Sheffield Hallam University

BEng (Hons) Materials Technology

Course briefing document

BEng Materials Technology (DA)
Course Delivery Pattern - January 2021 Start

Level	Year	Modules					
4	1			Engineering Mathematics and Statistics for Apprentices	Materials Science for Apprentices	Ethical Engineering Practice	Investigative Project for Apprentices
				Semester 2		*May to August*	
4/5	2	Materials & Manufacturing Engineering for Apprentices	Solid Mechanics and Materials Characterisation	Chemical and Thermodynamic Properties of Materials for Apprentices	Developing an Engineering Portfolio	Engineering Business Management for Apprentices	Applied Project for Apprentices
		Semester 1 & 2				*May to August*	
5/6	3	Engineering Ceramics and Polymers for Apprentices	Engineering Metallurgy for Apprentices	Composite Materials for Apprentices	Management Systems for Apprentices	Engineering Project and Portfolio	
		Semester 1 & 2				*May to August*	
6	4	Engineering Project and Portfolio (continued) until January (Year 4)		Advanced Manufacturing and Microstructural Engineering	Fracture, Degradation and Evaluation for Apprentices		
		Semester 1		*Semester 1 & 2*			

WBL module
PPD module

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Level 4

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MODULE DESCRIPTION

MODULE TITLE	Engineering Mathematics and Statistics for Apprentices
LEVEL	4
CREDITS	20
COLLEGE	*BTE*
DEPARTMENT	*Engineering and Mathematics*
SUBJECT GROUP	*Physics and Engineering Mathematics*

MODULE SUMMARY

This module aims to enable you to acquire and enhance the essential, mathematical skills and knowledge to support application of key engineering principles, and to encourage you to develop skill and confidence in the use of mathematical approaches and technology in solving engineering problems.

The skills and knowledge gained in this module will directly support the attainment of the following Knowledge, Skills and Behaviours in the Materials Science Technologist (Degree) Apprenticeship standard.

Knowledge

K10: Materials applications including theories, techniques, and relevant calculations to understand related disciplines and be able to work in a collaborative or cross-functional environment in more than one materials context.

Skills

S2: Determine and use industry standard and emerging digital technologies and data analysis tools to complete work activities and address problems that are ill defined or involve numerous interacting factors.
S3: Critically evaluate actions, methodologies, and results and their implications in analysing materials against parameters in product specifications.

INDICATIVE CONTENT

The teaching of mathematical topics will be illustrated and contextualised by examples from different branches of engineering.

- Algebra: revision of basic manipulations, brackets, factors, fractions, and indices; linear and quadratic equations, formulae; complex numbers and applications.
- Basic applied probability and statistics.
- Basic differential and integral calculus: concepts, techniques, applications.
- Common engineering functions (e.g. linear, quadratic, exponential, logarithmic, trigonometric).
- Linear ordinary differential equations of first and second order with constant coefficients: solution techniques from separation of variables, CF/PI, Laplace Transform.
- Numerical awareness, efficient use of technology.
- Probability, range of probability distributions and applications.
- Simultaneous linear equations, matrices, vectors.
- Statistical data analysis including error analysis.

Appropriate use of technology (calculators including graphic, Excel, Matlab, Wolfram Alpha and other CAS) is embedded throughout alongside pen and paperwork.

MODULE LEARNING OUTCOMES

- Be able to use the mathematical tools and techniques in the areas specified in the indicative content to describe and solve mathematical problems with the assistance of technology.
- Be able to use tools and techniques to develop/interpret mathematical descriptions of engineering systems relevant to your degree, analyse these descriptions and re-interpret solutions in physical terms.
- Be able to carry out basic statistical calculations on data sets relevant to your degree and represent those data using appropriate graphs and tables.

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- Demonstrate a learner's progress against achievement of the relevant KSB's as set out in the apprenticeship standard, listed below.

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MODULE DESCRIPTION

TITLE	ETHICAL ENGINEERING PRACTICE
LEVEL	4
CREDITS	20
FACULTY	*BTE*
DEPARTMENT	*Engineering and Mathematics*
SUBJECT GROUP	*Chemical and Materials Engineering*

MODULE SUMMARY

This module aims to provide the student with the opportunity for work-based learning by developing a deep understanding of the legal and ethical frameworks within which their employer organisation operates and discovering how the engineering activities of their employer promote sustainable development.

Knowledge

K17: Relevant materials science Health & Safety legislative and regulatory requirements relating to employees and clients in an industrial, laboratory, and/or field setting
K18: Up-to-date ethical and environmental impact of materials science applications and innovations.

Skills

S1: Utilise cognitive and practical skills in conjunction with adaptability and versatility in technical support both in-house and to clients to improve manufacturing processes, problem solving, innovation, and scale up formulations.
S7: Interpret, develop and implement UK and international materials standards, procedures and specifications across a range of operations and contexts.

Behaviours

B10: Health and safety conscious at all times – strict adherence to regulations, incorporating up-to-date knowledge into planning.
B11: Data hygienic and security sensitive when handling employer or client data.

INDICATIVE CONTENT

- Current UK and international environmental legislation and controls for the engineering industry in relation to health and safety, clean air, hazardous waste, recycling, noise, control of pollution, etc. Responsibilities and penalties for non-compliance. European Community initiatives. International groups and conferences; agreements and protocols.
- Engineering for sustainability.
- Legal, ethical and moral responsibilities of engineers with respect to the environment, society and their profession. Professional codes of conduct.
- The effect of engineering developments and industrialisation on social change and urbanisation.
- The relationship of different Frameworks including legal, ethical, British values, Professional body values and behaviours in the Apprenticeship Standard and specific employer policy and practice.

MODULE LEARNING OUTCOMES

- Develop an understanding of the effects of a broad range of engineering production processes and industrialisation in general on society and the natural environment, and of the requirement for engineering activities to promote sustainable development.
- Demonstrate an awareness of the relevant legal requirements governing engineering activities.
- Develop and apply a high level of professional and ethical conduct in engineering and a knowledge of professional codes of conduct.
- Demonstrate a learner's progress against achievement of the relevant KSB's as set out in the apprenticeship standard, listed below.

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MODULE DESCRIPTION

TITLE	INVESTIGATIVE PROJECT FOR APPRENTICES
LEVEL	4
CREDITS	20
FACULTY	*BTE*
DEPARTMENT	*Engineering and Mathematics*
SUBJECT GROUP	*Chemical and Materials Engineering*

MODULE SUMMARY

This module aims to provide the student with the opportunity for independent study, applying and integrating knowledge gained through undertaking a work-based engineering project under the guidance of industrial and academic mentors. It will help the student develop project management and communication skills; it also provides an opportunity for the student to reflect on their progress to date on the apprenticeship and identify future development needs.

The skills and knowledge gained in this module will directly support the attainment of the following Knowledge, Skills and Behaviours in the Materials Science Technologist (Degree) Apprenticeship standard.

Knowledge

K15: Report writing techniques, including how to synthesise information and write concisely using a formal or neutral language register and vocabulary appropriate to the target reader.
K16: Management techniques and theories, including problem solving methodologies, effective decision making, delegation and planning methods, time management, organisational awareness, motivational techniques, and conflict resolution.
K17: Relevant materials science Health & Safety legislative and regulatory requirements relating to employees and clients in an industrial, laboratory, and/or field setting

Skills

S1: Utilise cognitive and practical skills in conjunction with adaptability and versatility in technical support both in-house and to clients to improve manufacturing processes, problem solving, innovation, and scale up formulations.
S3: Critically evaluate actions, methodologies, and results and their implications in analysing materials against parameters in product specifications.
S5: Write clear and succinct technical and analytical reports.
S10: Communicate effectively with colleagues and stakeholders using the appropriate language register both verbally and in writing.

Behaviours

B1: Self-starter committed to continuing professional and personal development, refreshing and expanding knowledge of materials science and technology through a variety of methods.
B2: Clear and concise communicator – influence with integrity and exercise judgement.
B5: Results orientated – thoughtful and methodical planner, delivering successful outcomes utilising results and feedback in future activities.
B6: Anticipate situations and problems, finds appropriate contemporary solutions and grasps opportunities.
B9: Take personal responsibility to initiate and lead tasks, manage time and resources.
B10: Health and safety conscious at all times – strict adherence to regulations, incorporating up-to-date knowledge into planning.
B11: Data hygienic and security sensitive when handling employer or client data.

INDICATIVE CONTENT

- Engage in investigative project work on an engineering application
- Literature research skills
- Methods for project management, planning and reporting
- Presentation of work to stakeholders

- Report writing

MODULE LEARNING OUTCOMES

- Show initiative and independence in conducting an investigation of an engineering problem under the guidance of a mentor.
- Be able to critically discuss the results of their work and its accuracy within the context of the current understanding of the relevant environment, incorporating information from searches of information/literature related to the project topic.
- Be able to efficiently and effectively communicate the findings of an engineering investigation in the form of a technical report and, using reflection, identify personal development gained through undertaking the project and articulate future development needs.
- Demonstrate a learner's progress against achievement of the relevant KSB's as set out in the apprenticeship standard, listed below.

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MODULE DESCRIPTION

TITLE	Materials and Manufacturing Engineering for Apprentices
LEVEL	4
CREDITS	20
COLLEGE	*BTE*
DEPARTMENT	*Engineering and Mathematics*
SUBJECT GROUP	*Chemical and Materials Engineering*

MODULE SUMMARY

The module aims to introduce students to categories of engineering materials including metals, polymers, ceramics and composites and associated manufacturing techniques for domestic and commercial consumers.

The skills and knowledge gained in this module will directly support the attainment of the following Knowledge, Skills and Behaviours in the Materials Science Technologist (Degree) Apprenticeship standard.

Knowledge

K1: Contemporary chemical and physical properties of materials, including metals, ceramics, polymers, adhesives, glass, construction materials, composites, and new future materials and their key performance properties.
K2: Up-to-date conceptual and practical chemical and physical properties of materials and how these react to testing and synthesis including the chemical composition of a range of materials such as advanced ceramics, metals, glass, polymers, and their structural manipulation and transformation and problems and advances that may arise during change at a microstructural level.
K6: Material component forming methods and how these contribute to effective production methods, problem solving innovations, and novel product development.
K10: Materials applications including theories, techniques and relevant calculations to understand related disciplines and be able to work in a collaborative or cross-functional environment in more than one materials context.
K11: How engineering materials are manufactured and processed including understanding of UK and international materials standards, procedures and specifications across a range of operations and contexts.

Skills

S3: Critically evaluate actions, methodologies, and results and their implications in analysing materials against parameters in product specifications.
S7: Interpret, develop and implement UK and international materials standards, procedures and specifications across a range of operations and contexts.

Behaviours

B1: Self-starter committed to continuing professional and personal development, refreshing and expanding knowledge of materials science and technology through a variety of methods.
B10: Health and safety conscious at all times – strict adherence to regulations, incorporating up-to-date knowledge into planning.

INDICATIVE CONTENT

Manufacturing processes for engineering components: solidification; plastic deformation; powder processing; fabrication and joining; automation. Manufacture Laboratories including a selection from:

- Automate Cutting: Laser cut Disk, Plasma Cut Disk
- Casting: Bearing Housing (Cone) manufacture
- Composite Manufacture: Autoclave carbon fibre disk with magnet housing
- Joining: Brazing, welding, rivets and adhesive C block
- Metrology: Micrometer, Caliper, Coordinate Measurement Machine, IFM: Cast Bearing Housing compared to Turned Bearing Housing
- Robotics: Place screws into Plasma Disk

Material structure: crystalline and amorphous materials and bonding; structure-property relationships.
Material Laboratories including a selection from:

- Observation of Temperature Effects During Fracture of Materials Under Impact
- Property Structure relationships for plain carbon steels
- Tensile Strength & Deformation Characteristics of Engineering Materials
- Tensile Testing of Joints

Properties of engineering materials: elastic and plastic deformation; influence of temperature on mechanical properties; effect of chemical composition on material properties; hardness and wear resistance; ultimate strength, density.

While the module will cover materials and manufacturing processes in a broad engineering context, emphasis will be placed on domestic and commercial consumer markets. Students will be introduced to material and manufacturing process selection from a practical perspective.

MODULE LEARNING OUTCOMES

- Develop and apply an understanding of engineering materials in respect to material structure, how manufacture processes can change the structure and properties of materials.
- Develop and apply an understanding of the processing routes appropriate to specific materials and the ability to make an informed choice of manufacturing processes with respect to capabilities and the cost build-up of those processes.
- Apply knowledge of materials and manufacturing appropriately to applications relevant to domestic and commercial consumer markets in accordance with industry standards and regulations.
- Demonstrate a learner's progress against achievement of the relevant KSB's as set out in the apprenticeship standard, listed below.

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MODULE DESCRIPTION

TITLE	Materials Science for Apprentices
LEVEL	4
CREDITS	20
COLLEGE	*BTE*
DEPARTMENT	*Engineering and Mathematics*
SUBJECT GROUP	*Chemical and Materials Engineering*

MODULE SUMMARY

This module aims to provide the student with the necessary knowledge and understanding of the scientific principles that underpin the development of specialist materials engineering concepts and technologies later in the course.

The skills and knowledge gained in this module will directly support the attainment of the following Knowledge, Skills and Behaviours in the Materials Science Technologist (Degree) Apprenticeship standard.

Knowledge

K1: Contemporary chemical and physical properties of materials including: metals, ceramics, polymers, adhesives, glass, construction materials, composites, and new future materials and their key performance properties.
K2: Up-to-date conceptual and practical chemical and physical properties of materials and how these react to testing and synthesis including the chemical composition of a range of materials such as advanced ceramics, metals, glass, polymers, and their structural manipulation and transformation and problems and advances that may arise during change at a microstructural level.
K10: Materials applications including theories, techniques and relevant calculations to understand related disciplines and be able to work in a collaborative or cross-functional environment in more than one materials context.

Skills

S3: Critically evaluate actions, methodologies, and results and their implications in analysing materials against parameters in product specifications.
S7: Interpret, develop and implement UK and international materials standards, procedures and specifications across a range of operations and contexts.

Behaviours

B7: Collaborative – team player, and leader when appropriate, who works with a range of stakeholders to achieve goals.
B10: Health and safety conscious at all times – strict adherence to regulations, incorporating up-to-date knowledge into planning.

INDICATIVE CONTENT

Units	Base units and derived units in the SI system. Units and dimensions of common physical quantities. Algebraic relationships and units.
Experimental design and Technical Reports	Format and style of technical reports. Errors in measurements. Propagation of errors.
Atomic structure and interatomic bonding	Basic structure of the atom. Nuclear decay processes. Electronic orbital structure of atoms and energy levels. The Periodic Table. Bonding forces and energies. Interatomic bonds. Molecules.
Structure of crystalline solids	Unit cells. Crystal systems. Crystallographic points, directions and planes. Single crystals and polycrystalline materials.

Imperfections in solids	Point defects (vacancies, interstitials, impurities). Dislocations-linear defects. Interfacial defects. Volume defects. Microscopic examination of materials.
Phase diagrams	Phases. Phase equilibria. Binary phase diagrams. Eutectic, eutectoid and peritectic reactions.
Structure of metals, ceramics, polymers and composites	Ferrous alloys. Non-ferrous alloys. Ionic solids. Carbon and carbides. Hydrocarbon molecules (chemistry, molecular weight, shape, structure, configuration, crystallinity). Particle-reinforced composites. Fibre-reinforced composites. Structural composites.
Mechanical properties	Stress and strain behaviour (elastic and plastic). Modulus of elasticity. Poisson's ratio. Tensile, flexurar, compressive, shear and torsional properties. Hardness.
Electrical properties	Electrical conductivity. Energy band structures in solids. Conductors, semiconductors and insulators. Superconductivity. Capacitance. Ferroelectricity. Piezoelectricity.
Thermal properties	Heat capacity. Thermal expansion. Thermal conductivity.
Magnetic properties	Diamagnetism. Paramagnetism. Ferromagnetism. Magnetic domains and hysteresis.
Optical properties	Electromagnetic radiation. Refraction, reflection, absorption, transmission. Opacity. Translucency. Luminescence. Lasers.

MODULE LEARNING OUTCOMES

- Recall and explain principles relevant to materials science and engineering.
- Implement basic scientific laws to explain the behaviour of engineering materials with reference to appropriate data sources for analytical purposes.
- Describe the basic properties of engineering materials and relate these properties to the structure and microstructure of the materials.
- Demonstrate a learner’s progress against achievement of the relevant KSB’s as set out in the apprenticeship standard, listed below.

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MODULE DESCRIPTION

TITLE	Solid Mechanics and Materials Characterisation
LEVEL	4
CREDITS	20
COLLEGE	*BTE*
DEPARTMENT	*Engineering and Mathematics*
SUBJECT GROUP	*Chemical and Materials Engineering*

MODULE SUMMARY

The aim of the module is to develop knowledge and understanding of fundamental principles and concepts of solid mechanics and of key analytical techniques used in materials characterisation.

The skills and knowledge gained in this module will directly support the attainment of the following Knowledge, Skills and Behaviours in the Materials Science Technologist (Degree) Apprenticeship standard.

Knowledge

K2: Up-to-date conceptual and practical chemical and physical properties of materials and how these react to testing and synthesis including the chemical composition of a range of materials such as advanced .ceramics, metals, glass, polymers, and their structural manipulation and transformation and problems and advances that may arise during change at a microstructural level.
K17: Relevant materials science Health & Safety legislative and regulatory requirements relating to employees and clients in an industrial, laboratory, and/or field setting.

Skills

S3: Critically evaluate actions, methodologies, and results and their implications in analysing materials against parameters in product specifications.
S4: Conduct and interpret failure analysis of engineering components using relevant methodologies and systems such as but not limited to, for example, microscopy, macroscopy, and chemical analysis.
S6: Research, adapt and test new technologies through materials characterisation feedback.

Behaviours

B10: Health and safety conscious at all times – strict adherence to regulations, incorporating up-to-date knowledge into planning.

INDICATIVE CONTENT

Solid Mechanics

Statics:

- Forces, moments/couples, effects of friction.
- Free body diagrams, equations of equilibrium, frameworks.
- Reaction forces and moments in simple statically determinate assemblies of rigid bodies.
- Shear force and bending moment diagrams for beams with point and distributed loads.

Mechanics of Materials:

- Direct and shear stress- strain.
- Hooke's law and elastic moduli (Young's modulus, shear modulus, bulk modulus).
- Stress-strain relationships in 2D, Poisson's ratio.
- Applications: compound bars and composite beams.
- Thermal stresses and strains.
- Theory of elastic bending, second moment of area for simple sections.
- Torsion of circular sections.
- Thin cylinders and spheres subjected to internal pressure.

Materials Characterisation

Principles, instrumentation, applications, limitations, data recording, correlation and analysis for key analytical techniques for materials characterisation, including:

- Optical microscopy
- Scanning Electron Microscopy (SEM)
- Energy Dispersive Spectroscopy (EDS)
- X-ray Diffraction
- Thermal analysis
- Differential Thermal Analysis
- Differential Scanning Calorimetry
- Thermogravimetric Analysis)
- Dilatometry

MODULE LEARNING OUTCOMES

- Demonstrate knowledge and understanding of the principles of mechanics of solids.
- Demonstrate an understanding of key characterisation techniques for materials.
- Apply different characterisation techniques in materials engineering practices.
- Demonstrate a learner's progress against achievement of the relevant KSB's as set out in the apprenticeship standard, listed below.

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Level 5

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MODULE DESCRIPTION

TITLE	APPLIED PROJECT FOR APPRENTICES
LEVEL	5
CREDITS	20
FACULTY	*BTE*
DEPARTMENT	*Engineering and Mathematics*
SUBJECT GROUP	*Chemical and Materials Engineering*

MODULE SUMMARY

This module provides part-time foundation degree students with the opportunity for independent study of a realistic engineering problem in their place of work, requiring them to apply and integrate knowledge gained across the whole programme of study in achieving a solution to a real engineering problem. It also provides opportunities for critical reflection on the work and the students' development, with a view to identification of future development needs.

The skills and knowledge gained in this module will directly support the attainment of the following Knowledge, Skills and Behaviours in the Materials Science Technologist (Degree) Apprenticeship standard.

Knowledge

K9: Contemporary research and developments in the materials science community in terms of understanding different perspectives, methodologies, and schools of thought as well as the theoretical stances that underpin them.
K15: Report writing techniques, including how to synthesise information and write concisely using a formal or neutral language register and vocabulary appropriate to the target reader.
K16: Management techniques and theories, including problem solving methodologies, effective decision making, delegation and planning methods, time management, organisational awareness, motivational techniques, and conflict resolution.
K17: Relevant materials science Health & Safety legislative and regulatory requirements relating to employees and clients in an industrial, laboratory, and/or field setting
K18: Up-to-date ethical and environmental impact of materials science applications and innovations.

Skills

S1: Utilise cognitive and practical skills in conjunction with adaptability and versatility in technical support both in-house and to clients to improve manufacturing processes, problem solving, innovation, and scale up formulations.
S2: Determine and use industry standard and emerging digital technologies and data analysis tools to complete work activities and address problems that are ill defined or involve numerous interacting factors.
S3: Critically evaluate actions, methodologies, and results and their implications in analysing materials against parameters in product specifications.
S5: Write clear and succinct technical and analytical reports.
S10: Communicate effectively with colleagues and stakeholders using the appropriate language register both verbally and in writing.

Behaviours

B5: Results orientated – thoughtful and methodical planner, delivering successful outcomes utilising results and feedback in future activities.
B9: Take personal responsibility to initiate and lead tasks, manage time and resources.
B10: Health and safety conscious at all times – strict adherence to regulations, incorporating up-to-date knowledge into planning.
B11: Data hygienic and security sensitive when handling employer or client data.

INDICATIVE CONTENT

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The Project is designed to train students as investigators, able to take responsibility for their own development and independent work as engineering technicians. It will combine the study of specific areas of engineering technology but would also be expected to encompass aspects of financial appraisal, safety and management within the working environment. The final report should clearly show the integration of core themes into the work and the development of the KSBs relevant to the degree apprenticeship standard.

Each student will be required to identify an appropriate person within their employer organisation to take responsibility for supervising the project. By a progress of discussion and negotiation with the project supervisor, work colleagues and other senior staff in the place of work, the student must arrive at a suitable project topic that is acceptable to the module tutor.

The essential features that the topic for the project must embody are as follows:

- It must be substantially carried out by the student alone, although certain tasks may require specialist support, be sub-contracted or similar.
- It should provide the opportunity for at least some original work, to allow the student to demonstrate their creativity; an improvement to existing technology would be acceptable.
- It must involve some practical work, producing quantifiable data.
- The outcome of the project should be expected to produce some benefit to the employer organisation, for example a new or improved product/process route, or an improved understanding of a technology application.
- It should involve the application of current technology.
- It must be realistically achievable in 200 hours of work, i.e. the equivalent time allocated for a 20 credit module.

Task 2 is the final report, presented using a standard report format discussed as part of the module.

MODULE LEARNING OUTCOMES

- Show an ability to work independently and demonstrate and understanding of their responsibilities with respect to health and safety within their working environment.
- Demonstrate sound understand of experimental results and their interpretation/critical evaluation in the context of the current understanding of the relevant technology and in a way appropriate to the individual project aims.
- Demonstrate the learner's capability to communicate the findings of an engineering investigation in a structured and coherent report, in accordance with recognised guidelines for good practice issued by the various engineering professional bodies
- Demonstrate a learner's progress against achievement of the relevant KSB's as set out in the apprenticeship standard, listed below.

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MODULE DESCRIPTION

TITLE	Chemical and Thermodynamic Properties of Materials for Apprentices
LEVEL	5
CREDITS	20
COLLEGE	*BTE*
DEPARTMENT	*Engineering and Mathematics*
SUBJECT GROUP	*Chemical and Materials Engineering*

MODULE SUMMARY

This module aims to develop a fundamental understanding of the application of thermodynamic principles to chemical reactions and electrode processes and of chemical rate phenomena in homogeneous and heterogeneous systems, and to develop an appreciation of the relevance of chemical thermodynamics and kinetics to industrial processes and service performance.

The skills and knowledge gained in this module will directly support the attainment of the following Knowledge, Skills and Behaviours in the Materials Science Technologist (Degree) Apprenticeship standard.

Knowledge

K1: Contemporary chemical and physical properties of materials including: metals, ceramics, polymers, adhesives, glass, construction materials, composites, and new future materials and their key performance properties.
K2: Up-to-date conceptual and practical chemical and physical properties of materials and how these react to testing and synthesis including the chemical composition of a range of materials such as advanced ceramics, metals, glass, polymers, and their structural manipulation and transformation and problems and advances that may arise during change at a microstructural level.
K7: Practical, conceptual, and technological knowledge of thermodynamics; structural chemistry; solid state chemistry; rheology; microstructures; analytical chemistry; organic chemistry; inorganic chemistry.
K10: Materials applications including theories, techniques and relevant calculations to understand related disciplines and be able to work in a collaborative or cross-functional environment in more than one materials context.
K12: How materials fail in terms of fatigue, wear, impairment, corrosion, stresses, cracking, embrittlement, abrasion and cavitation erosion, including risk and mitigation factors. Understanding and ability to conduct failure testing using, for example, microscopy, macroscopy, and chemical analysis.
K17: Relevant materials science Health & Safety legislative and regulatory requirements relating to employees and clients in an industrial, laboratory, and/or field setting

Skills

S5: Write clear and succinct technical and analytical reports.

Behaviours

B10: Health and safety conscious at all times – strict adherence to regulations, incorporating up-to-date knowledge into planning.

INDICATIVE CONTENT

The First Law of Thermodynamics	Internal energy and enthalpy; standard state enthalpy values; enthalpy changes associated with chemical processes; Kirchhoff's Equation; Hess's Law.
The Second and Third Laws of Thermodynamics	Entropy; entropy changes associated with chemical reactions; Gibbs' Free Energy; the driving force for chemical change; the van't Hoff Isotherm; Ellingham Diagrams; application of Ellingham Diagrams to materials processing.

Chemical Equilibrium	The equilibrium constant for condensed and gaseous state systems; Le Chatelier's Principle; Law of Mass Action.
Chemical Process Kinetics	Homogeneous and heterogeneous reactions; rate laws; Arrhenius Equation; mass diffusion; convective mass transfer; catalysis.
Electrochemistry	The nature of electrolytes and behaviour of ions in aqueous solutions; electrode reactions; electrolysis; Faraday's Laws; electrode potentials; Nernst Equation; cell potentials.
Oxidation and 'Dry' Corrosion	Oxidation processes in metals and alloys; linear, parabolic and logarithmic rate equations and effect of temperature; Pilling-Bedworth ratio.
Aqueous Corrosion	Electrode reactions; corrosion cells; Pourbaix diagrams and passivation; types of corrosion damage to metals and alloys; corrosion environments; bacterial action.
Environmental Stability of Non-metallic Materials	Behaviour of polymers, ceramics and composites; mechanisms of corrosion by liquids, gases, solids and biological sources.

MODULE LEARNING OUTCOMES

- Apply thermodynamic concepts to analyse and evaluate chemical processes of relevance to materials engineers.
- Analyse the kinetics of chemical processes in homogeneous and heterogeneous systems.
- Describe and explain the chemical processes involved and the factors affecting the stability of materials in different environments.
- Demonstrate a learner’s progress against achievement of the relevant KSB’s as set out in the apprenticeship standard, listed below.

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MODULE DESCRIPTION

TITLE	DEVELOPING AN ENGINEERING PORTFOLIO
LEVEL	5
CREDITS	20
FACULTY	*BTE*
DEPARTMENT	*Engineering and Mathematics*
SUBJECT GROUP	*Engineering Design, Manufacture and Management*

MODULE SUMMARY

This module introduces approaches and techniques for reflection to enable learners to develop an understanding of how to situate learning in the workplace. The module encourages apprentice learners to take personal responsibility for their own learning and development of knowledge, skills and behaviours and as Apprentices, to become independent work-based learners.

Throughout the module learners will be encouraged to use the skills of self-analysis, self-reflection and self-management by exploring the impact of their own and others' styles and approaches. Learners will be required to review their initial learning needs analysis and Skills Scan to enabling them to produce a revised and SMART personal development plan that aligns with their Apprenticeship Standard.

The skills and knowledge gained in this module will directly support the attainment of the following Knowledge, Skills and Behaviours in the Materials Science Technologist (Degree) Apprenticeship standard.

Learners will be encouraged to use a number of simple tools to diagnose their existing skills and behaviours to identify the benefits of personal development. They will start to appreciate that the planning and development of these skills requires the exercise of a level of personal responsibility.

INDICATIVE CONTENT

- Emotional intelligence: self-regulation; positive thinking and positioning; positive attitudes; impact on others performance
- Identifying and defining personal performance indicators and standards:
    - Personal / role related
    - Employer training plans and experiential opportunities
    - Organisational
- Measuring and monitoring own personal performance
- Performance under pressure: prioritising, contingency planning, decision making and problem-solving
- Reflective practice models and techniques
- Selecting and presenting evidence of competency in preparation for End Point Assessment
- Sense-making through reflective practice

MODULE LEARNING OUTCOMES

- Ability to articulate an understanding of the need for continuing professional and personal development, and evidence this through development of a portfolio of evidence in preparation for the End-Point Assessment of their apprenticeship.
- Develop an understanding of reflective practice, assessing the impact of personal learning achieved and identifying further learning and development actions to support personal employability.
- Demonstrate a learner’s progress against achievement of the relevant KSB’s as set out in the apprenticeship standard, listed below.

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MODULE DESCRIPTION

TITLE	ENGINEERING BUSINESS MANAGEMENT FOR APPRENTICES
LEVEL	5
CREDITS	20
FACULTY	*BTE*
DEPARTMENT	*Engineering and Mathematics*
SUBJECT GROUP	*Engineering Design, Manufacture and Management*

MODULE SUMMARY

This module aims to introduce and examine the wider social, environmental, business and financial contexts in which a professional engineer operates.

The skills and knowledge gained in this module will directly support the attainment of the following Knowledge, Skills and Behaviours in the Materials Science Technologist (Degree) Apprenticeship standard.

Knowledge
K13: Systematic approaches to cost benefit analysis, including contextual financial understanding using industry standard metrics. Awareness of marketplace dynamics.
K16: Management techniques and theories, including problem solving methodologies, effective decision making, delegation and planning methods, time management, organisational awareness, motivational techniques, and conflict resolution.

Skills
S8: Maintain a working knowledge of a range of project management and financial management techniques to complete projects relevant to their discipline.
S9: Utilise emotional intelligence and identify a range of supervisory, management, and leadership skills in developing the ability to mentor, direct or lead teams or individuals.
S10: Communicate effectively with colleagues and stakeholders using the appropriate language register both verbally and in writing.

Behaviours
B2: Clear and concise communicator – influence with integrity and exercise judgement.
B3: Respond to others' feelings with emotional intelligence and take responsibility for work areas, people, and resources within their remit.
B4: Demonstrate personal and professional commitment to enhance the reputation of employer and the profession through interaction with internal and external customers alike.
B8: Recognise interdependencies and combine commercial and technical sensibility to assist employer/client in capitalising on opportunities exercising broad autonomy and refined judgement.

INDICATIVE CONTENT

- Continuous Improvement
- Effective decision making
- Introduction to operations management, the wider supply chain & ecosystem, procurement and the role of the contract
- Operations improvement and relevant tools
- Organisational governance, values, purpose and culture (including ethical and responsible management)
- Principles of lean manufacturing/lean operations
- Quality management, systems and models
- Stakeholder analysis and management
- Team working and time management
- The nature and context of organisations
- The structure of organisations and business models

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MODULE LEARNING OUTCOMES

- Be aware of business, customer and user needs, including considerations such as the wider engineering context.
- Apply and examine knowledge and understanding through the practical application of business management policies and practices.
- Awareness of quality issues and their application to continuous improvement in an engineering context.
- Demonstrate a learner's progress against achievement of the relevant KSB's as set out in the apprenticeship standard, listed below.

Sheffield Hallam University

MODULE DESCRIPTION

TITLE	ENGINEERING BUSINESS MANAGEMENT FOR APPRENTICES
LEVEL	5
CREDITS	20
FACULTY	*BTE*
DEPARTMENT	*Engineering and Mathematics*
SUBJECT GROUP	*Engineering Design, Manufacture and Management*

MODULE SUMMARY

This module aims to introduce and examine the wider social, environmental, business and financial contexts in which a professional engineer operates.

The skills and knowledge gained in this module will directly support the attainment of the following Knowledge, Skills and Behaviours in the Materials Science Technologist (Degree) Apprenticeship standard.

Knowledge
K13: Systematic approaches to cost benefit analysis, including contextual financial understanding using industry standard metrics. Awareness of marketplace dynamics.
K16: Management techniques and theories, including problem solving methodologies, effective decision making, delegation and planning methods, time management, organisational awareness, motivational techniques, and conflict resolution.

Skills
S8: Maintain a working knowledge of a range of project management and financial management techniques to complete projects relevant to their discipline.
S9: Utilise emotional intelligence and identify a range of supervisory, management, and leadership skills in developing the ability to mentor, direct or lead teams or individuals.
S10: Communicate effectively with colleagues and stakeholders using the appropriate language register both verbally and in writing.

Behaviours
B2: Clear and concise communicator – influence with integrity and exercise judgement.
B3: Respond to others' feelings with emotional intelligence and take responsibility for work areas, people, and resources within their remit.
B4: Demonstrate personal and professional commitment to enhance the reputation of employer and the profession through interaction with internal and external customers alike.
B8: Recognise interdependencies and combine commercial and technical sensibility to assist employer/client in capitalising on opportunities exercising broad autonomy and refined judgement.

INDICATIVE CONTENT

- Continuous Improvement
- Effective decision making
- Introduction to operations management, the wider supply chain & ecosystem, procurement and the role of the contract
- Operations improvement and relevant tools
- Organisational governance, values, purpose and culture (including ethical and responsible management)
- Principles of lean manufacturing/lean operations
- Quality management, systems and models
- Stakeholder analysis and management
- Team working and time management

- The nature and context of organisations
- The structure of organisations and business models

MODULE LEARNING OUTCOMES

- Be aware of business, customer and user needs, including considerations such as the wider engineering context.
- Apply and examine knowledge and understanding through the practical application of business management policies and practices.
- Awareness of quality issues and their application to continuous improvement in an engineering context.
- Demonstrate a learner's progress against achievement of the relevant KSB's as set out in the apprenticeship standard, listed below.

Sheffield Hallam University

MODULE DESCRIPTION

TITLE	Engineering Ceramics and Polymers for Apprentices
LEVEL	5
CREDITS	20
COLLEGE	*BTE*
DEPARTMENT	*Engineering and Mathematics*
SUBJECT GROUP	*Chemical and Materials Engineering*

MODULE SUMMARY

The module aims to provide knowledge and understanding of a range of ceramic and polymeric materials: their synthesis, properties and their engineering applications.

The skills and knowledge gained in this module will directly support the attainment of the following Knowledge, Skills and Behaviours in the apprenticeship standard.

Knowledge
K1: Contemporary chemical and physical properties of materials including: metals, ceramics, polymers, adhesives, glass, construction materials, composites, and new future materials and their key performance properties.
K2: Up-to-date conceptual and practical chemical and physical properties of materials and how these react to testing and synthesis including the chemical composition of a range of materials such as advanced ceramics, metals, glass, polymers, and their structural manipulation and transformation and problems and advances that may arise during change at a microstructural level.
K5: Bonding technologies utilising, for example, metals, ceramics, polymers, rubbers and glasses and full understanding of positive and negative interactions between materials.
K6: Material component forming methods and how these contribute to effective production methods, problem solving innovations, and novel product development.
K7: Practical, conceptual, and technological knowledge of thermodynamics; structural chemistry; solid state chemistry; rheology; microstructures; analytical chemistry; organic chemistry; inorganic chemistry.
K10: Materials applications including theories, techniques and relevant calculations to understand related disciplines and be able to work in a collaborative or cross-functional environment in more than one materials context.
K11: How engineering materials are manufactured and processed including understanding of UK and international materials standards, procedures and specifications across a range of operations and contexts.
K14: How IT and emerging digital technologies such as 3D printing can be applied to enhance materials science work practices.

Skills
S2: Determine and use industry standard and emerging digital technologies and data analysis tools to complete work activities and address problems that are ill defined or involve numerous interacting factors.
S6: Research, adapt and test new technologies through materials characterisation feedback.
S7: Interpret, develop and implement UK and international materials standards, procedures and specifications across a range of operations and contexts.

Behaviours
B2: Clear and concise communicator – influence with integrity and exercise judgement.
B3: Respond to others' feelings with emotional intelligence and take responsibility for work areas, people, and resources within their remit.
B7: Collaborative – team player, and leader when appropriate, who works with a range of stakeholders to achieve goals.
B10: Health and safety conscious at all times – strict adherence to regulations, incorporating up-to-date knowledge into planning.

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INDICATIVE CONTENT

Engineering Ceramics

Characterisation of Ceramic Materials	Definitions and general classifications. Characteristic structures and properties. Comparison with other groups of engineering materials. Useful properties and general limitations. Binary and ternary phase equilibria.
Glass	Definition of a glass. Structure of silicate glasses and relationship with glass formation. Commercial engineering glasses, their properties and applications. Raw materials for glass manufacture. Role of various mineral additives. Glass manufacturing processes.
Aluminosilicate Ceramic Materials	The alumina-silica phase diagram. Phase constitution. Polymorphism in crystalline silica and its implications. Structure-property relationships. Clay minerals, their structure, properties and constitution. The effect of heat on clay. Differential thermal analysis of clay minerals. The firing behaviour of clay minerals. Effect of contaminants and additives. Structural clay products. Synthetic and natural clay mixes. Whiteware and glazes. Manufacture of clayware.
Cement and Concrete	Constitution of Ordinary Portland Cement. Physical and structural changes during rehydration. Raw materials for cement manufacture. Cement kilns. Process control. Cement, mortar concrete - structure/property relationships. Special cements.
Refractory Materials	Classification of refractory materials. General manufacturing routes and products. Silica and aluminosilicate refractory materials. Basic refractories. Raw materials, structure, properties, characteristics and uses.
Industrial Abrasives	Abrasion and wear processes. Natural and synthetic abrasives. Classification of hard materials. Synthesis and process control of corundum and silicon carbide. Manufacture of coated and bonded abrasives. Property limitations, introduction to modern ceramics and tool materials.
Advanced Ceramics	Introduction to advanced ceramic materials. Superconductors, electrical ceramics, bioceramics, ceramics for extreme environments.

Engineering Polymers

Polymer Synthesis, Structure and Chemistry	Review of polymer molecules; structure, configuration. Synthesis of polymers by addition polymerisation, condensation polymerisation, copolymerisation and cross-linking. Crystallinity, melting and glass transition phenomena.
Physical Properties and Deformation Characteristics	Mechanical properties of key polymers. Stress-strain behaviour, viscoelasticity and fracture. Viscosity, bulk deformation. Optical, chemical and electrical properties of key engineering polymers.
Polymer Forming Techniques	Injection moulding process and material requirements, effects of operating variables on flow, final properties and microstructure. Introduction to injection, blow, compression and rotational moulding processes. Formation of polymer fibres and films.

Adhesives and Advanced Polymers	Introduction to advanced polymers including, but not limited to, adhesives, coatings, polymers for use in extreme environments, biopolymers and photovoltaic polymers.

MODULE LEARNING OUTCOMES

- Understand the raw materials, constitution, structure, production and characteristics of the principal groups of engineering ceramics and polymers
- Describe the atomic, molecular and microstructures of important engineering ceramics and polymers, and understand how these parameters affect physical properties
- Understand the operational parameters of key ceramic and polymer processing routes and their effects on resulting structures, properties and applications
- Demonstrate a learner's progress against achievement of the relevant KSB's as set out in the apprenticeship standard, listed below.

Sheffield Hallam University

MODULE DESCRIPTION

TITLE	Engineering Metallurgy for Apprentices
LEVEL	5
CREDITS	20
COLLEGE	*BTE*
DEPARTMENT	*Engineering and Mathematics*
SUBJECT GROUP	*Chemical and Materials Engineering*

MODULE SUMMARY

This module aims to relate the structure and property requirements of metallic materials. It will provide students with knowledge and skills that will enable them to be able to appraise and recognise factors and treatments that influence metal properties.

The skills and knowledge gained in this module will directly support the attainment of the following Knowledge, Skills and Behaviours in the Materials Science Technologist (Degree) Apprenticeship standard.

Knowledge
K1: Contemporary chemical and physical properties of materials including: metals, ceramics, polymers, adhesives, glass, construction materials, composites, and new future materials and their key performance properties.
K2: Up-to-date conceptual and practical chemical and physical properties of materials and how these react to testing and synthesis including the chemical composition of a range of materials such as advanced ceramics, metals, glass, polymers, and their structural manipulation and transformation and problems and advances that may arise during change at a microstructural level.
K5: Bonding technologies utilising, for example, metals, ceramics, polymers, rubbers and glasses and full understanding of positive and negative interactions between materials.
K7: Practical, conceptual, and technological knowledge of thermodynamics; structural chemistry; solid state chemistry; rheology; microstructures; analytical chemistry; organic chemistry; inorganic chemistry.
K10: Materials applications including theories, techniques and relevant calculations to understand related disciplines and be able to work in a collaborative or cross-functional environment in more than one materials context.
K11: How engineering materials are manufactured and processed including understanding of UK and international materials standards, procedures and specifications across a range of operations and contexts.
K12: How materials fail in terms of fatigue, wear, impairment, corrosion, stresses, cracking, embrittlement, abrasion and cavitation erosion, including risk and mitigation factors. Understanding and ability to conduct failure testing using, for example, microscopy, macroscopy, and chemical analysis.
K17: Relevant materials science Health & Safety legislative and regulatory requirements relating to employees and clients in an industrial, laboratory, and/or field setting

Skills
S6: Research, adapt and test new technologies through materials characterisation feedback.
S7: Interpret, develop and implement UK and international materials standards, procedures and specifications across a range of operations and contexts.

Behaviours
B3: Respond to others' feelings with emotional intelligence and take responsibility for work areas, people, and resources within their remit.
B7: Collaborative – team player, and leader when appropriate, who works with a range of stakeholders to achieve goals.
B10: Health and safety conscious at all times – strict adherence to regulations, incorporating up-to-date knowledge into planning.

INDICATIVE CONTENT

- Crystal Structure of Metals: BCC, FCC, CPH, plastic deformation and slip in metals.
- Non-ferrous alloy systems: copper alloys and brasses, aluminium alloys and precipitation hardening, nickel and titanium alloys, modification of aerospace grade materials to achieve optimum properties.
- Phase Equilibrium Diagrams: solidification behaviour, cooling curves, nucleation and growth of crystals, non-equilibrium behaviour, binary alloying, Isomorphous systems, eutectics, eutectoids, peritectics, and Lever rule.
- The Iron Carbon System: iron-carbon, iron-cementite phase diagram, solubility of carbon in iron, formation of pearlite, cementite, martensite, heat treatment, effect of alloying elements, CCT, TTT diagrams, applications of low alloy, medium alloy and high alloy steels, hardenability, surface hardening principles.

MODULE LEARNING OUTCOMES

- Examine metallic alloys in terms of the formation of their structures and properties, relating them to their phase equilibrium diagrams, in both theoretical and practical situations.
- Analyse and evaluate knowledge of the structures and properties of metals and alloys in order to understand how to develop important engineering products, through processing and heat treatment.
- Produce specimens for microstructural analysis, undertake heat treatment and test mechanical properties, relating structure to properties.
- Demonstrate a learner's progress against achievement of the relevant KSB's as set out in the apprenticeship standard, listed below.

Sheffield Hallam University

Level 6

Sheffield Hallam University

MODULE DESCRIPTION

TITLE	Advanced Manufacturing and Microstructural Engineering
LEVEL	6
CREDITS	20
COLLEGE	*BTE*
DEPARTMENT	*Engineering and Mathematics*
SUBJECT GROUP	*Chemical and Materials Engineering*

MODULE SUMMARY

The skills and knowledge gained in this module will directly support the attainment of the following Knowledge, Skills and Behaviours in the Materials Science Technologist (Degree) Apprenticeship standard.

Knowledge
K1: Contemporary chemical and physical properties of materials including: metals, ceramics, polymers, adhesives, glass, construction materials, composites, and new future materials and their key performance properties.
K2: Up-to-date conceptual and practical chemical and physical properties of materials and how these react to testing and synthesis including the chemical composition of a range of materials such as advanced ceramics, metals, glass, polymers, and their structural manipulation and transformation and problems and advances that may arise during change at a microstructural level.
K4: Current design and production of composite materials and additive manufacturing with the ability to engage with and evaluate complex theories and processes.
K6: Material component forming methods and how these contribute to effective production methods, problem solving innovations, and novel product development.
K7: Practical, conceptual, and technological knowledge of thermodynamics; structural chemistry; solid state chemistry; rheology; microstructures; analytical chemistry; organic chemistry; inorganic chemistry.
K9: Contemporary research and developments in the materials science community in terms of understanding different perspectives, methodologies, and schools of thought as well as the theoretical stances that underpin them.
K10: Materials applications including theories, techniques and relevant calculations to understand related disciplines and be able to work in a collaborative or cross-functional environment in more than one materials context.
K11: How engineering materials are manufactured and processed including understanding of UK and international materials standards, procedures and specifications across a range of operations and contexts.
K14: How IT and emerging digital technologies such as 3D printing can be applied to enhance materials science work practices.

Skills
S1: Utilise cognitive and practical skills in conjunction with adaptability and versatility in technical support both in-house and to clients to improve manufacturing processes, problem solving, innovation, and scale up formulations.
S6: Research, adapt and test new technologies through materials characterisation feedback.

Behaviours
B7: Collaborative – team player, and leader when appropriate, who works with a range of stakeholders to achieve goals.
B10: Health and safety conscious at all times – strict adherence to regulations, incorporating up-to-date knowledge into planning.

INDICATIVE CONTENT

Materials Manufacturing

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Casting and Solidification	Foundry melting furnaces. Moulds types, properties and characteristics of mould materials. Runners, risers and gating systems. The solidification behaviour of metals and alloys in a mould. Classification of defects in castings and foundry quality control. Ferrous and non-ferrous casting alloys. Ingot casting and continuous casting of steel.
Mechanical Shaping and Forming Processes	Process modelling and analysis of plastic flow in mechanical deformation processes; hot and cold work; friction and lubrication in working processes; heterogeneous deformation and redundant work; stress systems and workability.
Heat Treatment	Types of heat treatment furnaces and media; analysis of heat transfer; controlled atmospheres. • Surface treatment of steel; carburising; nitriding. • Quenching; types of quenchants; heat transfer and cooling curves; Quenching Power (H); residual stresses; hardenability, critical diameters and the Jominy Test.
Powder Processing	Characteristics of powders; analysis of powder flow and consolidation in a die; effects of die shape, size, lubricant and temperature; isostatic pressing. Sintering; analysis of liquid phase and reaction sintering mechanisms; hot pressing. Analysis of examples of metallic, ceramic and composite powder products.
Fabrication of advanced functional ceramics	Manufacture processes for capacitors, thermistors, sensors and actuators used in modern circuitry.
Additive Manufacturing	Additive manufacturing techniques for metals (powder bed fusion, direct energy deposition and binder jetting techniques), additive manufacturing techniques for ceramics (powder-based and suspension-based processes)

Microstructural Engineering

Structural Ceramics	Study of the following types of ceramics and processing/property interactions: alumina ceramics, silicon nitride ceramics, SiAlON ceramics, transformation toughened zirconia ceramics, partially stabilised zirconia, zirconia toughened alumina, fibre reinforced ceramics.
Electrical ceramics	Effects of structure and microstructure on electrical properties. Insulating ceramics in high voltage and microelectronic applications. Dielectric ceramics. Semiconducting ceramics: effects of structure and microstructure on properties. Structure and microstructure domination. Properties and applications. Conducting ceramics, gas sensors and fuel cells.
Magnetic Ceramics	Origin of magnetism in ceramics. Hard and Soft ferrites. Fabrication and applications of magnetic oxides.
Bioceramics	Properties and applications of ceramics in the biomedical arena. Processing of glass-ceramics as prosthetics.
Polymers	Processing / microstructure / property relationships for specific groups of engineering polymers. Polymers with special properties; for example, polymer with additives, electrically conducting polymers, heat resistant polymers, ultra high modulus polymers for medical applications.

Metals and Alloys	Processing / microstructure / property relationships for specific alloys, from the following list: Copper Alloys, Aluminium Alloys, Nickel Alloys, Titanium Alloys, Steels

MODULE LEARNING OUTCOMES

- Understand the underlying physical and chemical processes involved in the manufacture of engineering materials.
- Describe and critically evaluate processing routes for the production of engineering materials.
- Understand the underlying relationships between microstructure and the properties of engineering materials and analyse in detail the effects of processing variables on microstructure and properties.
- Demonstrate a learner's progress against achievement of the relevant KSB's as set out in the apprenticeship standard, listed below.

Sheffield Hallam University

MODULE DESCRIPTION

TITLE	Composite Materials for Apprentices
LEVEL	6
CREDITS	20
COLLEGE	*BTE*
DEPARTMENT	*Engineering and Mathematics*
SUBJECT GROUP	*Chemical and Materials Engineering*

MODULE SUMMARY

This module aims to provide the student with the necessary knowledge and understanding of the design of composite materials with polymer, metal and ceramic matrices, and of behaviour in smart materials and structures.

The skills and knowledge gained in this module will directly support the attainment of the following Knowledge, Skills and Behaviours in the apprenticeship standard.

Knowledge
K1: Contemporary chemical and physical properties of materials including: metals, ceramics, polymers, adhesives, glass, construction materials, composites, and new future materials and their key performance properties.
K2: Up-to-date conceptual and practical chemical and physical properties of materials and how these react to testing and synthesis including the chemical composition of a range of materials such as advanced ceramics, metals, glass, polymers, and their structural manipulation and transformation and problems and advances that may arise during change at a microstructural level.
K4: Current design and production of composite materials and additive manufacturing with the ability to engage with and evaluate complex theories and processes.
K6: Material component forming methods and how these contribute to effective production methods, problem solving innovations, and novel product development.
K9: Contemporary research and developments in the materials science community in terms of understanding different perspectives, methodologies, and schools of thought as well as the theoretical stances that underpin them.
K10: Materials applications including theories, techniques and relevant calculations to understand related disciplines and be able to work in a collaborative or cross-functional environment in more than one materials context.
K11: How engineering materials are manufactured and processed including understanding of UK and international materials standards, procedures and specifications across a range of operations and contexts.
K12: How materials fail in terms of fatigue, wear, impairment, corrosion, stresses, cracking, embrittlement, abrasion and cavitation erosion, including risk and mitigation factors. Understanding and ability to conduct failure testing using, for example, microscopy, macroscopy, and chemical analysis.
K17: Relevant materials science Health & Safety legislative and regulatory requirements relating to employees and clients in an industrial, laboratory, and/or field setting
K18: Up-to-date ethical and environmental impact of materials science applications and innovations.

Skills
S2: Determine and use industry standard and emerging digital technologies and data analysis tools to complete work activities and address problems that are ill defined or involve numerous interacting factors.
S3: Critically evaluate actions, methodologies, and results and their implications in analysing materials against parameters in product specifications.
S6: Research, adapt and test new technologies through materials characterisation feedback.

Behaviours

B10: Health and safety conscious at all times – strict adherence to regulations, incorporating up-to-date knowledge into planning.

INDICATIVE CONTENT

Composite Materials

- **Design**: Failure prediction. Laminate design.
- **Engineering applications:** Structural, aerospace, automobile etc. Case study work on specific applications.
- **Manufacturing**: Production of composites (Polymer, metal and ceramic matrices). Quality inspection methods.
- **Materials:** Types of metal, polymer and metal matrix composites (properties and applications). Types of reinforcement: fibres, whiskers and particulates (properties and production methods, surface treatment of fibres).
- **Mechanics:** Elastic properties (Slab model and Halpin-Tsai model), strength and toughness. Effect of fibre length (continuous and discontinuous fibres). Stress–Strain relationships for a lamina. Lamination Theory. Interlaminar stresses and role of interfaces in composites.
- **Performance**: Mechanical properties under static (tensile, compressive, flexural, shear) and dynamic (fatigue, high and low cycle) loading. Impact properties. Environmental effects. Fracture behaviour and damage tolerance.

Smart materials and structures

- Adaptive structures
- Auxetic materials
- Biomaterials and biomimetic materials
- Self healing materials
- Self sensing materials
- Shape memory and superelastic materials

MODULE LEARNING OUTCOMES

- Use predictive models to relate the properties of reinforcements and matrix materials to the properties of composites
- Propose matrix materials, reinforcement types and geometries, and manufacturing techniques for composite materials and critically evaluate their suitability for specific applications
- Explain the structure and properties of materials and systems with added functionality
- Demonstrate a learner's progress against achievement of the relevant KSB's as set out in the apprenticeship standard, listed below.

Sheffield Hallam University

MODULE DESCRIPTION

TITLE	ENGINEERING PROJECT AND PORTFOLIO
LEVEL	6
CREDITS	40
FACULTY	*BTE*
DEPARTMENT	*Engineering and Mathematics*
SUBJECT GROUP	*Engineering Design, Manufacture and Management*

MODULE SUMMARY

This module provides the apprentice with an opportunity for independent, self-managed study of a realistic engineering problem in their place of work, requiring them to apply and integrate knowledge gained across the whole programme of study in achieving a solution to a real engineering problem. It also provides opportunities for critical reflection on the work and their personal and professional development, with a view to identification of future development needs.

The skills and knowledge gained in this module will directly support the attainment of the following Knowledge, Skills and Behaviours in the Materials Science Technologist (Degree) Apprenticeship standard.

Knowledge
K8: Intellectual property rights issues and the implications and importance of patent, non-disclosure issues, and GDPR regulations.
K9: Contemporary research and developments in the materials science community in terms of understanding different perspectives, methodologies, and schools of thought as well as the theoretical stances that underpin them.
K15: Report writing techniques, including how to synthesise information and write concisely using a formal or neutral language register and vocabulary appropriate to the target reader.
K17: Relevant materials science Health & Safety legislative and regulatory requirements relating to employees and clients in an industrial, laboratory, and/or field setting
K18: Up-to-date ethical and environmental impact of materials science applications and innovations.

Skills
S1: Utilise cognitive and practical skills in conjunction with adaptability and versatility in technical support both in-house and to clients to improve manufacturing processes, problem solving, innovation, and scale up formulations.
S2: Determine and use industry standard and emerging digital technologies and data analysis tools to complete work activities and address problems that are ill defined or involve numerous interacting factors.
S3: Critically evaluate actions, methodologies, and results and their implications in analysing materials against parameters in product specifications.
S5: Write clear and succinct technical and analytical reports.
S8: Maintain a working knowledge of a range of project management and financial management techniques to complete projects relevant to their discipline.
S10: Communicate effectively with colleagues and stakeholders using the appropriate language register both verbally and in writing.

Behaviours
B1: Self-starter committed to continuing professional and personal development, refreshing and expanding knowledge of materials science and technology through a variety of methods.
B2: Clear and concise communicator – influence with integrity and exercise judgement.
B5: Results orientated – thoughtful and methodical planner, delivering successful outcomes utilising results and feedback in future activities.
B9: Take personal responsibility to initiate and lead tasks, manage time and resources.

B10: Health and safety conscious at all times – strict adherence to regulations, incorporating up-to-date knowledge into planning.
B11: Data hygienic and security sensitive when handling employer or client data.

INDICATIVE CONTENT

The Project is designed to train students as investigators, able to take responsibility for their own development and independent work as engineering technicians. It will combine the study of specific areas of engineering technology but would also be expected to encompass aspects of financial appraisal, safety and management within the working environment. The final report should clearly show the integration of core themes into the work and the development of the KSBs relevant to the degree apprenticeship standard.

For industry instigated projects, the scope of the project needs to be very clearly defined with the help and support of a university academic before a commitment is made to carry out the project. Depending on the level of company input and support and the outcomes expected, it may be necessary for an industrial supervisor to be allocated in addition to the academic supervisor. Issues such as non-disclosure and IP (Intellectual Property rights), and impact on equality, diversity and inclusion considerations will be dealt with on a case by case basis.

MODULE LEARNING OUTCOMES

- Conceive, plan, deliver and critique an individual project related to an engineering problem; demonstrate awareness of the wider economic, legal, social and environmental issues of this project.
- Effectively communicate information related to an engineering project using a variety of methods for both specialist and non-specialist audiences.
- Critically assess progress against the Apprenticeship Standard, and develop opportunities to generate and present evidence of specific knowledge, skills and behaviours that are relevant to the Apprenticeship Standard.
- Demonstrate a learner's progress against achievement of the relevant KSB's as set out in the apprenticeship standard, listed below.

Sheffield Hallam University

MODULE DESCRIPTION

TITLE	Fracture, Degradation and Evaluation for Apprentices
LEVEL	6
CREDITS	20
COLLEGE	*BTE*
DEPARTMENT	*Engineering and Mathematics*
SUBJECT GROUP	*Chemical and Materials Engineering*

MODULE SUMMARY (including indicative content)

The module aim is to provide the opportunity for students to develop their understanding of the processes of degradation and failure of materials under different conditions, to analyse the methods by which materials degradation can be prevented and to enable the students to develop knowledge and expertise in the principal methods of non-destructive evaluation and enhance their ability to inspect and evaluate structural engineering components.

The skills and knowledge gained in this module will directly support the attainment of the following Knowledge, Skills and Behaviours in the Materials Science Technologist (Degree) Apprenticeship standard.

Knowledge
K1: Contemporary chemical and physical properties of materials including: metals, ceramics, polymers, adhesives, glass, construction materials, composites, and new future materials and their key performance properties.
K10: Materials applications including theories, techniques and relevant calculations to understand related disciplines and be able to work in a collaborative or cross-functional environment in more than one materials context.
K12: How materials fail in terms of fatigue, wear, impairment, corrosion, stresses, cracking, embrittlement, abrasion and cavitation erosion, including risk and mitigation factors. Understanding and ability to conduct failure testing using, for example, microscopy, macroscopy, and chemical analysis.
K14: How IT and emerging digital technologies such as 3D printing can be applied to enhance materials science work practices.

Skills
S2: Determine and use industry standard and emerging digital technologies and data analysis tools to complete work activities and address problems that are ill defined or involve numerous interacting factors.
S3: Critically evaluate actions, methodologies, and results and their implications in analysing materials against parameters in product specifications.
S4: Conduct and interpret failure analysis of engineering components using relevant methodologies and systems such as but not limited to, for example, microscopy, macroscopy, and chemical analysis.
S7: Interpret, develop and implement UK and international materials standards, procedures and specifications across a range of operations and contexts.

Behaviours
B7: Collaborative – team player, and leader when appropriate, who works with a range of stakeholders to achieve goals.
B10: Health and safety conscious at all times – strict adherence to regulations, incorporating up-to-date knowledge into planning.

INDICATIVE CONTENT

- ***Degradation***

Mechanisms of materials degradation: Mechanical causes of materials degradation (wear, fatigue, creep). Chemical causes of materials degradation (aqueous corrosion, oxidation, softening and embrittlement of wood and polymers, damage to cement and concrete, glass and engineering ceramics, effect of

biological/biochemical factors). Materials degradation induced by heat and other forms of energy (thermal and photochemical degradation, radiation damage). Protection against degradation (cathodic protection, coatings, modified surface layers).

- ***Fracture***

Failure Modes and Typical Features of Fracture. Modes of failure; overload, fatigue, creep, corrosion/corrosion fatigue and wear. Typical features of fatigue; high cycle/low cycle, beach marks, initiation sites, multiple cracks, crack path, etc. Features of creep, corrosion and wear damage.
Fracture Mechanics. Introduction to the fracture analysis, linear elastic fracture mechanics concepts, fracture toughness, stress intensity factor, geometrical factors, critical crack length.

- ***Evaluation***

Critical evaluation of established non-destructive evaluation methods (Visual, Dye Penetrant, Magnetic particle, Ultrasonic, Electrical, Radiography, IR Thermography, Acoustic emission and advanced structural health monitoring (SHM) methods). National and international standards relating to non-destructive evaluation, Performance demonstration, Validation of procedures, equipment and personnel.

MODULE LEARNING OUTCOMES

- Identify and analyse the mechanisms of materials degradation and appraise the suitability of methods to protect against it.
- Recognise and analyse various modes of component failure by means of the basic principles of fracture analysis.
- Choose and employ non-destructive evaluation methods for effective pre-service and in-service examination applying the relevant standards and codes of practice.
- Demonstrate a learner's progress against achievement of the relevant KSB's as set out in the apprenticeship standard, listed below.

Sheffield Hallam University

MODULE DESCRIPTION

TITLE	MANAGEMENT SYSTEMS FOR APPRENTICES
LEVEL	6
CREDITS	20
FACULTY	*BTE*
DEPARTMENT	*Engineering and Mathematics*
SUBJECT GROUP	*Engineering Design, Manufacture and Management*

MODULE SUMMARY

Working as a professional engineer requires you to demonstrate skills and capabilities to understand the complexities of both the internal and external environments in which your organisation operates. The study of organisational behaviour will provide you with the skills and competencies to understand a range of actions to enhance the behaviour of others and how these can be managed to ensure the competitive success of the business enterprise. Likewise, gaining an understanding of the principles of financial management will support you in costing up a project and deliver it within budget.

The skills and knowledge gained in this module will directly support the attainment of the following Knowledge, Skills and Behaviours in the Materials Science Technologist (Degree) Apprenticeship standard.

Knowledge
K3: Systems and processes such as, but not limited to, CRM systems, client handling, profit and loss, and planning, in project management, business improvement, proof of concept, and scale up.
K13: Systematic approaches to cost benefit analysis, including contextual financial understanding using industry standard metrics. Awareness of marketplace dynamics.
K16: Management techniques and theories, including problem solving methodologies, effective decision making, delegation and planning methods, time management, organisational awareness, motivational techniques, and conflict resolution.

Skills
S1: Utilise cognitive and practical skills in conjunction with adaptability and versatility in technical support both in-house and to clients to improve manufacturing processes, problem solving, innovation, and scale up formulations.
S8: Maintain a working knowledge of a range of project management and financial management techniques to complete projects relevant to their discipline.
S9: Utilise emotional intelligence and identify a range of supervisory, management, and leadership skills in developing the ability to mentor, direct or lead teams or individuals.
S10: Communicate effectively with colleagues and stakeholders using the appropriate language register both verbally and in writing.

Behaviours
B3: Respond to others' feelings with emotional intelligence and take responsibility for work areas, people, and resources within their remit.
B4: Demonstrate personal and professional commitment to enhance the reputation of employer and the profession through interaction with internal and external customers alike.
B8: Recognise interdependencies and combine commercial and technical sensibility to assist employer/client in capitalising on opportunities exercising broad autonomy and refined judgement.
B11: Data hygienic and security sensitive when handling employer or client data.

INDICATIVE CONTENT:

Strategic Management

- Exploring and understanding the implications of approaches to organisational strategy

- Understanding of the student's own organisation's approach to strategy and the strategy process.

Leadership
- Developing leadership capabilities
- Exploring leadership approaches
- Leading and developing teams
- Leading organisational performance
- Role of emotion in leadership
- Understanding self as a leader

Business Development
- Building and maintaining good customer relationships
- Decision making strategies
- Introduction to financial management
- Management and use of financial Information for decision making
- Risk management

MODULE LEARNING OUTCOMES
- Evaluate the implications of approaches to organisational strategy and how strategic planning happens within your organisation.
- Evaluate different leadership approaches and the role played by culture and emotion in leadership.
- Ability to use financial management and customer relationship management tools within an engineering project context.
- Demonstrate a learner's progress against achievement of the relevant KSB's as set out in the apprenticeship standard, listed below.