

Health and Science: Science

T Level outline content: final version for approval

December 2018

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# Introduction

T Levels are new, two-year, technical study programmes, designed with employers to give young people the skills that industry needs. T Levels will provide a mixture of:

* technical knowledge and skills specific to their chosen industry or occupation
* an industry placement of at least 45 days in their chosen industry or occupation
* relevant maths, English and digital skills
* common workplace skills.

T Levels will become one of three major options for students to study at level 3, alongside apprenticeships for those who wish to study and train for a specific occupation ‘on the job’, and A levels for students who wish to continue academic education.

When they complete a T Level study programme, students will be able to choose between moving into a skilled occupation or further study, for example, a higher or degree level apprenticeship, or higher level technical study, including higher education.

Technical education has been categorised into fifteen different technical routes, according to occupational specialism. T Levels will be available across eleven of those routes, with occupations in the remaining four routes accessible through an apprenticeship only. Most routes have been split into a number of pathways; the T Level will broadly sit at pathway level. The occupations within scope for each T Level are set out in the Institute for Apprenticeships’ occupational maps.

**Outline content**

This outline content has been produced by [T Level panels](https://www.gov.uk/government/publications/t-level-panels-membership) 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. One awarding organisation will be appointed to develop and deliver each Technical Qualification following a procurement process.

The diagram below demonstrates how the same standard created by employer-led Trailblazer groups is used for both Apprenticeships, and as the basis for this outline content. It also shows that this outline content will be used by awarding organisations to develop the full Technical Qualification (TQ) specification.



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.

T Level study programmes will include the following mandatory elements:

* a ‘core’ set of underpinning knowledge, concepts and skills, tailored for their chosen industry and occupation: ‘core content’
* specialist content covering occupational or industry-specific skills: ‘occupational specialist content’
* an industry placement with an employer, which will last for a minimum of 45 working days.

The diagram below demonstrates the different elements of a T Level programme. This outline content relates solely to the Technical Qualification part of a T Level programme.



# Purpose Statement

Qualification Purpose

The purpose of the level 3 Technical Qualification (TQ) is to ensure students have the knowledge and skills needed to progress into skilled employment or higher level technical training relevant to the T Level.[[1]](#footnote-1)

To achieve this, each level 3 TQ must:

* provide reliable evidence of students’ attainment in relation to:
* the core knowledge and skills relevant to the route and occupational

specialisms covered by the qualification

* the knowledge and skills required for at least one occupational specialism relevant to the qualification.
* be up-to-date, providing the knowledge and skills needed for the

occupations have continued currency among employers and others.

* ensure that maths, English and digital skills are developed and applied where they are essential to achieve occupationally relevant outcomes.
* ensure that the minimum pass grade standard for occupational specialisms attests to threshold competence, meets employer expectations, and is as close to full

occupational competence as possible.

* allow the accurate identification of students’ level of attainment and the effective differentiation of their performance.
* provide a clear and coherent basis for development of suitably demanding high-quality level 3 courses, which enable students to realise their potential.
* provide students with the opportunity to manage and improve their own

performance.

* support fair access to attainment for all students who take the qualification, including those with special educational needs and disabilities (SEND).

**Technical Qualification Design**

T Level programmes will differ in length to reflect the requirements of different occupations, but are expected to last 1800 hours over two years (on average).

To accommodate legitimate differences in content across T Levels, we propose that the total time for the TQ:

* will fall within a defined range of between 900 and 1400 hours
* is no less than 50% of the time for the T Level programme as a whole and
* is no more than 75% of the total time for the programme as a whole.

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| --- | --- | --- | --- | --- |
| Component | Content | Assessment | Grading | Planned Hours |
| Core Students complete one component which covers all the core content | Knowledge and understanding of contexts, concepts, theories and principles relevant to the T LevelAbility to apply core knowledge and skills, through a project, to meet employer-set requirements | Assessed through an externally set test and an employer-set project | Six point scale plus ungraded (U)A\* – E and U | Between 20% and 50% of the qualification time |
| Occupational specialismsStudents must complete at least one, or more depending on the minimum requirements specific to the qualification | Knowledge and skills needed to achieve threshold competence | Synoptic assessment of performance outcomes, to determine whether a student meets the minimum requirements for threshold competence | Three point scale plus ungraded (U)Distinction, Merit, Pass and Ungraded | Between 50% and 80% of qualification time |

# Health and Science: Science

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 the final section of this document. Awarding organisations should integrate these within the qualification so that they are applied in occupationally relevant contexts. Other core skills and behaviours important for employability are already integrated within the content and must be clearly specified in the qualification specification.

## Core content

The core content relates to the whole route, and the pathway that the Technical Qualification covers. This breadth of content will help to ensure students are able to apply their skills in a variety of contexts and for a variety of different purposes. The content will vary depending on the requirements of the route and the pathway or occupations covered by the scope of the qualification.

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 students’ knowledge and understanding of contexts, concepts, theories and principles relevant to the T Level. This could include, where appropriate, assessment of knowledge, understanding and skills 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.

Awarding organisations can integrate knowledge in the employer-set project, to contextualise of core skills. The allocation of content to each type of assessment will need to be approved by the Institute for Apprenticeships.

**Core knowledge and understanding across the Health and Science route**

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| --- | --- |
| **Element**  | **Content**  |
| **Working within the Health and Science sector** | * Purpose and importance of adhering to organisational policies and methods of working, including policies

related to employment such as equality, diversity and inclusion, employment contracts, performance reviews, disciplinary procedures and grievance procedures* Purpose and importance of quality standards, quality management and audit processes
* Introduction to the importance of ethics and Codes of Conduct
* Awareness of employment and progression opportunities which exist within the sector, and opportunities which exist for membership and/or professional registration at a later stage in an individual’s career
 |
| **Health, Safety and Environmental regulations in the Health and Science sector** | The Health and Science sector is a highly regulated sector and as a result, there are a number of external and internal regulatory procedures that need to be adhered to in a range of working environments in the Health and Science sector.Regulations, legislation and procedures including:* Health and Safety at Work Act 1974
* Management of Health and Safety at Work Regulations 1999 including assessing potential hazards and risks, including specific levels of risk, minimising these risks through the use of relevant risk assessment strategies. Completing risk assessment documentation
* Control of Substances Hazardous to Health (COSHH) Regulations 1994 and subsequent amendments 2002
* Mandatory use of appropriate Personal Protective Equipment (PPE), Personal Protective Equipment at Work Regulations 1992
* Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013 (RIDDOR)
* Accident or “near miss” reporting
* Environmental Protection Act 1990
* Waste management and waste streams taking into consideration special waste and hazardous waste. The Special Waste Regulations 1996 & The Hazardous Waste Regulations 2005 & The Waste Electrical and Electronic Equipment Regulations (WEEE) 2012/19/EU
* Fire precaution (workplace regulations) 1999 and organisational procedures for carrying out evacuations
* Manual handling, including moving and positioning of equipment, and workplace ergonomics: Manual Handling Operations Regulations 1992
* Workplace ergonomics including the use of display screen equipment. Health and Safety (Display Screen Equipment) Regulations 1992

How to promote health and safety at workHow to deal with situations that can occur in a health or science environment that could cause harm to self or others, e.g. spillage of hazardous material |
| **Managing information and data within the Health and Science sector** | Recording and reporting information and data* How to collect and record information and data
* Importance of accuracy, attention to detail and legibility of any written information or data
* Sources of information and data: how to apply relevant data and information in a range of health and science working environments
* Application of new technology in the recording and reporting of information and data

Protection of information and data* Data protection legislation, regulations and local ways of working, including the importance of confidentiality and the General Data Protection Regulation (GDPR) 2018
* Ensuring confidentiality when using screen to input or retrieve information or data
* Positive use of and restrictions on the use of social media in the Health and Science sector

Data storage* How and why IT systems are used to record, retrieve and store information and data
* Security in relation to IT systems, including the need for back-up systems and required cyber security measures
* What to do if information is not stored securely
 |
| **Good Scientific and Clinical Practice** | Knowledge and understanding of the principles of good scientific and clinical practice is a key requirement of working in the health and science sector.  In any healthcare or science environment an understanding of the importance of adhering to the following is essential: Standard Operating Procedures* Use and importance of following Standard Operating Procedures (SOPs), including what an SOP is, who it is applicable to and how to access SOPs for a given activity

Management of equipment and work areas* Importance of regular cleaning of work areas and suitable preparation for use
* Importance of maintenance, cleaning and servicing of equipment
* Calibration and testing of equipment to ensure it is fit for use. Current calibration status of equipment and escalation routes if equipment is not correctly calibrated/unsuitable for intended use

Stock control* Management and ordering of stock to ensure sufficient supply of required consumables and materials

Storage* Appropriate storage of products, materials and equipment including storage and use of limited stability products
 |
| **Core Science concepts** | Fundamental scientific concepts which have application to the health, healthcare science and science pathways. These concepts demonstrate interaction between physical sciences, life sciences and chemistry to support occupations across the three pathways.**Structure and function of cells and tissues:** cell theory as an underlying concept, ultrastructure including organelles and similarities/differences between animal and plant cells, specialisation of cells**Large molecules:** Proteins, carbohydrates and lipids are the three key groups of large molecules: Understanding of structures to understand function related to their properties **Exchange and transport mechanisms;** need for exchange of substances, how/where this takes place, factors that affect requirements and give rise to specialised systems **Genetic information and inheritance:** including sequence of bases in DNA molecule relationship to the mechanism of inheritance, variation and relationship between organisms**Microbiology:** including classification and characteristics of micro-organisms and microscopy techniques**Structure of materials and the relationship with physical and chemical properties**: including physical properties of metals-conductivity (electrical and thermal), malleability, ductility. Chemical properties such as reactivity**Acids/bases and chemical change:** concept of strong and weak acids (as distinct from dilute and concentrated solutions), properties and characteristics, reactions and resulting salts produced**Rates of reaction and energy changes:** collision theory, relationship with temperature changes on rates of reaction, role of catalysts in reactions**Chemical analysis of substances:** use of a range of tests and techniques to detect, identify chemical composition and determine amounts of substances. To include simple tests, use of instrumental techniques and determination of amounts of acids and alkalis by titration**Electricity:** current, potential difference and resistance, electrical charge and current, resistors and mains electricity**Magnetism and electromagnetism**: poles of magnets, magnetic fields, use of electromagnetism**Waves:** function in terms of carrying both energy and information, properties of waves and uses**Particles and radiation:** types of radiation, properties and interaction with matter |

**Core knowledge and understanding across Science pathway**

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| **Element**  | **Content**  |
| **The Science sector** | How core knowledge of the Health and Science sector relates and is applied to the Science pathway, as well as specific knowledge on:* The diversity of employers, organisations and working environments within the Science sector
* Different job roles within the Science sector
* Application of science in non-science sectors: possible employers and job roles
* Individual roles and responsibilities in line with job description and person specification; how roles fit into organisational structures
* The impact of job role on others in the working environment (including colleagues within own team and others)
* Good Laboratory Practice (GLP), Good Manufacturing Practice (GMP)
* The key principles of continuous improvement for scientific tasks
* Internal and external regulatory environment pertinent to occupations in the Science sector and how to ensure compliance with all relevant regulations, for example pharmaceutical sector and food science sector
* When regulations do and don’t apply to different work activities within the Science sector
* Factors that impact on the commercial activities of science organisations
 |
| **Further science concepts** | How core Scientific knowledge relates to the Science pathway, as well as specific knowledge on further science concepts:* **Cell cycle:** Meiosis and Mitosis: stages and phases, knowledge of copying of genetic information and that this is passed to daughter cells. Daughter cells formed during mitosis have identical copies of genes, while cells formed during meiosis are not genetically identical
* **Cellular respiration**: breakdown of glucose and other respiratory substrates to make energy carrying molecules called ATP. ATP provides the immediate source of energy for biological processes
* **Enzyme and protein structure**: how the sequence of bases in the DNA molecule determines the structure of proteins, including enzymes, enzymes catalyse the reactions that determine structures and functions from cellular to whole-organism level, enzymes are proteins with a mechanism of action and other properties determined by their tertiary structure. Enzymes catalyse a wide range of intracellular reactions
* **Pathogens:** Pathogens are microorganisms that cause infectious disease. Pathogens are mostly bacteria but some are viruses, fungi and protoctists
* **Classification of biological materials:** division into four groups according to their molecular structures and the functions they perform
* **Formulae and equations:** empirical and molecular formulae, balanced equations, relative atomic mass and relative isotopic mass, mole concentrations and calculations
* **Kinetic changes**: conditions that effect chemical reactions, such as temperature and pressure: ways to reduce activation energy such as use of catalysts
* **Analytical techniques:** for example, chromatography, titrimetric and separation, theory and application
* **Gas laws:** definitions and applications to determine behaviour of gases in particular conditions, including use of Kelvin temperature
* **Pressure/fluid/viscosity:** laws and relationships
* **Units:** use of SI units and conversion between units, appropriate use of significant figures and science notation
 |
| **Application of Safety, Health and Environmental practices in the workplace** | How core knowledge of health and safety in the Health and Science Route Core relates and applies to the Science pathway, as well as specific knowledge on:* REACH guidelines
* Scientific environmental specific legislation
* Control of Major Accident Hazards (COMAH)
* Biohazards
* Controlled substances and controlled drugs
* Localised extraction and ventilation
* Environmental risks and regulations
* Containment levels
* Noise regulations, such as maximum decibel levels, and required PPE for potential noise hazards
* High risk environments or substances, for example working with gases, explosive environments, lasers or ionising radiation
* Electromagnetic regulations including use of devices such as radios and mobile phones in the proximity of specific equipment and instrumentation
* Decontamination procedures for dealing with a range of common substances in the scientific environment
 |
| **Scientific methodology** | How core knowledge of health and science relates to the Science pathway, as well as specific knowledge on:* Experimental design: the importance and purpose of planning
* Importance of a hypothesis and/or determining the performance criteria and/or outcomes which can be tested
* Planning methodologies: objective setting, critical path analysis, financial forecasting, risk management and time management
* Meeting customer/client requirements
* Making use of and accessing information from scientific literature and research databases
* Sampling techniques for a range of common scientific subject matter and outcomes
* Measurement techniques for a range of common scientific subject matter and outcomes (including micro and macro scales)
* Need for reliable, verifiable and accurate recording
* Problem recognition and application of problem solving techniques
* Evaluation of scientific methodology and making recommendations for improvements
 |
| **Data handling and processing** | How core knowledge of health and science relates to the Science pathway, as well as specific knowledge on:* How to collect, record, interpret and analyse data in the scientific environment
* Types of data: difference between Qualitative and Quantitative data
* Data recording: recording requirements e.g. laboratory notebooks, data storage, and Laboratory Information Management systems (LIMs)
* Data capture and software systems commonly used in scientific settings
* Identification of data errors: random errors and systematic errors, how to minimise errors
* Data processing and analysis, including trends in data
* Appreciation of the varying statistical techniques that can be used for data analysis and data presentation in the science sector
* Data evaluation: how to review data and make assessments based on that review
* Data presentation including reports, graphs, tables and charts
* Variables to consider: preventing/reducing bias
* Consideration of statistical analysis in determining sample size
 |
| **Experimental equipment and techniques** | How core knowledge of health and science relates to the Science pathway, as well as specific knowledge on:* Equipment faults and technical factors impacting on scientific results, requirements for positive and negative controls
* Selection and use of appropriate equipment such as: scientific balances, glassware, centrifuges, digital and non-digital pipettes, incubators, fridge/freezers, cryogenic equipment, fume cupboards, glove boxes, temperature and humidity recorders, pH meters, microbiological equipment, autoclaves
* Appropriate techniques for handling a range of different substances: i.e. solid, liquid and gases
* Measurement techniques for a range of different substances and measurement scales (e.g. kilo, mili, nano scales)
* Microscopy techniques including use of light microscope and haemocytometer
* How to follow, and reason for using, aseptic techniques
 |
| **Ethics** | How core knowledge of health and science relates to the Science pathway, as well as specific knowledge on:* Ethical practice in all areas of science, e.g. Rigour, respect, Responsibility A Universal Ethical Code For Scientists 2007
* Intellectual property rights
* Integrity
* Codes of practice within organisations
* Respect in the workplace
 |

**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.

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 organisations and employer.

For Science, in achieving the assessment objectives and meeting the brief, students must demonstrate the following core skills, through mostly self-directed activities to promote and develop independent learning:

* **Project management** to include independently producing a high-level project plan taking into account: timing of activities, resource considerations, ethical considerations, adherence to health and safety and the maintenance of quality outcomes
* **Researching** from independently identified sources including scientific literature and other appropriate sources, prior to the project commencement and referencing these sources appropriately
* **Working with others** e.g.to ensure that any scientific techniques meet all safety, health and environmental requirements
* **Problem solving** within a science context and where appropriate making use of new technologies to solve problems
* **Communication** e.g. providing results and recommendations in appropriate formats to clients and/or wider stakeholders which take into consideration “business benefits” or show commercial awareness in a variety of formats including written reports and verbal presentations
* **Reflective evaluation** to be able to make improvements to own practice e.g. having completed a task reviewing and suggesting improvements and consideration of lessons learnt for own professional development.

## Occupational Specialist Content

Specialist content is structured into different occupational specialisms, which correspond to the apprenticeship standards listed on the occupational map covered by the T Level. Occupational specialisms ensure students develop the knowledge and skills necessary to achieve ‘threshold competence’ in the occupational specialism.

Achievement of threshold competence signals that a student is well-placed to develop full occupational competence, with further support and development, once in work (including an apprenticeship). The knowledge and skills listed are required to achieve one or more ‘performance outcomes’. These indicate what the student will be able to do as a result of learning and applying the specified knowledge and skills.

In essence, each performance outcome describes, at a high level, what the student ‘can do’ to have achieved threshold competence in an occupational specialism.

### Occupational Specialism: Technical: Laboratory Sciences

**Performance Outcome 1: Perform a range of appropriate scientific techniques to collect experimental data in a laboratory**

**setting, complying with regulations and requirements**

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|  **Knowledge specific to Performance Outcome** | **Skills specific to Performance Outcome** |
| **Safety, health and environmental practices in laboratory science**How core knowledge of health, safety and environmental practices in Science relates to Technical: Laboratory Sciences when performing scientific techniques, this includes knowledge of all legislation and regulations, use of Personal Protective Equipment (PPE), and completing risk assessments | Work safely in a laboratory, maintaining excellent housekeeping whilst following appropriate safety, environment and risk management systemsComply with all relevant legislation and regulations in the handling and disposal of solids, liquids and gases (including toxics, corrosives, irritants, sensitisers, flammables, air/water sensitive materials, explosives, compressed gases, pyrophoric, oxidisers, radioactive materials, biohazards and contaminant levels)Assess hazards and risks when performing a scientific technique including writing a risk assessment and modifying work where required Use appropriate Personal Protective Equipment when performing scientific techniquesFollow all relevant legislation and risk assessments when performing scientific techniques |
| **Ethics**How core knowledge of ethics in science relates to Technical: Laboratory Sciences, this includes codes of conduct for areas such as confidentiality and intellectual property requirements  | Adhere to ethical practice and codes of conduct to ensure confidentiality and intellectual property requirements are met  |
| **Core Scientific knowledge**How route and pathway core knowledge of science relates to Technical: Laboratory Sciences, as well as occupationally specific knowledge, including, but not limited to:* **Atomic structure**: chemical properties of elements depends on their atomic structure. The arrangement of electrons is linked to the way in which elements are arranged within the periodic table
* **Molecular structure and bonding**: different types of bonds including ionic and covalent bonds, as well as metallic bonding and the shapes of molecules
* **Oxidation and reduction:** definitions in terms of oxygen transfer, hydrogen transfer and electron transfer, oxidising and reducing agents, redox reactions
* **Enthalpy and Entropy:** definition of these terms. Importance of understanding stability of compounds and why chemical reactions occur. Link between enthalpy and entropy change allowing free energy change to be calculated. Perform calculations of enthalpy changes using Born-Haber cycles
* **Materials science:** applications including polymers, alloys and composites. Definitions of terms, characteristics of addition polymerisation and condensation polymerisation
* **Metabolic pathways and bioenergetics**: anabolic and catabolic pathways, differences in terms of energy change. Awareness of the most important pathways: glycolysis, Krebs cycle, Acetyl-Co A oxidation, beta-oxidation and oxidative phosphorylation. Mechanisms of pathway control
* **Genotyping and Phenotyping:** genetic basis; understanding of terms. Process of determining differences through investigation of DNA sequencing using analytical techniques such as Polymerase Chain Reaction (PCR)
* **Ecosystems:** definitions and terms, biomass transfer, recycling within ecosystems, primary succession, measuring the distribution and abundance of organisms in an ecosystem
* **Nanoscience and nanotechnology:** general principles in terms of the manipulation of matter whose basic components are of a nanoscale size
* **Electronics:** analogue and digital signals, use of electronics in technology
* **Nuclear physics:** properties of stable and unstable nuclei, link between energy and mass
 | Apply core and occupationally specific scientific knowledge to techniques being performed in the laboratory environment |
| **Scientific tasks**The range of techniques used within laboratory sciences to complete scientific tasksHow core knowledge of scientific techniques relates to Technical: Laboratory Sciences, as well as occupationally specific knowledge, including, but not limited to: * Analysis of substances and environments
* Titration
* Micro and nanoscience

Knowledge of laboratory techniques to identify, separate and analyse substances and environments* Calorimetry
* Colorimetry
* Chromatography
* Distillation
* Filtration
* Electrochemistry
* Spectroscopy
* Thermochemistry
* Characterisation

Knowledge of laboratory techniques to include, but not be limited to:* Tissue culture
* Cloning, protein purification, genes and enzyme classification
* Microbiology techniques

Knowledge of environmental laboratory techniques, such as * Biochemical Oxygen Demand (BOD)
* Chemical Oxygen Demand (COD)
* Total Organic Carbon (TOC)
* suspended solids

Physics laboratory techniques in electronics, mechanics and ionising radiation, thermal, electricity and magnetism  | Perform a range of practical scientific techniques following multistep scientific methods and Standard Operating Procedures within a laboratory settingUse appropriate practical scientific techniques to analyse substances and environmentsUse appropriate practical scientific techniques to measure a range of physical properties such as polarity, temperature, pressure, conductivity and radioactivityUse appropriate practical scientific techniques to isolate materialsPrepare a solution of defined molar concentrationUse appropriate practical scientific techniques to separate materialsUse appropriate SI units and be able to work with a range of appropriate scales when conducting scientific tasksConvert between measurement units when requiredFollow a scientific paper in the conducting of a scientific technique |
| **Scientific equipment, instrumentation and use of raw materials and reagents****Equipment and instrumentation**How core knowledge of scientific equipment relates to Technical: Laboratory Sciences, as well as occupationally specific equipment, including, but not limited to: * Range of equipment used to separate samples such as: column chromatography, liquid and gas chromatography, mass spectrometry, nuclear magnetic resonance
* Electrical calorimeters
* Equipment to analyse Biochemical Oxygen Demand, Chemical Oxygen Demand and Total Organic Carbon content
* Cryogenic equipment
* Physics laboratory equipment e.g. oscilloscopes

**Raw materials and reagents**Understanding the importance of using appropriate reagents and raw materials to complete practical scientific tasks. Considering factors such as:* Sources and suppliers
* Handling and storage, including shelf life to ensure integrity
* Quality Assurance of raw materials and reagents
 | Use appropriate equipment to complete practical scientific techniquesCalibrate scientific equipment and check it is fit for useDemonstrate practical technical competence in the use of instrumentation and equipment |
| **Data Collection and Recording**How core knowledge of data collection and recording relates to Technical: Laboratory Sciences including producing reliable and verifiable results, recording in a clear and accurate manner and the use of appropriate units, notation and significant figures | Produce reliable and verifiable data from scientific techniquesRecord data and records of work undertaken in a clear and accurate mannerUse appropriate units, notation and use of significant figures when recording data |
| **Legislation, Regulations, Standards and Guidelines**How core knowledge of legislation, regulations, standards and guidelines relates to Technical: Laboratory Sciences, including all relevant regulations, regulatory bodies and standards Regulations including, but not limited to:* Good Laboratory Practice (GLP)
* Good Manufacturing Practice (GMP)
* Quality Management systems (QMS)
* Good clinical Practice (GcP)

Regulatory Bodies * MHRA
* FDA
* European Medical Agency

Standards including but not limited to:* Industry specific regulations
* UKAS
* ASTM
* Pharmacopoeia
* ISO

Use and importance of Standard Operating Procedures (SOP) within the Laboratory Environment  | Adhere to all procedures to ensure compliance with all relevant regulations and quality standards when conducting scientific techniques, including GLP and GMP Follow Standard Operating Procedures where applicable when performing scientific techniques |

**Performance Outcome 2: Plan, review, implement and suggest improvements to scientific tasks relevant to a laboratory setting**

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| **Knowledge specific to Performance Outcome** | **Skills specific to Performance Outcome** |
| **Planning laboratory techniques and use of equipment**How core knowledge of planning relates to Technical: Laboratory Sciences including but not limited to:* Determining the:
* customer requirements for laboratory analysis
* laboratory sampling requirements
* laboratory health, safety and environmental and

regulatory requirements* resources required including laboratory equipment,

reagents and consumables* scheduling of laboratory testing
* scientific methods
* storage of samples
* format for the presentation of the data
* Developing a specific hypothesis to test using laboratory techniques
* Use of positive and negative controls
* Undertaking literature searches and using scientific papers

As well as occupationally specific knowledge for planning laboratory techniques and equipment, including: * Laboratory method validation such as International Council of Harmonisation (ICH) requirements
* Laboratory equipment validation
 | Design a scientific task to address a particular hypothesis including the use of controls (including positive and negative controls)Perform an appropriate literature search to help in the planning of scientific tasksUse information from scientific papers to plan scientific tasksApply scientific knowledge and knowledge of scientific techniques to unfamiliar situations to plan a scientific task |
| * **Laboratory Data processing and analysis**
* How core knowledge of laboratory data processing and analysis relates to Technical: Laboratory Sciences, including but not limited to:
* Customer requirements for the processing of the results
* Regulatory requirements e.g. validation
* Relevant calculations
* Conversion of units
* Using the most appropriate statistical techniques
* Presentation of data
* The use of online databases
* Use of laboratory control charts and trend charts
* How to establish the validity of the results against the standards

Occupationally specific knowledge for planning laboratory techniques and equipment, including:* Data processing of laboratory information to support improvements e.g. stability studies, laboratory trend charts, laboratory method validation results, and proficiency testing
 | Complete relevant calculations on data obtained in the laboratory environmentSelect and use appropriate statistical techniques to analyse results from scientific tasksAnalyse, interpret and evaluate data from scientific tasks.Present data in an appropriate format using appropriate statistical techniques, including the use of laboratory information management systems (LIMS)Be able to find relevant information in online databases in relation to scientific tasks, statistical techniques and laboratory information management systems (LIMS)Recognise the need for, and source, expert help in relation to laboratory data processing and analysis when required |
| * **Reviewing and improving laboratory methods and use of equipment**
* Method:
* How core knowledge of reviewing and improving relates to Technical: Laboratory Sciences this occupational specialism, including but not limited to:
* Laboratory reviewing strategies
* How laboratory documents are created, reviewed and

approved* How laboratory improvements can be implemented

Equipment:As well as occupationally specific knowledge for reviewing and improving laboratory techniques and use of equipment, including: * How laboratory equipment documents are created, reviewed and approved, e.g. GLP requirements
* Quality control
* Laboratory method transfer
 | Review and modify the method of a scientific task to improve the taskSuggest, record and act upon improvements to a scientific task through the adoption of continuous improvement techniques |

**Performance Outcome 3: Identify and resolve issues with scientific equipment or data errors**

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| **Knowledge specific to Performance Outcome** | **Skills specific to Performance Outcome** |
| * **Equipment management**

How core knowledge of laboratory equipment and equipment management relates to Technical: Laboratory Sciences including but not limited to: * + maintenance, cleaning, calibration and validation of a range of laboratory equipment as outlined in the pathway core:
	+ How to interpret manufacturers information
	+ Employ the correct test equipment
	+ Maintain records
	+ Communicate the results
	+ Safe disposal if equipment cannot be repaired
* Recognising equipment faults/ technical factors and their impacts on laboratory results

Laboratory Equipment: Awareness of laboratory equipment to undertake scientific techniques commonly found in chemical, biological and physics laboratories as outlined in the pathway core | Set up and calibrate a range of different types of equipmentCarry out and record routine cleaning and maintenance of equipmentRecognise when a piece of equipment is producing inaccurate data Recognise when equipment is likely to be being damaged or cause injury due to malfunctionRecognise the need for, and source expert help when required |
| * **Laboratory Data errors**

How core knowledge of data errors relates to Technical: Laboratory Sciences including awareness of laboratory data errors, how they could occur and ways to minimise errors Potential data errors that could occur:* Contamination of samples or equipment
* Samples not stored correctly
* Incorrect laboratory equipment used
* Equipment not set-up correctly
* Method not followed
* Transcription error

Ways to minimise errors:* Plan the work and workplace requirements
* Read the risk assessment and COSHH sheet
* Follow a validated method
* Ensure equipment calibrated and set-up correctly
* Store and label samples and standards correctly
* Safely dispose of materials
 | Demonstrate an awareness of errors that can occur in scientific tasksIdentify how possible data errors could occur in scientific taskTake steps to minimise errors in scientific tasks following continuous improvement techniques |

### Occupational Specialism: Technical: Food Sciences

**Performance Outcome 1: Perform appropriate activities to support the food supply chain complying with regulatory**

**requirements**

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|  **Knowledge specific to Performance Outcome** | **Skills specific to Performance Outcome** |
| **Planning methodologies**How core knowledge of planning methodologies relates to Technical: Food Sciences and the planning of procedures to support the food supply chain | Plan food safety and regulatory procedures using a range of planning methodologies |
| **Legislation, regulations and ethics in the food and drink** **industry**Legislation and regulations that apply to the food and drink industry including understanding of food safety and Health and SafetyUse and purposes of food industry standards (e.g. British Retail Consortium, Standard Operating Processes, Quality Management Systems and internal and external specifications)Environmental legislation related to the food and drink industry* UK end-to-end food supply chain, its sustainability and vulnerabilities and food fraud including Threats Analysis (TACCP) risk assessment procedure of existing suppliers

Characteristics of the food and drink industry and the business workplaceEthical issues relating to the food and drink industry, for example: Fairtrade, use of sustainable palm oil, modern slavery, working time regulations | Label products to show nutritional; calorific; allergen; origin of product; use by and best before dates and weights and measuresCarry out a supplier assurance risk assessment for a variety of ingredients to ensure food safetyIdentify current supply chain and any potential areas of vulnerability using a Threats Analysis (TACCP) risk assessmentUtilise horizon scanning tools to identify potential areas for food fraud |
| **Health and safety in the food and drink industry**How core knowledge of health and safety relates to Technical: Food Sciences, as well as occupationally health and safety specific knowledge related to the food industry including:* Manual handling
* Safe use of equipment
* Standard operating procedures and personal protective equipment ergonomics
 | Work safely in the food environmentCarry out risk assessments, identifying risks and mitigating factors |
| **Hazard Analysis and Critical Control Points (HACCP) in the food and drink industry**The importance of HACCP-based food safety management procedures The preliminary processes for HACCP-based procedures How to implement and maintain a HACCP-based food safety management system | Create a HACCP plan for a simple product |
| **Food safety management**The importance of food safety management in a Food Business Good Hygiene Practices (GHP)Risks to food safety and compliance with regulatory requirements How to contribute to the maintenance of the food safety management systemMonitoring and review of food safety management Methods of pest control and prevention  | Maintain and implement a food safety system within a food production facilityCarry out monitoring and review of food safety management |
| **Technical and quality management in the food industry**Management systems, processes and industry standards used in food operations Technical and quality management procedures in food and drink operations Internal and external audit processes in food operations  | Carry out an internal audit against agreed audit checklist and suggest appropriate corrective action for any issues foundReview and maintain technical and quality management procedures |
| **Microbiology**How core knowledge of microbiology relates to Technical: Food Sciences, as well as occupationally specific knowledge related to the food industry including: * How to identify pathogens which cause food borne illness and disease
* Hygiene measures used to control pathogens
* How to sample an environment for contamination
* Use of appropriate laboratory skills and equipment to identify pathogens
 | Take samples from all food surface areas in order to identify any pathogens presentIdentify hygiene process failures and recommend system improvements |
| **Raw Materials in the food industry**Understanding of:* Sources and supply of raw materials
* Specifications of raw materials
* Functionality of raw materials
* Systems for handling raw materials
* Selection of raw materials
* Quality assurance of raw materials
* Storage of raw materials, in particular segregation and protection of integrity
 | Selection of raw materials as per recipe/client requirementProtection of integrity of products to ensure origin of product is maintainedFollow segregation of raw materials to prevent DNA, allergen or microbial cross contamination  |
| **Food Science**Understanding of:* Composition and functionality of food
* Human nutritional requirements
* Fermentation process
* Shelf life of food
 | Follow all customer requirements to ensure quality of product and shelf life is maintained |
| **Food technology**Understanding of:* Energy transfer in food technology
* Heat processing-based food technology
* Heat removal-based food technology
* Ambient temperature processing technologies
* Packing and labelling of food products
 | Verify existing procedures are meeting food safety and quality standards |
| **Food supply chain from end to end and relationships within it**Possible adulteration within the food supply chain* Food fraud – how and where it could occur
* Vulnerability, assessment and critical control points (VACCP)
* How the origin of the product will confirm quality, traceability and can highlight potential concerns
 | Recognise when food adulteration is taking place and escalate as appropriate |

**Performance Outcome 2: Develop new food and food related products to support the food supply chain**

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| **Knowledge specific to Performance Outcome** | **Skills specific to Performance Outcome** |
| **Product development process**Process from concept to launchPrinciples of New Product development (NPD) and Existing Product development (EPD)Impact of customer trends and requirements on the design of new product development; use of impact assessments to investigate such trends  | Perform an impact assessment of customer trends on the design of both a NPD and EPD |
| * **Advanced recipe formulation**
* First principles of:
* Recipe balance
* Ingredient substitution
* Ingredient functionality

Selecting correct ingredients for specific applicationsRaw material (RM) alternatives that can be used | Formulate a recipe from first principles using recipe balance and ingredient substitutionEnhance an existing recipe selecting the correct ingredients based on their functionalityDevelop a food product considering raw material alternatives |
| * **Packaging innovation**

New types of packaging to reduce plastic waste/increase opportunity for recycling | Develop a product considering innovations in packaging |
| * **Costing the production of products**
* How to cost both new and existing products
* Cost to include ingredients, packaging, time spent, potential labour costs, electricity, transportation and viability of product
 | Carry out a product costing on a new product and on a modification to an existing product |
| * **Sustainability**

Understanding of:* Raw materials: importance of procuring from sustainable sources, for example palm oil
* Packaging: reduction in use of plastic, particularly black plastic
* Reuse of waste, for example biomass products
* Energy usage: strategies for reduction of energy usage for example use of LED light bulbs
* Transportation: consideration of “food miles” move to “green food miles”, reduction of packaging in transportation
 | Carry out a sustainability analysis for a new product |
| * **Continuous Improvement (CI) Management in the food industry**

Key principles to include: * Workplace organisation techniques
* How to maximise equipment and consider process limitations
* Environmental and waste management systems and how to minimise waste
* Drivers for cost and quality
 | Contribute to Continuous Improvement to drive down costs and drive up quality, including using IT systems to analyse and interpret data to identify trends |
| * **Selecting a suitable sampling method**
* Considerations when selecting a suitable sampling method to include:
* Sample size
* Sample numbers per batch
* Frequency of sampling
 | Collect samples as per procedural requirements |
| **Selecting a suitable test method**The test methods that can be used, when they are used and how to select a suitable test method:* Taste panels
* Food allergen testing
* Food contaminant testing
* Nutritional analysis
* Microbiological
 | Carry out taste panels to check for quality against quality assurance sheets as prescribed by the customerAnalyse test results and provide recommendations for improvements |

**Performance Outcome 3: Identify and resolve issues in the food supply chain**

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| **Knowledge specific to Performance Outcome** | **Skills specific to Performance Outcome** |
| **Technical and quality problems in the food supply chain**Problem solving techniques, including root cause analysis and investigation techniques, to resolve problems in food and drink operationsIdentifying and resolving problems relating to customer complaints and quality issues | Identify and resolve problems relating to quality issues and/or customer complaints using appropriate problem solving techniquesCarry out root cause analysis of a problem and/or customer complaint and recommend suggestions for improvement |
| **Testing and evaluation in the food supply chain**Principles of sensory evaluation in food operations and how to carry out sensory analysisProcedures for quality control testing and sensory analysis in food operationsSampling and use of sensory panels to evaluate quality in food operationsRoles and maintenance of specifications and traceability in food operations | Carry out a taste panel and evaluate resultsCarry out procedures for quality control testing and sensory analysis  |

**Performance Outcome 4: Collect, analyse and interpret food production data**

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| **Knowledge specific to Performance Outcome** | **Skills specific to Performance Outcome** |
| **Food Production data**How to collect, interpret and analyse food production data Using information and communication technology to support the interpretation and analysis of food production dataUsing management information systems (MIS) to obtain food production dataTrends in food production data and relationship to continuous improvement  | Create a spreadsheet and input management data to track production trends and present information in written and visual format and/or presentations |

### Occupational Specialism: Technical: Animal Sciences

**Performance Outcome 1: Perform appropriate animal husbandry procedures on a range of laboratory animals in scientific**

**environments**

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| **Knowledge specific to Performance Outcome** | **Skills specific to Performance Outcome** |
| **Animal Husbandry and Welfare:**Specific husbandry and welfare considerations for all animals that are procured for the purpose of laboratory investigationsAppreciation of the range of legislation including ethical requirements that allows for the procurement of animals for laboratory investigationsAwareness that all animals are obtained from approved suppliers and can only be purchased by approved organisations for approved investigationsEnsuring that all animals in scientific environments are given the following considerations:* Culture of care principles that all those working with animals must adhere to
* Species specific requirements
* Animal housing requirements: including cage types, isolators and Individually Ventilated Cage (IVC) systems
* Requirements for social housing
* Nutritional requirements of laboratory animals
* Animal identifications options, following protocols to ensure unique identification
* Animal management systems: what these are, why they are used
* Animal facility cleaning procedures
* Biosecurity procedures
* Principles of handling and sexing of laboratory animals
* Principles of euthanasia and confirmation of death
* Techniques available appropriate to species
* Principles of microbiology
* Health check procedures including the recognition of

disease* Basic animal anatomy and physiology, including the

importance of maintaining homeostasis for a specific species | Demonstrate manual dexterity in undertaking all routine animal husbandry procedures such as appropriate animal restraint, manipulation of equipment used to administer or withdraw biological samplesProvide appropriate care and welfare for animals, including feeding, cleaning, handling, sexing and health checkingDemonstrate consideration of the specific requirements of a particular species Follow protocols to ensure each animal is uniquely identifiedObserve animals to identify any clinical conditions, pain, suffering or distress and report these as appropriateAdhere to all biosecurity procedures within an animal science environment to prevent transmission of any infectious diseases, parasites or pestsUse animal management systems to ensure efficient operation of an animal science environmentCarry out appropriate euthanasia dissection and disposal of animals |
| **Laboratory management procedures**How core knowledge of laboratory management procedures relates to Technical: Animals Sciences including how to ensure adequate and appropriate supplies and consumables are available | Ensure adequate and appropriate supplies and consumables are available to complete animal husbandry and welfare tasks |

**Performance Outcome 2: Plan the conducting of in-vivo investigations in compliance with regulatory and legal requirements**

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| **Knowledge specific to Performance Outcome** | **Skills specific to Performance Outcome** |
| **Planning methodologies for in-vivo investigations**Understanding of:* Ethical practice and the importance of the 3 R’s (reduction, refinement and replacement) in planning in-vivo investigations
* Use of Animals in Research
* Use of environmental enrichment
* Use of Statistical Analysis for determining groups sizes
* Blinding in-vivo studies
* Preventing/reducing bias during in-vivo studies
* Animal models
* Transgenic technologies
* Randomisation techniques
* Quality standards for in-vivo investigations
* Standard Operating Procedures for in-vivo

investigations* Importance of the study protocol in planning in-vivo

investigations | Support the planning of in-vivo investigations in animal sciencePlan the conduct of an in-vivo investigation using knowledge of methodologies, procedures and techniques |
| **Importance of health, safety and sustainability in in-vivo investigations**How core knowledge of health, safety and sustainability relates to Technical: Animals Sciences, as well as occupationally specific knowledge related to animal sciences including Laboratory Animal Allergens and use of genetically modified materials and employer specific requirements including risk assessment protocols | Ensure the plan for the conduct of an in-vivo investigation adheres to all health and safety, regulatory and legal requirements to ensure health and welfare of animalsComplete risk assessments for planned in-vivo investigations to comply with risk management protocolsAccess and follow all appropriate Standard Operating Procedures when planning in-vivo investigationsIdentify an appropriate euthanasia method |
| **Regulatory, legal requirements and quality standards for in-vivo investigations**Knowledge of:* Animals in Science Regulation Unit (ASRU) and the Animals (Scientific Procedures) Act 1986 (ASPA)
* Animal Welfare Act 2018
* EU directive 2010/63
* Personal licence conditions
* Project licence conditions
* Home office codes of practice for housing and care of laboratory animals
* Home office reporting requirements
* Schedule 1 methodology (Appropriate Methods of Humane Killing)

Employer specific policies including Standard Operating Procedures and guidance documents | Ensure adequate and appropriate supplies and consumables are availableCalculate blood volumes that comply with Home Office GuidelinesIdentify appropriate dosing routes and volumes in compliance with project licenceIdentify an appropriate euthanasia method |
| **Employment and types of working environments in animal science**Range of working environments in animal science including pharmaceutical research and development, contract research and development and university research and developmentJob roles and duties of Animal Technologists, including the planning and undertaking of in-vivo investigationsRange of employment and progression opportunities for Animal Technologists | Apply knowledge of employment and working environments to support the planning of in-vivo investigations |

**Performance Outcome 3: Perform planned in-vivo investigations, collect and analyse experimental data in scientific environments**

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| **Knowledge specific to Performance Outcome** | **Skills specific to Performance Outcome** |
| **Techniques and Procedures in in-vivo investigations** * Principles of animal welfare, including signs of ill health, stress or pain in accordance with product licence conditions
* Principles of animal handling including requirement for manual dexterity and species-specific techniques
* Principles of dosing and sampling techniques
* Administration of test materials to laboratory animals including specialism of choosing dosing routes / volumes to administer
* Identification methods
* Weighing techniques and bodyweight ranges for species/ age/strains
* Sampling methods for obtaining body fluids i.e. blood, urine, faeces, CSF
* Facility Hygiene i.e. decontamination, sterilisation, disinfectants
* Breeding of Genetically Modified Animals (GMA)
* Principles of aseptic surgical technique
* Cryo-preservatives
* Transgenic technologies
* Euthanasia techniques and procedures appropriate to individual species
* Terminal procedures i.e. perfusions, necropsy, tissue collection and preserving tissues
* Clinical Observations
* Physical examinations
* Welfare checks
* Food/water consumptions
* Surgical procedures
* Anaesthesia
* Analgesia
* Pre and post-operative care of animals
* Facility hygiene i.e. decontamination, sterilisation, disinfectants
* Breeding techniques i.e. mating, determining pregnancy, parturition, weaning, genotyping, selection of future breeding stock, speed congenics, development of breeding plans
 | Use appropriate techniques to complete an in-vivo investigation, e.g. weighing and administrationDemonstrate manual dexterity when conducting in-vivo investigationsComply with species specific animal handling techniquesEnsure all appropriate equipment is available to complete in-vivo investigation Follow risk assessments when conducting in-vivo investigationsComply with all relevant Standard Operating Procedures when conducting in-vivo investigationsComply with all relevant health and safety, regulatory and legal requirements, including complying with Scientific procedures act when conducting in-vivo investigationsIdentify any problems when conducting in-vivo investigations and respond appropriately, including recognising, reporting and recording pain, suffering or distress in animalsUse appropriate techniques to complete study e.g. euthanasia of animals post study, as per protocol |
| **Equipment used in animal sciences**How core knowledge of scientific equipment relates to Technical: Animals Sciences, as well as occupationally specific knowledge related to animal sciences including:* Balances (animal and analytical)
* Use of blood collection pots: types and requirements for centrifuging
* Animal facility equipment i.e. cage/rack washers, bottle washers, mechanical cleaning equipment
* Decontamination equipment i.e. Vaporised Hydrogen Peroxide (VHP) and fogging equipment
* Sample rollers
* Syringes and hypodermic needles: appropriate sizes for use
* Blood analysers
* Cell counters
* Use of callipers
* Use of fixatives
 | Demonstrate practical technical competence in the use of instrumentation and equipment |
| **Data recording collecting and analysis**How core knowledge of data collecting, recording and analysis relates to Technical: Animals Sciences, as well as occupationally specific knowledge related to animal sciences including: * Home office reporting of severities
* Project Licence Standard Condition 18 (PPL SC18) and Project Licence Standard Condition 20 (PIL SC20)
 | Maintain accurate experimental records e.g. observation of clinical signs, including severity and humane end pointsRecognise when signs of suffering and distress require further action and act appropriately seeking advice from senior colleagues as requiredCollect accurate and reliable data from in-vivo investigationsUse data capture and software systems when appropriate to collect reliable and accurate dataAnalyse, interpret and evaluate data from in-vivo investigations, identifying results requiring further investigation and notify senior colleagues as appropriateReview study outcomes and learnings, including data evaluation and condition of animals to inform future studies |

### Occupational Specialism: Technical: Metrology Sciences

**Performance Outcome 1: Plan appropriate scientific measurement for any measurand to comply with regulatory requirements**

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| **Knowledge specific to Performance Outcome** | **Skills specific to Performance Outcome** |
| **Fundamentals of metrology**Context in which scientific measurement is undertaken* Understanding of the context and purpose of “the Science of measurement”, i.e. metrology and its importance to society
* The role of measurement standards in the planning of appropriate scientific measurement
* The need for measurement and how this relates to cost, tolerance and timescales

Sources of uncertainty in scientific measurement* Measurement uncertainty, repeatability and reproducibility, and conformity assessment
* Traceability, calibration, testing and accreditation
* Measurement instrumentation
* How to calculate simple uncertainty budgets and understanding of why they are used
* Selecting an appropriate sample size
* Best practice for specific systems

Terminology and units which are used within metrology* Difference between validation and verification of scientific measurement equipment
* The correct nomenclature for scientific measurement terms and the impact of using incorrect terminology
* Understand how the Maximum Permissible error of a system is devised
* Knowledge of the seven SI units used in measurement tasks and how to convert between units
 | * Apply the knowledge of fundamentals of metrology in order to:
* Identify measurement needs and make informed decisions about the measurement process cost, tolerance and timescales required
* Determine the design of the measurement; taking into account all sources of uncertainty, including: correct sample size for the measurements which will be taken, number of repeats, operators, components, features to be inspected to obtain viable results

Read and apply a simple uncertainty budget to measurement task* Use different unit systems, and be able to convert between units

 Use the correct terminology for scientific measurement in metrology |
| **Operating principles, equipment and tools**Measurement operating principles, the equipment and tools used in each principle and how to select the most appropriateMost common operating principles used for measurementMeasurement and typical equipment and software programs within that operating principle including but not limited to:* + Atomic Clock
	+ Capacitance
	+ Chemical properties: pH scale, Density, Geiger Muller
	+ Contact probe: Atomic Force, Co-Ordinate Measurement Machine, Skidded and Skidless surface probes
	+ Electromagnetic: Scanning Electron Microscope, Capacitance, Resistance
	+ Frequency Modulated: Laser Rader
	+ Focal Plane: Focus Variation, Confocal Microscopy
	+ Laser Tracker: Interferometer Laser Tracker, Absolute Distance Measurement Laser Tracker
	+ Mechanical: Young Modulus, Stress Testing, Hardness Testing, Weighing Scales
	+ Phase Shift: Interferometry
	+ Thermal
	+ Time: Stopwatch, Atomic Clock
	+ Time of flight: 3D laser scanner
	+ Triangulation: iGPS, Photogrammetry, Structured Light, Laser Line Scanner
 | Select appropriate tools, equipment, instrumentation and software programs for a measurement task, e.g. phase shift for optical testing, time of flight for momentum |
| **Measurement systems**How to identify the most appropriate system to use for a measurement task* Advantages and limitations of each system
* Examples of commercially available systems within each operating principle
* Systems, equipment and tools used with each operating principle and knowledge of the advantages, limitations and typical applications of each
 | Apply underpinning knowledge of measurement systems to select the most appropriate measurement system to plan a measurement task |
| **Different sample preparation methods**Why different sample preparation methods are required, what these methods are and when these would be used, including but not limited to: * Cleaning: To ensure the sample is adequately prepared for the inspection
* Sectioning: To ensure the appropriate section of the sample is accessible for the inspection
* Mounting: Setting the sample in the correct orientation so all the required features can be inspected
* Polishing: Certain scientific measurements require specific surface conditions for the sample, knowing which systems need this special treatment and how it is achieved
* Coating: Certain scientific measurements need the sample to be coated to allow inspection, knowing which systems need this special treatment and how it is achieved
* Soaking: Scientific measurements are affected by the temperature of the sample, soaking is ensuring the sample has enough time to settle at the ambient temperature where the inspection will take place
* Solutions: Ensuring all liquids or other materials required for the scientific measurement are the correct quantities and have the correct properties for the measurement to occur
 | Plan the specific preparation tasks which will be needed on the item to be measured |
| **Extracting measurement requirements** How to identify potential and most relevant sources from which to extract measurement requirements, for example: * Manuals
* Specification sheets
* Catalogues
* Calibration certificates
* Computer-generated information
* ISO standards
* Accrediting bodies
* Technical drawings
* Design models
* Product labels
* Historical data
 | Access and interpret information and documentation to confirm measurement requirements for the item to be measured using appropriate sources of information e.g. Manuals, ISO standards and product labels |
| **Measurement plans**What these are and how they are createdInformation that is relevant to the plan, including, but not limited to:* Repeat count
* Sample size
* System used
 | Create a measurement plan with relevant information on aspects such as system to be used and sample size for the item to be measured |
| **Environmental effects** How environmental conditions can affect both the measuring equipment and the item to be measured, and hence on the data collectedConditions such as : Temperature, vibration, humidity and lighting  | Record the effect of environmental conditions on the item to be measured, e.g. temperature and vibration |
| **Application of metrology**Application of the principles of metrology to industry, law, business, science, as well as areas such as business, forensics, finance and architecture | Apply principles of metrology to industry, law, business, science, as well as areas such as business, forensics, finance and architecture |
| **Customer requirements**Customer requirements in metrology, including: * Tolerances: Knowing what the scientific measurement needs to achieve based upon the functionality of the component being inspected, and what the acceptable limits of error are for the component
* Timescales: More accurate measurements typically require more time to complete, so understanding the tolerance requirements will dictate what inspection times are required to achieve the tolerances
* Costs: The inspection of a component is typically at the end of a process, so scientific measurement must add sufficient value to the quality to the component to offset the cost of the measurement
* Methodology and techniques required: Selecting the correct methodology and technique for the scientific measurement is key to obtaining good quality results. This is the main task for a metrologist in ensuring the correct approach is adopted for each measurement they undertake
 | Extract customer requirements from customer brief e.g. tolerances, timescales, costs, methodology and techniques required |
| **Health and safety in metrology**How core knowledge of health and safety relates to Technical: Metrology Sciences including risk assessments, and use of correct Personal Protective Equipment | Complete and/or follow risk assessments in metrology, including those for handling possible hazardous samplesSelect appropriate Personal Protective Equipment |
| **Regulations and standards in metrology**National and international regulations and standards, industry and organisational procedures and requirements relating to metrology codes of conduct and the importance of their applicationUse of Standard Operating Procedures in metrology | Follow Standard Operating Procedures in metrologyIdentify and follow relevant regulatory procedures and standards from a range of sources when undertaking measurement tasksComply with all relevant legislation, statutory regulations, standards, policies, procedures and requirements relating to codes of conduct and safe working practice relating to the preparation, storage, standards, control and handling of samples, tools, equipment, instrumentation and software programs when carrying out measurement tasks |
| **Quality requirements in Metrology**Importance of quality requirements, assurance, verification, inspection, accreditation, audit systems and processes | Identify and adhere to the correct regulations, ISO standards and quality accreditations required for the type of industry |
| **Employment and working environments in metrology**Need for further professional development, undertaking CPD, and knowledge of the state-of-the-art technology in metrology and future developments including: * Automation
* Metrology and big data
* Industry 4.0
 | Maintain a record of personal development and training from undertaking CPD and knowledge of the state-of-the-art technology and future developments in metrologyUse feedback to develop and improve |

**Performance Outcome 2: Perform scientific measurement tasks using the most appropriate measurement for a measurand to ensure accuracy**

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| **Knowledge specific to Performance Outcome** | **Skills specific to Performance Outcome** |
| **Accuracy in Metrology**Validation and verification techniques for a range of measuring instrumentsCalibration and testing methods for a range of metrology equipment, current calibration status and escalation route if machine isn’t correctly calibrated | Perform a measurement task using developed plan including appropriate equipmentPrepare the work environment in order to perform measurement tasksSet up the measuring system and the item to be measuredPrepare the correct standard for the measurementRead and follow a calibration procedureDetermine the current calibration status of a system from a calibration certificate or calibration labelFollow best practice for the specific system being used |

**Performance Outcome 3: Collect, analyse and interpret data from measurement tasks**

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| **Knowledge specific to Performance Outcome** | **Skills specific to Performance Outcome** |
| **Processing data from measurement tasks**How to process raw data from measurement systems to retrieve, analyse, interpret, validate and record measurement results in line with specifications, identify patterns and assess repeatability and reproducibilityHow to process data such that the target measurands can be extracted for subsequent data processing. This includes but is not limited to: * Image processing
* Filtration
* Alignments
* Corrections
* Data recording
 | Retrieve, analyse, interpret, validate and record measurement results and data in line with specificationsIdentify patterns in collected dataAssess repeatability and reproducibility of measurements  |
| **Analysing data from measurement tasks**How core knowledge of analysing data relates to Technical: Metrology Sciences as well as occupationally specific knowledge related to measurement tasks including: * Statistics
* Measurement Systems Analysis
* Algebraic formulae
* Calculations on measurement data
 | Identify any anomalous results and re-run investigations to assess invalid dataSentencing the sample using the measurement data against the original customer requirementsContribute to the production of reports and other measurement documentationPresent data in most appropriate format to meet customer requirements |
| **Reviewing data obtained**How to review the measurement data obtained against measurement requirements |  |

**Performance Outcome 4: Identify and resolve issues with measurement tools and equipment**

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| **Knowledge specific to Performance Outcome** | **Skills specific to Performance Outcome** |
| **Identifying and resolving issues in metrology**How core knowledge of problem solving relates to Technical: Metrology Sciences as well as occupationally specific knowledge related to measurement tasks including: * Potential sources of uncertainty impact on data collection, analysis
* Interpretation/understanding of the meaning of data/correlation of standard deviation and data
* How to carry out basic repairs on measurement systems, tools and equipment
* How and when to discuss results and issues with peers and when to escalate issues to senior metrology colleagues
 | Carry out basic repairs on measurement systems, tools and equipmentUse problem solving techniques to identify and resolve issues relating to metrology measurementsDiscuss measurement results and issues with peers and determine when issues need to be escalatedWhen appropriate, source expert help from senior colleagues or others on metrology issues |

## Integrating maths, English and digital skills

### Maths

The completion of a level 2 mathematics qualification (GCSE mathematics or Functional Skills) is a minimum exit requirement for all T Levels. This will ensure that all students have demonstrated fluency and competence in mathematics, and are able to recognise the importance of mathematics in their own lives, in work and to society. Achievement of a level 2 mathematics qualification will also provide the foundation to access mathematics at a higher level, if required.

Technical Qualifications should contain sufficient and appropriate maths to help students reach threshold competence in their chosen specialism(s). The following General Maths Competencies (GMCs) have been developed with input from the Royal Society Advisory Committee on Maths Education (ACME), and awarding organisations will need to embed these, and the underpinning maths, into the specifications and assessments being developed as part of the Technical Qualification.

The GMCs below are relevant to this particular Technical Qualification:

* Communicate using mathematics
* Cost a project
* Estimate, calculate and error-spot
* Measure with precision
* Optimise work processes
* Process data
* Represent with mathematical diagrams
* Understand data
* Use rules and formulae
* Work with proportion.

Awarding organisations that are awarded an exclusive licence will need to integrate these into the Technical Qualification specification and assessments, drawing upon a more detailed framework of maths that underpins the GMCs, currently being developed in association with the Royal Society ACME.

### English

The completion of a level 2 English qualification (English language GCSE or Functional Skills) is a minimum exit requirement for all T Levels. This will ensure that all students have demonstrated that they can read fluently, communicate and write effectively, and demonstrate a confident control of Standard English.

The specification for a Technical Qualification should ensure that students acquire the technical vocabulary, and gain the practical communication skills (written and oral), needed to achieve threshold competence in their chosen occupational specialism(s).

The assessments for Technical Qualifications should ensure that students:

* Know the correct technical vocabulary and use it appropriately
* Apply their communication skills (written and oral) appropriately, using Standard English
* Use accurate spelling, punctuation and grammar.

### Digital

Technical Qualifications should contain sufficient and appropriate digital skills to help students reach threshold competence in their chosen specialism(s).

This Technical Qualification should support students to develop the digital knowledge and skills needed in order to:

* Adopt professional approaches to using digital communications and social media
* Collate, manage, access and use digital data in spreadsheets, databases and other formats
* Design and create new digital artefacts and materials such as digital writing, digital imagine, digital audio and video, digital code, apps and interfaces and web pages
* Follow licensing guidelines, using only approved and licensed software applications
* Gather and organise information from different digital sources
* Make use of standard analytical tools in applications to better interpret information.

Awarding organisations that are awarded an exclusive licence will need to integrate these into the Technical Qualification specification and assessment.

1. The Institute for Apprenticeships may only approve the qualification “if satisfied that by obtaining the qualification a person demonstrates that he or she has attained as many of the outcomes set out in the standards as may reasonably be expected to be attained by undertaking a course of education” (Technical and Further Education Act 2017). [↑](#footnote-ref-1)