NCCA
An Chomhairle Náisiúnta Curaclaim agus Measúnachta
National Council for Curriculum and Assessment

Draft Leaving Certificate Engineering Specification

For consultation

February 2025

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Senior cycle

Senior cycle aims to educate the whole person and contribute to human flourishing. Students' experiences throughout senior cycle enrich their intellectual, social and personal development and their overall health and wellbeing. Senior cycle has 8 guiding principles.

Senior Cycle Guiding Principles	
Wellbeing and relationships	Choice and flexibility
Inclusive education and diversity	Continuity and transitions
Challenge, engagement and creativity	Participation and citizenship
Learning to learn, learning for life	Learning environments and partnerships

These principles are a touchstone for schools and other educational settings, as they design their senior cycle. Senior cycle consists of an optional Transition Year, followed by a two-year course of subjects and modules. Building on junior cycle, learning happens in schools, communities, educational settings, and other sites, where students' increasing independence is recognised. Relationships with teachers are established on a more mature footing and students take more responsibility for their learning.

Senior cycle provides a curriculum which challenges students to aim for the highest level of educational achievement, commensurate with their individual aptitudes and abilities. During senior cycle, students have opportunities to grapple with social, environmental, economic, and technological challenges and to deepen their understanding of human rights, social justice, equity, diversity and sustainability. Students are supported to make informed choices as they choose different pathways through senior cycle and every student has opportunities to experience the joy and satisfaction of reaching significant milestones in their education. Senior cycle should establish firm foundations for students to transition to further, adult and higher education, apprenticeships, traineeships and employment, and participate meaningfully in society, the economy and adult life.

The educational experience in senior cycle should be inclusive of every student, respond to their learning strengths and needs, and celebrate, value, and respect diversity. Students vary in their family and cultural backgrounds, languages, age, ethnic status, beliefs, gender, and sexual identity as well as their strengths, needs, interests, aptitudes and prior knowledge, skills, values and dispositions. Every student's identity should be celebrated, respected, and responded to throughout their time in senior cycle.

At a practical level, senior cycle is supported by enhanced professional development; the involvement of teachers, students, parents, school leaders and other stakeholders; resources;

research; clear communication; policy coherence; and a shared vision of what senior cycle seeks to achieve for our young people as they prepare to embark on their adult lives. It is brought to life in schools and other educational settings through:

- effective curriculum planning, development, organisation, reflection and evaluation
- teaching and learning approaches that motivate students and enable them to improve
- a school culture that respects students and promotes a love of learning.

Rationale

Engineering is a dynamic field focused on designing, realising, manufacturing, and testing solutions to practical problems. It plays a pivotal role in addressing contemporary challenges, fostering innovation, and promoting sustainable living within a circular economy. Engineering requires a blend of theoretical knowledge, practical skills, and a creative mindset. It promotes fosters active learning and effective problem-solving techniques by applying scientific principles to real-world scenarios.

As part of the technology education suite of subjects, Leaving Certificate Engineering enables interdisciplinary learning, enriching students' overall experience. Engineering equips students with practical and technical skills for today's dynamic world, fostering teamwork, communication, and innovation. It helps them understand and address local, national, and global challenges, driving societal and economic progress.

Leaving Certificate Engineering emphasises the importance of ethical responsibility and the value of repair over replacement, which are essential values, helping students to understand the social and environmental consequences of business practices, cultivating a positive attitude toward enterprise and innovation. Leaving Certificate Engineering reflects the importance of engineering in society, inspiring STEM careers and enhancing technological literacy.

Aims

Leaving Certificate Engineering aims to develop a deep appreciation and understanding of the importance of sustainable and ethical engineering solutions for society. More specifically, Leaving Certificate Engineering aims to:

- foster an awareness of the environmental, social, and economic impacts of engineering decisions and promote sustainable practices and ethical responsibility.
- enable students to learn about the core concepts, processes and principles of engineering.
- develop the students' capability, accuracy and precision using resources and equipment available in the Engineering classroom in a safe and appropriate manner.
- foster an engineering mindset, by enhancing creativity, problem-solving skills and design thinking through practical applications to engineering problems.
- develop students' capacity to effectively articulate ideas, designs, and solutions through various media, enhancing collaboration and engagement.
- encourage the application of theoretical knowledge in a systematic way.
- provide a broad educational experience that prepares students for future studies and the workforce as well as developing awareness of future careers and opportunities.

Continuity and progression

Leaving Certificate Engineering builds on the knowledge, skills, values, and dispositions developed from learners' early education through to the Junior Cycle Engineering curriculum.

Leaving Certificate Engineering combines principles of mathematics, physics and material sciences to understand forces, energy, and materials. It also uses graphics to visually communicate design ideas and engineering solutions.

Junior cycle

The Junior Cycle Engineering subject aims to stimulate students' interest in engineering as a discipline. It offers students a lens through which to view the role and impact of engineering within their classroom, community and the world. Students have the opportunity to behave as engineers and develop an engineering mindset. This mindset is developed by engaging with engineering as a process which is both reflective and systematic.

The core learning of Junior Cycle Engineering focuses on cultivating practical skills, effective communication and problem-solving skills, and design thinking. Students are introduced to essential engineering principles, materials, processes, and technologies, which are foundational for understanding how engineering impacts society. The study of mechatronics creates a foundation for further study at Senior Cycle. Students develop proficiency in a range of processing skills and apply them in multiple contexts.

Beyond senior cycle

Leaving Certificate Engineering provides students with a strong foundation to transition to further, adult and higher education, apprenticeships, and employment. The subject also contributes to the development of technological literacy which is essential in navigating an increasingly digital and technological world.

Leaving Certificate Engineering not only develops skills in mechanical design and product development, but also equips students with practical life skills such as time management and project management, which are valuable in many careers and helpful throughout life, even outside traditional engineering roles. Students learn to address the challenges of the modern world related to energy, technology, sustainability, or manufacturing in a knowledgeable manner. This subject helps students make informed decisions about the impact of engineering and technology on society, and on their personal and professional lives.

Student learning in senior cycle

Student learning in senior cycle consists of everything students learn within all of the subjects and modules they engage with and everything students learn which spans and overlaps across all of their senior cycle experiences. The overarching goal is for each student to emerge from senior cycle more enriched, more engaged and more competent as a human being than they were when they commenced senior cycle.

For clarity, the learning which spans across all of their senior cycle experiences is outlined under the heading ‘key competencies’. The learning which occurs within a specific subject or module is outlined under the heading ‘strands and learning outcomes’. However, it is vital to recognise that key competencies and subject or module learning are developed in an integrated way. By design, key competencies are integrated across the rationale, aims, learning outcomes and assessment sections of specifications. In practice, key competencies are developed by students in schools via the pedagogies teachers use and the environment they develop in their classrooms and within their school. Subjects can help students to develop their key competencies; and key competencies can enhance and enable deeper subject learning. When this integration occurs, students stand to benefit

- during and throughout their senior cycle
- as they transition to diverse futures in further, adult and higher education, apprenticeships, traineeships and employment, and
- in their adult lives as they establish and sustain relationships with a wide range of people in their lives and participate meaningfully in society.

When teachers and students make links between the teaching methods students are experiencing, the competencies they are developing and the ways in which these competencies can deepen their subject specific learning, students become more aware of the myriad ways in which their experiences across senior cycle are contributing towards their holistic development as human beings.

Key competencies

Key competencies is an umbrella term which refers to the knowledge, skills, values and dispositions students develop in an integrated way during senior cycle.

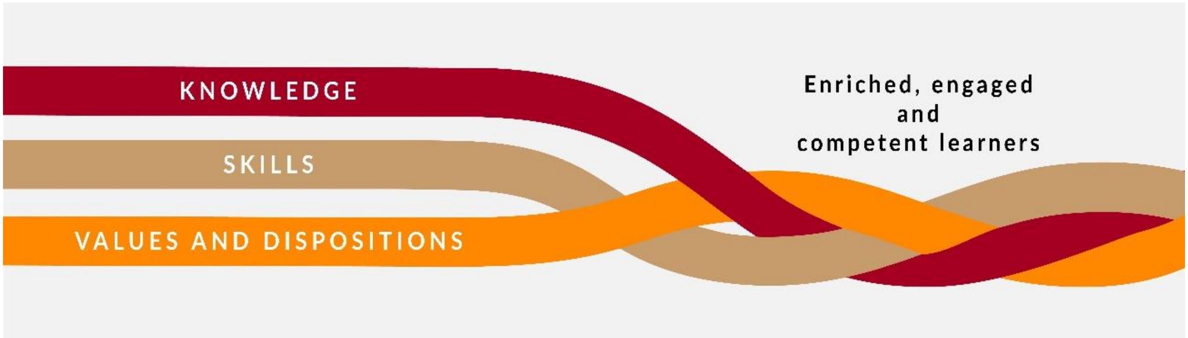

Figure 1 The components of key competencies and their desired impact

The knowledge which is specific to this subject is outlined below under 'strands of study and learning outcomes'. The epistemic knowledge which spans across subjects and modules is incorporated into the key competencies.

Figure 2 Key Competencies in Senior Cycle, supported by literacies and numeracy.

These competencies are linked and can be combined; can improve students' overall learning; can help students and teachers to make meaningful connections between and across different areas of learning; and are important across the curriculum.

The development of students' literacies and numeracy contributes to the development of competencies and vice-versa. Key competencies are supported when students' literacies and numeracy are well developed and they can make good use of various tools, including technologies, to support their learning.

The key competencies come to life through the learning experiences and pedagogies teachers choose and through students' responses to them. Students can and should be helped to develop their key competencies irrespective of their past or present background, circumstances or experiences and should have many opportunities to make their key competencies visible. Further detail in relation to key competencies is available at https://ncca.ie/en/senior-cycle/senior-cycle-redevelopment/student-key-competencies/

The key competencies can be developed in Leaving Certificate Engineering through a variety of hands-on, real-world experiences.

Thinking and Solving Problems
By recognising and investigating how real-world constraints affect possible solutions and actions, students are encouraged to engage in innovative thinking and practical problem-solving. Students develop critical thinking and technical problem-solving skills as they design, prototype, and refine engineering projects. Through the study of materials, processes, and technologies, students are encouraged to think creatively about how to apply engineering principles to real-world challenges.

Being Creative
Creativity is promoted as students explore innovative design solutions, experiment with materials, and develop prototypes. They are encouraged to take informed risks, test their ideas, and learn from setbacks, all of which are key aspects of the engineering mindset. The strong emphasis on design encourages students to be curious, open-minded, adventurous, and imaginative.

Communicating
Students learn to communicate their ideas clearly through effective means and appropriate media, whether through technical drawings, project documentation, prototypes, or presentations of their final designs. By engaging in discussions and collaborative projects, they learn to articulate their design decisions, listen to feedback, and consider different perspectives. This process enhances their ability to collaborate with others, work in teams, and navigate differing viewpoints, which are essential skills in both the engineering field and the broader world of work.

Working with Others
Collaboration is central to the engineering process, and students have many opportunities to work cooperatively with their peers and teacher. Working with others helps students develop their ability to share responsibility and manage different roles within a team. Through this process, they also develop an understanding of group dynamics, learning to give and take and navigate differences of opinion and approach.

Participating in Society
Engineering education also emphasises the importance of working ethically and sustainably. Students explore the environmental impact of materials and processes, fostering an

understanding of responsible engineering practices. As they become more aware of the societal implications of engineering innovations, they are empowered to make informed decisions that consider both technical and ethical factors.

Cultivating Wellbeing

Engineering education supports student wellbeing by encouraging resilience and self-confidence. As students take on increasingly complex tasks, they learn to cope with setbacks, overcome challenges, and develop perseverance. The emphasis on problem-solving and skills development fosters a sense of agency and achievement, contributing to their overall sense of purpose and belonging.

Managing Learning and Self

The development of project plans, with clearly defined goals, timelines, and resource management, is integral to the study of Engineering. This fosters self-management and self-regulation skills, as students monitor their progress and make adjustments when necessary to achieve successful outcomes. Through self-directed projects, students also develop personal responsibility and the ability to manage their learning, preparing them for lifelong learning and adapting to new challenges.

Strands of study and learning outcomes

This Leaving Certificate Engineering specification is designed for a minimum of 180 hours of class contact time. The specification is structured around four thematic strands:

- Engineering Processes
- Automation and Control Systems
- Design Capability
- Engineering Principles and Energy

Four cross-cutting themes are identified:

- Engineering capability and Technical Literacy
- Ethics and Sustainability
- Engineering Design
- Manufacturing Techniques and Applications.

These themes are woven throughout student learning where appropriate to act as lenses to explore the world of engineering. The cross-cutting themes are outlined briefly below.

Engineering Capability and Technical Literacy

Engineering capability and technical literacy equips students with the ability to understand, evaluate, and use modern technologies. It emphasises the critical assessment of technological advancements, and adaptability to a rapidly evolving technological landscape.

Ethics and Sustainability

Engineering ethics promotes sustainability and encourages students to reflect on the short and long term environmental, social, and economic impacts of engineering decisions. This theme promotes sustainable practices and ethical responsibility, fostering an awareness of the challenges and opportunities in creating a more equitable and sustainable future.

Engineering Design

This theme supports students in identifying challenges, exploring innovative solutions, and systematically applying engineering techniques to address real-world problems. Students enhance their ability to collaborate, present, and critically engage with others through verbal, written, graphical, engineering drafting standards, practical, digital or other suitable media.

Manufacturing Techniques and Applications

Students learn to integrate creativity and technical precision, develop an awareness and proficiency in a range of manufacturing processes and techniques in the engineering classroom. Students develop knowledge, skills and an appreciation of manufacturing techniques and applications all while fostering a deep understanding of how engineering shapes everyday life, industry, and society.

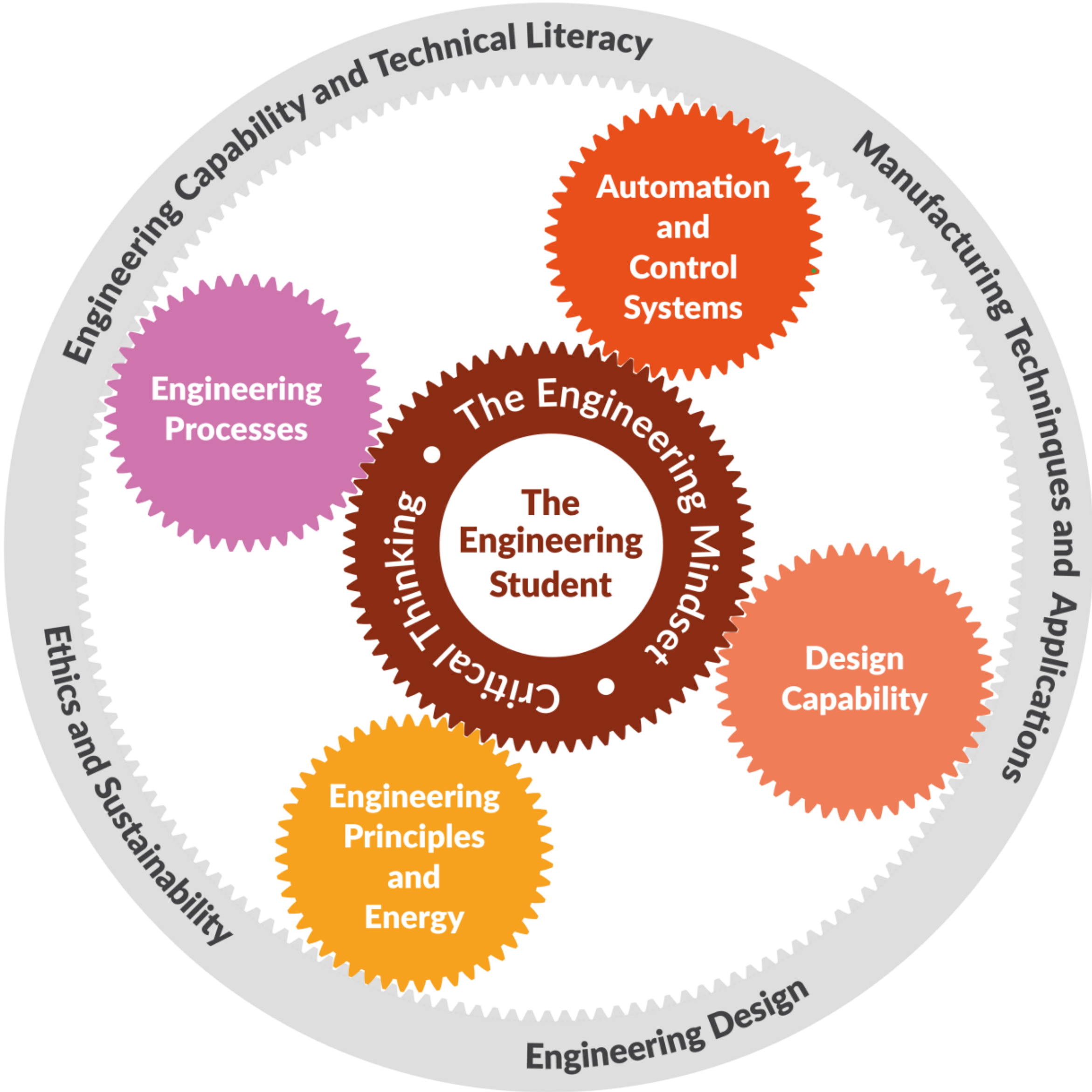

Figure 3 Subject overview

Learning outcomes should be achievable relative to each student's individual aptitudes and abilities. Learning outcomes promote teaching and learning processes that develop students' knowledge, skills, values and dispositions incrementally, enabling them to apply their key competencies to different situations as they progress. Students studying at both Ordinary level and Higher level will critically engage with Engineering, but the context, information and results arising from that engagement will be different.

Table 1: Design of learning outcomes for ordinary and higher level.

Ordinary Level	Higher Level

Students engage with a wide range of practical and theoretical engineering knowledge and skills, primarily concrete in nature with some elements of abstraction or theoretical thinking.	Students engage with an extensive range of practical and theoretical engineering knowledge and skills, including advanced theoretical concepts and abstract thinking, with significant depth in areas in an integrated manner.
Students demonstrate and apply a broad range of cognitive and technical skills to plan, implement, and evaluate solutions to problems in familiar and some unfamiliar contexts.	Students demonstrate a broad range of specialised cognitive and technical skills to evaluate information, design and test systems, and develop solutions to engineering problems. They demonstrate advanced skills in planning, prototyping, testing, and evaluating solutions, often addressing unfamiliar and complex contexts.
Students will demonstrate some proficiency in communication methods when interpreting information and presenting their work.	Students will demonstrate a high level of proficiency in communication methods when interpreting information and presenting their work. They will effectively select and use a range of media to communicate their work.
Students develop key practical skills, fostering confidence in the safe use of engineering equipment and materials. They show an understanding of the theory underpinning these processes.	Students develop key practical skills, fostering confidence in the safe use of engineering equipment and materials. They show a detailed understanding of the theory underpinning these processes.
Students develop an appreciation for the application of theoretical concepts and will apply them in familiar contexts. Students use data effectively to make design and problem-solving choices.	Students develop an appreciation for the application of theoretical concepts and will apply them in familiar and unfamiliar contexts. Students use theoretical methods effectively to make choices and justify their choices as part of problem solving and design processes.
Students demonstrate engineering capability and technical literacy in the context of concrete applications of engineering concepts and societal issues.	Students demonstrate a high level of engineering capability and technical literacy and apply their learning to diverse and complex contexts, both familiar and unfamiliar, reflecting on the broader societal, environmental, and technological impacts of their decisions.

An overview of each strand is provided below, followed by a table. The right-hand column contains learning outcomes which describe the knowledge, skills, values and dispositions students should be able to demonstrate after a period of learning. The left-hand column outlines specific areas that students learn about. Taken together, these provide clarity and coherence with the other sections of the specification. Appendix 1 sets out a glossary of action verbs used in the Learning Outcomes.

Strand 1: Engineering Processes

This strand explores the fundamental concepts and practices that underpin modern engineering, with a particular focus on manufacturing technologies. Through a blend of theoretical and practical application, students gain a comprehensive understanding of the processes involved in creating products, from initial design and material selection to production techniques and quality control. They explore a range of manufacturing technologies and their applications, including traditional methods as well as modern and digital technologies used in process automation.

The strong practical focus promotes the development of technical knowledge, manual skills, enabling students to approach manufacturing problems with confidence, creativity, and a forward-thinking mindset. They learn to analyse and select appropriate materials for different products, ensuring designs meet specific functional, safety, and sustainability criteria. They interpret and produce engineering drawings in compliance with drafting conventions and standards.

Students also come to appreciate the importance of optimising materials and processes to improve efficiency and reduce waste in manufacturing. This strand also promotes the problem-solving and critical thinking skills required to overcome manufacturing challenges, cultivates resilience and adaptability as students iterate their designs to meet evolving needs and constraints.

Strand 1 Learning outcomes

Students learn about	Students should be able to
• engineering developments past, present and in emerging areas. • how engineering contributes to the quality of daily life. • the contributions of notable engineers and scientists and the impact of their work.	1.1 evaluate and discuss the evolution of engineering practice. 1.2 appreciate the impact that engineering developments have had on our world. 1.3 describe the contributions of key figures in engineering and technology. 1.4 evaluate the role of key figures in the areas of engineering thinking and practice.
• engineering professions and pathways, to include an awareness of the main engineering disciplines for example mechanical engineering, materials engineering, aeronautical engineering, quality engineering or environmental engineering.	1.5 describe the role of the engineer within a range of engineering disciplines.

• the ethical issues involved in engineering including social, economic and environmental considerations and what measures can be put in place to promote them. • the principle of sustainable practices to include rethink, reduce, reuse, recycle, and the right to repair.	1.6 evaluate the environmental considerations, economic, and societal impacts of engineering decisions in historical and modern times.
• manufacturing processes and technology, including machining processes, thermal and non-thermal assembly techniques and manufacturing techniques	1.7 demonstrate proficiency in the use of craft skills, machining techniques and assembly techniques on a range of materials in the engineering classroom, ensuring an adherence to precision, quality and finish. 1.8 describe and use a range of additive and subtractive manufacturing techniques. 1.9 describe and apply the fundamental principles and theories relating to manufacturing processes, assembly techniques, and their applications in a range of contexts.
• the skills that are applicable in the engineering classroom to include both manual and automated processes.	1.10 apply appropriate manufacturing processes for required applications.
• transferring measurements and details from a working drawing to a workpiece, ensuring precision and adherence to specifications.	1.11 demonstrate proficiency in using hand and machine tools.
• best practice of health and safety in the engineering classroom	1.12 apply safe working techniques and practices and display an awareness of the importance of health and safety.
• digitally controlled manufacturing equipment and techniques	1.13 describe the fundamental concepts and principles of computer aided manufacturing techniques. 1.14 export data from CAD software systems to manufacture components. 1.15 perform a manufacturing sequence on digitally controlled equipment.

	1.16 recognise emerging trends and technologies in digital manufacturing.
• the treatment of materials to alter their properties for specific applications. • key criteria for selection of the optimum material for a particular application based on its properties.	1.17 explain the effects of heat treatments on materials, their properties, and their applications. 1.18 select appropriate materials for required applications based on their properties, displaying an awareness for sustainable design and the impact on our environment.
• planning and managing the manufacture of a product. • working in cooperation with others and reflect on their own contribution.	1.19 plan the manufacturing sequence for a range of projects and tasks. 1.20 manage time and resources within the allocated timeframe to produce a product. 1.21 evaluate and critically reflect on the outcome of work completed. 1.22 document work appropriately in tandem with a design process.
• measurement and metrology, to include application of the SI system, standardisation and calibration of measuring equipment. • the use of precision measuring equipment.	1.23 describe the necessity for a unified system of measurement. 1.24 demonstrate the correct use of simple and precision measuring tools and processes.
• intelligent and sustainable manufacturing technologies and innovations. • contemporary automated manufacturing systems, and the technologies used in them.	1.25 evaluate developments in manufacturing technologies and their impacts on manufacturing and society. 1.26 outline the features and the operations of an automated manufacturing facility.
• quality assurance in product design and manufacture. • fundamental concepts of reliability.	1.27 describe key concepts involved in quality management, statistical process control and sampling. 1.28 explain machine maintenance intervals and outline examples of preventative maintenance.

Strand 2: Automation and Control Systems

In this strand, students will study the principles of mechatronics and control, with a specific focus on smart manufacturing and digital technologies. The strand encourages learning by doing, where students are expected to design, build, and test control systems in the engineering classroom, gaining both theoretical knowledge and practical skills. Mechanical and electronic control systems are explored, integrating learning from Strand 4 and its applications in project realisation in Strand 1.

The learning outcomes in this strand begin with system analysis, inputs, and outputs, before advancing to local, remote, and autonomous control. Students will learn system analysis techniques, enabling them to capture the behaviour and communicate the functional requirements of systems involving automation and control. They will use a structured and systematic approach to map inputs, outputs, and their interactions, establishing a clear understanding and specification for system functionality. Additionally, they will learn to design and build circuits involving sensors and actuators, and employ them in practical applications.

For local and remotely controlled systems, students will learn about the design and implementation of Human Machine Interfaces (HMI) and the hardware and software required to provide local and wireless communication technologies for monitoring and control. The strand culminates in a focus on autonomous control systems, where students will learn about closed-loop control systems, Artificial Intelligence, machine learning, and robotics. They will apply this knowledge to automated systems in a design, make, and test project.

Through hands on experiences, students will identify and configure the hardware and software needed for automated systems and perform the analysis and testing required for their implementation. They will develop skills in building circuits, using test equipment, and debugging code and hardware systems.

Strand 2 Learning outcomes

Students learn about	Students should be able to
• mechatronic systems and their applications. • system analysis techniques to capture and communicate the operation of control and monitoring systems.	2.1 determine the functional requirements of an engineering control system. 2.2 model systems inputs, outputs and the relationships between them using state machine diagrams. 2.3 recognise the key role that control and energy systems play in engineering.

• hardware and software inputs and outputs required for control and monitoring of hydraulic, pneumatic, electronic, electrical and computer-based systems.	2.4 identify appropriate inputs and outputs for an automated system. 2.5 specify and configure sensors and actuators for a range of simple automated systems. 2.6 describe the design of a control system using an appropriate technical format.
• selecting the energy requirements and sources for a specific control system.	2.7 identify suitable energy sources to meet input and output requirements. 2.8 evaluate the relevant inputs and outputs for any energy requirements. 2.9 recognise the importance of energy efficiency and the necessity to use renewable energy sources.
• approaches to designing Human Machine Interfaces (HMI) to provide a system with local control and monitoring capabilities.	2.10 appreciate control and monitoring design practice, in terms of the user experience, safety and inclusion. 2.11 implement hardware, software, local control and monitoring interfaces using system analysis specifications.
• remote access control and monitoring facilities, using wired and/or wireless based communications.	2.12 use wired and/or wireless communication techniques to remotely control devices. 2.13 test and debug wired and/or wireless communication control and monitoring systems.
• open and closed loop control systems. • autonomous control systems such as electromechanical and mechatronic control systems. • automation projects and how to include the design, manufacture and testing of control systems.	2.14 describe the difference between open and closed loop control systems. 2.15 describe the advancements of autonomous control systems. 2.16 describe the role of control systems in advanced manufacturing and society. 2.17 solve design problems using suitable levels of control and automation technology.

Strand 3: Design Capability

In this strand, students will explore the creative and analytical processes involved in designing products with a manufacturing output. It emphasises the use of design principles and engineering tools to develop solutions to real-world problems, culminating in a fully developed design that can be manufactured in the engineering classroom. The strand draws on learning from Strand 4 to support design calculations, Strand 2 for the automation of designs, and feeds into Strand 1 where the design solution will be realised.

Through hands-on projects, students learn about visual communication, iterative problem-solving, and technical design, while deepening their understanding of the issues affecting the manufacture of their designs. They develop the ability to use freehand sketches and digital models to visualise concepts, document their designs, and analyse existing technical drawings, fostering both creativity and precision in representing design ideas.

A systematic and iterative approach to problem-solving is encouraged. Students apply this process to their design briefs, maintaining a portfolio to document the design from concept to solution. This approach helps students develop logical thinking and effective planning.

Students learn to incorporate environmental considerations and ethical decision-making into their designs. By exploring concepts such as product life cycles and the sustainable use of materials, they develop an understanding of how their choices in materials and processes can impact both the product and society over time.

There is a strong emphasis on the technical aspects of the design process, including specifying components, generating working drawings, and integrating CAD models with manufacturing processes. The strand explores the role of prototyping and testing in refining designs, using software and hardware for simulations, and creating physical prototypes.

Students will develop an understanding of how engineering design principles are applied from initial concept through to the final product, the trade-offs between functionality and manufacturability, and the integrated nature of the design and manufacturing processes in engineering.

Strand 3 Learning outcomes

Students learn about	Students should be able to
• communication of design principles and concepts using a range of media including sketching, digital and physical models.	3.1 use sketching in visualising concepts and documenting designs. 3.2 create prototypes and models to communicate the physical form of a design. 3.3 communicate engineering concepts and designs using appropriate media incorporating technical symbols and norms. 3.4 analyse and interpret technical sketches and drawings to extract relevant information.
• interpreting and creating engineering drawings in compliance with drafting standards.	3.5 create engineering working drawings that adhere to established drafting standards.
• the engineering design process as an iterative approach to a design problem. • following a systematic process to arrive at a solution to a design brief and documentation of the process.	3.6 describe and apply the steps involved in the engineering design process. 3.7 create a design folio to document and evaluate the design process.
• sustainable and ethical design including reuse, remanufacture and modular design. • ethical sourcing, energy optimisation, and design for safe use.	3.8 demonstrate sustainable design practices incorporating ethical design decisions and appropriate safety considerations.
• the product lifecycle.	3.9 describe the main stages and characteristics of the product lifecycle.
• systems thinking related to product design and functionality. • human factors and ergonomics in design.	3.10 apply principles of product functionality during the design process. 3.11 apply principles of human-centred design and universal design.
• specification of mechanical and electrical components.	3.12 use engineering judgement and/or basic calculations to specify mechanical components.

• principles of Engineering design including the design of machine elements, mechanisms and powered systems.	3.13 select the correct electrical components for engineering applications using technical data. 3.14 calculate the specifications and dimensions required for the design of machine components and powered systems.
• using SI units, basic and derived, for measurement and calculations, and giving due consideration to the limits of the precision and accuracy of measurement	3.15 apply tolerances, limits and fits to the design of assembled components.
• prototyping and testing in design.	3.16 create working prototypes to explore ideas, test functionality, and inform design decisions.
• key testing concepts and terminology in engineering.	3.17 explain the importance of testing in the engineering design and product development process.

Strand 4: Engineering Principles and Energy

In this strand, students explore the fundamental concepts that underpin engineering design, manufacturing processes, and energy systems. The focus is on understanding the properties and behaviour of materials, the application of mechanical and electrical principles, and the use of the SI system in engineering calculations. This approach ensures that students gain the necessary skills to apply theoretical knowledge in practical, hands-on projects, helping them understand how these principles influence design decisions and manufacturing outcomes.

Students will learn about the SI system of units and the importance of a standardised measurement system in engineering, providing a foundation for performing accurate calculations in various engineering contexts. They will develop their knowledge of materials and their applications in engineering, learning about the engineering properties of materials, how these properties are measured, and how to apply this knowledge in the design of engineered artifacts.

Energy management is a crucial component of this strand. Students will evaluate the energy requirements for various control systems, considering efficiency and the use of renewable energy sources. They will also use SI units to quantify energy needs and conversions, promoting a practical understanding of energy conservation.

Additionally, students will learn to apply calculations related to forces, motion, and load-bearing components, as well as the design of mechanical systems such as gears, linkages, and power transfer systems. This application of principles in the design process reinforces the importance of an analytical approach in solving real-world engineering problems.

Students will also learn about the design and troubleshooting of DC circuits, motors, and pneumatic and hydraulic systems, which they will integrate into control applications in Strand 2.

Strand 4 Learning outcomes

Students learn about	Students should be able to
• the SI system of units. • derivation and conversion of SI units.	4.1 calculate engineering quantities using appropriate SI units for design and manufacture.
• the production of materials including metals and non-metals and their impact on the environment. • sustainable management of natural resources.	4.2 describe the production of engineering materials. 4.3 explain the impact of production and disposal of materials on the environment. 4.4 identify approaches used to conserve natural resources.
• material testing.	4.5 describe the various tests available to assess material properties. 4.6 interpret and communicate test data from material tests to make informed material selection choices.
• the relationship between the microstructure and macro properties of a range of engineering materials. • corrosion to include galvanic corrosion, stress corrosion, intergranular corrosion, fretting corrosion, sacrificial and cathodic protection.	4.7 describe the relationship between microstructure and material properties. 4.8 use phase diagrams to explain the effects of heat treatment processes for altering the properties of metals. 4.9 identify the effects of mechanical working on material properties. 4.10 explain the process of corrosion and preventative measures.

• the concepts of work, energy and power.	4.11 calculate the requirements for energy, work and power in the context of engineering systems.
• forms of energy and energy conversions.	4.12 describe the energy conversions occurring in engineering systems and processes.
• the principle of conservation of energy.	4.13 analyse closed systems or steady flow systems using a simplified energy balance. 4.14 calculate mechanical and electrical power demands and the energy efficiency of engineering systems.
• energy efficiency, energy dissipation and energy storage.	4.15 evaluate solutions to engineering challenges based on energy efficiency.
• fundamental principles of mechanics, including loads, forces and motion.	4.16 describe the types and applications of forces and motion. 4.17 apply calculations of static forces in the design of load bearing elements and components.
• elements of machine design. • mechanics of machines to include the specification of machine components.	4.18 design linkages and mechanisms to produce given motion profiles.
• geared systems, and mechanisms.	4.19 describe and use different power transfer systems and drive systems.
• using calculations as part of the design process.	4.20 calculate and determine friction forces for drive and braking applications. 4.21 calculate mechanical advantage, velocity ratio and efficiency for simple machines. 4.22 apply calculations for forces and power in the specification of mechanisms and motor driven systems.
• AC electrical systems.	4.23 describe applications of AC and DC based power.
• voltage, current and power in DC circuits.	4.24 analyse DC circuits for sensor and drive systems.

• DC circuit design, motors and power. • the functions and application of off the shelf electronic components.	4.25 design and build circuits to integrate with control applications.
• fluid based systems. • basic concepts of pneumatic and hydraulic systems.	4.26 calculate the forces acting on master and slave cylinders involving static fluid pressure using Pascal's Law. 4.27 interpret and apply fluid circuit diagrams involving valves, cylinders and energy supplies. 4.28 describe the applications of fluid-based systems in real life.

Teaching for student learning

Engineering practice is a blended experience of practical application supported by the theoretical principles of engineering. For the student this means behaving like an engineer through hands-on experience of design ideation, trial and error, informed by a deep understanding of engineering concepts and principles. Leaving Certificate Engineering places the student at the centre of the educational experience, emphasising practical, hands-on engagement with engineering concepts and the development of an engineering mindset. The subject supports a wide range of teaching and learning approaches, allowing teachers to adapt their methods to meet the diverse strengths, needs, and interests of students.

The development of technical and processing skills is fundamental to the subject. A central pedagogy in Leaving Certificate Engineering is problem-solving through design and manufacture. Students are encouraged to integrate theoretical knowledge with practical application, developing design solutions and refining ideas while exploring the discipline of engineering. This approach allows students to engage critically with engineering and its impact on the real world. By iterating and testing their solutions, students gain insights into the constraints and possibilities available.

Students will learn to analyse a given problem to determine specific design criteria, consider appropriate materials and manufacturing processes to create a functioning prototype. Additionally, students are encouraged to design and conduct tests, interpret test data, and reach evidence-based conclusions to inform their work. Students are encouraged to effectively communicate their work using a range of media.

The opportunity to work independently provides students with autonomy to take ownership of their learning. This builds confidence and encourages students to think and act like engineers, drawing on both creativity and critical thinking to solve problems. Projects can also be designed to include collaborative work, promoting teamwork and the sharing of ideas. Students are encouraged to consider the environmental, social, and economic impact of engineered solutions. This includes making informed choices about materials prioritising renewable or recyclable options to ensure their designs reflect principles of sustainability.

The inclusion of modern and digital manufacturing technologies in Leaving Certificate Engineering provides a forward-looking dimension to classroom activities, ensuring the subject remains relevant in a rapidly evolving field. These technologies allow students to visualise, design, and manufacture with precision, fostering creativity and innovation while providing a tangible connection to modern engineering processes. By integrating these modern tools and processes into practical tasks, students gain hands-on experience with the technologies shaping the future of engineering.

Learning experiences are designed to promote inclusivity, with varying levels of teacher intervention and differentiated activities tailored to the individual needs and abilities of students. The use of approaches such as adjusting the degree of proficiency required, varying the amount and the nature of teacher intervention, and varying the pace and sequence of learning promote inclusivity and cater for diverse needs.

A variety of assessment strategies and instruments are used to evaluate both theoretical understanding and practical application. These assessments may include project-based work, practical demonstrations, presentations and written reflections, ensuring a holistic evaluation of student learning. Formative feedback and self-assessment are integral to this process.

The pedagogical approaches in Leaving Certificate Engineering encourage the students to develop the knowledge, skills, values and dispositions needed to approach engineering challenges with confidence. By fostering curiosity, creativity, and a sense of interconnectedness within the discipline, the learning in Leaving Certificate Engineering prepares students to think critically and contribute meaningfully to the world of engineering and beyond.

Assessment

Assessment in senior cycle involves gathering, interpreting, using and reporting information about the processes and outcomes of learning. It takes different forms and is used for a variety of purposes. It is used to determine the appropriate route for students through a differentiated curriculum, to identify specific areas of strength or difficulty for a given student and to test and certify achievement. Assessment supports and improves learning by helping students and teachers to identify next steps in the teaching and learning process.

As well as varied teaching strategies, varied assessment strategies will support student learning and provide information to teachers and students that can be used as feedback so that teaching and learning activities can be modified in ways that best suit individual learners. By setting appropriate and engaging tasks, asking questions and giving feedback that promotes learner autonomy, assessment will support learning and promote progression, support the development of student key competencies and summarise achievement.

Assessment for certification

Assessment for certification is based on the rationale, aims and learning outcomes of this specification. There are two assessment components: a written examination and an additional assessment component comprising of a design and manufacture project. The written examination will be at higher and ordinary level. The design and manufacture project will be based on a common brief. Each component will be set and examined by the State Examinations Commission (SEC).

In the written examination, Leaving Certificate Engineering will be assessed at two levels, Higher and Ordinary. Examination questions will require students to demonstrate learning appropriate to each level. Differentiation at the point of assessment will also be achieved through the stimulus material used, and the extent of the structured support provided for examination students at different levels.

Table 2 Overview of assessment for certification

Assessment component	Weighting	Level
Design and manufacture project	50%*	Common Brief
Written examination	50%*	Higher and Ordinary Level

Additional assessment component: The design and manufacture project

The design and manufacture project provides an opportunity for students to display evidence of their learning across all strands of the specification. The senior cycle key competencies of thinking and solving problems, being creative, communicating, working with others, and managing learning and self, developed through working with learning outcomes across the specification, will be applied through the student's engagement with the project.

A Design and Manufacture Project brief will be issued annually by the SEC. The brief will set out the requirements for the Design and Manufacture Project and will:

- set a context for the project
- provide guidance to students in the development of their project work
- allow students to develop their knowledge and understanding in areas related to the brief
- facilitate teachers and students in their planning.

This experience will allow students to demonstrate their creativity, showcase the breadth and depth of their practical and manufacturing ability, and refine their communication techniques as they develop, implement, and document their progress through the design and manufacturing process.

The project will involve the following:

- Students will be required to analyse the brief and will conduct independent research. In doing this the students will engage with real world sources, critically evaluate information gathered and use this information in the formulation of an engineering solution and a plan for the project.
- In implementing the plan they will be required to develop ideas, make informed decisions on materials selection, design and justification of an engineered solution and a manufacturing plan.
- In manufacturing the solution the students will draw on the breadth and depth of knowledge and skills they have acquired.
- The completed solution will be tested and evaluated against the initial brief.
- Throughout the process the students will document their work in the portfolio.

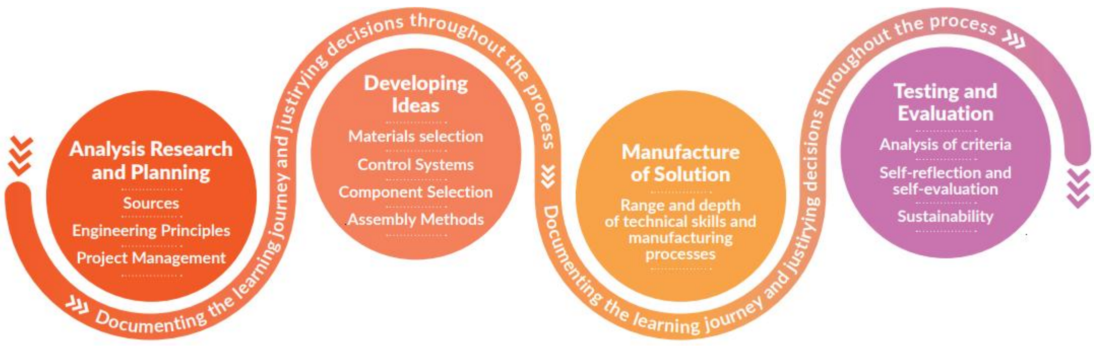

Figure 4 Additional Assessment Component (AAC)

This AAC should be integrated into the teaching and learning process, maximising its potential to motivate and engage students while emphasising the importance of the engineering mindset in their lives. In this way it will foster a learning experience where theoretical knowledge is integrated with practice, where students can engage in real-world scenarios that enhance their understanding and mastery of engineering concepts. Students have a high degree of autonomy in planning and organising the completion of the project.

Upon completion of the AAC, students will submit a solution and a supporting folio documenting the design and manufacturing process through an individual submission in a format specified by the SEC. The AAC will be marked by the SEC. It is envisaged that the AAC will take up to 45 hours to complete. Further details will be provided in the Guidelines to support the Leaving Certificate Engineering Design and Manufacture Project.

Descriptors of quality for additional assessment component.

The descriptors below relate to the learning achieved by students in the design and manufacture project. In particular, the design and manufacture project require students to:

- Analyse, Research and Plan
- Develop Ideas
- Manufacture Solutions
- Test and Evaluate
- Document the Learning Journey.

Table 3: Descriptors of quality: Design and Manufacture Project

	Students demonstrating a high level of achievement	Students demonstrating a moderate level of achievement	Students demonstrating a low level of achievement
Analysis, Research and Planning	Engage with the research, analysis and planning process, communicating in detail their comprehensive understanding of the brief. High level of interpretation of a brief with all key specifications and constraints considered in detail.	Engage with the research, analysis and planning process, communicating their moderate understanding of the brief. Moderate level of interpretation of a brief with most key specifications and constraints considered in some detail.	Engage with the research, analysis and planning process, partially communicating their limited understanding of the brief. Limited level of interpretation of a brief with some key specifications and constraints considered in limited detail.
Developing ideas	Present a solution that clearly communicates their ideas and concepts that satisfies all aspects of the brief. Create a highly effective workable solution with a high level of detail.	Present a solution that communicates their ideas and concepts that satisfies most aspects of the brief. Create an effective workable solution with some level of detail.	Present a solution that partially communicates their ideas and concepts that satisfies some aspects of the brief. Create a workable solution with a limited level of detail.
Manufacturing Solutions	Manufacture a solution demonstrating a wide range and depth of technical skills and processes incorporating accuracy, precision and high-quality finish.	Manufacture a solution demonstrating a moderate range and depth of technical skills and processes incorporating some accuracy, precision and high-quality finishes.	Manufacture a solution demonstrating a limited range and depth of technical skills and processes incorporating limited accuracy, precision and high-quality finishes.
Testing and Evaluation	Test and evaluate their solution showing a detailed and critical reflection of their design and manufacturing journey	Test and evaluate their solution showing moderate detail and some reflection of their design and manufacturing journey	Test and evaluate their solution showing limited detailed and limited reflection of their design and

	with clear recommendations for potential improvement.	with some recommendations for potential improvement.	manufacturing journey with limited recommendations for potential improvement.
Documenting the Learning	The presentation of the folio which clearly communicates and justifies their design and manufacture decisions to a high level.	The presentation of the folio which communicates and justifies their design and manufacture decisions to a moderate level.	The presentation of the folio which communicate their design and manufacture decisions to a limited level.

Written examination

The written examination will consist of a range of question types. The senior cycle key competencies (figure 2) are embedded in the learning outcomes and will be assessed in the context of the learning outcomes. The written examination paper will include a selection of questions that will assess learning, appropriate to each level.

Reasonable accommodations

This Leaving Certificate Engineering specification requires that students engage with the nature of the subject on an ongoing basis throughout the course. The assessment for certification in Leaving Certificate Engineering involves a written examination worth 50% of the available marks and an additional component worth 50%. In this context, the scheme of Reasonable Accommodations, operated by the State Examinations Commission (SEC), is designed to assist students who would have difficulty in accessing the examination or communicating what they know to an examiner because of a physical, visual, sensory, hearing, or learning difficulty. The scheme assists such students to demonstrate what they know and can do, without compromising the integrity of the assessment. The focus of the scheme is on removing barriers to access, while retaining the need to assess the same underlying knowledge, skills, values, and dispositions as are assessed for all other students and to apply the same standards of achievement as apply to all other students. The Commission makes every effort when implementing this scheme to accommodate individual assessment needs through these accommodations.

There are circumstances in which the requirement to demonstrate certain areas of learning when students are being assessed for certification can be waived or exempted, provided that this does not compromise the overall integrity of the assessment. However, some of the areas of learning in a subject specification cannot be waived because they are core to the subject specification.

More detailed information about the scheme of Reasonable Accommodations in the Certificate Examinations, including the accommodations available and the circumstances in which they may apply, is available from the State Examinations Commission's Reasonable Accommodations Section.

Before deciding to study Leaving Certificate Engineering, students, in consultation with their school and parents/guardians should review the learning outcomes of this specification and the details of the assessment arrangements. They should carefully consider whether or not they can achieve the learning outcomes, or whether they may have a special educational need that may prevent them from demonstrating their achievement of the outcomes, even after reasonable accommodations have been applied. It is essential that if a school believes that a student may not be in a position to engage fully with the assessment for certification arrangements, they contact the State Examinations Commission.

Leaving Certificate Grading

Leaving Certificate Engineering will be graded using an 8-point grading scale. The highest grade is a Grade 1; the lowest grade is a Grade 8. The highest seven grades (1-7) divide the marks range 100% to 30% into seven equal grade bands 10% wide, with a grade 8 being awarded for percentage marks of less than 30%. The grades at Higher level and Ordinary level are distinguished by prefixing the grade with H or O respectively, giving H1-H8 at Higher level, and O1-O8 at Ordinary level.

Table 4: Leaving Certificate Grading

Grade	% Marks
H1/O1	90 - 100
H2/O2	80 < 90
H3/O3	70 < 80
H4/O4	60 < 70
H5/O5	50 < 60
H6/O6	40 < 50
H7/O7	30 < 40
H8/O8	< 30

Appendix 1: Glossary of terms

Term	Meaning
Control System	A system designed to regulate the behaviour of devices or processes, often integrating feedback mechanisms.
State Machine Diagram	State Machine Diagrams allow the graphical capture and communication of a system's behaviour. This diagram details the inputs, outputs and relationship between them.
Human Machine Interface (HMI)	The Human Machine Interface involves the software and hardware components used by Humans to control and monitor machines and systems
State Machine Diagrams	State Machine Diagrams allow the graphical capture and communication of a system's behaviour. This diagram details the inputs, outputs and relationship between them
Universal Design and Inclusion	Design principles aimed at creating products and systems accessible to all people, regardless of abilities
Local Control	The ability to control a system directly at its source, without relying on remote or automated mechanisms
System Analysis	A systematic approach to studying a system, its components, functions, and interactions to improve its efficiency.
Open Loop and Closed Loop	Open loop systems operate without feedback, while closed loop systems use feedback to adjust performance.
Autonomous-Based Functionality	Features that enable a system to perform tasks independently using sensors, AI, or programmed logic.
Prototypes	Preliminary models of a product used for testing and refinement during design and development.

Engineering Design Process	An iterative approach to solving design problems, involving planning, prototyping, testing, and evaluation.
Human-Centred Design	A design philosophy focusing on user needs, preferences, and experiences to ensure accessibility and effectiveness.
Principles of Usability	Guidelines ensuring that products are easy to use, efficient, and satisfying for users.
Working Prototypes	Functional versions of a product that demonstrate its performance, used for validation and improvement.
SI Units	The globally-agreed system of measurement units formally named the 'International System of Units'
Systems Thinking	is a framework for seeing the interconnections in a system, or the ‘structures’ that underlie complex situations. For example, A State Machine Diagram is a tool that facilitates Systems Thinking.
Closed systems	– a system that can exchange energy (as heat or work) but not matter, with its surroundings.
Steady flow systems	A system with uniform flow – such as a turbine with a constant flow rate. Practically, this means that rates of change are not required for analysis, therefore simplifying calculations.
Simplified energy balance	Refers to the representation of the principle of conservation of energy of the form: $Initial\ energy\ of\ the\ system + Energy\ entering\ the\ system = Final\ energy\ of\ the\ system + Energy\ leaving\ the\ system$

Appendix 2: Glossary of action verbs

Action verb	Students should be able to
Allocate	to distribute or assign something
Analyse	study or examine something in detail, break down in order to bring out the essential elements or structure; identify parts and relationships, and to interpret information to reach conclusions
Apply	select and use information and/or knowledge and understanding to explain a given situation or real circumstances
Appreciate	recognise the meaning, value or importance of
Assess	judge, evaluate or estimate the nature, ability, quality or value of something
Calculate	obtain a numerical answer showing the relevant stages in the working
Collaborate	work jointly with another or others on an activity or project
Construct	develop information in a diagrammatic or logical form; not by factual recall but by analogy or by using and putting together information
Create	bring something into existence; to cause something to happen as a result of one's actions
Demonstrate	prove or make clear by reasoning or evidence, illustrating with examples or practical application
Describe	give a detailed account of the main points of the topic, using words, diagrams, sketches, and/or images
Design	conceive, create and execute according to plan
Develop	to evolve; to make apparent or expand in detail advance a piece of work or an idea from an initial state to a more advanced state
Devise	plan, develop or create something by careful thought
Discuss	offer a considered, balanced review that includes a range of arguments, perspectives, factors or hypotheses, grounded in appropriate evidence
Evaluate (data/information)	collect and examine data to make judgments and appraisals; describe how evidence supports or does not support a conclusion in an inquiry or investigation; identify the limitations of data in conclusions; make judgments about the ideas, solutions or methods

Evaluate (ethical judgement)	collect and examine evidence to make judgments and appraisals; describe how evidence supports or does not support a judgement; identify the limitations of evidence in conclusions; make judgments about the ideas, solutions or methods
Explain	give a detailed account supported by reasons or causes
Identify	recognise patterns, facts, or details; provide an answer from a number of possibilities; recognise and state briefly a distinguishing fact or feature
Interpret (data)	use knowledge and understanding to recognise trends and draw conclusions from given information
Interpret (non-data)	express ideas about the intended meaning of
Investigate	observe, study or examine in detail in order to establish facts, and reach new insights and/or conclusions
Implement	put a functioning and usable system into effect
Justify	give valid reasons or evidence to support an answer or conclusion
Manage	to work upon or try to alter for a purpose
Present	make objects perceivable to others
Prioritise	to arrange or deal with tasks, issues, or resources in order of importance or urgency
Recognise (data/information)	identify facts, characteristics or concepts that are critical (relevant/appropriate) to the understanding of a situation, event, process or phenomenon
Research	inquire specifically, through collecting, organising and analysing evidence in order to draw conclusions
Solve	find an answer through reasoning
Use	apply knowledge or rules to put theory into practice