An Roinn Oideachais
agus Scileanna

Junior Cycle Engineering

Contents

Introduction to junior cycle

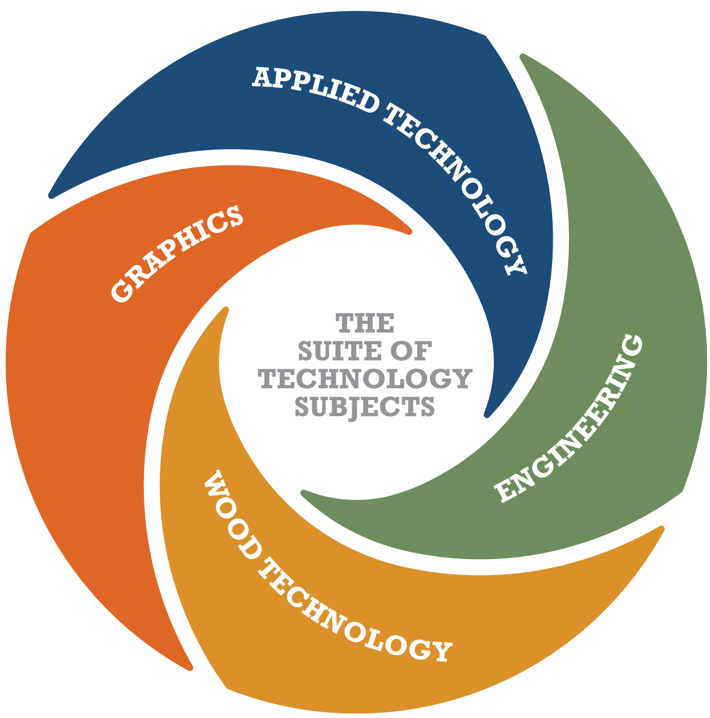
Junior cycle education places students at the centre of the educational experience, enabling them to actively participate in their communities and in society and to be resourceful and confident learners in all aspects and stages of their lives. Junior cycle is inclusive of all students and contributes to equality of opportunity, participation and outcome for all.

The junior cycle allows students to make a greater connection with learning by focusing on the quality of learning that takes place and by offering experiences that are engaging and enjoyable for them, and relevant to their lives. These experiences are of a high quality, contribute directly to the physical, mental and social wellbeing of learners, and where possible, provide opportunities for them to develop their abilities and talents in the areas of creativity, innovation and enterprise. The learner's junior cycle programme builds on their learning to date and actively supports their progress in learning and in addition, supports them in developing the learning skills that will assist them in meeting the challenges of life beyond school.

Preamble

Under the current *Framework for Junior Cycle*, students have access to a suite of technology subjects: Engineering, Wood Technology, Graphics and Applied Technology.

FIGURE 1: THE SUITE OF TECHNOLOGY SUBJECTS



Rationale

Each subject of the technology suite offers the student different experiences which contribute towards their education in technology education. As a result, preparing students for learning in the technology subjects is not just about teaching towards the technology but towards the skills that are fundamental to the technology subjects and are transferable into other areas of their learning: skills that encourage the student to problem-solve through creation, innovation, communication, collaboration and exploration, all of which are developed in an active learning environment where students can advance their ideas from conception to realisation.

Engineering addresses the process of cyclical design to produce products and systems that adhere to defined conventions and standards. The focus of junior cycle Engineering is goal-oriented problem solving for the manufacture of products, with emphasis on efficiency, accuracy, precision and a high- quality finish. This project-based approach to junior cycle Engineering requires students to develop a knowledge of materials and processes, and to demonstrate a capacity to select appropriate materials and processes for given applications.

Engineering offers students a lens through which to view the role and impact of engineering within their classroom, community and the world. Through the study of engineering, students will have the opportunity to behave as engineers, and develop an engineering mindset. The engineering process is both reflective and systematic. It is reflective in that students continually test their design and modify it based on what they have learned. It is systematic in that students undertake several characteristic steps in reaching a solution. Students identify problems, integrate ideas for how to solve identified problems, and try to improve the design or devise a better one.

Aim

The study of junior cycle Engineering aims to:

- enable students to develop the disciplinary skills and knowledge to engineer an end product
- enable students to engage in goal-oriented problem solving, creating an awareness of engineering processes
- develop the necessary skills and apply engineering processes to manipulate material to manufacture a product with efficiency, accuracy, precision and a high-quality finish
- develop an engineering mindset through the exploration of contemporary engineering developments.

Overview: Links

Engineering supports a broad range of learning objectives at junior cycle. Tables 1 and 2 on the following pages show how junior cycle Engineering is linked to central features of learning and teaching in junior cycle.

TABLE 1: LINKS BETWEEN ENGINEERING AT JUNIOR CYCLE AND THE STATEMENTS OF LEARNING

The statement	Examples of relevant learning
SOL 15: The student recognises the potential uses of mathematical knowledge, skills and understanding in all areas of learning.	Students will be able to apply numerical reasoning through marking out exercises from given dimensions.
SOL 19: The student values the role and contribution of science and technology to society, and their personal, social and global importance.	Students will evaluate the impact of technologies on their lives, society and the environment.
SOL 20: The student uses appropriate technologies in meeting a design challenge.	Students will determine the most suitable technologies available to them and apply them to fulfil the criteria of a given challenge.
SOL 21: The student applies practical skills as she/he develops models and products using a variety of materials and technologies.	Students model and engineer products. This process encourages the development of their practical skills while working with a range of materials and technologies.
SOL 23: The student brings an idea from conception to realisation.	Students will develop a product to its finished stage from a working drawing, either their own or that of others.
SOL 24: The student uses technology and digital media tools to learn, work and think collaboratively and creatively in a responsible and ethical manner.	Students will use digital media tools to research, create and present engineering solutions that can impact positively on the environment and sustainability and contribute to a better future.

Key skills

In addition to their specific content and knowledge, the subjects and short courses of junior cycle provide students with opportunities to develop a range of key skills. Figure 2 below illustrates the key skills of junior cycle. There are opportunities to support all key skills in this course, but some are particularly significant.

FIGURE 2: JUNIOR CYCLE KEY SKILLS

TABLE 2: LINKS BETWEEN ENGINEERING AT JUNIOR CYCLE AND KEY SKILLS

Key skill	Key skill element	Examples of student learning activities
Being creative	Exploring options and alternatives	Students will research alternative technologies to perform operations.
Being literate	Expressing ideas clearly and accurately	Students will select the most appropriate media to communicate their ideas/solutions.
Being numerate	Expressing ideas mathematically	Students will use correct mathematical notation when communicating dimensions.
Communicating	Using language	Students will demonstrate correct technical language when explaining a process and presenting ideas.
Managing information and thinking	Thinking creatively and critically	Students will engage in innovative thinking in designing solutions and critique their solution based on the needs related to the problem.
Managing myself	Setting and achieving personal goals	Students will establish a plan of work and apply it to the creation of a project.
Staying well	Being positive about learning	Students will be encouraged to develop a curiosity about the multi-disciplines of engineering and a positive outlook on the subject.
Working with others	Co-operating	Students will collaborate to design and build engineering solutions.

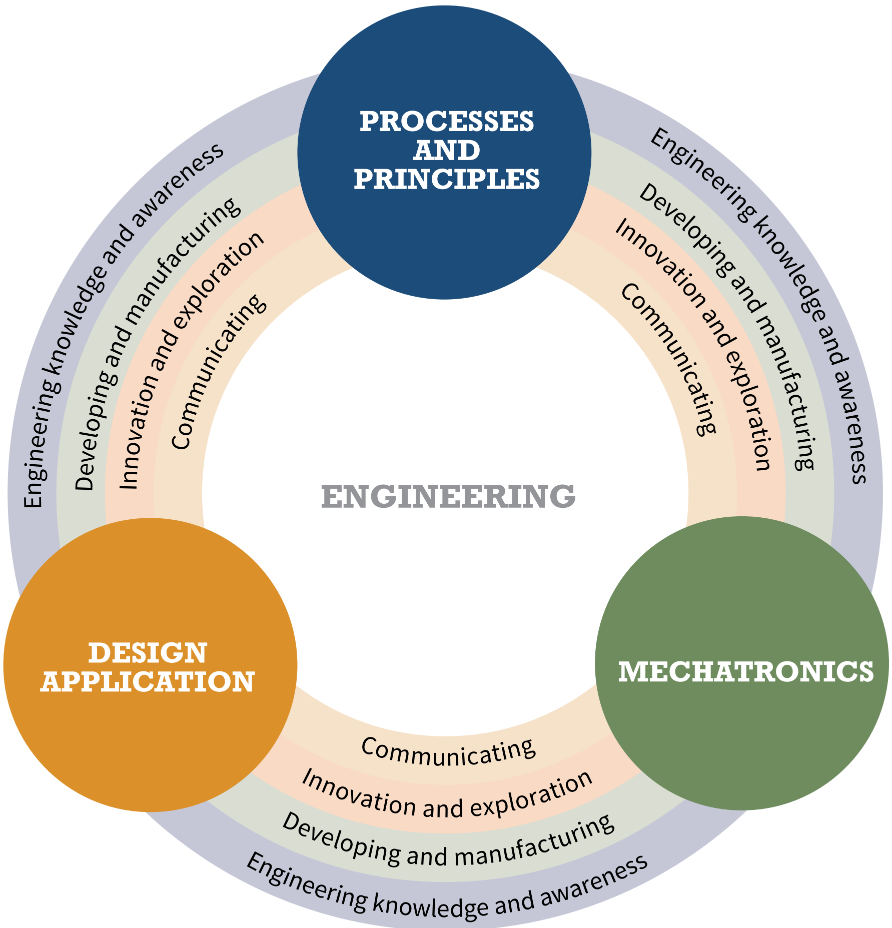
Overview: Course

Engineering focuses on developing students' understanding of, and skills in, the applications and impact of technologies in the world around them. This will be achieved through three inter-connected contextual strands: **Processes and principles**, **Design application** and **Mechatronics.** Throughout each of the strands, the use of four elements: **Engineering knowledge and awareness**, **Innovation and exploration**, **Developing and manufacturing** and **Communicating** creates a framework for learning that ensures a coherent learning experience for the students.

Engineering uses an interdisciplinary approach which encourages the integration of the three strands in the teaching and learning of the subject. It has been designed for a minimum of 200 hours of timetabled student engagement across the three years of junior cycle.

This specification aims to maintain a balance between depth and breadth in the study of the subject. This affords a certain amount of flexibility and freedom for teachers to facilitate learning in a way that reflects students' own choices, their curiosity and their creativity. The achievement of learning outcomes should be planned in a way that is active and stimulating.

FIGURE 3: THE STRANDS AND ELEMENTS OF ENGINEERING AT JUNIOR CYCLE



Strands

STRAND 1: PROCESSES AND PRINCIPLES

In this strand, students will learn about and employ the fundamental processes and principles of engineering. Students will apply their knowledge of materials and equipment to design and manufacture products.

Students will be encouraged to use the engineering principles and processes, together with accuracy and precision, to help develop an engineering 'mindset' which ultimately leads to the production of innovative and efficient solutions of high quality and finish.

STRAND 2: DESIGN APPLICATION

In this strand, students will learn about the key stages of the engineering design process. They will understand the importance of design in both the end-user experience and the economic and social impact of the product.

They will discover how informed choice of materials and processes combine to produce a solution that is functional and efficient. Students will learn the value of good project management and how to manage themselves and the product development through the journey from the design to the manufacture stage.

STRAND 3: MECHATRONICS

In this strand, students will use a combination of mechanical, manufacturing, electronic and software engineering to explore the relationship between simple inputs, processes and outputs[1].

Mechatronics engages students in learning how high-tech manufacturing is performed and why it is becoming one of the fastest-growing career areas. Students will develop an appreciation of how control systems operate on a much larger scale and consider how the design of control systems can impact positively on the environment and sustainability. They will appreciate the role that Engineering can play in employing 'systems thinking' to design products and services that contribute to a better future.

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1 See Appendix D.

Elements

Each strand includes the same four elements. The elements are consistent throughout the strands, so that there is a systematic development of students' fundamental knowledge, understanding and key skills as they progress through the course. This structure supports an integrated, non-linear approach to teaching and learning.

ELEMENT 1: ENGINEERING KNOWLEDGE AND AWARENESS

The learning outcomes in this element are designed to raise student awareness and develop knowledge of relevant engineering principles and developments. Students will learn how to use the materials and equipment available to them in Engineering to inform their decisions about material and resource selection to engineer a product or solution.

ELEMENT 2: INNOVATION AND EXPLORATION

In this element, the learning outcomes encourage students to explore the applications of engineering in the world around them. Students research existing and emerging developments and gain an appreciation of their impact and potential application to an engineered product.

ELEMENT 3: DEVELOPING AND MANUFACTURING

In this element, the learning outcomes develop the student's abilities to produce products and solutions through various materials. Students combine their learning from other elements to engineer products to a high, functional standard. The key focus is on efficiency, accuracy, precision and high-quality finish.

ELEMENT 4: COMMUNICATING

Throughout this element, the learning outcomes encourage students to communicate, through appropriate media, to relay technical information, design ideas and the impact engineering has on the environment around them.

Progression from primary to senior cycle

PRIMARY CURRICULUM

While Engineering is not a stand-alone subject or area within the Primary School Curriculum, through its strands, elements and outcomes, Engineering at junior cycle can progress related learning that has taken place at primary level.

A number of subjects in the primary curriculum such as science, mathematics and Visual Arts make reference to the development of problem-solving skills which are key skills for a student of Engineering. Throughout their years at primary school, learners engage in various activities that develop their creativity. They are also developing their fine motor skills, accuracy and spatial reasoning, all of which lend themselves directly to the study of Engineering.

SENIOR CYCLE

The study of Engineering at junior cycle develops the foundations for a student to continue their studies in the suite of technology subjects in both the Leaving Certificate and Leaving Certificate Applied programmes.

The subject Engineering is available in both the Leaving Certificate and Leaving Certificate Applied programmes. The learning outcomes in Engineering at junior cycle have strong links to the aims of both subjects. Engineering introduces some of the components of Leaving Certificate Computer Science, particularly strand 3, Mechatronics. The activities students engage in during junior cycle aim to develop a technological student who should be able to adapt themselves to any discipline related to the technology subjects at senior cycle.

Expectations for students

Expectations for students is an umbrella term that links learning outcomes with annotated examples of student work in the subject specification. When teachers, students or parents looking at the online specification scroll through the learning outcomes, a link will sometimes be available to examples of work associated with a specific learning outcome or with a group of learning outcomes. The examples of student work will have been selected to illustrate expectations and will have been annotated by teachers. The examples will include work that is:

- exceptional
- above expectations
- in line with expectations.

The purpose of the examples of student work is to show the extent to which the learning outcomes are being realised in actual cases.

Learning outcomes

Learning outcomes are statements that describe what knowledge, understanding, skills and values students should be able to demonstrate having studied Engineering in junior cycle. The learning outcomes set out in the following tables apply to all students. As set out here they represent outcomes for students at the end of their three years of study. **The specification stresses that the learning outcomes are for three years and therefore the learning outcomes focused on at a point in time will not have been 'completed' but will continue to support the students' learning of Engineering up to the end of junior cycle.**

The outcomes are numbered within each strand. The numbering is intended to support teacher planning in the first instance and does not imply any hierarchy of importance across the outcomes themselves. Engineering at junior cycle is offered at a common level. The examples of student work linked to learning outcomes will offer commentary and insights that support differentiation and inclusive classroom practices.

Strand 1: Processes and principles

BRIEF OVERVIEW OF STRAND

In this strand, students employ the fundamental processes and principles of engineering by applying their knowledge of materials and processes to manufacture and design products. Students develop an engineering mindset as they appreciate that accuracy and precision, together with the use of established engineering principles and processes lead to the production of innovative and efficient solutions of high quality and finish.

Elements	Learning outcomes *Students should be able to:*
Engineering knowledge and awareness	1.1 understand the concepts and approaches that are required when solving an engineering problem 1.2 demonstrate a range of manufacturing processes 1.3 recognise and adhere to health and safety standards 1.4 understand the properties associated with a range of engineered materials
Innovation and exploration	1.5 research applications of existing and emerging technological developments 1.6 engage with the various engineering disciplines[2] by relating them to everyday applications
Developing and manufacturing	1.7 develop engineered solutions to various challenges 1.8 identify appropriate tools and equipment specific to a task 1.9 apply suitable manufacturing processes to engineer a product 1.10 demonstrate high-quality work, to include accuracy and surface finish
Communicating	1.11 create sketches, models and working drawings 1.12 interpret working drawings 1.13 use appropriate technical language and notations

2 See Appendix A.

Strand 2: Design application

BRIEF OVERVIEW OF STRAND

In this strand, as they develop an engineering mindset, students learn about the key stages of the engineering design and manufacture process. They learn about the importance of design for both the end-user experience and the economic and social impact of the product. They discover how the combination of informed choice of materials and correct processes produces a solution that is functional and efficient. Students come to appreciate the value of good project management and learn how to manage themselves and the process of product development from design to manufacture.

Elements	Learning outcomes *Students should be able to:*
Engineering knowledge and awareness	2.1 understand the key stages of the engineering design process 2.2 evaluate the factors that influence design 2.3 choose a suitable material to engineer a product
Innovation and exploration	2.4 explore how design impacts on the function and quality of a product including ergonomic considerations 2.5 apply appropriate engineering concepts and approaches in the execution of their design solutions 2.6 use relevant information to enhance design and function
Developing and manufacturing	2.7 apply their knowledge of the properties associated with a range of engineering materials 2.8 manufacture a product from a working drawing 2.9 modify an existing product/design 2.10 incorporate basic project management techniques
Communicating	2.11 present ideas through modelling and prototyping, using appropriate media 2.12 communicate their design decisions using suitable media

Strand 3: Mechatronics

BRIEF OVERVIEW OF STRAND

In this strand, students may work with a combination of mechanical, manufacturing, electronic and computing systems and software to explore relationships between simple inputs, processes and outputs. They will learn about systems, and how they can be coordinated to ensure the desired output. Students develop the engineering mindset to appreciate how control systems operate on a larger scale, and how the design of control systems can impact on the environment and sustainability. They appreciate the role that engineers have in employing 'systems thinking' to design products and services that contribute to a better future.

Elements	**Learning outcomes** *Students should be able to:*
Engineering knowledge and awareness	3.1 explain the operation of basic mechatronic systems 3.2 investigate relationships between inputs, processes and outputs for basic control systems 3.3 appreciate the application of mechanisms in a controlled system
Innovation and exploration	3.4 explore the application of systems in an engineering setting such as the classroom, home and industry 3.5 investigate the impact of mechatronics on the environment and society 3.6 configure and program basic mechatronic systems using appropriate software 3.7 design a basic mechatronic system either individually or collaboratively
Developing and manufacturing	3.8 build and test a basic mechatronic system with specific inputs or outputs 3.9 incorporate basic mechatronics into their engineered products
Communicating	3.10 represent key information using appropriate media 3.11 justify their choice of the most appropriate system or systems for a specified purpose

Assessment and reporting

Assessment in education involves gathering, interpreting and using information about the processes and outcomes of learning. It takes different forms and can be used in a variety of ways, such as to record and report achievement, to determine appropriate routes for learners to take through a differentiated curriculum, or to identify specific areas of difficulty or strength for a given learner. While different techniques may be employed for formative, diagnostic and summative purposes, the focus of assessment and reporting is on the improvement of student learning. To do this it must fully reflect the aim of the curriculum.

The junior cycle places a strong emphasis on assessment as part of the learning process. This requires a more varied approach to assessment, ensuring that the assessment method or methods chosen are fit for purpose, timely and relevant to the students. Assessment in Engineering at junior cycle will optimise the opportunity for students to become reflective and active participants in their learning and for teachers to support this. This can be achieved through the provision of opportunities for students to negotiate success criteria against which the quality of their work can be judged by peer, self, and teacher assessment; and through the quality of the focused feedback they get in support of their learning.

Providing focused feedback to students on their learning is a critical component of high-quality assessment and a key factor in building students' capacity to manage their own learning and their motivation to stick with a complex task or problem. Assessment is most effective when it moves beyond marks and grades, and reporting focuses not just on how the student has done in the past but on the next steps for further learning. This approach will ensure that assessment takes place as close as possible to the point of learning. Final assessment still has an important role to play but is only one element of a broader approach to assessment.

Essentially, the purpose of assessment and reporting at this stage of education is to support learning. Parents/guardians should be given a comprehensive picture of student learning. Linking classroom assessment and other assessment with a new system of reporting that culminates in the awarding of the Junior Cycle Profile of Achievement (JCPA) will offer parents/guardians a clear and broad picture of their child's learning journey over the three years of junior cycle. To support this, teachers and schools have access to online assessment support material. Along with the guide to the Subject Learning and Assessment Review (SLAR) process, this focuses on learning, teaching and assessment support material, including:

- formative assessment
- planning for and designing assessment
- ongoing assessments for classroom use
- judging student work – looking at expectations for students and features of quality
- reporting to parents and students
- thinking about assessment: ideas, research and reflections
- a glossary.

The contents of the online support material include the range of assessment supports, advice and guidelines that enable schools and teachers to engage with the new assessment system and reporting arrangements in an informed way, with confidence and clarity.

Assessment for the JCPA

The assessment of Engineering for the purposes of the Junior Cycle Profile of Achievement (JCPA) will comprise:

- two Classroom-Based Assessments: Engineering in action, and Research and development
- a project
- a written examination.

TABLE 3: ASSESSMENT OF ENGINEERING

Classroom-Based Assessments

Assessment	**Assessment methods**
CBA 1: Engineering in action	The teacher's judgement is recorded for the purpose of subject learning and assessment review, and for the school's reporting to parents and students. The CBA will be completed within a three-week period during term two of second year.
CBA 2: Research and development	The teacher's judgement is recorded for the purpose of subject learning and assessment review, and for the school's reporting to parents and students. This CBA will inform the student's work under the Project assessment. The CBA will be completed within a three-week period during term one of third year.

	Weighting	
Project	70%	Will be specified and marked by the State Examinations Commission annually.
Written examination	30%	Set and marked by State Examinations Commission.

Rationale for the Classroom-Based Assessments in Engineering

Classroom-Based Assessments are the occasions when the teacher assesses the students in the specific assessments that are set out in the specification. Classroom-Based Assessments are similar to the formative assessment that occurs every day in every class. However, in the case of the Classroom-Based Assessments, the teacher's judgement is recorded for the purpose of subject learning and assessment review, and for the school's reporting to parents and students.

Over the three years of junior cycle students will be provided with opportunities to stimulate their curiosity and interest in Engineering. The Classroom-Based Assessments link to the priorities for learning and teaching in Engineering. It is envisaged that through the Classroom-Based Assessments students will actively engage in practical and authentic learning experiences.

The Classroom-Based Assessments will provide an opportunity for students to:

- research information using a range of methods
- analyse data and evidence to make informed valued judgements and decisions
- organise information and plan logically
- communicate clearly and effectively
- collaborate with others on tasks
- communicate evidence of the cyclical process of design and reflect on their learning.

Through these Classroom-Based Assessments they will develop their knowledge, understanding, skills, and values, thereby achieving the learning outcomes across the strands.

Assessing the Classroom-Based Assessments

More detailed information related to assessment of the Classroom-Based Assessments will be available in separate Assessment Guidelines. This will include, for example, the suggested length and formats for student pieces of work, the features of quality to be applied to the assessment, and support in using 'on balance' judgement in relation to the features of quality.

The assessment section of www.ncca.ie will also include substantial resource material for use and reference in ongoing classroom assessment of Engineering at junior cycle, as well as examples of student work and guidance for the Subject Learning and Assessment Review process.

Classroom-Based Assessment 1: Engineering in action

Engineering in action provides students with the opportunity to actively engage in a practical and authentic learning experience that allows them to, individually or collaboratively, explore the applications of engineering in the world around them. Students will investigate real-life applications of the processes and principles of engineering. Students can focus their investigation through the lens of a specific strand, a combination of two strands or can adopt an integrated approach across all three strands. The students will communicate their findings through any appropriate media[3]. Further information will be set out in the Assessment Guidelines for Engineering.

3 Such as practical work, verbal, electronic, written and/or a combination.

Classroom-Based Assessment 2: Research and development

This Classroom-Based Assessment will encourage students to carry out research based on a theme which will be reflective of an aspect of the final project. The purpose of this CBA is to research, explore and present their findings through any appropriate media. Classroom-Based Assessment 2 will inform the project assessment.

Further information will be set out in the Assessment Guidelines.

Features of quality

The features of quality support student and teacher judgement of the Classroom-Based Assessments and are the criteria that will be used by teachers to assess the pieces of student work. Features of quality for the Classroom-Based Assessments will be provided in the Assessment Guidelines.

Project

On completion of the Classroom-Based Assessments, students will undertake a project for assessment. The project is completed after the second Classroom-Based Assessment in third year. The project is prescribed and is marked by the State Examinations Commission.

Written examination

The written examination:

- is of 90 minutes' duration
- will take place at the end of third year and will be offered at a common level
- will be set and marked by the State Examinations Commission.

Inclusive assessment practices

This specification allows for inclusive assessment practices whether as part of ongoing assessment or Classroom-Based Assessments. Where a school judges that a student has a specific physical or learning difficulty, reasonable accommodations may be put in place to remove, as far as possible, the impact of the disability on the student's performance in Classroom-Based Assessments. The accommodations, e.g. the support provided by a special needs assistant or the support of assistive technologies, should be in line with the arrangements the school has put in place to support the student's learning throughout the year.

Appendix A: Glossary of Engineering terms

This glossary is designed to clarify the terminology used in the junior cycle Engineering specification, enabling teachers and students to understand how the terms are interpreted and applied.

Term	Interpretation
Systematic process	This is a process in which several characteristic steps are taken. Identifying the problem; generating ideas; and testing of potential solutions through the building and testing of models and prototypes. Students use the information from these steps to evaluate what is needed to improve the design or devise a better one.
Prototypes	This is a rough model of the final product that a student can then refine and perfect before they create the final product. It is the first full-size, complete item of a product which distinguishes it from a model, where scale is arbitrary.
Simulations	A computer ***simulation*** is a tool to virtually investigate the behaviour of a system. Simulations model real-***life*** or hypothetical situations on a computer; this allows students to see how a system works and enables them to change variables so that predictions can be made about the behaviour of the system.
Solutions	In this specification, a solution refers to a completed product or process. The solution integrates all the stages of manufacture or design, starting with the early design stages, and ending with the finished product or process. The solution incorporates optimum ergonomics, efficiency and sustainability.

Appendix B: Glossary of action verbs

This glossary is designed to clarify the learning outcomes. Each action verb is described in terms of what the learner should be able to do once they have achieved the learning outcome. This glossary will be aligned with the command words used in the assessment.

Verb	Description
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 of, have a practical understanding of
Build	construct by putting parts or material together
Calculate	obtain a numerical answer showing the relevant stages in the working
Choose	pick out as being the best or most appropriate of two or more alternatives
Communicate	use visual, gestural, verbal or other signs to share meaning or exchange information; interaction between sender and recipient; both work together to understand
Configure	arrange or put together in a particular form or configuration
Construct	develop information in a diagrammatic or logical form; not by factual recall but by analogy or by using and putting together information
Convert	change to another form
Create	process and give form to the topic that is to be created using selected methods and material and/or to give the material used a new form
Demonstrate	prove or make clear by reasoning or evidence, illustrating with examples or practical application
Describe	develop a detailed picture or image of, for example a structure or a process, using words or diagrams where appropriate; produce a plan, simulation or model
Design	planning the features of a solution that solves a perceived user problem
Determine	obtain the only possible answer by calculation, substituting measured or known values of other quantities into a standard formula
Develop	advance a piece of work or an idea from an initial state to a more advanced state
Draft	develop an idea or concept for planned work

Verb	Description
Engage	enter into or become occupied by an activity or interest; to attract or hold interest and attention
Engineer	develop/build an item for a specific purpose that includes critical-to-function components
Estimate	give a reasoned order of magnitude statement or calculation of a quantity
Evaluate (data)	collect and examine data to make judgements 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 judgements about the ideas, solutions or methods
Evaluate (ethical judgement)	collect and examine evidence to make judgements and appraisals; describe how evidence supports or does not support a judgement; identify the limitations of evidence in conclusions; make judgements about the ideas, solutions or methods
Explain	give a detailed account including reasons or causes
Examine	consider an argument or concept in a way that uncovers the assumptions and interrelationships of the issue
Evidence	provide information indicating if something is true, or valid or to establish facts in investigation
Explore	to think or talk about something in order to find out more about it
Identify	recognise patterns, facts, or details; provide an answer from a number of possibilities; recognise and state briefly a distinguishing fact or feature
Illustrate	use examples to describe something
Illustrate (graphically)	use drawings or examples to describe something
Incorporate	take in or contain something as part of a whole
Investigate	observe, study, or make a detailed and systematic examination, to establish facts and reach new conclusions
Interpret	use knowledge and understanding to recognise trends and draw conclusions from given information
Justify	give valid reasons or evidence to support an answer or conclusion
List	provide a number of points, with no elaboration
Manufacture	something made from raw materials by hand or by machinery
Measure	quantify changes in systems by reading a measuring tool
Model	generate a mathematical representation (e.g., number, graph, equation, geometric figure) for real-world or mathematical objects, properties, actions, or relationships
Modify	to alter one or more particulars of an object/product
Present	make objects perceivable for others

Verb	Description
Program	to instruct a device or system to operate in a particular way or at a particular time
Prove	use a sequence of logical steps to obtain the required result in a formal way
Realise	implement, execute or put into practice an idea or a product or a draft
Recognise	identify facts, characteristics or concepts that are critical (relevant/ appropriate) to the understanding of a situation, event, process or phenomenon
Respond	react to a stimulus which may be: critical emotional aesthetic or contextual based, or a combination of these
Represent	bringing clearly and distinctly to mind by use of description or imagination
Research	the study of materials and sources in order to establish facts and reach new conclusions; revision of accepted theories or laws in the light of new facts
Review	looking over or through material in order to correct, improve or revise
Sketch	represent by means of a diagram or graph (labelled as appropriate); the sketch should give a general idea of the required shape or relationship, and should include relevant features
Solve	find an answer through reasoning
Test	establish the quality, performance, or reliability of something
Understand	have and apply a well-organised body of knowledge
Use	apply knowledge or rules to put theory into practice; employ something in a targeted way
Verify	give evidence to support the truth of a statement
Visualise	make visible to the mind or imagination something that is abstract or not visible or present to the eye

Appendix C: Summary of some engineering disciplines

Below is a list of some of the more popular disciplines of engineering. This is by no means a complete list, and each discipline overlaps with other disciplines. Employers from all industries solicit and recruit engineers from all disciplines based on their problem-solving skills and critical-thinking skills.

Aerospace engineering encompasses the entire field of aerodynamics in the earth's atmosphere and in space. Aerospace engineers concentrate on several areas related to vehicle design, such as the development of power units, vehicle structure, aerodynamics, guidance control, and the launching of missiles and satellites.

Agricultural engineering is concerned with the design of machines and systems used in producing food and fibre. Agricultural engineers are also called upon to develop new ideas and methods and to apply general engineering techniques to soil, water, and air resources, power and energy sources, plant and animal environments, and food handling, processing and storing.

Architectural engineering is closely related to architecture. Whereas architecture emphasises the aesthetics, design and function of the built environment viewed as a whole, architectural engineering is concerned with the soundness of the structure itself and its components, such as the mechanical and environmental systems.

Bioengineering and biomedical engineering merge the disciplines of engineering, biology, and medicine to create techniques and devices that are based on an understanding of living systems and serve the objective of improving the quality of human and animal life.

Chemical engineering combines the science of chemistry with the discipline of engineering. Chemical engineers design nearly all of the equipment and processes needed for various types of manufacturing plants. Chemical engineers are also involved in developing pollution control processes and equipment, and the construction and operations of manufacturing facilities.

Civil engineering deals primarily with planning the design and construction of all the nation's constructed facilities (buildings, bridges, canals, dams, airports, railroads, etc.). The civil engineer is also involved in the operation of transportation facilities and environmental protection facilities relating to water, air, and solid wastes.

Computer engineering, computer information systems, computer science and information science all deal with digital equipment (computers). The spectrum covers the theory, design, and applications of computers (hardware) and information processing techniques (software). Design of hardware and systems is a predominant area of programs in computer engineering. Computer science programs emphasise theory of computation, probability, matrices, and similar subject matter. Computer information systems or information science programs, on the other hand, emphasise arrangement of input and output, rather than the mechanics of computing.

Electrical engineering and electronics engineering cover everything related to electricity. Electric power engineers concentrate on making electrical energy available and properly utilised. Electrical and electronics engineers are concerned with systems, circuits, and devices used in communication, computer and entertainment systems, health care instruments, and automated control systems. A great number of electrical and electronics engineers go directly into the design and production of computers.

Environmental engineering is a field that has emerged in response to the public's demand for clean air and water and a concern over the damage being done to the earth and ecological systems by pollution. Environmental engineers design or operate facilities for environmental protection.

Industrial engineering has to do with the organisation of materials, people, and equipment in the production process. Industrial engineers design systems and facilities with a view towards ensuring both quality and efficiency. A subdiscipline called operations research is concerned with decision making based on the management of organisational systems (Management of Technology).

Materials engineering, metallurgical engineering, ceramic engineering, materials science, and metallurgy have many things in common. They are concerned with the extraction, processing, refinement, combination, manufacture, and use of different natural substances. Engineers in metallurgy and metals deal with metals; those in materials may work with a broad scope of substances; and those in ceramics work with non-metallic minerals.

Mechanical engineering is concerned with the design, manufacture, and operation of a wide range of mechanical components, devices, and systems. Many mechanical engineers are involved in the design and production of machines to lighten the burden of human work while others practise in the areas of heating and air-conditioning, automotive, manufacturing, and refrigeration engineering.

Nuclear engineering is concerned with the development, design, maintenance, repair, and control of nuclear power plants and fuel processing facilities.

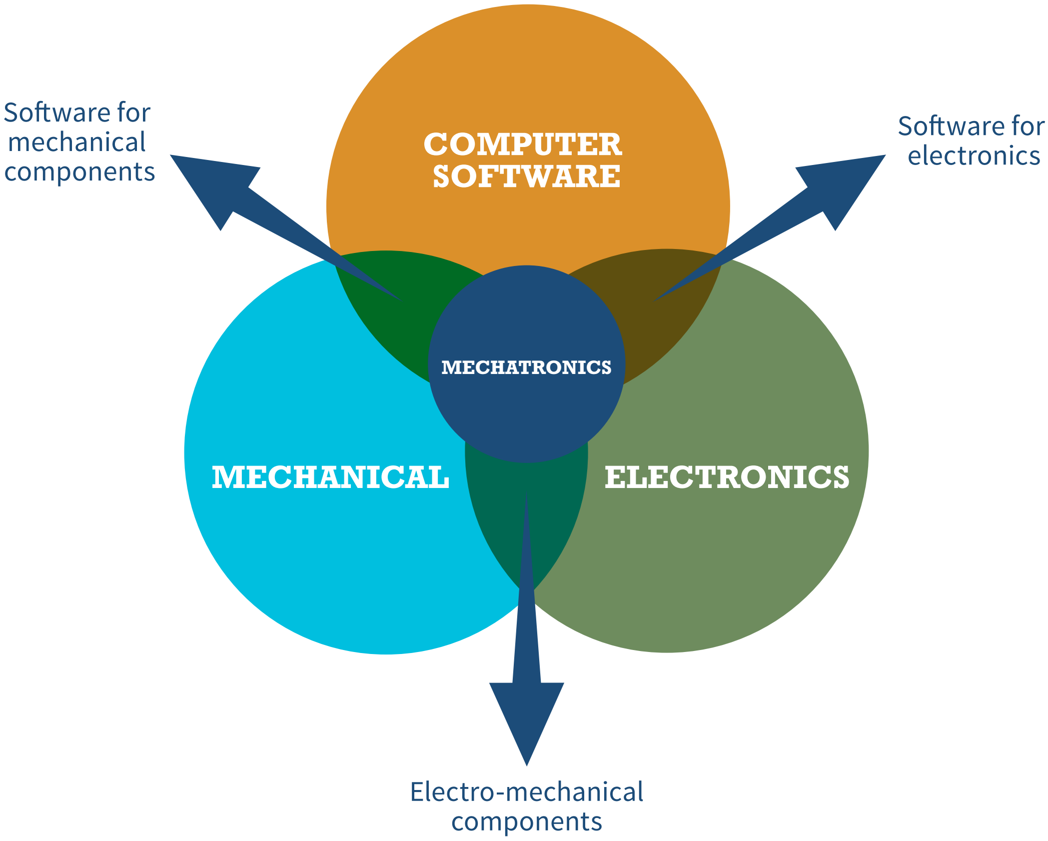
Petroleum engineering is concerned with exploration, drilling, and production of oil and gas. Petroleum engineers also are involved in developing and using increasingly-sophisticated recovery methods to obtain economical supplies of oil and natural gas.

Plastics engineering and polymer science is concerned with the production of nonmetallic synthetic polymers, with the goal of optimising the process and achieving desired properties of the manufactured material. In general, the field of polymer science limits itself to determining properties of polymers and does not deal with their application.

Structural engineering is a sub-discipline of civil engineering in which structural engineers are trained to understand, predict, and calculate the stability, strength and rigidity of built structures for buildings and nonbuilding structures, to develop designs and integrate their design with that of other designers, and to supervise construction of projects on site. They can also be involved in the design of machinery, medical equipment, and vehicles where structural integrity affects functioning and safety.

Systems engineering is concerned with designing a number of components that work together in a given situation. A growing number of systems engineers are involved with the integration of various pieces of computer hardware to accomplish specified tasks.

Appendix D: Mechatronics diagram



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