DEPARTMENT OF MECHANICAL & MANUFACTURING ENGINEERING

UNIVERSITY OF DUBLIN, TRINITY COLLEGE

BAI UNDERGRADUATE COURSE

JUNIOR SOPHISTER (3RD YEAR)

2011/2012

Mission Statement

The Department's main objective is the pursuit of excellence in teaching and research in Mechanical & Manufacturing Engineering with the central aim of producing graduate engineers with a capacity for independent thought in problem solving and creative analysis & design.

<u>To achieve this, we must</u>:

- instil in students an enthusiasm for the art and practice of Engineering;
- teach the engineering science and mathematics which underpin the subject areas of Mechanical & Manufacturing Engineering;
- demonstrate the application of these principles to the analysis, synthesis and design of engineering components and systems;
- foster the development of team working skills;
- encourage students to exercise critical judgement and develop the communication skills necessary to make written and oral presentations of their work.

<u>These objectives are underpinned by</u> :

- undertaking both basic and applied research
- provision of advanced facilities for students to undertake graduate research degrees
- the development of academic staff in teaching and research by ensuring that adequate resources are available to assist them
- ensuring that the research work is of the highest international standard by participation in international conferences and publication in learned journals

<u>In addition, we must consider</u> :

- the requirements of the relevant professional institutions
- the needs of Irish and European industry in the undergraduate curriculum

I. INTRODUCTION

Welcome to the Department of Mechanical and Manufacturing Engineering. Mechanical Engineering is the most expansive and demanding of the engineering disciplines, and in these present recessionary times will provide much of the innovation necessary for economic recovery. In Ireland, two vibrant themes are already emerging in renewable energy and bio-engineering manufacture. Both of these study areas are vigorously pursued in our department.

The Junior Sophister year is much more specialised than the general Freshman years. In your studies you should aim to work for a minimum of 40 hours per week. With a total timetable schedule of about 24 hours per week, this means you should be planning private study for about 14-16 hours/week on average. Developing proper study techniques and the capacity to use the library, the web, and most importantly interaction with peers and lecturers to supplement formal lecture material is a central aspect of a University education. You should not expect to be given full details of all aspects of the courses in lectures or tutorials. It is ultimately your responsibility to ensure that you have understood the fundamentals of each of the courses and that you can solve both tutorial problems and other examples to be found in appropriate textbooks. These developed study skills will of course carry forward to final year and beyond.

II. JUNIOR SOPHISTER COURSES

Courses undertaken by Junior Sophister students in the Department are:

3B1	Thermodynamics	(5 credits)
3B2	Fluid Mechanics	(5 credits)
3B3	Mechanics of Solids	(5 credits)
3B4	Mechanical Engineering Materials	(5 credits)
3B5	Mechanics of Machines	(5 credits)
3B6	Mechatronics (Instrumentation and Control)	(5 credits)
3B7	Manufacturing Technology and Systems	(5 credits)
3B8	Computer Aided Engineering and Design	(10 credits)
3E1a	Engineering Analysis	(5 credits)
3E1	Engineering Mathematics V	(5 credits)
3E2	Numerical Methods	(5 credits)
3E4	Management for Engineers	(5 credits)
JS	Laboratory Programme	

Language Options:

- French for Applied Scientists
- German for Applied Scientists

A detailed syllabus for each of the courses taken by Junior Sophister students in the Department is given in this booklet together with a timetable for the current year. Courses 3E1/3E1a, 3B4, 3B5, 3B6 and 3B7 will run during the first 12 weeks of the academic year (1st Semester) while 3E2, 3E4, 3B1, 3B2 and 3B3 will run from weeks 13 – 24 (2nd semester). 3B8 will run over both semesters. This is detailed on the lecture timetable. There will be one tutorial per week in each subject during the semester they are running.

THERMODYNAMICS describes how energy can be made available and transformed to serve our requirements whilst **FLUID MECHANICS** covers fluid flow, lubrication and fluid machinery. **MECHANICS OF SOLIDS** and **MECHANICAL ENGINEERING MATERIALS** cover structural and component design and integrity, and the effect of material characteristics, environment and structure on performance in service. **MECHANICS OF MACHINES** analyses moving components and evaluates forces and loadings on mechanical systems. **MECHATRONICS (**INSTRUMENTATION & CONTROL**)** covers the relationship and applications of electrical and electronic engineering within mechanical systems. **MANUFACTURING TECHNOLOGY & SYSTEMS** describes the fundamental approaches by which materials and components are produced and covers the quantitative techniques required in management processes. The **COMPUTER AIDED ENGINEERING AND DESIGN** course is central to the overall programme and it introduces students to the practical problems associated with the evolution of new products and also includes the basics of electrical power systems analysis required for design applications. In the Junior Sophister year, the programme of the BAI in the School of Engineering is closely integrated and students in Civil, Structural & Environmental and Mechanical & Manufacturing Engineering Departments undertake courses in **N**umerical Methods and **MANAGEMENT FOR ENGINEERS,** whilst they have a choice of taking **M**ATHEMATICS **V** or **E**NGINEERING **ANALYSIS**.

III. FACILITIES

The Department is located in the Parsons Building. All courses in the Sophister years are supplemented by a full programme of laboratory work. The Junior Sophister lab timetable is co-ordinated by Dr. Gareth Bennett. The laboratories are well equipped for undergraduate work and, in addition, we have extensive research facilities, which are available for final year projects. The Department has its own well-equipped workshops which are managed by Mr. Mick Reilly. All JS students undertake a course of practical workshop training (as part of 3B8) in which they learn to use the basic tools available for fabrication and manufacture of various components. The Computer Applications Laboratories are administered by Mr. John Gaynor and we have state of the art work stations which are used extensively in both the design course in third year and for the Project work and Manufacturing courses in fourth year. In general, students are encouraged to make use of these facilities at all times but particularly for the Design Course (3B8).

IV. VACATION EMPLOYMENT

Vacation Work at the end of the JS year is available in a number of companies including ESB, ICI, Ford, GEC, Shell, BP, Diageo, Team FLS and other multinationals with whom we have excellent connections. Dr. Ciaran Simms is the industry liaison and Ms Lee co-ordinates information on the availability of vacation employment and both can be contacted for further information.

V. STAFF/STUDENT COMMITTEE

Prof. Dermot Geraghty meets with each class representative once a semester to discuss matters of interest and concern to students and staff.

VI. EXAMINATIONS AND ASSESSMENT

Examinations in all subjects are held at the end of the academic year. In the case of 3B8, the course is examined by a mix of continuous assessment and open book exams. For subjects 3B1 to 3B7, the final mark is based on 85% examination and 15% laboratory or coursework, unless otherwise specified by the lecturer concerned. 20% of the total mark achieved at the <u>**first sitting**</u> of examinations in Junior Sophister year will count towards the final degree classification. All marks for labs/assignments are provisional until after the court of examiners meet.

VII. ENGINEERING COURSE EXAMINERS' RULES

B.A.I. EXAMINATION RULES 2011/2012

<u>*Freshman and Junior Sophister*</u>

Candidates undertake 60 credits during each of the four years of the degree programme. Each module has an individual rating of 5, 10, 15 or 20 credits, the amount dependent on the level of effort involved. It is the responsibility of each student to ensure that they are undertaking exactly 60 credits per year.

Students who pass the ANNUAL examinations are awarded 60 and an Honors grade for the year. This grade is based on the weighted average achieved, calculated using the credit ratings. In order to pass the ANNUAL examinations, students must:

- have achieved at least 40% in individual modules worth at least 50 ECTS credits **AND**
- have an overall average mark of at least 40% **AND**
- have <u>**EITHER**</u>

  not more than 10 module credits with marks of at least 35% and less than 40%

  <u>**OR**</u>

  not more than 5 module credits with marks of at least 30% and less than 40%.

Students who have failed the ANNUAL examination are required to take a SUPPLEMENTAL examination in all modules in which they have not satisfied the examiners, as specified on the published examination results.

In order to pass the SUPPLEMENTAL examinations, students must:

- have an overall combined average mark in the ANNUAL and SUPPLEMENTAL examinations taken of not less than 40% **AND**
- have not more than 5 ECTS module credits with marks of at least 35% and less than 40%.

Students who pass the SUPPLEMENTAL examinations obtain an overall **PASS** grade for the year. Overall supplemental marks for all modules are calculated in the same manner using the same weightings as for the annual examinations and include continuous assessment/laboratory marks.

The full set of overall grades is set out below;

Description	**Grade**	***Criterion***
First Class Honors	**I**	mark greater than or equal to 70%
Second Class Honors, First Division	**II.1**	mark greater than or equal to 60% and less than 70%
Second Class Honors, Second Division	**II.2**	mark greater than or equal to 50% and less than 60%
Third Class Honors	**III**	mark greater than or equal to 40% and less than 50%
Fail	**F**	the candidate has failed to satisfy the criteria listed above
Exclude	**EX**	the candidate has not made a serious attempt at the examinations <u>or</u> the candidate has not passed the year within eighteen months from that date on which they first became eligible <u>or</u> the candidate has at least one unexplained absence
Deferred	**D**	the candidate was absent with permission due to medical or other grounds and the result is incomplete
ERASMUS Awaiting Result	**ER**	Applies to Erasmus / International Exchange students
Result Withheld	**RW**	it may be necessary for academic or administrative reasons to withhold a result (e.g. unpaid fees or fines)
Withdrawn	**WD**	the candidate has withdrawn from the course
Repeat year	**R**	the candidates is given permission to repeat the year IN FULL (applies at SUPPLEMENTAL examinations ONLY)
Pass	**P**	the candidate may rise to the next year of the degree programme (applies at SUPPLEMENTAL examinations ONLY)

After the Court of Examiners' meeting, ANNUAL and SUPPLEMENTAL examination results are published anonymously in student number order.

<u>Individual module results</u>

All individual module results are published anonymously by student number on the College notice boards, on the local School of Engineering website - <u>http://www.tcd.ie/Engineering/Results/</u> (students will need their College username and password) and on the College’s Examinations Office website - http://www.tcd.ie/Examinations/Results/

Where a mark is not reported for a module the following codes apply where appropriate:

f	**=**	mark is less than 25%;
a	**=**	absent with permission/explained absence – may take a SUPPLEMENTAL examination;
A	=	absent without permission or explanation – automatic exclusion;
mc	=	medical certificate supplied to and accepted by the Senior Lecturer;
cr	=	credit for subject e.g. candidate is exempt on the basis of their performance in the Foundation Scholarship examination;
gw	=	grade withheld (e.g. unpaid fees or fines).
p	=	credit for subject passed on previous occasion.

Repeating the year

Candidates must repeat the year IN FULL which includes all continuous assessment requirements and laboratory experiments.

DESCRIPTION OF THE EUROPEAN CREDIT TRANSFER SYSTEM (ECTS)

The European Credit Transfer and Accumulation System (ECTS) is an academic credit system based on the estimated student workload required to achieve the objectives of a module or programme of study. It is designed to enable academic recognition for periods of study, to facilitate student mobility and credit accumulation and transfer. The ECTS is the recommended credit system for higher education in Ireland and across the European Higher Education Area.

The ECTS weighting for a module is a **measure of the student input or workload** required for that module, based on factors such as the number of contact hours, the number and length of written or verbally presented assessment exercises, class preparation and private study time, laboratory classes, examinations, clinical attendance, professional training placements, and so on as appropriate. There is no intrinsic relationship between the credit volume of a module and its level of difficulty.

The European **norm for full-time study over one academic year is 60 credits**.

ECTS credits are awarded to a student only upon successful completion of the course year. Progression from one year to the next is determined by the course regulations. Students who fail a year of their course will not obtain credit for that year even if they have passed certain component courses. Exceptions to this rule are one-year and part-year visiting students, who are awarded credit for individual modules successfully completed.

VIII. ATTENDANCE, NON-SATISFACTORY ATTENDANCE, COURSE WORK

Please note the following extract from the University Calendar: *“For professional reasons, lecture and tutorial attendance in all years is compulsory in the School of Engineering.”* Attendance at practical classes is also compulsory.

All students must fulfil the requirements of the School with regard to attendance and course work. Students whose attendance or work is unsatisfactory in any year may be refused permission to take all or part of the annual examinations for that year. Where specific attendance requirements are not stated, students are non-satisfactory if they miss more than a third of a required course in any term.

At the end of the teaching term, students who have not satisfied the department or school requirements may be returned to the Senior Lecturer’s Office as non-satisfactory for that term. In accordance with the regulations laid down by the University Council, non-satisfactory students may be refused permission to take their annual examinations and may be required by the Senior Lecturer to repeat their year. See also the sections dealing with College and engineering examination regulations.

Further details on the academic regulations concerning attendance, non-satisfactory attendance and course work are given in the University Calendar.

IX. KEY DATES

Semester 1 (Michaelmas Term)
12 weeks Monday, 26 September to Friday 16 December 2011.

Semester 2 (Hilary Term)
12 weeks Monday, 16 January to Friday 06 April 2012.

Revision/Examinations/Results (Trinity Term)
Annual Examinations commence Monday, 30 April 2012 and finish at the latest on Friday 25 May 2012.

X. JUNIOR SOPHISTER (3RD YEAR) COURSES

3B1 THERMODYNAMICS

Lecturer: Professor Anthony Robinson (arobins@tcd.ie)

Semester: 2

Course Organisation

The course runs for 12 weeks of the academic year and comprises three lectures per week. A tutorial is given every week. Total contact time is 44 hours.

Semester	Start Week	End Week	Lectures per week	Lectures total	Tutorials per week	Tutorials total
2	13	24	3	33	1	11

Course Description

This course is developed to strengthen the student's skills in the thermal fluid sciences and is organised into three main subsections: energy, energy conversion devices and power cycles. The energy part deals primarily with work and heat developing the mathematical modelling skills and analysis techniques for practical energy transfer problems based on the fundamental scientific principle of conservation of energy. The energy conversion devices focuses on traditional and novel approaches for energy transfer and conversion with focus on devices found in power generation and refrigeration systems. Power cycles will be considered ranging from internal combustion engines to steam power plants. Vapour compression cycles will also be studied in the context of refrigeration and heating.

Learning Outcomes

On successful completion of this course, students will (be able to):

- Recognise, classify and describe the basic operating functions and thermodynamic principles energy conversion devices.
- Understand the concepts related to perfect (Carnot), ideal (e.g. Rankine, Otto & Refrigeration) and actual cycles.
- Analyse and solve problems related to perfect (Carnot), ideal (e.g. Rankine, Otto & Refrigeration) and actual cycles
- Estimate the Thermal Efficiency (power generation systems) or Coefficient of Performance (refrigeration system).
- Recognise the environmental and socio-economic implications associated with desired system output (i.e. power/cooling) versus required 'cost' input (i.e. electrical/fuel).
- Recognise and evaluate the limitations of various mechanical components and engineering systems.
- Describe and explain problems relating to reheating and regeneration with focus on efficient energy use.
- Analyse and solve problems relating to the rational use of energy.

- Analyse and generate mathematical models for problems related to power generating thermodynamic cycles
- Solve problems related to power generating thermodynamic cycles.
- Recognise basic workshop and laboratory procedures and safety.
- Perform laboratory and engine workshop tasks as a group.
- Acquire, tabulate and analyse useful data in the laboratory.
- Communicate information and provide physical interpretation of measurements in technical laboratory reports.
- Utilise internet resources for general course material and lab report preparation.

Course Content

- Introduction to Entropy.
- Steam and gas power cycles: e.g. Carnot cycle, ideal and actual Rankine, Otto, Diesel and Brayton cycles (including regeneration etc.).
- The Reverse Heat Engine: The Carnot reverse heat engine, ideal and actual refrigeration cycles, practical refrigerators and heat pumps.

Teaching Strategies

The course encompasses a diverse range of teaching and learning strategies. This is accomplished by coordinating formal lectures with problem solving tutorial sessions supplemented by 'hands-on' laboratory experimentation, technical report writing and workshops. The course is delivered in a technologically up-to-date fashion by providing access to computerised course notes, by using modern audio-visual equipment and by exposing the students to digital control and data acquisition whilst encouraging the use of modern software packages.

Assessment Modes

Written examination, group assignment and laboratory experiments (with logbook and formal written reports)

Recommended Texts

- Cengel and Bowles, *Thermodynamics: an Engineering Approach* (McGraw-Hill)

Other Relevant Texts

- Moran and Shapiro, *Fundamentals of Engineering Thermodynamics* (Wiley and Sons)
- Rogers and Mayhew, *Engineering Thermodynamics Work and Heat Transfer*, 4th. edition, S.I. units (Longman)
- Van Wylen, Sonntag and Borgnakke, *Fundamentals of Classical Thermodynamics*, S.I. units, 4th. edition (Wiley)

Laboratories:

1. Refrigeration study
2. Diesel Engine

3B2 FLUID MECHANICS 1

Lecturer: Professor Craig Meskell (cmeskell@tcd.ie)

Semester: 2

Course Organisation

The course runs for 12 weeks of the academic year and comprises three lectures per week. A tutorial is given every week. Total contact time is 46 hours.

Semester	Start Week	End Week	Lectures per week	Lectures total	Tutorials per week	Tutorials total
2	13	24	3	33	1	10

Course Description

This course introduces the student to the basic concepts underlying the mechanics of fluid motion. The appropriate scientific principles and mathematical modelling techniques are described and then applied to practical engineering problems including turbines, pumps, pipe networks and the aerodynamics of vehicles. Three different modelling techniques are discussed: fundamental (Navier-Stokes equations), approximate (boundary layer integral analysis) and similarity (dimensional) analyses. Real life problem-solving skills are cultivated within the framework of practical flow devices and systems (e.g. piping systems, fluid machines, vehicle drag).

Learning Outcomes

On successful completion of this course, students will (be able to):

- Explain the fundamental scientific principles underlying the generalised equations of fluid motion.
- Reduce the generalised equations of fluid motion to simplified versions in rectilinear and cylindrical coordinates and solve for simple flow problems, including lubrication.
- Use Buckingham's Pi theorem to develop dimensionless groups and apply similarity and modelling procedures.
- Generate mathematical models for boundary layer flows, using integral analysis procedures.
- Estimate skin friction coefficients and drag for aircraft, ships and vehicles.
- Explain the safety and efficiency considerations around boundary layer control techniques for aircraft.
- Discuss the characteristics of laminar and turbulent flow and describe flow visualisation methods and techniques for the measurement of turbulence.
- Analyse head losses in piping systems and estimate the flow distribution in pipe networks.

- Recognise, classify and describe the basic operating functions and hydrodynamic principles of water turbines.
- Calculate the hydraulic efficiency and power output of Pelton wheel and Francis turbines.
- Critique flow measurement techniques concisely.
- Follow formatting requirements typical of grant applications or contract tender process.

Course Syllabus

- Generalised Equations of Motion: Navier Stokes equations;
- Dimensional Analysis: Buckingham Pi theorem, modelling;
- Introduction to turbulence;
- Boundary Layer Analysis: momentum integral equation, boundary layer profiles and thickness, skin friction coefficient, drag, separation and boundary layer control;
- Pipe Flow: major losses; abrupt head losses; pipe network analysis;
- Fluid Machinery: impulse (Pelton wheel) and reaction turbines (Francis turbine); cavitation;
- Experimental Techniques: turbulence measurement concepts (HWA, LDA, PIV); flow visualisation methods.

Teaching Strategies

The course is delivered through a combination of formal podium lectures and problem solving tutorial sessions. In addition every student will perform a laboratory experiment on a scale model of a Pelton wheel.

Assessment Modes

Written 2 hour examination at end of year (Students answer any 4 questions out of a choice of 6). An individual written assignment, worth 20% of the overall subject marks.

Essential required text

This is the course textbook. Students are expected to have access to a copy.

Fundamentals of fluid mechanics 6e (SI Version) Munson, Yound, Okiishi, Huebsch. Publisher: Wiley & Sons, ISBN: 978-0-470-39881-4

Other Relevant Texts

The following textbooks provide useful addition material:

1) *Introduction to Fluid Mechanics 7e* Fox, Pritchard, McDonald. ISBN 978-0-470-23450-1

2) *Centrifugal Pump Design* J. Tuzon ISBN 0-471-36100-3

Laboratories:

Pelton Wheel

3B3 MECHANICS OF SOLIDS

Lecturers: Professor Bruce Murphy (bruce.murphy@tcd.ie)

Semester: 2

Course Organisation

The course runs for 12 weeks of the academic year and comprises three lectures per week. A tutorial is given every week. Total contact time is 44 hours.

Semester	Start Week	End Week	Lectures per week	Lectures total	Tutorials per week	Tutorials total
2	13	24	3	33	1	11

Course Description

This is a course on the fundamentals of stress analysis which is a central subject in the mechanical engineering discipline. Students learn how to determine the stresses and strains in typical mechanical components, such as beams and pressure vessels, as well as in structures under combined loads of torsion and bending. Buckling and stability of structures is also introduced and experimental strain measurement is covered by lectures and laboratory sessions. In addition to the development of modeling skills, the analysis also relies on mathematical techniques commonly used in advanced engineering such as solution of differential equations, Laplace transform and eigenvalue analysis. The subject also introduces computing as a tool for the solution of more complex structural problems.

This course completes the essential requirements of a mechanical engineer in the mechanics area. It builds on earlier introductory (but fundamental and applied) courses in mechanics, mathematics and numerical methods. It provides a basis for advanced courses in solid mechanics, fluid mechanics, vibration and bioengineering. It is essential that a course such as this is completed before commercial software particularly finite element software is used in independent project work which will be done in the 4th year.

Learning Outcomes

On successful completion of this course, students will (be able to):

- Understand the fundamentals of stress/strain analysis and be able to apply them with confidence to simple structures
- Abstract a physical problem and reformulate it in a frame (a differential equation, eigenvalue problem for example) for which he/she has developed the mathematical tools.
- Develop free-body diagrams which form the basis of many formulations in mechanics. This latter activity is the implementation of Newton's third law which is at the centre of deep understanding of mechanics.

Course Content

- Relationships between Stress and Strain

An understanding of axial and shearing stress and strain and the relationships between them are developed.

- Two Dimensional Stress Analysis

Muliaxial stress stress/strain analysis is introduced and the concept of principal loads and simple failure mechanisms. The use of traditional mohr circle and computer based tensor methods are also introduced. The application to strain gauge methods is then developed.

- Energy Methods

Energy approaches based on tghe concept of virtual work and the theorems of Castigliano are now developed and shown to be often a useful alternative to direct force equilibrium modelling.

- Torsion of circular and general Thin Sections

Torsional deflection analysis of circular sections is introduced in the context of a special case of shear loading. A variety of problems in shaft design are considered with an extension of the analysis to tapered sections and non-circular thin walled sections where an energy based method is developed.

- Advanced Beam Theory

Beam theory developed from fundamental equations to study a variety of loadings and solution approaches. Direct integration methods are used with appropriate development of the mathematics of discontinuous functions. Various strategies are developed to analyse statically indeterminate problems and finally analysis of shear stress distributions are introduced.

- Buckling of Struts

Beam theory is used to derive governing differential equations of buckling which are then solved using laplace techniques which have been developed in earlier courses. Various end loadings, eccentricity and some simple structures are analysed.

- Analysis of Composites

Various beam problems using composite material crosssections are considered and design contraints for these types of problems are explored.

Lab/Assignments:
Strain Gauges: The performance of a strain gauge rosette mounted on a simply support beam is studied. This allows the student to draw directly from beam theory, strain gauge and experimental techniques.

Beam Analysis Assignment: A Matlab model of a beam with complex loading is formulated and solved with post-processing of the results

Teaching Strategies

Lectures: The teaching strategy follows a single well established text book. This subject has been well developed for teaching at this level so student accessibility and consistency of notation is easily established.

Tutorials: Tutorials follow a series of question sheets. The solutions for these are available on the web and are released gradually as the couse progresses. The tutorials are given to class groupings and are informal. No assessment of tutorial performance is noted.

Assessment Modes
Written Exam and Laboratory Experiments

Recommended Texts
Gere and Timoshenko Mechanics of Materials 3rd Ed ITP 1990

Laboratories
Strain Gauges

3B4 MECHANICAL ENGINEERING MATERIALS

Lecturer(s): Prof. Kevin O'Kelly (okellyk@tcd.ie)
Prof. David Taylor (dtaylor@tcd.ie)

Semester: 1

Course organisation
The course runs for 12 weeks of the academic year and comprises three lectures per week. A tutorial is given every week. Total contact time is 44 hours.

Semester	Start week	End week	Lectures		Tutorials	
			Per week	Total	Per week	Total
1	1	12	3	33	1	11

Course description, aims and contribution to programme
This course introduces the student to essential concepts in the selection and use of engineering materials. This includes a study of the mechanical properties of materials and their structure at the atomic and microscopic scales, as well as other important properties such as price and availability. Material processing is also discussed, allowing the student to obtain an overview of the various considerations necessary when selecting materials as part of the design process. Failure modes are described, including short-term and long-term types of failure, which are related to their underlying causes such as cracks and dislocations. Ethical issues are discussed relating to material recycling and safe design procedures. This is a key course in the study of mechanical engineering, which builds on work established in the second year curriculum.

Learning outcomes
On completion of this course the student will be able to:

- describe and conduct tests to measure mechanical properties, making use of data collection and analysis systems;

- perform calculations relating deformation under load to atomic structure and microstructure;
- predict the failure loads and times for simple structures, appreciate how these predictions can be made for complex engineering components and how they can be used to ensure safe life in conjunction with maintenance;
- describe the assumptions and approximations that must be made in predicting deformation and failure and the likely errors that will arise as a result;
- describe the microstructures and phases that will occur in material alloys in general and in steels and aluminium alloys in particular;
- predict how microstructure will be affected by alloy composition and thermo-mechanical treatment;
- describe the structure and processing of some typical engineering ceramic materials; to compare the mechanical properties of these materials to those of metals, explaining under what circumstances ceramics might be used in industry and to predict the probability of failure of a ceramic structure using a Weibull analysis;
- describe the structure, processing and mechanical properties of polymers and composites; to compare the mechanical properties of these materials with those of metals and to explain under what circumstances these materials might be used in industry; to estimate the mechanical properties of a composite material knowing the properties of its constituents;
- appreciate the considerations involved in materials selection: to use a systematic approach to the selection of the optimum material for a given application, including considerations of material price and availability;
- explain the importance of sustainable technology as applied to materials selection and use, including recycling and maintenance scheduling;
- be aware of the importance of preventing failure in engineering components, especially its social and ethical consequences;
- work as part of a team to solve a problem in materials selection and failure prediction.

Course content

Static properties

- elasticity
- plasticity
- fracture

Time and temperature dependent properties

- fatigue
- creep
- oxidation and corrosion

Advanced materials

- metal alloys
- cermets
- polymers
- composites

Materials selection in design

- price and availability
- environmental and sustainability issues
- property optimisation

Teaching strategies

This course is taught using a combination of lectures, laboratory classes and tutorial sessions. The tutorial sessions are overseen by a Teaching Assistant - during these sessions, students are encouraged to work in groups to develop their communication and teamwork skills.

Assessment

This course is assessed by means of a formal written examination at the end of the second semester and with a laboratory experiment and an assignment (with logbook and formal written reports). Examination questions are designed to test students' ability to use the knowledge gained in lectures to solve practical problems, bringing together different aspects of the course and of other courses, such as mechanics of solids and manufacturing technology.

Recommended text

- Engineering Materials Books 1 and 2, Ashby and Jones, Pergamon
- Selection and Use of Engineering Materials, Crane and Charles
- Introduction to Engineering Materials, John
- Materials Science and Engineering, Callister
- The New Science of Strong Materials, Gordon

Laboratories

Lead Creep

3B5 MECHANICS OF MACHINES

Lecturer: Professor Ciaran Simms (csimms@tcd.ie)

Semester: 1

Course Organisation

The course runs for 12 weeks of the academic year and comprises three lectures per week. A tutorial is given every week. Total contact time is 44 hours.

Semester	Start Week	End Week	Lectures per week	Lectures total	Tutorials per week	Tutorials total
1	1	12	3	33	1	11

Course Description

This is a course on the application of fundamental mechanics to realistic machine configurations. This includes engines, whole body vehicles, linkages and friction devices. The analysis provides the link between conceptual design resulting in motion and the generation of internal forces resulting in stresses. Prior to this these subjects are studied separately. Further modelling skills are developed together with the use of vector and matrix algebra in the synthesis of solutions. The subject also introduces computing as a tool for the solution of more complex robotics/linkage problems.

This course completes the essential requirements of a Mechanical Engineer in the machine dynamics area and prepares the students for project work which is focused on machine design. This subject also provides a good basis for study in robotics and some aspects of biomechanics/engineering. It builds on earlier introductory (both fundamental and applied) courses in mechanics, mathematics and programming.

Learning Outcomes

On successful completion of this course, students will (be able to):

- outline a practical methodology in the application of mechanics and vector analysis to real machine configurations. This learning in abstraction is complementary to other courses being taken by the student at this point.
- use vector mathematics and other academic subject matter in an applied situation for the first time.
- analyse common elements in machine design.
- apply and develop computer programmes to implement matrix analysis which models the forces being generated in a linkage system.

Course Syllabus

- Review of Mechanics

  Fundamentals of rigid body mechanics are reviewed, starting with Newton's laws and with a particular emphasis on vector analysis. Fundamental equations and concepts in mechanics are few, however correct implementation can only be achieved once deep understanding is developed.

- Balancing

  Rotating and reciprocating engine balance is analysed. The utility of vector analysis for automotive engineering is firmly established. In addition, practical balancing solutions are analysed.

- Vibration

  This applies single degree of freedom theory to vibration transmission and isolation problems. The theory which has been developed in the previous year is revisited. In practice trouble shooting these types of problems is common and some case studies are explored.

- Friction

  Screw friction and clutch plate friction are analysed with reference to some common designs assuming simple Coulomb friction models.

- Kinematics

The theory of kinematics with particular emphasis on relative motion is analysed. The role of matrix and vector algebra is emphasised with attendant computer modelling using a matlab environment.

- Linkages
  Kinetic analysis is now added to the kinematic models and some common linkages are analysed.

Lab/Assignments:
Identification of Material properties using vibration tests: Natural frequencies of bar specimens of bending and torsion modes of vibration are measured and compared with simple formulae to determine Young's modulus and Shear Modulus and Poisson's ratio. Such properties will have been measured directly by the students earlier in the programme using static tests. A main objective in this lab, apart from introducing basic modal testing, is to illustrate the detailed use of error analysis in the experimental procedure. (In this case the student sees that this is an excellent method to measure moduli but a poor way to measure Poisson's ratio).

Development of a computer model for a 4 bar linkage analysis: A Matlab program is developed to implement the matrix algebra associated with a four bar linkage and returns component motions and loadings for given driver motions. The students formulate and run their own code based on a skeleton program.

Teaching Strategies
Lectures: The teaching strategy does not follow a single text book, as interpretation of the essential elements of this subject tend to vary widely among teaching institutions. This is because of the bridging nature of the subject. This presents some extra challenges to the student which mirrors the challenge of bringing fundamental concepts into the design forum. Computing implementations using Matlab routines are also incorporated into the lectures.

Tutorials: Tutorials follow a series of question sheets. The solutions for these are available on the web and are released gradually as the course progresses. The tutorials are given to class groupings and are informal. No assessment of tutorial performance is noted.

Assessment Modes
The assessment is by a single written examination which is held at the end of the year term and an extended Matlab/Working Model project during the year. The written examination carries 75% of the total marks, the project 10% and the laboratory accounts for 15% of the Mark.

Recommended Texts
- Kinematics and Dynamics of Machines, C.E.Wilson and J.P. Sadler (Pearson Prentice Hall)
- Dynamics, J.L.Meriam (Wiley)
- Mechanics of Machines, B.Crossland and J.Morrison (Longmans)
- Mechanics of Machines, J.Hannah and R.C.Stephens (Arnold)

- Theory of Machines and Mechanisms, J.E.Shigley and J.J.Uicker Jr (McGraw Hill)

Laboratories

Vibrations

Further Information EMAIL: CSIMMS@TCD.IE

3B6 MECHATRONICS (CONTROL AND INSTRUMENTATION)

Lecturer: Professor Dermot Geraghty (tgerghty@tcd.ie)

Semester: 1

Course Organisation

The course runs for 12 weeks of the academic year and comprises three lectures per week. A tutorial is given every week. Total contact time is 44 hours.

Semester	Start Week	End Week	Lectures per week	Lectures total	Tutorials per week	Tutorials total
1	1	12	3	33	1	11

Course Description

This course introduces the student to various systems of continuous control of electrical, electronic, mechanical and combined systems. First and Second order systems are studied, with extensions to higher order systems using approximate methods and computer modelling (using Matlab). Aspects of control systems which are discussed include stability, steady state error and frequency response. Techniques covered include transfer functions, block diagram algebra, the root-locus method and frequency response design methods.

Learning Outcomes

On successful completion of this course, students will (be able to):

- Develop the transfer function for any electro-mechanical system
- Use the Laplace Transform to transform between the time domain and frequency domain and find the time domain responses of 1st and 2nd order systems to standard test inputs e.g. the step input
- Use s-plane analysis to determine the performance characteristics of systems e.g. settling time, peak time, find lines of constant damping
- Draw a block diagram for a control system starting with a schematic of the system and find the overall transfer function for the system
- Determine if a system is stable, marginally stable or unstable using a Routh table or using Matlab

- Find the steady state error in a system due to a standard test input e.g. a step input. Understand how to reduce or remove this error. Understand steady-state error behaviour of P, PI and PID controlled systems
- Use the root-locus as a means of assessing the performance of a system including its stability and its behaviour as gain is
- Use the root locus as a design tool to alter the response of a control system/ plant by introducing a compensator
- Apply frequency response methods to the analysis of control systems including stability analysis
- Use Matlab Control Systems Toolbox to analyze control systems and design

Course content

1. Introduction to control systems
2. Brief review of the Laplace Transform and its application in the design of control systems
3. Transfer functions
4. Time response of 1^{st} and 2^{nd} order systems
5. Modelling in the frequency domain
6. Block diagram algebra
7. Stability and the Routh-Hurwitz criterion
8. Steady state errors
9. Root locus techniques – analysis and design of compensators
10. Frequency response techniques; Bode plots and Nyquist criterion
11. Use of Matlab and Control Systems Toolbox in Analysis and Design of Control Systems

Course Notes

Some course notes will be posted on the course website. Details will be supplied as the lectures progress.

Teaching Strategies

The course is taught using a combination of lectures, laboratories and tutorials. During the tutorials the students work in groups, thereby encouraging teamwork and cooperation. The tutorials are overseen by a Teaching Assistant. The use of Matlab (Control Systems Toolbox) as a design tool for control systems is introduced via a combination of lecture demonstrations and tutorial sessions based on 'Control Tutorials for Matlab and Simulink' which is a HTML based teaching tool for Control systems and introduces the student to many typical problems and alternative approaches to solving these problems.

Assessment Modes

Written Exam and Laboratory Experiments. The examination questions test the student's ability to use the techniques explained in the lectures and to apply them to the analysis and design of control systems.

Recommended Texts

The course will use the following text:

Control Systems Engineering by Norman S Nise, Wiley, 3rd or 4th Edition

These texts are also useful:

Modern Control Systems by Richard C. Dorf and Robert H. Bishop, 9th Edition, Prentice-Hall
Modern Control Engineering by Katsuhiko Ogata, 4th Edition, Prentice-Hall

Laboratories
Process control

3B7 MANUFACTURING TECHNOLOGY

Lecturers: Professor Biqiong Chen (chenb@tcd.ie)
Professor John Monaghan (jmonghan@tcd.ie)

Semester: 1

Course Organisation
The course runs for 12 weeks of the academic year and comprises three lectures per week. A tutorial is given every week. Total contact time is 44 hours.

Semester	Start Week	End Week	Lectures per week	Lecture total	Tutorials per week	Tutorial total	Lab total	Assignment total
1	1	12	3	33	1	11	1	1

Course Description
This course introduces the basic concepts of manufacturing via shaping, forming, machining and assembly, enabling the students to develop a basic knowledge of the mechanics, operation and limitations of basic machining tools and machining processes.
Additionally the course has the following aims and objectives:

- To develop a knowledge of appropriate parameters to be used for various machining operations
- To introduce the relationship between design and manufacture, with regard to surface finish, process limitations and CNC machining
- To introduce ancillary technologies such as manufacture of cutting tools, use of cutting fluids, and surface treatment and coating.
- To develop a knowledge of workshop practice and basic use of machine tools and workshop equipment
- To introduce students to the scientific principles underlying material behaviour during forming processes to enable them to undertake calculations of workpiece and tool stresses and forming loads.
- To introduce students to traditional and non-traditional forming processes with particular emphasis on forging, extrusion, wire drawing, sheet forming, casting, joining, basic polymer processing and composite fabrication.

- To introduce students to the role of manufacturing in an economy and to show the relationship between design and manufacturing.
- To make students aware of the necessity to manage manufacturing processes and systems to achieve high quality products free of defects, couples with the necessity to achieve this with the best use of material and human resources and with particular emphasis on the safety of workers, product users and environmental considerations related to manufacture, recycling, etc.

Learning Outcomes

On successful completion of this course, students will (be able to):

- Analyse various machining processes and calculate relevant quantities such as velocities, forces, powers etc.
- Identify and explain the function of the basic components of a machine tool
- Suggest appropriate process parameters and tool materials for a range of different operations and workpiece materials
- Have a basic knowledge of safe workshop practice and the environmental implications of machining process decisions
- Understand the basic mechanics of the chip formation process and how these are related to surface finish and process parameters
- Recognise cutting tool wear and identify possible causes and solutions
- Be familiar with common surface treatment and coating processes and aware of their strengths, limitations and environmental impact
- Understand the limitations of various machining processes with regard to shape formation and surface quality and the impact this has on design
- Develop simple CNC code, and use it to produce components while working in groups. Write a short report based on their work;
- Be familiar with basic polymer processing and composite fabrication methods;
- Explain the relationship between manufacturing technology and systems, the impact of manufacturing on the economy and the relationship between materials selection, design and manufacture.
- Describe the process involved in taking a product from concept through material selection and design to manufacture and delivery to the customer with particular emphasis to the use of safe design, efficient use of materials, product safety and environmental considerations.
- Describe and explain applications and perform calculations of the more common bulk and sheet forming, casting, welding and polymer processes and given a particular component select the most appropriate manufacturing process to achieve optimum productivity, product quality through the efficient use of materials, energy and people.
- Describe, explain and perform calculations on the stress systems associated with the deformation of metals during bulk and sheet forming and perform calculations to determine the forming loads and the loads on both the forming tools and the workpiece.

Course Syllabus

- Shape formation in manufacturing

- Introduction to Turning, Milling and Drilling. Basic machine tool structure and terminology, work-holding and tool-setting, and quantitative analysis of machining processes.
- Introduction to CNC machining
- Fundamentals of Machining. Analysis of chip formation process, cutting mechanics, tool life and machinability.
- Cutting-tool materials and cutting fluids
- Surface treatment and coating;
- Introduction to polymer processing and composite fabrication;
- Introduction to manufacturing processes and systems. The relationship between material selection, product design, manufacturing decisions, product uses and safety and environmental considerations.
- Introduction to stress, strain, yielding and plastic flow, complex stress systems, principle stresses and yield criterion (von.mises and Tresca criterion), plane stress and plane strain conditions, homogeneous deformation and work formulae as used in metal forming calculations.
- Crystal structure of metals, dendrite formation, recrystallisation, the advantages and disadvantages associated with hot and cold working.
- Introduction to the technology associated with forging; rolling; extrusion; wiredrawing; piercing and blanking; bending, casting; joining processes and basic polymer processing.
- Calculations of forming forces and tool/workpiece stresses for each of the forming processes listed above.

Teaching Strategies

This course is taught using a combination of lectures and tutorial sessions. During the tutorial sessions the students work alone to develop their capability for independent thought, which should contribute to lifelong learning, while the group work is used to build up their ability to cooperate and work as a member of a team. The tutorial sessions are overseen by a Teaching Assistant.

Assessment Modes

Written exam, laboratory experiments and assignment. Examination questions are designed to test the student's ability to use the knowledge gained in lectures to solve practical problems, bringing together different aspects of the course and of other courses, such as design.

Recommended Texts

- *Manufacturing Engineering & Technology*, S. Kalpakjian & R.S. Schmidt, (Pearson/Prentice Hall: ISBN 0-13-148965-8)
- *Principles of Manufacturing Processes,* J.Beddoes & M.J.Bibby, (Arnold: ISBN 0-340-73162-1)
- *Fundamentals of Modern Manufacturing*, M.P.Groover, (Wiley: ISBN 0-471-40051-3)

Other Relevant Texts

- *Introduction to Manufacturing Engineering*, J.A. Schey, (McGraw Hill: ISBN 0-07-055274-6)
- *Manufacturing Engineering Technology*, L .Smyth & L .Hennessy, (Educational Company of Ireland: ISBN 0-8616-7448-0).
- *Process Selection – from design to manufacture,* K G. Swift & J. D. Brooker, (Butterworth-Heinemann: ISBN 0-75-065437-6)

Laboratories

CNC Machining

3B8 Computer Aided Engineering and Design (10ECTS)

Course Coordinator: Prof. Gareth J. Bennett (gareth.bennett@tcd.ie)

Lecturers: Prof. Gareth J. Bennett (gareth.bennett@tcd.ie)
Mr. John Gaynor (jgaynor@tcd.ie)
Prof. John Monaghan (jmonghan@tcd.ie)
Mr. Paul Normoyle
Mr. Gerry Byrne
Mr. Mick Reilly

Aims/Objectives

- to develop design skills according to a Conceive-Design-Implement-Operate (CDIO) compliant methodology
- to apply engineering sciences through learning-by-doing project work
- to provide a framework to encourage creativity and innovation
- to develop team work and communication skills through group based activity
- to foster self-directing learning and critical evaluation

Course Organisation

The course runs for both semesters of the academic year and comprises of two lectures per week plus significant additional practical laboratory time-see timetable. The lecture time is given in the table below.

Element	Semester	Start Week	End Week	Hours per week timetabled	Hours total per student
Lectures	1&2	1	24	2	44
CAD/CAM	1&2	1	14	6	12
LabView	1&2	1	23	2	4
Engine	1&2	1	15	2	2
Workshop	1&2	1	15	3	6
Design Project	1&2	8	16	2/3	22

Course Description

This course is comprised of two basic modules contributed to by a number of elements each focusing on specific aspects of Engineering Design.

Design Module

This aims to provide students with a clear understanding of the paths and techniques of engineering design, to empower them to develop practical, well analysed designs. The power and utility of systematic design methods is emphasized, making use of the relevant mathematics and mechanics for both Finite and Infinite Life components. The module also aims to instil in the student the engineer's responsibility to humankind and to our environment for their designs. The students will develop skills with paper based projects in the 1st semester moving onto practical design challenges in the 2nd semester.

Computer Aided Engineering Module
This module allows the student to use a number of different software packages which facilitate design. Engineering drawings will be created electronically and used to develop machining code to practically illustrate the CAD/CAM process. The underlying mathematics of Finite Element (FE) systems is covered to the extent that students will be able to formulate an element stiffness matrix and solve simple 2D problems. Students will develop basic skills in the use of commercial packages such as Pro-Mechanica and DEFORM, and in their analysis in the context of their knowledge of engineering design, solid mechanics, thermodynamics and manufacturing technology.

Course Elements

Design Process and Machine Element Design (Dr. Gareth Bennett)
This will take place during the 1st and 2nd semesters in the lecture slots. This element will introduce systematic design methods used by engineers to structure innovation. Case studies and paper based projects will be used to develop skills in design along with communication and team skills. This element will include a workshop on communication skills given by the Student Development Services (TCD).

In addition, standard engineering components will be examined and the skills for analysis studied to allow for correct component choice/design.

When: *1st semester lecture slots: Monday. 3pm, Tuesday 12pm.*
2nd semester lecture slots: Monday & Tuesday 12pm.

Computer Aided Drawing/Computer Aided Manufacture (Mr. John Gaynor)
Laboratories 9 and 10 are part of the 3B8 course, marks achieved in which count exclusively towards the 3B8 final mark. In these labs, the student will learn how to use and apply AutoCAD and Pro-E for drawing. AlphaCAM will be used in the Mechanical Workshop to machine a part. The CAM/machining functionality of Pro-E will also be explored.
When: *1st and 2nd semester Engineering lab slots: Tuesday & Friday 2-5pm.*

LabView (Mr. Paul Normoyle)
Virtual prototyping is a cost effective means for industry to reduce the time to manufacature. “LabView” is a powerful software platform issued by National Instruments and is fast becoming the industry standard. In this lab the students will gain hands on experience in virtual engineering. This experience will form the basis for 2nd semester practical design work where the student will employ LabView for automation and control.
When: *1st semester 3B8 lab slot: Thursday 2-4pm.*
2nd semester 3B8 lab slot: Monday 2-5pm

Internal Combustion Engine Practical (Mr. Gerry Byrne)
The students will gain hands on experience with the disassembly and examination of a petrol engine. The students will be required to take measurements and calculate performance characteristics.

When: *1st semester 3B8 lab slot: Thursday 2-4pm.*
2nd semester 3B8 lab slot: Monday 2-5pm

Finite Element Analysis (Prof. John Monaghan)
The underlying theory and mathematics of Finite Element (FE) systems is covered to the extent that students will be able to formulate an element stiffness matrix and solve simple 2D problems. The students will apply this theory to real engineering problems using two software packages Pro-Mechanica and DEFORM. Drawings produced in the CAD/CAM element will be used here.
When: *2nd semester lecture slots: Monday & Tuesday 12pm.*

Industrial Lecture Series (Engineering Managers from Industry)
Guest speakers from industry will address the students, presenting their company profile and underlining the importance of Design and Innovation to the success of their company. Penciled in are speakers from O2, Wyeth, HP, Daimler and Thermoking.
When: *2nd semester lecture slots: Monday & Tuesday 12pm.*

Workshop Course (Mr. Mick Reilly)
It is vital that design engineers appreciate the skill and difficulties involved in manufacturing parts and assemblies. In this element, the students will gain hands on experience using typical mechanical workshop equipment. Welding, manual machining, CNC machining and turning will be covered.
When: *1st semester 3B8 workshop slot: Tuesday 1:30-4:30pm.*
2nd semester 3B8 workshop slot: Tuesday 1:30-4:30pm.

Design Project (Dr. Gareth J. Bennett)
The students will Conceive Design Implement and Operate a machine to crush cans using solar power. The project will bring together the skills developed in the earlier elements and will draw on technical skills obtained from the other engineering science subjects.
When: *2nd semester 3B8 lab slots: Thursday 2-5pm.*

Learning Outcomes
On successful completion of this course, students will (be able to):

Design Module
On successful completion of this course module, students will (be able to):
- Understand and use techniques for;
    - Group based thought generation processes
    - Specification processes
    - Conceptual design processes
    - Embodiment design
    - Costing
    - Following the function of Standards and other regulatory issues in design
    - Calculations for the correct selection of Standard Components in a design

Computer Aided Engineering Module

On successful completion of this course module, students will (be able to):

- Understand and describe both the advantages and the limitations of FEA as an engineering modelling tool in design, process investigation or defect analysis.
- Understand the concept of element stiffness and be able to derive the underlying mathematical expressions used in the development of an element stiffness matrix
- Set up and model simple 2D structural and thermal problems using two commercial software packages and incorporating realistic loading and constraint conditions.
- Interpret the results of the analysis, e.g. stress/thermal distributions, but more importantly recognise errors in the results arising from incorrect or insufficient input data or the setup of the FEA model.

Course Syllabus

Design Module

- Developing and clarifying the specification
- Abstracting from the specification
- Group thought development processes – Brainstorming – method 365
- The conceptual Design phase and thinking conceptually
- Developing the Overall Function and a Function Structure (Sub functions, Auxiliary functions)
- Developing and ranking Concept Variants.
- Embodiment Design techniques and their application to a chosen Concept Variant (Function Carriers)
- Introduction to Anthropometrics & Ergonomics
- Detail design & the Bill of Materials
- Case studies
- Standard Components, their role in, and there incorporation into the designed object
- The machine design of standard components (shafts, sheaves, gears, drive belts, springs etc)
- Finite life components and Hertzian stresses

Computer Aided Engineering Module

- Introduction to Finite element analysis as a numerical modelling technique providing approximate solutions to engineering problems.
- Introduction to the concept of Stiffness – focus on solid mechanics approach using a loaded spring as an example.
- Introduction to stiffness coefficients, element stiffness matrices and the overall stiffness matrix for a model.
- Introduce the concept, and provide examples, of various forms of boundary conditions for loading and restraint.
- Describe various element types including constant strain and Isoparametric elements.

- Derive the equations for the development of an element stiffness matrix taking account of loading conditions, element geometry and material properties.
- Introduce the commercial software package Pro-E(ngineer)/Pro-Mechanica. Present worked examples involving 2D stress and temperature analyses after which students then undertake a series of hands-on exercises in these areas.
- Introduce the commercial elastoplastic FEA package DEFORM – present work examples involving plastic flow for processes such as extrusion and forging. Students them undertake hands-on exercise on the compression of a billet into the plastic range.

Teaching Strategies

The design module lectures are punctuated by short exercises, peer-to-peer discussion and generalized question-and-answer sessions on current topics. The drive is always to foster that aspect of thought – *divergent thinking* - which is so essential to the design engineer and so different from the *convergent* thinking processes used for solving engineering science problems. Although the design portfolio is individual, group methods (brainstorming etc) are encouraged in the early phases of design work.

The lectures on CAD/CAM use the same practice of short exercises, peer-to-peer discussion and generalized question-and-answer sessions on current topics.

Assessment Modes

- The course marks are derived from ***fully*** from continuous assessment. An indicative rubric is given below (subject to change)

Element	Assignment	Form	Semester	%
Lectures-GB	Product Range Analysis	Report	1	**2.5**
	Brainstorming (Bike stand)	Report	1	**5**
		Presentation	1	**5**
	Design Project (SolarCrush)	Report	1&2	**15**
		FMEA Excel	1&2	**2.5**
		Presentation	1&2	**10**
	Limits and Fits	Report	2	**7.5**
	Shaft Analysis	Report	2	**7.5**
	Guest Lectures	Attendance	1&2	
Practical Design	LabView 1	Report	1&2	**2.5**
	LabView 2	Report&Solution	2	**7.5**
	Engine Analysis	Report	1&2	**5**
	Workshop	Participation X 2	1&2	**5**
FEA - JM	Deform/Pro Mechanica	Pro-Mechanica Assignment	2	**10**
CAD/CAM	AutoCad/Alpha CAM	Report+Drawings	1	**7.5**
	Pro-E/Machining	Report+Drawings/Models	1&2	**7.5**
				100

Recommended Texts

Full notes are given for the Design module and for the CAD/CAM element of the computer aided engineering module

- *Parametric Modeling with Pro/Engineer Wildfire 5.0* (SDC Publications: ISBN:978-1-58503-539-7)
- *Introduction to Finite Element Analysis Using Pro/MECHANICA Wildfire 5.0* (SDC Publications: ISBN: 978-1-58503-549-6)
- *Finite Element Primer*, B.Irons & N.Shrive, (Ellis Horwood Series in Engineering Science: ISBN 0-85312-440-X)
- *The Finite Element Method*, K. Rockey, H. Evans, D.Griffiths, D.Nethercot, (Granada Publishing: ISBN 0 246 12053 3)

Other Relevant Texts

- *Conceptual design for engineers*. Michael French. Springer, 3rd Edition, c1999. (ISBN 1852330279)
- *Invention by design: how engineers get from thought to thing,* Petroski H. Cambridge, Mass., London, Harvard University Press, 1996. ISBN 0674463676.
- *CAD CAM: Principles, Practice and Manufacturing Management,* Chris McMahon & Jimmie Brown, Addison Wesley Longman Ltd., England. 1998. ISBN 0-201-17819-2

IMPORTANT NOTE:

As the course is evaluated fully through continuous assessment, there are no exams. Therefore, there are no associated supplemental exams which can be taken if the subject is failed. Similarly, it is not possible to complete work over the summer individually, as an alternative to exams. This is due to the group work nature of the course. As the course counts for 10ECTS, it therefore is possible that you will have to repeat the year if you fail this subject.

JUNIOR SOPHISTER LABORATORIES

Each course in JS has one or two laboratory experiments attached to it. Students are expected to keep a log book recording the details of every experiment performed and to write a technical report about each experiment. Each student is required to submit her/his report neatly presented and by the date specified to avoid penalty. Guidelines as to the required length and format of each report will be specified by the lecturer concerned.

Please note that you must attend the particular tutorial and laboratory sessions to which you have been assigned. Students cannot swap sessions because of the complexity of the timetable, the large numbers in the year and the limited accommodation available.

LABORATORY EXPERIMENTS

Lab. No.	**Description**	**Course**	**Staff**	**Location**
1	Refrigeration study	3B1	Dr. Robinson	Basement – Testing Hall
2	Diesel Engine	3B1	Dr. Robinson	Thermo Lab
3	Pelton Wheel	3B2	Dr. Meskell	Basement – Testing Hall
4	Process Control	3B6	Mr. Geraghty	Mechatronics Lab
5	Vibration Test	3B5	Dr. Simms	Basement – Testing Hall
6	CNC Machining	3B7	Dr. Chen	Basement – Testing Hall
7	Lead Creep	3B4	Dr. O'Kelly	Basement – Testing Hall
8	Strain Guages	3B3	Dr. Murphy	Basement – Testing Hall
9a/9b	Design 1	3B8	Mr. Gaynor	ECAL
10a/10b	Design 2	3B8	Mr. Gaynor	ECAL

JUNIOR SOPHISTER - COMMON COURSES
Students may choose either 3E1 or 3E1a

3E1 ENGINEERING MATHEMATICS V (Dept. of Mathematics)

Lecturer Prof. Brendan Browne (browne@maths.tcd.ie)

Credits 5

Course organization
The course runs over 12 weeks of the academic year and comprises of three lectures plus one tutorial per week – the total number of contact hours per student is 44.

Semester	Start week	End week	Lectures Per Week	Lectures Total	Tutorials Per Week	Tutorials Total
1	1	12	3	33	1	11

Course description, aims and contribution to programme
Engineering Mathematics V is a one semester course for all engineering streams and continues and extends the material from the previous mathematics courses in the first and second years - 1E1, 1E2, 2E1 and 2E2. The emphasis is primarily on analytical techniques

Learning outcomes
Upon completion of this course, students will be able to:

- calculate the coefficients of both the complex and the real Fourier series for a variety functions, and to use them to solve some ordinary differential equations.
- calculate Fourier transforms, discrete or continuous, for a variety of simple functions - students will then be able to use these to compute convolutions in simple cases;
- solve the Laplace, heat and wave equations for a variety of boundary conditions in domains of simple geometry and with simple boundary conditions; the techniques available will include, separation of variables, Laplace and Fourier Transform methods.
- solve linear and non-linear optimization problems.
- apply above methods to solve problems in different areas of engineering.

Course content

- Review of Fourier Methods
  - definition of complex and real Fourier series;
  - application of Fourier series to solve ordinary differential equations;
  - even and odd half-range expansions;
  - definition of Fourier transform;
  - interpretation of Fourier modes as frequencies;
  - convolution.

- Partial Differential Equations
    - Laplace’s equation;
    - the heat equation;
    - the wave equation;
    - D’Alembert’s solution;
    - fundamental solutions;
    - separation of variables;
    - application of Fourier analysis to initial value problems.

- Optimisation
    - linear programming.
    - non-linear optimization. Lagrange multipliers.
    - Newton’s and Conjugate Gradient methods.

Teaching strategies

The teaching strategy is a mixture of lectures and problem-solving tutorials. Whilst the format of lectures is conventional and the atmosphere is informal, some interaction and discussion is common and students are encouraged to ask questions. In the tutorials, all students work on problems which practice and apply the methods introduced in the lectures. Discussion of problems in small groups is encouraged and facilitated.

Assessment

Assessment for this course is carried out by means of a written two-hour examination at the end of the academic year. The subject mark is based entirely on the result of this written exam.

Recommended texts

- Advanced Engineering Mathematics, E. Kreyszig,

3E1a APPLIED ENGINEERING ANALYSIS

Lecturer: Professor Liam Dowling

Semester : 1

Credits: 5

Prerequisite Course(s): 2E1 and 2E2, or permission of lecturer

Course Organization
The course runs for 12 weeks of the academic year and comprises three lectures per week. A tutorial is given every week. Total contact time is 44 hours.

Semester	Start Week	End Week	Lectures per week	Lectures total	Tutorials per week	Tutorials total
1	1	12	3	33	1	11

Aims/Objectives
This course is developed to strengthen the student's skills in applied engineering analysis and is organised into three main subsections: signal and system analysis; partial differential equations; and optimization. The first section deals with transform analysis applied to engineering signals and systems. The second part of the course deals with methods for solving partial differential equations. The final section focuses on linear and nonlinear optimization for engineering design.

Learning Outcomes
On completion of this course the student will be able to:

- Analyse continuous-time signals using Fourier transforms and Fourier series.
- Analyse linear time-invariant systems using Fourier and Laplace transform methods.
- Solve the Wave equation, Heat equation, and Laplace's equation for various initial and boundary conditions.
- Solve linear programming problems using the Simplex algorithm.
- Use gradient methods to optimize a function.

Course Syllabus

***Signal and System Analysis*:**
Properties and applications of Fourier and Laplace transforms.

Linear Time-Invariant Systems: Impulse response and the convolution integral; properties of LTI systems; transfer function and frequency response of an LTI system.

Sampling Theorem: Representation of a continuous-time signal by its samples; undersampling and aliasing; the sampling theorem; reconstruction of a bandlimited signal from its samples.

Partial Differential Equations
Solution by separating variables: the Wave Equation; the Heat Equation; and Laplace's Equation. D'Alembert's solution of the Wave Equation.

Optimization
Linear Programming: The Simplex Algorithm
Unconstrained Optimization: The gradient method.

Teaching Strategies
The course is taught using a combination of lectures and problem solving tutorials.

Assessment

The annual examination counts for 70% and each of the two in-class tests count for 15% of the overall subject mark.

Recommended Texts

Kreyszig, E., *Advanced Engineering Mathematics.* 9th ed. New York: Wiley, 2006

3E2 NUMERICAL METHODS

Lecturers: Prof. Ciaran Simms (csimms@tcd.ie)

Course Organisation
The course runs for 11 weeks of the academic year and comprises three lectures per week. A tutorial is given in every teaching week. Total student contact time is 44 hours.

Semester	Start Week	End Week	Lectures per week	Lectures total	Tutorials per week	Tutorials total
2	1	12	3	33	1	11

Course Description
This is a course on the application of mathematical methods to gain approximate solutions to real world problems in Civil and Mechanical Engineering. This course demonstrates why there is frequently a need for numerical solutions to real-world problems, and introduces the high level programming environments of Excel and Matlab to code basic solutions to problems experienced in Civil and Mechanical Engineering. The Mathematics which underpin this course has been covered in previous Mathematics courses, and the physical problems solved are typically taken from accompanying Civil and Mechanical engineering core subjects, and this course therefore provides a link between pure Mathematics and the Engineering applications students will encounter in research and industry.

Learning Outcomes
On successful completion of this course, students will (be able to):

- understand the need for numerical solutions to real-world engineering problems
- understand how numerical methods incur errors
- use Matlab and Excel to code basic solution methods for Civil and Mechanical Engineering problems
- use the Taylor Series as a basis for error estimation in numerical techniques
- find numerical solutions to systems of linear and nonlinear algebraic equations
- perform 1-Dimensional nonlinear optimization
- perform multidimensional linear optimization
- program basic curve fitting techniques
- perform numerical integration and differentiation
- find numerical solutions to partial and ordinary differential equations
- understand the basis of, and apply, the linear finite element method to basic engineering problems

Course Syllabus

- The need for numerical methods
- Machine representation of numbers and associated errors
- Review of the Taylor Series
- Roots of nonlinear equations
- Roots of systems of linear equations
- One dimensional nonlinear optimization
- Multidimensional linear optimization
- Curve fitting
- Numerical integration
- Numerical differentiation
- Solutions to differential equations
- The linear finite element method

Lab/Assignments:
Where practical, each topic is covered in two podium lectures, one demonstration lecture showing the techniques implemented in Excel or Matlab, and one computer based tutorial which students submit for grading.

Teaching Strategies
Lectures: The teaching strategy attempts to mainly follow a single text book for the core material, to assist in student revision. Examples from the lecturer's research experience are frequently introduced to demonstrate the need for the methods covered.

Tutorials: there are weekly tutorials using either Excel or Matlab to implement each numerical method. These tutorials are taught by teaching assistants who are recruited from the postgraduate student body in the School of Engineering.

Assessment Modes

The assessment is by a 2 hour examination which is held at the end of the Trinity term and by grading of a random selection of 4 of the 11 submitted assignments done on a weekly basis. The written examination carries 70% of the total marks and the 4 graded assignments together carry 30% of the marks.

Recommended Texts
Matlab primer

- **Introduction to Matlab 7, by DM Etter, DC Kunkicky & H Moore, Pearson Prentice Hall, 2005.**
- Matlab for Engineers, Biran & Breiner, Addison Wesley, 1995.
- The Matlab Handbook, Enander, et al., Addison Wesley, 1996.

Numerical Methods

- **Numerical Methods for Engineers by Steven Chapra & Raymond Canale, McGraw Hill, 5th Edition 2006.**
- Numerical Methods with Matlab – Recktenwald, Prentice Hall,2000
- Numerical Methods using Matlab – Mathews & Fink, Prentice Hall, 1999

Further Information

EMAIL: CSIMMS@TCD.IE

3E4 MANAGEMENT FOR ENGINEERS

Lecturers: Prof. Niamh Harty niamh.harty@tcd.ie
Ms. Joanna Gardiner
Prof. Brian Caulfield brian.caulfield@tcd.ie

Credits: 5

Course Organisation

Semester	Start Week	End Week	Associated Practical Hours	Lectures		Tutorials	
				Per Week	Total	Per Week	Total
2	13	24	0	2	24	1	12
Total Contact Hours: 36							

Course Description

Management for Engineers introduces engineering students to Entrepreneurship and Communication. The aims of the course are:

- To foster a sense of entrepreneurship among the JS Engineering students, by requiring the students to come up with a business idea and during the semester produce a business plan.
- To enable students to communicate well in engineering contexts, both when *talking* about projects, plans and problems, and when *writing* about these.

Learning Outcomes

On completion of this course the student will be able to:

- Prepare a business plan, including details of marketing, market research, finance, legal issues and growth.
- Give a presentation
- Summarise a technical article

Course Content

The course covers the following topics:
Entrepreneurship:

- Coming Up with a Business Idea
- Marketing
- Feasibility
- Market Research
- Legal Issues
- Finance and Accounting
- Business Plan
- Ethics
- Growth of the Business

Communication:

- Intersubjectivity
- Emails
- Reports
- Presentations
- Intercultural communication
- Media Interviews

Recommended Text

To be announced

Assessment Modes

There will be three assignments on Entrepreneurship, and two assignments on Communication, plus a final examination.

Entrepreneurship counts for 50% of overall mark in 3E4. Marks for Entrepreneurship will be divided 60% for continuous assessment, and 40% for questions on the Final examination.

Communication counts for 50% of overall mark in 3E4. Marks for Communication will be divided 40% for continuous assessment, and 60% for questions on the Final examination.

Further Information

Web page: http://www.tcd.ie/Engineering/Courses/BAI/JS_Subjects/3E3/

DEPARTMENT OF MECHANICAL & MANUFACTURING ENGINEERING

GUIDELINES ON EXAMINATIONS

The following pages set out some guidelines on examinations, including extracts from the University Calendar on plagiarism and anonymous marking procedures

Plagiarism

53 Plagiarism is interpreted by the University as the act of presenting the work of others as one's own work, without acknowledgement.

Plagiarism is considered as academically fraudulent, and an offence against University discipline. The University considers plagiarism to be a major offence, and subject to the disciplinary procedures of the University.

54 Plagiarism can arise from deliberate actions and also through careless thinking and/or methodology. The offence lies not in the attitude or intention of the perpetrator, but in the action and in its consequences.

Plagiarism can arise from actions such as:

- (a) copying another student's work;
- (b) enlisting another person or persons to complete an assignment on the student's behalf.
- (c) quoting directly, without acknowledgement, from books, articles or other sources, either in printed, recorded or electronic format;
- (d) paraphrasing, without acknowledgement, the writings of other authors;

Examples (c) and (d) in particular can arise through careless thinking and/or methodology where students:

- (i) fail to distinguish between their own ideas and those of others.
- (ii) fail to take proper notes during preliminary research and therefore lose track of the sources from which the notes were drawn;
- (iii) fail to distinguish between information which needs no acknowledgement because it is firmly in the public domain, and information which might be widely known, but which nevertheless requires some sort of acknowledgement;
- (iv) come across a distinctive methodology or idea and fail to record its source;

All the above serve only as examples and are not exhaustive.

Students should submit work done in co-operation with other students only when it is done with the full knowledge and permission of the lecturer concerned. Without this, work submitted which is the product of collusion with other students may be considered to be plagiarism.

55 It is clearly understood that all members of the academic community use and build on the work of others. It is commonly accepted also, however, that we build on the work of others in an open and explicit manner, and with due acknowledgement. Many cases of plagiarism that arise could be avoided by following some simple guidelines:

- (i) Any material used in a piece of work, of any form, that is not the original thought of the author should be fully referenced in the work and attributed to its source. The material should either be quoted directly or paraphrased. Either way, an explicit citation of the work referred to should be provided, in the text, in a footnote, or both. Not to do so is to commit plagiarism.

(ii) When taking notes from any source it is very important to record the precise words or ideas that are being used and their precise sources.

(iii) While the Internet often offers a wider range of possibilities for researching particular themes, it also requires particular attention to be paid to the distinction between one's own work and the work of others. Particular care should be taken to keep track of the source of the electronic information obtained from the Internet or other electronic sources and ensure that it is explicitly and correctly acknowledged.

56 It is the responsibility of the author of any work to ensure that he/she does not commit plagiarism.

57 Students should ensure the integrity of their work by seeking advice from their lecturers, tutor or supervisor on avoiding plagiarism. All departments should include, in their handbooks or other literature given to students, advice on the appropriate methodology for the kind of work that students will be expected to undertake.

58 If plagiarism as referred to in §34 above is suspected, the Head of Department will arrange an informal meeting with the student, the student's tutor[1], and the lecturer concerned, to put their suspicions to the student and give the student the opportunity to respond.

59 If the Head of Department forms the view that plagiarism has taken place, he/she must notify the Senior Lecturer in writing of the facts of the case and suggested remedies, who will then advise the Junior Dean. The Junior Dean will interview the student if the facts of the case are in dispute. Whether or not the facts of the case are in dispute, the Junior Dean may implement the procedures set out in CONDUCT AND COLLEGE REGULATIONS §2.

Note 1: As an alternative students may nominate a representative from the Students' Union to accompany them to the meeting

pp. G12-G13 Calendar 2000-2001

Anonymous Marking

Candidates taking will have their new examination number forwarded to their home addresses, by letter, from the Examinations Office before the end of the first semester. Examination option information (XIDs) will not be included in these letters. Students will be able to access their own examination information on the new Student Information System in late February/early March, following completion of XID and option maintenance by Faculty Offices and the Examinations Office. An email will be sent to [JF, SF and JS] students asking them to check their examination subjects on the Student Information System and contact the appropriate Department or Faculty Office if there are any corrections.

Safety in the Department.

Dear Student,

The Department of Mechanical & Manufacturing Engineering operates a 'safe working environment' policy and we take all practical precautions to ensure that hazards or accidents do not occur. We maintain safety whilst giving you the student very open access to the departmental facilities. Thus safety is also your personal responsibility and it is your duty to work in a safe manner when within the department. By adopting safe practices you ensure both your own safety and the safety of others.

Please read the Safety Document on the Departmental website: http://www.mme.tcd.ie/ and comply with the instructions given within. Failure to behave in a safe manner may result in your being refused the use of departmental facilities.

Professor Biqiong Chen
Dept Safety Officer

Student Disability Services

If you have a disability or a specific learning disability (such as dyslexia) you may want to register with Student Disability Services.

Do you know what supports are available to you in College if you have a disability or a specific learning disability? Further information on our services can be found at www.tcd.ie/disability

Declan Reilly and Alison Doyle are the Disability Officers in College. You can make an appointment to see them by phoning 6083111, or emailing them at: disab@tcd.ie.