Institute for Apprenticeships & Technical Education

Engineering and Manufacturing: Maintenance, Installation and Repair

T Level outline content

November 2019

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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: Maintenance, Installation and Repair 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: Maintenance, Installation and Repair" 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.

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: • 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: • 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: • 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: • engineering and manufacturing from an historical perspective, including awareness of important

		technological advances across different sectors, and significant periods of change; • 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: ○ principles of sustainability, including product lifecycle, circular economy, exploring alternatives, waste and disposal.
Engineering representations	**3.1**	**Engineering drawings and graphical language** An understanding of: • 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**	**Mathematical theory and applications** A Level 3 knowledge and understanding of mathematics for engineering and manufacturing, including: • standard arithmetic: ○ Ordering, intergers, fractions, decimals, percentages, ratios ○ algebra – transposing, factorising and quadratics, Indices and standard forms ▪ including sequences and series, ▪ Problem solving involving growth and decay • Geometry including: ○ 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: ○ 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). • standard calculus including: ○ 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.
	4.2	**Number systems used in engineering and manufacturing** An understanding of: • numbering systems and their applications e.g. decimal, binary, octal and hexadecimal
Essential science for engineering and manufacturing	**5.1**	**Scientific methods** An understanding of standard international systems and units of measurement including: • 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: • 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: • 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)

	5.4	**Physical forces and behaviours**
		
		An understanding of:
		• work, efficiency, energy, and power including:
		  ○ 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:
		  ○ 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.
		
		A basic understanding of:
		• 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.
		
		An understanding of:
		• Effects of forces on materials including:
		  ○ Tensile force
		  ○ Compressive force
		  ○ Sheer force
		  ○ Stress and strain
		  ○ Elasticity and elastic limit
		  ○ Hooke’s law

Materials and their properties	**6.1**	An understanding of: • the properties, structures, and classification of materials including: ○ 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:

		○ 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: ○ 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: ○ 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).
Mechanical principles	**7.1**	An understanding of: • the fundamentals of motion and mechanics (static and dynamic) underpinning engineering and manufacturing systems, including: ○ (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: ○ 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,

		principle of conservation of momentum, principle of conservation of energy; ○ 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.
Electrical and electronic principles	**8.1**	**Electrical and electronic principles** An understanding of: • the basic principles of electricity and electronics, including: ○ 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: ○ 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: ○ 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.): ○ analysis of voltage and current in DC circuit networks comprising resistors, capacitors and

		inductors in series, parallel, and combined series parallel circuits; ○ 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. • 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**	An understanding of the key components of integrated mechanical and electrical systems; their design, operation, and applications, including: • 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**	**Control systems** An understanding of: • control system theory, including: ○ 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) An understanding of: • how sensors and actuators are used in automation control systems, including:

		○ 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**	**Recognised engineering and manufacturing standards** An understanding of: • the framework of relevant established engineering and engineering standards, for example: ○ 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: ○ 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**	An understanding of: • 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**	**Health and safety principles, coverage, and legislation** An understanding of: ○ essential Health and Safety principles, practices, and procedures which apply in engineering and manufacturing contexts, including:

		○ 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: ○ 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: ○ 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.
Business, commercial and financial awareness	**14.1**	An understanding of: • basic commercial principles, contexts and operations, including: ○ commercial priorities, principles relating to efficiency and “added value”; ○ markets, customers/clients/partners and resource allocation.

		• Standard and emerging business and commercial practices, including: ○ tendering and contracts and legal issues; ○ management practices, business models, staffing, training, development, research and innovation. An understanding of: • 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**	An understanding of: • professional conduct and responsibilities in the workplace (and in different engineering and manufacturing contexts), including those relating to: ○ 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: ○ 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**	**Stock and inventory management and control** A general understanding of: • stock and inventory management principles and practices including: ○ 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: ○ product life cycles, write down, redundant stock, obsolescence, and minimum stock levels; supply chain issues; packaging/storage (e.g. electro-static discharge).

		Asset management and control
		
		An understanding of:
		• asset management principles and practices including:
		  ○ asset lifecycle management processes.
		• key issues, risks, advantages and disadvantages associated with different asset management and budgetary control practices including:
		  ○ 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**	An understanding of:
		  ○ 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**	An understanding of:
		• the principles and practices of continuous improvement;
		• specific stages and methods for planning, implementing, monitoring and evidencing continuous improvement, including:
		  ○ 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:
		  ○ 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**	An awareness of: ○ 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

		including external stakeholders and communication channels. An understanding of: o project planning, control methodologies and practices; o risk management o budget, quality, cost and time.

Core knowledge and understanding across Maintenance, Installation, and Repair pathway

Element		Content
Principles, practices and techniques for maintenance and repair	**P1**	Demonstrate understanding of the fundamental principles and practices of maintenance and repair work in engineering and manufacturing contexts (e.g. principles of preventative and reactive maintenance; conditioning monitoring techniques), including: • maintenance philosophies, schedules and related specifications; methods and procedures; records and documentation procedures; equipment operating, care and control procedures; authorisation procedures and limits of responsibility and authority; reporting lines and procedures. • an understanding of standard types of, reasons for, servicing frequency and maintenance condition monitoring techniques and technologies • maintenance costs, implications and effects on production Demonstrate understanding of how maintenance and repair tasks are undertaken in engineering and manufacturing contexts, including: • how maintenance plans are produced, implemented and managed for specific types of tools, equipment, plant, processes and systems • how engineering tools and technology are adjusted to meet operating requirements • safety requirements, analysis, and precautions to be applied and their purpose and effects; appropriate occupational behaviours, understanding of relevant practices, and awareness of protocols. Demonstrate understanding of how components are removed and replaced from assemblies and sub-assemblies, including tightening techniques (e.g. use of torque wrenches) Demonstrate understanding of how the feasibility of component and system repair is evaluated and determined.

		Demonstrate understanding of standard methods and techniques for restoring components to operational condition by repair. Demonstrate understanding of how variations and defects in engineering products and components are managed.
Principles, practices and techniques for configuration and installation	**P2**	Demonstrate understanding of how the planning, configuration and modification of engineering products, processes and components should operate, including: • An understanding of the types of configuration required for different engineering products or processes; procedures for obtaining information on a client's requirements • Configuration, controls, regulations and guidelines, methods, procedures, problems and solutions (e.g. control methods; incorrect fitting of components) Demonstrate understanding of how engineering components are dismantled effectively, including: • relevant health and safety legislation, regulations and safe working practices • engineering drawings, representations and related specifications; dismantling techniques and waste disposal procedures Demonstrate understanding of the standard methods and techniques for installing and modifying engineering components, sub-assemblies, assemblies and systems, including: • an understanding of standard commissioning methods and procedures; methods for evaluating and identifying types of commissioning
Principles, practices and techniques for decommissioning	**P3**	Demonstrate understanding of how to propose and plan products and processes for decommissioning • An understanding of standard methods that could be used for assessing the effectiveness of engineering products and processes and potential decommissioning options available for consideration Demonstrate understanding of how to plan and implement decommissioning methods and procedures, including:

		• An understanding of factors which might affect decommissioning; common types of decommissioning problems that can occur and how they are dealt with or mitigated including relevant regulations and guidelines; and appropriate procedures for obtaining information on regulations and guidelines; systems and recording information and the importance of using information systems effectively.

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

By completing the project brief, learners will develop an appreciation of the breadth and diversity of Engineering and Manufacturing and have an opportunity to demonstrate high-quality workplace practices, which allow them to work safely and effectively across different workplace contexts and contemporary workshop environments.

By achieving the assessment objectives and meeting the employer-set brief, students will demonstrate the following core skills while working on complex, integrated engineering and manufacturing systems, products and components:

Analyse and interpret an employer-set brief

- Evaluate and confirm the brief with reference to context, objectives and constraints (e.g. requirements, resources, precedents, technical issues, costs, health and safety, regulations, possibilities)

Plan and prepare suitable responses to the brief

- Propose, plan and prepare key activities, stages, methods, processes, techniques, documentation, tools, equipment and work areas, including producing risk assessments.

Carry out or develop these response/s using key skills and processes

- Apply maintenance, installation and repair processes and workshop practices to achieve specific objectives and quality outcomes, using relevant techniques, tools, equipment and technology, within limits of own authority.

Evaluate and quality assure processes and outcomes

- Carry out suitable investigations and tests on components and systems at relevant stages, to gather and evaluate relevant evidence and data, and to confirm the suitability of processes, actions and outcomes (including quality control and quality assurance activities)

Communicate and present outcomes and evidence

- Record, report, communicate and present plans, proposals, processes, issues, risks and outcomes to both technical and non-technical audiences, across a range of suitable formats and media (e.g. diagrams; physical and digital records; presentations).

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.

Programme: **Engineering and Manufacturing T Level**

Specialism: **Maintenance, installation and repair (Maintenance engineering technology: Mechanical)**

Performance outcome 1: **Analyse** requirements, specifications and technical information to enable the delivery of successful maintenance, installation, servicing and repair of mechanical plant and equipment.

Knowledge specific to performance outcome	Skills specific to performance outcome
Scientific knowledge Understand the operation of different mechanical principles and systems in practice (e.g. how they manage forces, power and motion) Understand the fundamentals of common mechanisms and lifting machines, including how controllers maintain and control performance (e.g. governors, brakes, levers, gear boxes and torque converters). Understand key principles relating to the storage and transfer of energy in practical contexts. Understand key principles relating to static, dynamic, structural, and fluid loads in practical contexts. Understand the effects of mechanical loadings on structures and components (e.g. weight, torque, fatigue, aerodynamics). Understand the nature, behaviour and measurement of electricity in systems and the key characteristics of power flow analysis and its applications in practical contexts. Understand the construction and operation of standard power conversion systems. Know the components of electrical installations and their uses, including	**Confirm the nature, scope and requirements** of the mechanical maintenance, installation and repair activity, task or problem to be addressed: - Gather and analyse relevant information, data and other evidence to confirm issues, problems, faults, areas for investigation, likely causes, agreed processes, methods, expectations and outcomes. - Examine, explore and interrogate information and data (e.g. client complaint details; maintenance records and schedules) to develop an understanding of issues and appropriate methods for resolution. **Evaluate the condition, quality and performance** of components, systems, materials and resources relating to mechanical maintenance, installation and repair activities: - Observing and making informed judgements about the condition/wear on components and materials - Assessing whether components and materials conform to required grade quality standards or requirements **Interpret and analyse** technical information, data, results, task requirements and supporting documentation from different sources, with

common failure modes and protection methods. Understand common drive devices, their purposes, parameters and applications. Understand the properties and applications of different electrical circuits and their applications. Understand the main characteristics of standard electronic systems, components and their uses. Understand the purposes and applications of electronic sensing and measurement techniques and technologies. Understand standard component classification, numbering and referencing systems and how they apply to mechanical engineering and manufacturing contexts. **Mathematical knowledge** Understand how to use number systems, measurement techniques, and estimation in practical engineering and manufacturing contexts. Understand standard mathematical methods and calculations, including statistical analysis, for measuring, checking and confirming mechanical engineering testing and performance data in practice. Know how to carry out standard calculations in practical engineering and manufacturing contexts, using relevant strands of arithmetic, algebra, geometry and statistics. Understand how to apply trigonometry and standard calculus, matrices and determinants in practical contexts.	reference to performance, quality and compliance: - Interpret mechanical process - Consider the accuracy, relevance and completeness of technical information - Use and respond effectively to specifications, repair information, observed evidence, recall instructions, maintenance tables and, technical bulletins. **Use diagnostic information and other evidence** to determine system and component serviceability for mechanical maintenance, installation and repair activities

Performance outcome 2: **Plan and prepare** the maintenance, installation, servicing and repair of mechanical plant and equipment, taking into account the specific requirements and context.

Knowledge specific to performance outcome	Skills specific to performance outcome
Materials Understand the structure, composition, properties and classification of common materials used in engineering and manufacturing contexts. Understand the uses, applications and disposal requirements of materials in practical contexts. Understand characteristics relating to material quality and condition, how materials degrade and fail, and how these properties are monitored and maintained (e.g. identification; preventative techniques) in practice. Know the range of standard materials testing methods and techniques, their purposes, applications, and relative advantages and disadvantages in practice. Understand materials processing techniques and their effects on materials in practical engineering and manufacturing contexts (e.g. heat treatment). Understand failure modes of materials. **Technical information** Understand the purposes and types of standard technical documentation, including how to produce, interpret and amend them. Know the representations, symbols, annotations and conventions used in engineering and manufacturing technical information, with specific reference to maintenance, servicing, installation and repair (e.g. for geometrical dimensions:- tolerances, limits, fits and finishes; other	**Prioritise and plan** processes, resources, scope of tasks, suitable technology, tools and equipment, in order to demonstrate how to complete mechanical projects, tasks and activities appropriately (e.g. reactive over preventative) to meet specific requirements, quality and standards specifications, and client expectations: - Components, parts and other resources required - Review, confirm and record stock levels, ordering processes, and lead-in times. - Evaluate and plan appropriately for wastage, disposal, recyclability and sustainability in mechanical maintenance, service and repair tasks and activities. **Identify any potential issues and risks** (e.g. commissioning, permits to work, timescales, health and safety considerations), interdependencies, and areas for further investigation (confirming relevant processes and timeframes): - Carry out necessary risk assessments (e.g. moving under suspended loads; noise; height; stored spring energy) - Confirm processes, outcomes and determine potential risks and issues. **Source and check the quality, accuracy and completeness** of information and resources: e.g. - technical bulletins and repair method statements; correct issue dates; accurate amendments

terminology and nomenclature; component assembly and system diagrams). Understand technical drawings, diagrams and representations (e.g. produce 3D model from 2D diagrams). Understand document management and version change control in practice.	- components are correct, complete, free of fault, and conform to specifications, grades and dimensions. - correct calibration of equipment **Carry out required preparatory checks** for compliance, quality, and functionality using correct procedures, processes, techniques and equipment: - Correctly prepare materials, resources, tools, equipment and other technologies - Undertake calibration checks on tools and test equipment (e.g. laser calibrators) - Ensure equipment safe to work on (e.g. rotating parts are guarded or isolated) **Prepare work areas** for planned work processes and outcomes, setting up tools, equipment and work-holding devices (making necessary adjustments, according to specifications and relevant parameters)

Performance outcome 3: **Perform** relevant maintenance, installation, servicing and repair of mechanical plant and equipment, using appropriate techniques and procedures to achieve the required quality outcomes and solutions.

Knowledge specific to performance outcome	Skills specific to performance outcome
Tools and equipment Know the types and purposes of standard hand and power tools and equipment used in engineering and manufacturing contexts. Know how to select, prepare, safely use and maintain hand and power tools and equipment in engineering and manufacturing environments Know how to follow relevant guidelines and instructions, and to seek advice and guidance, where necessary.	**Maintain, install and repair** mechanical systems, equipment and components to agreed expectations and timeframes, and in accordance to specifications, safe practices and legal and regulatory requirements (e.g. BS; ISO DIN, COSHH, HASAWA standards): - Work individually and collaboratively to meet task, client and organisational standards and expectations.

Understand the operation and principles of use for a variety of hand and power tools (including air tools; measuring tools e.g. micrometers; Vernier calipers) commonly used in engineering and manufacturing contexts (and the risks of “non-authorised” tools and equipment). Understand the effects of environmental conditions on materials, plant, and equipment, including appropriate maintenance, management, storage, preservation techniques, and preventative maintenance methods in practice. Understand the range and purposes of standard CAD and CAM systems and software. Understand how to use CAD and CAM systems and software in engineering and manufacturing contexts, across multiple dimensions and collaboratively (e.g. standard features, functions, formats, program tools, techniques, operations and outputs). **Machinery and technology** Understand how to safely operate machinery and technology (e.g. both manual and CNC machine tools) used in engineering and manufacturing environments. Understand how to follow relevant guidelines and instructions (e.g. safety precautions when using drilling machines; the use and repair of different threads when tapping holes), and to seek advice and guidance, where necessary. Be aware of standard parts and machine elements, their uses and applicability in practice. **Workplace practices** Understand roles, responsibilities, functions and tasks in engineering and manufacturing workplace contexts	**Accurately use** diagnostic and measurement techniques, tools and equipment (e.g. hydraulic pressure, thermal checks, torque devices) to measure performance, condition, and compliance of mechanical equipment **Identify and locate faults** and their causes in mechanical devices, systems and equipment (e.g. gasket or O-ring failure; complete manual system checks; utilising fault code readers on specific equipment and technologies) **Complete reactive and preventative maintenance** procedures on mechanical components and systems, making informed decisions about appropriate scheduling of tasks and activities. **Remove, replace and repair** mechanical components and systems, based upon issues identified and agreed task requirements, following relevant instructions and guidance (e.g. manufacturer’s instructions) **Correctly disassemble and assemble** mechanical components, devices and systems, according to appropriate instructions and procedures **Accurately position, install and adjust** mechanical components (e.g. replacement parts, pipework, fasteners) to agreed specifications **Commission and return to service** mechanical equipment, technology and systems to fully operational condition **Effectively perform** a range of essential maintenance, servicing and repair tasks for mechanical maintenance, repair and servicing operations, including the following processes: measuring; cutting;

(specifically mechanical), including the limits of own authority and expertise. Know how to carry out functions in accordance with standard workplace practices, with a particular focus on health and safety, standard engineering processes, hand and power tools, and equipment, machinery and technology. Understand the effects of service and environmental conditions (e.g. material characteristics, temperature, and working pressures) in practice. Understand factors which affect quality in mechanical engineering and manufacturing, and quality assurance processes. **Maintenance, servicing, installation and repair methods and techniques:** Know standard mechanical maintenance and servicing strategies, methods and practices, including preventative, reactive and condition monitoring techniques in practice. Know standard installation techniques, configuration, and integration of engineering systems in practice. Know standard fault diagnosis and resolution methods (both quantitative and qualitative) in practice. Know effective fault detection and isolation methods in mechanical engineering and manufacturing contexts. Know techniques for assembly, disassembly, configuration, installation, modification and integration of systems in practice. Understand manufacturing, production and joining techniques (including welded, riveted, folded, fastened, bonded and bolted joints), relevant to mechanical maintenance, installation and repair.	drilling; filing; removing and replacing bolts, screws and clips; replacing seals; extracting and replacing damaged fasteners; applying surface treatments. **Effectively carry out common engineering fabrication processes** (including producing standard welds to meet specific requirements) in line with detailed specifications, using appropriate techniques, technology, tools and equipment. **Re-instate work areas**, managing and storing tools and equipment appropriately

Understand the limits of own authority and expertise, and how and when to seek advice, guidance, and relevant expertise and support, as necessary.	

Performance outcome 4: **Review and evaluate** activities to help improve workplace systems and processes associated with maintenance, installation, servicing and repair of mechanical plant and equipment, demonstrating commercial awareness and accountability.

Knowledge specific to performance outcome	Skills specific to performance outcome
Standards Know and understand relevant engineering standards to ensure quality, compliance, performance and function (e.g. traceability; revisions management; specific British Standards; ISO9001) Know and understand the purpose of standard operating procedures in engineering, manufacturing and organisational contexts. **Legal and regulatory context** Know and understand relevant legal and regulatory frameworks and documentation, including how to access sources of authoritative information. Understand relevant statutory, quality, environmental quality and compliance procedures and systems in practice. **Health and safety** Understand health and safety regulations and procedures in engineering and manufacturing contexts. Understand relevant site and process safety, environment and risk management systems and practices.	**Consistently apply safe systems of work** in the delivery of all activities, taking responsibility for safe practices and legal compliance **Monitor work area practices**, anticipating and identifying potential and actual risks, issues and problems, while taking effective steps to prevent, resolve, manage and mitigate them. **Deal promptly and effectively with issues (e.g.safety) and problems** within the limits of own authority, using appropriate techniques and processes to address them **Report and escalate issues and problems**, where necessary. **Carry out quality monitoring and assurance** checks as part of a team's mechanical maintenance, servicing and repair operations and processes - Complete second-line or supervisory checks at relevant points **Evaluate and review** maintenance, servicing and repair processes, practices and outcomes, providing relevant technical

Understand how to confirm, interpret, follow and comply with health and safety requirements at all times. **Programme and project management** Know how projects (and programmes) are defined, structured, reported on and measured in standardised management practices, including project planning and control methodologies. Understand risk analysis and management (including statistical risk analysis) in practice. Understand relevant roles, responsibilities, accountability andhow management operates in relevant engineering and manufacturing contexts. Understand how to support and improve projects through research, evidence and evaluation. **Business and commercial awareness** Know how to evaluate mechanical engineering and manufacturing activities in terms of quality, cost and time. Understand commercial and financial objectives and constraints, considering project objectives, resources, efficiency, cost, reputation and risk. Understand company management systems, policies and procedures in practice. **Quality control, assurance and improvement** Understand the purposes and application of quality control, quality assurance and quality improvement in engineering and manufacturing contexts. Understand standard quality inspection and testing methods and techniques in engineering and manufacturing contexts.	information, advice, and suggestions about quality, performance and potential improvements **Make positive contributions** to mechanical maintenance and operations contexts whilst working effectively with others. Respond constructively to feedback and identify opportunities for personal and organisational improvement (e.g. commercial, productivity-related, safety-related).

Know how to complete and record relevant quality processes in engineering and manufacturing contexts.	

Performance outcome 5: **Communicate** mechanical operations, maintenance, installation, servicing and repair information, proposals and solutions, **producing, recording and explaining** relevant technical information.

Knowledge specific to performance outcome	Skills specific to performance outcome
Communication Understand how to communicate technical information and data in engineering and manufacturing contexts. **Information technology and digital** Know how to use relevant digital and information and communication technology (ICT) to record, manage, store, and amend information, data and records (including using collaborative technologies) in engineering and manufacturing contexts.	**Accurately record, amend and correct** relevant technical information, data, risks and issues to support mechanical maintenance, servicing and repair work at relevant stages, within limits of authority - update service books; test certificates; certification of work; major assembly changes; modifications; recall service completions. - record all test results including independent tests. - Use records, information and data to inform improved practices, recommendations, and continuous improvement. **Complete effective handover** procedures (e.g. following service, complex repair, pre-delivery inspection), confirming and communicating quality standards, specific requirements, outcomes, and any other issues relevant to activities **Produce accurate engineering and manufacturing representations** to support maintenance, installation and repair processes - Produce an appropriate representation using recognised conventions to communicate and confirm details, issues, processes and requirements

	- Apply and amend information using accurate annotations, symbols, and conventions. **Demonstrate effective team-working**, inter-personal skills and communication with technical and non-technical audiences **Support effective communication**, conveying and confirming information, requirements, expectations, plans, performance, and outcomes using different methods (e.g. written, oral) and media.

Programme: **Engineering and Manufacturing T Level**

Specialism: **Maintenance, installation and repair (Maintenance engineering technology: Mechatronics)**

Performance outcome 1: **Analyse** requirements, specifications and technical information to enable the delivery of successful maintenance, installation, servicing and repair of mechatronic technology, systems, and equipment.

Knowledge specific to performance outcome	Skills specific to performance outcome
Scientific knowledge Understand the operation of different mechanical principles and systems in practice (e.g. how they manage forces, power and motion). Understand the fundamentals of common mechanisms and lifting machines, including how controllers maintain and control performance (e.g. governors, brakes, levers, gear boxes and torque converters) Understand key principles relating to the storage and transfer of energy in practical contexts. Understand key principles relating to static, dynamic, structural, and fluid loads in practical contexts, and the effects of mechanical loadings on structures and components (e.g. weight, torque, fatigue, aerodynamics). Understand the nature, behaviour and measurement of electricity in systems, the key characteristics of power flow analysis and its applications in practice. Understand the construction and operation of standard power conversion systems in practice. Know the components of electrical installations and their uses, including common failure modes and protection methods.	**Confirm the nature, scope and requirements** of the mechatronics maintenance, installation and repair activity, task or problem to be addressed: - Gather and analyse relevant information, data and other evidence to confirm issues, problems, faults, areas for investigation, likely causes, agreed processes, methods, expectations and outcomes. - Examine, explore, and interrogate information and data (e.g. client complaint details; maintenance records and schedules) to develop an understanding of issues and the appropriate methods for resolution. **Evaluate the condition, quality and performance** of components, systems, materials and resources relating to mechatronic maintenance, installation and repair activities: - Observing and making informed judgements about the condition/wear on components and materials - Assessing whether components and materials conform to required grade quality standards or requirements **Interpret and analyse** technical information, data, results, task requirements, and supporting documentation from different sources (e.g. specifications, repair information, maintenance tables, wiring diagrams, recall instructions), with reference to quality and compliance requirements:

Understand common drive devices, their purposes, parameters and applications. Understand the properties and applications of different electrical circuits and their applications. Understand the main characteristics of standard electronic systems, components and their uses. Understand the purposes and applications of electronic sensing and measurement techniques and technologies in practice. Understand standard component classification, numbering and referencing systems and how they apply to mechatronics contexts. **Mathematical knowledge** Understand how to use number systems, measurement techniques, and estimation in practical engineering and manufacturing contexts. Understand standard mathematical methods and calculations, including statistical analysis, for measuring, checking and confirming mechanical engineering and manufacturing testing and performance data Know how to carry out standard calculations in engineering and manufacturing contexts, using relevant strands of arithmetic, algebra, geometry and statistics. Understand how to apply trigonometry and standard calculus, matrices and determinants in practical contexts.	- Interpret mechanical process - Consider the accuracy, relevance and completeness of technical information - Use and respond effectively to specifications, repair information, observed evidence, recall instructions, maintenance tables, and technical bulletins. **Use diagnostic information and other evidence** e.g sight, smell, customer/user information to determine mechatronic system and component serviceability for maintenance, installation and repair activities

Performance outcome 2: **Plan and prepare** the maintenance, installation, servicing and repair of mechatronic technology, systems, and equipment, taking into account the specific requirements and context.

Knowledge specific to performance outcome	Skills specific to performance outcome
Materials Understand the structure, composition, properties and classification of common materials used in engineering and manufacturing contexts. The uses, applications and disposal requirements of materials in mechatronics contexts. Understand characteristics relating to material quality and condition, how materials degrade and fail, and how these properties are monitored and maintained (e.g. identification; preventative techniques) in practice. Know the range of standard materials testing methods and techniques, their purposes, applications, and relative advantages and disadvantages in mechatronics contexts. Understand materials processing techniques and their effects on materials in practical engineering and manufacturing contexts. (e.g. heat treatment). Understand failure modes of materials. **Technical information** Understand the purposes and types of standard technical documentation, including how to produce, interpret and amend them. Know the representations, symbols, annotations and conventions used in engineering and manufacturing technical information, with specific reference to maintenance, servicing, installation and repair (e.g. for geometrical dimensions, tolerances, limits, fits and finishes; other terminology and nomenclature;	**Prioritise and plan** processes, resources, scope of tasks, suitable technology, tools and equipment, in order to demonstrate how to complete projects, tasks and activities appropriately (e.g. reactive over preventative) to meet specific requirements, quality and standards specifications, and client expectations: - Components, parts and other resources required - Review, confirm and record stock levels, ordering processes, and lead-in times. - Evaluate and plan appropriately for wastage, disposal, recyclability and sustainability in mechanical maintenance, service and repair tasks and activities. **Identify any potential issues, and risks** (e.g. commissioning, permits to work, timescales, health and safety considerations), interdependencies, and areas for further investigation (confirming relevant processes and timeframes): - Carry out necessary risk assessments (e.g. moving under suspended loads; stored electrical energy; stored mechanical energy, pressurised gases) - Confirm processes, outcomes and mitigations used to reduce potential risks and issues. **Source and check the quality, accuracy and completeness** of information and resources: e.g. - technical bulletins and repair method statements; correct issue dates; accurate amendments - components are correct, complete, free of fault, and conform to specifications, grades and dimensions.

component assembly and system diagrams). Understand technical drawings, diagrams and representations (e.g. produce 3D model from 2D diagrams). Understand document management and version control in practice	**Carry out required preparatory checks** for compliance, quality, and functionality using correct procedures, processes, techniques and equipment (e.g. testing for dead): - Correctly prepare materials, resources, tools, equipment and other technologies - Undertake calibration checks on tools and test equipment (e.g. laser calibrators) - Ensure equipment safe to work on (e.g. rotating parts are guarded or isolated) **Prepare work areas** for planned work processes and outcomes, setting up tools, equipment and work-holding devices (making necessary adjustments, according to specifications and relevant parameters)

Performance outcome 3: **Perform** relevant maintenance, installation, servicing and repair of mechatronic technology, systems, and equipment, using appropriate techniques and procedures to achieve the required quality outcomes and solutions.

Knowledge specific to performance outcome	Skills specific to performance outcome
Tools and equipment Know the types and purposes of standard hand and power tools and equipment (including test equipment such as multi-meters, ECU diagnostic testers etc) used in engineering and manufacturing contexts. Know how to select, prepare, safely use and maintain hand and power tools and equipment in engineering and manufacturing environments, to follow relevant guidelines and instructions, and to seek advice and guidance, where necessary. Know how to follow relevant guidelines and instructions, and to seek advice and guidance, where necessary. Understand the operation and principles of use for a variety of hand and power	**Maintain, install and repair** mechatronic systems, equipment and components to agreed expectations and timeframes, and in accordance to specifications, safe practices and legal and regulatory requirements (e.g. the current edition of the IET regulations): - Work individually and collaboratively to meet task, client and organisational standards and expectations. **Accurately use** diagnostic and measurement techniques, tools and equipment (e.g. ECU diagnostic testers; dial gauges; laser calibraters) to measure performance, condition, and compliance of mechatronic equipment **Identify and locate faults** and their causes in mechatronic devices, systems

tools (including air tools; measuring tools e.g. micrometers; Vernier calipers) commonly used in engineering and manufacturing contexts (and the risks of "non-authorised" tools and equipment). Understand the effects of environmental conditions on materials, plant, and equipment, including appropriate maintenance, management, storage, preservation techniques, and preventative maintenance methods in practice. Understand electro-static sensitive devices and components (ESDs), and suitable measures for protecting them in different practical contexts, including transport, storage, and during maintenance, servicing and repair work (e.g. ESD-safe bags and foam; grounding mats and grounding tools; anti-static garments or wrist straps). Understand the range and purposes of standard CAD and CAM systems and software in mechatronic contexts. Understand how to use CAD and CAM systems and software in engineering and manufacturing contexts, across multiple dimensions and collaboratively (e.g. standard features, functions, formats, program tools, techniques, operations and outputs). **Machinery and technology** Understand how to safely operate machinery and technology used in engineering and manufacturing environments. Understand how to follow relevant guidelines and instructions (e.g. safety precautions when using drilling machines; the use and repair of different threads when tapping holes), and to seek advice and guidance, where necessary. Be aware of standard parts and machine elements, their uses and applicability in mechatronics contexts.	and equipment (e.g. control valve failure; gasket failure, sensor failure, electrical circuit/supply integrity faults etc) **Complete reactive and preventative maintenance** procedures on mechatronic components and systems, making informed decisions about appropriate scheduling of tasks and activities. **Remove, replace and repair** mechatronic components and systems, based upon issues identified and agreed task requirements, following relevant instructions and guidance (e.g. manufacturer's instructions) **Correctly disassemble and assemble** mechatronic components, devices and systems, according to appropriate instructions and procedures **Accurately position and install** mechatronic devices and equipment (e.g. sensors, wiring, motors) to agreed specifications **Commission and return to service** mechatronic devices, systems and technology to fully operational condition **Effectively perform** a range of essential maintenance, servicing and repair tasks for mechanical maintenance, repair and servicing operations, including the following processes: measuring; cutting, drilling, filing, removing and replacing bolts, screws and clips, replacing seals, extracting and replacing damaged fasteners; soldering and brazing; applying surface treatments. **Re-instate work areas**, managing and storing tools and equipment appropriately

Workplace practices Understand roles, responsibilities, functions and tasks in engineering and manufacturing workplace contexts (specifically mechatronic), including limits of own authority and expertise. Know how to carry out functions in accordance with standard workplace practices, with a particular focus on health and safety, standard engineering and manufacturing processes, hand and power tools and equipment, machinery and technology. Understand the effects of service and environmental conditions (e.g. material characteristics, temperature, and working pressures) in practice. Understand factors which affect quality in mechatronic engineering and manufacturing processes, including quality assurance processes. **Maintenance, servicing, installation and repair methods and techniques:** Know standard mechatronic maintenance and servicing strategies, methods and practices, including preventative, reactive and condition monitoring techniques. Know standard installation techniques, configuration, and integration of engineering and manufacturing systems. Know standard fault diagnosis and resolution methods (both quantitative and qualitative) in mechatronic contexts. Know effective fault detection and isolation methods in mechatronic contexts. Know techniques for assembly, disassembly, configuration, installation, modification and integration of systems in mechatronic contexts.	

Understand manufacturing, production and joining techniques (including welded, riveted, folded, fastened, bonded and bolted joints), relevant to mechatronic maintenance, installation and repair. Understand the limits of own authority and expertise, and how and when to seek advice, guidance, and relevant expertise and support, as necessary	

Performance outcome 4: **Review and evaluate** activities to help improve workplace systems and processes associated with maintenance, installation, servicing and repair of mechatronic technology, systems, and equipment, demonstrating commercial awareness and accountability.

Knowledge specific to performance outcome	Skills specific to performance outcome
Standards Know and understand relevant engineering and manufacturing standards to ensure quality, compliance, performance and function (e.g. traceability; revisions management; specific British Standards; ISO9001) in practice. Know and understand the purpose of standard operating procedures in engineering, manufacturing and organisational contexts. **Legal and regulatory context** Know and understand relevant legal and regulatory frameworks and documentation, including how to access sources of authoritative information. Understand relevant statutory, quality, environmental quality and compliance procedures and systems in practice. **Health and safety**	**Consistently apply safe systems of work** in the delivery of all activities, taking responsibility for safe practices and legal compliance **Monitor work area practices**, anticipating and identifying potential and actual risks, issues and problems, while taking effective steps to prevent, resolve, manage and mitigate them: - Check and confirm stock levels, materials and availability of resources. **Deal promptly and effectively with issues (e.g. safety) and problems** within the limits of own authority, using appropriate techniques and processes to address them **Report and escalate issues and problems**, where necessary. **Carry out appropriate quality monitoring and assurance** checks as part of mechatronic maintenance, servicing and repair operations and processes:

Understand health and safety regulations and procedures in engineering and manufacturing contexts. Understand relevant site and process safety, environment and risk management systems and practices. Understand how to confirm, interpret, follow and comply with health and safety requirements at all times. **Programme and project management** Know how projects (and programmes) are defined, structured, reported on and measured in standardised management practices, including project planning and control methodologies. Understand risk analysis and management (including statistical risk analysis) in practical contexts. Understand relevant roles, responsibilities, accountability and how management operates in relevant engineering and manufacturing contexts. Understand how to support and improve projects through research, evidence and evaluation. **Business and commercial awareness** Know how to evaluate engineering and manufacturing activities in terms of quality, cost and time. Understand commercial and financial objectives and constraints, considering project objectives, resources, efficiency, cost, reputation and risk. Understand company management systems, policies and procedures in practice. **Quality control, assurance and improvement**	- Complete second-line or supervisory checks at relevant points **Evaluate and review** maintenance, servicing and repair processes, practices and outcomes, providing relevant technical information, advice, and suggestions about quality, performance and potential improvements **Make positive contributions** to mechatronic maintenance and operations' contexts whislt working effectively with others. Respond constructively to feedback, and identify opportunities for personal and organisational improvement (e.g. commercial, productivity-related, safety-related).

Understand the purposes and application of quality control, quality assurance and quality improvement in engineering and manufacturing contexts. Understand standard quality inspection and testing methods and techniques in engineering and manufacturing contexts. Know how to complete and record relevant quality processes in engineering and manufacturing contexts.	

Performance outcome 5: **Communicate** mechatronic maintenance, installation, servicing and repair information, proposals and solutions, **producing, recording and explaining** relevant technical information.

Knowledge specific to performance outcome	Skills specific to performance outcome
Communication Understand how to communicate technical information and data in engineering and manufacturing contexts. **Information technology and digital** Know how to use relevant digital and information and communication technology (ICT) to record, manage, store, and amend information, data and records (including using collaborative technologies) in engineering and manufacturing contexts.	**Accurately record, amend and correct** relevant technical information, data, risks and issues to support mechatronic maintenance, servicing and repair work at relevant stages, within limits of authority - update service books; test certificates; certification of work; major assembly changes; modifications; recall service completions. - record all test results, including independent tests - Use records, information and data to inform improved practices, recommendations, and continuous improvement. **Complete effective handover** procedures (e.g. following service, complex repair, pre-delivery inspection), confirming and communicating quality standards, specific requirements, outcomes, and any other issues relevant to the activities carried out. **Produce accurate engineering and manufacturing representations** to

	support maintenance, installation and repair processes - Produce an appropriate representation using recognised conventions to communicate and confirm details, issues, processes and requirements - Apply and amend information using accurate and appropriate annotations, symbols, and conventions. **Demonstrate effective team-working**, inter-personal skills and communication with technical and non-technical audiences **Support effective communication**, conveying and confirming information, requirements, expectations, plans, performance, and outcomes using different methods (e.g. written, oral) and media.

Programme: **Engineering and Manufacturing T Level**

Specialism: **Maintenance, installation and repair (Maintenance engineering technology: Electrical and Electronic)**

Performance outcome 1: **Analyse** requirements, specifications and technical information to enable the delivery of successful maintenance, installation, servicing and repair of electrical and electronic technology, systems and equipment.

Knowledge specific to performance outcome	Skills specific to performance outcome
Scientific knowledge Understand the nature, behaviour and measurement of electricity in systems, the key characteristics of power flow analysis and its applications in practice. Understand the construction and operation of standard power conversion systems in practical contexts. Know the components of electrical installations and their uses, including common failure modes and protection methods. Understand common drive devices, their purposes, parameters and applications. Understand the properties and applications of different electrical circuits and their applications. Understand the main characteristics of standard electronic systems, components and their uses. Understand the purposes and applications of electronic sensing and measurement techniques and technologies in practice. Understand standard component classification, numbering and referencing systems and how they apply to electrical and electronic contexts. Understand the operation of different mechanical principles and systems (e.g. how they manage forces, power and motion) in practice.	**Confirm the nature, scope and requirements** of the electrical and electronic maintenance, installation and repair activity, task or problem to be addressed: - Gather and analyse relevant information, data and other evidence to confirm issues, problems, faults, areas for investigation, likely causes, agreed processes, methods, expectations and outcomes. - Examine, explore, and interrogate information and data (e.g. client complaint details; maintenance records and schedules) to develop an understanding of issues and appropriate methods for resolution. **Evaluate the condition, quality and performance** of components, systems, materials and resources relating to electrical and electronic maintenance, installation and repair activities: - Observing and making informed judgements about the condition of components and materials - Assessing whether components and materials conform to required grade quality standards or requirements **Interpret and analyse** technical information, data, results, task requirements, test results, and relevant documentation from different sources, with reference to performance, quality and compliance:

Understand the fundamentals of common mechanisms and lifting machines, including how controllers maintain and control performance (e.g. governors, brakes, levers, gear boxes or torque converters) in practical contexts. Understand key principles relating to the storage and transfer of energy in practical contexts Understand key principles relating to static, dynamic, structural, and fluid loads in practical contexts, and the effects of mechanical loadings on structures and components (e.g. weight, torque, fatigue, aerodynamics) in practice. **Mathematical knowledge** Understand how to use number systems, measurement techniques, and estimation in practical engineering and manufacturing contexts. Understand standard mathematical methods and calculations, including statistical analysis, for measuring, checking and confirming engineering and manufacturing testing and performance data in practice. Know how to carry out standard calculations in engineering and manufacturing contexts, using relevant strands of arithmetic, algebra, geometry and statistics. Understand how to apply trigonometry and standard calculus, matrices and determinants in practical contexts.	- Interpret electrical and electronic wiring diagrams - Consider the accuracy, relevance and completeness of technical information - Use and respond effectively to specifications, repair information, observed evidence, recall instructions, maintenance tables, technical bulletins. **Use diagnostic information and other evidence** to determine electrical and electronic system and component serviceability.

Performance outcome 2: **Plan and prepare** the maintenance, installation, servicing and repair of electrical and electronic technology, systems and equipment, taking into account the specific requirements and context.

Knowledge specific to performance outcome	Skills specific to performance outcome

Materials

Understand the structure, composition, properties and classification of common materials used in engineering and manufacturing contexts.

Understand the uses, applications and disposal requirements of materials in electrical and electronic contexts.

Understand characteristics relating to material quality and condition, how materials degrade and fail, and how these properties are monitored and maintained (e.g. identification; preventative techniques) in practice.

Know the range of standard materials testing methods and techniques, their purposes, applications, and relative advantages and disadvantages in practical contexts.

Understand materials processing techniques and their effects on materials in engineering and manufacturing contexts. (e.g. heat treatment)

Understand failure modes of materials

Technical information

Understand the purposes and types of standard technical documentation, including how to produce, interpret and amend them.

Know the representations, symbols, annotations and conventions used in engineering and manufacturing technical information, with specific reference to maintenance, servicing, installation and repair (e.g. for geometrical dimensions, tolerances, limits; fits and finishes; other terminology and nomenclature; wiring diagrams).

Understand technical drawings, diagrams and representations (e.g. produce 3D model from 2D diagrams).

Prioritise and plan processes, resources, scope of tasks, suitable technology, tools and equipment in order to demonstrate how to complete electrical and electronic projects, tasks and activities appropriately (e.g. reactive over preventative) to meet specific requirements, quality and standards specifications, and client expectations:

- Components, parts and other resources required
- Review, confirm and record stock levels, ordering processes, and lead-in times.
- Evaluate and plan appropriately for wastage, disposal, recyclability and sustainability in electrical and electronic maintenance, service and repair tasks and activities.

Identify any potential issues and risks (e.g. permits to work, timescales, electrical and health and safety considerations), interdependencies, and areas for further investigation (confirming relevant processes and timeframes):

- Carry out necessary risk assessments (e.g. stored electrical energy; testing for dead)
- Confirm processes, outcomes and determine potential risks and issues.

Source and check the quality, accuracy and completeness of information and resources: e.g.

- technical bulletins and repair method statements; correct issue dates; accurate amendments
- components are correct, complete, free of fault, and conform to specifications, grades and dimensions.
- correct calibration of equipment

Carry out required preparatory checks for compliance, quality, and functionality using correct procedures, processes, techniques and equipment:

Understand document management and version change control in practice.	- Correctly prepare materials, resources, tools, equipment and other technologies - Undertake calibration checks on tools and test equipment (e.g. laser calibrators) - Ensure equipment is safe to work on (e.g. testing for dead; isolation) **Prepare work areas** for planned work processes and outcomes, setting up tools, devices and equipment (making necessary adjustments, according to specifications and relevant parameters): - Effectively set up and use relevant maintenance, repair, testing and diagnostic tools and equipment

Performance outcome 3: **Perform** relevant maintenance, installation, servicing and repair of electrical and electronic technology, systems, and equipment, using appropriate techniques and procedures to achieve the required quality outcomes and solutions.

Knowledge specific to performance outcome	Skills specific to performance outcome
Tools and equipment Know the types and purposes of standard hand and power tools and equipment used in engineering and manufacturing contexts. Know how to select, prepare, safely use and maintain hand and power tools and equipment in engineering and manufacturing environments. Know how to follow relevant guidelines and instructions, and to seek advice and guidance, where necessary. Understand the operation and principles of use for a variety of hand and power tools (including air tools; measuring tools e.g. micrometers; Vernier calipers) commonly used in engineering and manufacturing contexts (and the risks of "non-authorised" tools and equipment).	**Maintain, install and repair** electrical and electronic systems, equipment and components based upon agreed expectations and timeframes, and in accordance to specifications, safe practices and legal and regulatory requirements (e.g. the current edition of the IET regulations): - Work individually and collaboratively to meet task, client and organisational standards and expectations. **Accurately use** diagnostic and measurement techniques, tools and equipment (e.g. oscilloscope, spectrum analyser, electronic multimeter) to measure performance, condition, and compliance of electrical and electronic equipment **Identify and locate faults** and their causes in electrical and electronic devices, systems and equipment (e.g. interpret and

Understand the effects of environmental conditions on materials, components, wiring, and equipment including appropriate maintenance, management, storage, preservation techniques, and preventative maintenance methods in practice. Understand electro-static sensitive devices and components (ESDs), and suitable measures for protecting them in different contexts, including transport, storage, during maintenance, servicing and repair work (e.g. ESD-safe bags and foam; grounding mats and grounding tools; anti-static garments or wrist straps). Understand the range and purposes of standard CAD and CAM systems and software in electrical and electronic contexts. Understand how to use CAD and CAM systems and software in engineering and manufacturing contexts, across multiple dimensions and collaboratively (e.g. standard features, functions, formats, program tools, techniques, operations and outputs). **Machinery and technology** Understand how to safely operate machinery and technology used in engineering and manufacturing environments. Understand how to follow relevant guidelines and instructions (e.g. safety precautions when using drilling machines; the use and repair of different threads when tapping holes), and to seek advice and guidance, where necessary. Be aware of standard parts and machine elements, their uses and applicability in electrical and electronic engineering and manufacturing contexts. **Workplace practices**	interrogate built in tests, complete manual system checks, use recognised fault finding methodologies). **Complete reactive and preventative maintenance** procedures on electrical and electronic components and systems, making informed decisions about appropriate scheduling of tasks and activities. **Remove, replace and repair** electrical and electronic components and systems, based upon issues identified and agreed task requirements, following relevant instructions and guidance (e.g. manufacturer's instructions) **Correctly disassemble and assemble** electrical and electronic components, devices and systems, according to appropriate instructions and procedures **Accurately position, install and adjust** electrical and electronic devices and equipment (e.g. sensors, wiring, generators, motors) to agreed specifications **Support the commissioning and return to service** of electrical and electronic devices, systems and technology to fully operational condition **Effectively perform** a range of essential maintenance, servicing and repair tasks for electrical and electronic maintenance operations, to include procedures such as: wiring, crimping, measuring, cutting, soldering, stripping, removing and replacing circuits. **Re-instate work areas**, managing and storing tools and equipment appropriately

Understand roles, responsibilities, functions and tasks in engineering and manufacturing workplace contexts, including the limits of own authority and expertise. Know how to carry out functions in accordance with standard workplace practices, with a particular focus on health and safety, standard engineering and manufacturing processes, hand and power tools and equipment, machinery and technology. Understand the effects of service and environmental conditions (e.g. material characteristics, temperature, and working pressures) in practical contexts. Understand factors which affect quality in electrical and electronic engineering and manufacturing, and quality assurance processes. **Maintenance, servicing, installation and repair methods and techniques:** Know standard mechanical maintenance and servicing strategies, methods and practices, including preventative, reactive and condition monitoring techniques in electrical and electronic contexts. Know standard installation techniques, configuration, and integration of engineering systems in electrical and electronic contexts. Know standard fault diagnosis and resolution methods (both quantitative and qualitative) in electrical and electronic contexts. Know effective fault detection and isolation methods in electrical and electronic engineering and manufacturing contexts. Know techniques for assembly, disassembly, configuration, installation, modification and integration of systems in practice.	

Understand manufacturing, production and joining techniques (e.g. welded, riveted, folded, fastened, bonded and bolted joints), relevant to electrical and electronic maintenance, installation and repair. Understand the limits of own authority and expertise, and how and when to seek advice, guidance, and relevant expertise and support, as necessary.	

Performance outcome 4: **Review and evaluate** activities to help improve workplace systems and processes associated with maintenance, installation, servicing and repair of electrical and electronic technology, systems, and equipment, demonstrating commercial awareness and accountability.

Knowledge specific to performance outcome	Skills specific to performance outcome
Standards Know and understand relevant engineering standards to ensure quality, compliance, performance and function (e.g. traceability; revisions management; specific British Standards; ISO9001) in practice. Know and understand the purpose of standard operating procedures in engineering, manufacturing and organisational contexts. **Legal and regulatory context** Know and understand relevant legal and regulatory frameworks and documentation, including how to access sources of authoritative information. Understand relevant statutory, quality, environmental quality and compliance procedures and systems in practice. **Health and safety** Understand health and safety regulations and procedures in engineering and manufacturing contexts.	**Consistently apply safe systems of work** in the delivery of all activities, taking responsibility for safe practices and legal compliance **Monitor work area practices**, anticipating and identifying potential and actual risks, issues and problems, while taking effective steps to prevent, resolve, manage and mitigate them: - Check, confirm and record stock levels, materials and availability of resources. **Deal promptly and effectively with issues and problems** within the limits of own authority, using appropriate techniques and processes to address them **Report and escalate issues and problems**, where necessary. **Carry out appropriate quality monitoring and assurance** checks as part of a team's electrical and electronic maintenance, servicing and repair operations and processes

Understand relevant site and process safety, environment and risk management systems and practices. Understand how to confirm, interpret, follow and comply with health and safety requirements at all times. **Programme and project management** Know how projects (and programmes) are defined, structured, reported on and measured in standardised management practices, including project planning and control methodologies. Understand risk analysis and management (including statistical risk analysis) in electrical and electronic contexts. Understand relevant roles, responsibilities, accountability and management operates in relevant engineering and manufacturing contexts. Understand how to support and improve projects through research, evidence and evaluation. **Business and commercial awareness** Know how to evaluate engineering and manufacturing activities in terms of quality, cost and time. Understand commercial and financial objectives and constraints, considering project objectives, resources, efficiency, cost, reputation and risk. Understand company management systems, policies and procedures in practice. **Quality control, assurance and improvement** Understand the purposes and application of quality control, quality assurance and	- Complete second-line or supervisory checks at relevant points **Evaluate and review** maintenance, servicing and repair processes, practices and outcomes, providing relevant technical information, advice, and suggestions about quality, performance and potential improvements **Make positive contributions** to electrical and electronic maintenance and operations' contexts, whilst working effectively with others. Respond constructively to feedback, and identifying opportunities for personal and organisational improvement (e.g. commercial, productivity-related, safety-related).

quality improvement in engineering and manufacturing contexts. Understand standard quality inspection and testing methods and techniques in engineering and manufacturing contexts. Know how to complete and record relevant quality processes in engineering and manufacturing contexts.	

Performance outcome 5: **Communicate** electrical and electronic maintenance, installation, servicing and repair information, proposals and solutions, **producing, recording and explaining** relevant technical information.

Knowledge specific to performance outcome	Skills specific to performance outcome
Communication Understand how to communicate technical information and data in engineering and manufacturing contexts. **Information technology and digital** Know how to use relevant digital and information and communication technology (ICT) to record, manage, store, and amend information, data and records (including using collaborative technologies) in engineering and manufacturing contexts.	**Accurately record, amend and correct** relevant technical information, data, risks and issues to support electrical and electronic maintenance, servicing and repair work at relevant stages, within limits of authority - update service books; test certificates; certification of work; major assembly changes; modifications; recall service completions. - record all test results, including independent tests - Use records, information and data to inform improved practices, recommendations, and continuous improvement. **Complete effective handover** procedures (e.g. following service, complex repair, pre-delivery inspection), confirming and communicating quality standards, specific requirements, outcomes, and any other issues relevant to activities **Produce accurate engineering and manufacturing representations** to support maintenance, installation and repair processes:

	- Produce an appropriate representation using recognised conventions to communicate and confirm details, issues, processes and requirements - Apply and amend information using accurate annotations, symbols, and conventions. **Demonstrate effective team-working**, inter-personal skills and communication with technical and non-technical audiences **Support effective communication**, conveying and confirming information, requirements, expectations, plans, performance, and outcomes using different methods (e.g. written, oral) and media.

Programme: **Engineering and Manufacturing T Level**

Specialism: **Maintenance, installation and repair (Maintenance engineering technology: control and instrumentation)**

Performance outcome 1: **Analyse** requirements, specifications and technical information to enable the delivery of successful maintenance, installation, servicing and repair of control and instrumentation technology, systems, and equipment.

Knowledge specific to performance outcome	Skills specific to performance outcome
Scientific knowledge Understand the nature, behaviour and measurement of electricity in systems, the key characteristics of power flow analysis and its applications in practice. Understand the construction and operation of standard power conversion systems. Know the components of electrical installations and their uses, including common failure modes and protection methods. Understand common drive devices, their purposes, parameters and applications. Understand the properties and applications of different electrical circuits and their applications in practice. Understand the main characteristics of standard electronic systems, components and their uses in practical contexts. Understand the purposes and applications of electronic sensing and measurement techniques and technologies in practice. Understand standard component classification, numbering and referencing systems and how they apply to control and instrumentation contexts. Understand the operation of different mechanical principles and systems (e.g. how they manage forces, power and motion) in practice.	**Confirm the nature, scope and requirements** of the control and instrumentation maintenance, installation and repair activity, task or problem to be addressed: - Gather and analyse relevant information, data and other evidence to confirm issues, problems, faults, areas for investigation, likely causes, agreed processes, methods, expectations and outcomes. - Examine, explore, and interrogate information and data (e.g. client complaint details; maintenance records and schedules) to develop an understanding of issues and appropriate methods for resolution. **Evaluate the condition, quality and performance** of components, systems, materials and resources relating to control and instrumentation maintenance, installation and repair activities: - Observing and making informed judgements about the condition of components and materials - Assessing whether components and materials conform to required grade quality standards or requirements **Interpret and analyse** technical information, data, results, task requirements, test results, and relevant documentation from different sources, with

Understand the fundamentals of common mechanisms and lifting machines, including how controllers maintain and control performance (e.g. governors, brakes, levers, gear boxes or torque converters) in practice. Understand key principles relating to the storage and transfer of energy in practical contexts. Understand key principles relating to static, dynamic, structural, and fluid loads in practical contexts, and the effects of mechanical loadings on structures and components (e.g. weight, torque, fatigue, aerodynamics) in practice. **Mathematical knowledge** Understand how to use number systems, measurement techniques, and estimation in practical engineering and manufacturing contexts. Understand standard mathematical methods and calculations, including statistical analysis, for measuring, checking and confirming engineering and manufacturing testing and performance data in practical contexts. Know how to carry out standard calculations in engineering and manufacturing contexts, using relevant strands of arithmetic, algebra, geometry and statistics. Understand how to apply trigonometry and standard calculus, matrices and determinants in practical contexts.	reference to performance, quality and compliance: - Interpret electrical and electronic wiring diagrams - Consider the accuracy, relevance and completeness of technical information - Use and respond effectively to specifications, repair information, observed evidence, recall instructions, maintenance tables, and technical bulletins. **Use diagnostic information and other evidence** to determine control and instrumentation system and component serviceability to include data collection from the system

Performance outcome 2: **Plan and prepare** the maintenance, installation, servicing and repair of control and instrumentation technology, systems and equipment, taking into account the specific requirements and context.

Knowledge specific to performance outcome	Skills specific to performance outcome
Materials Understand the structure, composition, properties and classification of common materials used in engineering and manufacturing contexts. Understand the uses, applications and disposal requirements of materials in control and instrumentation contexts. Understand characteristics relating to material quality and condition, how materials degrade and fail, and how these properties are monitored and maintained (e.g. identification; preventative techniques) in practice. Know the range of standard materials testing methods and techniques, their purposes, applications, and relative advantages and disadvantages in control and instrumentation contexts. Understand materials processing techniques and their effects on materials in engineering and manufacturing contexts. (e.g. heat treatment) Understand failure modes of materials **Technical information** Understand the purposes and types of standard technical documentation, including how to produce, interpret and amend them. Know the representations, symbols, annotations and conventions used in engineering and manufacturing technical information, with specific reference to maintenance, servicing, installation and repair (e.g. for geometrical dimensions, tolerances, limits; fits and finishes, other terminology and nomenclature; and wiring diagrams).	**Prioritise and plan** processes, resources, scope of tasks, suitable technology, tools and equipment in order to demonstrate how to complete control and instrumentation projects, tasks and activities appropriately (e.g. reactive over preventative) to meet specific requirements, quality and standards specifications, and client expectations: - Components, parts and other resources required - Review, confirm and record stock levels, ordering processes, and lead-in times. - Evaluate and plan appropriately for wastage, disposal, recyclability and sustainability in control and instrumentation maintenance, service and repair tasks and activities. **Identify any potential issues, risks** (e.g. permits to work, timescales, control and instrumentation health and safety considerations), interdependencies, and areas for further investigation (confirming relevant processes and timeframes): - Carry out necessary risk assessments (e.g. stored electrical energy; testing for dead; confined space) - Confirm processes, outcomes and determine potential risks and issues. **Source and check the quality, accuracy and completeness** of information and resources: - technical bulletins and repair method statements; correct issue dates; accurate amendments - components are correct, complete, free of fault, and conform to specifications, grades and dimensions. - correct calibration of equipment

Understand technical drawings, diagrams and representations (e.g. produce 3D model from 2D diagrams) in practice. Understand document management and version change control in practice.	**Carry out required preparatory checks** for compliance, quality, and functionality using correct procedures, processes, techniques and equipment: - Correctly prepare materials, resources, tools, equipment and other technologies - Undertake calibration checks on tools and test equipment (e.g. laser calibrators) - Ensure equipment safe to work on (e.g. testing for dead; isolation) **Prepare work areas** for planned work processes and outcomes, setting up tools, devices and equipment (making necessary adjustments, according to specifications and relevant parameters): - Effectively set up and use relevant maintenance, repair, testing and diagnostic tools and equipment

Performance outcome 3: **Perform** relevant maintenance, installation, servicing and repair of control and instrumentation technology, systems, and equipment, using appropriate techniques and procedures to achieve the required quality outcomes and solutions.

Knowledge specific to performance outcome	Skills specific to performance outcome
Tools and equipment Know the types and purposes of standard hand and power tools and equipment used in engineering and manufacturing contexts. Know how to select, prepare, safely use and maintain hand and power tools and equipment in engineering and manufacturing environments. Know how to follow relevant guidelines and instructions, and to seek advice and guidance, where necessary. Understand the operation and principles of use for a variety of hand and power tools (including air tools; measuring tools e.g. micrometers; Vernier calipers)	**Maintain, install and repair** control and instrumentation systems, equipment and components based upon agreed expectations and timeframes, and in accordance to specifications, safe practices and legal and regulatory requirements (e.g. the current edition of the IET regulations): - Work individually and collaboratively to meet task, client and organisational standards and expectations. **Accurately use** diagnostic and measurement techniques, tools and equipment (e.g. oscilloscope, spectrum analyser, electronic multimeter) to measure performance, condition, and

commonly used in engineering and manufacturing contexts (and the risks of “non-authorised” tools and equipment). Effects of environmental conditions on materials, components, wiring, and equipment, including appropriate maintenance, management, storage, preservation techniques, and preventative maintenance methods in control and instrumentation contexts. Understand the range and purposes of standard CAD and CAM systems and software in control and instrumentation contexts. Understand how to use CAD and CAM systems and software in engineering and manufacturing contexts, across multiple dimensions and collaboratively (e.g. standard features, functions, formats, program tools, techniques, operations and outputs). **Machinery and technology** Understand how to safely operate machinery and technology in engineering and manufacturing environments, Understand how to follow relevant guidelines and instructions (e.g. safety precautions when using drilling machines; the use and repair of different threads when tapping holes), and to seek advice and guidance, where necessary. Be aware of standard parts and machine elements, their uses and applicability in control and instrumentation contexts. **Workplace practices** Understand roles, responsibilities, functions and tasks in engineering and manufacturing workplace contexts, including knowing the limits of own authority and expertise. Know how to carry out functions in accordance with standard workplace practices, with a particular focus on	compliance of control and instrumentation equipment **Identify and locate faults** and their causes in control and instrumentation devices, systems and equipment (e.g. interpret and interrogate built in tests, complete manual system checks, use recognised fault-finding methodologies). **Complete reactive and preventative maintenance** procedures on control and instrumentation components and systems, making informed decisions about appropriate scheduling of tasks and activities. **Remove, replace and repair** control and instrumentation components and systems, based upon issues identified and agreed task requirements, following relevant instructions and guidance (e.g. manufacturer’s instructions) **Correctly disassemble and assemble** control and instrumentation components, devices and systems, according to appropriate instructions and procedures **Accurately position, install, calibrate and configure** control and instrumentation devices and equipment (e.g. sensors, actuators, wiring, generators, motors) to agreed specifications **Support the commissioning and return to service** of control and instrumentation devices, systems and technology to fully operational condition **Effectively perform** a range of essential maintenance, servicing and repair tasks for control and instrumentation maintenance operations, to include procedures such as: wiring, crimping, measuring, cutting, soldering, stripping, removing and replacing circuits. **Re-instate work areas**, managing and storing tools and equipment appropriately

health and safety, standard engineering and manufacturing processes, hand and power tools and equipment, machinery and technology. Understand the effects of service and environmental conditions (e.g. material characteristics, temperature, and working pressures) in practical contexts. Understand factors which affect quality in control and instrumentation engineering and manufacturing, including quality assurance processes. **Maintenance, servicing, installation and repair methods and techniques:** Know standard mechanical maintenance and servicing strategies, methods and practices, including preventative, reactive and condition monitoring techniques. Know standard installation techniques, configuration, and integration of engineering and manufacturing systems. Know standard fault diagnosis and resolution methods (both quantitative and qualitative) in control and instrumentation contexts. Know effective fault detection and isolation methods in control and instrumentation contexts. Know techniques for assembly, disassembly, configuration, installation, modification and integration of systems in control and instrumentation contexts. Understand manufacturing, production and joining techniques (e.g. welded, riveted, folded, fastened, bonded and bolted joints), relevant to control and instrumentation maintenance, installation and repair. Understand the principles of control, control loops, P&ID tuning (Positive, Integral and Derivative) and feedback	

Understand the limits of own authority and expertise, and how and when to seek advice, guidance, and relevant expertise and support, as necessary.	

Performance outcome 4: **Review and evaluate** activities to help improve workplace systems and processes associated with maintenance, installation, servicing and repair of control and instrumentation technology, systems, and equipment, demonstrating commercial awareness and accountability.

Knowledge specific to performance outcome	Skills specific to performance outcome
Standards Know and understand relevant engineering standards to ensure quality, compliance, performance and function (e.g. traceability; revisions management; specific British Standards; ISO9001) in practice. Know and understand the purpose of standard operating procedures in engineering, manufacturing and organisational contexts. **Legal and regulatory context** Know and understand relevant legal and regulatory frameworks and documentation, including how to access sources of authoritative information. Understand relevant statutory, quality, environmental quality and compliance procedures and systems in practice. **Health and safety** Understand health and safety regulations and procedures in engineering and manufacturing contexts. Understand relevant site and process safety, environment and risk management systems and practices.	**Consistently apply safe systems of work** in the delivery of all activities, taking responsibility for safe practices and legal compliance **Monitor work area practices**, anticipating and identifying potential and actual risks, issues and problems, while taking effective steps to prevent, resolve, manage and mitigate them: - Check, confirm and record stock levels, materials and availability of resources. **Deal promptly and effectively with issues and problems** within the limits of own authority, using appropriate techniques and processes to address them **Report and escalate issues and problems**, where necessary. **Carry out appropriate quality monitoring and assurance** checks as part of a team's control and instrumentation maintenance, servicing and repair operations and processes - Complete second-line or supervisory checks at relevant points **Evaluate and review** maintenance, servicing and repair processes, practices

Understand how to confirm, interpret, follow and comply with health and safety requirements at all times. **Programme and project management** Know how projects (and programmes) are defined, structured, reported on and measured in standardised management practices, including project planning and control methodologies. Understand risk analysis and management (including statistical risk analysis) in control and instrumentation contexts. Understand relevant roles, responsibilities, accountability and management operates in relevant engineering and manufacturing contexts. Understand how to support and improve projects through research, evidence and evaluation. **Business and commercial awareness** Know how to evaluate engineering and manufacturing activities in terms of quality, cost and time. Understand commercial and financial objectives and constraints, considering project objectives, resources, efficiency, cost, reputation and risk. Understand company management systems, policies and procedures in practice. **Quality control, assurance and improvement** Understand the purposes and application of quality control, quality assurance and quality improvement in engineering and manufacturing contexts. Understand standard quality inspection and testing methods and techniques in engineering and manufacturing contexts	and outcomes, providing relevant technical information, advice, and suggestions about quality, performance and potential improvements **Make positive contributions** to control and instrumentation maintenance and operations' contexts, whilst working effectively with others. Respond constructively to feedback, and identify opportunities for personal and organisational improvement (e.g. commercial, productivity-related, safety-related).

Know how to complete and record relevant quality processes in engineering and manufacturing contexts.	

Performance outcome 5: **Communicate** control and instrumentation maintenance, installation, servicing and repair information, proposals and solutions, **producing, recording and explaining** relevant technical information.

Knowledge specific to performance outcome	Skills specific to performance outcome
Communication Understand how to communicate technical information and data in engineering and manufacturing contexts. **Information technology and digital** Know how to use relevant digital and information and communication technology (ICT) to record, manage, store, and amend information, data and records (including using collaborative technologies) in engineering and manufacturing contexts.	**Accurately record, amend and correct** relevant technical information, data, risks and issues to support control and instrumentation maintenance, servicing and repair work at relevant stages, within limits of authority - update service books; test certificates; certification of work; major assembly changes; modifications; recall service completions. - record all test results, including independent tests. - Use records, information and data to inform improved practices, recommendations, and continuous improvement. **Complete effective handover** procedures (e.g. following service, complex repair, pre-delivery inspection), confirming and communicating quality standards, specific requirements, outcomes, and any other issues relevant to activities **Produce accurate engineering and manufacturing representations** to support maintenance, installation and repair processes: - Produce an appropriate representation using recognised conventions to communicate and confirm details, issues, processes and requirements

	- Apply and amend information using accurate annotations, symbols, and conventions. **Demonstrate effective team-working**, inter-personal skills and communication with technical and non-technical audiences **Support effective communication**, conveying and confirming information, requirements, expectations, plans, performance, and outcomes using different methods (e.g. written, oral) and media.

Programme: **Engineering and Manufacturing T Level**

Specialism: **Maintenance, installation and repair (Vehicles)**

Performance outcome 1: **Analyse** requirements, specifications and technical information to enable the delivery of successful maintenance, installation, servicing and repair of vehicles.

Knowledge specific to performance outcome	Skills specific to performance outcome
Scientific knowledge Understand the operation of different mechanical principles and systems in practice (e.g. how they manage forces, power and motion). Understand energy, force, power, motion and mechanics as they relate to vehicles and their maintenance, servicing, installation and repair. Understand the fundamentals of common mechanisms and lifting machines, including how controllers maintain and control performance (e.g. governors, brakes, levers, gear boxes and torque converters). Understand different power sources, power units, and engine types, processes, functions and performance in practical contexts. Understand primary and auxiliary systems (e.g. engine, transmission, electrical, braking, steering, suspension; wheel and tyre types) used in vehicles, and relevant components, including their operation, adjustment, maintenance and repair. Understand key principles relating to the storage and transfer of energy in practical contexts. Understand key principles relating to static, dynamic, structural, and fluid loads in practical contexts. Understand the effects of mechanical loadings on structures and components	**Confirm the nature, scope and requirements** of the vehicle maintenance, installation and repair activity, task or problem to be addressed - Gather and analyse relevant information, data and other evidence to confirm issues, problems, faults, areas for investigation, likely causes, agreed processes, methods, expectations and outcomes. - Examine, explore, and interrogate information and data (e.g. client complaint details; maintenance records and schedules) to develop an understanding of issues and appropriate methods for resolution or further investigation. **Evaluate the condition, quality, and performance** of components, systems, materials and resources relating to vehicle maintenance, installation and repair activities - Observing and making informed judgements about the condition/wear on components and materials - Assessing whether components and materials conform to required grade quality standards or requirements **Interpret and analyse** technical information, data, results, task requirements, and supporting documentation from different sources, with reference to performance, quality and compliance: -

(e.g. weight, torque, fatigue, aerodynamics) in practice. Understand the nature, behaviour and measurement of electricity in systems, and the key characteristics of power flow analysis and its applications in practice. Understand the construction and operation of standard power conversion systems in practice. Know the components of electrical installations and their uses, including common failure modes and protection methods. Understand common drive devices, their purposes, parameters and applications in practice. Understand the properties and applications of different electrical circuits and their applications in practice. Understand the main characteristics of standard electronic systems, components and their uses in practice. Understand the purposes and applications of electronic sensing and measurement techniques and technologies in practice. Understand standard component classification, numbering and referencing systems and how they apply to vehicles maintenance, servicing and repair contexts. **Mathematical knowledge** Understand how to use number systems, measurement techniques, and estimation in practical contexts. Understand standard mathematical methods and calculations, including statistical analysis, for measuring, checking and confirming vehicle testing and performance data in practice.	- Interpret mechanical process, instrument and wiring diagrams - Consider the accuracy, relevance and completeness of technical information. - Use and respond effectively to specifications, repair information, observed evidence, recall instructions, maintenance tables and technical bulletins **Use diagnostic information and other evidence** to determine system and component serviceability for vehicle maintenance, installation and repair activities - Evaluate client information, requirements, performance data and diagnostic information and other evidence to confirm objectives, tasks, processes, costs, resources, timeframes, resources, and outcomes.

Know how to carry out standard calculations in vehicle maintenance and repair contexts, using relevant strands of arithmetic, algebra, geometry and statistics in practical contexts. Understand how to apply trigonometry and standard calculus, matrices and determinants in practical contexts. Know mathematical methods and calculations relevant to vehicle maintenance and repair operations (e.g. steering and suspension geometries; electrical circuit calculations)	

Performance outcome 2: **Plan and prepare** the maintenance, installation, servicing and repair of vehicles, taking into account the specific requirements and context.

Knowledge specific to performance outcome	Skills specific to performance outcome
Materials Understand the structure, composition, properties and classification of common materials used in engineering and manufacturing contexts. Understand the uses, applications and disposal requirements of materials in practical contexts. Understand characteristics relating to material quality and condition, how materials degrade and fail, and how these properties are monitored and maintained (e.g. identification; preventative techniques) in practice. Know the range of standard materials testing methods and techniques, their purposes, applications, and relative advantages and disadvantages in vehicles maintenance, installation and repair contexts. Understand materials processing techniques and their effects on materials in engineering and	**Prioritise and plan** processes, resources, scope of tasks, suitable technology, tools and equipment, in order to demonstrate how to complete projects, tasks and activities appropriately (e.g. reactive over preventative) to meet specific requirements, quality and standards specifications, and client expectations: - Components, parts and other resources required - Confirm stock levels, ordering processes, lead-in times. - Evaluate and plan appropriately for wastage, disposal, recyclability and sustainability in maintenance, service and repair tasks and activities. **Identify any potential issues, risks** (e.g. commissioning, permits to work, timescales, health and safety considerations), interdependencies, and areas for further investigation (confirming relevant processes and timeframes): - Carry out necessary risk assessments (e.g. noise; height; emissions) - Confirm processes, outcomes and determine potential risks and issues.

manufacturing contexts (e.g. heat treatment) Understand failure modes of materials. **Technical information** Understand the purposes and types of standard technical documentation, including how to produce, interpret and amend them. Know the representations, symbols, annotations and conventions used in engineering and manufacturing technical information, with specific reference to vehicle maintenance, servicing, installation and repair (e.g. for geometrical dimensions, tolerances, limits, fits and finishes; other terminology and nomenclature; component assembly and system diagrams). Understand technical drawings, diagrams and representations (e.g. produce 3D model from 2D diagrams). Understand document management and version change control in practice.	**Source and check quality, accuracy and completeness** of information and resources: e.g. - technical bulletins and repair method statements; correct issue dates; accurate amendments - components are correct, complete, free of fault, and conform to specifications, grades and dimensions. - correct calibration of equipment **Carry out required preparatory checks** for compliance, quality, and functionality using correct procedures, processes, techniques and equipment: - Correctly prepare materials, resources, tools, equipment and other technologies - Undertake calibration checks on tools and test equipment (brake tester; emissions tester) - Ensure vehicle type safe to work on (e.g. specific checks on alternative power systems; start/stop; isolation) **Prepare work areas** for planned work processes and outcomes, setting up tools and equipment (e.g. vehicle lifts, garage pit equipment), making necessary adjustments, according to specifications and relevant parameters (e.g. vehicle type; specific vehicle system)

Performance outcome 3: **Perform** relevant maintenance, installation, servicing and repair of vehicles, using appropriate techniques and procedures to achieve the required quality outcomes and solutions.

Knowledge specific to performance outcome	Skills specific to performance outcome
Tools and equipment Know the types and purposes of standard hand and power tools and equipment used in vehicle maintenance and repair contexts.	**Maintain, install and repair** vehicles (or vehicle parts), based upon agreed expectations and timeframes, and in accordance to specifications, safe practices and legal and regulatory requirements (e.g. current vehicle inspection regulations; DVSA standards)

Know how to select, prepare, safely use and maintain hand and power tools and equipment in vehicle maintenance and repair environments, to follow relevant guidelines and instructions, and to seek advice and guidance, where necessary. Know how to follow relevant guidelines and instructions, and to seek advice and guidance, where necessary. Understand the operation and principles of use for a variety of hand and power tools (including air tools; measuring tools e.g. micrometers; Vernier calipers) commonly used in engineering and manufacturing contexts (and the risks of "non-authorised" tools and equipment). Understand the effects of environmental conditions on materials, tools, and equipment, including appropriate maintenance, management, storage, preservation techniques, and preventative maintenance methods in vehicle-related contexts. Understand the range and purposes of standard CAD and CAM systems and software in vehicles maintenance, servicing and repair contexts. Understand how to use CAD and CAM systems and software in engineering and manufacturing contexts, across multiple dimensions and collaboratively (e.g. standard features, functions, formats, program tools, techniques, operations and outputs). **Machinery and technology** Understand how to safely operate machinery and technology used in the engineering and manufacturing environments. Understand how to follow relevant guidelines and instructions (e.g. safety precautions when using drilling machines; the use and repair of different threads	- Work individually and collaboratively to meet task, client and organisational standards and expectations. **Accurately use** diagnostic and measurement techniques, tools and equipment (e.g. emission tester; brake tester; other diagnostic equipment) to measure performance, condition, and compliance of mechanical equipment **Identify and locate faults** and their causes in vehicle systems and equipment (e.g. interpret and interrogate built in tests and vehicle systems, complete manual system checks) **Complete reactive and preventative maintenance** procedures on vehicle components and systems, making informed decisions about appropriate scheduling of tasks and activities. **Remove, replace and repair** vehicle components and systems, based upon issues identified and agreed task requirements, following relevant instructions and guidance (e.g. vehicle repair methods; current vehicle inspection standards and regulations) **Correctly disassemble and assemble** vehicle components and systems, according to vehicle repair methods **Accurately position, install and adjust** mechanical components (e.g. rods, pistons, valves, drivetrains) to agreed specifications **Carry out stage and post-work inspections** - Sign-off point confirmations **Effectively perform** a range of essential maintenance, servicing and repair tasks for vehicle maintenance and servicing operations, including the following processes: measuring; cutting, drilling, filing, removing and replacing bolts, screws and clips, replacing seals, extracting and

when tapping holes), and to seek advice and guidance, where necessary. Be aware of standard parts and machine elements, their uses and applicability in vehicles maintenance, servicing and repair contexts. **Workplace practices** Understand roles, responsibilities, functions and tasks in vehicle maintenance and repair workplace contexts, including knowing the limits of own authority and expertise. Know how to carry out functions in accordance with standard workplace practices, with a particular focus on health and safety, standard engineering processes, hand and power tools and equipment, machinery and technology. Understand the effects of service and environmental conditions (e.g. material characteristics, temperature, and working pressures) in practice. Understand factors which affect quality in vehicle maintenance, repair and quality assurance processes. **Maintenance, servicing, installation and repair methods and techniques:** Know standard vehicle maintenance and servicing strategies, methods and practices, including preventative, reactive and condition monitoring techniques. Know standard installation, configuration, and integration of engineering systems techniques. Know standard fault diagnosis and resolution methods (both quantitative and qualitative). Know effective fault detection and isolation methods across vehicle types.	replacing damaged fasteners; applying surface treatments. **Re-instate work areas**, managing and storing tools and equipment appropriately

Know techniques for assembly, disassembly, configuration, installation, modification and integration of systems in practice. Understand manufacturing, production and joining techniques (including welded, riveted, folded, fastened, bonded and bolted joints), relevant to vehicle maintenance, installation and repair. Understand the limits of own authority and expertise, and how and when to seek advice, guidance, and relevant expertise and support, as necessary.	

Performance outcome 4: **Review and evaluate** activities to help improve workplace systems and processes associated with vehicle maintenance, installation, servicing and repair, demonstrating commercial awareness and accountability.

Knowledge specific to performance outcome	Skills specific to performance outcome
Standards Know and understand relevant engineering standards to ensure quality, compliance, performance and function (e.g. traceability; revisions management; specific British Standards; ISO9001) in practice. Know and understand the purpose of standard operating procedures in engineering, manufacturing and organisational contexts. **Legal and regulatory context** Know and understand relevant legal and regulatory frameworks and documentation, including how to access sources of authoritative information. Understand relevant statutory, quality, environmental quality and compliance procedures and systems in practical contexts. **Health and safety**	**Consistently apply safe systems of work** in the delivery of all activities, taking responsibility for safe practices and legal compliance **Monitor work area practices**, anticipating and identifying potential and actual risks, issues and problems, while taking effective steps to prevent, resolve, manage and mitigate them - Check and confirm stock levels, materials and availability of resources. **Deal promptly and effectively with issues and problems** within the limits of own authority, without heightening risk/s, using suitable techniques and processes to address them. **Report and escalate issues and problems,** where necessary. **Carry out quality monitoring and assurance** checks as part of a team's

Understand health and safety regulations and procedures in vehicle maintenance and repair contexts. Understand relevant site and process safety, environment and risk management systems and practices. Understand how to confirm, interpret, follow and comply with health and safety requirements at all times. **Programme and project management** Know how projects (and programmes) are defined, structured, reported on and measured in standardised management practices, including project planning and control methodologies. Understand risk analysis and management (including statistical risk analysis) in vehicles maintenance, servicing and repair contexts. Understand relevant roles, responsibilities, accountability and management operates in relevant vehicle manufacture, maintenance and repair contexts. Understand how to support and improve projects through research, evidence and evaluation. **Business and commercial awareness** Know how to evaluate manufacturing activities in terms of quality, cost and time. Understand commercial and financial objectives and constraints, considering project objectives, resources, efficiency, cost, reputation and risk. Understand company management systems, policies and procedures in practice. **Quality control, assurance and improvement**	vehicle maintenance, servicing and repair operations and processes - Complete second-line or supervisory checks at relevant points **Evaluate and review** maintenance, servicing and repair processes, practices and outcomes, providing relevant technical information, advice, and suggestions about quality, performance and potential improvements to systems, including post-repair performance and functional tests. **Make positive contributions** to vehicle maintenance and business operations' contexts whilst working effectively with others. Respond constructively to feedback, and identify opportunities for personal and organisational improvement (e.g. commercial, productivity-related, safety-related).

Understand the purposes and application of quality control, quality assurance and quality improvement in vehicle maintenance and repair contexts. Understand standard quality inspection and testing methods and techniques in vehicle maintenance and repair contexts. Know how to complete and record relevant quality processes in vehicle maintenance and repair contexts.	

Performance outcome 5: **Communicate** vehicle maintenance, installation, servicing and repair information, proposals and solutions, **producing, recording and explaining** relevant technical information.

Knowledge specific to performance outcome	Skills specific to performance outcome
Communication Understand how to communicate technical information and data in vehicle maintenance and repair contexts. **Information technology and digital** Know how to use relevant digital and information and communication technology (ICT) to record, manage, store, and amend information, data and records (including using collaborative technologies) in vehicle maintenance and repair contexts. Understand digital technologies used in vehicle engineering and maintenance and repair contexts.	**Accurately record, amend and correct** relevant technical information, data, risks and issues to support maintenance, servicing and repair work at relevant stages, within limits of authority - update service books; test certificates; certification of work (e.g. wheel alignment testing; major assembly changes; modifications; recall service completions). - record all test results including independent tests. - Use records, information and data to inform improved practices, recommendations, and continuous improvement. **Complete effective handover** procedures (e.g. following service, complex repair, pre-delivery inspection), confirming and communicating quality standards, specific requirements, outcomes, and any other issues relevant to activities **Produce accurate engineering and manufacturing representations** to

	support maintenance, installation and repair processes - Produce an appropriate representation using recognised conventions to communicate and confirm details, issues, processes and requirements - Apply and amend information using accurate annotations, symbols, and conventions. **Demonstrate effective team-working**, inter-personal skills and communication with technical and non-technical audiences **Support effective communication**, conveying and confirming information, requirements, expectations, plans, performance, and outcomes using different methods (e.g. written, oral) and media.

Programme: **Engineering and Manufacturing T Level**

Specialism: **Maintenance, installation and repair (Energy and Utilities Technologies)**

Performance outcome 1: **Analyse** requirements, specifications and technical information to enable the delivery of successful maintenance, installation, servicing and repair of energy and utilities technologies, systems, and equipment.

Knowledge specific to performance outcome	Skills specific to performance outcome
Scientific knowledge Gas, Power, Water, Waste Management Understand specific sector knowledge of gas, power, water, and waste management networks. Understand the principles and operation of energy systems (e.g. how energy is produced, stored, transported and supplied). Understand the generation of electricity and the environmental impact of different fuel types Understand the production, transportation and supply of gas Understand of the operation of water supply and waste management systems (e.g. how water is collected, purified and supplied; how waste is collected and treated). Understand the fundamentals of common mechanisms and lifting machines, including how controllers maintain and control performance (e.g. governors, brakes, levers, gear boxes and torque converters) in practice. Understand key principles relating to the storage and transfer of energy in practical contexts. Understand key principles relating to static, dynamic, structural, and fluid loads in practical contexts, and the effects of mechanical loadings on structures and components (e.g. weight, torque, fatigue, aerodynamics) in practice.	**Confirm the nature, scope and requirements** of the energy and utilities maintenance, installation and repair activity, task or problem to be addressed - Gather and analyse relevant information, data and other evidence to confirm issues, problems, faults, areas for investigation, likely causes, agreed processes, methods, expectations and outcomes. - Examine, explore, and interrogate information and data (e.g. maintenance records and schedules) to develop an understanding of issues and appropriate methods for resolution. **Evaluate the condition, quality, and performance** of components, systems, materials, and resources relating to energy and utilities maintenance, installation and repair activities: - Observing and making informed judgements about the condition/wear on components and materials - Evaluate performance, efficiency and efficacy of systems and processes - Assessing whether components and materials conform to required grade quality standards or requirements **Interpret and analyse** technical information, data, results, task requirements, and supporting documentation from different sources, with reference to performance, quality and compliance. -

Understand the nature, behaviour and measurement of electricity in systems, the key characteristics of power flow analysis and its applications in practice. Understand the construction and operation of standard power conversion systems. Know the components of electrical installations, including generators, power lines, cables, transformers, motors and switchgear, including common failure modes and protection methods. Know the components of pipleline systems, including pumps, valves, compressors, filters, including common failure modes Understand common drive devices, their purposes, parameters and applications. Understand the properties and applications of different electrical circuits and their applications in practical contexts. Understand the main characteristics of standard electronic systems, components and their uses in practical contexts. Understand the purposes and applications of electronic control, sensing and measurement techniques and technologies. Understand the operations and infrastructure of key utilities processes, and relevant monitoring, maintenance and repair practices applied across power, water, gas and waste (e.g. water treatment; waste removal; power and gas supply). Understand standard component classification, numbering and referencing systems and how they apply to energy and utilities contexts (e.g. power; water; gas; and waste). **Mathematical knowledge**	- Interpret mechanical process diagrams; electrical and electronic wiring diagrams - Consider the accuracy, relevance and completeness of technical information - Use and respond effectively to specifications, repair information, observed evidence, recall instructions, maintenance tables, and technical bulletins. **Use diagnostic information and other evidence** to determine system and component serviceability for energy and utilities maintenance, installation and repair activities

Understand how to use number systems, measurement techniques, and estimation in practical contexts. Understand standard mathematical methods and calculations, including statistical analysis, for measuring, checking and confirming energy and utilities maintenance and repair testing and performance data in relevant contexts (e.g. power, water, gas, and waste). Know how to carry out standard calculations in a practical context, using relevant strands of arithmetic, algebra, geometry and statistics. Understand how to apply trigonometry and standard calculus, matrices and determinants in practical contexts.	

Performance outcome 2: **Plan and prepare** the maintenance, installation, servicing and repair of energy and utilities technology, systems, and equipment, taking into account the specific requirements and context.

Knowledge specific to performance outcome	Skills specific to performance outcome
Materials Understand the structure, composition, properties and classification of common materials used in energy and utilities contexts (e.g. power, water, gas, and waste). Understand the uses, applications and disposal requirements of materials in energy and utilities contexts (e.g. power, water, gas, and waste). Understand characteristics relating to material quality and condition, how materials degrade and fail, and how these properties are monitored and maintained (e.g. identification; preventative techniques) in practice. Know a range of standard materials testing methods and techniques, their	**Prioritise and plan** processes, resources, scope of tasks, suitable technology, tools and equipment, in order to demonstrate how to complete projects, tasks and activities appropriately (e.g. reactive over preventative) to meet specific requirements, quality and standards specifications, and client expectations: - Components, parts and other resources required - Review, confirm and record stock levels, ordering processes, and lead-in times. - Evaluate and plan appropriately for wastage, disposal, recyclability and sustainability in mechanical maintenance, service and repair tasks and activities. **Identify and address potential issues, risks** (e.g. commissioning, permits to work,

purposes, applications, and relative advantages and disadvantages in energy and utilities contexts (e.g. power, water, gas, and waste). Understand materials processing techniques and their effects on materials in engineering and manufacturing contexts (e.g. heat treatment). Understand failure modes of materials. **Technical information** Understand the purposes and types of standard technical documentation, including how to produce, interpret and amend them in specific maintenance and repair operational contexts (e.g. power, water, gas, and waste). Know the representations, symbols, annotations and conventions used in engineering and manufacturing technical information (e.g. for geometrical dimensions, tolerances, limits, fits and finishes; other terminology and nomenclature; component assembly and system diagrams), with specific reference to energy and utilities maintenance, servicing, installation and repair contexts (e.g. power, water, gas, and waste). Understand technical drawings, diagrams and representations (e.g. produce 3D model from 2D diagrams). Understand document management and version change control in practice.	timescales, health and safety considerations), interdependencies, and areas for further analysis or investigation (confirming relevant processes and timeframes): - Carry out necessary risk assessments (e.g. point of work; dynamic or significant; confined space). - Take personal responsibility for health and safety and work to remove any risks, according to organisational and sector-based guidelines and compliance requirements. **Source and check the quality, accuracy and completeness** of information and resources: - technical bulletins and repair method statements; correct issue dates; accurate amendments - components are correct, complete, free of fault, and conform to specifications, grades and dimensions. - correct calibration of equipment **Carry out required preparatory checks** for compliance, quality, and functionality using correct procedures, processes, techniques and equipment (e.g. testing for dead): - Correctly prepare materials, resources, tools, equipment and other technology - Undertake calibration checks on tools and test equipment - Ensure equipment safe to work on (e.g. rotating parts are guarded or isolated) - Take part in necessary pre-job briefings and seek relevant guidance prior to commencing work (e.g. full job perspective; tool box talks). **Prepare work areas** for planned work processes and outcomes, setting up tools, equipment and work-holding devices, making necessary adjustments, according to specifications and relevant parameters.

Performance outcome 3: **Perform** relevant maintenance, installation, servicing and repair of energy and utilities technology, systems, and equipment, using appropriate techniques and procedures to achieve the required quality outcomes and solutions.

Knowledge specific to performance outcome	Skills specific to performance outcome
Tools and equipment Know the types and purposes of standard hand and power tools and equipment used in relevant maintenance, installation, servicing and repair contexts (e.g. power, water, gas, and waste). Know how to select, prepare, safely use and maintain hand and power tools and equipment in relevant maintenance and repair environments. Know how to follow relevant guidelines and instructions, and to seek advice and guidance, where necessary. Understand the operation and principles of use for a variety of hand and power tools (including air tools; measuring tools e.g. micrometers; Vernier calipers) commonly used in engineering and manufacturing contexts (and the risks of "non-authorised" tools and equipment). Understand the effects of environmental conditions on materials, plant, and equipment, including appropriate maintenance, management, storage, preservation techniques, and preventative maintenance methods in practice. Understand the range and purposes of standard CAD and CAM systems and software in engineering and utilities contexts (e.g. power, water, gas, and waste). Understand how to use CAD and CAM systems and software in relevant contexts, across multiple dimensions and collaboratively (e.g. standard features, functions, formats, program tools, techniques, operations and outputs).	**Maintain, install and repair** energy and utilities equipment based upon agreed expectations and timeframes, and in accordance to specifications, safe practices and legal and regulatory requirements (e.g. BS; ISO DIN, COSHH, HASAWA standards): - Work individually and collaboratively to meet task, client and organisational standards and expectations. **Accurately use** diagnostic and measurement techniques, tools and equipment (e.g. condition monitoring equipment) to measure performance, condition, and compliance of energy and utilities equipment, including for power, water, gas and waste processing, treatment and testing operations (e.g. filtration; chemical treatment; removal of contaminants or separation of impurities). **Identify and locate faults** and their causes in energy and utilities components, systems and equipment (e.g. interpret and interrogate built in tests, complete manual system checks) **Complete reactive and preventative maintenance** procedures on energy and utilities components and systems, making informed decisions about appropriate scheduling of tasks and activities. **Remove, replace and repair** components and devices in energy and utilities systems, based upon issues identified and agreed task requirements, following relevant instructions and guidance (e.g. manufacturer's instructions) **Correctly disassemble and assemble** energy and utilities components, devices

Machinery and technology Understand how to safely operate machinery and technology used in specific energy and utilities maintenance and repair environments (e.g. power, water, gas and waste). Understsand how to follow relevant guidelines and instructions (e.g. safety precautions when using drilling machines; the use and repair of different threads when tapping holes), and to seek advice and guidance, where necessary. Be aware of standard parts and machine elements, their uses and applicability in energy and utilities contexts (e.g. power, water, gas, and waste). **Workplace practices** Understand roles, responsibilities, functions and tasks in relevant workplace contexts, including knowing the limits of own authority and expertise. Know how to carry out functions in accordance with standard workplace practices, with a particular focus on health and safety, standard engineering and manufacturing processes, hand and power tools and equipment, machinery and technology. Understand the effects of service and environmental conditions (e.g. material characteristics, temperature, and working pressures) in practice. Understand factors which affect quality in energy and utilities maintenance and repair quality assurance processes. **Maintenance, servicing, installation and repair methods and techniques:** Know standard energy and utilities maintenance and servicing strategies, methods and practices, including	and systems, according to appropriate instructions and procedures **Accurately install and adjust** energy and utilities technology and equipment (e.g. sensors, wiring, pumps, motors, pipes, valves, flanges, conveyors) to agreed specifications **Commission and support the return to service** of energy and utilities components, devices, systems and technology to operational condition **Effectively perform** a range of essential maintenance, servicing and repair tasks for energy and utilities maintenance operations, to include procedures such as: measuring; cutting, drilling, filing, removing and replacing bolts, screws and clips, replacing seals, extracting and replacing damaged fasteners; applying surface treatments; removing and replacing circuits; maintaining and replacing consumables. **Re-instate work areas**, managing and storing tools and equipment appropriately

preventative, reactive and condition monitoring techniques. Know standard installation techniques, configuration, and integration of engineering and manufacturing systems. Know standard fault diagnosis and resolution methods (both quantitative and qualitative) in practice. Know effective fault detection and isolation methods in specific energy and utilities maintenance and repair contexts (e.g. power, water, gas, and waste). Know techniques for assembly, disassembly, configuration, installation, modification and integration of systems in specific energy and utilities maintenance and repair contexts (e.g. power, water, gas, and waste). Understand manufacturing, production and joining techniques (e.g. welded, riveted, folded, fastened, bonded and bolted joints), relevant to energy and utilities maintenance, installation, servicing and repair, and specific operational contexts (e.g. power, water, gas, and waste). Understand the limits of own authority and expertise, and how and when to seek advice, guidance, and relevant expertise and support, as necessary.	

Performance outcome 4: **Review and evaluate** activities to help improve workplace systems and processes associated with maintenance, installation, servicing and repair of energy and utilities technology, systems, and equipment, demonstrating commercial awareness and accountability.

Knowledge specific to performance outcome	Skills specific to performance outcome
Standards Know and understand relevant engineering standards to ensure quality, compliance, performance and function	**Consistently apply safe systems of work** in the delivery of all activities, taking responsibility for safe practices and legal compliance within limits of own authority.

(e.g. traceability; revisions management; specific British Standards; ISO9001) in practice. Know and understand the purpose of standard operating procedures in relevant energies and utilities maintenance and repair for specific operational and organisational contexts (e.g. power, water, gas, and waste). **Legal and regulatory context** Know and understand relevant legal and regulatory frameworks and documentation, including how to access sources of authoritative information. Understand relevant statutory, quality, environmental quality and compliance procedures and systems in practice. **Health and safety** Understand health and safety regulations and procedures in relevant energy and utilities maintenance and repair contexts (e.g. power, water, gas, and waste). Understand relevant site and process safety, environment and risk management systems and practices. Understand how to confirm, interpret, follow and comply with health and safety requirements at all times. **Programme and project management** Know how projects (and programmes) are defined, structured, reported on and measured in standardised management practices, including project planning and control methodologies. Understand risk analysis and management (including statistical risk analysis) in energy and utilities contexts (e.g. power, water, gas, and waste). Understand relevant roles, responsibilities, accountability and how management	**Monitor work area practices**, anticipating and identifying potential and actual risks, issues and problems, while taking effective steps to prevent, resolve, manage and mitigate them. **Deal promptly and effectively with issues and problems** within the limits of own authority and without increasing risk/s, using appropriate techniques and processes to address them **Report and escalate issues and problems**, where necessary. **Carry out quality monitoring and assurance** checks as part of a team's energy and utilities maintenance, servicing and repair operations and processes - Complete second-line or supervisory checks at relevant points **Evaluate and review** maintenance, servicing and repair processes, practices and outcomes, providing relevant technical information, advice, and suggestions about quality, performance and potential improvements **Make positive contributions** to energy and utilities maintenance contexts whilst working effectively with others. Respond constructively to feedback, and identify opportunities for personal and organisational improvement (e.g. commercial, productivity-related, safety-related).

operates in relevant energy and utilities contexts. Understand how to support and improve projects through research, evidence and evaluation. **Business and commercial awareness** Understand key aspects of current industrial and sector-based engineering processes, practices, technology, and operations across national infrastructure and energy production (e.g. energy production, telecommunications, chemicals, oil and gas refining), with specific reference to energy and utilities maintenance and operational requirements. Know how to evaluate energy and utilities maintenance and repair activities in terms of quality, cost and time. Understand commercial and financial objectives and constraints, considering project objectives, resources, efficiency, cost, reputation and risk. Understand company management systems, policies and procedures in practice. **Quality control, assurance and improvement** Understand the purposes and application of quality control, quality assurance and quality improvement in specific energy and utilities maintenance and repair contexts (e.g. power, water, gas, and waste) Understand standard quality inspection and testing methods and techniques in specific energy and utilities maintenance and repair contexts (e.g. power, water, gas and waste). Know how to complete and record relevant quality processes in specific energy and utilities maintenance and repair contexts.	

Performance outcome 5: **Communicate** energy and utilities maintenance, installation, servicing and repair information, proposals and solutions, **producing, recording and explaining** relevant technical information.

Knowledge specific to performance outcome	Skills specific to performance outcome
Communication Understand how to communicate technical information and data in energy and utilities maintenance and repair contexts (e.g. power, water, gas, and waste). **Information technology and digital** Know how to use relevant digital and information and communication technology (ICT) to record, manage, store, and amend information, data and records (including using collaborative technologies) in energy and utilities maintenance and repair contexts.	**Accurately record, amend and correct** relevant technical information, data, risks and issues to support energy and utilities maintenance, servicing and repair work at relevant stages, within limits of authority - update service books; certification of work; major assembly changes; modifications; recall service completions. - record all test results, including independent tests. - Use records, information and data to inform improved practices, recommendations, and continuous improvement. **Complete effective handover** procedures, confirming and communicating progress, quality standards, specific requirements, outcomes, and any other issues relevant to activities **Produce accurate engineering and manufacturing representations** to support maintenance, installation and repair processes: - Produce an appropriate representation using recognised conventions to communicate and confirm details, issues, processes and requirements - Apply and amend information using accurate annotations, symbols, and conventions. **Demonstrate effective team-working**, inter-personal skills and communication with technical and non-technical audiences - Work effectively across teams and inter-dependent programmes. **Demonstrate and support effective communications**, confirming information,

	requirements, expectations, plans, performance, and outcomes in ways appropriate to purpose and context.