

# MATERIALS & PROCESSING

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[www.eng.waikato.ac.nz](http://www.eng.waikato.ac.nz)

*Materials & Processing is concerned with all the processes and activities of converting raw materials and commodity materials into valuable products required by manufacturers or the end-consumer.*

Processing our raw materials and commodity goods more effectively is important to New Zealand's continuing economic welfare. We need to develop products that have significant value in world markets. To do this, we need to understand fully the properties of materials as diverse as food, wood, metals, plastics and fuel. We then need to know how to use this knowledge to design, manufacture and process these materials into high-value products such as dietary formula, ceramics that can withstand high temperatures, titanium alloys, pharmaceuticals, laminated boards and functional proteins. We also need to understand the properties of these high-value products and how they will interact with their environment, whether it be within the body or in the atmosphere.

The discipline serves industrial and other activities where material is undergoing a change, be it chemical, biochemical or physical. Process engineering involves knowing how to prepare feed materials, how to make reactions occur, separating and purifying products, controlling wastes, minimizing energy usage, and ultimately adding value to the raw materials used to produce something useful to people. These skills form the basis for the majority of New Zealand's export earnings.

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## CONTACTS FOR THE SCHOOL OF ENGINEERING

Materials & Processing is administered by the School of Engineering.

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<b>Enrolment Contact Person &amp; First Year Mentor</b> Professor Janis Swan	Room: EG.04C Phone: 07 838 4049 Email: <a href="mailto:j.swan@waikato.ac.nz">j.swan@waikato.ac.nz</a>
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## Degrees

Materials & Processing is a major subject for the Bachelor of Science or Bachelor of Science (Technology) degrees.

A specified programme in Materials & Process Engineering is also available for the Bachelor of Engineering or Bachelor of Engineering (Honours) degrees. Refer to page 137.

Papers in Materials & Processing are offered at all levels of study from undergraduate degrees through to postgraduate and doctoral studies. Some papers are only available to students enrolled in the BE or BE(Hons) degree.

# MATERIALS & PROCESSING

## Materials & Processing Major – BSc / BSc(Tech)

### General Structure of a Materials & Processing Major for the BSc and BSc(Tech) degrees

<b>100 LEVEL</b>	ENGG180 15 points	ENMP102 15 points		<p><b>100 Level</b> – ENGG180 Foundations of Engineering and ENMP102 Introduction to Materials Science and Engineering.</p> <p><b>200 Level</b> – 60 Points at Level 200 Materials and Processing. ENMP211 Materials 1 and ENMP221 Engineering Thermodynamics are highly recommended.</p> <p><b>300 Level</b> – 60 points at Level 300 Materials and Processing.</p>
<b>200 LEVEL</b>	ENMP2XX 20 points	ENMP2XX 20 points	ENMP2XX 20 points	
<b>300 LEVEL</b>	ENMP3XX 20 points	ENMP3XX 20 points	ENMP3XX 20 points	

### Specialisations

Students may undertake the following specialisations for the BSc and BSc(Tech) major in Materials and Processing.

» Agribusiness	*
» Science International	page 157
» Te Pūtaiao me ngā take Māori	page 162

*\*Enrolment in this specialisation should be completed in consultation with both the Faculty of Science & Engineering and the Waikato Management School.*

## Choosing Papers

### Entry into Materials & Processing Papers

There are no formal prerequisites for entry into 100 Level papers in Materials & Processing. The best prepared candidates will have, at a minimum, completed secondary study at Level 3 NCEA in chemistry, physics, mathematics and/or technology. Nonetheless, students without this formal background who can demonstrate sufficient motivation are able to attempt these papers. Higher entrance requirements are expected for students who wish to enrol in a Bachelor of Engineering degree.

In some cases, we are able to relax the rules on prerequisites. If you would particularly like to take a paper for which you have not satisfied a specified requirement, please come and talk to the staff in the School.

## Materials & Processing Major

### 100 Level – Papers are worth 15 points.

If you are doing a BSc or BSc(Tech) degree and are interested in a Materials & Processing major, you should take the following core papers.

#### *Prerequisites*

- » ENGG180A – Foundations of Engineering
- » ENMP102B – Introduction to Materials Science and Engineering

It is a good idea to do at least two mathematics papers, at least one chemistry paper and one physics paper. Papers for the Materials & Process Engineering programme for the BE degree are specified (see page 137).

### 200 Level – Papers are worth 20 points unless specified.

#### *Highly recommended papers*

- » ENMP211A – Materials 1
- » ENMP221A – Engineering Thermodynamics
- » 20 points from 200 Level Materials & Processing papers

Additional papers may be taken from other materials and processing papers offered at 200 Level or can be supported by papers from other subjects. For example, students interested in materials science are advised to take some chemistry papers; students interested in biotechnology are advised to take 200 Level biological sciences papers.

### 300 Level – Papers are worth 20 points unless specified.

Students need to take at least 60 points at Level 300 in materials and processing.

#### *Recommended papers*

- » ENMP311B – Materials 2
- » ENMP321B – Process Engineering and Design
- » 20 points from 300 Level Materials & Process Engineering papers

The other papers needed to complete the degree requirements of the BSc and BSc(Tech) may come from further optional papers in materials and processing, other science subjects or may even include some papers from other faculties/schools of studies.

## Students not intending to major in Materials & Processing

If you are not a Materials & Processing major, please feel free to sample from our wide variety of paper offerings. Generally, it will be easiest for you to pick up materials and processing papers at 100 and 200 Level, as these papers will be less affected by prerequisites. Two very popular papers amongst students in this category are ENMP282 and ENMP283 Science and Engineering Management A and B.

If you intend to major in Chemistry, Biological Sciences, Earth Sciences, Electronics, or Physics, ENGG180 and ENMP102 will help you see how your subject major fits in to New Zealand's industry and manufacturing.

200 Level materials and processing papers can be useful adjuncts to students majoring in Chemistry, Biological Sciences, Earth Sciences, Electronics and Physics. For instance, Chemistry and Earth Science students will find materials science papers (ENMP211 Materials 1, ENMP214 Manufacturing Processes, ENMP215 Manufacturing Practice) useful; Environmental Science students will find ENMP241 Environmental Technology 1 useful; and Biological Science and Chemistry students interested in biotechnology and food processing will find ENMP222 Biotechnology: Food and Bioresources and ENMP322 Biotechnology useful. Process engineering papers, ENMP221 Engineering Thermodynamics and ENMP223 Thermofluids, provide an understanding of the key principles in fluid, heat and mass flows, and are useful for Chemistry and Biotechnology majors.

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## Timetable Clashes

Your selection of papers may depend on your timetable. You will not usually be permitted to take papers which have lecture clashes. Laboratory clashes can usually be resolved. You should initially contact the relevant department if you have a laboratory clash.

## Materials & Processing Papers

### 100 Level Papers

**ENGG180-12A (HAM) – Foundations of Engineering**

*15 Points*

*For details refer to Engineering ENGG180.*

**ENMP102-12B (HAM) – Introduction to Materials Science and Engineering**

*15 Points*

Engineers in all disciplines encounter and use materials in their various practices. To function effectively, an engineer needs to have some understanding of the properties and behaviour of materials. This is particularly relevant in design and maintenance, when engineers need to make important decisions on the choice of materials to be used in a component. This paper is, therefore, designed to address the introductory materials science requirements for first-year engineering programmes.

*Co-ordinator(s): Dr Rob Torrens*

*Recommended book(s): Callister et al **Materials Science and Engineering – An Introduction** 7th ed (Wiley) 2007*

*Assessment: Internal assessment/examination ratio: 1 : 1*

### 200 Level Papers

**ENGG282-12B (HAM) – Engineering Design**

*10 Points*

*For details refer to Engineering ENGG282.*

**ENMP211-12A (HAM) – Materials 1**

*20 Points*

Why are some materials as hard as nails, soft as putty, tough as old boots, or as strong as an ox? And how can they be improved? This paper introduces the basic concepts of materials technology and how to apply these concepts to everyday environments. You will be introduced to the uses and limitations of metals (ferrous and non-ferrous), ceramics/fine ceramics (superconductors, ionic conductors etc), cements and concrete, polymers and composite materials (natural, such as wood, and synthetic, such as carbon fibre reinforced composites).

*Co-ordinator(s): Associate Professor Kim Pickering*

*Prerequisite(s): CHEM101 or CHEM102 or ENMP102*

*Assessment: Internal assessment/examination ratio: 1 : 1*

**ENMP213-12B (HAM) – Mechanics of Materials 1***20 Points*

Students learn the basics of stress analysis used in mechanical engineering design. This course introduces the essential aspects of designing structures subjected to axial, bending and torsional loads. An important outcome is an introduction to the fundamental principles of stress analysis. This paper is taught through lectures, tutorials and a weekly workshop for problem solving.

*Co-ordinator(s):* Professor Deliang Zhang  
*Prerequisite(s):* MATH101 or PHYS103  
*Assessment:* Internal assessment/examination ratio: 1 : 1

**ENMP214-12B (HAM) – Manufacturing Processes***10 Points*

This paper gives students an understanding of the fundamental principles and basic relationships underlying selected major manufacturing processes widely used in industry, including machining processes, metal casting, forming processes such as extrusion, welding and joining processes. Knowledge on metrology and non-destructive testing techniques will also be introduced.

It is highly recommended that students taking this paper also take ENMP215.

*Co-ordinator(s):* Professor Deliang Zhang  
*Prerequisite(s):* ENMP102  
*Assessment:* Internal assessment/examination ratio: 1 : 1

**ENMP215-12B (HAM) – Manufacturing Technology***10 Points*

This paper covers the practical aspects of manufacturing processes, and students have the opportunity to increase their practical workshop skills. The major processes covered by the paper include machining, casting, mechanical forming, welding, and printed board manufacturing. It is highly recommended that students taking this paper also take ENMP214.

*Co-ordinator(s):* Dr Chi Kit Au  
*Prerequisite(s):* ENMP102  
*Assessment:* Internal assessment/examination ratio: 1 : 1

**ENMP221-12A (HAM) – Engineering Thermodynamics***20 Points*

This paper teaches fundamental concepts and laws of thermodynamics and thermodynamic properties of engineering materials, with applications to mass and energy analysis of chemical processes, power cycles, and refrigeration cycles. It includes laboratory work.

*Co-ordinator(s):* Dr Michael Walmsley  
*Prerequisite(s):* ENGG180 or ENMP102  
*Required book(s):* Cengel and Boles *Thermodynamics, an Engineering Approach 6th ed (McGraw Hill)*  
*Assessment:* Internal assessment/examination ratio: 1 : 1

## MATERIALS & PROCESSING

### ENMP222-12B (HAM) – Biotechnology: Food and Bioresources

20 Points

This paper is delivered jointly by the Department of Biological Sciences and the School of Engineering. It introduces biotechnology, microbiology and processing of bioproducts, composition and processing of selected foods, and food processing. There is a compulsory laboratory component offered. Subject to sufficient enrolments.

*Co-ordinator(s):* Professor Janis Swan and Associate Professor Ian McDonald  
*Prerequisite(s):* BIOL101 and a further 15 points at 100 Level from Biological Sciences, Chemistry, Engineering or Materials and Processing

*Assessment:* Internal assessment/examination ratio: 1 : 1

### ENMP223-12B (HAM) – Thermofluids

20 Points

This paper teaches fundamental concepts and laws related to static and dynamic behaviour of fluids, and heat transfer in steady and transient systems. It includes laboratory work.

*Co-ordinator(s):* Dr Michael Walmsley  
*Prerequisite(s):* MATH101, PHYS103 or ENMP221  
*Recommended book(s):* Turner et al *Fundamentals of Thermal-Fluid Sciences* 3rd ed (McGraw Hill) 2008  
*Assessment:* Internal assessment/examination ratio: 1 : 1

### ENMP241-12B (HAM) – Environmental Technology 1

20 Points

The Earth's natural environment suffers from the effects of past exploitative development. This paper combines the principles of science and engineering to find technological solutions for existing problems and design processes for future sustainable development. In this introductory paper, processes for maximising the benefit of the material resources taken from the environment (minerals, water, air, fossil fuels and biomass) and minimising waste and negative impacts will be discussed.

*Co-ordinator(s):* Dr Mark Lay  
*Prerequisite(s):* Any 30 points from 100 Level Science and Engineering papers, and 15 points from 100 Level Mathematics or Statistics  
*Recommended book(s):* Nazaroff and Alvarez-Cohen *Environmental Engineering Science* (Wiley) 2001  
*Assessment:* Internal assessment/examination ratio: 1 : 1

### ENMP282-12A (HAM) – Science and Engineering Management A

10 Points

A study of the management function and activities relating to the needs of scientists and engineers. Topics include technology and innovation, effective oral and written communication and financial management.

This paper will not normally be available for a major in Materials and Processing.

*Co-ordinator(s):* Dr Johan Verbeek  
*Restriction(s):* ENGG280 and ENMP281  
*Assessment:* Internal assessment/examination ratio: 1 : 1

### ENMP283-12B (HAM) – Science and Engineering Management B

10 Points

This core management paper for BE and BSc(Technology) is normally taken before the first industry placement. It is also a useful paper for other science students who want to be familiar with management terms and concepts. This paper provides a broad introduction to the essential aspects of management functions and activities. Topics include marketing, total quality management and ethics.

This paper will not normally be available for a major in Materials and Processing.

*Co-ordinator(s):* Dr Johan Verbeek  
*Restriction(s):* ENMP281  
*Assessment:* Internal assessment/examination ratio: 1 : 1

### 300 Level Papers

#### ENME351-12A (HAM) – Dynamics and Mechanisms

20 Points

**This paper is normally only available to students enrolled in the BE or BE(Hons) degree.**

Introduction to force, moment, equilibrium, free body diagram, work, energy, impulse, momentum and Newton's Laws. Kinematics and kinetics of particles and rigid bodies, vibrations. Function and design of mechanical components. Students will learn to construct and solve mathematical models describing the effects of force and motion on a variety of structures, machines and other dynamic systems.

Co-ordinator(s): Associate Professor Ilanko

Prerequisite(s): PHYS103

Equivalent: ENGG351

Required book(s): Meriam and Kraige *Engineering Mechanics* Vol 12 (Wiley) 2003

Assessment: Internal assessment/examination ratio: 1 : 1

#### ENME352-12B (HAM) – Machine Dynamics and Control

20 Points

**This paper is normally only available to students enrolled in the BE or BE(Hons) degree.**

Topics covered include vibrations in multiple degree of freedom systems, modelling and analysis for design improvements, vibration control, mathematical modelling, time, feedback and frequency response, control actions and controllers. Students will gain skills to allow them to design dynamic systems.

Co-ordinator(s): Associate Professor Ilanko

Prerequisite(s): ENME351

Equivalent: ENGG352

Restriction(s): ENEL317

Recommended book(s): Tongue *Principles of Vibration* (Oxford)

Assessment: Internal assessment/examination ratio: 1 : 1

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## ENME380-12B (HAM) – Mechanical Engineering Design

20 Points

*This paper is normally only available to students enrolled in the BE or BE(Hons) degree.*

Aspects of machine design and power transmission are covered. Engineering drawing and design techniques are further developed and applied through project work. The benefits and pitfalls of simulating mechanical designs is demonstrated and discussed. Electrical machines including DC, AC motors and solenoids are explained in a mechanical engineering context.

Co-ordinator(s): Dr Mike Duke  
 Prerequisite(s): ENGG282 and ENMP213  
 Required book(s): Childs, **Mechanical Design** 2nd ed (Arnold) 2004  
 Assessment: Internal assessment/examination ratio: 1 : 1

## ENMP301-12A/B/S/Y (HAM) – Special Topics in Technology

20 Points

This paper consists of directed studies on an aspect of technology or technological innovation. It may involve specified topics from other papers and/or independent theoretical literature, or experimental investigations. Students require permission from the chair of the school to enrol in this course.

Co-ordinator(s): Professor Janis Swan  
 Assessment: Internal assessment/examination ratio: 1 : 0

## ENMP311-12B (HAM) – Materials 2

20 Points

This paper advances knowledge presented in ENMP211 on structure, property, processing relationships fundamental to materials science engineering. The paper focuses on aspects of new materials, and the concept of advanced hi-tech materials. This paper includes microstructure modification, new materials and applications. With a basic understanding of the concepts, students will now start to understand the design philosophy. By the end of the paper, students will be able to understand the requirements for a particular application and be able to select materials on the basis of their properties.

**Note(s):** *This paper is recommended if proceeding to Masters-level study in materials-related research.*

Co-ordinator(s): Associate Professor Kim Pickering  
 Prerequisite(s): ENMP211  
 Assessment: Internal assessment/examination ratio: 1 : 1

## ENMP313-12A (HAM) – Mechanics of Materials 2

20 Points

This paper aims to provide students with the knowledge and skills to design components and structures at an advanced level. It examines the scientific principles and relationships underlying mechanics and performance of materials, stress and strain transformations, failure criteria, deflections and angle of twist, stress in bending and fatigue. A major design project is incorporated in the paper to give students opportunities to apply the knowledge learnt in solving practical problems. By the end of the course students will have the essential knowledge and skills needed in designing components and structures in many engineering situations.

Co-ordinator(s): Associate Professor Brian Gabbitas  
 Prerequisite(s): ENMP213  
 Assessment: Internal assessment/examination ratio: 1 : 1

**ENMP321-12B (HAM) – Process Engineering and Design***20 Points*

This paper provides advanced aspects of design and process technology for commercial production of biological, chemical and mineral products. The principles of chemical and biological engineering, including designing production systems, process simulation; process economics equipment design and separation technology. Once physical processes have been reviewed, the emphasis moves to process design – how to put together an integrated process and how to assess and implement it.

A key component in the paper is process economics – will the process make money or not?

<i>Co-ordinator(s):</i>	<i>Dr Johan Verbeek</i>
<i>Prerequisite(s):</i>	<i>ENMP221</i>
<i>Required text(s):</i>	<i>Seider, et al <b>Product &amp; Process Design Principles</b> 2nd ed (John Wiley and Sons, Inc.) 2004</i>
<i>Assessment:</i>	<i>Internal assessment/examination ratio: 1 : 1</i>

**ENMP322-12B (HAM) – Biotechnology***20 Points*

The paper includes: Industrial biotechnological applications of enzymes and micro-organisms, principles of bioreactor and fermenter design and operation, industrial separation and purification of biological material, and selected unit operations for bioprocessing. Topics may also include biomass and alcohol production, enzymes in food processing, and biotechnologies in food and by-products. The computing laboratories cover aspects of bioreactor operation, fermentations and bioseparations.

<i>Co-ordinator(s):</i>	<i>Dr Giridhar Nair</i>
<i>Prerequisite(s):</i>	<i>One of BIOL241, ENMP221 or ENMP222</i>
<i>Assessment:</i>	<i>Internal assessment/examination ratio: 1 : 1</i>

**ENMP323-12A (HAM) – Transport Processes and Unit Operations***20 Points*

This paper covers analysis and application of fluid phase equilibria, heat and mass transfer and separation processes. The fundamentals of drying, evaporation, membrane separations, and distillation are discussed.

<i>Co-ordinator(s):</i>	<i>Dr James Carson</i>
<i>Required book(s):</i>	<i>Seader and Henley <b>Separation Processes</b> 2nd ed (Wiley)</i>
<i>Prerequisite(s):</i>	<i>ENMP223</i>
<i>Assessment:</i>	<i>Internal assessment/examination ratio: 1 : 1</i>

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### ENMP325-12A (HAM) – Engineering Microbiology

20 Points

*This paper is normally only available to students enrolled in the BE or BE(Hons) degree.*

This paper looks at the great metabolic diversity of bacteria and their ability to respond to fluctuating and extreme environments. Emphasis will be placed on the unifying principles and the relationship of bacterial physiology to the taxonomy and ecology of archaeobacteria and eubacteria. The role of adhesion will be discussed leading to the importance of bacterial biofilms and the metabolic interactions that occur within these consortia. Bacterial phylogeny will be used to introduce new methods of molecular ecology.

Lecturer(s):	Professor Hugh Morgan and Associate Professor Ian McDonald
Prerequisite(s):	ENMP221 and either BIOL101 or BIOL102
Restriction(s):	BIOL241
Required book(s):	Madigan et al <b>Brock Biology of Microorganisms 9th ed</b> (Prentice-Hall)
Assessment:	Internal assessment/examination ratio: 1 : 2

### ENMP341-12A (HAM) – Environmental Technology 2

20 Points

The paper focuses on technologies for air, water and energy that maximise the efficiency of resource utilisation and minimise waste generation and environmental impact. Energy technology and fuel science, particularly the development of renewable energy sources, minimisation of carbon emissions and air quality issues (indoor and outdoor) are important themes of the paper.

Co-ordinator(s):	Associate Professor Alan Langdon
Prerequisite(s):	30 points at 100 Level in Science and Engineering papers
Required book(s):	Nazaroff and Alvarez-Cohen <b>Environmental Engineering Science</b> (Wiley) 2001
Assessment:	Internal assessment/examination ratio: 1 : 1

### ENMP381-12B (HAM) – Technological Innovation and its Management

20 Points

This paper is directed towards understanding the innovation process and examines the issues and important factors that ensure the new knowledge generated by scientific research finds application. It is designed to be interactive and draws upon and develops students' differing experiences of science and technology. Course content is organised in teaching blocks with topics including invention and creative thinking, technology evaluation, information technology, technological economics and technology project management. A feature of the paper is creating, evaluating and business planning for technological innovations, which is done in a small group environment.

The paper is internally assessed. Exercises of appropriate weighting are based upon each of the teaching blocks.

This paper will not normally be available for a major in Materials and Processing.

Co-ordinator(s):	To be advised
Prerequisite(s):	20 points from either ENMP282 or any 100 level Management subject, or 60 points from any 200 level Science and Engineering subject(s)
Assessment:	Internal assessment/examination ratio: 1 : 0

## 400 Level Papers

### ENME440-12A (HAM) – Computer Aided Engineering

20 Points

**This paper is normally only available to students enrolled in the BE or BE(Hons) degree.**

Computer Aided Engineering (CAE) involves using software to model and predict the behaviour of engineering components and systems. Virtual models are analysed instead of physical prototypes, reducing cost and product development time. This paper explains the theory behind key CAE areas and how to use advanced computer software to solve real engineering problems.

The modules to be covered may include two or more of the following:

- » Finite element method (theory and applications)
- » Computational fluid dynamics
- » Vibrational analysis

Co-ordinator(s): Associate Professor Sinniah Ilanko  
 Prerequisite(s): ENGG285 or MATH285, and ENGG284 and ENEL284 or MATH255  
 Restriction(s): ENGG440, ENSC440, ENGG540 and ENSC540  
 Assessment: Internal assessment/examination ratio: 1 : 0

### ENME451-12A (HAM) – Mechanics of Vibration

10 Points

**This paper is normally only available to students enrolled in the BE or BE(Hons) degree.**

**Note(s):** This paper will be offered only if there is sufficient student interest.

Students will learn how to apply Newton's laws of motion and energy principles to mechanical systems and how to calculate natural frequencies and dynamic response of machines and machine components. This paper covers 'multi-degree of freedom' systems as well as solving by exact and approximate methods.

Co-ordinators(s): Associate Professor Ilanko  
 Prerequisite(s): ENME351, ENME352  
 Assessment: Internal assessment / examination ratio: 1 : 1

### ENME480-12A (HAM) – Advanced Product Development

10 Points

**This paper is normally only available to students enrolled in the BE or BE(Hons) degree.**

The paper explains the technologically-driven changes affecting modern product development. It also teaches the most common rapid prototyping technologies and when to apply them. Examples of virtual engineering and simulation are demonstrated. CAD/CAM simulation and visualisation is used to give accelerated time-to-market engineering solutions.

Co-ordinator(s): Dr Mike Duke  
 Prerequisite(s): ENGG180 and ENGG282  
 Assessment: Internal assessment/examination ratio: 1 : 0

### ENMP407-12A/B (HAM) – Materials and Process Engineering Elective

10 Points

**This paper is normally only available to students enrolled in the BE or BE(Hons) degree.**

An advanced study in materials and processing. Possible options include: advanced composites; metals; bioseparations processing; environmental technology. Sub-topics include: available processing options; effect of material characteristics on processing parameters.

Co-ordinator(s): Professor Janis Swan  
 Assessment: Internal assessment/examination ratio: 1 : 0

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### ENMP411-12A (HAM) – Advanced Materials Engineering

10 Points

**This paper is normally only available to students enrolled in the BE or BE(Hons) degree.**

An advanced study of the relationships between processing and microstructure of engineering materials. Sub-topics include solidification, ceramic processing, joining and repairs of composite materials and powder metallurgy.

Co-ordinator(s): Professor Deliang Zhang

Prerequisite(s): ENMP311

Assessment: Internal assessment/examination ratio: 1 : 4

### ENMP413-12B (HAM) – Materials Performance in Service

10 Points

**This paper is normally only available to students enrolled in the BE or BE(Hons) degree.**

Students will learn the importance of design to avoid fracture using fracture mechanics, advanced stress analysis, including plasticity and advanced fatigue, and creep behaviour at elevated temperature.

Co-ordinator(s): Associate Professor Brian Gabbitas

Prerequisite(s): ENMP313

Required book(s): Jones *Engineering Materials 3* (Pergamon) 1993

Assessment: Internal assessment/examination ratio: 3 : 7

### ENMP421-12A (HAM) – Advanced Process Engineering and Control

10 Points

**This paper is normally only available to students enrolled in the BE or BE(Hons) degree.**

An introduction to applied process control and automation, control hardware dynamics, digital controllers, open loop and closed loop properties of real systems, control loop stability and tuning.

Co-ordinator(s): Dr Michael Walmsley

Prerequisite(s): ENMP321 or ENME352

Required book(s): Seborg et al *Process Dynamics and Control* (Wiley) 2004

Assessment: Internal assessment/examination ratio: 2 : 3

### ENMP422-12A (HAM) – Advanced Process Simulation and Control

20 points

**This paper is normally only available to students enrolled in the BE or BE(Hons) degree.**

Process dynamics, simulation and control and modern control systems, including open and closed loop, linear and non-linear systems, PID control, stability and tuning. Includes process simulation with commercial software packages.

Convenor(s): Dr Michael Walmsley

Prerequisite(s): ENMP321 or ENME352

Restriction(s): ENMP421

Required book(s): Seborg, et al *Process Dynamics and Control* (Wiley)

Assessment: Internal assessment/examination ratio: 2 : 3

**ENMP427-12A (HAM) – Biological Engineering***20 points****This paper is normally only available to students enrolled in the BE or BE(Hons) degree.***

This paper describes concepts of using biological materials for producing biomolecules, cell-based products and tissues, and carrying out transformations. The principles of downstream separation processes important in the bioprocess industries; modelling and costing such processes are included.

Convenor(s): *Dr Giridhar R Nair*  
 Prerequisite(s): *ENMP321 and ENMP322*  
 Restriction(s): *ENMP426*  
 Assessment: *Internal assessment/examination ratio: 1 : 1*

**ENMP442-12A (HAM) – Environmental Technology 3***20 points****This paper is normally only available to students enrolled in the BE or BE(Hons) degree.***

Topics in the engineering and science of water resources and water and wastewater treatment and management.

Convenor(s): *Associate Professor Alan Langdon*  
 Prerequisite(s): *ENMP341 or equivalent*  
 Restriction(s): *ENMP543, ENMP544*  
 Assessment: *Internal assessment/examination ratio: 1 : 2*

**BSc(Tech) Work Placement Papers**

*For details refer to Work Placements.*