the integrated environment of business processes, transactional application software, data, IT infrastructure and telecommunications, data warehousing, and the necessary management information needed at various levels in an organization.

The module covers:

- Technology trends
- Context diagram of application software portfolio
- Review of typical transactional information systems
- Role of Business Intelligence and data warehousing
- Business dimensional lifecycle
- Business requirement definition
- Basic elements of the data warehouse
- Extraction, Transformation and Loading processes
- Dimensional modelling (star schema)
- Metadata
- Information delivery

BLC 780 Lean supply chain strategies and systems (Elective module) - Credits: 16

Academic organisation: Industrial and Systems Engineering
Contact time: 24 contact hours per semester
Period of presentation: Semester 1 or 2
Language of instruction: English

Module content:

Supply chain executives need to contribute and support long-term strategic objectives by providing a competitive edge through an aligned supply chain strategy. The course addresses the impact of lean principles in supply chain management and practical approach to implementing lean thinking and demand driven supply chains. The course provides a framework for the strategic supply chain decisions, both in designing and managing an efficient extended supply chain. The latest innovations, trends and challenges in agile supply chain strategies and systems are reviewed. Team leadership skills are developed through practical applications, approaches and best practices of lean supply chain design and management. Supply chain leadership perspectives will be provided by executives and managers from industry and team-based simulation games.

The module covers:

- Fundamentals of lean management
- Lean thinking and supply chain (SC) management
- Customer value
- Network design strategies
- Supply chain integration and barriers to integration
- SC performance measurement
- Extended value chain and value stream mapping
- Eliminating waste in the supply chain
- Applying lean principles to supply chain operations
- Inventory positioning approaches
- Operational executive problems
- A3 Performance Management

BLK 781 Supply chain processes (Core module) – Credits: 16

Module credits	16.00
NQF Level	08
Prerequisite	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.

The module covers:

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

BMK 780 Process optimization (Elective module) - Credits: 16

Academic organisation: Industrial and Systems Engineering
*Prerequisites: Module only available to students with a BEng Industrial degree
Contact time: 24 contact hours per semester
Period of presentation: Semester 1 or 2
Language of instruction: English

Module content:

Process optimisation is an engineering discipline, which focuses on the tools and techniques used specifically for business process analysis, design, and optimisation. As physics determines the physical behaviour of tangibles, process physics forms the foundation of business process behaviour. Traditionally, operations research techniques are used by Industrial Engineers to optimise business processes, process optimisation provides a more focused approach using techniques such as Social Network Analysis, System Dynamics, image profiling and process mining to uncover analytical models. The outcome of this course is to enable the student to create an integrated, analytical business process behaviour profile. This supports the analysis, design and optimisation of business processes in a Business Engineering lifecycle. Process optimisation requires an understanding of operations research within the business engineer framework. This course requires a full understanding of undergraduate Industrial Engineering modules as well as a postgraduate understanding of resource optimisation and enterprise architecture.

The module covers:

- Standard process physics principles, facts and models
- Process Intelligence
- Adaptive process control and SMART processes
- Robustness and complexity analysis
- Process mining
- Social network analysis

BOZ 780 Operations research[2] (Core module) – Credits: 32

Module credits	32.00
NQF Level	08
Prerequisite	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
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.

BPZ 782 Manufacturing planning and control systems (Core prerequisite module) – Credits: 32

Module credits	32.00
NQF Level	08
Prerequisite	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 covers:

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 (DEL) 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 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; NP completeness, worst- 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.

BSI 780 Business engineering (Elective module) - Credits: 16

Academic organisation: Industrial and Systems Engineering
Contact time: 24 contact hours per semester
Period of presentation: Semester 1 or 2
Language of instruction: English

Module content:

Organisations are complex systems, which consist of people, processes, customers, resources and regulatory environments. Business Engineering (BE) is a discipline which uses an engineering approach towards introducing planned business change into the organisation. This includes formal analysis, design, implementation and maintenance of the holistic business system; requiring a deep understanding and knowledge of the interaction and balance of complex business system elements. The outcome of the course is to enable the student to understand the art and science of engineering complex business systems. Business engineering is the ultimate pinnacle of industrial engineering competency – being able to construct business systems serving complicated organisational value propositions. The course requires a full understanding of undergraduate Industrial Engineering modules as well as a postgraduate understanding of resource optimisation, enterprise architecture, and supply chain engineering.

The module covers:

- BE principles for design, implementation and optimisation of complex business systems
- BE programme process which governs the implementation of holistic business changes
- BE programme and project structures
- BE Tools and techniques used throughout the BE lifecycle for engineering modelling and optimisation.
- Business
- Models and innovation approaches
- Integrated Business planning
- Business Process reference models for strategic, tactical, core and support processes.

BSS 780 Systems Engineering (Elective Module) - Credits: 24

Module credits	24.00
NQF Level	08
Prerequisite	BBA 781
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:

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.

The module covers:

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.

BTH 780 Reliability engineering (Elective module) - Credits: 16

Academic organisation: Industrial and Systems Engineering
Contact time: 24 contact hours per semester
Period of presentation: Semester 1 or 2
Language of instruction: English

Module content:

To make students conversant with the concepts, tools and techniques of reliability engineering
The module covers:

- Introduction to reliability engineering
- Reliability mathematics
- Probability plotting
- Reliability prediction for design
- Reliability testing
- Reliability growth
- Maintainability
- Reliability management

BUY 780 Simulation modelling (Core elective module) – Credits: 16

Module credits	16.00
NQF Level	08
Prerequisite	BUY 321 or BAN 780
Contact time	24 contact hours per semester
Language of tuition	Module is presented in English
Academic organisation	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.

The module covers:

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

BVK 780 Supply chain design (Core module) - Credits: 16

Module credits	16.00
NQF Level	08
Prerequisite	BLK 781 or BLK 320
Contact time	24 contact hours
Language of tuition	Module is presented in English
Academic organisation	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.

The module covers:

- 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

The following modules are currently NOT offered

● Advanced aspects of operations research	BAO 780	(Elective module)
● Solution algorithms in operations research	BAR 780	(Core elective module)
● Supply chain information & decision technology	BCI 780	(Elective module)
● Design and analysis of experiments	BDE 780	(Elective module)
● Inventory modelling	BEE 780	(Elective module)
● Applied engineering statistics	BES 780	(Elective module)
● Probability models	BHM 780	(Elective module)
● Information systems	BIS 780	(Elective module)
● Lean supply chain strategies and systems	BLC 780	(Elective module)
● Process optimization	BMK 781	(Elective module)
● Business engineering	BSI 780	(Elective module)
● Reliability engineering	BTH 780	(Elective module)
● Quality management	BGH 780	(Elective module)