University College Dublin
National University of Ireland, Dublin

Engineering

Session 2003/2004

Contents

Degrees in Engineering
Extract from the Statute of the University

The University may grant the following degrees to students who, under conditions laid down in the statutes and regulations, have completed approved courses of study, and have passed the prescribed examinations of the University, and fulfilled all other prescribed conditions.

- Bachelor of Engineering (BE)
- Master of Engineering Science (MEngSc)
- Master of Engineering (ME)
- Master of Engineering Design (MED)
- Master of Industrial Engineering (MIE)
- Master of Science (MSc)
- Doctor of Philosophy (PhD)

The provisions as to the Degree of Doctor of Philosophy (PhD) in the Faculty of Engineering and Architecture are the same as in the other Faculties.

The BE Degree is offered in the following five Departments of the School of Engineering:

- Agricultural and Food Engineering
- Chemical Engineering
- Civil Engineering
- Electronic and Electrical Engineering
- Mechanical Engineering

The approved courses of study in each branch must be pursued during at least twelve terms.

Degree of Bachelor of Engineering (BE)

Entry Regulations and Scholarships

Denominated Entry to First Year Engineering Degree Programmes
For the student intake of 2003/04 the denominated entry mode will be provided for all Engineering degree programmes:

Agricultural and Food Engineering*
Chemical Engineering
Civil Engineering
Electronic & Electrical Engineering
Mechanical Engineering.

Provision is also made for an undenominated First Year Civil/Mechanical course. Students in this group, after successful completion of First Year, will be offered free choice to enter either Civil Engineering or Mechanical Engineering in Second Year.

Application and Limitation of Numbers in First Engineering
The number of students that can be accepted for the session 2003/2004 will be limited in accordance with the accommodation available. If the number of qualified applicants exceeds the number of places available, selection will be on the basis of academic record.

Intending students must obtain a form of application from the Central Applications Office (Tower House, Eglinton Street, Galway) and must return it completed not later than the date stated on the form. Students whose entry to the University depends on their gaining scholarships or grants should, pending the award of such scholarships or grants, lodge the application form provisionally.

Matriculation
All students must fulfil the matriculation requirements of the National University of Ireland. These requirements may be fulfilled by:

i. Passing the Leaving Certificate of the Department of Education or the GCE/GCSE (Northern Ireland) in the required subjects at prescribed levels; or
ii. Obtaining stated grades in the required subjects in a combination of Matriculation and Leaving Certificate Examinations**; or
iii. Having been recommended to NUI by the University.

* From September 2004 onwards new entrants will be admitted to the new degree programme in Biosystems Engineering.
** Relevant only to those who presented for the Matriculation Examination which was held for the last time in 1992.

Special Qualifications in Mathematics
For entry to the first year courses in Engineering in session 2003/2004, students must qualify in Mathematics by one of the following methods:

(a) By obtaining Grade C3 or better on the higher papers in Mathematics at the Irish Leaving Certificate Examination: Grade B3 or better will be required for entry into First Year Electronic & Electrical Engineering;

(b) By obtaining Grade C in Mathematics at Advanced Level at the General Certificate of Education Examination, Northern Ireland (Grade B for Electronic & Electrical Engineering);

(c) By reaching a suitable standard at some other examination approved by the University. A pass in Mathematics at a First University Examination in University College Dublin would be deemed to meet the required standard for exemption.

Entrance Scholarships
An entrance scholarship of €1270 will be awarded to First Year students who have gained 575 points or higher at the first sitting of the Leaving Certificate examination. A similar scholarship of €1270 will be awarded to students who have gained the following grades at Advanced Level at the GCE/GCSE (Northern Ireland): AAA, AAB or ABB.

General Regulations

Electronic Engineering and Electrical Engineering
Students in *Electronic and Electrical Engineering* will be required, on entering the final year, to indicate their preference as between Electronic Engineering and Electrical Engineering.

Language Requirement
Candidates who enter courses for the Degree of BE shall be required to pass an examination in foreign languages. Students will not be conferred with the BE Degree until they have satisfied the language requirement.

Courses are provided in a range of foreign languages approved by the Faculty. Students will normally take the course in the first year of the degree programme. Courses are offered at different levels; the language skills of individual students determine the level at which a course is taken. The current programme of languages includes French, German, Spanish and Japanese.

The course and examination shall comprise four sections: oral communication, functional writing, listening comprehension and technical reading. All sections must be taken at one session.

Examination Regulations

The University Examinations for the Degree of Bachelor of Engineering are:
1. The First University Examination;
2. The Second University Examination;

3. The Third University Examination;
4. The Final University Examination for the Degree.

For eligibility for admission to each of the examinations, the prescribed course of study for that examination must have been attended satisfactorily.

The First University Examination may be taken not earlier than the end of the third term after matriculation. The Second University Examination may be taken not earlier than the end of the sixth term after matriculation. The Third University Examination may be taken not earlier than the end of the ninth term after matriculation. The Fourth or Final University Examination for the Degree of Bachelor of Engineering may be taken not earlier than the end of the twelfth term.

Honours may be awarded at each Summer examination.

The attention of students is directed to the following: Credit for a course, Pass or Honours, requires satisfactory attendance and performance of all work prescribed during the Year.

The examinations may in each subject include a written and an oral examination.

In all practical examinations, the examiners will, where possible, take into account the work done by the candidate while preparing for the examination as shown by the certified record of his/her work, such as notebooks, project and laboratory reports, library investigations, drawings and designs etc. , which must be submitted for inspection.

Special Requirements for Honours in the BE Degree Examination
Candidates for First Class Honours in Electronic and Electrical Engineering must satisfy the examiners in at least one unit of Mathematics.

Time Limit for Passing Examinations
Attention is drawn to the following University Regulations which will be rigidly enforced:

1) No student will be allowed to present himself/herself for any examination in the University prior to the completion of the preceding examination.

2) a) Students must pass the First University Examination in Engineering within two academic years from the date of entering the Engineering School. First year students who do not pass the First University Examination at the end of their first year may be permitted to re-attend their first year lectures but will not be permitted to re-attend practical classes in Drawing Office, Laboratory or Workshop. Exceptions to this rule will be made only on grounds of ill health or for some other grave reason.

   b) Students must complete the Second University Examination in Engineering within two academic years from the date of passing the First University Examination in Engineering.

   c) Students must complete the Third University Examination in Engineering within two academic years from the date of passing the Second University Examination in Engineering.

   d) Students failing to pass any of these examinations within the specified interval will be ineligible to proceed further with their Engineering studies in any of the NUI

constituent universities. Exceptions to this rule will be granted by the Academic Council, on the recommendation of the Faculty of Engineering and Architecture, only for very serious reasons.

e) "Old Regulations" examination papers will be available for one year only following a change in the syllabus of any subject.

For the purpose of computing the time allowed to students to pass the First Engineering University Examination in any branch of Engineering, a student who *in any University* enters for a course containing three or more subjects of the First Engineering course will be deemed to have entered for the First Engineering course.

European Credit Transfer System (ECTS)

Note: The course titles in this section on the ECTS do not necessarily refer exactly to the same course material as that associated with courses having the same or similar titles in subsequent sections of the booklet.

Agricultural and Food Engineering

First Year

Course Title:	*Credits:*
Mathematics	12
Experimental Physics	8
Chemistry	8
Mathematical Physics	8
Computer Science	6
Engineering Graphics	6
Electronic and Electrical Engineering	4
Engineering Thermodynamics	4
Engineering Fluid Mechanics	4
Total:	60

Second Year

Course Title:	*Credits:*
Electrical and Electronic Engineering	5
Introduction to Biosystems	2
Food Science	10
Thermodynamics	2
Mechanics of Fluids	2
Applied Dynamics	4
Mechanics of Materials	4
Mathematics	8
Computer Science	3
Literature Research Project and Course Work	20
Total:	60

Third Year

Course Title:	*Credits:*
Computer Methods in Engineering	2
Engineering Computation	2
Mathematics (Modules A and B)	2
Process Engineering Principles	8
Thermodynamics	5
Power and Machinery I	8
Crop Husbandry and Animal Husbandry	4
Electronic Engineering	4
Structural and Soil Engineering	7
Design Project and Course Work	18
Total:	60

Fourth Year

Course Title:	*Credits:*
Buildings and Environment	8
Environmental Engineering (including Course Work)	8
Food Process Engineering	8
Food Manufacturing Systems	6
Power and Machinery II (including Course Work)	8
Major Project	18
Four credits from two of the following:	
Farm Management	2
Management and its Environment	2
Managing Manufacturing Enterprise	2
Mathematics A	2
Mathematics B	2
Renewable Energy Systems	2
Surveying	2
Environmental Policy and Management	2
Total:	60

Chemical Engineering

First Year

Course Title:	*Credits:*
Mathematics	12
Experimental Physics	8
Chemistry	8
Mathematical Physics	8
Computer Science	6
Chemical Engineering Process Principles I	4
Electronic and Electrical Engineering	4
Engineering Thermodynamics	4
Engineering Fluid Mechanics	4
Introduction to Chemical Engineering	2
Total:	60

Second Year

Course Title:	*Credits:*
Chemical Engineering and Measurement	12
Chemistry	7
Mechanics of Fluids	4
Mechanics of Materials	4
Biotechnology I	5
Mathematics	10
Experimental Physics	6
Computers in Chemical Engineering I	4
Chemical Thermodynamics and Kinetics	8
Total:	60

Third Year

Course Title:	*Credits:*
Unit Operations I	8
Heat Transfer I and Mass Transfer	8
Fluid Flow I	6
Mechanical Design and Engineering Materials	6
Pure and Applied Mathematics	8
Chemical Engineering Thermodynamics	6
Computers in Chemical Engineering II	6
Electrical Engineering	4
Applied Chemistry and Biotechnology II	8
Total:	60

Fourth Year

Course Title:	*Credits:*
Unit Operations II	6
Reactor Design and Automatic Control	6
Heat Transfer II and Fluid Flow II	6
Process Design	5
Management and its Environment	3
Environmental Studies	4
Chemical and Biochemical Engineering Processes	4
Design Project	12
Research Project	12
Two credits from one of the following elective subjects:	
Mathematics A	2
Mathematics B	2
Total:	60

Civil Engineering

First Year

Course Title:	*Credits:*
Mathematics	12
Experimental Physics	8
Chemistry	8
Mathematical Physics	8
Computer Science	6
Engineering Graphics	6
Electronic and Electrical Engineering	4
Engineering Thermodynamics	4
Engineering Fluid Mechanics	4
Total:	60

Second Year

Course Title:	*Credits:*
Introduction to Biosystems	6
Surveying	6
Building Construction	6
Engineering Materials 1	4
Engineering Materials 11	4
Mechanics of Fluids	6
Mechanics of Solids	6
Computer Applications in Civil Engineering	4
Mathematics	8
Year's Work	10
Total:	60

Third Year

Course Title:		*Credits:*
Hydraulics		7
Engineering Computation	}	8
Pure and Applied Mathematics	}	
Financial Management		6
Geology		6
Soil Mechanics		7
Theory of Structures		7
Design of Structures		7
Year's Work		12
Total:		60

Fourth Year

Course Title:	*Credits:*
Civil Engineering Design	25
The Engineer and Society	7
Engineering Report and Year's Work	14
Fourteen credits from the following elective subjects:	
Mathematics 4601	3. 5
Mathematics 4602	3. 5
Structural Modelling	7
Structural Design	7
Soil Mechanics and Geotechnical Engineering	7
Transportation Operations and Planning	7
Hydraulic Engineering Design	7
Unit Treatment Processes in Water Engineering	7
Total:	60

Electronic and Electrical Engineering

First Year

Course Title:	*Credits:*
Mathematics	12
Electronic and Electrical Engineering	10
Experimental Physics	8
Chemistry	8
Mathematical Physics	8
Computer Science	6
Engineering Thermodynamics	4
Engineering Fluid Mechanics	4
Total:	60

Second Year

Course Title:	*Credits:*
Experimental Physics	5
Computer Engineering 1	5
Applied Dynamics	5
Mathematics	10
Solid State Electronics 1	10
Circuit Theory 1	5
Electromagnetics 1	5
Electronic Circuits 1	5
Electrotechnics	5
Year's Work	5
Total:	60

Third Year

Course Title:	*Credits:*
Engineering Computation	3
Computer Engineering 2	4
Pure and Applied Mathematics	6
Electrical Machines 1	4
Solid State Electronics 2	5
Circuit Theory 2	4
Electronic Circuits 2	5
Communication Theory 1	4
Electromagnetics 2	4
Linear Systems Analysis	5
Control Theory 1	4
Power Systems 1	4
Year's Work	8
Total:	60

Fourth Year – Electrical Engineering

Course Title:		*Credits:*
Electronic Circuits 3	}	
Control Systems	}	
Optoelectronics and Filters	}	15
Digital Signal Processing	}	
Electrical Machines 2	}	
High Voltage Engineering	}	
Power Systems 2	}	15
Power Electronics	}	

Four options chosen from the following list:

Mathematics 2	}	
Mathematics 3	}	
Management and its Environment	}	
Biomedical Engineering	}	
Circuit Synthesis	}	
Dielectric and Magnetic Materials	}	
Semiconductor Devices and Applications	}	15
Optoelectronics	}	
Non-Linear Circuits and Systems	}	
Electrical Machines 3	}	
Power Systems 3	}	
Renewable Energy Systems	}	
Power Electronic Systems	}	
Applications of Digital Signal Processing	}	
Year's Work	}	15
Total		60

Fourth Year – Electronic Engineering

Course Title:		*Credits:*
Electronic Circuits 3	}	
Control Systems	}	
Optoelectronics and Filters	}	15
Digital Signal Processing	}	
Antennas and Propagation	}	
Communication Theory 2	}	
Digital Electronics	}	15
RF Circuits and Systems	}	

Four options chosen from the following list:

Course Title:		*Credits:*
Mathematics 2	}	
Mathematics 3	}	
Management and its Environment	}	
Biomedical Engineering	}	
Circuit Synthesis	}	
Dielectric and Magnetic Materials	}	
Semiconductor Devices and Applications	}	15
Optoelectronics	}	
Optical Engineering	}	
Non-Linear Circuits and Systems	}	
Communication Systems	}	
Digital Communications	}	
Hardware/ Software for Co-Design	}	
Microwave Engineering	}	
Applications of Digital Signal Processing	}	
Year's Work	}	15
Total		60

Mechanical Engineering

First Year

Course Title:	*Credits:*
Mathematics	12
Experimental Physics	8
Chemistry	8
Mathematical Physics	8
Computer Science	6
Engineering Graphics	6
Electronic and Electrical Engineering	4
Engineering Thermodynamics	4
Engineering Fluid Mechanics	4
Total	60

Second Year

Course Title:	*Credits:*
Experimental Physics	4.5
Electrical and Electronic Engineering	6.0
Computer Science	4.5
Mathematics	9.0
Applied Dynamics	4.5
Mechanics of Materials	4.5
Thermodynamics and Engineering Measurement	4.5
Mechanics of Fluids	4.5
Production Engineering and Cost Analysis	4.5
Process Metallurgy	4.5
Year's Work	9.0
Total:	60

Third Year

Course Title:	*Credits:*
Thermodynamics and Fluid Mechanics	4.5
Engineering Computation	3.0
Computer Science	3.0
Pure and Applied Mathematics	7.5
Applied Dynamics and Control Systems	4.5
Stress Analysis in Design	4.5
Electrical Engineering	5.5
Electronic Engineering	5.5
Design and Production	4.5
Engineering Materials	4.5
Management Accounting and Finance	4.5
Year's Work	8.5
Total:	60. 0

Fourth Year

Course Title:	*Credits:*
Energy Conversion Systems	6.0
Fluid Mechanics and Heat Transfer	6.0
Applied Dynamics and Control	6.0
Managing Manufacturing Enterprise	3.0
Materials Engineering and Design	6.0
Manufacturing Engineering	3.0
Electronic Engineering	3.0
The Engineer in Society: The Economy	2.0

Three options to be chosen from the following list:		
Advanced Composites and Polymer Engineering	}	
Advanced Materials Processing	}	
Bioengineering	}	
Electrical Engineering	}	
Engineering Failure Analysis	}	9.0
Manufacturing Information Systems	}	
Power Generation	}	
Technical Ceramics	}	
Year's Work		16.0
Total:		60.0

Syllabus of Courses for Degree of Bachelor of Engineering

Agricultural and Food Engineering[*]

First Year

Mathematics	MATH 1600
Experimental Physics*	EXPH 1603
Chemistry*	CHEM 1604
Mathematical Physics	MAPH 1014
Computer Science*	COMP 1604
Engineering Graphics*	CVEN 1001
Electronic and Electrical Engineering	EEEN 1001
Engineering Fluid Mechanics	CVEN 1003
Engineering Thermodynamics	MEEN 1003
Introduction to Agricultural and Food Engineering	AFEN 1101
Languages	ENGF 1002

* These subjects have a laboratory or other practical component in addition to the lecture course.

Second Year

Food Science	AFEN 2001
Literature Research Project	AFEN 2002
Thermodynamics	MEEN 2003
Applied Dynamics	MEEN 2001
Mechanics of Materials	MEEN 2002
Mechanics of Fluids	MEEN 2008
Electrical Engineering	EEEN 2036
Electronic Engineering	EEEN 2035
Introduction to Biosystems	CVEN 2001
Mathematics	MATH 2600
Computer Science	COMP 2605
Literature Research Project and Course Work	AFEN 2020

[*] From September 2004 onwards new entrants will be admitted to the new degree programme in Biosystems Engineering.

Third Year

Power and Machinery I		AFEN 3002
Process Engineering Principles		AFEN 3001
Thermodynamics		MEEN 3001
Structural and Soil Engineering		AFEN 3003
Electronic Engineering		EEEN 3025
Computer Methods in Engineering		MEEN 3006
Engineering Computation		MAPH 3034
Mathematics (Module A)		MATH 3601
Mathematics (Module B)		MATH 3602
Crop Husbandry and Animal Husbandry		ANSC 3600
Design Project	}	AFEN 3021
Year's Work	}	AFEN 3022

Fourth Year

Food Process Engineering	AFEN 4003
Food Manufacturing Systems	AFEN 4004
Buildings and Environment	AFEN 4001
Environmental Engineering	AFEN 4002
Power and Machinery II	AFEN 4005
Major Project	AFEN 4007

Two elective units:

Management and its Environment (1 unit)*	BMGT 4001
Farm Management (1 unit)	AERD 4600
Renewable Energy Systems (1 unit)	ELEN 4005
Surveying (1 unit)	AFEN 4006
Forest Engineering (1 unit)	AFEN 4010
Mathematics A or B (1 unit)	MATH 4601/2
Environmental Policy and Management (1 unit)	ENVS 4030
Managing Manufacturing Enterprise (1 unit)	MEEN 4004

* 1 unit = 24 lecture hours.

First Year

MATH 1600 Mathematics
Four course units, each unit comprises approximately 24 lectures.

Unit 1:
Sets, functions, continuity, differentiation, curve sketching, optimization.

Unit 2:
Solutions of systems of linear equations, matrix algebra, determinants, complex numbers, eigenvalues and eigenvectors, vectors in 3-space, scalar and vector products, lines and planes in 3-space.

Unit 3:
Definite and indefinite integration, techniques of integration, applications of integration, first and second order ordinary differential equations.

Unit 4:
Infinite series, power series, Taylor's theorem and series, partial differentiation of functions of two or more variables, Lagrange multiplier method.

EXPH 1603 Experimental Physics
Lectures: Three lectures each week in the first semester and two lectures each week in the second semester.

Laboratory: Two hours each week.

Introduction to Mechanics: gravitation;

Wave motion: light and sound, reflection, refraction, interference, diffraction, Doppler effect, ray optics, mirrors and lenses;

Electricity and magnetism: electrostatics, capacitance, magnetism, electromagnetic induction, electromagnetic waves;

Quantum physics: quantization of radiant energy, atomic levels, electric charge; Radioactivity: unstable nuclei, α, β, γ decay, fission, fusion.

CHEM 1604 Chemistry
Lectures: Two lectures each week.

Laboratory: Nine laboratory sessions, each of three hours duration, in the second semester.

Atomic structure and the periodic table; bonding, valency, formulae and shape of molecule; moles and stoichiometry; molecular/ionic equilibrium; acids and bases; redox reactions; volumetric analysis; rates of reaction; thermochemistry; electrochemistry and metals; non-metals; organic chemistry.

MAPH 1014 Mathematical Physics
Lectures: Two per week in the first semester and three per week in the second semester.

Vectors, relative velocity, equilibrium of a particle, Newton's Second Law of Motion applied to particle; momentum and impulse; work, power and energy; conservative forces in one dimension; linear motion with constant acceleration; projectiles; circular motion; simple harmonic

motion; linear motion with variable acceleration; compound pendulum motion; motion of a rigid body; small oscillations of a rigid body; equilibrium of a rigid body; reduction of a system of coplanar forces; distributed forces; centre of gravity; equilibrium of two and three forces acting on a rigid body; equilibrium of more than three forces acting on a rigid body.

COMP 1604 Computer Science
Lectures: One lecture each week.
Laboratory: Two hours per week.
Introduction to computers; basic hardware; concept of a program; operating systems; files; syntax and semantics; logic; loops; data structures; sorting; structured programming; debugging; program validation; application packages.

CVEN 1001 Engineering Graphics
One lecture and one practical class per week.
Manual draughting:
Use of drawing instruments. Lettering, linework and preparation of computation sheets. Descriptive geometry, orthographic and isometric projection. Sections. Dimensioning. Freehand sketching. Plane curves and Developments.

Computer-aided draughting (CAD):
File creation and management. Element placement, manipulation and modification. Shapes, patterning, dimensioning and drawing with constraints.

CVEN 1003 Engineering Fluid Mechanics
One lecture per week.
Introduction: states of matter, definition of a fluid; fluid properties; fluid statics: pressure intensity, pressure measurement, fluid pressure on surfaces, Archimedes law, flotation/stability; fluid kinematics: streamlines, continuity equation, Bernoulli's equation, flow measurement, orifices, trajectory of a liquid jet; fluid dynamics: momentum equation, fluid acceleration; applications.

EEEN 1001 Electronic and Electrical Engineering
Overview of electronic and electrical engineering; elementary electrical concepts; basic DC circuit analysis; basic transients; electrical signals; frequency spectrum; analogue signals, amplifiers, applications; digital signals, basic logic circuits, applications; elementary electromagnetics.

MEEN 1003 Engineering Thermodynamics
One lecture per week.
Basic concepts of thermodynamics; properties of pure substances; work and heat; First Law of thermodynamics for a closed system; control volume; conservation of mass and energy; introduction to the Second Law and entropy; conduction, convection and radiation; applications.

AFEN 1101 Introduction to Agricultural & Food Engineering
An introductory series of lectures will introduce students to various elements of the degree programme in Agricultural and Food Engineering.

ENGF 1002 Languages
Thirty six hours of language classes in the academic Year.

Candidates who enter for the Degree of BE shall be required to pass a College Examination in foreign languages. Students will not be conferred with the BE Degree until they have satisfied the language requirement.

Second Year

AFEN 2001 Food Science
Food Biochemistry
Fundamentals of food biochemistry as applied to food and nutrition with emphasis on the biochemistry of carbohydrates, proteins, fats, enzymes and vitamins.

Food Microbiology
Basic food microbiology, mould, yeasts, bacteria; contamination, preservation and spoilage of selected foods.

Food Physics
Rheological and thermal properties of foods. Measurement of colour of foods. Mass transfer in foods.

AFEN 2002 Literature Research Project
Students will be required to carry out a comprehensive literature survey in a selected aspect of agricultural and food engineering. An oral progress presentation and comprehensive final report will be required.

MEEN 2003 Thermodynamics
(For Agricultural and Food and Mechanical Engineering students)
First Law of Thermodynamics; Control system analysis; control volume analysis; steady-state, steady-flow energy equation. Second Law of Thermodynamics; Work and heat; quality of energy; reversible and irreversible processes; Carnot cycle; absolute temperature scale; definition of entropy; Clausius inequality; derivation of T-ds relations. Analysis of thermodynamic cycles; Rankine, Vapour Compression, Brayton-Joule, Otto, Diesel Cycles.

MEEN 2001 Applied Dynamics
(For Agricultural & Food, Electronic & Electrical and Mechanical Engineering Students)
Three-dimensional force systems: resultants and equilibrium. Topics in friction. Particle kinematics. Plane kinematics of rigid bodies. Plane kinetics of rigid bodies: force and acceleration; impulse and momentum; work and energy. Vibration, free and forced. Central force motion.

MEEN 2002 Mechanics of Materials
(For Agricultural & Food, Chemical and Mechanical Engineering students)
One dimensional stress and strain. Biaxial stress. Principal stresses and strains in 2-D. Hookes Law. Strain gauges. Thin-walled pressure vessels. Torsion of circular shafts. Bending stresses and deflections. Buckling of slender bars.

MEEN 2008 Mechanics of Fluids
A continuation course on fluid flow from a physical viewpoint.

Review of fluid properties. Fluid statics. Kinematics of fluid flow. Continuity equation. Stream function – Two-dimensional-incompressible. Rotational and irrotational motion. Circulation. Equations of irrotational motion. Dynamics of fluids. Force, energy and momentum. Effects of pressure, weight, viscosity, turbulence and compressibility. Dynamic similitude. Boundary layers, surface drag, form drag. Turbo-machinery.

EEEN 2036 Electrical Engineering
(For Agricultural & Food and Mechanical Engineering students)
Review of DC analysis, superposition, Thevenin's Theorem. Transient analysis: RL, RC, LC, RLC circuits. AC concepts: phasors, complex impedance, combining impedances, AC superposition. Frequency response of 1^{st} and 2^{nd} order circuits. RLC circuits. DC bridges and measurement. AC power.

EEEN 2035 Electronic Engineering
(For Agricultural and Food and Mechanical Engineering students)
PN junction: Diode, LED. Rectification. Power supply design. FET and MOSFET as circuit elements (switch, amplifier). BJT transistor. Simple amplifiers: operating point and bias. AC equivalent circuits.

CVEN 2001 Introduction to Biosystems
(For Agricultural and Food, Chemical and Civil Engineering students)
Definitive properties and levels of organisation of living systems. Chemical composition of living systems. Cell metabolism. Origin of life-metabolic evolution. Diversity of life forms. Animal and plant tissues and organs. Physiological systems. Protists. Nutrient requirements of organisms. Populations, communities and ecosystems. Biogeochemical cycles. Emergence of man. Impact of man on the biosphere. Social implications of recent advances in biology.

MATH 2600 Mathematics
Unit 1. Vector spaces, basis and dimension. Linear transformations and matrices. Change of basic matrices. Reflection and rotation matrices. Orthogonal and perspective projections. Further theory of determinants. Row, column and determinantal rank of matrices and their equivalence. Nullity. Systems of equations. Eliminants. Resultants. Sylvester's determinantal criterion for two polynomials to have a common root. Discriminants. Further properties of eigenvalues and eigenvectors.

Unit 2. Symmetric bilinear forms. Quadratic forms. Positive definiteness. Inner products. Orthonormal bases. Gram-Schmidt process. Diagonalizability of matrices. Preservation of characteristic polynomial. Eigenvalues determinant and trace under similarity. Principal axis theorem. Classification of quadratic forms. Simultaneous reduction of a pair of forms, one being positive definite.

Unit 3. Functions of two or more variables. Graphs, contours, continuity. Partial derivatives. Linear approximation. Tangent planes and normals to surfaces. Differentiability, gradient, directional derivative, grad, div and curl. Laplacian. Taylor's theorem for functions of two or

more variables. Critical points and their classification. Hessian matrix. Lagrange multipliers. Line integrals, introduction to double integrals and Green's theorem.

Unit 4. Counting procedures. Probability spaces. Events, conditional events, independent events. Bayes' theorem. Random variables. Density and distribution functions. Mean and variance. Basic discrete and continuous distributions: Uniform, binomial, geometric, Poisson, exponential and normal. Random samples. Confidence intervals. Chi-square distribution. Student's *t*-distribution. Use of tables. Hypothesis testing. Engineering examples.

COMP 2605 Computer Science
Software engineering: Requirements analysis, formal and semi-formal specification, top-down structured programming, abstract data types, modularity, validation and verification. Software systems: Assemblers, compilers, high-level languages, operating systems.

Programming problems related to the course material will be assigned.

AFEN 2020 Literature Research Project and Course Work
The Year's Work consists of assignments in the following areas:

Computer Applications (Introduction to PCs, word processing, spreadsheet analysis, databases, presentation graphics, 2D and 3D computer aided drafting)
Electrical and Electronic Engineering
Engineering Technology
Food Science
Literature Research (AFEN 2002)

Third Year

AFEN 3002 Power and Machinery I
Philosophy and practice of design. Materials. Geometric tolerances. Physical, chemical and biochemical characteristics of biological materials including grass, cereals, potatoes, vegetables, fruit, timber and peat. The design of machine components including bearings, shafting, springs and gears. Stress analysis and design for fatigue. Computer-based systems design. Finite element analysis. Computer aided design. International standards.

Engines and fuels. Energy resources. Energy conversion systems. Thermodynamic limits to engine performance. Electric motors. Heat exchangers. Engine testing. Biofuels. Mechanical and fluid power transmission systems, including gearboxes, clutches, torque converters and electronic control systems. Hydraulic power systems.

AFEN 3001 Process Engineering Principles
Basic modes of heat transfer. Steady state conduction. Unsteady state conduction. Free and forced convection. Finned surfaces. Heat exchangers. Radiation. Heat transfer with phase change. Process laboratory practicals. Computer applications.

Mass balances. Mass transfer. Principles and applications of separation processes including: distillation, leaching, filtration, membrane processes, protein fractionation, centrifugation, reactor design. Process laboratory practicals. Computer applications.

MEEN 3001 Thermodynamics
(For Agricultural & Food and Mechanical Engineering students).
Entropy, reversibility and availability. Second Law efficiency.

Rankine, Re-Heat & Regenerative cycles. Brayton-Joule gas turbine cycle. Combined steam & gas turbine cycles. Combined heat & power systems.

Mixtures of gases. Psychrometry. Air Conditioning.

Fuels & Combustion. First Law for reacting systems.

Compressible internal flow: Ideal gas relationships, Mach number and speed of sound. Isentropic flow in converging diverging nozzles. Non-isentropic flow: Fanno and Rayleigh flow, shock waves.

AFEN 3003 Structural and Soil Engineering
Soil classification. Phase relations. Failure theory. Retaining walls. Slope stability. Foundation pressures. Consolidation and compaction.

Structural analysis. Estimation of loading on structures including wind load. Steel, reinforced concrete and wood as structural materials. Design for bending, shear, deflection, compression and buckling in basic structural elements including beams, slabs, walls, columns, trusses and simple frames.

EEEN 3025 Electronic Engineering
(For Agricultural & Food and Mechanical Engineering students)
Amplifiers: Frequency response. The operational amplifier: ideal properties, standard circuit configurations, non-ideal behaviour.
Transducers: brief overview and examples.
Filters: Passive, active, implementations using op-amps.
Data acquisition: sensor impedance; noise types, sources & precautions; signal conditioning; filtering; differential/single inputs; AtoD conversion.
Digital electronics: Gates, transistor implementation. Fundamentals of digital logic, Boolean algebra, Karnaugh maps. Combinational digital logic building blocks, half adder, full adder. Sequential digital logic: JK flip-flop, D and T flip-flops, and memory.

MEEN 3006 Computer Methods in Engineering
(For Agricultural & Food and Mechanical Engineering students)
Statistical methods: interpretation of experimental data, curve fitting, statistical analysis, validation of models. Introduction to finite element analysis. Introduction to rapid application development languages.

MAPH 3034 Engineering Computation
Error analysis, numerical solution of algebraic and transcendental equations, matrix inversion, determination of eigenvalues and eigenvectors, numerical differentiation and integration, application of finite difference methods to ordinary and partial differential equations, interpolation and sampled data and finite element techniques. Non-linear optimisation.

MATH 3600 Mathematics

MATH 3601 Mathematics [Module A: LT-FS-CV] (1 unit)*

Laplace transform (LT). Heavyside-step and Dirac-Delta functions, convolution, solutions of differential equations, engineering examples.

Fourier series (FS). Hilbert spaces, partial differential equations (wave and heat), engineering applications.

Introduction to theory of functions of a complex variable (CV). Cauchy-Riemann equations. Harmonic functions. Conformal mappings. Cauchy integral formulae.

MATH 3602 Mathematics [Module B: Integral Calculus] (1 unit)*

Further advanced calculus. Scalar and vector fields over curves and surfaces. Grad, div and curl. Change of variable. Curvilinear co-ordinates. Integration over domains, curves and surfaces. Divergence theorem. Stokes' theorem. Applications.

ANSC 3600 Crop Husbandry and Animal Husbandry

Climate and soils. Principles of tillage and grass production. Conservation and utilisation of farm foods. Principles of feeding, breeding and management of farm animals. Animals in disease. Animal behaviour; shelter needs of the animal. Interdependence of livestock and crops.

AFEN 3021 Design Project

Students will carry out a design project involving the design of a machine, machine element, item of equipment, building or system associated with a selected aspect of agricultural and food engineering.

AFEN 3022 Year's Work

The year's work consists of projects in the following areas:

Computer Methods in Engineering
Process Engineering (Laboratory)
Electrical/Electronic Engineering (Laboratory)
Mechanics and Thermodynamics (Laboratory)
Structural and Soil Engineering (Design and Laboratory)
Design Project

Fourth Year

AFEN 4003 Food Process Engineering

Pasteurisation, UHT and aseptic processing, microwave and dielectric heating, crystallisation, freezing, homogenisation, emulsification, sensors for food process automation. Computer applications. Laboratory process practicals.

Drying theory and applications, including water binding mechanisms, high and low temperature drying, constant and falling rate periods, industrial applications with reference to foods, feed,

* 1 unit = 24 lecture hours.

peat and timber. Other unit operations connected with the drying process, such as evaporation, extrusion, packaging and storage. Simulation of the drying process, computer applications laboratory. Laboratory process practicals.

AFEN 4004 Food Manufacturing Systems
Quality systems standards. Food legislation. Process plant layout. Principles of cleaning, hygienic design.

Food refrigeration: refrigeration cycles, equipment, thermal properties, cooling and freezing processes, mathematical modelling, IT, chilled and frozen foods.

AFEN 4001 Buildings and Environment
Siting of agricultural buildings and food facilities. Internal layout. Internal environment control systems. Crop storage. Reinforced concrete. Structural steel. Computer applications.

Animal production buildings. Food facilities. Milking parlour design. Agricultural building services. Management and disposal of animal manures. Technologically advanced methods of manure management. Rural roads. Computer applications.

AFEN 4002 Environmental Engineering
Legislation, waste and waste-water treatment, solid waste, atmospheric emissions, noise, IPC licensing, environmental management and auditing. Land as a waste treatment and disposal medium, hydrology, treatment processes in the soil, design.

AFEN 4005 Power and Machinery II
Precision Agriculture
Global Positioning Systems (GPS), Geographic Information Systems (GIS), sensors, yield maps, variable rate technology, satellite imagery, decision support, soil and environmental properties.

Control
Modelling dynamic systems, system response, feedback control. Instrumentation, measurement of pressure, flow and temperature, compact data loggers. Programmable logic controller (PLC) technology.

AFEN 4007 Major Project
Students will carry out a comprehensive project involving experimentation, systems analysis and/or design in an approved topic in agricultural and food engineering. The project will include:
(i) A survey of the literature;
(ii) Oral progress report (seminar style);
(iii) The presentation of a comprehensive report.
In addition to the above, a total of two units[*] of the following course/s must be studied:

BMGT 4001 Management and its Environment (1 unit)
The Irish economy, its institutions and international relationships. The firm and its environment. Organisational objectives and corporate behaviour. Economic concepts. Market structure and the competitive process. Demand analysis. Forms of organisation, private and public bodies.

[*] 1 unit = 24 lecture hours.

Management, its nature and functions – planning, organising, directing, controlling. Financial management. Presentation and analysis of financial statements. Forecasting. Working capital. Capital budgeting. Financial institutions. Marketing management. Market research. Product life cycle. Product mix. Marketing mix. Operations management. Concept of a system. System design, planning and control. Personnel management. Industrial relations. Trade unions. Collective bargaining.

AERD 4600 Farm Management (1 unit)
Objectives and goals of the farm manager, farm management functions and organisation, farm family life cycle. Farm accounting definitions and analysis techniques, capital budgeting and investment appraisal, partial budgeting and whole farm planning and budgeting; enterprise budgets, direct payments, REPS and other State supports. Farm management controls, computerisation and IT; alternative enterprises, farm labour and risk analysis, part-time farming. Farm security and safety, management for quality production at farm level.

ELEN 4005 Renewable Energy Systems (1 unit)
Aspects of renewable energy systems (e. g. windpower, hydropower, wavepower, photovoltaic conversion, direct solar heating, biomass, hydrogen as an energy vector, introduction to economic analysis).

AFEN 4006 Surveying (1 unit)
Chain surveying; surveys of small areas and buildings; survey instruments and their use in plane surveying; ordnance survey maps; triangulation, calculation and adjustment of traverses; circular curves. Contouring and topographic surveying; tacheometry. Electronic distance measurement. Areas and volumes. Aerial surveying and associated area mensuration.

AFEN 4010 Forest Engineering (1 unit)
Forest machinery design, selection and operation. Timber transport. Environmental impact. Central tyre inflation (CTI) and telemetric control systems.

Mathematics (1 unit):

MATH 4601 Mathematics (1 unit)
A series of lectures on selected topics in Mathematics. Topics will be declared at the beginning of each academic Year.

MATH 4602 Mathematics (1 unit)
A series of lectures on selected topics in Mathematics. Topics will be declared at the beginning of each academic Year.

ENVS 4030 Environmental Policy and Management (1 unit)
This will provide an overview of analytical techniques applied in management and policy analysis in regard to key environmental challenges, including climate change, acidification, water, air, waste. Sectoral issues in agriculture, industry (IPC licensing), transport and energy will be addressed. Students will acquire some insights as to the key issues, and an analytical framework with which to address them. Lectures will be complemented as appropriate by the views of key leaders in environmental policy and management in Ireland.

MEEN 4004 Managing Manufacturing Enterprise (1 unit)
For course description, see under 'Mechanical Engineering', page 89.

Chemical Engineering

First Year

Mathematics	MATH 1600
Experimental Physics*	EXPH 1603
Chemistry*	CHEM 1604
Mathematical Physics	MAPH 1014
Computer Science*	COMP 1604
Introduction to Chemical Engineering	CHEN 1101
Chemical Engineering Process Principles 1	CHEN 1001
Electronic and Electrical Engineering	EEEN 1001
Engineering Fluid Mechanics	CVEN 1003
Engineering Thermodynamics	MEEN 1003
Languages	ENGF 1002

* These subjects have a laboratory or other practical component in addition to the lecture course.

Second Year

Chemical Engineering and Measurement	CHEN 2001
Chemical Thermodynamics and Kinetics	CHEN 2007
Chemistry	CHEN 2008
Computers in Chemical Engineering I	CHEN 2010
Mechanics of Fluids	MEEN 2008
Biotechnology I	CHEN 2005
Mechanics of Materials	MEEN 2002
Mathematics	MATH 2604
Experimental Physics	EXPH 2607
Chemical Engineering & Process Principles II	CHEN 2006
Year's Work	CHEN 2012

Third Year

Note: Third year students should note that in the assessment for the BE Degree the performance of candidates at both the Third and Final Examinations is taken into account in the following manner: An adjusted overall percentage mark will be computed by adding 30% of the percentage mark obtained at the first sitting of the Third Examination to 70% of the percentage mark obtained in the Final Examination. Ranking of students and the award of Honours in the BE Degree will be based on such adjusted overall percentage mark.

Unit Operations	CHEN 3010
Heat Transfer I and Mass Transfer	CHEN 3002
Fluid Flow I	CHEN 3003
Mechanical Design and Engineering Materials	CHEN 3011
Applied Chemistry	CHEN 3009
Chemical Engineering Thermodynamics	CHEN 3006
Computers in Chemical Engineering II	CHEN 3012
Biotechnology II	CHEN 3008
Electrical Engineering	EEEN 3027
Engineering Computation	MAPH 3014
Pure and Applied Mathematics	MATH 3615
Year's Work	CHEN 3021

Fourth Year

Unit Operations II	CHEN 4001
Reactor Design and Automatic Control	CHEN 4002
Heat Transfer II and Fluid Flow II	CHEN 4003
Process Design	CHEN 4004
Chemical and Biochemical Engineering Processes	CHEN 4005
Environmental Studies	CHEN 4006
Management and its Environment	BMGT 4001
Design Project	CHEN 4007
Research Project	CHEN 4008

Elective Courses:

One course from MATH 4601 or MATH 4602	
Mathematics	MATH 4601
Mathematics	MATH 4602

Students may choose their elective course in consultation with the staff of the Department and they must inform the Head of the Department of the course in which they wish to be examined not later than *four* weeks after the commencement of the academic Year Students may not sit examinations in more than one elective course. An elective course will not be offered unless at least five students register for it.

First Year

MATH 1600 Mathematics

Four course units, each unit comprises approximately 24 lectures.

Unit 1: Sets, functions, continuity, differentiation, curve sketching, optimization.

Unit 2: Solutions of systems of linear equations, matrix algebra, determinants, complex numbers, eigenvalues and eigenvectors, vectors in 3-space, scalar and vector products, lines and planes in 3-space.

Unit 3: Definite and indefinite integration, techniques of integration, applications of integration, first and second order ordinary differential equations.

Unit 4: Infinite series, power series, Taylor's theorem and series, partial differentiation of functions of two or more variables, Lagrange multiplier method.

EXPH 1603 Experimental Physics

Lectures: Three lectures each week in the first semester and two lectures each week in the second semester.

Laboratory: Two hours each week.

Introduction to Mechanics: gravitation;

Wave motion: light and sound, reflection, refraction, interference, diffraction, Doppler effect, ray optics, mirrors and lenses;

Electricity and magnetism: electrostatics, capacitance, magnetism, electromagnetic induction, electromagnetic waves;

Quantum physics: quantization of radiant energy, atomic levels, electric charge; Radioactivity: unstable nuclei, α, β, γ decay, fission, fusion.

CHEM 1604 Chemistry

Lectures: Two lectures each week.

Laboratory: Nine laboratory sessions, each of three hours duration, in the second semester.

Atomic structure and the periodic table; bonding, valency, formulae and shape of molecule; moles and stoichiometry; molecular/ionic equilibrium; acids and bases; redox reactions; volumetric analysis; rates of reaction; thermochemistry; electrochemistry and metals; non-metals; organic chemistry.

MAPH 1014 Mathematical Physics

Lectures: Two per week in the first semester and three per week in the second semester.

Vectors, relative velocity, equilibrium of a particle, Newton's Second Law of Motion applied to particle; momentum and impulse; work, power and energy; conservative forces in one dimension; linear motion with constant acceleration; projectiles; circular motion; simple harmonic motion; linear motion with variable acceleration; compound pendulum motion; motion of a rigid body; small oscillations of a rigid body; equilibrium of a rigid body; reduction of a system of coplanar forces; distributed forces; centre of gravity; equilibrium of two and three forces acting on a rigid body; equilibrium of more than three forces acting on a rigid body.

COMP 1604 Computer Science
Lectures: One lecture each week.
Laboratory: Two hours per week.

Introduction to computers; basic hardware; concept of a program; operating systems; files; syntax and semantics; logic; loops; data structures; sorting; structured programming; debugging; program validation; application packages.

CVEN 1003 Engineering Fluid Mechanics
One lecture per week.

Introduction: states of matter, definition of a fluid; fluid properties; fluid statics: pressure intensity, pressure measurement, fluid pressure on surfaces, Archimedes law, flotation/stability; fluid kinematics: streamlines, continuity equation, Bernoulli's equation, flow measurement, orifices, trajectory of a liquid jet; fluid dynamics: momentum equation, fluid acceleration; applications.

EEEN 1001 Electronic and Electrical Engineering
Overview of electronic and electrical engineering; elementary electrical concepts; basic DC circuit analysis; basic transients; electrical signals; frequency spectrum; analogue signals, amplifiers, applications; digital signals, basic logic circuits, applications; elementary electromagnetics.

MEEN 1003 Engineering Thermodynamics
One lecture per week.

Basic concepts of thermodynamics; properties of pure substances; work and heat; First Law of thermodynamics for a closed system; control volume; conservation of mass and energy; introduction to the Second Law and entropy; conduction, convection and radiation; applications.

CHEN 1101 Introduction to Chemical Engineering
Approximately one hour per week. History of Chemical Engineering. Chemical and Process Industries in Ireland. Careers in Chemical Engineering. Introduction to the Professional Institutions. Library orientation. Industry site visits (3-4 per annum).

CHEN 1001 Engineering Process Principles 1
One lecture per week.

Conservation of mass, energy and momentum. Rate equations. Equilibrium relations. SI units. Industrial stoichiometry. Introduction to transport phenomena. Modelling of simple chemical engineering systems.

ENGF 1002 Languages
Thirty six hours of language classes in the academic Year.

Candidates who enter for the Degree of BE shall be required to pass a College Examination in foreign languages. Students will not be conferred with the BE Degree until they have satisfied the language requirement.

Second Year

CHEN 2001 Chemical Engineering Measurement
Principles of engineering measurement and experimentation; report-writing; data presentation and analysis; temperature measurement; pressure measurement; laminar and turbulent pipe flow; flow measurement; principles of fluid rheology; rotational viscometers; tank-tube viscometer; basic particle size analysis; introduction to centrifugal pumps; basic engineering statistics; histograms; probability density function; basics of probability; probability density functions; normal and lognormal distributions; confidence intervals on the mean and variance; hypothesis testing ;t-test, chi-squared test, f-test, p-values; one-way ANOVA.

CHEN 2007 Chemical Thermodynamics and Kinetics
Thermodynamics: Introduction. The first law, stoichiometry and enthalpy balance problems. The second law, reversibility and irreversibility, the Carnot cycle, Clausius' theorem, entropy, entropy calculations. The Gibbs and Helmholtz functions. Equilibrium criteria. The fundamental property relations for a homogeneous fluid of constant composition. Maxwell's relations. The third law. The thermodynamics of open systems. Gas, steam and refrigeration cycles.

Chemical Kinetics: The rate equation. Analysis of kinetic data. The Arrhenius equation. Elementary and complex reactions. Batch and flow reactors. Physical and chemical adsorption. Adsorption isotherms. Measurement of surface area and pore size distribution. L-H and H-W models.

CHEN 2008 Chemistry
Introduction to industrial and applied chemistry. Unit processes in organic synthesis and industrial applications. Laboratory work relating to the content of lecture courses.

CHEN 2010 Computers in Chemical Engineering I
An applied programming course to introduce computer based problem solving techniques. Students are expected to complete a number (6 to 8) of assignments covering a range of problems drawn from different areas of chemical engineering and which use selected numerical methods in their solution. Both Matlab® and Excel are used extensively throughout the course.

MEEN 2008 Mechanics of Fluids
A continuation course on fluid flow from a physical viewpoint. Review of fluid properties. Fluid statics. Kinematics of fluid flow. Continuity equation. Stream function – two-dimensional-incompressible. Rotational and irrotational motion. Circulation. Equations of irrotational motion. Dynamics of fluids. Force, energy and momentum. Effects of pressure, weight, viscosity, turbulence and compressibility. Dynamic similitude. Boundary layers, surface drag, form drag. Turbo-machinery.

CHEN 2005 Biotechnology I
Relevance of biochemistry, industrial microbiology and biotechnology to chemical engineering; biological catalysis; enzymes; protein structure and function; sugars and polysaccharides; macromolecules; DNA double helix; transcription and translation; the genetic code; control of expression; energy coupling; ATP; glycolysis; TCA cycle; electron transport; aerobic and anaerobic metabolism; higher organisms and cellular differentiation; microbial cells; microbial nutrition; microbial metabolism; microbial growth; microbial genetics; asepsis; applications.

MEEN 2002 Mechanics of Materials
One dimensional stress and strain. Biaxial stress. Principal stresses and strains in 2-D. Hookes Law. Strain gauges. Thin-walled pressure vessels. Torsion of circular shafts. Bending stresses and deflections. Buckling of slender bars.

MATH 2604 Mathematics
Unit 1. Vector spaces, basis and dimension. Linear transformations and matrices. Changes of basic matrices. Reflection and rotation matrices. Orthogonal and perspective projections. Further theory of determinants. Row, column and determinantal rank of matrices and their equivalence. Nullity. Systems of equations. Eliminants. Resultants. Sylvester's determinantal criterion for two polynomials to have a common root. Discriminants. Further properties of eigenvalues and eigenvectors.

Unit 2. Symmetric bilinear forms. Quadratic forms. Positive definiteness. Inner products. Orthonormal bases. Gram-Schmidt process. Diagonalizability of matrices. Preservation of characteristic polynomial. Eigenvalues determinant and trace under similarity. Principal axis theorem. Classification of quadratic forms. Simultaneous reduction of a pair of forms, one being positive definite.

Unit 3. Functions of two or more variables. Graphs, contours, continuity. Partial derivatives. Linear approximation. Tangent planes and normals to surfaces. Differentiability, gradient, directional derivative, grad, div and curl. Laplacian. Taylor's theorem for functions of two or more variables. Critical points and their classification. Hessian matrix. Lagrange multipliers. Line integrals, introduction to double integrals and Green's theorem.

Unit 4. Counting procedures. Probability spaces. Events, conditional events, independent events. Bayes' theorem. Random variables, Density and distribution functions. Mean and variance. Basic discrete and continuous distributions: Uniform, binomial, geometric. Poisson, exponential and normal. Random samples. Confidence intervals. Chi-square distribution. Student's *t*-distribution. Use of tables. Hypothesis testing. Engineering examples.

EXPH 2607 Experimental Physics
Two lectures a week during Michaelmas, Hilary and Trinity terms.

Thermal radiation, theory and application. Photons. Light as waves and particles. Quantisation of energy and momentum in atoms. Demonstration of quantised energy levels. Wavelike properties of particles. Wave mechanics and the Schrodinger equation. Time independent wave equation and applications. The one electron atom. Radiation and energy transitions. Atoms in magnetic fields. Anomalous Zeeman effect. Electron spin. Many electron atoms. Pauli exclusion principle. Emission and absorption. Introduction to statistical mechanics, microstates and macrostates. Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein distributions. Applications to solids. Laser cooling of atoms and ions, Bose-Einstein condensation. Low-dimensional structures: quantum wells, wires and dots. Periodic structures. Lasers: Einstein coefficients, population inversion, feedback and cavity design. Diode lasers, quantum well and quantum cascade lasers. Magnetism, ferromagnetism, domains and boundaries, hysteresis, new magnetic materials. Laboratory: Four Laboratory experiments involving measurements of the physical quantities discussed in the course of lectures.

CHEN 2012 Year's Work
Chemical Engineering Graphics: A practical introduction to computer-based drafting. Flow sheets in standard format and graphical presentations relevant to chemical engineering.

Chemical Engineering Laboratory I: A course of laboratory experiments and computing sessions designed to illustrate fundamental principles of chemical engineering, measurement and Chemistry. Experiments are undertaken in heat and mass transfer, fluidflow, liquid pumping, rheological characterisation and particle size distribution analysis. Chemical analysis – Volumetric and gravimetric methods. Electrochemistry – Conductance behaviour of electrolytes, the Nernst equation, potentiometric methods. Surface chemistry – Adsorption from solution, surface tension, ion exchange. Chemical kinetics – Reaction order, the Arrhenius equation. Instrumental analytical techniques – The use of conductance bridges, pH meters, potentiometers, ion activity meters, gas chromatography and atomic adsorption spectrophotometry.

CHEN 2006 Chemical Engineering and Process Principles II
Introduction to Transport Phenomena in Chemical Engineering Processes.

Third Year

CHEN 3010 Unit Operations I
Momentum Transfer Operations: Fluid flow through packed beds, filtration, particle movement through a fluid, free and hindered setting, sedimentation, dust collection, air pollution control theory and technology.

Heat Transfer Operations: Humidification, operations, psychometric chart, humidity measurement, solids drying, rotary dryers, evaporation.

CHEN 3002 Heat Transfer I and Mass Transfer
Heat Transfer I: Modes of heat transfer. Steady state conduction. Unsteady state conduction. Free and forced convection. Design of heat exchangers. Introduction to: boiling; condensation.

Mass Transfer: Molecular diffusion in gases and liquids. Diffusivity. Diffusion in turbulent flow. Analogies between heat, mass and momentum transfer. Interphase mass transfer. Mass transfer coefficients. Various theories of interphase mass transfer. Eddy diffusion. Diffusion in solids. Applications to chemical and biochemical engineering problems.

CHEN 3003 Fluid Flow I
Flow measurement, pressure drop in heat exchanges and packed beds. Drag coefficients and particle trajectories. Two-phase pipe flow. Non-Newtonian fluids and power law flow. The classification and characteristics of pumps, fans and compressors. Agitator power requirements.

CHEN 3011 Mechanical Design and Engineering Materials
Mechanical Design: Introduction to pressure vessel design methods. Pressure relief. Piping design. Quality assurance in design.

Engineering Materials: Structure of engineering materials. Mechanical properties. Metals and alloys. Ceramics and inorganic glasses. Organic polymers. Composites, Coatings. Laboratory demonstrations of related techniques.

CHEN 3006 Chemical Engineering Thermodynamics
Introduction to the thermodynamics of multi-component systems. Molar and partial molar quantities. Experimental measurement of partial molar volume and partial molar enthalpy. Partial molar free energy. The Gibbs-Duhem equation. Phase equilibrium and reaction equilibrium criteria. The ideal gas mixture. The ideal solution. Fugacity, fugacity coefficient correlations. The Lewis and Randall rule. Excess properties, activity coefficients. The phase rule; phase behaviour in vapour-liquid, liquid-liquid and solid-liquid systems – the use of activity coefficient correlations and equations of state. Chemical reaction equilibria; equilibrium constants, the van't Hoff equation. Reactions in homogeneous and heterogeneous systems.

CHEN 3012 Computers in Chemical Engineering II
An applied programming course to introduce computer based problem solving techniques. Students are expected to complete a number (6 to 8) of assignments covering a range of problems drawn from different areas of chemical engineering and which use selected numerical methods in their solution. Both Matlab® and Excel are used extensively throughout the course.

CHEN 3008 Biotechnology II
Properties and function of DNA; DNA polymerase; gene cloning; gene libraries; analytical techniques; vectors and hosts; choice of a vector; drug resistance genes; the lac operon; gene sequencing; overexpression systems; promotors; eukaryotic and prokaryotic genes; post-translational modification; codon usage; protein engineering; methods of selecting for mutant overwild-type; monitoring protein production; solubilisation and refolding; protein recovery; biospecific methods; PCR; introduction to ethics and patenting in Biotechnology; basic bioreactor technology; monitoring and control; stoichiometry of bioreactions; heat generation and mass transfer in bioreactors; shear effects in fermentation systems.

CHEN 3009 Applied Chemistry
Study of selected topics in industrial and applied Chemistry.

EEEN 3027 Electrical Engineering
DC circuit analysis. AC circuit analysis. Energy power, reactive power, phasor analysis applied to single phase circuits. Power factor correction. Series resonance. Operational amplifier and applications. Elementary active and passive filters. Phasor analysis of three phase circuits. Power measurement in three phase circuits. Magnetic circuits. Operating principle of the single phase transformer. Equivalent circuit of the transformer. Rotating fields in three phase machines. Operating principle of the three phase induction machine. Development of the equivalent circuit of the three phase induction machine. Starting and speed control of induction motors. Electrical safety. Protection. Codes of Practice. Electrical safety in potentially flammable atmospheres.

MAPH 3014 Engineering Computation
Error analysis, numerical solution of algebraic and transcendental equations, matrix inversion, determination of eigenvalues and eigenvectors, numerical differentiation and integration, application of finite difference methods to ordinary and partial differential equations, interpolation and sampled data and finite element techniques. Non-linear optimisation.

MATH 3615 Pure and Applied Mathematics

MATH 3601 Mathematics (LT, FS and CV or CofV)

Laplace transform (LT). Heavyside-step and Dirac-Delta functions, convolution, solutions of differential equation, engineering examples.

Fourier series (FS). Hilbert spaces, partial differential equations (wave and heat) engineering applications. Introduction to calculus of variations (CofV) or introduction to theory of functions of a complex variable (CV). Cauchy-Riemann equations. Harmonic functions. Conformal mappings. Cauchy integral formulae.

MATH 3602 Mathematics (Integral Calculus)

Further advanced calculus. Scalar and vector fields over curves and surfaces. Grad, div and curl. Change of variable. Curvilinear co-ordinates. Integration over domains, curves and surfaces. Divergence theorem. Stokes' theorem. Applications.

MAPH 3024 Mathematics Physics (Differential Equations)

Ordinary differential equations. Isoclines. Linear systems of first order. Phase plane. Singular points. First order p.d.e. How they arise. Sketching characteristics. Solutions. Second order p.d.e. How they arise. The Cauchy problem. Characteristics. Difference schemes for Laplace. Wave and diffusion equations. Motivation for different initial or boundary value problems. Properties of solutions.

CHEN 3021 Year's Work

Chemical Engineering Laboratory II: A course of laboratory experiments designed to illustrate fundamental chemical engineering and chemical principles and to afford experience of selected unit operations. A written report, detailing measurements, results, discussion and conclusion to be submitted for each experiment.

Fourth Year

CHEN 4001 Unit Operations II

Calculation methods for multi-stage mass transfer operations. Liquid-liquid extraction. Leaching. The air-water system. Drying mechanisms. Design of water cooling towers and humidification processes. Multicomponent separation processes. Batch distillation. The design of trays and other column contacting devices.

CHEN 4002 Reactor Design and Automatic Control

Reactor Design: Design of batch, continuous plug-flow, and stirred tank reactors for single and multiple reaction schemes. Non-catalytic and catalytic heterogeneous reactions and reactor design for heterogeneous systems. Mixing and residence time distribution concepts. Unsteady state operation of continuous stirred tank reactors. Non-isothermal reactor performance. Selected examples from chemical engineering and biochemical engineering reactor design.

Automatic Control: Feedback. Transfer functions. Characteristic equations and root locus. Routh-Hurwitz stability. Bode and Nyquist diagrams. State space analysis. Liapunov stability. Pontryagin's maximum principle. Sampled data systems. Microcomputer-based control systems.

CHEN 4003 Heat Transfer II and Fluid Flow II
Heat Transfer II: Radiant heat exchange. Radiation from gases. Boiling liquids. Condensing vapours. Analysis of heat transfer by convection. Design of heat transfer equipment.

Fluid Flow II: The Navier-Stokes equations. Applications to film flows and viscometric flows. Potential flow. Boundary layer theory. Theories of turbulence. Fluid-particle interactions. Applications to process equipment design. One-dimensional compressible flow in pipes, nozzles and diffusers. Choked flow.

CHEN 4004 Process Design
The design method. Chemical engineering specifications. Factories Act. Patents. Process simulation. Capital and operating costs of process plants. Project evaluation methods. Uncertainty and risk in process design. Safety in design and operation of plants. Loss prevention.

CHEN 4005 Chemical and Biochemical Engineering Processes
A selection from the following topics: Energy management in process plants. Multicomponent distillation. Absorption with chemical reaction. Adsorption. Chromatography. Membrane separation processes. Ion-exchange. Surface phenomena. Sterilisation and pasteurisation. Fermentation processes. Bioreactor performance.

CHEN 4006 Environmental Studies
Selected topics from the following:
Air Pollution: Introduction. The nature of air pollution. Effects on human health, fauna and materials. Global effects. Monitoring of source and ambient levels of gaseous and particulate pollutants. Outline of current control technologies. Gaussian plume dispersion models. Use of US EPA software. EU and Irish legislation.

Water Pollution: Description of a river in its natural state and the chemical cycles in nature. Chemical tests and analysis of river water and effluents and the significance and interpretation of the results; the nature and effects of water pollution; causes of pollution with particular reference to the results of surveys carried out in Ireland; mathematical models of river pollution and recovery; water quality standards and legislation; effluent treatment models; case studies.

Waste Disposal: Waste Management Act (1996). Definition of Waste and Hazardous Waste. National Waste Database. Waste Flows in Ireland. National Hazardous Waste Management Plan. Methodologies used for the collection of information on waste arisings and disposal/recovery practices. European Waste Catalogue and Hazardous Waste List. Waste Minimisation. Hazardous Waste Incineration. Thermo-chemistry and stoichiometry of incineration reactions. Liquid Injection and Rotary Kiln Incinerator Design. Emission Control. Dioxins. Landfilling of Hazardous Wastes.

BMGT 4001 Management and its Environment
The Irish economy, its institutions and international relationships. The firm and its environment. Organisational objectives and corporate behaviour. Economic concepts. Market structure and the competitive process. Demand analysis. Forms of organisation, private and public bodies. Management, its nature and functions – Planning, organising, directing, controlling. Financial management. Presentation and analysis of financial statements. Forecasting. Working capital. Capital budgeting. Financial institutions. Marketing management. Market research. Product life cycle. Product mix. Marketing mix. Operations management. Concept of a system. System design, planning and control. Personnel management. Industrial relations. Trade unions. Collective bargaining.

CHEN 4007 Design Project
Students undertake a design project which includes the preparation of flow sheets, material and energy balances, detailed design, mechanical design and the preparation of process instrumentation drawings. Safety, loss prevention and environmental impact are included in the design. Capital and operating costs of the plant are evaluated.

CHEN 4008 Research Project
Students working singly or in pairs undertake a research project.

Elective Course
One course to be chosen from MATH 4601 or MATH 4602. Students must inform the Head of the Department of the course in which they wish to be examined not later that *four* weeks after the commencement of the academic Year Students may not sit examinations in more that one elective course. An elective course will not be offered unless at least five students register for it. Details of the elective courses are given overleaf.

MATH 4601 Mathematics
A series of lectures on selected topics in Mathematics. Topics will be declared at the beginning of each academic Year.

MATH 4602 Mathematics
A series of lectures on selected topics in Mathematics. Topics will be declared at the beginning of each academic Year.

Civil Engineering

First Year

Mathematics	MATH 1600
Experimental Physics*	EXPH 1603
Chemistry*	CHEM 1604
Mathematical Physics	MAPH 1014
Computer Science*	COMP 1604
Engineering Graphics*	CVEN 1001
Electronic and Electrical Engineering	EEEN 1001
Engineering Fluid Mechanics	CVEN 1003
Engineering Thermodynamics	MEEN 1003
Introduction to Civil and Mechanical Engineering	CVEN 1101
Languages	ENGF 1002

* These subjects have a laboratory or other practical component in addition to the lecture course.

Second Year

Mechanics of Solids	CVEN 2006
Mechanics of Fluids	MEEN 2008
Surveying	CVEN 2002
Building Construction	CVEN 2003
Introduction to Biosystems	CVEN 2001
Computer Applications in Civil Engineering	CVEN 2007
Engineering Materials I	CVEN 2004
Engineering Materials II	MEEN 2009
Mathematics	MATH 2600
Year's Work	CVEN 2020

Third Year

Theory of Structures	CVEN 3004
Design of Structures	CVEN 3005
Hydraulics	CVEN 3001
Engineering Economy	CVEN 3002
Soil Mechanics	CVEN 3003
Year's Work	CVEN 3020
Engineering Computation	MAPH 3034
Mathematics	MATH 3613
Mathematics	MATH 3614
Mathematical Physics	MAPH 3025
Geology	GEOL 3611

Fourth Year

The academic programme for the Fourth Year in the Department of Civil Engineering consists of four core subjects and two elective subjects. Candidates must choose the elective subjects in which they propose to present themselves for examination, in consultation with the Professor of Civil Engineering. The number admitted to any elective subject offered within the department will be limited to thirty (30). Admission to any particular elective subject will depend on performance in the Third Year Examination.

Core Subjects

Civil Engineering Design		CVEN 4001
The Engineer and Society		CVEN 4002
Engineering Report	}	
Course Work	}	CVEN 4020

Elective Subjects

Each of the following seven courses constitutes one full elective subject.

Structural Modelling	CVEN 4003
Structural Design	CVEN 4004
Soil Mechanics and Geotechnical Engineering	CVEN 4005
Transportation Operations and Planning	CVEN 4006
Hydraulic Engineering Design	CVEN 4010
Unit Treatment Processes in Water Engineering	CVEN 4008

Each of the following courses constitutes half an elective subject; any two may be selected as comprising an elective subject.

Mathematics	MATH 4601
Mathematics	MATH 4602

First Year

MATH 1600 Mathematics

Four course units, each unit comprises approximately 24 lectures.

Unit 1: Sets, functions, continuity, differentiation, curve sketching, optimization.

Unit 2: Solutions of systems of linear equations, matrix algebra, determinants, complex numbers, eigenvalues and eigenvectors, vectors in 3-space, scalar and vector products, lines and planes in 3-space.

Unit 3: Definite and indefinite integration, techniques of integration, applications of integration, first and second order ordinary differential equations.

Unit 4: Infinite series, power series, Taylor's theorem and series, partial differentiation of functions of two or more variables, Lagrange multiplier method.

EXPH 1603 Experimental Physics

Lectures: Three lectures each week in the first semester and two lectures each week in the second semester.

Laboratory: Two hours each week.

Introduction to Mechanics: gravitation;

Wave motion: light and sound, reflection, refraction, interference, diffraction, Doppler effect, ray optics, mirrors and lenses;

Electricity and magnetism: electrostatics, capacitance, magnetism, electromagnetic induction, electromagnetic waves;

Quantum physics: quantization of radiant energy, atomic levels, electric charge; Radioactivity: unstable nuclei, α, β, γ decay, fission, fusion.

CHEM 1604 Chemistry

Lectures: Two lectures each week.

Laboratory: Nine laboratory sessions, each of three hours duration, in the second semester.

Atomic structure and the periodic table; bonding, valency, formulae and shape of molecule; moles and stoichiometry; molecular/ionic equilibrium; acids and bases; redox reactions; volumetric analysis; rates of reaction; thermochemistry; electrochemistry and metals; non-metals; organic chemistry.

MAPH 1014 Mathematical Physics

Lectures: Two per week in the first semester and three per week in the second semester.

Vectors, relative velocity, equilibrium of a particle, Newton's Second Law of Motion applied to particle; momentum and impulse; work, power and energy; conservative forces in one dimension; linear motion with constant acceleration; projectiles; circular motion; simple harmonic motion; linear motion with variable acceleration; compound pendulum motion; motion of a rigid body; small oscillations of a rigid body; equilibrium of a rigid body; reduction of a system of coplanar forces; distributed forces; centre of gravity; equilibrium of two and three forces acting on a rigid body; equilibrium of more than three forces acting on a rigid body.

COMP 1604 Computer Science
Lectures: One lecture each week.
Laboratory: Two hours per week.
Introduction to computers; basic hardware; concept of a program; operating systems; files; syntax and semantics; logic; loops; data structures; sorting; structured programming; debugging; program validation; application packages.

CVEN 1001 Engineering Graphics
One lecture and one practical class per week.
Manual draughting:
Use of drawing instruments. Lettering, linework and preparation of computation sheets. Descriptive geometry, orthographic and isometric projection. Sections. Dimensioning. Freehand sketching. Plane curves and Developments.

Computer-aided draughting (CAD):
File creation and management. Element placement, manipulation and modification. Shapes, patterning, dimensioning and drawing with constraints.

CVEN 1003 Engineering Fluid Mechanics
One lecture per week.
Introduction: states of matter, definition of a fluid; fluid properties; fluid statics: pressure intensity, pressure measurement, fluid pressure on surfaces, Archimedes law, flotation/stability; fluid kinematics: streamlines, continuity equation, Bernoulli's equation, flow measurement, orifices, trajectory of a liquid jet; fluid dynamics: momentum equation, fluid acceleration; applications.

EEEN 1001 Electronic and Electrical Engineering
Overview of electronic and electrical engineering; elementary electrical concepts; basic DC circuit analysis; basic transients; electrical signals; frequency spectrum; analogue signals, amplifiers, applications; digital signals, basic logic circuits, applications; elementary electromagnetics.

MEEN 1003 Engineering Thermodynamics
One lecture per week.
Basic concepts of thermodynamics; properties of pure substances; work and heat; First Law of thermodynamics for a closed system; control volume; conservation of mass and energy; introduction to the Second Law and entropy; conduction, convection and radiation; applications.

CVEN 1101 Introduction to Civil and Mechanical Engineering
One lecture per week in the first term and site or laboratory visits in the second/third term.
A series of lectures and Engineering laboratory or site visits will be given by staff of Civil and Mechanical Engineering. This programme is designed to provide first year students with a broad overview of both disciplines. It will also assist those who have entered the Civil or Mechanical stream in making an informed choice as to which degree they will opt for in second Year

ENGF 1002 Languages
Thirty-six hours of language classes in the academic Year.

Candidates who enter for the Degree of BE shall be required to pass a College Examination in foreign languages. Students will not be conferred with the BE Degree until they have satisfied the language requirement.

Second Year

CVEN 2006 Mechanics of Solids
Force equilibrium. Statically determinate structures. Trusses and planar frameworks. Rigid bodies supported on deformable supports. Statically indeterminate structures. Concepts of stress and strain. Stress-strain behaviour. Bulk modulus and shear modulus. Plane stress and plane strain. Transformation of axes and the Mohr circle. Principal stresses. Strain energy. Case studies in stress. Bending, shear and torsional stresses in beams. Stress trajectories. Effects of plasticity. Deflection analysis. Buckling of struts. Factors of safety.

MEEN 2008 Mechanics of Fluids
A continuation course on fluid flow from a physical viewpoint. Review of fluid properties. Fluid statics. Kinematics of fluid flow. Continuity equation. Stream function - Two-dimensional-incompressible. Rotational and irrotational motion. Circulation. Equations of irrotational motion. Dynamics of fluids. Force, energy and momentum. Effects of pressure, weight, viscosity, turbulence and compressibility. Dynamic similitude. Boundary layers, surface drag, form drag. Turbo-machinery.

CVEN 2002 Surveying
Survey instruments and their use in plane surveying. Base line measurements, triangulation, calculation and adjustment of traverses. Contouring and topographic survey. Hydrographic surveys. Circular transition and vertical curves. Cross-section and earthwork quantities. Tacheometry, subtense measurement, electronic distance measurement.

CVEN 2003 Building Construction
Fundamentals of building construction for domestic, industrial and commercial buildings. Site preparation, foundations, ground and suspended floors, roofs, walls, stairs. Construction materials, timber, concrete, structural steelwork, dampness, fire protection, finishes. Water supply, drainage, sewage disposal, heating and ventilation, insulation, condensation, energy use. Site organisation, plant and equipment, temporary works. Health and safety: context, legislation, hazard identification and risk assessment, health and safety management, recent developments'.

CVEN 2001 Introduction to Biosystems
(For Agricultural & Food, Chemical and Civil Engineering students)
Definitive properties and levels of organisation of living systems. Chemical composition of living systems. Cell metabolism. Origin of life-metabolic evolution. Diversity of life forms. Animal and plant tissues and organs. Physiological systems. Protists. Nutrient requirements of organisms. Populations, communities and ecosystems. Biogeochemical cycles. Emergence of man. Impact of man on the biosphere. Social implications of recent advances in biology.

CVEN 2007 Computer Applications in Civil Engineering
Programming in Visual Basic: control structures, user-friendly interface development, graphical applications, implementation of engineering mathematical examples, developing stable programmes. Using Visual Basic with Applications. Introduction to Visual Fortan. Control structures. Using spreadsheets: general orientation, equation manipulation, graphs, goal seek, solver, matrix inversion, macros.

CVEN 2004 Engineering Materials I
Timber: structure, strength and durability, manufactured products.

Cements: manufacture, types, uses, hydration process. Aggregates.

Concrete: structural properties, durability. New and emerging engineering materials.

Soils: origin, description/classification. Mass, volume and basic relationships. Microstructure of clayey materials. Suitability criteria for soils in earthworks.

Bituminous Materials.

MEEN 2009 Engineering Materials II
Introduction to Materials, their classification and selection. Fundamentals of material structure and properties. Mechanical properties and their measurement. Introduction to failure mechanisms, ductile and brittle failure, creep and fatigue. Introduction to iron and steel, carbon in steel, the iron/iron carbide phase diagram, types and properties of steels. Welding, weldable structural steel, the heat affected zone, weldability and weld defects. Non-destructive examination, principles and methods. Corrosion, stainless steels. Surface treatment.

MATH 2600 Mathematics
Unit 1. Vector spaces, basis and dimension. Linear transformations and matrices. Change of basic matrices. Reflection and rotation matrices. Orthogonal and perspective projections. Further theory of determinants. Row, column and determinantal rank of matrices and their equivalence. Nullity. Systems of equations. Eliminants. Resultants. Sylvester's determinantal criterion for two polynomials to have a common root. Discriminants. Further properties of eigenvalues and eigenvectors.

Unit 2. Symmetric bilinear forms. Quadratic forms. Positive definiteness. Inner products. Orthonormal bases. Gram-Schmidt process. Diagonalizability of matrices. Preservation of characteristic polynomial. Eigenvalues determinant and trace under similarity. Principal axis theorem. Classification of quadratic forms. Simultaneous reduction of a pair of forms, one being positive definite.

Unit 3. Functions of two or more variables. Graphs, contours, continuity. Partial derivatives. Linear approximation. Tangent planes and normals to surfaces. Differentiability, gradient, directional derivative, grad, div and curl. Laplacian. Taylor's theorem for functions of two or more variables. Critical points and their classification. Hessian matrix. Lagrange multipliers. Line integrals, introduction to double integrals and Green's theorem.

Unit 4. Counting procedures. Probability spaces. Events, conditional events, independent events. Bayes' theorem. Random variables. Density and distribution functions. Mean and variance. Basic discrete and continuous distributions: Uniform, binomial, geometric, Poisson,

exponential and normal. Random samples. Confidence intervals. Chi-square distribution. Student's *t*-distribution. Use of tables. Hypothesis testing. Engineering examples.

CVEN 2020 Year's Work
Engineering Laboratory. An integrated course of laboratory experiments designed to illustrate the fundamental principles dealt with in lectures and the fundamental principles of engineering measurement.

Graphics and Design: Development of computer-aided drafting skills. Specific topics: working units and co-ordinate systems; seed files, cells and reference files; menus, dialogue boxes, drawing tools and controls; input and output systems; elements - attributes, association, groups; complex and multiline elements; element manipulation and modification; levels; auto-dimensioning; patterning and rendering. Introduction to 3-D modelling.

Engineering Project Work: Students will be required to carry out exercises in oral and written communications.

Third Year

There are no lectures in the third term of Third Year to facilitate industrial placements or study periods in other universities. Examinations will take place after the second term.

CVEN 3004 Theory of Structures
Structural forms and quantitative analysis. Role of the modern structural engineer. Manual vs computer aided design/analysis. Behaviour resistance of structural sections from zero load to collapse for steel, concrete and timber. Analysis for stress resultants of statically determinate structures. Virtual work theorems. Deformation analysis of frameworks. Stiffness and flexibility formulation for statically indeterminate planar structures. Influence lines. Simple plastic theory. Introduction to buckling. Laboratory experiments designed to illustrate the principles of structural analysis and the properties of materials.

CVEN 3005 Design of Structures
Codes of practice. Building regulations. Actions on structures including wind load. Design resistance. Load factors. Steel: Steel as a structural material and its use in building. Design of steel beams, girders, trusses, stanchions and simple frames. Design of steel connections. Concrete: Reinforced concrete as a structural material. Design of beams and slabs, columns and column bases and simple statically indeterminate structures. Retaining walls. Timber: Timber as a structural material. Introduction to the design of timber structures.

CVEN 3001 Hydraulics
Calculation and design for pressure conduits and open channels. Hydraulics of pressure conduits, flow in pipe networks, unsteady flow in pipes. Hydraulic machines including pumps and turbines. Non-uniform flow in open channels; critical depth and hydraulic jump; control sections and transitions in open channels. Groundwater hydraulics of wells, drains and ditches. Elementary physical hydrology: The hydrological cycle and water balances; precipitation; evaporation and transpiration; infiltration and percolation; groundwater storage and outflow; surface runoff.

A course of laboratory experiments illustrating the principles of flow in pressure conduits and open channels. Problems related to the subject matter of the lectures.

CVEN 3007 Engineering Finance

Management Accounting & Finance:

Management accounting. Cost allocation and absorption. Product costing. Budgeting, responsibility, accounting and motivation. Capital budgeting techniques. Decision-making: cost-volume-profit relationships. Financial analysis. Accounting conventions; statements of standard accounting practice: ratio analysis; financial ill-health (through trading losses, overtrading etc.); capital structure.

Microeconomics with applications in Transportation:

Demand analysis, regulation of transport firms & industries, congestion pricing and the application of cost-benefit analysis.

Public Procurement processes:

General characteristics of various types of procurement, EU regulations and procedures. Risks in Design, construction, operations & maintenance. Value engineering, negotiated change and value for money. Construction Contracts. Project Finance & PPP.

CVEN 3003 Soil Mechanics

Soil mechanics problems and their solution. Mass, volume and basic relationships. Stresses in soils. Stress-strain behaviour. Shear strength of cohesive and cohesionless soils. Total and effective stresses. Excess pore water pressure. Steady state flow and permeability. Earth pressure and earth retaining structures. Bearing pressures and bearing capacity of foundations. Transient pore water pressure and deformation. Settlement of foundations. Soil compaction. Laboratory testing.

CVEN 3020 Year's Work

Analytical, design and laboratory exercises complementary to the lecture programme in hydraulics, soil mechanics and structures; practical work in surveying, computation and CAD.

MAPH 3014 Engineering Computation

Error analysis, numerical solution of algebraic and transcendental equations, matrix inversion, determination of eigenvalues and eigenvectors, numerical differentiation and integration, application of finite difference methods to ordinary and partial differential equations, interpolation and sampled data and finite element techniques. Non-linear optimisation.

MATH 3617 Pure and Applied Mathematics

MATH 3613 Mathematics [LT-FS]

Laplace transform (LT). Heavyside-step and Dirac-Delta functions, convolution, solutions of differential equation, engineering examples.

Fourier series (FS). Hilbert spaces, partial differential equations (wave and heat), engineering applications.

MATH 3614 Mathematics (Integral Calculus)

Further advanced calculus. Scalar and vector fields over curves and surfaces. Grad, div and curl. Change of variable. Curvilinear co-ordinates. Integration

over domains, curves and surfaces. Divergence theorem. Stokes' theorem. Applications.

MAPH 3025 Mathematical Physics (Differential Equations)
Ordinary differential equations. Isoclines. Linear systems of first order. Phase plane. Singular points. First order p.d.e. How they arise. Sketching characteristics. Solutions. Second order p.d.e. How they arise. The Cauchy problem. Characteristics. Difference schemes for Laplace. Wave and diffusion equations. Motivation for different initial or boundary value problems. Properties of solutions.

GEOL 3611 Geology
The course provides a general introduction to (a) Geology and geological processes, (b) the application of Geology to Civil Engineering, (c) the methodology for geologically-based site investigation and (d) Engineering Geology problems and Geotechnical solutions. Lectures deal with mineralogy, rock types, tectonics, weathering processing and geomorphology, hydrology and engineering geology (geological aspects of site investigation, slopes, foundations, dams/reservoirs and tunnels). Laboratory-based practical classes deal with mineral and rock identification and map work. Two field classes examine the geological and engineering aspects of Killiney and Bray Head.

Fourth Year

CVEN 4001 Civil Engineering Design

(a) Preliminary Design of Structures
Qualitative structural behaviour and load paths. Choice of structural material. Preliminary sizing of reinforced concrete members.

(b) Engineering Materials
Elasticity. Stress and strain tensors. Stress function. Plane stress and plane strain problems. Inelastic behaviour. Yield criteria. Plasticity. Viscoplasticity. Viscoelasticity. Composites. Polymers and ceramics. Engineering uses. Fatigue life. Brittle and ductile fracture. Properties of cements, aggregates and concrete. Specification and testing of concrete specimens and products. Design of concrete mixes. Placing of concrete. Highway materials (see under (g)).

(c) Civil Engineering Systems
General systems. Planning and design as conceptual systems. Physical planning and civil engineering systems. Goals and objectives. Projecting the system. Models, networks and continua. Simulation and optimisation. Implementation and evaluation.

(d) Design of Structures
Elastic and elastic-plastic structural analysis & plastic moment redistribution. Prestressed concrete. Analysis and design of slabs. Columns and interaction diagrams. Masonry design. Structural steel design. Composite construction.

(e) Design in Soils Engineering
Site investigation. Harmful constituents in soils. Bearing capacity and deformation of granular and cohesive soils. Shallow and deep foundations. Piles in granular and cohesive

soils. Settlement of piled foundations. Pile testing. Earth retaining structures. Sheet piled walls. Reinforced earth. Geotextiles. Stability of highway embankments and cuttings. Case histories. Laboratory testing.

(f) Design of Water Resource Systems
Elements of applied hydrology. Water quantity requirements for domestic and industrial uses. Water sources and their development. Quality of natural waters. Quality standards for potable and industrial water supplies. Water purification processes. Water distribution. Design of sewer systems. Purification of domestic and industrial wastes. Control of water pollution. Atmospheric pollution. Refuse disposal.

(g) Design in Highway Engineering
Properties of highway materials, such as bitumens and aggregates. Specification, testing and quality control of highway construction. Compaction and stabilisation techniques to improve material properties. Design off road drainage and road foundations. Bituminous mix design. Design and management of pavements, including the maintenance of skid resistance. Geometric design of roads and junctions for safety and capacity.

CVEN 4002 The Engineer and Society

(a) Engineering Law
Contract law. The promoter-engineer-contractor relationship. The engineer's responsibilities as agent and as arbitrator. The contract form.

(b) Professional Practice
Civil engineering procedure. Various forms of contract. Contract documents, drawings, specifications, bills of quantities, schedules. Sources and presentation of technical information. Report writing. Learned societies and professional bodies.

(c) Environmental Appraisal
Sustainable Development, Statutory Environmental Conservation, Stage of Appraisal, Public Consultation/Stakeholder Communication, EIS Principles and Assessment, Statutory Processes.

(d) Urban and Regional Planning
Law, administration, infrastructure, architecture, landscape design, conservation.

CVEN 4021 Engineering Report
Course Work

Engineering Report
Each student must submit a report containing the results of a special project involving experimentation or analysis or design.

Course Work
Each student is required to complete a set of civil engineering design assignments.

Electives:

CVEN 4003 Structural Modelling
Approximate methods of analysis using vector and energy approaches. Stiffness formulation. Finite Element analysis. Elastic Plastic Response. Dynamic response. Buckling analysis.

Structural Forms - rings, arches, vaults, grillages, plates. Application of computer software. Analysis for material and geometric non-linearity.

CVEN 4004 Structural Design
Sources and assessment of structural loading. Design criteria. Selection and control of materials and workmanship. Comparison of elastic and plastic design. Limit state design in reinforced concrete, structural steelwork and timber. Structural masonry. Structural steel and reinforced concrete frameworks and continua. Applications of prestressed concrete and composite steel/concrete construction. Design of timber structures. Design for fire.

CVEN 4005 Soil Mechanics and Geotechnical Engineering
Introduction to critical state soil mechanics. Pre-yield behaviour of soils. Yielding. Soil models. Characteristic soil parameter values. Partial safety factors and Eurocode 7. Shallow foundations. Raft foundations. Piled/raft foundations. Pile design/construction in Ireland. Ground improvement. Settlement of structures. Structural tolerance to movement. Recent developments in retaining wall analysis and design. Tunnels and tunnelling. Soil nailing.

CVEN 4006 Transportation Operations and Planning
Nature of transportation problem. Characteristics of demand and of transport systems. Steps in transportation planning process, generation, distribution, model choice and assignment models. Models to describe behaviour of road links, junctions, bottlenecks and public transport systems. Safety and environmental problems resulting from transportation. Parking characteristics, parking and road solutions for Irish towns. Land use, location and transportation. Development control aspects of transportation.

CVEN 4010 Hydraulic Engineering Design
Hydrologic design. Dam ancillary works. Stormwater drainage design. River engineering. Pumping station design. Coastal engineering.

CVEN 4008 Unit Treatment Processes in Water Engineering
Water chemistry, biology and analysis. Principles of sedimentation, flotation, filtration, aeration, flocculation, water softening, demineralisation. Biological processes. Design of water and wastewater treatment processes.

MATH 4601 Mathematics
A series of lectures on selected topics in Mathematics. Topics will be declared at the beginning of each academic Year.

MATH 4602 Mathematics
A series of lectures on selected topics in Mathematics. Topics will be declared at the beginning of each academic Year.

Electrical Engineering

First Year

Mathematics	MATH 1600
Experimental Physics*	EXPH 1603
Chemistry*	CHEM 1604
Mathematical Physics	MAPH 1014
Computer Science*	COMP 1604
Electronic and Electrical Engineering*	EEEN 1002
Engineering Fluid Mechanics	CVEN 1003
Engineering Thermodynamics	MEEN 1003
Introduction to Electronic & Electrical Engineering	EEEN 1101
Languages	ENGF 1002

* These subjects have a laboratory or other practical component in addition to the lecture course.

Second Year

Circuit Theory 1	EEEN 2003
Electromagnetics 1	EEEN 2004
Electronic Circuits 1	EEEN 2005
Electrotechnics	EEEN 2006
Solid State Electronics 1	EEEN 2002
Applied Dynamics	MEEN 2001
Computer Engineering 1	EEEN 2001
Mathematics	MATH 2600
Experimental Physics*	EXPH 2605
Year's Work	EEEN 2020

* This subject has a laboratory component in addition to the lecture course.

Third Year

Note: Third year students should note that in the assessment of the B. E. (Electrical) Degree, the performance of candidates at both the Third and Final Year Examinations is taken into account in the following manner:

A scaled percentage of the total mark obtained at the first sitting of the Third Year Examination is added to the total mark obtained in the Final Year Examination. The additional mark represents a maximum of 20% of the adjusted overall mark. In the B. E. Degree, a pass or fail decision is based on the results of the final year Examinations, while the ranking of candidates and the award of honours is based on the adjusted overall mark.

Circuit Theory 2	EEEN 3005
Electronic Circuits 2	EEEN 3006
Electrical Machines 1	EEEN 3004
Linear Systems Analysis	EEEN 3009
Control Theory 1	EEEN 3010
Communication Theory 1	EEEN 3007
Electromagnetics 2	EEEN 3008
Solid State Electronics 2	EEEN 3003
Computer Engineering 2	EEEN 3002
Power Systems 1	EEEN 3001
Engineering Computation	MAPH 3014
Mathematics (Module B)	MATH 3602
Mathematics (Module C)	MATH 3603
Mathematical Physics (Module D)	MAPH 3024
Year's Work	EEEN 3020

Fourth Year

Electronic Circuits 3	EEEN 4001
Control Systems	EEEN 4002
Optoelectronics and Filters	EEEN 4003
Digital Signal Processing	EEEN 4004
Electrical Machines 2	ELEN 4001
Power Systems 2	ELEN 4003
High Voltage Engineering	ELEN 4002
Power Electronics	ELEN 4004
Year's Work	ELEN 4020

Electives: (At least **four** of the following to be chosen from the permitted combinations with the approval of the Head of Department)

Electrical Machines 3	ELEN 4006
Biomedical Engineering	EEEN 4005
Renewable Energy Systems	ELEN 4005
Power Electronic Systems	ELEN 4007
Optoelectronics	EEEN 4008
Power Systems 3	ELEN 4008

Applications of Digital Signal Processing	EEEN 4012
Mathematics 2	MATH 4602
Mathematics 3	MATH 4603
Management and its Environment	BMGT 4001

First Year

MATH 1600 Mathematics

Four course units, each unit comprises approximately 24 lectures.

Unit 1: Sets, functions, continuity, differentiation, curve sketching, optimization.

Unit 2: Solutions of systems of linear equations, matrix algebra, determinants, complex numbers, eigenvalues and eigenvectors, vectors in 3-space, scalar and vector products, lines and planes in 3-space.

Unit 3: Definite and indefinite integration, techniques of integration, applications of integration, first and second order ordinary differential equations.

Unit 4: Infinite series, power series, Taylor's theorem and series, partial differentiation of functions of two or more variables, Lagrange multiplier method.

EXPH 1603 Experimental Physics

Lectures: Three lectures each week in the first semester and two lectures each week in the second semester.

Laboratory: Two hours each week.

Introduction to Mechanics: gravitation;

Wave motion: light and sound, reflection, refraction, interference, diffraction, Doppler effect, ray optics, mirrors and lenses;

Electricity and magnetism: electrostatics, capacitance, magnetism, electromagnetic induction, electromagnetic waves;

Quantum physics: quantization of radiant energy, atomic levels, electric charge; Radioactivity: unstable nuclei, α, β, γ decay, fission, fusion.

CHEM 1604 Chemistry

Lectures: Two lectures each week.

Laboratory: Nine laboratory sessions, each of three hours duration, in the second semester.

Atomic structure and the periodic table; bonding, valency, formulae and shape of molecule; moles and stoichiometry; molecular/ionic equilibrium; acids and bases; redox reactions; volumetric analysis; rates of reaction; thermochemistry; electrochemistry and metals; non-metals; organic chemistry.

MAPH 1014 Mathematical Physics

Lectures: Two per week in the first semester and three per week in the second semester.

Vectors, relative velocity, equilibrium of a particle, Newton's Second Law of Motion applied to particle; momentum and impulse; work, power and energy; conservative forces in one dimension; linear motion with constant acceleration; projectiles; circular motion; simple harmonic motion; linear motion with variable acceleration; compound pendulum motion; motion of a rigid body; small oscillations of a rigid body; equilibrium of a rigid body; reduction of a system of coplanar forces; distributed forces; centre of gravity; equilibrium of two and three forces acting on a rigid body; equilibrium of more than three forces acting on a rigid body.

COMP 1604 Computer Science
Lectures: One lecture each week.
Laboratory: Two hours per week.

Introduction to computers; basic hardware; concept of a program; operating systems; files; syntax and semantics; logic; loops; data structures; sorting; structured programming; debugging; program validation; application packages.

CVEN 1003 Engineering Fluid Mechanics
One lecture per week.

Introduction: states of matter, definition of a fluid; fluid properties; fluid statics: pressure intensity, pressure measurement, fluid pressure on surfaces, Archimedes law, flotation/stability; fluid kinematics: streamlines, continuity equation, Bernoulli's equation, flow measurement, orifices, trajectory of a liquid jet; fluid dynamics: momentum equation, fluid acceleration; applications.

EEEN 1002 Electronic and Electrical Engineering
One lecture per week.

Overview of electronic and electrical engineering; basic electrical concepts; DC circuit analysis, circuit theorems, examples and applications; transients; electrical signals; frequency spectrum; analogue signals, amplifiers, applications; digital signals, Boolean algebra, combinational and sequential logic circuits, applications; elementary electromagnetics.

MEEN 1003 Engineering Thermodynamics
One lecture per week.

Basic concepts of thermodynamics; properties of pure substances; work and heat; First Law of thermodynamics for a closed system; control volume; conservation of mass and energy; introduction to the Second Law and entropy; conduction, convection and radiation; applications.

ENGF 1002 Languages
Thirty six hours of language classes in the academic year.

Candidates who enter for the Degree of BE shall be required to pass a College Examination in foreign languages. Students will not be conferred with the BE Degree until they have satisfied the language requirement

Second Year

EEEN 2003 Circuit Theory 1
Elementary network theory. Theory of two-port networks. Electric transients. Alternating current theory with complex number analysis.

EEEN 2004 Electromagnetics 1
Coulomb's law, Gauss' law. Electric potential. Energy and forces in the electric field. Magnetic field. Electromagnetic induction. Energy and forces in the magnetic field.

EEEN 2005 Electronic Circuits 1
Modelling, DC analysis and small-signal analysis. The PN-junction as a circuit element; rectification and power supplies. Models of the bipolar junction transistor, JFET and MOSFET. Large- and small-signal applications of BJTs and FETs: combinational logic, single-stage amplifiers, frequency response.

EEEN 2006 Electrotechnics
Errors and standards; D.C. and A.C. meters; potentiometers; D.C. and A.C. bridges; oscilloscopes; electronic instruments; transducers; energy method for force calculations in electric and magnetic fields; magnetic circuits, single-loop and coupled circuits; self and mutual inductance; transformers and basic principles of three-phase systems.

EEEN 2002 Solid State Electronics 1
Introductory Quantum Mechanics. Energy levels and energy bands for solids. Fermi-Dirac statistics and Fermi level. Conduction in metals. Intrinsic and extrinsic semiconductors. Conductivity and mobility of carriers. Excess carriers; minority and majority conduction, lifetime and diffusion. Semiconductor junctions, including introduction to bipolar transistors, FETs and other devices.

MEEN 2001 Applied Dynamics
(For Agricultural & Food, Electronic & Electrical and Mechanical Engineering Students)
Three-dimensional force systems: resultants and equilibrium. Topics in friction. Particle kinematics. Plane kinematics of rigid bodies. Plane kinetics of rigid bodies: force and acceleration; impulse and momentum; work and energy. Vibration, free and forced. Central force motion

EEEN 2001 Computer Engineering 1
(a) *The C Programming Language*
Types, operators and expressions. Input/output. Functions and flow of control. Arrays and strings. Dynamic storage allocation. Structures.

(b) *Software Engineering*
Program design language. Structured programming. Data abstraction.

(c) *Algorithms and Data Structures*
Linked lists. Pushdown stacks. Queues. Trees.

(d) *Digital Electronics*
Boolean algebra. Combinatorial logic and the Karnaugh map. Flip-flops and digital memory. Introduction to synchronous design.

MATH 2600 Mathematics
Unit 1. Vector spaces, basis and dimension. Linear transformations and matrices. Change of basic matrices. Reflection and rotation matrices. Orthogonal and perspective projections. Further theory of determinants. Row, column and determinantal rank of matrices and their equivalence. Nullity. Systems of equations. Eliminants. Resultants. Sylvester's determinantal criterion for two polynomials to have a common root. Discriminants. Further properties of eigenvalues and eigenvectors.

Unit 2. Symmetric bilinear forms. Quadratic forms. Positive definiteness. Inner products. Orthonormal bases. Gram-Schmidt process. Diagonalizability of matrices. Preservation of characteristic polynomial. Eigenvalues determinant and trace under similarity. Principal axis theorem. Classification of quadratic forms. Simultaneous reduction of a pair of forms, one being positive definite.

Unit 3. Functions of two or more variables. Graphs, contours, continuity. Partial derivatives. Linear approximation. Tangent planes and normals to surfaces. Differentiability, gradient, directional derivative, grad, div and curl. Laplacian. Taylor's theorem for functions of two or more variables. Critical points and their classification. Hessian matrix. Lagrange multipliers. Line integrals, introduction to double integrals and Green's theorem.

Unit 4. Counting procedures. Probability spaces. Events, conditional events, independent events. Bayes' theorem. Random variables. Density and distribution functions. Mean and variance. Basic discrete and continuous distributions: Uniform, binomial, geometric, Poisson, exponential and normal. Random samples. Confidence intervals. Chi-square distribution. Student's *t*-distribution. Use of tables. Hypothesis testing. Engineering examples.

EXPH 2605 Experimental Physics
Two lectures a week during Michaelmas, Hilary and Trinity terms.

Thermal radiation, theory and application. Photons. Light as waves and particles. Quantisation of energy and momentum in atoms. Demonstration of quantised energy levels. Wavelike properties of particles. Wave mechanics and the Schrodinger equation. Time independent wave equations and applications. The one electron atom. Radiation and energy transitions. Atoms in magnetic fields. Anomalous Zeeman effect. Electron spin. Many electron atoms. Pauli exclusion principle. Emission and absorption.

Introduction to statistical mechanics, microstates and macrostates. Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein distributions. Applications to solids. Laser cooling of atoms and ions, Bose-Einstein condensation. Low-dimensional structures: quantum wells, wires and dots. Periodic structures. Lasers: Einstein coefficients, population inversion, feedback and cavity design. Diode lasers, quantum well and quantum cascade lasers. Magnetism, ferromagnetism, domains and boundaries, hysteresis, new magnetic materials.

Laboratory: Four Laboratory experiments involving measurements of the physical quantities discussed in the course of lectures.

EEEN 2020 Year's Work
The material presented in courses EEEN 2001 to EEEN 2006 is supplemented by laboratory classes and tutorials in Electrical and Electronic Engineering. These classes constitute the subject *Year's Work*.

Third Year

EEEN 3005 Circuit Theory 2
Further treatment of two-port networks, including the scattering matrix. Modified nodal analysis. Elements of network topology. Transient and steady state circuit analysis using the Laplace transform. Sinusoidal steady state and transient analysis of transmission lines.

EEEN 3006 Electronic Circuits 2
Single- and two-transistor stages. Current mirrors and active loads. Output stages. Operational amplifiers; linear and non-linear operational amplifier applications. Frequency response. Power electronics. Introduction to data converters.

EEEN 3004 Electrical Machines 1
Introduction to ideal magnetic circuits. Elementary treatment of eddy currents, hysteresis and magnetic saturation in magnetic circuits. Development of an electrical equivalent circuit for the single phase transformer. Analysis of losses, efficiency and regulation in circuits containing transformers. Fundamental operation of DC machines leading to the development of an electrical equivalent circuit and analysis of DC machines in various circuit configurations. Idealised treatment of distributed windings and calculation of flux distributions and inductances. Rotating fields in three phase machines. Operation of synchronous machines and development of elementary equivalent circuit. Introduction to analysis of machine operation when connected to power systems. Fundamental operating mechanism of the 3-phase induction motor and the development of the electrical equivalent circuit leading to the elementary determination of the terminal characteristics of the induction motor.

EEEN 3009 Linear Systems Analysis
Linear systems. Hilbert spaces. Fourier series. Fourier transform. Frequency domain. Convolution. Autocorrelation and cross-correlation for finite energy and finite power signals in time and frequency domain. Laplace transform. Transfer function. Partial fraction expansion inversion procedure. Sampling. The sampling theorem. Practical sampling and reconstruction. Discrete systems. Z transform.

EEEN 3010 Control Theory 1
Basic principles of feedback control systems. Transfer functions and their manipulation. Ziegler-Nichols rule for tuning P, PI and PID controllers. The Smith Predictor for systems with time delay. The root locus method. The Routh stability criterion. Frequency response, leading to the Nyquist criterion and the use of Bode diagrams for identification of transfer functions. Integral performance measures and their evaluation using the Liapunov matrix equation.

EEEN 3007 Communication Theory 1
Introduction to communication systems, signals and channels. Amplitude and angle modulation. Pulse modulation. Digital transmission. Noise and its effects on these systems.

EEEN 3008 Electromagnetics 2
Maxwell's equations; Solutions for Maxwell's equations in insulating and conducting media; The Poynting vector; Boundary phenomena; Propagation in ionised gases; Guided propagation; The rectangular waveguide.

EEEN 3003 Solid State Electronics 2
Further treatment of PN-junctions, bipolar and FET transistors, including non-idealities, switching behaviour, static, small- and large-signal models. Transistor structures for power, high frequency and integrated circuit applications. Main bipolar and MOS logic families. Introduction to compound semiconductors, quantum devices and heterostructures.

EEEN 3002 Computer Engineering 2

(a) *Algorithms, Data Structures, and Introduction to Object-Oriented Design*
Recursion. Divide-and-conquer algorithms. Sorting Algorithms. Analysis of algorithms and O-notation. Introduction to Object-Oriented Design.

(b) *Computer Architectures*
Introduction to assembly language. Basic computer architecture. Instruction word formats. Addressing modes. Structure of basic RISC and CISC processors. Interrupts. Serial communications – synchronous and asynchronous. Microcontrollers and peripherals.

EEEN 3001 Power Systems 1

Function and characteristics of interconnected power systems. Power, reactive power, complex power. Per unit system. Three phase systems. Synchronous machine steady state model. Power transformer model. Capacitance and inductance of three phase lines and effect of transposition and bundling. Line models. Steady state stability limit. Surge impedance loading. Formulation and solution of power flow equations for a multibus system. Symmetrical fault analysis. The method of symmetrical components. Unsymmetrical fault analysis.

MAPH 3014 Engineering Computation

Error analysis, numerical solution of algebraic and transcendental equations, matrix inversion, determination of eigenvalues and eigenvectors, numerical differentiation and integration, application of finite difference methods to ordinary and partial differential equations, interpolation and sampled data and finite element techniques. Non-linear optimisation.

MAPH 3612 Pure and Applied Mathematics

MATH 3602 Mathematics (Module B - Integral Calculus)

Further advanced calculus. Scalar and vector fields over curves and surfaces. Grad, div and curl. Change of variable. Curvilinear co-ordinates. Integration over domains, curves and surfaces. Divergence theorem. Stoke's theorem. Applications.

MATH 3603 Mathematics (Module C - Complex Variables)

Cauchy-Riemann equations, Cauchy's Integral Theorems, Taylor and Laurent expansions, Residues, Principle of the argument, stability criteria.

MAPH 3024 Mathematical Physics (Module D – Differential Equations)

Ordinary differential equations. Isoclines. Linear systems of first order. Phase plane. Singular points. First order p.d.e. How they arise. Sketching characteristics. Solutions. Second order p.d.e. How they arise. The Cauchy problem. Characteristics. Difference schemes for Laplace. Wave and diffusion equations. Motivation for different initial or boundary value problems. Properties of solutions.

EEEN 3020 Year's Work
The material presented in courses EEEN 3001 to EEEN 3010 is supplemented by laboratory classes in Electrical and Electronic Engineering and in the computer solution of engineering problems.

Fourth Year

EEEN 4001 Electronic Circuits 3
Principles of feedback including formal two-port analysis and example feedback circuits. Stability of feedback amplifiers, dominant pole and pole-zero compensation. Oscillators: Barkhausen criterion, control of amplitude with large signal gain, general oscillator configuration, crystal oscillator and Wien bridge oscillator. Active filters: Sallen-Key, MFB, state-variable and bi-quad. Phase locked loop, analysis of transient and steady state response. Analogue signal processing circuits: instrumentation amplifiers, chopper stabilised amplifiers, analogue multipliers, V-F and F-V converters. Noise: sources of noise, Johnson noise, Shot noise, available noise power. Noise modelled by voltage and current source (e_n & i_{in}) at input, equivalent input noise for BJT and differential amplifier.

EEEN 4002 Control Systems
Modern control theory; state space; observability, controllability and stability; eigenvalue assignment, linear optimal control. Digital control theory: basic principles; discretisation schemes; sample period selection; deadbeat control; observers; stability.

EEEN 4003 Optoelectronics and Filters
Introduction to optoelectronics; LEDs, lasers, photodetectors.

Analogue filters: transfer functions; approximation problem; realisation of normalised lowpass filters; scaling and transformations; design procedure. Digital filters.

EEEN 4004 Digital Signal Processing
Discrete Fourier Transform. Fast Fourier Transform. Discrete convolution. Discrete-time linear systems. FIR and IIR digital filters. Finite arithmetic effects.

ELEN 4001 Electrical Machines 2
Magnetic circuits. Effects of eddy currents and hysteresis. Permanent magnets. 1-Phase and 3-Phase power transformers. D.C. commutator machines. Distributed windings. Rotating fields. Induction machine. Synchronous machine.

ELEN 4003 Power Systems 2
Power system operation: load forecasting, unit commitment, economic dispatch, spinning reserve, security, environmental considerations. Power system control: automatic voltage regulation, models of exciter and generator, automatic load frequency control, automatic generator control, models of speed governor, hydraulics, turbo generator and hydro generator. Transient stability: single generator case, equal area criterion, transient analysis of large system.

ELEN 4002 High Voltage Engineering
The special properties of high voltages and high current and the problems that these pose for the design of high-voltage equipment will be considered. Travelling waves on transmission lines and

in cables and the effects of lightning and switching transients on power systems will be considered. Insulation co-ordination, generation and testing and new measurement methods will also be treated.

ELEN 4004 Power Electronics
Power Electronic devices. Line commutated converters. Power factor and harmonic generated in bridge rectifiers. D.C. Motor drives. Chopper circuits. 1-phase and 3-phase inverters. Induction motor variable speed drives.

Elective Subjects: At least **four** and not more than **five** of the following subjects must be chosen from permitted combinations with the approval of the Head of the Department.

ELEN 4020 Year's Work
In addition to a major experimental project, laboratory classes are held in Electrical and Electronic Engineering. Students are required to submit a substantial report on their project.

ELEN 4006 Electrical Machines 3
Analysis and synthesis of magnetic systems. Numerical solutions of magnetic field problems. Calculation of force by Maxwell stress and energy models. Transient model of induction machine. Effects of harmonics on operation of induction machine. Transient performance of synchronous machine. Switched reluctance motors.

EEEN 4005 Biomedical Engineering
This course is intended to serve as an introduction to some of the many ways in which the fields of engineering and medicine interact. Topics covered will include the principles of biomedical apparatus and the application of engineering analysis to the functioning of various physiological systems.

ELEN 4005 Renewable Energy Systems
Aspects of renewable energy systems (e. g. windpower, hydropower, wavepower, photovoltaic conversion, direct solar heating, biomass, hydrogen as an energy vector, introduction to economic analysis).

ELEN 4007 Power Electronic Systems
Characteristics of electric drives. Principles and implementation of adjustable speed induction motor drives and synchronous motor drives. Principles and implementation of HVDC transmission. Principles of load compensation. Reactive compensation requirements for unbalanced loads. Principles and implementation of controllable reactive compensators using thyristor controlled reactors and thyristor switched capacitors.

EEEN 4008 Optoelectronics
Role of optics. Optical fibres. Semiconductor sources. Detectors. Fibre systems and components; design and testing. Multiplexing options. Atmospheric links. Integrated optics. Photonics and data storage. Coherent optical communication systems. Opto-electronic sensors. Lasers in industry.

ELEN 4008 Power Systems 3
Synchronous machine under fault conditions. Symmetrical fault analysis of large power systems. Sequence impedance networks for the synchronous machine, transformer and transmission line.

Sequence networks for different fault types. Application to unsymmetrical fault calculations. Unsymmetrical fault analysis of large power systems. Circuit breakers. Fuses. Discrimination and co-ordination. Current transformers. Voltage transformers. Protection relays. Protection of transformers, overhead lines, cables, rotating machines and busbars.

EEEN 4012 Applications of Digital Signal Processing
Digital filter design; Butterworth and Chebyshev filters; impulse invariance techniques; the bilinear transformation; computer-automated techniques and algorithms; spectral analysis, periodogram; speech processing; models for speech signals; short-time Fourier analysis; linear predictive coding; fundamentals of digital image processing; two dimensional Fourier transform; discrete cosine transform; image compression; DSP implementation issues; DSP chip architectures; adaptive filters and signal modelling; Wiener (stochastic) filtering; LMS algorithm. A total of up to 20% of marks may be awarded for course work carried out prior to the examination.

MATH 4602 Mathematics 2
A series of lectures on selected topics in Mathematics. Topics will be declared at the beginning of each academic Year.

MATH 4603 Mathematics 3
A series of lectures on selected topics in Mathematics. Topics will be declared at the beginning of each academic Year.

BMGT 4001 Management and its Environment
The Irish economy, its institutions and international relationships. The firm and its environment. Organisational objectives and corporate behaviour. Economic concepts. Market structure and the competitive process. Demand analysis. Forms of organisation, private and public bodies. Management, its nature and functions - Planning, organising, directing, controlling. Financial management. Presentation and analysis of financial statements. Forecasting. Working capital. Capital budgeting. Financial institutions. Marketing management. Market research. Product life cycle. Product mix. Marketing mix. Operations management. Concept of a system. System design, planning and control. Personnel management. Industrial relations. Trade unions. Collective bargaining.

Electronic Engineering

First Year

Mathematics	MATH 1600
Experimental Physics*	EXPH 1603
Chemistry*	CHEM 1604
Mathematical Physics	MAPH 1014
Computer Science*	COMP 1604
Electronic and Electrical Engineering*	EEEN 1002
Engineering Fluid Mechanics	CVEN 1003
Engineering Thermodynamics	MEEN 1003
Introduction to Electronic & Electrical Engineering	EEEN 1101
Languages	ENGF 1002

* These subjects have a laboratory or other practical component in addition to the lecture course.

Second Year

Circuit Theory 1	EEEN 2003
Electromagnetics 1	EEEN 2004
Electronic Circuits 1	EEEN 2005
Electrotechnics	EEEN 2006
Solid State Electronics 1	EEEN 2002
Applied Dynamics	MEEN 2001
Computer Engineering 1	EEEN 2001
Mathematics	MATH 2600
Experimental Physics*	EXPH 2605
Year's Work	EEEN 2020

*This subject has a laboratory component in addition to the lecture course.

Third Year

Note: Third year students should note that in the assessment of the B. E. (Electronic) Degree, the performance of candidates at both the Third and Final Year Examinations is taken into account in the following manner:

A scaled percentage of the total mark obtained at the first sitting of the Third Year Examination is added to the total mark obtained in the Final Year Examination. The additional mark represents a maximum of 20% of the adjusted overall mark. In the B. E. Degree, a pass or fail decision is based on the results of the final year Examinations, while the ranking of candidates and the award of honours is based on the adjusted overall mark.

Circuit Theory 2	EEEN 3005
Electronic Circuits 2	EEEN 3006
Electrical Machines 1	EEEN 3004
Linear Systems Analysis	EEEN 3009
Control Theory 1	EEEN 3010
Communication Theory 1	EEEN 3007
Electromagnetics 2	EEEN 3008
Solid State Electronics 2	EEEN 3003
Computer Engineering 2	EEEN 3002
Power Systems 1	EEEN 3001
Engineering Computation	MAPH 3014
Mathematics (Module B)	MATH 3602
Mathematics (Module C)	MATH 3603
Mathematical Physics (Module D)	MAPH 3024
Year's Work	EEEN 3020

Fourth Year

Electronic Circuits 3	EEEN 4001
Control Systems	EEEN 4002
Optoelectronics and Filters	EEEN 4003
Digital Signal Processing	EEEN 4004
Antennas and Propagation	ECEN 4001
Communication Theory 2	ECEN 4002
Digital Electronics	ECEN 4003
RF Circuits and Systems	ECEN 4004
Year's Work	ECEN 4020

Electives: (At least **four** of the following to be chosen from the permitted combinations with the approval of the Head of Department)

Microwave Engineering	ECEN 4007
Digital Communications	ECEN 4006
Biomedical Engineering	EEEN 4005
Communication Systems	ECEN 4005
Optoelectronics	EEEN 4008
Optical Engineering	EEEN 4015
Applications of Digital Signal Processing	EEEN 4012
Mathematics 2	MATH 4602
Mathematics 3	MATH 4603
Management and its Environment	BMGT 4001
Hardware/Software Co-Design	COMP 4623

First Year

MATH 1600 Mathematics

Four course units, each unit comprises approximately 24 lectures.

Unit 1: Sets, functions, continuity, differentiation, curve sketching, optimization.

Unit 2: Solutions of systems of linear equations, matrix algebra, determinants, complex numbers, eigenvalues and eigenvectors, vectors in 3-space, scalar and vector products, lines and planes in 3-space.

Unit 3: Definite and indefinite integration, techniques of integration, applications of integration, first and second order ordinary differential equations.

Unit 4: Infinite series, power series, Taylor's theorem and series, partial differentiation of functions of two or more variables, Lagrange multiplier method.

EXPH 1603 Experimental Physics

Lectures: Three lectures each week in the first semester and two lectures each week in the second semester.

Laboratory: Two hours each week.

Introduction to Mechanics: gravitation;

Wave motion: light and sound, reflection, refraction, interference, diffraction, Doppler effect, ray optics, mirrors and lenses;

Electricity and magnetism: electrostatics, capacitance, magnetism, electromagnetic induction, electromagnetic waves;

Quantum physics: quantization of radiant energy, atomic levels, electric charge; Radioactivity: unstable nuclei, α, β, γ decay, fission, fusion.

CHEM 1604 Chemistry

Lectures: Two lectures each week.

Laboratory: Nine laboratory sessions, each of three hours duration, in the second semester.

Atomic structure and the periodic table; bonding, valency, formulae and shape of molecule; moles and stoichiometry; molecular/ionic equilibrium; acids and bases; redox reactions; volumetric analysis; rates of reaction; thermochemistry; electrochemistry and metals; non-metals; organic chemistry.

MAPH 1014 Mathematical Physics

Lectures: Two per week in the first semester and three per week in the second semester.

Vectors, relative velocity, equilibrium of a particle, Newton's Second Law of Motion applied to particle; momentum and impulse; work, power and energy; conservative forces in one dimension; linear motion with constant acceleration; projectiles; circular motion; simple harmonic motion; linear motion with variable acceleration; compound pendulum motion; motion of a rigid body; small oscillations of a rigid body; equilibrium of a rigid body; reduction of a system of coplanar forces; distributed forces; centre of gravity; equilibrium of two and three forces acting on a rigid body; equilibrium of more than three forces acting on a rigid body.

COMP 1604 Computer Science
Lectures: One lecture each week.
Laboratory: Two hours per week.
Introduction to computers; basic hardware; concept of a program; operating systems; files; syntax and semantics; logic; loops; data structures; sorting; structured programming; debugging; program validation; application packages.

CVEN 1003 Engineering Fluid Mechanics
One lecture per week.
Introduction: states of matter, definition of a fluid; fluid properties; fluid statics: pressure intensity, pressure measurement, fluid pressure on surfaces, Archimedes law, flotation/stability; fluid kinematics: streamlines, continuity equation, Bernoulli's equation, flow measurement, orifices, trajectory of a liquid jet; fluid dynamics: momentum equation, fluid acceleration; applications.

EEEN 1002 Electronic and Electrical Engineering
One lecture per week.
Overview of electronic and electrical engineering; basic electrical concepts; DC circuit analysis, circuit theorems, examples and applications; transients; electrical signals; frequency spectrum; analogue signals, amplifiers, applications; digital signals, Boolean algebra, combinational and sequential logic circuits, applications; elementary electromagnetics.

MEEN 1003 Engineering Thermodynamics
One lecture per week.
Basic concepts of thermodynamics; properties of pure substances; work and heat; First Law of thermodynamics for a closed system; control volume; conservation of mass and energy; introduction to the Second Law and entropy; conduction, convection and radiation; applications.

ENGF 1002 Languages
Thirty six hours of language classes in the academic Year.

Candidates who enter for the Degree of BE shall be required to pass a College Examination in foreign languages. Students will not be conferred with the BE Degree until they have satisfied the language requirement.

Second Year

EEEN 2003 Circuit Theory 1
Elementary network theory. Theory of two-port networks. Electric transients. Alternating current theory with complex number analysis.

EEEN 2004 Electromagnetics 1
Coulomb's law, Gauss' law. Electric potential. Energy and forces in the electric field. Magnetic field. Electromagnetic induction. Energy and forces in the magnetic field.

EEEN 2005 Electronic Circuits 1
Modelling, DC analysis and small-signal analysis. The PN-junction as a circuit element; rectification and power supplies. Models of the bipolar junction transistor, JFET and MOSFET. Large- and small-signal applications of BJTs and FETs: combinational logic, single-stage amplifiers, frequency response.

EEEN 2006 Electrotechnics
Errors and standards; D.C. and A.C. meters; potentiometers; D.C. and A.C. bridges; oscilloscopes; electronic instruments; transducers; energy method for force calculations in electric and magnetic fields; magnetic circuits, single-loop and coupled circuits; self and mutual inductance; transformers and basic principles of three-phase systems.

EEEN 2002 Solid State Electronics 1
Introductory Quantum Mechanics. Energy levels and energy bands for solids. Fermi-Dirac statistics and Fermi level. Conduction in metals. Intrinsic and extrinsic semiconductors. Conductivity and mobility of carriers. Excess carriers; minority and majority conduction, lifetime and diffusion. Semiconductor junctions, including introduction to bipolar transistors, FETs and other devices.

MEEN 2001 Applied Dynamics
(For Agricultural & Food, Electronic & Electrical and Mechanical Engineering Students)
Three-dimensional force systems: resultants and equilibrium. Topics in friction. Particle kinematics. Plane kinematics of rigid bodies. Plane kinetics of rigid bodies: force and acceleration; impulse and momentum; work and energy. Vibration, free and forced. Central force motion

EEEN 2001 Computer Engineering 1

(a) *The C Programming Language*
Types, operators and expressions. Input/output. Functions and flow of control. Arrays and strings. Dynamic storage allocation. Structures.

(b) *Software Engineering*
Program design language. Structured programming. Data abstraction.

(c) *Algorithms and Data Structures*
Linked lists. Pushdown stacks. Queues. Trees.

(d) *Digital Electronics*
Boolean algebra. Combinatorial logic and the Karnaugh map. Flip-flops and digital memory. Introduction to synchronous design.

MATH 2600 Mathematics

Unit 1. Vector spaces, basis and dimension. Linear transformations and matrices. Change of basic matrices. Reflection and rotation matrices. Orthogonal and perspective projections. Further theory of determinants. Row, column and determinantal rank of matrices and their equivalence. Nullity. Systems of equations. Eliminants. Resultants. Sylvester's determinantal criterion for two polynomials to have a common root. Discriminants. Further properties of eigenvalues and eigenvectors.

Unit 2. Symmetric bilinear forms. Quadratic forms. Positive definiteness. Inner products. Orthonormal bases. Gram-Schmidt process. Diagonalizability of matrices. Preservation of characteristic polynomial. Eigenvalues determinant and trace under similarity. Principal axis theorem. Classification of quadratic forms. Simultaneous reduction of a pair of forms, one being positive definite.

Unit 3. Functions of two or more variables. Graphs, contours, continuity. Partial derivatives. Linear approximation. Tangent planes and normals to surfaces. Differentiability, gradient, directional derivative, grad, div and curl. Laplacian. Taylor's theorem for functions of two or more variables. Critical points and their classification. Hessian matrix. Lagrange multipliers. Line integrals, introduction to double integrals and Green's theorem.

Unit 4. Counting procedures. Probability spaces. Events, conditional events, independent events. Bayes' theorem. Random variables. Density and distribution functions. Mean and variance. Basic discrete and continuous distributions: Uniform, binomial, geometric, Poisson, exponential and normal. Random samples. Confidence intervals. Chi-square distribution. Student's *t*-distribution. Use of tables. Hypothesis testing. Engineering examples.

EXPH 2605 Experimental Physics

Two lectures a week during Michaelmas, Hilary and Trinity terms.

Thermal radiation, theory and application. Photons. Light as waves and particles. Quantisation of energy and momentum in atoms. Demonstration of quantised energy levels. Wavelike properties of particles. Wave mechanics and the Schrodinger equation. Time independent wave equation and applications. The one electron atom. Radiation and energy transitions. Atoms in magnetic fields. Anomalous Zeeman effect. Electron spin. Many electron atoms. Pauli exclusion principle. Emission and absorption.

Introduction to statistical mechanics, microstates and macrostates. Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein distributions. Applications to solids. Laser cooling of atoms and ions, Bose-Einstein condensation. Low-dimensional structures: quantum wells, wires and dots. Periodic structures. Lasers: Einstein coefficients, population inversion, feedback and cavity design. Diode lasers, quantum well and quantum cascade lasers. Magnetism, ferromagnetism, domains and boundaries, hysteresis, new magnetic materials.

Laboratory: Four Laboratory experiments involving measurements of the physical quantities discussed in the course of lectures.

EEEN 2020 Year's Work
The material presented in courses EEEN 2001 to EEEN 2006 is supplemented by laboratory classes and tutorials in Electrical and Electronic Engineering. These classes constitute the subject *Year's Work*.

Third Year

EEEN 3005 Circuit Theory 2
Further treatment of two-port networks, including the scattering matrix. Modified nodal analysis. Elements of network topology. Transient and steady state circuit analysis using the Laplace transform. Sinusoidal steady state and transient analysis of transmission lines.

EEEN 3006 Electronic Circuits 2
Single- and two-transistor stages. Current mirrors and active loads. Output stages. Operational amplifiers; linear and non-linear operational amplifier applications. Frequency response. Power electronics. Introduction to data converters.

EEEN 3004 Electrical Machines 1
Introduction to ideal magnetic circuits. Elementary treatment of eddy currents, hysteresis and magnetic saturation in magnetic circuits. Development of an electrical equivalent circuit for the single phase transformer. Analysis of losses, efficiency and regulation in circuits containing transformers. Fundamental operation of DC machines leading to the development of an electrical equivalent circuit and analysis of DC machines in various circuit configurations. Idealised treatment of distributed windings and calculation of flux distributions and inductances. Rotating fields in three phase machines. Operation of synchronous machines and development of elementary equivalent circuit. Introduction to analysis of machine operation when connected to power systems. Fundamental operating mechanism of the 3-phase induction motor and the development of the electrical equivalent circuit leading to the elementary determination of the terminal characteristics of the induction motor.

EEEN 3009 Linear Systems Analysis
Linear systems. Hilbert spaces. Fourier series. Fourier transform. Frequency domain. Convolution. Autocorrelation and cross-correlation for finite energy and finite power signals in time and frequency domain. Laplace transform. Transfer function. Partial fraction expansion inversion procedure. Sampling. The sampling theorem. Practical sampling and reconstruction. Discrete systems. Z transform.

EEEN 3010 Control Theory 1
Basic principles of feedback control systems. Transfer functions and their manipulation. Ziegler-Nichols rule for tuning P, PI and PID controllers. The Smith Predictor for systems with time delay. The root locus method. The Routh stability criterion. Frequency response, leading to the Nyquist criterion and the use of Bode diagrams for identification of transfer functions. Integral performance measures and their evaluation using the Liapunov matrix equation.

EEEN 3007 Communication Theory 1
Introduction to communication systems, signals and channels. Amplitude and angle modulation. Pulse modulation. Digital transmission. Noise and its effects on these systems.

EEEN 3008 Electromagnetics 2
Maxwell's equations; Solutions for Maxwell's equations in insulating and conducting media; The Poynting vector; Boundary phenomena; Propagation in ionised gases; Guided propagation; The rectangular waveguide.

EEEN 3003 Solid State Electronics 2
Further treatment of PN-junctions, bipolar and FET transistors, including non-idealities, switching behaviour, static, small- and large-signal models. Transistor structures for power, high frequency and integrated circuit applications. Main bipolar and MOS logic families. Introduction to compound semiconductors, quantum devices and heterostructures.

EEEN 3002 Computer Engineering 2
(a) *Algorithms, Data Structures, and Introduction to Object-Oriented Design*
Recursion. Divide-and-conquer algorithms. Sorting Algorithms. Analysis of algorithms and O-notation. Introduction to Object-Oriented Design.

(b) *Computer Architectures*
Introduction to assembly language. Basic computer architecture. Instruction word formats. Addressing modes. Structure of basic RISC and CISC processors. Interrupts. Serial communications - synchronous and asynchronous. Microcontrollers and peripherals.

EEEN 3001 Power Systems 1
Function and characteristics of interconnected power systems. Power, reactive power, complex power. Per unit system. Three phase systems. Synchronous machine steady state model. Power transformer model. Capacitance and inductance of three phase lines and effect of transposition and bundling. Line models. Steady state stability limit. Surge impedance loading. Formulation and solution of power flow equations for a multibus system. Symmetrical fault analysis. The method of symmetrical components. Unsymmetrical fault analysis.

MAPH 3014 Engineering Computation
Error analysis, numerical solution of algebraic and transcendental equations, matrix inversion, determination of eigenvalues and eigenvectors, numerical differentiation and integration, application of finite difference methods to ordinary and partial differential equations, interpolation and sampled data and finite element techniques. Non-linear optimisation.

MATH 3612 Pure and Applied Mathematics

MATH 3602 Mathematics (Module B – Integral Calculus)
Further advanced calculus. Scalar and vector fields over curves and surfaces. Grad, div and curl. Change of variable. Curvilinear co-ordinates. Integration over domains, curves and surfaces. Divergence theorem. Stoke's theorem. Applications.

MATH 3603 Mathematics (Module C – Complex Variables)
Cauchy-Riemann equations, Cauchy's Integral Theorems, Taylor and Laurent expansions, Residues, Principle of the argument, stability criteria.

MAPH 3024 Mathematical Physics (Module D – Differential Equations)
Ordinary differential equations. Isoclines. Linear systems of first order. Phase plane. Singular points. First order p.d.e. How they arise. Sketching characteristics. Solutions. Second order p.d.e. How they arise. The Cauchy problem. Characteristics. Difference schemes for Laplace. Wave and diffusion equations. Motivation for different initial or boundary value problems. Properties of solutions.

EEEN 3020 Year's Work
The material presented in courses EEEN 3001 to EEEN 3010 is supplemented by laboratory classes in Electrical and Electronic Engineering and in the computer solution of engineering problems.

Fourth Year

EEEN 4001 Electronic Circuits 3
Principles of feedback including formal two-port analysis and example feedback circuits. Stability of feedback amplifiers, dominant pole and pole-zero compensation. Oscillators: Barkhausen criterion, control of amplitude with large signal gain, general oscillator configuration, crystal oscillator and Wien bridge oscillator. Active filters: Sallen-Key, MFB, state-variable and bi-quad. Phase locked loop, analysis of transient and steady state response. Analogue signal processing circuits: instrumentation amplifiers, chopper stabilised amplifiers, analogue multipliers, V-F and F-V converters. Noise: sources of noise, Johnson noise, Shot noise, available noise power. Noise modelled by voltage and current source (e_n&i_{in}) at input, equivalent input noise for BJT and differential amplifier.

EEEN 4002 Control Systems
Modern control theory; state space; observability, controllability and stability; eigenvalue assignment, linear optimal control. Digital control theory: basic principles; discretisation schemes; sample period selection; deadbeat control; observers; stability.

EEEN 4003 Optoelectronics and Filters
Introduction to optoelectronics; LEDs, lasers, photodetectors.

Analogue filters: transfer functions; approximation problem; realisation of normalised lowpass filters; scaling and transformations; design procedure. Digital filters.

EEEN 4004 Digital Signal Processing
Discrete Fourier Transform. Fast Fourier Transform. Discrete convolution. Discrete-time linear systems. FIR and IIR digital filters. Finite arithmetic effects.

ECEN 4001 Antennas and Propagation
Principles of antennae for use from the low frequency to the microwave region of the spectrum, and the factors influencing radio wave propagation in the same range.

ECEN 4002 Communication Theory 2
Further treatment of analogue and PCM communications. Principles of digital transmission. Random signal theory. Detection of signals in noise. Decision theory. Introduction to information theory.

ECEN 4003 Digital Electronics
Logic Families-switching characteristics, noise margins, power dissipation. IC design methodologies and circuit layout. Clocking Schemes and dynamic logic. ASIC design-PLAs, standard cell, gate array, FPGA, full custom. Introduction to VHDL. Combinational logic design. Synchronous and asynchronous sequential logic systems.

ECEN 4004 RF Circuits and Systems
Radio-frequency electronic circuits and the building blocks of electronic communication systems. Transmission lines. Noise. High-frequency active devices and circuit design. Frequency generators. Radio transmitters and receivers. Modulators and demodulators.

ECEN 4020 Year's Work
In addition to a major experimental project, laboratory classes are held in Electrical and Electronic Engineering. Students are required to submit a substantial report on their project.

Elective Subjects: At least **four**, and not more than **five**, of the following subjects must be chosen from permitted combinations, with the approval of the Head of the Department.

ECEN 4007 Microwave Engineering
Further treatment of coaxial lines and waveguides; attenuation analysis; cavity resonators; microstrip lines; design and fabrication of hybrid and monolithic MICs; filters and couplers; theory of ferrites with microwave applications; survey of thermionic and solid-state microwave sources and devices; the scattering matrix; computer methods; microwave measurements and selected microwave system applications.

ECEN 4006 Digital Communications
Further information theory. Channel coding. Bandpass signals and systems. Bandpass transmission. Digital modulation methods. Carrier and symbol synchronisation. Channel characterisation and equalisation.

EEEN 4005 Biomedical Engineering
This course is intended to serve as an introduction to some of the many ways in which the fields of engineering and medicine interact. Topics covered will include the principles of biomedical apparatus and the application of engineering analysis to the functioning of various physiological systems.

ECEN 4005 Communication Systems
Topics include: Telecommunication networks, switching and transmission systems. Computer networks, structure and protocols. Introduction to queuing theory.

EEEN 4008 Optoelectronics
Role of optics. Optical fibres. Semiconductor sources. Detectors. Fibre systems and components; design and testing. Multiplexing options. Atmospheric links. Integrated optics. Photonics and data storage. Coherent optical communication systems. Opto-electronic sensors. Lasers in industry.

EEEN 4015 Optical Engineering
Linear systems transforms, System Invariants, (Fractional) Fourier, Fresnel, transfer matrices, Wigner Distribution function. Reflection and Refraction, Geometric/wave optics, Snell, Huygen, dispersion. Lenses and Aberrations, Imaging systems, aberrations, resolution. Applications: Confocal CD laser head read/write, Microlens passive and adaptive arrays. Electromagnetic Theory, Anisotropic and magneto-optic effects, radiation. Diffraction, Fraunhofer/Fresnel regimes, gratings and coherence. Holography (optical phase matched filters), Geometries, models, Applications: Multiplex elements, interconnects. Optical Signal Processing, Coherent/incoherent complex spatial filters, Joint transform correlators.

EEEN 4012 Applications of Digital Signal Processing
Digital filter design; Butterworth and Chebyshev filters; impulse invariance techniques; the bilinear transformation; computer-automated techniques and algorithms; spectral analysis, periodogram; speech processing; models for speech signals; short-time Fourier analysis; linear predictive coding; fundamentals of digital image processing; two dimensional Fourier transform; discrete cosine transform; image compression; DSP implementation issues; DSP chip architectures; adaptive filters and signal modelling; Wiener (stochastic) filtering; LMS algorithm. A total of up to 20% of marks may be awarded for course work carried out prior to the examination.

MATH 4602 Mathematics 2
A series of lectures on selected topics in Mathematics. Topics will be declared at the beginning of each academic Year.

MATH 4603 Mathematics 3
A series of lectures on selected topics in Mathematics. Topics will be declared at the beginning of each academic Year.

BMGT 4001 Management and its Environment
The Irish economy, its institutions and international relationships. The firm and its environment. Organisational objectives and corporate behaviour. Economic concepts. Market structure and

the competitive process. Demand analysis. Forms of organisation, private and public bodies. Management, its nature and functions - Planning, organising, directing, controlling. Financial management. Presentation and analysis of financial statements. Forecasting. Working capital. Capital budgeting. Financial institutions. Marketing management. Market research. Product life cycle. Product mix. Marketing mix. Operations management. Concept of a system. System design, planning and control. Personnel management. Industrial relations. Trade unions. Collective bargaining.

COMP 4623 Hardware/Software Co-Design
Hardware/software co-design models and architectures; hardware languages; target architectures; compilation techniques and tools for embedded systems; design specification; prototyping and emulation.

Mechanical Engineering

First Year

Mathematics	MATH 1600
Experimental Physics*	EXPH 1603
Chemistry*	CHEM 1604
Mathematical Physics	MAPH 1014
Computer Science*	COMP 1604
Engineering Graphics*	CVEN 1001
Electronic and Electrical Engineering	EEEN 1001
Engineering Fluid Mechanics	CVEN 1003
Engineering Thermodynamics	MEEN 1003
Introduction to Civil and Mechanical Engineering	CVEN 1101
Languages	ENGF 1002

* These subjects have a laboratory or other practical component in addition to the lecture course.

Second Year

Applied Dynamics	MEEN 2011
Mechanics of Materials	MEEN 2002
Thermodynamics	MEEN 2003
Manufacturing Engineering	MEEN 2004
Materials Science and Engineering	MEEN 2005
Engineering Measurement	MEEN 2006
Fluid Mechanics and Heat Transfer	MEEN 2007
Computer Science	COMP 2605
Electrical Engineering	EEEN 2026
Electronic Engineering	EEEN 2025
Experimental Physics	EXPH 2606
Mathematics	MATH 2604
Year's Work in Mechanical Engineering	MEEN 2020
Year's Work in Electronic and Electrical Engineering	EEEN 2028

Third Year

Thermodynamics	MEEN 3008
Fluid Mechanics and Heat Transfer	MEEN 3007
Applied Dynamics and Control Systems	MEEN 3009
Mechanics of Materials	MEEN 3003
Design and Production	MEEN 3010
Materials Engineering	MEEN 3011
Electronic Engineering	EEEN 3028
Electrical Engineering	EEEN 3029

Engineering Computation	MAPH 3014
Computer Methods in Engineering	MEEN 3012
Mathematics (Module A - LT, FS)	MATH 3601
Mathematics (Module B - Integral Calculus)	MATH 3602
Mathematical Physics (Module D - Differential Equations)	MAPH 3024
Management Accounting and Finance	ACC 3023
Year's Work in Mechanical Engineering	MEEN 3020
Year's Work in Electronic and Electrical Engineering	EEEN 3030

Fourth Year

Energy Conversion Systems	MEEN 4001
Fluid Mechanics and Heat Transfer	MEEN 4002
Applied Dynamics and Control Systems	MEEN 4003
Managing Manufacturing Enterprise	MEEN 4004
Materials Engineering and Design	MEEN 4005
Manufacturing Engineering	MEEN 4008
Electronic Engineering	EEEN 4014
The Engineer in Society: The Economy	ECON4011
Course Work	MEEN 4020

Elective subjects: **Three** of the following to be chosen from permitted combinations, with the approval of the Head of Department:

Advanced Composites & Polymer Engineering	MEEN 4009
Advanced Materials Processing	MEEN 4010
Bioengineering	MEEN 4007
Electrical Engineering	EEEN 4013
Engineering Failure Analysis	MEEN 4018
Manufacturing Information Systems	MEEN 4015
Power Generation	MEEN 4016
Technical Ceramics	MEEN 4017

First Year

MATH 1600 Mathematics
Four course units, each unit comprises approximately 24 lectures.

Unit 1: Sets, functions, continuity, differentiation, curve sketching, optimization.

Unit 2: Solutions of systems of linear equations, matrix algebra, determinants, complex numbers, eigenvalues and eigenvectors, vectors in 3-space, scalar and vector products, lines and planes in 3-space.

Unit 3: Definite and indefinite integration, techniques of integration, applications of integration, first and second order ordinary differential equations.

Unit 4: Infinite series, power series, Taylor's theorem and series, partial differentiation of functions of two or more variables, Lagrange multiplier method.

EXPH 1603 Experimental Physics
Lectures: Three lectures each week in the first semester and two lectures each week in the second semester.
Laboratory: Two hours each week.
Introduction to Mechanics: gravitation;

Wave motion: light and sound, reflection, refraction, interference, diffraction, Doppler effect, ray optics, mirrors and lenses;

Electricity and magnetism: electrostatics, capacitance, magnetism, electromagnetic induction, electromagnetic waves;

Quantum physics: quantization of radiant energy, atomic levels, electric charge; Radioactivity: unstable nuclei, α, β, γ decay, fission, fusion.

CHEM 1604 Chemistry
Lectures: Two lectures each week.
Laboratory: Nine laboratory sessions, each of three hours duration, in the second semester.
Atomic structure and the periodic table; bonding, valency, formulae and shape of molecule; moles and stoichiometry; molecular/ionic equilibrium; acids and bases; redox reactions; volumetric analysis; rates of reaction; thermochemistry; electrochemistry and metals; non-metals; organic chemistry.

MAPH 1014 Mathematical Physics
Lectures: Two per week in the first semester and three per week in the second semester.
Vectors, relative velocity, equilibrium of a particle, Newton's Second Law of Motion applied to particle; momentum and impulse; work, power and energy; conservative forces in one dimension; linear motion with constant acceleration; projectiles; circular motion; simple harmonic motion; linear motion with variable acceleration; compound pendulum motion; motion of a rigid body; small oscillations of a rigid body; equilibrium of a rigid body; reduction of a system of coplanar forces; distributed forces; centre of gravity; equilibrium of two and three forces acting on a rigid body; equilibrium of more than three forces acting on a rigid body.

COMP 1604 Computer Science
Lectures: One lecture each week.
Laboratory: Two hours per week.
Introduction to computers; basic hardware; concept of a program; operating systems; files; syntax and semantics; logic; loops; data structures; sorting; structured programming; debugging; program validation; application packages.

CVEN 1001 Engineering Graphics
One lecture and one practical class per week.
Manual draughting:
Use of drawing instruments. Lettering, linework and preparation of computation sheets. Descriptive geometry, orthographic and isometric projection. Sections. Dimensioning. Freehand sketching. Plane curves and Developments.

Computer-aided draughting (CAD):
File creation and management. Element placement, manipulation and modification. Shapes, patterning, dimensioning and drawing with constraints.

CVEN 1003 Engineering Fluid Mechanics
One lecture per week.
Introduction: states of matter, definition of a fluid; fluid properties; fluid statics: pressure intensity, pressure measurement, fluid pressure on surfaces, Archimedes law, flotation/stability; fluid kinematics: streamlines, continuity equation, Bernoulli's equation, flow measurement, orifices, trajectory of a liquid jet; fluid dynamics: momentum equation, fluid acceleration; applications.

EEEN 1002 Electronic and Electrical Engineering
One lecture per week.
Overview of electronic and electrical engineering; basic electrical concepts; DC circuit analysis, circuit theorems, examples and applications; transients; electrical signals; frequency spectrum; analogue signals, amplifiers, applications; digital signals, Boolean algebra, combinational and sequential logic circuits, applications; elementary electromagnetics.

MEEN 1003 Engineering Thermodynamics
One lecture per week.
Basic concepts of thermodynamics; properties of pure substances; work and heat; First Law of thermodynamics for a closed system; control volume; conservation of mass and energy; introduction to the Second Law and entropy; conduction, convection and radiation; applications.

CVEN 1101 Introduction to Civil and Mechanical Engineering
One lecture per week in the first term and site or laboratory visits in the second/third term.
A series of lectures and Engineering laboratory or site visits will be given by staff of Civil and Mechanical Engineering. This programme is designed to provide first year students with a broad overview of both disciplines. It will also assist those who have entered the Civil or Mechanical stream in making an informed choice as to which degree they will opt for in second Year.

ENGF 1002 Languages
Thirty six hours of language classes in the academic Year.

Candidates who enter for the Degree of BE shall be required to pass a College Examination in foreign languages. Students will not be conferred with the BE Degree until they have satisfied the language requirement

Second Year

MEEN 2003 Thermodynamics
(For Agricultural & Food and Mechanical Engineering students)
First Law of Thermodynamics; Control system analysis; control volume analysis; steady-state, steady-flow energy equation. Second Law of Thermodynamics; Work and heat; quality of energy; reversible and irreversible processes; Carnot cycle; absolute temperature scale; definition of entropy; Clausius inequality; derivation of T-ds relations. Analysis of thermodynamic cycles; Rankine, Vapour Compression, Brayton-Joule, Otto, Diesel Cycles.

MEEN 2006 Engineering Measurement
Generalised measurement systems. Instrument static characteristics. Accuracy and error analysis. Calibration. Uncertainty analysis. Dynamic measurement issues. Statistical issues in measurement, statistical distributions. Measurement of temperature, fluid flow, strain, pressure, force, torque, rotational speed and power. Data acquisition systems.

MEEN 2001 Applied Dynamics
(For Agricultural & Food, Electronic & Electrical and Mechanical Engineering Students)
Three-dimensional force systems: resultants and equilibrium. Topics in friction. Particle kinematics. Plane kinematics of rigid bodies. Plane kinetics of rigid bodies: force and acceleration; impulse and momentum; work and energy. Vibration, free and forced. Central force motion.

MEEN 2002 Mechanics of Materials
(For Agricultural & Food, Chemical and Mechanical Engineering students)
One dimensional stress and strain. Biaxial stress. Principal stresses and strains in 2-D. Hookes Law. Strain gauges. Thin-walled pressure vessels. Torsion of circular shafts. Bending stresses and deflections. Buckling of slender bars.

MEEN 2004 Manufacturing Engineering
Introduction to manufacturing. Primary and secondary processing of metals. Casting and forming processes. Joining of metals. Machining of metals. Theory and economics of metal cutting. Machine tools. Gear manufacturing. Grinding. Cutting tool materials. Tool life. Non-traditional machining processes. Numerical control and computer numerical control of machine tools. Programming for CNC. Economics of production. Group technology. Flexible manufacturing systems. Introduction to metrology. Measurement of small linear displacement. Measurement of small angular displacement. Surface metrology.

Economic analysis of engineering investments, discounted cash flows, net present value, equivalent maintenance costs, obsolescence, life-cycle costs and risk. Methods engineering, time

standards and productivity improvement in engineering operations. Costing systems, cost reduction and control, and profit optimisation in manufacturing.

MEEN 2005 Materials Science and Engineering
Introduction to engineering materials and properties, using plain-carbon steel as a model material. Thermodynamics of Materials. Crystallography. Phase transformations. Phase diagrams and microstructure. Mechanical properties. Failure mechanisms.

MEEN 2007 Fluid Mechanics and Heat Transfer
Fluid properties; Newton's law of viscosity; steady and unsteady flow; Compressible and incompressible flow. System Analysis: general motion of fluid particles; acceleration of fluid particles; conservation laws. Control Volume Analysis: continuity equation; momentum equation; applications to include impinging jet on flat plate and curved vanes, flow in bends and nozzles; energy equation; head loss and loss factors Bernoulli's equation: derivation and application to pipe and nozzle flow.

Introduction to Conduction, Convection and Radiation Heat Transfer. One-dimensional steady state heat conduction; the plane wall, the cylinder. Thermal resistance, thermal contact resistance, thermal resistance networks, parallel and series networks. U value, the composite wall, the composite cylinder. Insulation: Properties, R value, critical insulation thickness. Heat Exchangers: Types, concurrent and countercurrent flow, temperature profiles, overall heat transfer coefficient, mean temperature difference, fouling.

EEEN 2026 Electrical Engineering
(For Agricultural & Food and Mechanical Engineering students)
Review of DC analysis, superposition, Thevenin's Theorem.

Transient analysis: RL, RC, LC, RLC circuits.

AC concepts: phasors, complex impedance, combining impedances, AC superposition. Frequency response of 1st and 2nd order circuits. RLC circuits.

DC bridges and measurement. AC power.

EEEN 2025 Electronic Engineering
(For Agricultural and Food and Mechanical Engineering students)
PN-junction: Diode, LED. Rectification. Power supply design. FET and MOSFET as circuit elements (switch, amplifier). BJT transistor. Simple amplifiers: operating point and bias. AC equivalent circuits.

COMP 2605 Computer Science
Advanced C programming, data abstraction, modular program design, object-oriented programming, introduction to C++; software engineering, requirements analysis, design and implementation, testing and maintenance. Software systems: operating systems, inter-process communication, UNIX programming, introduction to compilers.

MATH 2604 Mathematics
Unit 1. Vector spaces, basis and dimension. Linear transformations and matrices. Change of basic matrices. Reflection and rotation matrices. Orthogonal and perspective projections.

Further theory of determinants. Row, column and determinantal rank of matrices and their equivalence. Nullity. Systems of equations. Eliminants. Resultants. Sylvester's determinantal criterion for two polynomials to have a common root. Discriminants. Further properties of eigenvalues and eigenvectors.

Unit 2. Symmetric bilinear forms. Quadratic forms. Positive definiteness. Inner products. Orthonormal bases. Gram-Schmidt process. Diagonalizability of matrices. Preservation of characteristic polynomial. Eigenvalues determinant and trace under similarity. Principal axis theorem. Classification of quadratic forms. Simultaneous reduction of a pair of forms, one being positive definite.

Unit 3. Functions of two or more variables. Graphs, contours, continuity. Partial derivatives. Linear approximation. Tangent planes and normals to surfaces. Differentiability, gradient, directional derivative, grad, div and curl. Laplacian. Taylor's theorem for functions of two or more variables. Critical points and their classification. Hessian matrix. Lagrange multipliers. Line integrals, introduction to double integrals and Green's theorem.

Unit 4. Counting procedures. Probability spaces. Events, conditional events, independent events. Bayes' theorem. Random variables. Density and distribution functions. Mean and variance. Basic discrete and continuous distributions: Uniform, binomial, geometric, Poisson, exponential and normal. Random samples. Confidence intervals. Chi-square distribution. Student's *t*-distribution. Use of tables. Hypothesis testing. Engineering examples.

EXPH 2606 Experimental Physics
Thermal radiation, theory and application. Photons. Light as waves and particles. Quantisation of energy and momentum in atoms. Demonstration of quantised energy levels. Wavelike properties of particles. Wave mechanics and the Schrodinger equation. Time independent wave equation and applications. The one electron atom. Radiation and energy transitions. Atoms in magnetic fields. Anomalous Zeeman effect. Electron spin. Many electron atoms. Pauli exclusion principle. Emission and absorption.

Course Work: Measurement of physical quantities studied in the lectures.

MEEN 2020 Year's Work in Mechanical Engineering
Drawing and Design: Engineering drawing, free-hand sketching, CAD, design assignments.

Laboratory practical work and tutorials associated with courses in Applied Dynamics, Mechanics of Materials, Thermodynamics, Manufacturing Engineering, Materials Science and Engineering, Engineering Measurement, Fluid Mechanics and Heat Transfer.

EEEN 2028 Year's Work in Electronic and Electrical Engineering
Laboratory practical work and tutorials associated with courses in Electronic and Electrical Engineering.

Third Year

MEEN 3001 Thermodynamics
(For Agricultural and Food and Mechanical Engineering students).
Entropy, reversibility and availability. Second Law efficiency.

Rankine, Re-Heat & Regenerative cycles. Brayton-Joule gas turbine cycle. Combined steam & gas turbine cycles. Combined heat & power systems.

Mixtures of gases. Psychrometry. Air Conditioning.

Fuels & Combustion. First Law for reacting systems.

Compressible internal flow: Ideal gas relationships, Mach number and speed of sound. Isentropic flow in converging diverging nozzles. Non-isentropic flow: Fanno and Rayleigh flow, shock waves.

MEEN 3002 Applied Dynamics and Control Systems
Vibration analysis of lumped parameter systems with one and two degrees of freedom. Two and three dimensional motion of rigid bodies with respect to rotating axes. Computer analysis of mechanisms. Balancing of reciprocating masses.

System modelling. Transfer functions. System simulation. System identification. Transient response of systems. State space representation and analysis. Frequency response. Feedback and closed loop control. Stability and stability criteria. Root locus method. System compensation.

MEEN 3003 Mechanics of Materials
Three dimensional stress and strain. Failure criteria. Stress concentrations. Introduction to linear elastic fracture mechanics. Calculation of fatigue life. Torsion of non-circular sections. Bending of asymmetric beams.

MEEN 3005 Materials Engineering
Physical and process metallurgy: heat treatment, surface hardening, metallurgy of welding, ferrous alloys.
Powder metallurgy and ceramics: powder production and processing, sintering mechanisms, powder metallurgical materials including hardmetals; classification and properties of ceramics.
Polymers: structure and classification, polymerisation processes; mechanical behaviour including viscoelasticity, viscolastic mathematical models.

MEEN 3007 Fluid Mechanics and Heat Transfer
Internal Flow: Reynolds experiment, Entrance region and fully developed flow, Fully developed laminar flow, Hagen-Poisseuille flow, fully developed turbulent flow, dimensional analysis, Moody chart, pipe flow, flow rate measurement.

External Flow: Influence of Reynolds number, qualitative description of a boundary layer, boundary layer thickness, displacement and momentum thickness, momentum integral boundary layer equation, laminar and turbulent flows on flat plate with assumed velocity profiles, wall shear stress, separated flow: influence of pressure gradient. Lift and drag.

Heat conduction: general conduction equation, boundary and initial conditions.

Fin heat transfer: fin equation, boundary conditions, fin temperature distributions, fin heat transfer, fin efficiency, fin effectiveness, fin array effectiveness.

Heat exchangers: heat exchanger types, heat exchanger resistance, heat exchanger U-value, log-mean temperature difference approach.

MEEN 3004 Design and Production
The design process. Design methodology. Partial and total design. Application of mechanics of materials to design of machines and structures. Product Liability. Design of bolted, welded, riveted joints. Factors affecting fatigue life. Cumulative damage. Design for fatigue. Design of shafts and clamped components for fatigue applications. Gear design. Continuous system modelling. Simulation as a design method. Advanced Continuous Simulation Language (ACSL). Structure of models. System representation with block diagrams. Design of dynamic systems with worked examples. Design assignment. Integration methods. Input/output devices, interpretation of results. Runtime control. Project management. Critical path analysis. Resource and cost control. PERT.

EEEN 3027 Electrical Engineering
Power and power factor correction: Three phase systems. Power measurement in 3-phase systems.

Safety. Earthing. Fuses. Circuit breakers. Residual current devices. Insulation.

Magnetic devices: B-H curve for iron. Magnetic circuits.

DC machines: machine models, series, shunt and compound connected, speed control, torque speed characteristics, starting.

Single Phase Transformer: Ideal transformer. Approximate equivalent circuit. Open and short circuit.

Induction Machines: Three phase winding and rotating magnetic field, slip, equivalent circuit model, torque and mechanical power, open and short circuit tests, speed control theory and practice.

EEEN 3025 Electronic Engineering
(For Agricultural & Food and Mechanical Engineering students)
Amplifiers: Frequency response. The operational amplifier: ideal properties, standard circuit configurations, non-ideal behaviour .

Transducers: brief overview and examples.

Filters: Passive, active, implementations using op amps.

Data acquisition: sensor impedance; noise types, sources & precautions; signal conditioning; filtering; differential/single inputs; AtoD conversion.

Digital electronics: Gates, transistor implementation. Fundamentals of digital logic, Boolean algebra, Karnaugh maps. Combinational digital logic building blocks, half adder, full adder. Sequential digital logic: JK flip-flop, D and T flip-flops, memory.

MAPH 3014 Engineering Computation
Error analysis, numerical solution of algebraic and transcendental equations, matrix inversion, determination of eigenvalues and eigenvectors, numerical differentiation and integration, application of finite difference methods to ordinary and partial differential equations, interpolation and sampled data and finite element techniques. Non-linear optimisation.

MEEN 3006 Computer Methods in Engineering
(For Agricultural & Food and Mechanical Engineering students)
Statistical methods: interpretation of experimental data, curve fitting, statistical analysis, validation of models. Introduction to finite element analysis. Introduction to rapid application development languages.

MATH 3615 Pure and Applied Mathematics

MATH 3601 Mathematics [LT-FS-CV or CofV] (1 unit) *

Laplace transform (LT). Heavyside-step and Dirac-Delta functions, convolution, solutions of differential equation, engineering examples.

Fourier series (FS). Hilbert spaces, partial differential equations (wave and heat), engineering applications. Introduction to calculus of variations (CofV).

OR

Introduction to theory of functions of a complex variable (CV). Cauchy-Riemann equations. Harmonic functions. Conformal mappings. Cauchy integral formulae.

MATH 3602 Mathematics (Integral Calculus)
Further advanced calculus. Scalar and vector fields over curves and surfaces. Grad, div and curl. Change of variable. Curvilinear co-ordinates. Integration over domains, curves and surfaces. Divergence theorem. Stoke's theorem. Applications.

MAPH 3024 Mathematical Physics (Differential Equations)
Ordinary differential equations. Isoclines. Linear systems of first order. Phase plane. Singular points. First order p.d.e. How they arise. Sketching characteristics. Solutions. Second order p.d.e. How they arise. The Cauchy problem. Characteristics. Difference schemes for Laplace. Wave and diffusion equations. Motivation for different initial or boundary value problems. Properties of solutions.

ACC 3020 Management Accounting and Finance
Fundamentals of management accounting. Purpose of management accounting. Cost terms and purposes. Cost allocation and absorption. Product costing - Job cost, contract costing and process costing. Budgeting, responsibility, accounting and motivation. Capital budgeting techniques. Decision-making: Cost-volume-profit relationships. Relevant costs and the contribution approach to decisions. Financial analysis: Review of financial statements (balance sheet, profit and loss account, statement of sources and uses of funds). Accounting conventions;

* 1 unit = 25 lecture hours.

statements of standard accounting practice: Ratio analysis; financial ill-health (through trading losses, overtrading etc.); capital structure.

MEEN 3020 Year's Work in Mechanical Engineering
Laboratory practical and design project work associated with lecture courses in Thermodynamics, Fluid Mechanics & Heat Transfer, Applied Dynamics & Control Systems, Materials Engineering, Mechanics of Materials, Design & Production, and Computer Methods in Engineering.

EEEN 3020 Year's Work in Electronic and Electrical Engineering
Laboratory practical work associated with lecture courses in Electronic Engineering and Electrical Engineering.

Fourth Year

MEEN 4001 Energy Conversion Systems
Internal Combustion Engines: Introduction to internal combustion engine design and operating characteristics, ideal thermodynamic cycles, engine parameters, engine testing, 4-stroke engine gas exchange processes, supercharging and exhaust gas turbocharging, two-stroke engine scavenging, combustion and pollutant formation in compression ignition and in spark ignition engines, exhaust after-treatment systems.

Building Energy Systems: Psychrometry, thermal comfort, psychrometric processes, adiabatic saturation, heating, cooling, humidification, dehumidification, building air conditioning analysis, cooling towers.

Turbomachinery: Fluid flow in turbomachines. Euler equation. Application to hydraulic and compressible flow turbomachines. Dimensional analysis. Similarity and modelling.

MEEN 4002 Fluid Mechanics and Heat Transfer
Differential equations of mass and momentum conservation: The Navier-Stokes equations, exact solutions of the Navier-Stokes equation; introduction to lubrication theory; Reynolds averaged Navier-Stokes equations.

Introduction to computational fluid dynamics.

Inviscid flow theory.

Conduction: lumped capacitance method, lumped system analysis.

Convection: velocity and thermal boundary layers, forced convection, free convection

Heat exchangers: review, log-mean temperature difference approach, NTU-effectiveness approach.

Radiation: thermal radiation, blackbody radiation, surface emission, absorption, reflection and transmission; view factors, black surface radiation exchange, diffuse and gray surface radiation exchange, radiation shields.

MEEN 4003 Applied Dynamics and Control Systems
Multi-dimensional discrete and continuous vibrating systems. Orthogonality properties of normal modes. Rayleigh Quotient and Rayleigh-Ritz Method. Lagrange equations. Angular momentum equations in three dimensions. Random vibrations, spectral analysis. Sampled data control systems. Modern control theory.

MEEN 4005 Materials Engineering and Design
Strengthening mechanisms in non-ferrous alloys. The light alloys: aluminium, magnesium and titanium. Copper and its alloys. High temperature alloys and coatings. Degradation of metallic materials: creep, fatigue, corrosion and wear. Non-destructive testing and failure analysis of metals. Quality assurance. Fracture toughness testing. Metal forming and casting processes. Case studies in materials selection. Structural adhesives in joint design. Introduction to polymer composites. Introduction to polymer processing.

MEEN 4004 Managing Manufacturing Enterprise
Management functions and objectives. The competitive and changing manufacturing environment. Types of production. Influence of automation. Production and operations management. Materials control. Production and inventory control. Group technology. Just-in-time. Forecasting principles and methodology. Material requirements planning. Environmental issues. Quality assurance. Total quality management. ISO 9000 quality systems. Safety in the workplace. Safety regulations.

Product life cycle. Product development. Prototyping. Concurrent engineering. Marketing engineering products. Enterprise. New venture research. Planning and early growth management.

Contract law, Professional liability, Product liability, Arbitration, Employment Law, Negligence, Employment Equality.

MEEN 4008 Manufacturing Engineering
Advanced treatment of conventional and non-conventional manufacturing processes, precision and ultra-precision manufacturing systems, design of machine tools, accuracy of machine tools, machining centres, flexible manufacturing systems, monitoring and diagnostics of manufacturing systems, computer integrated manufacturing.

EEEN 4014 Electronic Engineering
Non-ideal behaviour of operational amplifiers, sources of noise in measurement, signal conditioning and filtering. Analogue-to-Digital and Digital–to-Analogue converters. Sampling theorem and introduction to digital signal processing. Components of digital systems, counters, decoders, multiplexers. Introduction to computer architecture, addressing, interrupts, input/output. Digital systems, including microcontrollers and microprocessors. Power electronic devices, silicon-controlled rectifiers, thyristors.

ECON4011 The Engineer in Society: The Economy
Recent Irish economic history. Population and the labour market. Industrial and trade policies. Finance for development. External economic relations. Macroeconomic policy.

MEEN 4020 Course Work
Course work includes exercises in computer aided drafting, design and finite element analysis; programming of CNC machining centres; advanced techniques of photo-elastic, brittle lacquer and strain gauge stress analysis; fracture mechanics; vibration and control exercises; data logging and introduction to techniques of data collection and condition monitoring; testing of internal combustion engines and evaluation of results; tests on heat transfer and fluid mechanics rigs and experimental evaluation of water turbines and pumps; tests on tribology rigs.

Project work involves specialisation, on an individual basis, at some depth in one area of the above formal experimental work or in such areas as detailed design of equipment, development of foundry, pattern shop or machine shop technology, for which facilities are available, non-destructive testing including X-ray and gamma ray inspection techniques etc.

Students will carry out individual projects on a self-contained subject, or as an independent member of a team on an integrated subject having several clearly distinguished areas of interest. The project will involve a survey of published literature or such other material as is available, followed by the design and construction of apparatus, experimental measurements and the preparation of a comprehensive report. Some projects will concentrate on design, while others may be more concerned with test and analysis of specific systems or rigs.

Elective subjects: **Three** of the following to be chosen from permitted combinations, with the approval of the Head of Department.

MEEN 4009 Advanced Composites and Polymer Engineering
Fibre reinforcements. Mechanics of composites. Strength and fracture of composites. Failure analysis and NDE of composites. Design, manufacture and applications of composites. Isothermal flow of viscous non-Newtonian fluids. Viscoelastic response of polymeric fluids. Mixing of polymer melts. Extrusion and extrusion dies. Moulding and forming. Mould design.

MEEN 4010 Advanced Materials Processing
Innovation in the processing of materials, with a concentration on metals, alloys, and metals matrix composites. Novel solidification and deformation processes. Microstructural evolution during the processing of alloys. Engineered materials, including gradient materials and nonostrucutured materials. Modelling the processing of alloys at macro- and micro-scopic length scales. Advanced characterisation techniques. And a look to the future.

MEEN 4007 Bioengineering
Biomechanics: geometry, loading, and kinematics of joints; lubrication and wear of joints; design of joint arthroplasties. Biomaterials: properties of natural materials; biocomaptibility; metallic and polymeric biomaterials; synthetic bioceramics; tissue engineering.

EEEN 4013 Electrical Engineering
More advanced treatment of EEEN 3027 where appropriate. Synchronisation; infinited busbar and power output of alternators. Transformers; in rush current, PTs and CTs, parallel operation. Three-phase and single-phase induction motors; starting and braking; transient analysis and special applications; linear and stepper motors. Power electronic devices and power-electronic converters and inverters for DC and AC motor drives. Electrical safety, protection, step and touch voltages. Heating of metals and non-conducting materials. Industrial installations, circuit breakers and protection. Industrial tariffs and power factor correction. Sensors and the electrical measurement of mechanical variables.

MEEN 4018 Engineering Failure Analysis
Case study based approach. Failure mechanisms examined include elastic and plastic deformation, fatigue, brittle fracture and environmentally-induced failures.

MEEN 4015 Manufacturing Information Systems
Computer Integrated Manufacturing, Supervisory Control and Data Acquisition, Flexible Manufacturing Cells, Programmable Control, Factory Communication, Computer Aided Design and Manufacture, Concurrent Engineering, Product and Process Data Management Systems.

MEEN 4016 Power Generation
Fossil fuels in power generation: Analysis of power generation cycles, technical, economic and environmental aspects of current and future fossil-fuel power generation technologies.

Nuclear power generation: Nuclear fission and fusion in power generation.

MEEN 4017 Technical Ceramics
Models of sintering mechanisms. Silicon nitride based ceramics including SiAiONs. DIMOX process and materials. Transformation toughened ceramics. Selected topics in fracture of ceramic materials.

Scholarships and Bursaries

Pierce Malone Scholarship in Engineering

1. The Scholarship in Engineering will be awarded in connection with the BE Degree Examination in Civil Engineering.
2. The examination will consist of an essay on any suitable topic in the Civil Engineering course and will be conducted by the extern examiner in Civil Engineering at each NUI constituent university in connection with the BE (Civil) Degree Examination held in Summer.
3. The examination will be held within one month before the commencement of the Summer examination for the BE (Civil) Degree.
4. Candidates must submit an entry form to the National University of Ireland.*
5. The Scholarship, or such special prize as may be awarded in lieu thereof, shall be awarded to the successful competitor in the examination. In the case where none of the students presenting themselves for the examination for the Scholarship shall have reached the standard of requirement for the Scholarship, it shall be open to the Senate, on the report of the examiner, either to recommend for a special prize any student whose answering, in the opinion of the examiner, may have reached such standard as to entitle him/her to such special prize or to award neither Scholarship nor prize.
6. Candidates for the Pierce Malone Scholarship in Engineering must obtain the BE (Civil) Degree:
    a. Within the minimum number of terms after passing the Third University Examination in Engineering;
    b. In the Summer of the year in which they enter for the Scholarship.
7. Candidates, otherwise eligible, may compete for both the Bursary in Civil Engineering and the Pierce Malone Scholarship in Engineering but no candidate shall be eligible to receive both awards. Should a candidate be first in both competitions, he/she shall be free to select which prize he/she will accept.

* For date of examination and latest day for receiving entry forms, application should be made to the Registrar, National University of Ireland, 49 Merrion Square, Dublin 2, after 1 January.

Bursaries in Engineering

The following Bursaries will be offered for competition in 2003:
One Bursary in Civil Engineering;
One Bursary in Electronic and Electrical Engineering;
One Bursary in Mechanical Engineering.

Details are given below:

1. The Bursaries in Engineering will be tenable for one Year. The value of the bursary will be set by the University.
2. The Bursary in each branch will be awarded on the results of an examination to be held within one month before the commencement of the BE Summer Examination.
3. Candidates must obtain the BE Degree with at least Second Class Honours, Grade I.
4. A candidate may not present for the Bursary in a particular branch of Engineering on more than *one* occasion. When a Bursary is offered for competition in a year in which a candidate is presenting for the BE Degree Examination, he/she may present for the Bursary in that year only. Otherwise a candidate may present for the Bursary only on the first subsequent occasion on which it is offered for competition in his/her branch of Engineering.
5. No Bursary shall be awarded unless, in the judgement of the examiners, sufficient merit has been shown.
6. Each Bursary shall be held upon the condition that the student shall:
   a. attend an approved postgraduate course in another university or similar institution; or
   b. engage in research in an approved laboratory; or
   c. become a trainee in an approved engineering office or works.

   Such postgraduate courses, research or training period shall be pursued outside Ireland in such place as may be approved by the Faculty of Engineering and Architecture of the student's University; provided that a student shall not obtain salary, wages or other allowance in respect of the period whilst he/she is holding the Bursary without prior approval from the University.
7. The successful candidate must furnish to the University, after six months, a report signed by the head of the university department, laboratory or engineering firm as to his/her progress and experience.
8. Entry forms and information on dates of examinations and on latest day for receiving entry forms may be obtained from the Registrar, National University of Ireland, 49 Merrion Square, Dublin 2, after 1 January.

Postgraduate Degrees

Degree of Master of Engineering
Degree of Master of Engineering Science
Degree of Master of Engineering Design
Degree of Master of Industrial Engineering
Degree of Master of Science (Technology Management)
Degree of Master of Science (Environmental Policy)

Degree of Doctor of Philosophy

Degree of Master of Engineering (ME)

(ENMRF0001)

A candidate who is the holder of the Bachelor of Engineering Degree shall be eligible to obtain the Degree of Master of Engineering after the expiration of nine terms from the time at which the candidate obtained the BE Degree.

A candidate:
(a) must pass the prescribed examination;
(b) must present a dissertation; and
(c) must present such evidence of professional experience as may be prescribed.

The following Regulations apply to the ME Degree:

1. Candidates for the Degree of ME must be accepted by the Faculty of Engineering and Architecture as prospective candidates at least six months before entering for the examination. They are required to give notice to the Dean of the Faculty before 15 January of the year in which they intend to present themselves for examination with particulars of the branch of study selected, title of the proposed dissertation and details of their professional experience. *

2. They must pass a special examination in the special branch of Engineering selected by the candidate. The examination may be taken in Summer and the thesis submitted in Autumn. Exemption from the examination may be granted by the Faculty to a candidate who has obtained First Class Honours in the BE Degree, or who submits satisfactory evidence that he/she has been engaged on works of considerable importance.

3. The dissertation shall consist of a record (published or not) of original work, or of an essay on some branch of Engineering involving criticism. The candidate shall be examined on the subject-matter of his/her dissertation or on any matter intimately connected with it.

4. A candidate for the Degree shall have had professional experience of an approved character in a responsible capacity extending over a period of not less than three years. A detailed statement as to such experience vouched for by the Engineer or Engineers in charge must be submitted.

* Candidates are reminded that they must also complete a University Entrance Form on or before the last date for entry as advertised by the University.

Degree of Master of Engineering Science (MEngSc)

1. **Methods of Proceeding to the Degree**
The Degree of MEngSc may be obtained by thesis (Mode I) or by examination following a taught course (Mode II).

Mode I
A candidate must carry out a full-time research project for at least three terms under the direction of the supervisor appointed by the head of the department concerned. The thesis presented by the candidate is to embody the result of this research project. At least one examiner shall be an external examiner. A candidate may be required to pass a *viva voce* examination on the subject matter of the thesis if the examiners so decide.

Mode II
A candidate must attend, for at least three terms, a full-time postgraduate course approved by the Faculty and must pass a University examination on the subject matter of the course. A candidate may be required to submit a dissertation on a project undertaken as part of the course; this dissertation will form part of the material to be assessed by the examiners.

The Faculty must approve the syllabus of the course to be attended by a candidate proceeding under Mode II.

2. **Admission Procedure**
An applicant for admission as a candidate for the Degree of MEngSc by Mode I or by Mode II shall submit an application on a prescribed form to the head of the department in which the applicant wishes to study. If the head of the department is satisfied as to the applicant's general suitability to undertake an MEngSc programme, the department shall forward the candidate's application to the Dean for consideration by the Faculty. Candidates for the Degree of MEngSc must obtain permission of the Faculty before entering on the programme.

There are three intakes each academic year in September, January and March to the programme leading to the award of MEngSc (Mode I) by thesis. It may be possible to commence at a different time, subject to the agreement of the Supervisor and with Faculty approval. Normally the closing dates are:

	(i) **September** Intake	(ii) **January** Intake	(iii) **April** Intake
non-EU candidates	31st March	30th July	30th September
EU candidates	30th July	30th November	27th February

Taught Master's Programmes
The programme leading to the award of MEngSc (mode II) by examination has one intake per year and commences in September, and to avoid disappointment applications should be submitted by no later than 31 March for non-EU and 31 July for EU candidates. Applications received after the closing date may be considered subject to the availability of places.

3. **Entry Standards**
A candidate must qualify for entry by meeting the requirements of one of the sections 3. 1, 3. 2 or 3. 3 below.

3. 1 By holding a primary degree in Engineering from the National University of Ireland with at least Second Class Honours, Grade II (2H2).

3. 2 By holding a primary degree in Engineering or a related discipline with at least a Second Class Honours, Grade II award from a university or other third level institution, subject to the requirement that the Faculty *may* decide that the candidate must achieve a satisfactory performance in a qualifying examination or test whose form shall be decided by the Faculty on the advice of the head of the department in which the candidate intends to study.

(a) If a qualifying *examination* is appropriate, candidates will be required to spend one academic year studying (i) at least two courses of the Fourth Year core programme; and (ii) complete a project on a specified topic. The courses studied and project topic will be relevant to the proposed area of research.

(b) If a qualifying *test* is appropriate, candidates will be required to complete an essay of *circa* 5, 000 words on the topic of their proposed research. They will be given an oral examination on the essay and their proposed programme by the head of the department and a staff member who is familiar with the field of research.

Candidates must obtain a minimum of a Second Class Honours, Grade II in each paper and project of the qualifying examination or in the assessment of the essay for the qualifying test.

3. 3 Where there is evidence of substantial professional experience in engineering or a related discipline, then the holder of (a) a pass degree or (b) chartered membership of a professional institution approved by the Faculty may, on the recommendation of the head of the department and with the permission of the Faculty, be admitted to the MEngSc programme on condition that the candidate *must* take a qualifying examination or a test as outlined in 3. 2 above.

4. A candidate may, in exceptional circumstances, be permitted to pursue the practical work of the research project required under Mode I in an institution other than the University, provided that:

(i) The field of research and the institution in which the practical work is to be pursued are approved in advance by the Faculty;

(ii) The course of training in research is supervised directly by a member of the academic staff of the department in the University as if the work were being pursued totally within the University.

5. A candidate will not be permitted to attend courses for any other university degree or diploma whilst in attendance at the MEngSc Degree programme.

6. An applicant may have to satisfy an English language requirement before registration.

7. Registration

A candidate by Mode I or Mode II shall register on or before the date of commencement of the period of study and shall re-register annually (if appropriate) at the prescribed times until the studies are completed. Candidates in the category described by Section 3. 2 (a) shall register first as 'qualifying students' for the Degree of MEngSc, and, after satisfying the required entry conditions, they will register for the Degree of MEngSc by Mode I or Mode II.

Candidates must pay the appropriate fees at the specified times.

Mode II MEngSc Programmes

The School of Engineering offers Mode II MEngSc Degree programmes as follows:

Food Engineering, Water & Environmental Engineering, Transportation Engineering, Structural Engineering and Environmental Engineering

Details of the MEngSc (Mode II) programmes provided in Session 2002/03 are as follows:

Food Engineering:

AFFD P001 Introduction To Food Engineering
Basic modes of heat transfer in foods. Heat transfer with phase change. Heat exchangers in food processing. Mass transfer in food separation processes including: distillation, leaching, filtration, ultrafiltration, reverse osmosis, electrodialysis, centrifugation. Process laboratory

AFFD P002 Food Process Engineering
Unit processes, heat and mass transfer systems and equipment in food processing including pasteurisation, UHT and aseptic processing, microwave and dielectric heating, crystallisation, freezing, homogenisation, emulsification. Drying theory and applications. Unit processes associated with drying including evaporation, extrusion, packaging and storage. Process simulation, assignments.

AFFD P003 Food Product Development
Food product development incorporating product conceptualisation, product formulation, sensory analysis, colour measurement, principal component analysis, statistical analysis, shelf life, market analysis. Laboratory practicals. Mini-project involving product and process development for a selected food product or ingredient.

AFFD P004 Food Process Development
Food process development incorporating process engineering, quality control, plant layout, project management, environmental engineering, legislation, health and safety.

AFFD P005 Sensors in Food Process Automation
On-line measurement systems for physical properties of foods including optical (NIR, MIR, visible), rheological, ultrasonic and hot wire sensors. Process automation systems. Case studies on selected food products. Laboratory practicals. Assignments.

AFFD P006 Advanced Food Process Engineering
Novel food manufacturing techniques in one of more selected areas including fermentation, refrigeration, ohmic heating, high pressure processing, supercritical extraction, sous vide processing. Basic theory, process strategy, equipment, food quality, market niche.

AFFD P007 Advances in Food Engineering Research
Detailed outline of advances in food engineering research in **one** selected area such as rheology, storage systems or dehydration technologies. Basic theory, systems modelling, experimental protocols, instrumentation, data analysis, interpretation and application of results. Assignments including review of advanced research papers.

AFFD P008 Project and Research Methods
Each student undertakes a major project under the direction of a supervisor, the findings of which are presented in the form of a written dissertation. Initial guidance in project management will be provided by a series of lectures on research methods.

Water & Environmental Engineering:

CVWE P001 Unit treatment processes
Theory and technology relating to sedimentation, flotation, filtration, chemical coagulation, chemical precipitation, ion exchange, adsorption, disinfection, fluoridation, aeration; design of water and wastewater treatment systems.

CVWE P002 Sanitary engineering hydraulics
Steady flow in pipes, manifolds and pipe networks; form losses; pumping station hydraulics; waterhammer analysis and control; open channel flow - steady, gradually varied and unsteady; hydraulics of sewer systems; hydraulic structures for flow measurement.

CVWE P003 Engineering hydrology
The hydrological cycle; water balances; measurement and analysis of hydrological processes; stochastic and deterministic models; analysis of floods and droughts; application of hydrological techniques to water supply, urban drainage, wastewater dilution; other engineering applications such as hydropower, flood forecasting, irrigation and drainage.

CVWE P005 Water resource systems analysis
Sustainable development and investment in water resource projects; project life cycle; objectives of water resource development; performance indices; engineering alternatives – size, location, allocation and timing; evaluation and selection with multiple objectives; system simulation; sampling experiments; synthetic hydrology; system control; dynamic programming; heuristic rules; system optimisation; linear and non-linear programming; case studies.

Water quality modelling
Definition and measurement of water quality parameters; pollutant sources, pathways and sinks; pollutant variability; modelling of kinetics; water quality modelling in rivers, dispersion, self-purification, oxygen and mass balance equations; water quality modelling for lakes and reservoirs; estuarine water quality models, tides, saline intrusion, mixing; modelling of discharge to the marine environment, sea outfalls.

CVWE P004 Applied chemistry and microbiology
Review of basic principles of chemistry; chemical equilibrium in true solutions; gas-liquid and liquid-solid equilibria; surface chemistry; fundamentals of biochemistry; biologically-mediated transformations in aquatic systems; general systems of classification of water-dispersed substances; chemical and biological water quality criteria; critical review of water quality standards; methods of chemical and microbiological analysis.

CVWE P006 Environmental management and Environmental engineering
Policy, law and administration. Assessment of ecological impact: ecology of wetlands and freshwaters. Air pollution and noise. Disposal of solid and hazardous wastes.

CVWE P007 Laboratory programme
Students carry out practical work programmes in the following laboratory disciplines:

Water and Wastewater Analysis, Unit Treatment Processes, Hydraulics, and Microcomputers.

CVWE P008 Project
Each student undertakes a major project under the direction of a supervisor, the findings of which are presented in the form of a written dissertation. Project topics generally relate to engineering aspects of the analysis, design and operation of a water supply and wastewater disposal system.

Computer methods
Computer organisation and computer languages; problem solving and problem development; computer applications in water engineering; computer exercises; practical evaluation of relevant computer packages.

Degree of Master of Engineering Design (MED)

(ENMXF0013) (ENMXP0019)

Admission Requirements

1. A candidate for the degree must obtain the permission of the Faculty of Engineering and Architecture before entering the course. Application on the prescribed form which is obtainable from the School of Engineering must be made to the Faculty of Engineering and Architecture (before the second week of October). A candidate for admission must be an engineering graduate or must fulfil the conditions described in section 2 below.

   A candidate for selection will be required to have had suitable industrial experience for a period of at least one year. Candidates who have obtained First Class Honours in the primary degree, or who have pursued a suitable postgraduate course, may be accepted without industrial experience, provided that adequate vacation training has been obtained.

   Candidates will be interviewed in November. The number of entrants to the course shall be limited.

2. A suitable candidate who is not a university graduate, but who is a corporate member of the Institution of Engineers of Ireland, or of equivalent status in a similar professional engineering institution, may be recommended to the Faculty for admission to the course.

Course

The course is a part-time course over two years and will consist of lectures, seminars, tutorials and project work. Project work will account for about 40 per cent of the course and a typed and bound thesis must be presented for examination. The course project and examination must be passed within nine terms from the commencement of studies unless special permission is granted by the Faculty with the agreement of the Head of Department.

Subjects

The subjects will be chosen by students with the permission of the Professor from among the following:

MHED P001 Design Methodology and Practice

Design as an engineering discipline. How to initiate design. Analytical and experimental support tools for design. Developing the concept. Mechanism modelling. Form modelling. O. E. M. supply sources. Use of standards. Quality assurance. Patents and patenting procedure. Legal responsibilities. Product liability claims. Value analysis. Cost in design and in product. Ergonomics. Aesthetics.

MHED P002 Computer Aided Design

Product and system design. Computer integrated design and manufacture. Simultaneous engineering. Design for manufacture. Group technology. CAE/CAD/CAM applications. Solid, surface and wire frame modelling. Programmable graphics. Optimisation of mechanical design. Graphics exchange standards. Computer graphic workstations. Graphic devices and software. Knowledge-based engineering systems.

MHED P003 Design of Machine Elements
Stress management and analysis. Machine element design, static and dynamic finite element modelling and applications, element shape functions, computer procedures, design with viscoelastic materials, impact absorption, design with anisotropic materials, properties of carbon fibre composites etc.

MHED P004 Materials Selection
Cast irons. Carbon alloy steel products. Heat treatment of carbon alloy steels. Fabrication and service characteristics of carbon and alloy steels. Non ferrous metals. Heat treatment of non ferrous metals. Fabrication and service characteristics of non ferrous metals. Production processes for polymer materials, ceramics and coatings. Classification methods for metals, polymers and ceramics. Case studies in alternative materials selection and substitution of materials. Material selection by computer.

MHED P005 Production Systems, Design and Management
Production standard data. Value engineering. Human factors in engineering design. Learning and progress functions. Motivation and industrial relations. Productivity agreements and controls. Plant and investment analysis. Inventory systems. Quality management. Plant engineering systems. Management and organisation. Design of a production system - case study.

MHED P006 Design of Automated Manufacturing Systems
Types of manufacture: Continuous, batch, one-off. Manufacturing resource planning and control. Computer integrated manufacturing. Just-in-time and kanban methods. Flexible manufacturing systems and cells for metal cutting, welding, assembly etc. off-line CNC and robot programming. Communication networks and protocols. Machine systems engineering. Robot kinematics, dynamics and control. Drive systems, actuators and sensors. Programmable logic controllers.

MHED P007 Microprocessor Applications
Binary maths, logic, number systems and codes. Microcomputer components and architecture. Instruction sets and assembly language programming. Programme structure. Compilers and high level languages. Ports and input/output. Polling. Interrupt and direct memory access. Microcontrollers. Actuators. Practical exercises in microprocessor based data acquisition and control. Networks. Overview of application design and development.

MHED P008 Digital Electronics Design and Interfacing
Boolean algebra. Combinational logic. Gates. Minimisation. Examples. Sequential logic elements. Synchronisation. Sequential logic system design. Registers, counters, multiplexers and other MSI components. Programmable logic devices. Circuit operation and types: transistors, TTL, CMOS. Practical circuit design issues: loading, timing, buses, line driving, noise sources and avoidance. Signal conditioning.

MHED P009 Tribology and Design Applications
Fundamentals of tribology and surface texture interactions. Emphasis on design and energy aspects. Case studies and applications. Practical lubrication examples including Elastohydrodynamics. Application to design of machinery systems. Prototypes and Bearings.

MHED P010 Technology and Innovation Strategy
Principles of economics, macroeconomics and social indicators, growth models, production functions, the technological factor, industrial policy, venture capital. The role of technology in economic growth, industrial innovation, industrial policy, and sectoral and inter-firm competition. Patenting, licensing and the finance of technology. Technology and skill change. Technology in higher education. Telecommunications. Technological forecasting and assessment. European programmes in science and technology.

MHED P011 Design of Internal Combustion Engines
Study of internal combustion engine design issues – based on fundamentals of thermodynamics, fluid mechanics, heat transfer and combustion. Four-stroke spark-ignition and compression-ignition engine thermodynamics. Spark-ignition and compression-ignition combustion systems. Fluid flow in intake and exhaust systems. Turbocharging and supercharging. Exhaust emission control systems. Heat transfer in engine cooling systems. Engine-vehicle integration.

MHED P012 Design of Thermal Power Plant
Thermodynamics of heat engines. First and Second Law analysis of cycles and systems. Equivalent Carnot cycles. Advanced cycles. Combustion systems. Turbomachinery. Flue gas emissions control systems. Auxiliary plant.

MHED P013 Micro-climate Management Design
Specification of micro-climate. Fundamentals of heat transfer. Psychrometry. Analysis of heat gain calculation methods. Estimation of cooling load. Solar design. Passive cooling. Mechanical heating and cooling. First and Second Law analysis of climate manipulation systems. Energy auditing. Energy management.

MHED P014 Design of Building Energy Systems
Study of building energy system design issues. Air conditioning systems. Air heating systems. Humidification and dehumidification systems. Air handling equipment. System integration. System control design.

MHED P015 Polymer Matrix Composite Materials: Performance and Design
Fibres. Fibre-matrix interface. Elastic properties - classical laminate theory. Strength of unidirectional laminae. Strength of laminates. Structural component design. Case studies.

MHED P016 Manufacturing and Design with Engineering Polymers
Extrusion process. Injection moulding. Blow moulding. Thermoforming process. Rotational moulding. Dies and moulds. Environmental aspects of plastics.

MHED P017 Design of Biomechanical Systems
Introduction to anatomy and physiology. Biomaterials. Mechanics of hard tissue. Mechanics of soft tissue. Bio-viscoelastic solids. Joint mechanics. Bio-viscoelastic fluids. Design of implantable devices.

MHED P018 Design Project Work

Degree of Master of Industrial Engineering (MIE)

(ENMXP0020)

Course Description

The MIE degree programme provides a structured approach for engineers and scientists to acquire the engineering and managerial disciplines necessary to effectively manage operations across a wide spectrum of industry. The course is designed for those already involved in operations management or hoping to move into the area. It contains a mixture of Analytical, Operations, Technology and Business topics aimed at giving participants a balanced foundation in theory and modern day industrial practice.

Admission of Candidates

1. A candidate for the degree must obtain the permission of the Faculty of Engineering and Architecture before entering on the course. Application on the prescribed form which is obtainable from the Department of Mechanical Engineering must be made to the Faculty of Engineering and Architecture. A candidate for admission must be an Engineering graduate of a recognised university, or must be an Architecture or Science graduate with suitable experience and the required standard of mathematics, or must fulfil the conditions described in Section 2 below.
2. A suitable candidate, who is not a university graduate, but who is a corporate member of the Institution of Engineers of Ireland, or of equivalent status in a similar professional engineering institution, may be recommended to the Faculty for admission to the course.

Part-time Course (Two Years)

The course is a part-time course over two years. Attendance is required for at least six terms after admission and during attendance candidates cannot at the same time engage in any other course in the University.

Students must make arrangements with their employers for release for attendance on the afternoons on which the prescribed courses are held as set out in the timetable.

Modular Course

The programme will be provided as a credit system to be taken by candidates over a period of two or more years. In order to obtain the Degree, candidates must attend an approved set of courses and pass the relevant University Examinations. The courses and credits are shown below and the Degree will be awarded when the candidate has successfully attained a total of 18 credits.

Subjects and Credits

Part A		***Credits***
MHIE P016	Operations Management	1.5
MHIE P017	Process Operations and Reliability	1
MHIE P018	Quality management	1
MHIE P019	Project management	1
MHIE P020	Statistics and Optimisation	1.5
HRM P618	Human Resource Management	1
PSY P500	Organisational Psychology	1
ACC P623	Management Accounting	1
Part B		
MHIE P021	Operations Strategy	1
MHIE P022	Computer Integrated Manufacture	1
MHIE P023	Technology, Innovation and Design	1
MHIE P024	System Simulation	1
MHIE P025	Advanced Statistics	1
MIS P651	Management Information systems	1
FIN P659	Finance	1
MKT P645	Marketing and Innovation	1
BMGT P768	Strategic Management	1
Total:		18

Candidates will be required to pass university examinations in the following subjects:

MIE Part A

Operations Management	(Course MHIE P016)
Process Operations and Reliability	(Course MHIE P017)
Quality Management	(Course MHIE P018)
Project Management	(Course MHIE P019)
Statistics and Optimisation	(Course MHIE P020)
Human Resource Management	(Course HRM P618)
Organisational Psychology	(Course PSY P500)
Management Accounting	(Course ACC P623)

MIE Part B

Operations Strategy	(Course MHIE P021)
Computer Integrated Manufacture	(Course MHIE P022)
Technology, Innovation and Design	(Course MHIE P023)
System Simulation	(Course MHIE P024)
Advanced Statistics	(Course MHIE P025)
Management Information Systems	(Course MIS P651)
Finance	(Course FIN P659)
Marketing and Innovation	(Course MKT P645)
Strategic Management	(Course BMGT P768)

Candidates for the degree are required to complete the course within 4 years of registration.

MIE – Part A

MHIE P016 Operations Management
Operations strategy and competitiveness, process choice, capacity planning, facility location and layout. Job design and work measurement, payment schemes, managing productivity. Lean manufacturing. World Class Manufacturing. Materials management, inventory systems, aggregate planning and master scheduling. Material requirements planning (MRP), capacity requirements planning (CRP), supply chain management, production activity control, scheduling, learning curves. Just-in-Time.

MHIE P017 Process Operations and Reliability
Asset management, maintenance principles, reliability theory, equipment failure, reliability and risk, preventative and predictive maintenance, process equipment maintenance, recovery, business continuity, health and safety, environmental.

MHIE P018 Quality Management
Quality Management philosophy and methodology, the ISO9000 Quality Assurance Standards series. Total Quality Management. Quality costs, quality auditing. Benchmarking. Continuous Improvement Value Analysis. Failure Mode and Effects Analysis (FMEA). Business excellence models. Application of statistical methods to process and quality control.

MHIE P019 Project Management
Project definition, project selection, economic analysis, the role of the project manager, project organisation, planning, budgeting and estimation, scheduling, resource allocation, control, project termination.

MHIE P020 Statistics and Optimisation
Introduction to probability and statistics. Binomial, Poisson, normal and other probability distributions. Decision theory. Significance tests. Estimation, regression and correlation. Time series. Topics in linear programming including applications and extensions. Dynamic programming. Markov decision processes. Time series forecasting models.

ACC P623 Management Accounting
Fundamentals of cost accounting; purpose of management accounting; cost terms and purposes. Cost-volume-profit relationships; product costing; job costing and process costing. Management control systems; budgeting and standard costing techniques; system design. Responsibility accounting and motivation; decision making. Relevant costs and the contribution approach to decisions; cost allocation and absorption. Decentralisation; performance evaluation and transfer pricing.

HRM P618 Human Resource Management
The management of employee relations in Ireland. Human Resource policy and practice, recruitment and selection, performance management, reward systems, employee voice systems, work systems. Models of HRM, links between HR strategy and business strategy.

PSY P500 Organisational Psychology
Systems theory approach to the human side of enterprise, with a focus on the individual, the group and the overall organisation. Developments in social and organisational psychology. Group dynamics, team development and performance. Transformational leadership. Stress in the workplace. A model of organisational change.

MIE – Part B

FIN P659 Finance
Financial Institutions: forecasting financial requirements, sources of finance, capital structure. Financial analysis and planning. Investment appraisal: measurements of return and risk. Cost of Capital. Management and sources of working capital. Long term capital: shares, fixed return and other sources. Mergers and acquisitions. Corporate failure and rehabilitation.

MHIE P021 Operations Strategy
Management principles and practice. Competitive manufacturing strategies. The management of service operations. Focussed manufacturing. Managing change in manufacturing. Managing the supply chain, make or buy. Global operations. World Class Manufacturing.

MHIE P022 Computer Integrated Manufacture
Computer Integrated Manufacturing, manufacturing information systems, concurrent engineering, computer aided design and manufacture, product data management, database management, factory communication, supervisory control and data acquisition, flexible manufacturing, automation, programmable control.

MHIE P023 Technology Innovation and Design
Product design and development – factors for success. The role of creativity in product success. Stimulating personal and organisational creativity. The formulation of development strategy and the selection and implementation of product development Life Cycle models. The influence of organisational structure and communication on design and development success. National and corporate application of Technology Foresight tools and techniques and the formulation of technology strategy. Intellectual property capture and management.

MHIE P024 System Simulation
Introduction to simulation and modelling, underlying theory and concepts. Problem formulation, verification and validation, analysis of model outcomes. Discrete event simulation, continuous simulation. Computational tools for simulation and modelling. Applications from sectors including: Service, Industrial, Manufacturing and Financial.

MHIE P025 Advanced Statistics
Queuing theory. Introduction to simulation. Discrete event simulation. Verification and validation of models, Analysis and interpretation of results. Analysis of variance and covariance. Multiple regression. Design of experiments. Evolutionary operation.

MIS P651 Management Information Systems
Information resource management. Management and decision making. Information systems and the value chain. Information systems and organisational models. Information systems in functional business areas. Information management. Transaction processing systems, management reporting systems, decision support systems, knowledge based systems, office information systems, e – commerce, electronic markets, inter organisational systems, enterprise resource management, business process reengineering,. Building management information systems. System development life cycle.

MKT P645 Marketing and Innovation
The Marketing Process, Core concepts in strategic marketing, managing the marketing process. Market information systems, market surveys. Buyer behaviour. Market segmentation, targeting and positioning. New product development, product policy. Marketing services and quality. Pricing strategies. Advertising and promotion. Channel management and distribution.

Commercialisation of innovation. Evaluation and management methodologies for emerging technologies. Decision parameters, uncertainty, risk, time, subjectivity, utility. Funding innovation, valuation, venture capital market, stock market.

BMGT P768 Strategic Management
This course examines how the organisation finds and enacts its strategic intentions. The aim is to optimise the positioning and performance of the firm within its business environment through an appreciation of the way organisations work in terms of their structures and management processes. Contemporary paradigms and emerging trends in strategic management will be discussed. Among topics covered are: models of strategic management, strategic control, leadership, organisational politics, corporate culture, business ethics, quality management, organisational change and renewal, organisational learning, and the management of multi-business companies.

Degree of Master of Science (Technology Management) (MSc)

(IFMXP00012)

Course Description

The MSc in Technology Management is a collaboration between the Faculties of Commerce and of Engineering & Architecture. It is designed for engineers and scientists who are responsible, or who will soon become responsible, for managing technological innovation.

They will work primarily, but not exclusively, in the R & D departments of companies whose success depends critically on the introduction of new products (including services) and processes. The management of technological innovation involves putting in place and operating the strategies, structures, staffing and systems needed for the effective development and commercialisation of products and services, together with their associated production processes and delivery systems, and for the acquisition, development and timely embodiment of their constituent technologies and supporting knowledge bases. The degree courses will provide a comprehensive coverage of these topics.

Course Structure and Examination Requirements

The course is on a part-time basis. The current delivery mode starts in September, with classes on Friday afternoon and Saturday morning. It is designed to be completed in two years, five subjects from the following list in each half year, with a major project in the second Year (An alternative additional mode may be initiated, with classes on three days per month with electronic learning support between classes.) The degree must be completed within four years of first registering. The subjects offered will be selected from the following list:

Courses of Study:

ACC P621	Management Accounting
BMGT P640	Organisation and Innovation I
BMGT P641	Business Strategy
BMGT P642	Organisation and Innovation II
BMGT P643	Marketing New Products
BMGT P644	Technology Strategy
BMGT P645	Operations Strategy
BMGT P646	Intellectual Asset Management
BMGT P647	Development Productivity and Portfolio Management
BMGT P648	Development Project Management
BMGT P649	Technology Policy
BMGT P651	New Business Development
BMGT P652	Project Seminar
BMGT P738	Managing Technological Innovation
BMGT P739	Organisational Change
ECON P200	Business Economics
FIN P623	Finance
MEEN P001	Product Design and Development
MEEN P002	Manufacturing Systems Design

MEEN P003	Emerging Technologies
MEEN P004	Quantitative Methods for Management
MIS P622	Management Information Systems
MIS P642	eBusiness and Organisational Transformation
MIS P643	Management Support Systems
MIS P653	Issues in Technology Management

Year 2:
BMGT P652 Major Project

Examinations:
Examinations are held in **December and May**, and the subjects examined are those covered in the previous half Year Candidates are required to submit a report on a project, undertaken during their second year, before completing their degree. The degree awarded is determined from the composite grade for the written examination in both years and the project report.

Entry Requirements
A candidate for admission must hold a degree in Engineering or Science, deemed appropriate by the Board of Studies, or must fulfil the conditions described below. A suitable candidate, who is not a graduate, but who is a corporate member of the Institution of Engineers of Ireland, or of equivalent status in a similar professional engineering or scientific institution, may be eligible for consideration for admission. A candidate must normally have a minimum of three years' relevant work experience in a business/industrial organisation. Candidates who already hold the MIE or MBA degree may be eligible for exemption on a subject-by-subject basis at the discretion of the Board of Studies. Suitably qualified candidates who reach honours standard in the Higher Diploma in Technology Management may petition the Board of Studies to be admitted to the M.Sc. (Technology Management) degree, with exemption on a subject-by-subject basis.

Application Procedure
Applications for admission should be made to the Programme Director, MSc (Technology Management). Applications should be received not later **than July 25**, for admission in **September**.

Course Syllabus
For details of the course syllabus, please refer to the Faculty Booklet for Postgraduate and Interdisciplinary Studies.

Degree of Master of Science (Environmental Policy) (MSc) (Department of Environmental Studies)

(ENMRF0006)

The Master of Science (MSc) degree in Environmental Policy is directed at those wishing to conduct research into the economics and policy of environmental issues. It is the only such degree available in Ireland. Candidates are required to prepare a major thesis in a minimum period of one Year. Prior to beginning the thesis, candidates attend short courses in environmental economics and research methods. The number of places on offer is limited to five. Studentships are available which cover fees and provide a stipend.

Admission Procedure
Applications must be made to the Head of Department, Environmental Studies. If the Head of Department is satisfied as to the applicant's general suitability to undertake the programme, the Department shall forward the candidate's application to the Dean for consideration by the Faculty. Candidates for the Degree of Master of Science (Environmental Policy) must obtain the permission of the Faculty of Engineering and Architecture before commencing the programme.

There are three intakes each academic year in September, January and March to the programme leading to the award of Master of Science (Environmental Policy). It may be possible to commence at a different time, subject to the agreement of the Supervisor and with Faculty approval. Normally the closing dates are:

	(i) **September** Intake	(ii) **January** Intake	(iii) **April** Intake
non-EU candidates	31st March	30th July	30th September
EU Candidates	30th July	30th November	27th February

Entry Standards
Applicants should have a good undergraduate degree in economics or a related subject. Normally a second class Grade I Honours degree is required.

Year One (MSc and PhD)

ENVS P901 Research Methods and Presentation Skills in Environmental Economics and Policy

This course provides students with the basic skills necessary for embarking on a research degree. Topics covered include: introduction to the department and its workings; choosing a thesis topic; working with a supervisor; devising a thesis outline and work programme; reviewing literature (including using electronic databases etc.) and writing a literature review; developing a methodology; target setting; team work; interpersonal skills; presentation skills including use of overhead, multimedia presentations and whiteboard. The course provides plenty of opportunity for discussion and will involve set work.

ENVS P902 Topics in European Environmental Economics and Policy
This course examines the rationale, use and importance of economic approaches in European Environmental Policy including the use of market based instruments and cost-benefit analysis. Applications of such approaches will be examined with topics varying from year to year but previous topics have included: global warming, acidification, biodiversity, ozone depletion and water quality.

ENVS P903 Resource and Environmental Economics in a European Context
The key objectives of this course are to understand the key principles of economics as they apply to environmental endowments, to develop the capacity to apply these principles to improve the quality of analysis and decision-making, to understand some of the technical and scientific underpinnings of some key global, regional and national environmental challenges, and how economics can be employed to address them. Topics include: underlying theory; market failure; Coasian solutions; sustainability measures and their application; green accounting and environmental protection expenditure; command and control and integrated pollution control; emission trading; environmental taxes and charges; the impediments to environmental policy reform; introduction to cost-benefit ana lysis and environmental valuation. Applications will be drawn from the EU and international experience.

ENVS P904 Advanced Environmental Economics and Policy
This course presents some of the major themes in the academic literature on the economics of natural resources and the environment. The majority of the course concerns itself with applying the findings of advanced academic research to answering the following two questions: what are the causes of national and international environmental problems? What are the appropriate policy responses to these problems? In addition the course examines the legitimacy of claims that the earth's natural resources are being depleted too rapidly. Topics include: the theory of environmental externalities, environmental policy design, cost-benefit analysis and environmental valuation, models of natural resource exploitation, international environmental issues.

ENVS P905 European Union Environmental Policy in a Global Context
The driving force behind regulatory reform in the context of EU environmental policy is the increased prominence of sustainable development and environmental protection in EU legislation and the shift in emphasis from regulatory environmental policy instruments to economic instruments. This course examines the development of EU environmental policy, the environmental policy instruments in use, and explores how a shift from regulation to economic instruments in the EU can result in the more effective protection of the environment. The course compares and contrasts performance at member-state level. In addition, it examines the global context for EU environmental policy including, for example, the Gothenburg Protocol on acidification precursors and the Kyoto Protocol on greenhouse gas emissions. In this regard and with regard to policy instrument use (such as environmental taxes, emissions trading, integrated pollution control etc.), the EU position is compared with that of other jurisdictions such as the US, the CEECs and the rest of the OECD.

ENVS P906 Statistical Computing Methods in Environmental Economics and Policy
The course presents an overview of statistical computing methods including elements of survey research and the analysis of datasets. Topics include inferential statistics; hypothesis testing, statistical significance and confidence intervals; analysis of variance; correlation; OLS

regression; multiple regression; logistic regression, Probit analysis. The application of these methods to environmental economics and policy analysis is discussed and set work is provided.

ENVS P907 Professional Preparation: Teaching of Environmental Economics and Policy

This course prepares advanced graduate students for careers in teaching environmental economics and policy at university level. Successful completion of the course allows students to be considered for Teaching Assistant posts. The course follows a workshop format. Topics include: an introduction to learning; getting to know the class; teaching methods for different groups; appropriate presentation methods; presentation skills (including multimedia presentation, whiteboard, overhead); stimulating discussion; problem review and development; course development; standards; setting of examinations; conflict resolution.

Degree of Doctor of Philosophy (PhD)

An applicant for admission as a candidate for the degree of Doctor of Philosophy (PhD) shall submit an application to the Professor or the Head of Department in which the applicant wishes to study. Candidates for this degree are required to be admitted by the Faculty on the recommendation of the Professor; their admission must then be confirmed by the Academic Council. Candidates who have not graduated in this University may be admitted if suitably qualified.

There are three intakes each academic year in September, January and March to the programme leading to the award of PhD. It may be possible to commence at a different time, subject to the agreement of the Supervisor and with Faculty approval. Normally the closing dates are:

	(i) **September** Intake	(ii) **January** Intake	(iii) **April** Intake
non-EU candidates	31st March	30th July	30th September
EU candidates	30th July	30th November	27th February

No candidate can be allowed to enter on a course of study and research for the Degree of PhD unless he/she has reached a high Honours standard at the examination for the primary degree or presented such other evidence as will satisfy the Professor and the Faculty of his/her fitness.

The degree is normally taken nine terms after a master's degree or primary degree. A reduction in the number of terms would be dependent on progress by the candidate and would be a matter for consideration and decision by the Faculty.

Candidates for the PhD Degree will be allowed six years from the date of registration in which to complete their degree. If they have not done so within that period they must re-apply for registration.

The thesis must normally be prepared under the supervision of the Professor, but the Faculty may, on the recommendation of the Professor, assign another member of the staff to supervise the candidate's research, under the Professor's general direction. The thesis must be prepared in the University, unless permission is given to the candidate to work elsewhere under the Professor's general direction. Such permission will only be given to candidates who have attended courses in the University for twelve terms before admission to the course for the PhD.

Candidates may enter for examination in January of the year in which their work is to be examined; the time of examination to be arranged as may be convenient to the candidate and the examiners. If the thesis is not presented before 1 February following, the candidate must re-enter.

Candidates may be required to take an oral examination on the subject matter of their thesis.

This degree will not be awarded unless the examiners report that the work is worthy of publication, as a whole or in part, as a work of serious scholarship.