



Engineering and Manufacturing: Design and Development

T Level outline content: draft version

January 2020

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Introduction

Outline content

This outline content has been produced by [T Level panels](#) of employers, professional bodies and providers, and is based on the same standards as those used for apprenticeships. The outline content will form the basis of the specifications for T Level Technical Qualifications, which will be developed by awarding organisations for approval by the Institute for Apprenticeships and Technical Education. One awarding organisation will be appointed to develop and deliver each Technical Qualification following a procurement process.

Colleges and other education and training providers will decide how to structure the T Level courses they offer, based on the qualification specifications. This will enable them to deliver the study programme's mandatory components in the most effective way for students.

A T Level programme consists of a Technical Qualification, substantial industry placement, English and maths, and other occupation-specific requirements where essential for entry to skilled employment. This outline content relates solely to the Technical Qualification part of a T Level programme.

To support progression to skilled employment and further study, the outline content for Engineering and Manufacturing includes a significant level of maths content. However, the admissions requirements of individual Higher Education institutions vary and may also require students to undertake an A level in maths or equivalent alongside their T Level. Additional funding is available to ensure providers are able to offer maths A level, or further maths alongside the T Level should they deem it appropriate to support student progression, and the T Level panel have recommended this is made available to students where appropriate.

A reference document has also been prepared by the T Level panel to provide further detail on the knowledge and skills that they would expect a student to develop as part of the T Level. This will be shared with the awarding organisation selected to deliver this T Level ahead of their direct engagement with the panels prior to milestone 1 of the contract.

Further information about T Levels is available on the website of the Institute for Apprenticeships and Technical Education here: www.instituteforapprenticeships.org, and at www.education.gov.uk.

Engineering and Manufacturing route: Design and Development pathway

Awarding organisations will need to ensure that students have an up-to-date knowledge of the legal and regulatory obligations relating to employment in the occupations relevant to the T Level, and understand the practical implication of these on their work.

Maths, English and digital skills are set out in a separate annex. Awarding organisations should integrate these within the qualification so that they are applied in occupationally relevant contexts.

Core content

The core content relates to the whole route 'route core', and the pathway that the Technical Qualification covers 'pathway core'. The core knowledge and understanding is assessed through an examination and core skills through a practical employer-set project.

The core knowledge and understanding focuses on the students' knowledge and understanding of contexts, concepts, theories and principles relevant to the T Level. This could include, where appropriate, assessment of knowledge and understanding relevant to the route and the pathway.

The employer-set project provides the opportunity to develop and apply a minimum range of core skills important for employability. The allocation of content to each type of assessment will need to be approved by the Institute for Apprenticeships and Technical Education.

Engineering and Manufacturing: core skills and workplace practices

The outline content for the T Level "Engineering and Manufacturing: Design and Development" confirms the knowledge, skills and behaviours which form the basis of its syllabus and its assessment requirements. The outline content will be designed and developed into a high-quality technical qualification by the awarding organisation that is awarded the licence for this T Level.

The outline content presents knowledge and skills statements across the different components based upon the intended assessment method (e.g. examinations; employer set project; occupational specialism assignments). It is important to recognise that the structure of the document does not illustrate intended course design, indicate recommended teaching and learning strategies, or imply that these components should be delivered discretely or even sequentially.

T Levels are intended to support flexible delivery models, and to increase the opportunities for centres and practitioners to work with their awarding organisation to determine how best to develop and deliver the knowledge and skills outlined, and to tailor programmes to meet the diverse needs of their students.

Engineering and Manufacturing T Level students must start to develop technical and practical skills from the beginning of their programmes, while becoming familiar with the

workplace practices that are essential to safe and effective engineering and manufacturing activities. The content specified is to be developed and secured through experience-led learning where possible, and students should begin to develop and apply fundamental knowledge and skills – using relevant tools and equipment – from the outset. These skills proficiencies, which will lead to defined “levels of competence” in the relevant occupational specialisms, must be developed in ways that reflect genuine workplace demands and world-class industry practices.

While the outline content defines the occupational specialist skills which will be acquired and developed by T Level students, it is important to recognise that these more advanced, specialist skills are underpinned by basic engineering and manufacturing skills and workplace practices, which form the foundation of operating safely and effectively in all engineering and manufacturing environments.

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Core knowledge and understanding across Engineering and Manufacturing Route

Element		Content
Working within the Engineering and Manufacturing Sectors	1.1	Engineering and manufacturing design practices An understanding of: <ul style="list-style-type: none"> • key principles, tools and methodologies in engineering and manufacturing design practice and processes; • how materials, conditions and context influence engineering and manufacturing design processes and products; • how user requirements are translated into engineering and manufacturing designs; • how research and testing, and different research and testing methodologies, support effective design practices and outcomes.
	1.2	Maintenance, installation and repair practices An understanding of: <ul style="list-style-type: none"> • the roles, functions and operations in this area of engineering and manufacturing practice, and how they relate to the sectors generally; • the key principles, techniques and methodologies relevant to engineering and manufacturing maintenance, installation and repair; • the tools and equipment used in maintenance, installation and repair; • key innovations, changing practices, and trends relevant to maintenance, installation and repair.
	1.3	Manufacturing, processing and control practices An understanding of: <ul style="list-style-type: none"> • key principles and practices that apply in manufacturing, processing and control; • key manufacturing, processing and control tools, equipment, infrastructure, systems and operations; • an understanding of the relationship between manufacturing, processing and control, and engineering design, and engineering maintenance, servicing, installation and repair.
Engineering and manufacturing past, present, and future	2.1	An understanding of: <ul style="list-style-type: none"> • engineering and manufacturing from an historical perspective, including awareness of important technological advances across different sectors, and significant periods of change;

		<ul style="list-style-type: none"> significant areas of innovation and emerging trends, and their implications for the sector, including artificial intelligence (AI), robotics, autonomous systems, distributed energy, new and smart materials, hybrid technologies; the influence, effects, and consequences of significant technological advances, and changing practices, in engineering and manufacturing, to include: <ul style="list-style-type: none"> principles of sustainability, including product lifecycle, circular economy, exploring alternatives, waste and disposal.
Engineering representations	3.1	<p>Engineering drawings and graphical language</p> <p>An understanding of:</p> <ul style="list-style-type: none"> how to accurately produce, interpret, and amend engineering representations, drawings, and graphical information (e.g. sketches, schematics, diagrams) in different contexts, using various techniques and relevant communications media; how best to calculate and apply the rules and principles of dimensioning, tolerancing and sizing within engineering and manufacturing contexts.
Essential mathematics for engineering and manufacturing	4.1	<p>Mathematical theory and applications</p> <p>A Level 3 knowledge and understanding of mathematics for engineering and manufacturing, including:</p> <ul style="list-style-type: none"> standard arithmetic: <ul style="list-style-type: none"> Ordering, intergers, fractions, decimals, percentages, ratios algebra – transposing, factorising and quadratics, Indices and standard forms <ul style="list-style-type: none"> including sequences and series, Problem solving involving growth and decay Geometry including: <ul style="list-style-type: none"> Calculation of areas and volumes of regular solids e.g. cylinders and spheres, Graphs and charts, relevant to straightforward engineering and manufacturing contexts; standard trigonometry including: <ul style="list-style-type: none"> Pythagoras’ theorem; circular measure; functions, sine and cosine rules; triangular measurement; graphs of trigonometric functions, logs (base 10 and natural) Common ergonomic identities; common ergonomic values. Applications of vectors including dot and cross product (in forces and motions, and alternating current). An understanding of moments (in mathematics and physics).

		<ul style="list-style-type: none"> • standard calculus including: <ul style="list-style-type: none"> ○ An understanding of the use of basic calculus to solve defined engineering-based problems using differential and integral calculus. • Standard matrices and determinants including: matrices and determinants for routine and non-routine operations; • Statistical analysis and probability relevant to fundamental engineering and manufacturing practices.
Essential science for engineering and manufacturing	4.2	Number systems used in engineering and manufacturing An understanding of: <ul style="list-style-type: none"> • numbering systems and their applications e.g. decimal, binary, octal and hexadecimal
	5.1	Scientific methods An understanding of standard international systems and units of measurement including: <ul style="list-style-type: none"> • the system of SI base quantities; • the relationship between metric and imperial measures and methods for converting between these two systems; • the nature (and differences) between scalars and vectors. An understanding of scientific method and effective approaches to scientific inquiry and research including: <ul style="list-style-type: none"> • the concept of the “scientific method”; • different methods, techniques, and models for scientific enquiry and research; • how to analyse, evaluate, synthesise and apply information, data, research findings, deliberation, and the processes, results and outcomes of testing, modelling, and experimenting; • the difference between accuracy, reliability and precision.
	5.2	Measurement An understanding of: <ul style="list-style-type: none"> • techniques for making appropriate and accurate measurements along with use of a range of measurement instruments, technologies, tools and equipment.

5.3 Chemical composition and behaviours

An understanding of:

- atomic and chemical structures of matter including:
 - the structure, composition, interaction and taxonomy of matter i.e. elements, atoms, molecules and compounds; mixtures, solutions, suspensions and solubility; density; crystals; metals;
 - simple to complex chemical structures.
- the principle behaviours and effects of chemical interactions in straightforward engineering and manufacturing contexts, including:
 - atomic structure, including the three types, and how this relates to material property
 - how chemicals are used in electricity, including electrochemical cells, the simple cell, internal resistance of a cell, primary and secondary cells, cell capacity, electrolysis and electroplating;
 - common behaviours and effects of chemical reactions in engineering and manufacturing contexts, such as acidity and alkalinity, corrosion and corrosion resistance, material degradation, and potentially dangerous chemical reactions in high-risk operational and manufacturing contexts, and appropriate management and control of these substances;
 - the nature and purpose of chemical interactions and reactions commonly used within engineering and manufacturing contexts, such as chemical etching, surface finishing, bonding, and applications for oils and lubricants
 - the relationship between chemical composition and material qualities (e.g. strength, ductility, weldability)

	<p>5.4</p>	<p>Physical forces and behaviours</p> <p>An understanding of:</p> <ul style="list-style-type: none"> • work, efficiency, energy, and power including: <ul style="list-style-type: none"> ○ the basic terminology and concepts; ○ force, displacement and cause in “work”; ○ mathematical equations for representing work and how the amount of work done by forces is calculated, negative work, and units of work; ○ potential, kinetic and mechanical energy including the interrelationship; ○ embodied energy. • the principal behaviours and effects of physical forces (static and dynamic) in straightforward engineering and manufacturing contexts including: <ul style="list-style-type: none"> ○ speed, velocity, acceleration, force, and mass; ○ forces acting at a point, linear and angular motion, linear momentum and impulse (and impulsive forces), the principles of conservation of energy and energy conversion, friction, effects of forces on materials, torque, forces acting within supported beams and structures. <p>A basic understanding of:</p> <ul style="list-style-type: none"> • fluid dynamics and general applications including flow, conditions of flow, viscosity, key differences between liquid and aerodynamics, gas flow, Bernoulli’s principle; • thermodynamics and applications including heating and cooling, thermal expansion, heat transfers mechanisms, the four laws of thermodynamics, steam cycles, heat engines, gas cycles, ideal gas laws. <p>An understanding of:</p> <ul style="list-style-type: none"> • Effects of forces on materials including: <ul style="list-style-type: none"> ○ Tensile force ○ Compressive force ○ Sheer force ○ Stress and strain ○ Elasticity and elastic limit ○ Hooke’s law
<p>Materials and their properties</p>	<p>6.1</p>	<p>An understanding of:</p> <ul style="list-style-type: none"> • the properties, structures, and classification of materials including: <ul style="list-style-type: none"> ○ material structures, composition, and bonding in relation to (i.e.): metals (ferrous and non-ferrous), plastics, polymers, natural materials, and composites, and comparative evaluation of materials. • the selection (including rationale), applications and disposal requirements of materials, including:

		<ul style="list-style-type: none"> ○ mechanical, electrical, thermal, magnetic, optical, and deteriorative contexts, and applications; ○ the nature, applications, and advantages of contemporary and smart materials. ● material processing techniques and their effects on materials, including: <ul style="list-style-type: none"> ○ common methods of materials processing and their appropriateness to particular materials and contexts e.g. welding, joining, shaping, brazing, soldering, tempering, hardening, annealing, casting, moulding, sintering, forging, machining, ceramics, composites, wood, foam, smart materials, additive manufacturing; measuring and marking out; ● how different materials respond to processing; ● heat treatments and surface treatments; ● material quality, the condition of materials, how these are managed, and materials testing methods and techniques (destructive and non-destructive), including: <ul style="list-style-type: none"> ○ how materials degrade and fail, mitigation and prevention; ○ how the condition of materials is identified, monitored, and maintained; ○ the range of standard materials testing methods and techniques, their purposes, applications, and relative advantages and disadvantages (e.g. tensile, hardness, ultrasonic, magnetic particle, disposal).
<p>Mechanical principles</p>	<p>7.1</p>	<p>An understanding of:</p> <ul style="list-style-type: none"> ● the fundamentals of motion and mechanics (static and dynamic) underpinning engineering and manufacturing systems, including: <ul style="list-style-type: none"> ○ (Newtonian) 'laws of motion'; principles and laws relating to inertia, friction, momentum, and gravity; different types of forces (e.g. concurrent forces, non-concurrent co-planar force systems, and non-contact forces); ○ simply supported beams, including static equilibrium (and associated conditions), loading, load distribution, supported reactions; loaded components; ○ relevant laws and theories of motion and mechanics, and how they relate to forces and force systems. ● storage and transfer of forces and energy in operation, including: <ul style="list-style-type: none"> ○ kinetic energy, principles and parameters, to include displacement, velocity and uniform linear acceleration; ○ dynamic parameters and principles; tractive effort, braking force, gravitational force, frictional resistance, momentum, mechanical work power, Newton's laws of motion, D'Alembert's principle,

		<p>principle of conservation of momentum, principle of conservation of energy;</p> <ul style="list-style-type: none"> ○ practical examples of storage, potential and transfer of energy (e.g. fly wheels, springs, height, pressurised fluids); ○ the range of power sources available across physical, mechanical, electrical, and renewable, including examples of solar, hydro, wind, electric motors, internal combustion, and steam; ○ the operation of mechanical principles and systems.
<p>Electrical and electronic principles</p>	<p>8.1</p>	<p>Electrical and electronic principles</p> <p>An understanding of:</p> <ul style="list-style-type: none"> ● the basic principles of electricity and electronics, including: <ul style="list-style-type: none"> ○ the physical principles underpinning electrical and electronic systems and devices (e.g. basic atomic theory, structure and composition, energy, power, networks, charges, flow, force, current, capacitance, waves, conduction, magnetism, inductance, and standard units of measure). ● the fundamentals of electric circuit theory and its applications including the coverage of: <ul style="list-style-type: none"> ○ electricity, electronics, voltage, current, AC/DC, power, resistance, potential difference and dividers, basic electrical elements, Ohm and Kirchhoff's current and voltage laws; ○ use of Ohm's law to calculate parameters in series circuits, parallel circuits and mixed circuits; ○ calculation of current, voltage, and resistance, using circuit theory. ● the basic principles of analogue and digital electronics and their applications, including: <ul style="list-style-type: none"> ○ the differences in signals used in transmission of information, usually electronic signals; ○ characteristics of analogue and digital signals, their definitions, waveforms, voltage and current values, fan in and fan out, signal conditioning, and relevant control systems; ○ examples and relevant technologies, waves, representations (e.g. block diagrams and hierarchical design), flexibilities, uses, memory, power and cost; ○ mathematical methods applied to signal processing. ● how to apply knowledge of theories, laws and relevant representations to investigate and solve straightforward problems relating to voltage, current, and resistance in engineering contexts (e.g.): <ul style="list-style-type: none"> ○ analysis of voltage and current in DC circuit networks comprising resistors, capacitors and

		<p>inductors in series, parallel, and combined series parallel circuits;</p> <ul style="list-style-type: none"> ○ the relationship between voltage, current and power in AC circuits and represent them in graphs and phasor diagrams; ○ the key electrical properties of semiconductor devices such as diodes operating in forward and reverse mode; ○ High power electrical equipment and electronic devices, their specific issues and applications. <ul style="list-style-type: none"> ● basic properties and principles of magnetism and their common applications in relevant engineering and manufacturing contexts, for example, the relationship between flux density and field strength.
Mechatronics	9.1	<p>An understanding of the key components of integrated mechanical and electrical systems; their design, operation, and applications, including:</p> <ul style="list-style-type: none"> ● the operation of electronic devices and circuits in mechatronic contexts; ● the operation, use and applications of programmable logic controllers, and the integration and application of mechatronic systems; ● the basic principles and applications of hydraulics and pneumatics in relevant contexts.
Engineering and manufacturing control systems	10.1	<p>Control systems</p> <p>An understanding of:</p> <ul style="list-style-type: none"> ● control system theory, including: <ul style="list-style-type: none"> ○ open and closed loop systems, including their functions and operation, applications, advantages and disadvantages; ○ how control systems are represented in diagrams and their key features (e.g. input/output; transfer function; feedback; summing points) in different applications (e.g. electrical, pneumatic); ○ the relationship between input and output (e.g. steady rate error); ○ feedback and performance in closed loop systems, including under or over-damped, and time dependency; ○ a basic understanding of pulse width and amplitude modulation for control; ○ the advantages and disadvantages of analogue and digital control systems; ○ An understanding of measured parameters (e.g. pressure flow, temperature, speed, position) <p>An understanding of:</p> <ul style="list-style-type: none"> ● how sensors and actuators are used in automation control systems, including:

		<ul style="list-style-type: none"> ○ the purpose and functions of sensors and actuators in control systems (e.g. position and volume of objects being processed; mechanised lifting and moving of objects); ○ types of sensors (e.g. analogue; digital; active; passive), their applications (e.g. switches; proximity sensors; laser; vision systems) and their measurement applications, including electrical, mechanical, thermal, chemical, biological, optical, acoustic and radiation; ○ types of actuators and applications, and different power sources.
Recognised standards in engineering and manufacturing	11.1	<p>Recognised engineering and manufacturing standards</p> <p>An understanding of:</p> <ul style="list-style-type: none"> ● the framework of relevant established engineering and engineering standards, for example: <ul style="list-style-type: none"> ○ British Standards (BS) and International Organisation for Standardisation standards (ISO), in terms of range, purposes, and applications in engineering contexts; some awareness of other standards, in terms of types, jurisdictions (e.g. CE), content differences and purposes standards, symbols, conventions and annotations. ● the authorities (e.g. Engineering Council), agencies and professional bodies (e.g. IET, IMechE, SOE,) responsible for established engineering and manufacturing standards, their roles and responsibilities; ● the purposes, value and applications of established engineering and manufacturing standards in engineering contexts including: <ul style="list-style-type: none"> ○ the intended effects of these standards on the quality and safety of goods, products, processes, people, and the environment.
Standard operating procedures (SOPs)	12.1	<p>An understanding of:</p> <ul style="list-style-type: none"> ● standard operating procedures, in terms of types, purposes, functions, value, and applications; ● how and why standard operating procedures are produced, implemented and evaluated in different contexts and for different purposes; ● how to access, interpret and comply with standard operating procedures.
Health and safety principles and coverage	13.1	<p>Health and safety principles, coverage, and legislation</p> <p>An understanding of:</p> <ul style="list-style-type: none"> ○ essential Health and Safety principles, practices, and procedures which apply in engineering and manufacturing contexts, including:

		<ul style="list-style-type: none"> ○ the importance of Health and Safety practices within the workplace; ○ potential risks and hazards in engineering and manufacturing contexts e.g. equipment, tools; electricity, harmful substances including gases, environments; common industrial injuries that can occur without appropriate precautions ○ the importance of health and safety requirements and practices within high power electrical contexts, across generation, distribution, isolation and storage ○ how health and safety practices, legal requirements and duties apply to different spheres and at different levels e.g. personal/individual, employee and employer obligations, local, national, and global requirements; ○ the health and safety issues, risks and practices that apply generally to engineering and manufacturing workplaces (e.g. safe systems of work; fire safety, oxygen use in the workplace, fire and explosion hazards, manual handling), and an awareness that specific requirements and regulations apply in specialist areas (e.g. Chemicals, Electrical testing, Guarding, Asphyxiation hazards); ○ effective risk and hazard management in different workplace and engineering and manufacturing specific contexts, for example: <ul style="list-style-type: none"> ○ an understanding of risk and hazard identification, and grading methods and procedures; ○ control measures (e.g. ERICPD, HAZOPs, HAZIDs) ○ key health and safety legislation, relevant regulations, duties, and authorities, including how to access them, for example: <ul style="list-style-type: none"> ○ Health and Safety Executive (HSE); ○ Reporting of Injuries, Diseases, and Dangerous Occurrences 2013 (RIDDOR); Health and Safety at Work etc. Act 1974 (HASAWA); Control of Substances Hazardous to Health regulations 2002 (COSHH); ○ sector specific examples of relevant legislation, regulations, duties and obligations; ● the principles and practices relating to environmental standards, legislation, regulations, compliance and wider sustainability issues, including waste disposal requirements and regulations.
<p>Business, commercial and financial awareness</p>	<p>14.1</p>	<p>An understanding of:</p> <ul style="list-style-type: none"> ● basic commercial principles, contexts and operations, including: <ul style="list-style-type: none"> ○ commercial priorities, principles relating to efficiency and “added value”; ○ markets, customers/clients/partners and resource allocation.

		<ul style="list-style-type: none"> • Standard and emerging business and commercial practices, including: <ul style="list-style-type: none"> ○ tendering and contracts and legal issues; ○ management practices, business models, staffing, training, development, research and innovation. <p>An understanding of:</p> <ul style="list-style-type: none"> • financial and economic concepts and terms relating to the management of money, sources of finance, transactions, revenue, cash flow, profit, costs, payments, assets, liabilities, solvency, financial responsibility, performance; • basic financial literacy e.g. budgets and recording financial transactions, business taxes and rates.
Professional responsibilities, attitudes, and behaviours	15.1	<p>An understanding of:</p> <ul style="list-style-type: none"> • professional conduct and responsibilities in the workplace (and in different engineering and manufacturing contexts), including those relating to: <ul style="list-style-type: none"> ○ an understanding of own role and responsibilities, relationship to others, organisational structure, accountabilities and inter-dependencies; ○ equality, access and inclusion. • “human factors” within engineering and manufacturing contexts, including: <ul style="list-style-type: none"> ○ human characteristics, capabilities and limitations; ○ how design, performance and evaluation consider safety, comfort and productivity; ○ human performance, error, and error reduction tools and methodologies. • reputation, ethics, personal, professional, and wider, responsibilities which apply in the workplace, in commercial settings, and in different engineering and manufacturing contexts; • Continuous professional development (CPD) and professional recognition.
Stock and asset management	16.1	<p>Stock and inventory management and control</p> <p>A general understanding of:</p> <ul style="list-style-type: none"> • stock and inventory management principles and practices including: <ul style="list-style-type: none"> ○ the purpose of effective stock inventory management and control; ○ common models and their purposes. • key issues, risks, advantages and disadvantages associated with different stock inventory management and control practices, including: <ul style="list-style-type: none"> ○ product life cycles, write down, redundant stock, obsolescence, and minimum stock levels; supply chain issues; packaging/storage (e.g. electro-static discharge).

		<p>Asset management and control</p> <p>An understanding of:</p> <ul style="list-style-type: none"> • asset management principles and practices including: <ul style="list-style-type: none"> ○ asset lifecycle management processes. • key issues, risks, advantages and disadvantages associated with different asset management and budgetary control practices including: <ul style="list-style-type: none"> ○ understand the asset “life cycle” and the “whole life” approach; ○ issues and requirements associated with the operation and maintenance of assets; ○ the importance of asset management and budgetary control practices.
Quality assurance, control and improvement	17.1	<p>An understanding of:</p> <ul style="list-style-type: none"> ○ quality in engineering and manufacturing developments, processes and activities, including: ○ the main principles, purposes and outcomes of quality assurance; quality control, inspection and testing; quality improvement systems, processes and practices; ○ Workplace practices e.g. 6S methodology – “sort”, “set in order”, “shine”, “standardise”, “sustain” and “safety”.
Continuous improvement	18.1	<p>An understanding of:</p> <ul style="list-style-type: none"> • the principles and practices of continuous improvement; • specific stages and methods for planning, implementing, monitoring and evidencing continuous improvement, including: <ul style="list-style-type: none"> ○ reflection and evaluation of processes and practices, continual, incremental changes, improvements and refinements; ○ different methods for gathering feedback and evidence about performance; • different approaches to continuous improvement including: <ul style="list-style-type: none"> ○ different methods and objectives appropriate to specific roles; ○ lean principles and practices; ○ management philosophies focused on continuous improvement (e.g. Six Sigma, Kaizen)
Project and programme management	19.1	<p>An awareness of:</p> <ul style="list-style-type: none"> • how projects are defined, structured, reported on, and measured, according to standardised project management practices, protocols, processes and documentation; • the roles, responsibilities, structure and management of relevant personnel in project management practices

		<p>including external stakeholders and communication channels.</p> <p>An understanding of:</p> <ul style="list-style-type: none">• project planning, control methodologies and practices;• risk management<ul style="list-style-type: none">○ budget, quality, cost and time.
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Core knowledge and understanding across Design and Development Pathway

Element		Content
Customer and client requirements	P1	<p>An understanding of:</p> <ul style="list-style-type: none"> • how to identify and interpret client and customer requirements, including: <ul style="list-style-type: none"> ○ how to accurately identify, interpret, and confirm client and customer requirements; ○ an awareness of client and customer expectations and commercial and operational context. • how to appropriately record, evaluate and develop client and customer requirements, including: <ul style="list-style-type: none"> ○ how to record and present client or customer requirements, proposals, ideas, objectives and aspirations; ○ how to agree the nature and scope of particular projects (acknowledging that this may normally occur at a senior level); ○ how to evaluate, develop, challenge, and refine ideas, proposals and objectives, where appropriate.
Principles of design	P2	<p>An understanding of the principles of design, and its methodologies, processes, techniques and tools, including:</p> <ul style="list-style-type: none"> • process: the clearly defined “need to be met”, the creative response to the need, and the methods to deliver solutions to the need; • design focus: technical, ergonomic and aesthetic; • ideas generation techniques and creative processes; • making and production methods; tools, technology and equipment; • design optimisation: practical application, design constraint variables and objectives, the use of mathematics for design, and the impact of digital tools in design processes and outcomes.
Design processes	P3	<p>Key stages and roles in the design process, including:</p> <ul style="list-style-type: none"> • the iterative process of design from research, design requirements, feasibility conceptualisation, preliminary designs, detailed designs, and modelling and testing; • problem identification, research and information gathering, creative stage/s, concept selection, embodiment, modelling, detailed design, design management, and presentation.
Design focus and application	P4	<p>An understanding of:</p> <ul style="list-style-type: none"> • design for specific fields: <ul style="list-style-type: none"> ○ manufacture and processing (including additive);

		<ul style="list-style-type: none"> ○ maintenance, installation, servicing, repair and decommissioning; ○ engineering and manufacturing product life cycles; ○ re-use; ○ sustainability; ○ safety; ○ compliance. ● how to design solutions to well defined engineering and manufacturing problems using established methodologies.
Communication in design	P5	An understanding of how to communicate design ideas, proposals and solutions to technical and non-technical audiences.

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Employer-set project

The employer-set project ensures students have the opportunity to combine core knowledge and skills to develop a substantial piece of work in response to an employer-set brief. The employer-set project forms part of the Technical Qualification and is a separate part of the T Level programme to the Industry Placement.

To ensure consistency in project scope and demand, awarding organisations will develop assessment objectives, which require students to:

- plan their approach to meeting the brief
- apply core knowledge and skills as appropriate
- select relevant techniques and resources to meet the brief
- use maths, English and digital skills as appropriate
- realise a project outcome and review how well the outcome meets the brief

The awarding organisation will work with a relevant employer or employers, to devise a set brief that:

- ensures a motivating starting point for students' projects, for example, a real-world problem to solve
- ensures students can generate evidence that covers the assessment objectives
- is manageable for providers to deliver
- is officially approved by the awarding organisation and employer

For Engineering and Manufacturing: Design and Development in achieving the assessment objectives and meeting the brief, students must demonstrate the following core skills (which are relevant across design, manufacture, and maintenance and repair practices):

Planning and preparation

- Interpret and confirm project requirements;
- Plan and scope project (e.g. timescales, requirements, resources, cost);
- Develop project plans.

Communication

- Interpret, use and produce engineering representations and drawings (including graphical language/conventions);
- Interpret and use relevant technical information in a range of formats and media;
- Communicate appropriately with technical and non-technical audiences (using appropriate technology, as appropriate).

Develop and Manufacture

- Design or devise a proposal to meet the brief;
- Develop, model and revise concept/s;
- Manufacture a suitable artefact;
- Safely use a range of basic hand and power tools and equipment.

Evaluation

- Carry out appropriate tests, evaluation and analysis (at relevant stages);
- Confirm appropriate model for final realisation, testing for suitability;

- Evaluate how well the final “working artefact” meets the brief (e.g. performance, quality, time, resources, cost, and client expectations).

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Occupational Specialist Content

Specialist content is structured into different occupational specialisms, which correspond to the apprenticeship standards listed on the relevant occupational map. Occupational specialisms ensure students develop the knowledge and skills necessary to achieve a level of competence needed to enter employment in the occupational specialism, and are organised around 'performance outcomes' that indicate what the student will be able to do, as a result of learning and applying the specified knowledge and skills.

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Occupational Specialism: Design and Development (Mechanical Engineering)

Performance Outcome 1: Analyse and interpret engineering and manufacturing requirements, systems, processes, technical drawings and specifications

Knowledge specific to performance outcome	Skills specific to performance outcome
<p>Common design methodologies, practices, processes, applications and integration, relevant to contemporary mechanical engineering contexts.</p> <p>Engineering representations, symbols, conventions, and annotations (e.g. geometrical dimensions, tolerances, limits, fits and finishes, terminology and nomenclature), specifically in mechanical engineering contexts and activities.</p> <p>Engineering standards and regulatory requirements relevant to mechanical engineering.</p> <p>Mathematical theory and methods and their application in mechanical engineering contexts.</p> <p>Scientific principles relevant to mechanical engineering activities.</p>	<p>Access, examine, review, interpret and respond effectively to mechanical design projects and tasks and requirements from different sources (e.g. specifications, concepts, stakeholders).</p> <p>Critique, challenge and confirm design project expectations and requirements appropriately, including requirement risks.</p> <p>Interpret information in a range of formats, media and technology (e.g. BIM; PIM; CAD).</p> <p>Interpret mechanical process and instrument diagrams, critically appraising and effectively responding to relevant technical information.</p> <p>Identify inaccuracies or discrepancies in engineering drawings and specifications, make necessary amendments, and propose solutions.</p> <p>Verify mechanical design concepts, briefs and specifications, in relation to context, function and specific requirements (e.g. components, materials, application, location, risk and environment).</p> <p>Use appropriate technology to review, analyse and interpret mechanical design elements in proposals, representations, systems, components, assemblies, products and processes.</p>

Performance Outcome 2: Evaluate systems, designs, components and processes, managing and integrating design information, proposals and specifications, to develop and improve mechanical engineering and manufacturing proposals and solutions

Knowledge specific to performance outcome	Skills specific to performance outcome
<p>Standard engineering and manufacturing processes and technologies relevant to mechanical engineering, and their implications for design concepts, decision-making, performance, and outcomes, including:</p> <ul style="list-style-type: none"> • materials and material performance; • manufacturing, production and joining techniques; • static, dynamic, structural, fluid loads; • effects of service and environmental conditions (e.g. material characteristics, flow rates, temperature and working pressures); • standard parts and machine elements, uses and applicability (e.g. valves, sensors, piping, supports and fittings) • component assembly and system diagrams; • standards and conventions in engineering representations and technical information for mechanical systems, assemblies, sub-assemblies, and components. <p>Verification and validation in design practices (i.e. verification activities to ensure that design/s meet specifications, requirements, expectations at key stages; validation activities to confirm that outcomes realise or meet original specification, brief etc.)</p>	<p>Select and use appropriate technology to model and evaluate mechanical design features, issues, performance and potential.</p> <p>Analyse factors (e.g. materials, application, location, risk and environment) that affect mechanical design concepts, design components, and complete designs, making suggestions and recommendations about development, improvement, refinement and optimisation.</p> <p>Use appropriate information sources and judgement to select, evaluate, recommend, and confirm suitable engineering and manufacturing materials for specific uses, explaining and justifying choices with reference to context.</p> <p>Apply knowledge of material degradation and failure processes, and prevention and mitigation methods, to investigate and evaluate proposals, projects, processes, and outcomes.</p> <p>Consider the relevance, implications, and value of mechanical and materials test results with reference to purpose and context, materials/products traceability, recording and reporting on tests, modelling and research.</p> <p>Evaluate mechanical engineering designs, design elements, and design processes for compliance, quality and performance, in relation to purpose, function, conditions (e.g. material</p>

	<p>change in certain conditions) and specific requirements (e.g. cost and value engineering).</p> <p>Evaluate mechanical engineering designs, design elements and design processes to compare design options and iterations, delivering improvements and determining the most appropriate solutions for purpose, context and constraints (having established sound or agreed metrics).</p> <p>Reflect upon, review, develop and seek to improve methods, quality, standards and performance across mechanical engineering design and manufacture, individually, within teams, and organisation-wide.</p> <p>Respond constructively and creatively to project and task changes and feedback, confirming the nature and scope of new requirements, and the process for revision or resolution.</p>
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Performance Outcome 3: Propose and design mechanical engineering and manufacturing systems, products, components, processes and solutions, considering requirements, constraints and context

Knowledge specific to performance outcome	Skills specific to performance outcome
<p>Different design purposes, metrics, contexts and constraints, and how they affect design methodologies, processes and practices (e.g. design for manufacture or design for re-use; commercial and operational factors and context).</p> <p>How mechanical principles, material selection and application affect key design stages, decision-making, processes and outcomes.</p> <p>Effects of mechanical loadings on structures and components (e.g. weight, torque, fatigue, aerodynamics).</p> <p>Appropriate mathematical methods and calculations for design development practices in mechanical engineering.</p> <p>Application of scientific principles which affect design processes, decisions and outcomes.</p>	<p>Design and model mechanical engineering concepts, components and features, and develop existing design elements and proposals, to address or solve engineering and manufacturing challenges.</p> <p>Produce effective 2D and 3D drawings, models and simulations, and accurate 3D assemblies of components, using appropriate CAD software, tools, and technology.</p> <p>Apply effective design, manufacturing and production principles and practices to develop high-quality, working models.</p> <p>Assemble and disassemble common mechanical systems, showing understanding of system, function, and configuration.</p> <p>Determine the dynamic effects associated with the acceleration of straightforward mechanical systems (e.g. linear and rotational), showing an ability to practically model systems, demonstrate relevant calculations, and report effects and findings.</p> <p>Calculate and accurately determine the performance of simple and complex rotating systems, and analyse the characteristics and operation of simple and complex lifting machines.</p> <p>Develop effective mechanical engineering solutions which satisfy the required standards and can be manufactured, proven, operated and maintained effectively, whilst meeting</p>

	<p>functional and non-functional requirements, including cost and quality.</p> <p>Produce detailed mechanical engineering drawings to relevant standards and codes.</p> <p>Propose and design mechanical systems, products, components and solutions, applying relevant mechanical principles (including scientific and mathematical understanding and methods) and suitable materials selection.</p> <p>Complete high-quality, producible designs, ready for realisation, using appropriate technology, tools and equipment.</p> <p>Use basic hand and powered tools safely and effectively for specific purposes, checking them before use and storing them appropriately.</p> <p>Carry out basic engineering processes according to straightforward specifications, instructions and guidance (e.g. cutting, grinding, milling, turning, shaping, welding and 3D printing).</p>
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Performance outcome 4: Collaborate to help manage, develop, test and quality assure mechanical engineering and manufacturing design information, systems, processes and outcomes

Knowledge specific to performance outcome	Skills specific to performance outcome
<p>Company management systems, policies and procedures.</p> <p>Standard operating procedures.</p> <p>Document management.</p> <p>Version and change control.</p> <p>Technical, quality, and safety standards, regulations and legal requirements (e.g. traceability; revisions management, specific British Standards; ISO9001).</p> <p>Health and safety procedures, conduct and compliance.</p> <p>Quality assurance and quality control practices.</p> <p>Installation and integration of systems.</p> <p>A range of standard testing methods in mechanical engineering, including destructive and non-destructive testing.</p> <p>A range of measurement and testing instruments, technologies, tools and equipment.</p> <p>Risk analysis and management (including statistical risk analysis).</p>	<p>Work in accordance with professional standards, and company management systems, policies and procedures.</p> <p>Work safely at all times (complying with relevant national and industry health and safety requirements), assessing, managing and mitigating risks present in mechanical engineering contexts (e.g. mechanical handling, high power applications).</p> <p>Work effectively with others, directly and virtually, to agree and complete assigned mechanical design, development, testing and quality assurance tasks and activities (including consideration of timeframes and deadlines).</p> <p>Contribute effectively to collaborative tasks, projects and activities relating to mechanical design processes and outcomes, considering and responding appropriately to other inputs, and dynamic contexts and conditions.</p> <p>Carry out research and work with others to investigate, test, optimise, quality assure, and validate mechanical design proposals, specifications, concepts, models, products, systems, processes and outcomes (including those involving modern and smart materials).</p> <p>Complete detailed risk management analyses in response to specific requirements, projects and activities.</p> <p>Develop and test models and prototypes for different purposes and design questions (e.g. technical function; concept testing,</p>

Mathematical methods and calculations, including statistical analysis, for measuring, checking and confirming mechanical engineering testing and performance data.

Scientific and mechanical principles relevant to mechanical engineering practices (e.g. materials properties and performance, physical forces and behaviours, storage and transfer of forces and energy).

Factors which affect quality in mechanical engineering and quality assurance processes, failure modes, and the properties, standard forms, and failure modes of materials.

production prototype), investigating and analysing tests, performance, and results, and accurately reporting and responding to findings.

Produce, manage, develop, test and quality assure work in accordance with relevant professional engineering standards and protocols.

Check completed drawings for quality, technical compliance and completeness (i.e. own and those of colleagues).

Investigate, check and confirm relevant mechanical design proposals, information, models or prototypes, and outcomes.

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Performance Outcome 5: Communicate proposals, design information and solutions, producing, recording and explaining engineering and manufacturing representations, systems, processes, outcomes, specifications and technical drawings.

Knowledge specific to performance outcome	Skills specific to performance outcome
<p>Engineering representations and communication technology, media, formats and conventions.</p> <p>Presentation techniques and standard requirements for design and technical information relevant to purpose and audience, specifically in mechanical engineering design contexts.</p> <p>Appropriate terminology and nomenclature in mechanical engineering contexts and activities.</p> <p>Standard mechanical data and annotations (e.g. geometrical tolerances, limits and fits, surface finishes).</p> <p>Design and communication technologies used in mechanical engineering contexts and processes.</p>	<p>Communicate and co-ordinate mechanical engineering design information and options with technical and non-technical audiences (e.g. relevant stakeholders, colleagues and clients), using a range of formats, media and technology (e.g. sketches, schemes, detailed drawings, diagrams, models, and reports).</p> <p>Effectively annotate mechanical engineering design drawings and representations (e.g. geometrical tolerances, limits and fits, surface finishes).</p> <p>Produce appropriate representations (e.g. professional standard drawings with appropriate conventions) and technical information for mechanical design concepts, components, products, processes and outcomes.</p> <p>Use digital (including collaborative) tools and technology to manage, review, update, revise, integrate, and quality assure technical and mechanical design information, data and associated documentation.</p> <p>Accurately record and explain proposals, specifications, representations, technical and non-technical information and data, systems, processes, projects, tasks, progress, issues, risks, solutions and outcomes.</p> <p>Effectively produce, amend, check, manage and version control technical documentation, using appropriate</p>

	<p>conventions, annotations and protocols, and standard document management systems.</p> <p>Communicate and present design information and evidence of each of the design stages accurately, clearly and appropriately (e.g. technical design information; visualisations), complying with business and company protocols where necessary.</p>
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Occupational Specialism: Design and Development (Electrical and Electronic Engineering)

Performance outcome 1: Analyse and interpret engineering and manufacturing requirements, systems, processes, technical drawings and specifications

Knowledge specific to performance outcome	Skills specific to performance outcome
<p>Common design methodologies, practices, processes, applications and integration, relevant to contemporary electrical and electronic engineering contexts.</p> <p>Engineering representations, symbols, conventions, and annotations (e.g. circuit symbols, component references and annotations, terminology and nomenclature), specifically in electrical and electronic engineering contexts and activities.</p> <p>Engineering standards and regulatory requirements relevant to electrical and electronic.</p> <p>Mathematical theory and methods and their application in electrical and electronic engineering contexts.</p> <p>Scientific principles relevant to electrical and electronic engineering activities.</p>	<p>Access, examine, review, interpret and respond effectively to electrical and electronic projects and tasks and requirements from different sources (e.g. specifications, concepts, stakeholders).</p> <p>Critique, challenge and confirm design project expectations and requirements appropriately, including requirement risks.</p> <p>Interpret information in a range of formats, media and technology (e.g. Circuit/system diagrams; Verilog/VHDL).</p> <p>Interpret electrical and electronic process and instrument circuit/system diagrams, critically appraising and effectively responding to relevant technical information.</p> <p>Identify inaccuracies or discrepancies in circuit/system diagrams and specifications, make necessary amendments, and propose solutions.</p> <p>Verify electrical and electronic design concepts, briefs and specifications, in relation to context, function and specific requirements (e.g. components, application, location, risk and environment).</p> <p>Use appropriate technology to review, analyse and interpret electrical and electronic design elements in proposals,</p>

	representations, systems, components, assemblies, products and processes.
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Performance outcome 2: Evaluate systems, designs, components and processes, managing and integrating design information, proposals and specifications, to develop and improve electrical and electronic engineering and manufacturing proposals and solutions

Knowledge specific to performance outcome	Skills specific to performance outcome
<p>Standard engineering processes and technologies relevant to electrical and electronic engineering, and their implications for design concepts, decision-making, performance, and outcomes, including:</p> <ul style="list-style-type: none"> • contemporary available electrical and electronic components (passive and active e.g. resistors, inductors, transformers, semiconductors, resistors, capacitors, connectors, a range of cable types), sub-assemblies, and systems (e.g. motors and generators, solar panels, heat pumps); • common terminology used in component datasheets, including electrical and non-electrical parameters (e.g. thermal performance); • context specific factors for consideration in design e.g. the electricity distribution network, electrical vehicles; • common circuit configurations (e.g. amplifiers, power supply architectures, PWM circuits, operational amplifier circuits); • circuit analysis methods (e.g. DC / AC / Monte-Carlo); • circuit implementation technologies (e.g. PCB, hybrid, breadboard, strip board); • effects of service and environmental conditions (e.g. surrounding air temperature, vibration, humidity); • component assembly and system diagrams; • standards and conventions in engineering representations and technical information for electrical and electronic systems, assemblies, sub-assemblies, and components. 	<p>Select and use appropriate technology to model and evaluate electrical and electronic design features, issues, performance and potential.</p> <p>Analyse factors (e.g. materials, application, location, risk and environment) that affect electrical and electronic design concepts, design components, and complete designs, making suggestions and recommendations about development, improvement, refinement and optimisation.</p> <p>Use appropriate information sources and judgement to select, evaluate, recommend, and confirm suitable engineering and manufacturing materials for specific uses, explaining and justifying choices with reference to context.</p> <p>Evaluate electrical and electronic engineering circuit/system designs, components and sub-assemblies, and design processes for compliance, quality and performance, in relation to purpose, function, conditions (e.g. material change in certain conditions) and specific requirements (e.g. cost and value engineering).</p> <p>Evaluate electrical and electronic engineering designs, design elements and design processes to compare design options and iterations, delivering improvements and determining the most appropriate solutions for purpose, context and constraints (having established sound or agreed metrics).</p>

Verification and validation in design practices (i.e. verification activities to ensure that design/s meet specifications, requirements, expectations at key stages; validation activities to confirm that outcomes realise or meet original specification, brief etc.)

Evaluate systems, designs, components and processes in relation to power generation, distribution (e.g. voltage transformation principles) and installation (e.g. cable types), helping to manage and integrate design information, and to develop and improve proposals and solutions.

Consider the relevance, implications, and value of electrical and electronic test results with reference to purpose and context, recording and reporting on tests, modelling and research.

Reflect upon, review, develop and seek to improve methods, quality, standards and performance across electrical and electronic engineering design and manufacture, individually, within teams, and organisation-wide.

Respond constructively and creatively to project and task changes and feedback, confirming the nature and scope of new requirements and the process for revision or resolution.

Performance outcome 3: Propose and design electrical and electronic engineering and manufacturing systems, products, components, processes and solutions, considering requirements, constraints and context

Knowledge specific to performance outcome	Skills specific to performance outcome
<p>Different design purposes, metrics, contexts and constraints, and how they affect design methodologies, processes and practices (e.g. Design for X, where X stands for manufacturing viability or feasibility, reuse, testability etc.; commercial and operational factors and context).</p> <p>How electrical and electronics principles, component selection and application affect key design stages, decision-making, processes and outcomes.</p> <p>Effects of non-electrical parameters (e.g. heat dissipation) and the effect on circuit/system implementation (e.g. device placement) and enclosure design.</p> <p>Application of scientific principles which affect design processes, decisions and outcomes.</p> <p>Appropriate mathematical methods and calculations for design development practices in electrical and electronic engineering.</p>	<p>Design and model electrical and electronic engineering concepts, components and features, and develop existing design elements and proposals, to address or solve engineering and manufacturing challenges.</p> <p>Develop effective electrical and electronic engineering solutions which satisfy the required standards and can be manufactured, proven, operated and maintained effectively, whilst meeting functional and non-functional requirements including cost and quality.</p> <p>Produce detailed electrical and electronic engineering circuit/system diagrams, models and simulations (e.g. circuit simulation software to investigate behaviour of electricity), to relevant standards and codes, using appropriate CAD software, tools and technology.</p> <p>Propose and design electrical and electronic systems (e.g. small power systems), products (e.g. lighting), components and solutions, applying relevant electrical and electronic principles (including scientific and mathematical understanding and methods), suitable materials selection, and relevant manufacturing and production processes.</p> <p>Complete high-quality, producible designs, ready for realisation, using appropriate technology, tools and equipment.</p>

	<p>Use basic hand and powered tools safely and effectively for specific purposes, checking them before use and storing them appropriately.</p>
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Carry out basic engineering processes according to straightforward specifications, instructions and guidance (e.g. cutting, milling, shaping, soldering, and 3D printing).

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Performance outcome 4: Collaborate to help manage, develop, test and quality assure electrical and electronic engineering and manufacturing design information, systems, processes and outcomes

Knowledge specific to performance outcome	Skills specific to performance outcome
<p>Company management systems, policies and procedures.</p> <p>Standard operating procedures.</p> <p>Document management; version and change control.</p> <p>Technical, quality, and safety standards, regulations and legal requirements (e.g. traceability; revisions management, specific British Standards; ISO9001).</p> <p>Health and safety procedures, conduct and compliance:</p> <ul style="list-style-type: none"> • specific health and safety procedures and protocols, and relevant legal and regulatory requirements that apply to electrical and electronic design systems, processes, outcomes and development activities. <p>Quality assurance and quality control practices.</p> <p>Installation and integration of systems.</p> <p>A range of standard test and diagnostic methods in electrical and electronic engineering.</p> <p>Circuit/system verification and diagnostic equipment (e.g. oscilloscope, multi-meter, logic analyser).</p> <p>Risk analysis and management (including statistical risk analysis).</p>	<p>Work in accordance with professional standards, and company management systems, policies and procedures.</p> <p>Work safely at all times (complying with relevant national and industry health and safety requirements), assessing, managing and mitigating risks present in electrical and electronic engineering contexts (e.g. high power, electrocution; fire).</p> <p>Work effectively with others, directly and virtually, to agree and complete assigned electrical and electronic design, development, testing and quality assurance tasks and activities.</p> <p>Contribute effectively to collaborative tasks, projects and activities relating to electrical and electronic design processes and outcomes, considering and responding appropriately to other inputs, and dynamic contexts and conditions.</p> <p>Carry out research and work with others to investigate, test, optimise, quality assure, and validate electrical and electronic design concepts, proposals, specifications, products, systems, processes and outcomes (including those including modern and smart materials).</p> <p>Complete detailed risk management analyses in response to specific requirements, projects and activities.</p> <p>Develop and test models and prototypes for different purposes and design questions (e.g. technical function; concept testing,</p>

Mathematical methods and calculations, including equivalent circuits, statistical methods for variation in component values, time and frequency domain analysis.

Electrical principles relevant to electrical and electronic engineering practices.

production prototype), investigating and analysing tests, performance, and results, and accurately reporting and responding to findings.

Examine, develop, test and quality assure information, systems, processes and outcomes relating to earthing and lightning protection.

Produce, manage, develop, test and quality assure work in accordance with relevant professional engineering standards and protocols.

Check completed drawings for quality, technical compliance and completeness (i.e. own and those of colleagues).

Investigate, check and confirm relevant electrical and electronic design proposals, information, models or prototypes, and outcomes.

Performance outcome 5: Communicate proposals, design information and solutions, producing, recording and explaining engineering and manufacturing representations, systems, processes, outcomes, specifications and technical drawings

Knowledge specific to performance outcome	Skills specific to performance outcome
<p>Engineering representations and communication technology, media, formats and conventions.</p> <p>Presentation techniques and standard requirements for design and technical information relevant to purpose and audience, specifically in electrical and electronic engineering design contexts.</p> <p>Appropriate terminology and nomenclature in electrical and electronic engineering contexts and activities.</p> <p>Engineering representations, symbols, conventions, and annotations (e.g. circuit symbols, component references and annotations, terminology and nomenclature), specifically in electrical and electronic engineering contexts and activities.</p> <p>Design and communication technologies used in electrical and electronic engineering contexts and processes (e.g. PCB netlists, Verilog/VHDL).</p>	<p>Communicate and co-ordinate electrical and electronic engineering design options with technical and non-technical audiences (e.g. relevant stakeholders, colleagues and clients), using a range of formats and media (e.g. sketches, schemes, models, components, detailed drawings, diagrams, and reports).</p> <p>Effectively annotate electrical and electronic engineering design drawings and representations.</p> <p>Produce appropriate representations (e.g. professional standard drawings with appropriate conventions) and technical information for electrical and electronic design concepts, components, products, processes and outcomes.</p> <p>Use digital (including collaborative) tools and technology to manage, review, update, revise, integrate, and quality assure technical (e.g. electrical and electronic) design information, data and associated documentation.</p> <p>Accurately record and explain proposals, specifications, representations, technical and non-technical information and data, systems, processes, projects, tasks, progress, issues, risks, solutions and outcomes.</p> <p>Effectively produce, amend, check, manage and version control technical documentation, using appropriate</p>

	<p>conventions, annotations and protocols, and standard document management systems.</p> <p>Communicate and present design information and evidence of each of the design stages accurately, clearly and appropriately (e.g. technical design information; schematics; reports), complying with business and company protocols where necessary.</p>
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Occupational Specialism: Design and Development (Control and Instrumentation Engineering)

Performance outcome 1: Analyse and interpret control and instrumentation engineering and manufacturing requirements, systems, processes, technical drawings and specifications

Knowledge specific to performance outcome	Skills specific to performance outcome
<p>Common design methodologies, practices, processes, applications and integration, relevant to contemporary control and instrumentation engineering and manufacturing contexts.</p> <p>Engineering representations, symbols, conventions, and annotations (e.g. process flowcharts, terminology and nomenclature), specifically in control and instrumentation engineering contexts and activities.</p> <p>Engineering standards and regulatory requirements relevant to control and instrumentation.</p> <p>Mathematical theory and methods and their application in control and instrumentation engineering contexts.</p> <p>Scientific principles relevant to control and instrumentation engineering activities (e.g. measurement technologies).</p>	<p>Access, examine, review, interpret and respond effectively to control and instrumentation projects and tasks and requirements from different sources (e.g. specifications, concepts, stakeholders).</p> <p>Critique, challenge and confirm design project expectations and requirements appropriately, including requirement risks.</p> <p>Interpret information in a range of formats, media and technology (e.g. BIM; PIM; CAD, process flowcharts; Circuit/system diagrams; Verilog/VHDL).</p> <p>Interpret control and instrumentation process flowcharts, critically appraising and effectively responding to relevant technical information.</p> <p>Identify inaccuracies or discrepancies in engineering drawings and specifications, make necessary amendments, and propose solutions.</p> <p>Verify control and instrumentation concepts, briefs and specifications, in relation to context, function and specific requirements (e.g. materials, components, application, location, risk and environment).</p>

	Use appropriate technology to review, analyse and interpret control and instrumentation elements in proposals, representations, systems, components, assemblies, products and processes.
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Performance outcome 2: Evaluate systems, designs, components and processes, managing and integrating design information, proposals and specifications, to develop and improve control and instrumentation-related engineering and manufacturing proposals and solutions

Knowledge specific to performance outcome	Skills specific to performance outcome
<p>Standard engineering processes and technologies relevant to control and instrumentation, and their implications for design concepts, decision-making, performance, and outcomes, including:</p> <ul style="list-style-type: none"> • contemporary available components and sub-assemblies (e.g. controllers, valves, sensors); • common terminology used in component datasheets, including electrical and non-electrical parameters (e.g. flow rates, maximum current); • common control and instrumentation configurations (e.g. PID, adaptive control); • control analysis methods (e.g. root locus analysis); • control and instrumentation system implementation; • effects of service and environmental conditions (e.g. surrounding air temperature, vibration, humidity, chemicals); • component assembly and system diagrams; • standards and conventions in engineering representations and technical information for control and instrumentation systems, assemblies, sub-assemblies, and components; • Combinational and sequential logic and control systems <p>Verification and validation in design practices (i.e. verification activities to ensure that design meets specifications, requirements, expectations at key stages; validation activities to confirm that outcomes realise or meet original specification, brief etc.).</p>	<p>Select and use appropriate technology to model and evaluate control and instrumentation features, issues, performance and potential.</p> <p>Analyse factors (e.g. materials, application, location, risk and environment) that affect control and instrumentation design concepts, design components, and complete designs, making suggestions and recommendations about development, improvement, refinement and optimisation.</p> <p>Evaluate control and instrumentation engineering designs, design elements, and design processes for compliance, quality and performance, in relation to purpose, function, conditions (e.g. material change in certain conditions) and specific requirements (e.g. cost and value engineering).</p> <p>Use appropriate information sources and judgement to select, evaluate, recommend, and confirm suitable engineering and manufacturing materials for specific uses, explaining and justifying choices with reference to context.</p> <p>Evaluate control and instrumentation designs, design elements and design processes to compare design options and iterations, delivering improvements and determining the most appropriate solutions for purpose, context and constraints (having established sound or agreed metrics).</p>

	<p>Evaluate systems, designs, components and processes in relation to power generation, distribution (e.g. voltage transformation principles) and installation (e.g. cable types), helping to manage and integrate design information, and to develop and improve proposals and solutions.</p> <p>Consider the relevance, implications, and value of control and instrumentation test results with reference to purpose and context, recording and reporting on tests, modelling and research.</p> <p>Reflect upon, review, develop and seek to improve methods, quality, standards and performance across control and instrumentation design and manufacture, individually, within teams, and organisation-wide.</p> <p>Respond constructively and creatively to project and task changes and feedback, confirming the nature and scope of new requirements and the process for revision or resolution.</p>
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Performance outcome 3: Propose and design control and instrumentation-related engineering and manufacturing systems, products, components, processes and solutions, considering requirements, constraints and context

Knowledge specific to performance outcome	Skills specific to performance outcome
<p>Different design purposes, metrics, contexts and constraints, and how they affect design methodologies, processes and practices (e.g. design for manufacture or design for re-use; commercial and operational factors and context).</p> <p>How electrical and electronics principles, component selection and application affect key design stages, decision-making, processes and outcomes.</p> <p>Effects of parameters (e.g. heat dissipation, accuracy) and the effect on control and instrumentation system design.</p> <p>Effects of mechanical loadings on structures and components (e.g. weight, torque, fatigue, aerodynamics).</p> <p>Appropriate mathematical methods and calculations for design development practices in control and instrumentation (e.g. complex numbers; frequency domain analysis).</p> <p>Application of scientific principles which affect design processes, decisions and outcomes.</p>	<p>Design and model control and instrumentation engineering concepts, components and features, and develop existing design elements and proposals, to address or solve engineering and manufacturing challenges.</p> <p>Develop effective control and instrumentation engineering solutions which satisfy the required standards and can be manufactured, proven, operated and maintained effectively, whilst meeting functional and non-functional requirements (e.g. cost, weight, quality, schedule).</p> <p>Produce detailed control and instrumentation engineering diagrams to relevant standards and codes (e.g. frequency response plots), using appropriate CAD software, tools and technology.</p> <p>Propose and design control and instrumentation systems (e.g. system models), products, components and solutions, applying relevant electrical and electronic principles (including scientific and mathematical understanding and methods), suitable materials selection, and relevant manufacturing and production processes.</p> <p>Complete high-quality, producible designs, ready for realisation, using appropriate technology, tools and equipment.</p>

	<p>Use basic hand and powered tools safely and effectively for specific purposes, checking them before use and storing them appropriately.</p>
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Carry out basic engineering processes according to straightforward specifications, instructions and guidance (e.g. cutting, milling, shaping, soldering, and 3D printing).

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Performance outcome 4: Collaborate to help manage, develop, test and quality assure control and instrumentation related engineering and manufacturing design information, systems, processes and outcomes

Knowledge specific to performance outcome	Skills specific to performance outcome
<p>Company management systems, policies and procedures.</p> <p>Standard operating procedures.</p> <p>Document management; version and change control.</p> <p>Technical, quality, and safety standards, regulations and legal requirements (e.g. traceability; revisions management, specific British Standards; ISO9001).</p> <p>Health and safety procedures, conduct and compliance:</p> <ul style="list-style-type: none"> • specific health and safety procedures and protocols, and relevant legal and regulatory requirements that apply to electrical and electronic design systems, processes, outcomes and development activities. <p>Quality assurance and quality control practices.</p> <p>Installation and integration of systems.</p> <p>A range of standard test and diagnostic methods in control and instrumentation engineering. (e.g. corner analysis).</p> <p>Control and instrumentation verification and diagnostic equipment (e.g. oscilloscope, multi-meter, logic analyser).</p>	<p>Work in accordance with professional standards, and company management systems, policies and procedures.</p> <p>Work safely at all times (complying with relevant national and industry health and safety requirements), assessing, managing and mitigating risks present in control and instrumentation contexts (e.g. high power, mechanical handling; electrocution).</p> <p>Work effectively with others, directly and virtually, to agree and complete assigned control and instrumentation design, development, testing and quality assurance tasks and activities.</p> <p>Contribute effectively to collaborative tasks, projects and activities relating to control and instrumentation design processes and outcomes, considering and responding appropriately to other inputs, and dynamic contexts and conditions.</p> <p>Carry out research and work with others to investigate, test, optimise, quality assure, and validate control and instrumentation concepts, proposals, specifications, products, systems, processes and outcomes (including those with modern and smart materials).</p> <p>Complete detailed risk management analyses in response to specific requirements, projects and activities.</p>

Risk analysis and management (including statistical risk analysis).

Mathematical and data science methods and calculations, including equivalent circuits, statistical methods for variation in component values, time and frequency domain analysis, diagnostic data analysis techniques including machine learning.

Develop and test models for different purposes and design questions (e.g. technical function; concept testing, production prototype), investigating and analysing tests, performance, and results, and accurately reporting and responding to findings.

Produce, manage, develop, test and quality assure work in accordance with relevant professional engineering standards and protocols.

Examine, develop, test and quality assure information, systems, processes and outcomes relating to earthing and lightning protection.

Check completed drawings for quality, technical compliance and completeness (i.e. own and those of colleagues).

Investigate, check and confirm relevant electrical and electronic design proposals, information, models or prototypes, and outcomes.

Performance outcome 5: Communicate proposals, design information and solutions, producing, recording and explaining engineering and manufacturing representations, systems, processes, outcomes, design specifications and technical drawings

Knowledge specific to performance outcome	Skills specific to performance outcome
<p>Engineering and manufacturing representations and communication technology, media, formats and conventions.</p> <p>Presentation techniques and standard requirements for design and technical information relevant to purpose and audience, specifically in control and instrumentation engineering and manufacturing design contexts.</p> <p>Appropriate terminology and nomenclature in control and instrumentation engineering and manufacturing contexts and activities.</p> <p>Engineering representations, symbols, conventions, and annotations (e.g. process flowcharts, terminology and nomenclature), specifically in control and instrumentation engineering and manufacturing contexts and activities.</p> <p>Design and communication technologies used in control and instrumentation engineering and manufacturing contexts and processes (e.g. process flowcharts, frequency response plots).</p>	<p>Communicate and co-ordinate control and instrumentation engineering design options with technical and non-technical audiences (e.g. relevant stakeholders, colleagues and clients) using sketches, schemes, models, components, detailed drawings, diagrams, and reports).</p> <p>Effectively annotate control and instrumentation engineering design drawings and representations.</p> <p>Produce appropriate representations (e.g. professional standard drawings with appropriate conventions) and technical information for control and instrumentation design concepts, components, products, processes and outcomes.</p> <p>Use digital (including collaborative) tools and technology to manage, review, update, revise, integrate, and quality assure technical (e.g. control and instrumentation) design information, data and associated documentation.</p> <p>Accurately record and explain proposals, specifications, representations, technical and non-technical information and data, systems, processes, projects, tasks, progress, issues, risks, solutions and outcomes.</p> <p>Effectively produce, amend, check, manage and version control technical documentation, using appropriate</p>

	<p>conventions, annotations and protocols, and standard document management systems.</p> <p>Communicate and present design information and evidence of each of the design stages accurately, clearly and appropriately (e.g. technical design information; visualisations; reports), complying with business and company protocols where necessary.</p>
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Occupational Specialism: Design and Development (Structural Engineering)

Performance outcome 1: Analyse and interpret engineering and manufacturing requirements, systems, processes, technical drawings and specifications

Knowledge specific to performance outcome	Skills specific to performance outcome
<p>Common design methodologies, practices, processes, applications and integration, relevant to contemporary structural engineering contexts.</p> <p>Engineering representations, symbols, conventions, and annotations (e.g. geometrical dimensions and global coordinates, tolerances, limits, fits and finishes, terminology and nomenclature), specifically in structural engineering contexts and activities.</p> <p>Knowledge of engineering standards and regulatory requirements relevant to structural engineering.</p> <p>Mathematical theory and methods and their application in structural engineering contexts.</p> <p>Scientific principles relevant to structural engineering activities.</p>	<p>Access, examine, review, interpret and respond effectively to structural design projects and tasks and requirements, including technical information and requirements from different sources (e.g. specifications, concepts, stakeholders).</p> <p>Critique, challenge and confirm design project expectations and requirements appropriately, including requirement risks.</p> <p>Interpret information in a range of formats, media and technology (e.g. BIM; CAD).</p> <p>Interpret structural process documents and drawings, critically appraising and effectively responding to relevant technical information.</p> <p>Identify inaccuracies or discrepancies in engineering drawings, models and specifications, make necessary amendments, and propose solutions.</p> <p>Verify structural design concepts, briefs and specifications, in relation to context, function and specific requirements (e.g. components, materials, application, loads, location, risk and environment).</p>

	Use appropriate technology to review, analyse and interpret structural design elements in proposals, representations, systems, components, assemblies, products and processes.
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Performance outcome 2: Evaluate systems, designs, components and processes, managing and integrating design information, proposals and specifications, to develop and improve structural engineering, manufacturing and construction proposals and solutions

Knowledge specific to performance outcome	Skills specific to performance outcome
<p>Standard engineering processes and technologies relevant to structural engineering, and their implications, limitations, advantages for design concepts, decision-making, performance, and outcomes, including:</p> <ul style="list-style-type: none"> - materials and material performance; - fabrication, transportation, construction and joining techniques; - static, dynamic, structural loads; - effects of service and environmental conditions (e.g. material characteristics, seismic, wind, snow, corrosion, heat and light); - standard products and fixings, uses and applicability; - standards and conventions in engineering representations and technical information for structural elements and layouts. <p>Verification and validation in design practices (i.e. verification activities to ensure that design meets specifications, requirements, expectations at key stages; validation activities to confirm that outcomes realise or meet original specification, brief etc.)</p>	<p>Select and use appropriate technology to model and evaluate structural design features, issues, performance and potential.</p> <p>Analyse factors (e.g. materials, application, location, risk and environment) that affect structural design concepts, design components, and complete designs, making suggestions and recommendations about development, improvement, refinement and optimisation.</p> <p>Use appropriate information sources and judgement to select, evaluate, recommend, and confirm suitable engineering and manufacturing materials for specific uses, explaining and justifying choices with reference to context.</p> <p>Apply knowledge of material degradation and failure processes, and prevention and mitigation methods, to investigate and evaluate proposals, projects, processes, and outcomes.</p> <p>Consider the relevance, implications, and value of structural and materials test results with reference to purpose and context, recording and reporting on tests, modelling and research.</p> <p>Evaluate structural engineering designs, design elements, and design processes for compliance, quality and performance, in relation to purpose, function, conditions (e.g. material change</p>

in certain conditions) and specific requirements (e.g. cost and value engineering).

Evaluate structural engineering designs, design elements and design processes to compare design options and iterations, delivering improvements and determining the most appropriate solutions for purpose, context and constraints (having established sound or agreed metrics).

Reflect upon, review, develop and seek to improve methods, quality, standards and performance across structural engineering design and construction, individually, within teams, and organisation-wide.

Respond constructively and creatively to project and task changes and feedback, confirming the nature and scope of new requirements and the process for revision or resolution.

Performance outcome 3: Propose and design structural engineering and manufacturing systems, products, components, processes and solutions, considering requirements, constraints and context

Knowledge specific to performance outcome	Skills specific to performance outcome
<p>Different design purposes, metrics, contexts and constraints, and how they affect design methodologies, processes and practices (e.g. design for construction or design for re-use; commercial and operational factors and context).</p> <p>How structural principles, material selection and application affect key design stages, decision-making, processes and outcomes.</p> <p>Effects of structural loadings on structures and components e.g. static and dynamic loads.</p> <p>Appropriate mathematical methods and calculations for design development practices in structural engineering.</p> <p>Application of scientific principles which affect design processes, decisions and outcomes.</p>	<p>Design structural engineering concepts, components and features, and develop existing design elements and proposals, to address or solve engineering and construction challenges.</p> <p>Produce effective 2D and 3D drawings, models and simulations, using appropriate CAD software, tools, and technology.</p> <p>Apply effective design, manufacturing and production principles and practices to develop high-quality, working models.</p> <p>Develop effective structural engineering solutions which satisfy the required standards and can be constructed, proven, operated and maintained effectively, whilst meeting functional and non-functional requirements, including cost and quality.</p> <p>Produce detailed structural engineering drawings to relevant standards and codes.</p> <p>Propose and design structural systems, products, components and solutions, applying relevant structural principles (including scientific and mathematical understanding and methods) and suitable materials selection.</p> <p>Complete high-quality, producible designs, ready for realisation, using appropriate technology, tools and equipment.</p>

	<p>Use basic hand and powered tools safely and effectively for specific purposes, checking them before use and storing them appropriately.</p>
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Carry out basic engineering processes according to straightforward specifications, instructions and guidance (e.g. cutting, grinding, milling, drilling, turning, shaping, welding and 3D printing).

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Performance outcome 4: Collaborate to help manage, develop, test and quality assure structural engineering and manufacturing design information, systems, processes and outcomes

Knowledge specific to performance outcome	Skills specific to performance outcome
<p>Company management systems, policies and procedures.</p> <p>Standard operating procedures.</p> <p>Document management; version and change control.</p> <p>Technical, quality, and safety standards, regulations and legal requirements (e.g. traceability; revisions management, specific British Standards; ISO9001, European Codes).</p> <p>Health and safety procedures, conduct and compliance.</p> <p>Quality assurance and quality control practices.</p> <p>Installation and integration of systems.</p> <p>A range of standard testing methods in structural engineering, including destructive and non-destructive testing.</p> <p>A range of measurement and testing instruments, technologies, tools and equipment.</p> <p>Risk analysis and management (including statistical risk analysis).</p> <p>Mathematical methods and calculations, including statistical analysis, for measuring, checking and confirming structural engineering testing and performance data.</p>	<p>Work in accordance with professional standards, and company management systems, policies and procedures.</p> <p>Work safely at all times, complying with relevant national and industry health and safety requirements, and analysing, managing and mitigating risks present in structural engineering contexts (e.g. site safety, high power).</p> <p>Work effectively with others, directly and virtually, to agree and complete assigned structural design, development, testing and quality assurance tasks and activities (including consideration of timeframes and deadlines).</p> <p>Contribute effectively to collaborative tasks, projects and activities relating to structural design processes and outcomes, considering and responding appropriately to other inputs, and dynamic contexts and conditions.</p> <p>Carry out research and work with others to investigate, test, optimise, quality assure, and validate structural design concepts, proposals, specifications, processes and outcomes (including those involving modern and smart materials).</p> <p>Complete detailed risk management analyses in response to specific requirements, projects and activities.</p> <p>Develop and test models for different purposes and design questions (e.g. technical function; concept testing, human structural interfaces), investigating and analysing tests,</p>

<p>Scientific and structural principles relevant to structural engineering practices (e.g. materials properties and performance, physical forces and behaviours, storage and transfer of forces and energy).</p> <p>Factors which affect quality in structural engineering and quality assurance processes, failure modes, and the properties, standard forms, and failure modes of materials.</p>	<p>performance, and results, and accurately reporting and responding to findings.</p> <p>Produce, manage, develop, test and quality assure work in accordance with relevant professional engineering standards and protocols.</p> <p>Check completed drawings for quality, technical compliance and completeness (i.e. own and those of colleagues).</p> <p>Investigate, check and confirm relevant structural design proposals, information, models, and outcomes.</p>
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Performance outcome 5: Communicate proposals, design information and solutions, producing, recording and explaining engineering and manufacturing representations, systems, processes, outcomes, specifications and technical drawings

Knowledge specific to performance outcome	Skills specific to performance outcome
<p>Engineering representations and communication technology, media, formats and conventions.</p> <p>Presentation techniques and standard requirements for design and technical information relevant to purpose and audience, specifically in structural engineering design contexts.</p> <p>Appropriate terminology and nomenclature in structural engineering contexts and activities.</p> <p>Standard structural data and annotations (e.g. geometrical tolerances, limits and fits, surface finishes).</p> <p>Design and communication technologies used in structural engineering contexts and processes.</p>	<p>Communicate and co-ordinate structural engineering design information and options with technical and non-technical audiences (e.g. relevant stakeholders, colleagues and clients) using a range of formats, media and technology (e.g. verbal, drafting, sketches, schemes, detailed drawings, models, and reports).</p> <p>Effectively annotate structural engineering design drawings and representations (e.g. geometrical tolerances, limits and fits; layouts and details).</p> <p>Produce appropriate representations (e.g. professional standard drawings with appropriate conventions) and technical information for structural design concepts, components, products, processes and outcomes.</p> <p>Use digital (including collaborative) tools and technology to manage, review, update, revise, integrate, and quality assure technical (e.g. structural) design information, data and associated documentation.</p> <p>Accurately record and explain proposals, specifications, representations, technical and non-technical information and data, systems, processes, projects, tasks, progress, issues, risks, solutions and outcomes.</p> <p>Effectively produce, amend, check, manage and version control technical documentation, using appropriate</p>

	<p>conventions, annotations and protocols, and standard document management systems.</p> <p>Communicate and present design information and evidence of each of the design stages accurately, clearly and appropriately (e.g. technical design information; visualisations), complying with business and company protocols where necessary.</p>
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