Chemical and Bioprocess Engineering course overview

1.3.1 Chemical and Bioprocess Engineering (CBE)

A student graduating with the major of Chemical and Bioprocess Engineering has the following body of knowledge that distinguishes them from other majors within the BE(Hons):

- Can apply chemical and biological principles to both large scale dynamic processing operations and small-scale systems
- Use process engineering fundamentals such as heat and mass transfer principles applied to chemical and biological reaction systems and separation processes
- Have an ability to mathematically model complex chemical and biological processes
- Have broad generic chemical engineering skills to enable design and control of chemical and biological processes

The Chemical and Bioprocess Engineering major consists of 29 courses, worth a total of 480 credits. In the full-time mode, students study four courses per semester, and the duration to complete the programme is eight semesters. Figure 1.8 illustrates how the courses are distributed over the semesters.

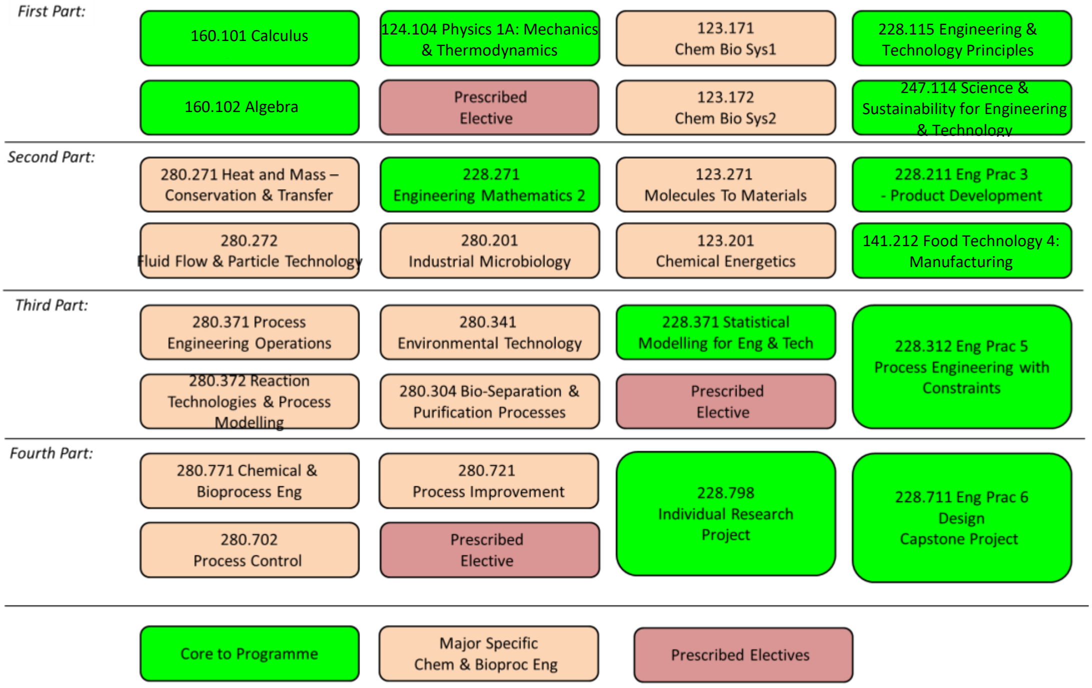

Figure 1.8 Programme Map for the Chemical and Bioprocess Engineering Major

There are courses that are core to the programme, major specific and electives.

Core to programme courses develop:

1. **D**esign & **P**rofessional Practice attributes – referred to as the 'Project Based Spine'. Students have to complete a project (one per semester or double semester) that involves utilising the common practice of the engineering method to solve a variety of problems. The problems and the students' solutions increase in sophistication as the students advance through the four-year programme. The results of this project-based spine approach are that students gain experience at developing technically detailed problem-solutions, and develop other attributes, such as communication, teamwork, financial and sustainable design skills.

For the Chemical and Bioprocess Engineering major the following are examples of projects that the students undertake:

First Part	The first project has well-defined system boundaries, stakeholders and deliverables, where significant support is provided with information and decision- making. Students start developing their practical skills needed to design and solve engineering problems. The Chemical and Bioprocess Engineering students designed and built a continuous process to treat a waste stream containing hydrogen peroxide. Students examined how to immobilize an enzyme and how to control the pH and temperature. The second project requires the definition of system boundaries and deliverables, where available information is both ambiguous and incomplete. Teams are made up of students from across the different engineering and food technology majors. An existing NZ industry is selected by each team and students examine the life cycle of the product. Ideas are generated for how the industry can become more sustainable in the future. Feasibility of the ideas are examined taking into account social, cultural, environmental, and financial considerations. Industries selected include avocados, salmon, timber, mushrooms, wine and hemp.
Second Part	The third project is based on the context of a specific company/industry requiring the definition of system boundaries, the identification of constraints and decision making based on uncertainty (mainly related to market information) and trade-offs (mainly related to prioritization of product features). Teams select a company and examples from recent Chemical and Bioprocess Engineering groups include Remedy Drinks, Bean Supreme, SIG Group, Tahi Spirulina, and The Herb Farm. The fourth project involves design of a processing plant to manufacture a new milk-based product for targeted domestic or export markets for a large dairy company. Students design a full-scale manufacturing process, conduct mass and energy balances for the plant, select and cost equipment, estimate operating costs, evaluate alternatives, and define operational procedures including startup and CIP. Design is informed by literature and experimental research and key unit operations are validated through building and operating a 'pilot' scale process.
Third Part	The fifth project is focused on process design within constraints faced by the processing industry. The project is centred on a brewery as an example of a typical industrial bioprocess. Students characterize the process and then the utilities required for efficient and safe plant operation as well as technologies to treat the wastes produced by it. The students are introduced to the concept of constraints at the outset of the course by a review of classical and then engineering ethics which leads to the Engineering NZ (IPENZ) code of ethics. Particular focus is then placed on practical tools that will enable the students to meet their ethical obligations to health and safety and environmental protection. Key modules include learnings in HAZOP, PINCH analysis for energy recovery, noise analysis and mitigation, wastewater design including operation of bench top wastewater treatment reactors to collect design data. Learnings also extend out to include application of mass and heat balances including prediction and then practical measurement; and, in the wastewater treatment part, sizing for full scale design, practical aspects of operation and control, site and process flow drawings and specific consideration of how to design to give consideration to traditional Māori cultural values relating to water. Although clear briefs regarding expectations are provided, the level of direction and supervision is significantly reduced relative to previous projects. Definition of team goals and milestones, allocation of individual responsibilities (based on disciplines) with the team, and overall project management are central to successful project outcomes and assessment. A strong emphasis is also placed on technical problem solving, using knowledge from within the

	degree programme and acquiring new knowledge from literature and practical measurements/research they undertake.
Fourth Part	A sixth, capstone project is regarded as the culmination of the degree – the bringing together of all learning from throughout the programme, a demonstration of the students' ability to clearly define the scope, outcomes, and deliverables from a complex engineering problem, and to enable successful resolution of this problem through appropriate project planning and implementation. As such, the project places significant demands on the student to solve a problem of significant complexity, where complexity is largely defined by the breadth of scope and the need to seek and resolve inputs from a broad range of stakeholders and disciplines. A particular feature of the Capstone project is the requirement for the students to take full responsibility for project definition, planning and completion with limited supervision and guidance. Chemical and Bioprocess Engineering students are required to design a greenfields processing plant to manufacture a new or novel product through valorization of a waste steam (e.g. fisheries waste streams, food waste, biomass repurposing). The class work in design groups on the same industry problem but identify different product opportunities and therefore plant designs. Plant design, technical risk, operation, control, costings, economic feasibility, environmental impact, HAZOP and regulatory requirements are all key aspects that must be considered in the design. Students are required to conduct an individual detailed design of one key unit operation within the process. They complete the year by developing a business case.

2. **K**nowledge attributes – these courses are focused on embedding the underlying sciences (such as mathematics and physical principles). Along with the project spine, a final year individual 30 credit research project ensures that students apply their technical knowledge and have an opportunity to explore the forefront of chemical and bioprocess engineering. Examples of possible topics include production and optimisation of microbial fermentations, pyrolysis, industrial crystallisation, phosphate removal from wastewater, nano-structure of leather, catalysis, and adding value to solid waste streams.

Major specific courses develop:
Knowledge attributes - These courses provide a systematic coverage of the coherent body of knowledge related to that particular branch of engineering. They are focused on embedding the underlying sciences and engineering technical knowledge specific to the major. Core knowledge subjects include underlying chemical and biochemical fundamentals, process engineering principles and their application to a range of unit operations and processes, engineering mathematics applied to process engineering problems. In later stages of the degree courses focus on application of these underlying fundamentals to specific processes including environmental technology, reactor systems, separation processes and chemical and bioprocessing systems modelling and control. The regular focus on bioprocessing systems is deliberate and is in response to the strong bioprocessing focus of NZ industry. Similarly the concept of sustainable processing is present throughout the degree.

Prescribed electives courses develop specialist knowledge. Students can choose to build on core knowledge courses in areas relevant to their intended process industry (broadly chemical, biotech, food/bioprocessing and environmental/sustainability) or interest. Each course builds on knowledge developed in core courses included in the degree.

The prescribed electives are illustrated in Table 1.8. Table 1.9 show how courses contribute to building the specific body of knowledge for the Chemical and Bioprocessing Engineering major.

Table 1.8 Prescribed Electives for the Chemical and Bioprocess Engineering Major

First Part Electives
15 credits from: • 120.101 Plant Biology • 159.100 Programming for Engineering and Technology
Third Part Electives
15 credits from: • 125.230 Business Finance • 141.312 Food Technology 6: Food Characterisation • 141.358 Nutrition and Food Choice • 141.362 Food Formulation Technology • 152.203 Business and Society • 152.232 Small Business Management • 162.304 Applied and Environmental Microbiology • 240.364 Purchasing and Supply Management • 240.366 Global Logistics • 280.760 Industrial Refrigeration
Fourth Part Electives
15 credits from: • 141.709 Emerging Technologies for Food Industry • 141.710 Food Packaging Engineering & Legislation • 141.723 Industrial Systems Improvement • 141.724 Food Quality, Safety and Innovation • 235.701 Māori Values and Resource Management • 287.740 Innovation Management • 282.758 Simulation, Modelling and Optimisation • 228.760 Industrial Refrigeration

Table 1.9 Chemical and Bioprocess Engineering Major Body of Knowledge

Knowledge Profile	Courses that Contribute to Building the Body of Knowledge for the Major
WK1: A systematic, theory-based understanding of the **natural sciences** applicable to the discipline	123.104 Chemical for Biological Systems 123.105 Chemical and the Physical World 123.201 Chemical Energetics 123.271 Molecules to Materials 124.104 Physics 1A: Mechanics and Thermodynamics 280.201 Industrial Microbiology
WK2: Conceptually based **mathematics**, numerical analysis, statistics and formal aspects of computer and information science to support analysis and modelling applicable to the discipline	160.101 Calculus 160.102 Algebra 228.271 Eng Maths 2 228.371 Stats Modelling for Engineers & Technologists 280.372 Reaction Tech & Process Modelling 280.702 Process Control 280.771 Chemical & Bioprocess Engineering
WK3: A systematic, theory-based formulation of **engineering fundamentals** required in the engineering discipline	124.104 Physics 1A: Mechanics and Thermodynamics 280.271 Heat & Mass – Conservation & Transfer 280.272 Fluid Flow & Particle Technology 280.304 Bio-Separation Purification Processes 280.371 Process Engineering Operations 280.372 Reaction Tech & Process Modelling 280.702 Process Control 280.771 Chemical & Bioprocess Engineering

WK4: Engineering **specialist knowledge** that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.	228.312 Eng Practice 5: Process Engineering with Constraints 228.371 Stats Modelling for Engineers & Technologists 228.798 Individual Research Project 280.201 Industrial Microbiology 280.341 Environmental Technology 280.702 Process Control 280.721 Process Improvement Prescribed Elective
WK5: Knowledge that supports **engineering design** in a practice area	228.115 Engineering and Technology Principles 247.114 Science and Sustainability for Engineering and Technology 228.211 Eng Practice 3: Product Development 141.212 Food Tech 4: Manufacturing 228.312 Eng Practice 5: Process Engineering with Constraints 228.711 Eng Practice 6: Design Capstone Project 228.798 Individual Research Project 280.271 Heat & Mass – Conservation & Transfer 280.272 Fluid Flow & Particle Technology 280.304 Bio-Separation Purification Processes 280.341 Environmental Technology 280.371 Process Engineering Operations 280.372 Reaction Tech & Process Modelling 280.702 Process Control 280.771 Chemical & Bioprocess Engineering
WK6: Knowledge of **engineering practice** (technology) in the practice areas in the engineering discipline	141.212 Food Tech 4: Manufacturing 228.312 Eng Practice 5: Process Engineering with Constraints 228.711 Eng Practice 6: Design Capstone Project 280.304 Bio-Separation Purification Processes 280.371 Process Engineering Operations 280.372 Reaction Tech & Process Modelling 280.721 Process Improvement 280.771 Chemical & Bioprocess Engineering
WK7: Comprehension of the role of engineering in society and identified issues in engineering practice in the discipline: ethics and the professional responsibility of an engineer to public safety; the impacts of engineering activity: economic, social, cultural, environmental and sustainability	228.115 Engineering and Technology Principles 247.114 Science and Sustainability for Engineering and Technology 228.211 Eng Practice 3: Product Development 141.212 Food Tech 4: Manufacturing 228.312 Eng Practice 5: Process Engineering with Constraints 228.711 Eng Practice 6: Design Capstone Project 280.341 Environmental Technology 280.721 Process Improvement
WK8: Engagement with selected knowledge in the **research literature** of the discipline	228.115 Engineering and Technology Principles 247.114 Science and Sustainability for Engineering and Technology 228.211 Eng Practice 3: Product Development 141.212 Food Tech 4: Manufacturing 228.312 Eng Practice 5: Process Engineering with Constraints 228.711 Eng Practice 6: Design Capstone Project 228.798 Individual Research Project 280.721 Process Improvement

The Engineering Body of Knowledge (WA1 Learning Outcome Summary) table and the Accord Attribute tables (WA2 to WA12) for the CBE Major are provided in Appendix 1.1. A concise overview of the alignment of the compulsory courses to the Washington Accord attributes is shown in Table 1.10.

Table 1.10 Washington Accord Attributes alignment map for BE(Hons) – CBE courses

Core to Programme / Major specific

		Course number	Course name	WA1: Engineering Knowledge	WA2: Problem Analysis	WA3: Design/Development of Solutions	WA4: Investigation	WA5: Modern Tool Usage	WA6: The Engineer and Society	WA7: Environment and Sustainability	WA8: Ethics	WA9: Individual and Teamwork	WA10: Communication	WA11: Project Management and Finance	WA12: Lifelong Learning
Year 1	S1	123.104	Chemistry for Biological Systems	x		x	x								
		124.104	Physics 1A: Mechanics and Thermodynamics	x	x	x		x					x		
		160.102	Algebra	x	x			x					x		
		228.115	Engineering and Technology Principles		x	x	x	x	x	x	x		x		
	S2	123.105	Chemistry and the Physical World	x			x						x		
		160.101	Calculus	x	x			x					x		
		247.114	Science and Sustainability for Engineering and Technology		x	x	x		x	x		x	x	x	x
			Year 1 Elective												
Year 2	S1	123.271	Molecules to Materials	x			x						x		
		280.271	Heat and Mass- Conservation and Transfer	x	x	x	x	x					x		
		228.271	Engineering Mathematics 2	x	x			x							
		228.211	Engineering Practice 3: Product Development		x	x	x		x	x	x	x	x	x	x
	S2	123.201	Chemical Energetics	x			x						x		
		280.272	Fluid Flow and Particle Technology	x	x	x	x								
		280.201	Industrial Microbiology	x		x	x								
		141.212	Food Technology 4: Manufacturing	x	x	x	x	x	x					x	x
Year 3	S1	228.371	Statistical Modelling for Engineers and Technologists	x	x		x	x							
		280.341	Environmental Technology	x		x									
		280.371	Process Engineering Operations	x	x	x	x						x		
		228.312	Engineering Practice 5: Process Engineering with Constraints	x	x	x	x	x	x	x			x		
	S2	280.304	Bioseparation and Purification Processes	x		x	x	x				x	x		
		280.372	Reaction Technologies and Process Modelling	x	x		x	x							
		228.312	Engineering Practice 5: Process Engineering with Constraints	x	x	x	x	x	x	x			x		
			Year 3 Elective												
Year 4	S1	280.702	Process Control	x	x	x	x	x							
		280.771	Chemical and Bioprocess Engineering	x	x	x	x	x		x			x		
		228.711	Engineering Practice 6: Design Capstone Project	x	x		x	x	x	x	x	x	x	x	x
		228.798	Individual Research Project		x		x	x			x		x		x

	S2	280.721	Process Improvement	x	x	x	x	x	x	x	x			x	
		228.711	Engineering Practice 6: Design Capstone Project	x	x	x	x	x	x	x	x	x	x	x	x
		228.798	Individual Research Project		x		x	x			x		x		x
			Year 4 Elective												