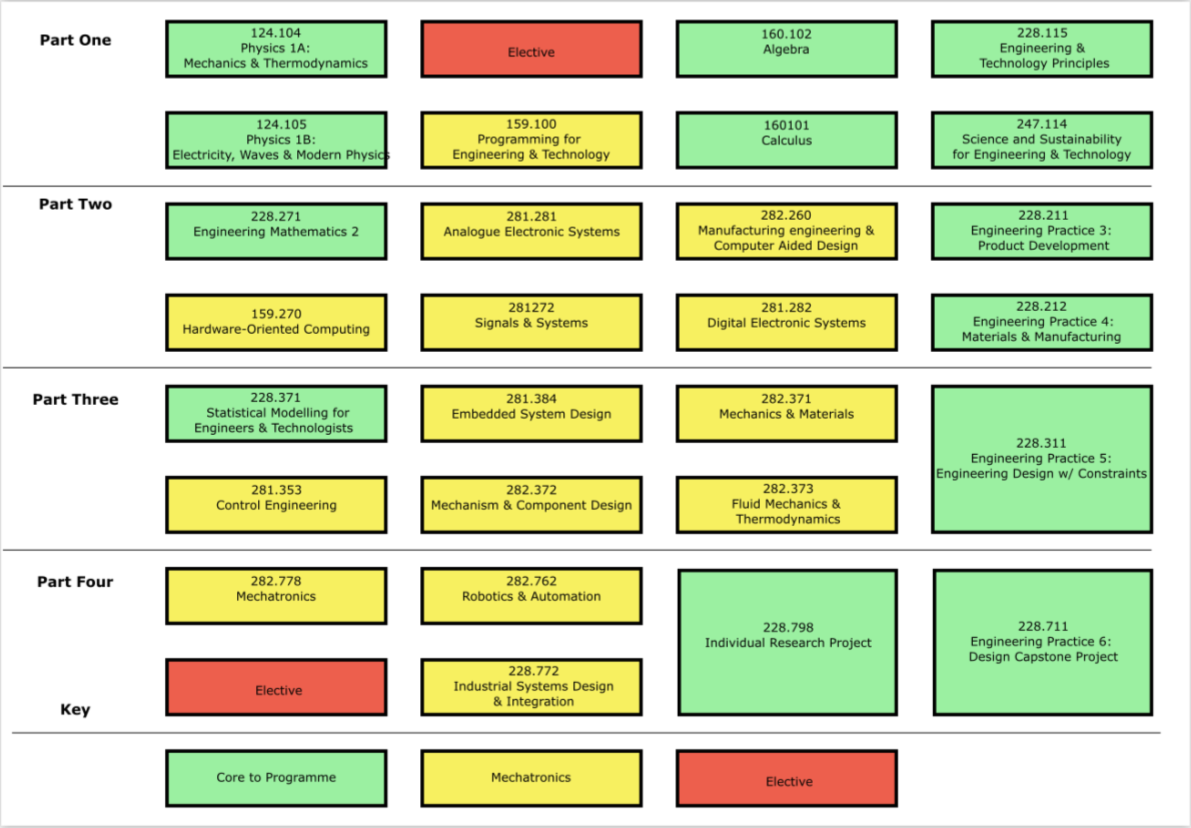
Mechatronics course overview

1.3.3 Mechatronics

Students graduating with a BE (Hons), majoring in Mechatronics, distinguish themselves from other BE (Hons) majors by being able to:

- Apply a systematic design process to develop practical solutions to real-world problems; concurrently, and coherently, integrating mechanical-, electrical-, and software-based knowledge to address a stakeholder's need, regardless of their industry.
- Use software used in industry, e.g., Solidworks, Altium, Visual Studio, OpenCV, PyTorch, and TwinCAT, to design mechanical and electrical systems or program embedded systems and desktop PCs.
- Operate machines used in industry, e.g., CNC mills and lathes, laser and water-jet cutters, 3D printers, and PCB routers, to physically make designed systems.
- Use products used in industry, e.g., PLCs, to control a system or automate a process.
- Integrate mechanical-, electrical-, and software-based systems effectively as part of realising a solution to a complex engineering problem.

The BE (Hons) programme is a four-year programme. It is divided up into four parts. Each part is further divided up into two semesters. Each semester is further divided into four courses. Students will complete a total of 29 courses, some of which are double semester courses, i.e., 228.311 Engineering Practice 5: Engineering Design with Constraints, 228.711 Engineering Practice 6: Design Capstone Project, and 228.798 Individual Research Project. Figure 1.10 illustrate how the BE (Hons) Mechatronics major's courses are distributed over the programme's duration.



Part One	🟩 124.104 Physics 1A: Mechanics & Thermodynamics	🟥 Elective	🟩 160.102 Algebra	🟩 228.115 Engineering & Technology Principles
	🟩 124.105 Physics 1B: Electricity, Waves & Modern Physics	🟨 159.100 Programming for Engineering & Technology	🟩 160101 Calculus	🟩 247.114 Science and Sustainability for Engineering & Technology
Part Two	🟩 228.271 Engineering Mathematics 2	🟨 281.281 Analogue Electronic Systems	🟨 282.260 Manufacturing engineering & Computer Aided Design	🟩 228.211 Engineering Practice 3: Product Development
	🟨 159.270 Hardware-Oriented Computing	🟨 281272 Signals & Systems	🟨 281.282 Digital Electronic Systems	🟩 228.212 Engineering Practice 4: Materials & Manufacturing
Part Three	🟩 228.371 Statistical Modelling for Engineers & Technologists	🟨 281.384 Embedded System Design	🟨 282.371 Mechanics & Materials	🟩 228.311 Engineering Practice 5: Engineering Design w/ Constraints
	🟨 281.353 Control Engineering	🟨 282.372 Mechanism & Component Design	🟨 282.373 Fluid Mechanics & Thermodynamics	
Part Four	🟨 282.778 Mechatronics	🟨 282.762 Robotics & Automation	🟩 228.798 Individual Research Project	🟩 228.711 Engineering Practice 6: Design Capstone Project
	🟥 Elective	🟨 228.772 Industrial Systems Design & Integration		
Key	🟩 Core to Programme	🟨 Mechatronics	🟥 Elective	

Figure 1.10 Programme Map for the BE (Hons) Mechatronics Major

The Core to Programme courses develop:

1. **D**esign & **P**rofessional Practice attributes. Students have to complete one project per course, which 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 BE (Hons)'s Mechatronics major the following are examples of projects that the students undertake:

Part One	228.115 Engineering and Technology Principles' project involves developing a battery-powered car that is tasked with driving 10 m in the shortest time period possible, while carrying the largest amount of weight as possible. This multifaceted project introduces students to Computer Aided Design (CAD), e.g., SolidWorks; Electronic Design Automation (EDA), e.g., Altium; Additive Manufacturing, e.g., 3D printing, the engineering and electronics workshop; engineering design thinking; and project-based learning. Students are given a Tamiya car kit and a small budget, e.g., $50.00, to purchase additional components. Student's work in groups of three-four members. Students are assessed via project demonstration. 247.114 Science and Sustainability for Engineering and Technology's project involves identifying an engineering process, e.g., export of word bark; perform Life Cycle Analysis (LCA); and propose ways to reduce the environmental impact of the process. Students work in groups of three-four members. Students are assessed via a report that examines the feasibility of the group's ideas, considering social, cultural, environmental, and financial considerations.
Part Two	228.211 Engineering Practice 3: Product Development's project is based on the context of a specific company/industry; where, 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). The types of companies the students study are Spidertracks, Tait Communications, and Fisher & Paykel Healthcare. 228.212 Engineering Practice 4: Materials & Manufacturing's project involves planning the launch (i.e., designing and testing the machine and meeting the initial marketing plan) of a new coil winding machine, which is complementary to a hypothetical company's existing range. The company is of medium size and is well established as a supplier of a range of coil winders, mainly to Europe. It has Marketing, Sales, Design and Production departments and the typical infrastructure departments (Finance HR etc.).
Part Three	228.311 Engineering Practice 5: Engineering Design with Constraints' project is based on the design of an autonomous vacuum cleaner. The context for the project is well defined, centred on a hypothetical NZ based company that has experience in the design, manufacturing and marketing of robotic systems and is seeking to expand into the European market. Although there is significant freedom in the development of the design concept, significant constraints are imposed in terms of the target market, system functionality, and development budget. Sustainability is imposed as an essential requirement for the final product concept, particularly emphasising legislative constraints, and Life Cycle Analysis (LCA). Although a clear design brief is 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:

	1. Technical problem solving, using knowledge from within the programme including mechanical design, electronic circuit design, embedded system design, computer programming, mathematics, communication, and control systems; and, 2. Acquiring knowledge required to resolve specific project issues.
Part Four	228.711 Engineering Practice 6: Design Capstone Project's project is regarded as the culmination of the degree – the bringing together of all learning from throughout the programme and 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. The problems are ones encountered by the industry or research organizations. An example is the development of a mobile terrestrial robot for remote inspection of electrical substations for Transpower, New Zealand.

The Mechatronics courses develop:

1. **K**nowledge attributes. These courses provide a systematic coverage of the coherent body of knowledge related to that particular branch of engineering. They are focused on the technical knowledge in the use of advanced electronics, computer hardware and software design, system design and integration, and hardware control for automation embedding the underlying sciences and engineering technical knowledge specific to the BE (Hons)'s Mechatronics major.

The Elective courses develop:

2. **K**nowledge attributes. These courses compliment the Mechatronics courses' body of knowledge. Students can choose to develop their own expertise in one or more areas of electronics, software or mechanics that are of interest to them.

Table 1.13 Electives for the BE (Hons) Mechatronics Major

Part One Elective
Any 100-level 15 credit course.
Part Four Elective
Any 700-level 15 credit course selected from the following prefixes: • 158 Information Technology; • 159 Computer Science; • 281 Electronics and Information Engineering; • 282 Mechatronics and Automation Engineering; or. • 287 Industrial Innovation.

Table 1.14 shows how the BE (Hons) Mechatronics Major's courses contribute to building the specific body of knowledge for the major:

Table 1.14 Mechatronics Major Body of Knowledge

Knowledge Profile	Courses that Contribute to Building the Body of Knowledge
WK1: A systematic, theory-based understanding of the natural sciences applicable to the discipline.	124.104 Physics 1A: Mechanics and Thermodynamics. 124.105 Physics 1B: Electricity, Waves and Modern Physics. 247.114 Science and Sustainability for Engineering and Technology. 282.371 Mechanics and Materials. 282.373 Fluid Mechanics & Thermodynamics.
WK2: Conceptually based mathematics, numerical analysis, statistics and formal aspects of computer and information science to support analysis and modelling applicable to the discipline.	159.100 Programming for Engineering and Technology. 160.101 Calculus. 160.102 Algebra. 1592.70 Hardware-Oriented Computing. 228.271 Engineering Mathematics 2. 281.272 Signals and Systems. 282.260 Manufacturing Engineering and Computer Aided Design. 281.353 Control Engineering. 282.371 Mechanics and Materials. 282.778 Mechatronics.
WK3: A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.	124.104 Physics 1A: Mechanics and Thermodynamics. 124.105 Physics 1B: Electricity, Waves and Modern Physics. 228.115 Engineering and Technology Principles. 228.271 Engineering Mathematics 2. 281.272 Signals and Systems. 282.260 Manufacturing Engineering and Computer Aided Design. 281.353 Control Engineering. 282.371 Mechanics and Materials.
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.	228.115 Engineering and Technology Principles. 228.212 Engineering Practice 4: Materials & Manufacturing. 228.311 Engineering Practice 5: Engineering Design with Constraints. 228.711 Engineering Practice 6: Design Capstone Project. 159.100 Programming for Engineering and Technology. 159.270 Hardware-Oriented Computing. 281.272 Signals and Systems. 281.281 Analogue Electronic Systems. 281.282 Digital Electronic Systems. 282.260 Manufacturing Engineering and Computer Aided Design. 281.353 Control Engineering. 281.384 Embedded Systems Design. 282.371 Mechanics and Materials. 282.372 Mechanism and Component Design. 282.762 Robotics and Automation. 282.772 Industrial Systems Design and Integration.

	282.778 Mechatronics.
WK5: Knowledge that supports engineering design in a practice area.	228.115 Engineering and Technology Principles. 228.212 Engineering Practice 4: Materials & Manufacturing. 228.311 Engineering Practice 5: Engineering Design with Constraints. 228.711 Engineering Practice 6: Design Capstone Project. 159.100 Programming for Engineering and Technology. 159.270 Hardware-Oriented Computing. 281.272 Signals and Systems. 281.281 Analogue Electronic Systems. 281.282 Digital Electronic Systems. 282.260 Manufacturing Engineering and Computer Aided Design. 281.353 Control Engineering. 281.384 Embedded Systems Design. 282.371 Mechanics and Materials. 282.372 Mechanism and Component Design. 282.762 Robotics and Automation. 282.772 Industrial Systems Design and Integration. 282.778 Mechatronics.
WK6: Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.	228.115 Engineering and Technology Principles. 228.212 Engineering Practice 4: Materials & Manufacturing. 228.311 Engineering Practice 5: Engineering Design with Constraints. 228.711 Engineering Practice 6: Design Capstone Project. 282.260 Manufacturing Engineering and Computer Aided Design. 282.372 Mechanism and Component Design. 282.762 Robotics and Automation. 282.772 Industrial Systems Design and Integration. 282.778 Mechatronics.
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.	247.114 Science and Sustainability for Engineering and Technology. 228.115 Engineering and Technology Principles. 228.211 Engineering Practice 3: Product Development. 228.212 Engineering Practice 4: Materials & Manufacturing. 228.311 Engineering Practice 5: Engineering Design with Constraints. 228.711 Engineering Practice 6: Design Capstone Project.
WK8: Engagement with selected knowledge in the research literature of the discipline.	247.114 Science and Sustainability for Engineering and Technology. 228.115 Engineering and Technology Principles. 228.211 Engineering Practice 3: Product Development. 228.212 Engineering Practice 4: Materials & Manufacturing.

	228.311 Engineering Practice 5: Engineering Design with Constraints. 228.711 Engineering Practice 6: Design Capstone Project. 228.798 Individual Research Project.

The Engineering Body of Knowledge (WA1 Learning Outcome Summary) table and the Accord Attribute tables (WA2 to WA12) for the Mechatronics Major are provided in Appendix 1.3. A concise overview of the alignment of the compulsory courses to the Washington Accord attributes is shown in Table 1.15.

Table 1.15 Washington Accord Attributes alignment map for BE(Hons) – Mechatronics courses

🟦 Common courses
🟩 Mechatronics courses
🟨 Project-spine courses

				WA Attributes											
				Engineering Knowledge	Problem Analysis	Design/Development of Solution	Investigation	Modern Tool Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork	Communication	Project Management	Lifelong Learning
		Course Number	**Course Title**	1	2	3	4	5	6	7	8	9	10	11	12
Year 1	**S1**	124.104	Physics 1A: Mechanics and Thermodynamics	☒	☒		☒	☒							☒
		160.102	Algebra	☒	☒			☒							
		228.115	Engineering and Technology Principles	☒	☒	☒	☒	☒	☒	☒	☒		☒	☒	
		Elective													
	S2	159.100	Programming for Engineering and Technology	☒				☒					☒		
		124.105	Physics 1B: Electricity, Waves and Modern Physics	☒	☒		☒	☒							☒
		160.101	Calculus	☒	☒			☒							
		247.114	Science and Sustainability for Engineering and Technology	☒		☒	☒		☒	☒	☒	☒	☒	☒	☒
Year 2	**S1**	281.281	Analogue Electronic Systems	☒	☒			☒							
		228.271	Engineering Mathematics 2	☒	☒			☒							
		282.260	Manufacturing Engineering and Computer Aided Design	☒		☒	☒	☒							
		228.211	Engineering Practice 3: Product Development	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒
	S2	281.282	Digital Electronic Systems	☒	☒			☒							
		281.272	Signals & Systems	☒	☒										
		159.270	Hardware-Oriented Computing	☒	☒			☒					☒		
		228.212	Engineering Practice 4: Materials & Manufacturing	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒
Year 3	**S1**	281.384	Embedded Systems Design	☒				☒					☒		
		282.371	Mechanics and Materials	☒	☒		☒	☒							
		228.371	Statistical Modelling for Engineers & Technologists	☒	☒		☒	☒							
		228.311	Engineering Practice 5: Engineering Design with Constraints	☒	☒	☒	☒	☒	☒	☒	☒		☒	☒	☒
	S2	281.353	Control Engineering	☒	☒		☒	☒							
		282.372	Mechanism and Component Design	☒	☒		☒	☒							
		282.373	Fluid Mechanics & Thermodynamics	☒	☒			☒							
		228.311	Engineering Practice 5: Engineering Design with Constraints	☒	☒	☒	☒	☒	☒	☒	☒		☒	☒	☒
Year 4	**S1**	282.778	Mechatronics	☒	☒	☒	☒	☒						☒	
		282.762	Robotics and Automation	☒	☒	☒	☒	☒							
		228.798	Individual Research Project	☒	☒		☒	☒			☒		☒	☒	
		228.711	Engineering Practice 6: Design Capstone Project	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒
	S2	282.772	Industrial Systems Design and Integration	☒	☒	☒	☒	☒						☒	
		228.798	Individual Research Project	☒	☒		☒	☒			☒		☒	☒	
		228.711	Engineering Practice 6: Design Capstone Project	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒
		Elective													