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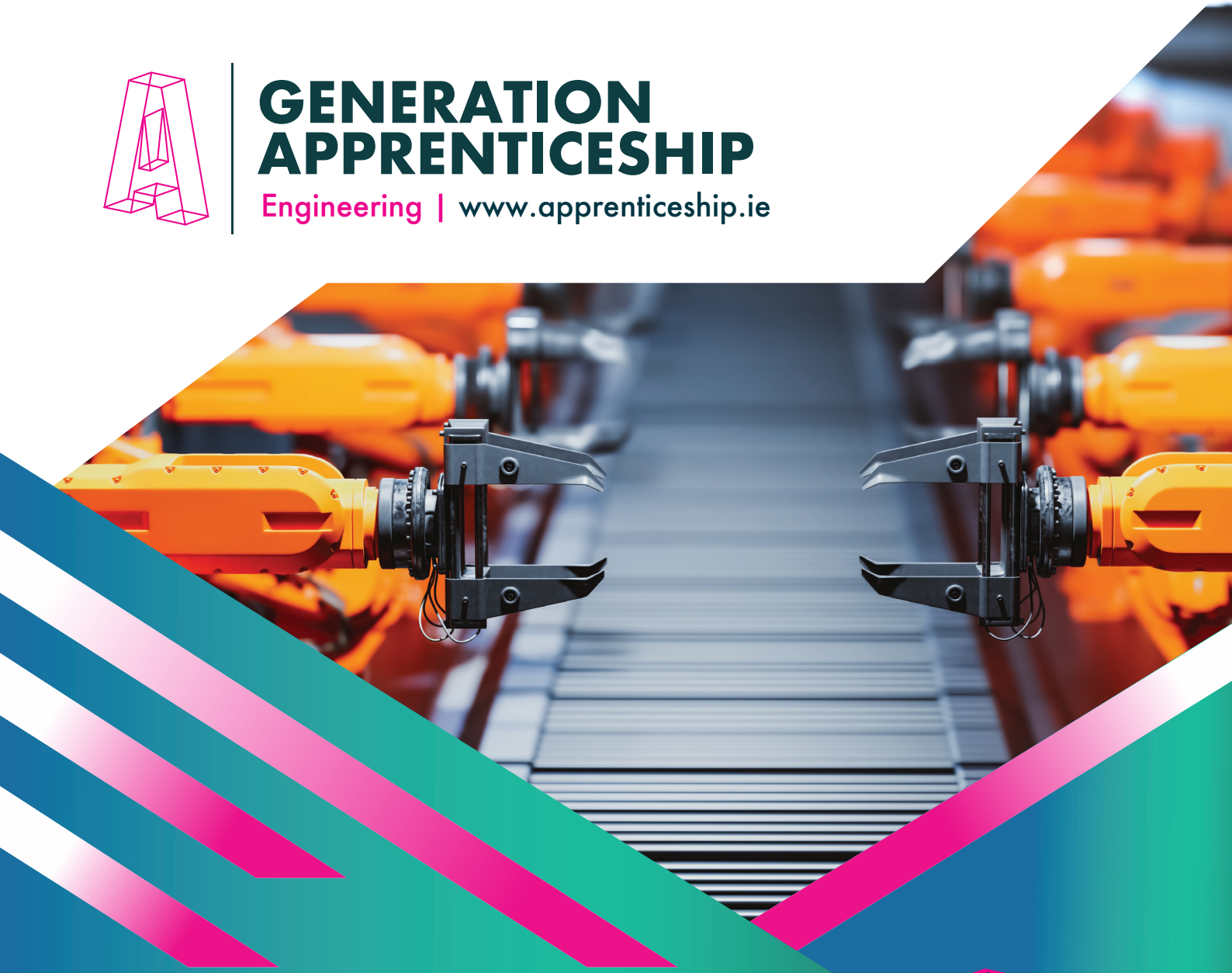

Robotics and Automation Apprenticeship Programme

NFQ LEVEL 6 ADVANCED CERTIFICATE

PROGRAMME OVERVIEW

ENGINEERING

AMTCE Ionad Oiliúna Barr Feabhais Ard-Déantúsaíochta Advanced Manufacturing Training Centre of Excellence

Rialtas na hÉireann Government of Ireland

SOLAS learning works

etbi Education and Training Boards Ireland Boird Oideachais agus Oiliúna Éireann

lmetb Bord Oideachais agus Oiliúna Lú agus na Mí Louth and Meath Education and Training Board

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INTRODUCTION

The National Robotics and Automation Apprenticeship is for people who want to build a career working with advanced robotic and automation technologies that drive Ireland's manufacturing and engineering sectors.

This apprenticeship was developed through collaboration between industry partners and the Louth and Meath Education and Training Board (LMETB), which serves as the lead educational provider. It has been designed to meet the evolving needs of Ireland's advanced manufacturing, robotics and automation sectors. The programme provides apprentices with the theoretical knowledge and practical skills required to install, operate, maintain and optimise robotic and automated systems in modern industrial environments.

The Robotics and Automation Apprenticeship (RAA) programme prepares the next generation of advanced manufacturing technicians with the skills, knowledge, and practical experience needed to succeed in a rapidly evolving industry. Designed to meet the needs of sectors such as engineering, food and drink, and pharmaceuticals, the programme develops professionals who can operate, design, install, and maintain complex robotic and automation systems that power modern production environments.

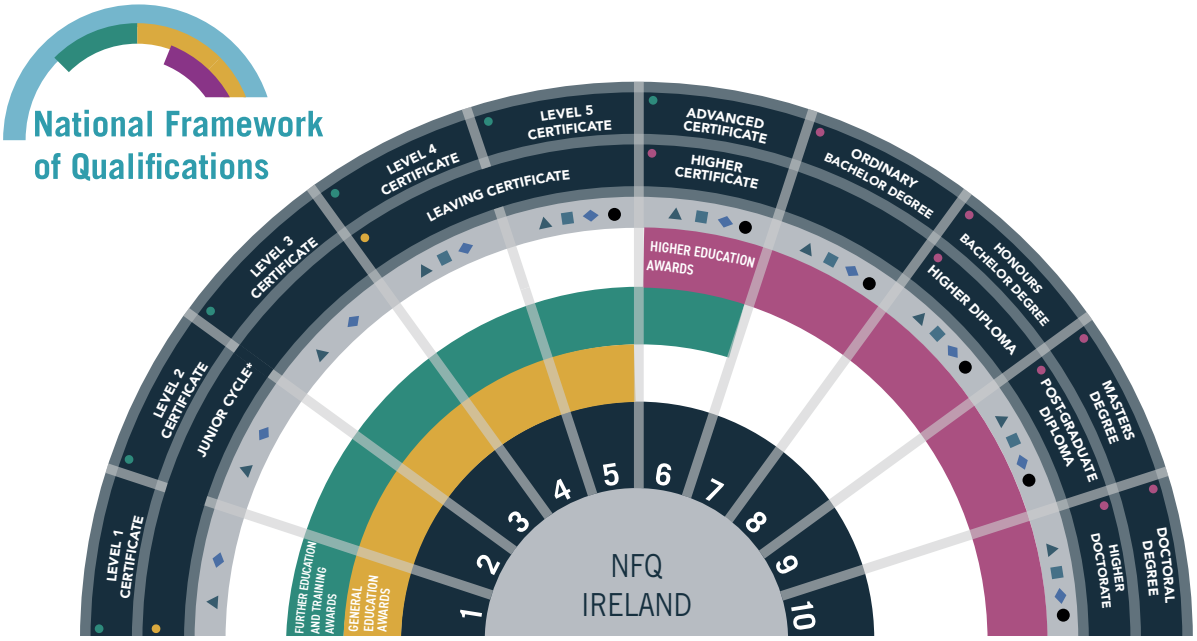
Over two years, apprentices gain a strong foundation in areas such as robotics operation, process control, and maintenance, along with expertise in engineering systems, PLCs, CAD/CAM, and Industrial Internet of Things (IIoT) technologies. Through hands-on experience, they learn to manage and monitor automated manufacturing equipment, ensure product quality, perform system upgrades, troubleshoot production issues, and maintain clear, compliant documentation in line with industry standards such as Good Manufacturing Practices (GMP) and Standard Operating Procedures (SOPs).

The RAA programme combines academic learning, technical training, and personal development, guiding each apprentice through a structured journey of professional growth. Graduates emerge as highly capable Robotics and Automation Technicians, equipped not only with technical excellence but also with strong communication, teamwork, and problem-solving skills. With these competencies, they are well positioned to contribute immediately to their workplaces and to progress into supervisory or management roles as the sector continues to evolve.

The programme is 2 years in duration and was developed by a team of industry experts. It includes both off-the-job (in a Training Centre) and on-the-job (with an Approved Employer) over seven phases. On successful completion of the programme the apprentice will be awarded an Advanced Certificate in Robotics and Automation at Level 6 on the National Framework of Qualifications (NFQ).

THE ROBOTICS AND AUTOMATION PROGRAMME OVERVIEW

Programme Title	Robotics and Automation Apprenticeship
Duration	Two years
Certification	Advanced Certificate in Robotics and Automation
Awarding Body	Quality and Qualifications Ireland (QQI)



CLASSES OF AWARD

- **Major Awards:** named in the outer rings, are the principal class of awards made at a level
- **Minor Awards:** are for partial completion of the outcomes for a Major Award
- **Supplemental Awards:** are for learning that is additional to a Major Award
- **Special Purpose Awards:** are for relatively narrow or purpose-specific achievement
- **Professional Awards:** are for occupation-orientated qualifications including apprenticeships

*Please refer to NCCA website, ncca.ie/en/junior-cycle/

IRISH REGISTER OF QUALIFICATIONS

For more information on

- Qualifications
- Providers
- Courses

visit www.irq.ie

Programme Aim and Purpose

The Robotics and Automation Apprenticeship is focused on the installation, operation and maintenance of advanced robotic and automation technologies.

The programme aims to provide a dedicated and practical programme for apprentices wishing to secure and retain employment in a robotics and automation technician role.

The overall objective of the programme is to provide apprentices with the underpinning academic knowledge combining learning ''off-the-job'' and significant ''on-the-job'' practical experience to enhance their employment and educational opportunities. Upon successful completion of the programme, they will receive an NFQ Level 6 Advanced Certificate in Robotics and Automation.

The academic and work-based training throughout the programme ensures that all apprentices will graduate from the programme with an enriched experience of the classroom blocks of study that can be directly applied to the workplace. This applied feature of the programme provides a unique experience and ensures its durability as the learning and assessment undertaken is always current and responsive to individual and industry trends in real time.

The programme culminates with a Work Based Capstone Project drawn from workplace learning. It consolidates the apprentice's learnings over the life of the programme.

Programme Objectives

- To provide apprentices with a broad knowledge of robotics and automation in the advanced manufacturing sector.
- To provide apprentices with related specialised knowledge, a safety mindset, practical skills, and competence for autonomous professional practice as a robotics and automation technician.
- To enable apprentices to fully participate in the related professional community of practice.
- To provide apprentices with the skills to evaluate information and evidence and to generate creative solutions to problems arising in their professional activity.
- To develop the ability for apprentices to exercise autonomy, judgement and responsibility in applying their knowledge and skills in compliance with safety requirements.
- To enable apprentices to communicate effectively and to achieve a professional standard of communications across various forms of technical and non-technical communications.
- To provide apprentices with the ability to act effectively in team roles, exercise supervision, lead activities and contribute to development of the workplace and the performance of others.

Minimum Intended Programme Learning Outcomes (MIPLOs)

On successful completion of the Robotics and Automation Apprenticeship, learners will be able to:

- Identify and appraise the key elements and principles of advanced manufacturing and Industry 4.0/5.0, including the fundamentals and benefits of robotic systems.
- Evaluate problems and develop solutions autonomously in the design, programming, system integration and use of robotic systems while adhering to health and safety regulations and guidelines.
- Adhere to a safety mindset in their own professional activity and be able to apply the relevant safety concepts, regulations and standards that apply to automation and robotic systems within the context of the community of practice.
- Demonstrate an ability to apply tools and techniques to the digitisation of the design, maintenance and optimisation of manufacturing processes with due regard to ethical considerations.
- Apply knowledge, initiative, good decision making autonomously, and the practical skills required to operate, maintain, calibrate, troubleshoot, and upgrade industrial systems and engineering workshop processes.
- Describe various types of control systems used in manufacturing and robotics; and how to configure, programme, maintain and troubleshoot them.
- Use a range of mathematical techniques to solve problems and describe how this approach can be applied to improve manufacturing processes.
- Work effectively as an individual, in teams and lead others in the field of advanced manufacturing, robotics and automation, taking responsibility for their own work while continually engaging in ongoing learning and professional development.
- Communicate complex information effectively in both technical and non-technical contexts.
- Manage and evaluate their own learning and help others to identify their needs in the context of the potential impact of the technologies and how they are used.

Programme Structure

Apprentices will be trained in a progressive manner and will get to put their skills into practice during both on and off the job training stages. On successful completion, the apprentice will be fully competent in the role of a Robotics and Automation Technician.

Phase 1 On the job 3 Months approx. 62 days	**Phase 2** Off the job - AMTCE Training Centre 3 Months approx. 64 days	**Phase 3** On the job 3 Months approx. 65 days
Phase 4 Off the job - AMTCE Training Centre 3 Months approx. 66 days	**Phase 5** On the job and commencement of Work-Based Capstone Project 6 Months approx. 130 days	**Phase 6** Off the job - AMTCE Training Centre 2 Months approx. 43 days

Phase 7 - On the job 4 months approx. 88 days with presentation of Work-Based Capstone Project

Year 1	**Stage 1**	**Phase 1** will provide the apprentice with the opportunity to become familiar with the workplace. The employer with the mentor will provide an induction into the company and begin integrating the apprentice into their workplace team. HR, Health and Safety Policies, and workplace expectations will be communicated
		Phase 2 in the FET centre will develop the apprentice's foundational understanding of Robotics and Automation. The apprentice inductions will include a centre orientation, ID card creation, introduction to Academia, etc. The workplace logbook will be introduced and explained to the apprentice.
		In **Phase 3**, the apprentice returns to the workplace equipped with the knowledge gained from the off the job training. The apprentice will begin completing the workplace logbook with the Workplace mentor.
	Stage 2	**Phase 4** will introduce the Work Based Capstone Project which commences in Phase 5. Modules 5 and 6 will be covered further advancing the apprentice's understanding of the RAA.
Year 2	**Stage 2**	**Phase 5** will see the apprentice continue compiling their work-based logbook completing the sections relevant to modules 2-6. Work will commence on their Work Based Capstone Project. The apprentice will have a developed understanding of what is expected.
	Stage 3	In **Phase 6**, the apprentice will cover Modules 7 and 8, concluding their academic learning. The apprentice will review and reflect on their Work Based Capstone Project. The apprentice will receive critical feedback on their Work Based Capstone Project.
		The **Final Phase** will see the completion of the workplace logbook (focused on the material covered in modules 7 and 8) in the first 2 months. The Work Based Capstone Project will be finalised and presented.

Note: Progression from one stage to the next is contingent upon the successful completion of the preceding stage.

Phase 1

Phase 1 **(On-the-Job)** will provide the apprentice the opportunity to become familiar with the workplace. The employer with the Workplace Mentor will provide an induction into the company and begin integrating the apprentice into their workplace team and the tasks they complete. HR policies and workplace expectations will be communicated to them.

Phase 2

Phase 2 **(Off-the-Job)** in the Training Centre will develop the apprentices foundational understanding of Robotics and Automation, building on their initial experience with the employer. The Apprentice induction will include a centre orientation and an introduction to academic expectations, study skills, etc. The Workplace Task Logbook will be introduced and explained to the apprentice.

Phase 3

Phase 3 **(On-the-Job)** The apprentice returns to the workplace equipped with the knowledge gained from the off the job training. The Apprentice will begin completing the Workplace Logbook with the Workplace Mentor.

Phase 4

Phase 4 **(Off-the-Job)** will introduce the Work Based Capstone Project. Programme modules 5 & 6 will be undertaken further advancing the apprentices understanding of the RAA programme.

Phase 5

Phase 5 **(On-the-Job)** will see the Apprentice continue completing their Workplace Logbook completing the sections relevant to programme modules 2-6. The apprentice will, in consultation with their work-based mentor commence work on their Work Based Capstone Project for the final module.

Phase 6

Phase 6 **(Off-the-Job)** The Apprentice will undertake programme modules 7 & 8 concluding their academic learning. The Apprentice will review and reflect on their Work Based Capstone Project and will receive critical feedback from their Instructors on their Work Based Capstone Project.

Phase 7

The final Phase 7 **(On-the-Job)** will see the completion of the Workplace Logbook (focused on the material covered in modules 7 & 8) in the first 2 months. The Work Based Capstone Project (WBCP) will be finalised and presented.

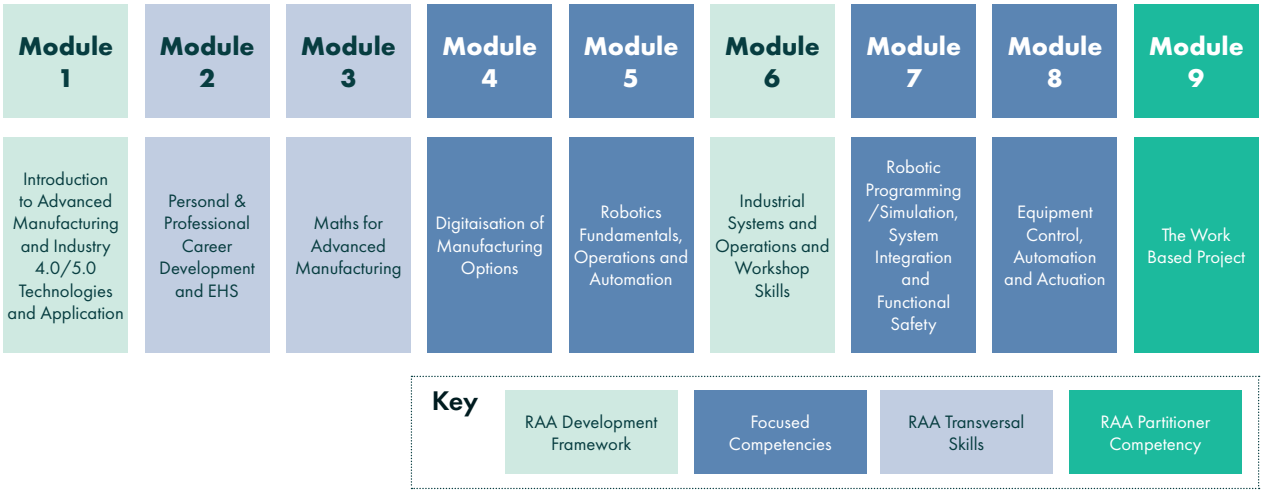
Entry Criteria

Applicants must be 17 years or older, have strong numeracy and literacy skills, and meet minimum educational requirements, five Leaving Certificate subjects including Maths and English (O6/H7) or a full QQI Level 5 qualification or equivalent, with alternatives considered through Recognition of Prior Learning. They must demonstrate at least B2 CEFR English proficiency and complete an initial aptitude test. Successful candidates will be motivated, analytical, and adaptable, with good communication and interpersonal skills, an interest in manufacturing technology, and the ability to learn quickly, work effectively in teams, and absorb product knowledge.

What the apprentice will be taught

Throughout the Robotics and Automation Apprenticeship, apprentices will gain a solid foundation in the key principles, technologies and practices that underpin modern automated and robotic systems. The programme combines theoretical knowledge with extensive practical experience, enabling apprentices to develop the technical, analytical, and problem-solving skills required to work confidently in advanced manufacturing and engineering environments.

Module category



Module No.	Module Credits	Directed Classroom Hours	Directed Practical Hours	Independent Learning Hours	On-the-job Learning Hours	Total Effort
1	15	80	10	40	20	**150**
2	15	75	15	30	30	**150**
3	10	75	-	25	-	**100**
4	15	70	20	30	30	**150**
5	15	80	10	30	30	**150**
6	15	65	25	30	30	**150**
7	15	70	20	30	30	**150**
8	15	70	20	30	30	**150**
9	30	50	-	250	-	**300**
Total	**145**	**635**	**120**	**495**	**200**	**1450**

MODULE ONE

Introduction to Advanced Manufacturing and Industry 4.0/5.0 Technologies and Application

This module will provide the apprentice with an understanding of the evolution of Manufacturing from traditional to advanced and will review the implication of Industry 4.0/5.0 technologies and their application in the modern manufacturing process. It will incorporate an introduction to the scope and significance of manufacturing worldwide, followed by an overview of the industry in Ireland. Key industry disciplines and processes will be outlined, and their respective usage will be reviewed. Underlying principles of sustainability, lean practices, product life cycle and design will be presented.

Indicative Syllabus:

Unit 1: Advanced Manufacturing and Industry 4.0 and Industry 5.0— Inception and Application

This unit will present an overview of manufacturing in industrial and economic development. Provide a concise account of the contribution of Industry 4.0 and Industry 5.0 in the digitisation of manufacturing and the adoption of new technologies and processes in the production process; their implications with respect to productivity focus and flexibility; resource efficiency, and sustainability; and the evolution of Industry 5.0 human centric and enabling technologies.

Unit 2: Overview of Workshop Skills and Practices

This unit describes key manufacturing methods such as turning and milling, welding and fabrication and their essential functions in the manufacturing process.

Unit 3: Summary of other key manufacturing processes

This unit will provide the learner with an overview of other key functions in manufacturing including:

i) Injection moulding, the most widely used plastics manufacturing process.

ii) Thermoforming and Sheet Metal Forming, addressing the sheet forming of plastics and metals.

iii) Casting process, explaining how a metal part is made by solidification within a mould.

iv) Introduce the spectrum of additive manufacturing / 3D printing, key applications and reasons for its rapid growth and significance.

Unit 4: Quality Control and Variation

This unit will explain basic statistical methods for analysing, monitoring, and controlling process variation, including the use of quality control systems.

Unit 5: Lean Manufacturing and Assembly Systems

This unit will give examples of key manufacturing and assembly concepts such as production rate, capacity, buffers, and provide industry and case study examples. Lean methodologies will be introduced which focus on minimising waste and maximising productivity.

Unit 6: Manufacturing Cost

This unit will focus on the cost of manufacturing parts or products, outlining the significance of cost control methods. It will present and discuss case studies of making of specific products.

Unit 7: Sustainability in Industry 4.0 / 5.0 Manufacturing

This unit will review the role and impact of digitisation on the sustainability of the manufacturing process, product life cycle, product development and the circular economy. It will also explore digitisation and emerging technologies capability to enable innovation with respect to product development and enhancement and capacity for bespoke small batch customisation versus high volume production.

Unit 8: Application of Robotics Automation across Advanced Manufacturing Sectors

This unit provides an overview of the usage and benefits of robotic automation across a wide range of advanced manufacturing sectors. It outlines the advantages of utilising robotic automation in such sectors, including increased safety, accuracy, and efficiency, while exploring potential applications of the technology. It will demonstrate that advanced manufacturing encompasses a variety of sectors, including automotive, aerospace, industrial, electronics, and medical and how each sectors unique set of needs and goals, are addressed using varied automaton process and technologies. Finally, it explores the socio-economic and environmental implications of advanced manufacturing and provides insights into the strategic direction of the industry. It also examines the impact of technology, government policies, sustainability, and global markets on the advanced manufacturing sectors.

Learning Outcomes:

On successful completion of this module, learners will be able to:

1. Describe the evolution of advanced manufacturing and the impact of emerging technologies.
2. Explain the key workshop functions, equipment, and application.
3. Outline key manufacturing processes for component and product production.
4. Present quality control systems and the use of statistical methods for an analysing, monitoring, and controlling process variation.
5. Summarise key manufacturing and assembly concepts, and the importance of lean methodologies in the production process.
6. Discuss the importance of manufacturing costs and control methods and the necessity to identify key elements of cost such as materials, labour, capital and overheads.
7. Explain the circular economy and the contribution of digitisation to the sustainability of the manufacturing.
8. Outline the application of Robotics Automation across Advanced Manufacturing Sectors

MODULE TWO

Personal & Professional Career Development and Environmental Health & Safety (EHS)

This module will provide the learner with the key skills and knowledge required to operate effectively in a professional collaborative working environment. The apprentice will acquire the practical knowledge of how to work and communicate effectively in teams, demonstrate team leadership, to include team building, supporting team members at different stages of team development, interpersonal communications and reporting structures. The module will provide the apprentice with all the modalities of communication including reading, writing, verbal, visual and oral. The apprentice will be provided with the fundamentals of digital and mobile communication methods including their application and implications. The apprentice will be given the opportunity to practice their communication skills in a variety of settings.

The apprentice will also gain an understanding of how to engage in personal and professional development activities, how to set personal goals and plan for career success. The module will also provide the learner with an understanding of the legislation and associated obligations necessary for a safe working environment and will equip the learner with an understanding of the characteristics of a functional safety culture.

Indicative Syllabus:

Unit 1: Communications in the Professional Workplace

In this unit, apprentices will gain an understanding of the basic principles of communication and the various contexts in which communication occurs. Topics will include verbal and nonverbal communication, active listening, and communication styles. Apprentices will explore the dynamics of communication within groups, including the roles of each member and the importance of understanding group dynamics. This unit will explore the challenges of working within remote teams and appropriate techniques for effective communication. This unit will also explore the role of technology in communication, including the professional use of social media, email, text messaging, and other forms of digital communication. Finally, the unit will introduce the fundamentals of successful technical writing and the creation of high-quality technical specifications, reports and technical documentation.

Unit 2: Personal Development and Goal Setting

Through this unit, participants will learn to recognise their strengths and weaknesses, identify their goals and motivations, and develop the necessary skills to reach their full potential. Apprentices will be introduced to various topics such as self-awareness, self-esteem, self-reflection decision-making and personal goal setting. They will learn strategies for dealing with challenging situations and how to maintain a positive attitude in the workplace. This unit will introduce the concept of accepting personal responsibility, and the importance of taking ownership of one's actions, decisions, and outcomes. Apprentices will also explore the importance of maintaining a positive attitude and developing a

growth mindset. Participants will learn how to identify and analyse problems, develop solutions, and set goals. The unit will cover self-care, stress management, resilience and how to stay motivated in the professional workplace.

Unit 3: Professional Development within the Community of Practice

This unit is designed to help individuals gain the skills and knowledge necessary to succeed in the workplace. The unit will provide apprentices with the opportunity to explore key concepts and strategies for professional development, such as goal setting, time management and problem solving. The unit will also focus on the importance of maintaining awareness of and acquiring technical competency on emerging technologies. It will explain how to engage in professional development activities through networking, finding mentors, forums, professional bodies, and industry organisations within the community of practice. This unit will provide apprentices with the opportunity to apply the concepts and strategies they have learned to create a personalised plan for achieving their professional goals. Upon completion of the unit, apprentices will have a better understanding of the importance of professional development and the strategies that can be employed to enhance their career.

Unit 4: Developing an Agile Learning, Creative, Design-Focused and Adaptable Mindset

This unit is designed to help participants develop an agile learning, creative, and design-focused mindset. Apprentices will explore how to think outside the box and apply creative problem-solving techniques to their work. Topics will include developing an agile mindset, utilizing creative thinking to generate innovative solutions, and understanding the fundamentals of design-thinking. The unit will explore the rapidly changing future of work and technology and the adaptability challenge focusing on our ability to learn, unlearn, and adapt. Through lectures, hands-on activities, and online resources, apprentices will explore how to apply an agile methodology to their learning, how to think creatively and design solutions to problems, and how to create and use design thinking to develop innovative ideas.

Unit 5: Teamwork and Leadership Principles and Skills

This unit is designed to provide apprentices with the skills and knowledge to work effectively in a team, lead others, and be adaptable in the workplace. Apprentices will gain an understanding of effective team working, leadership, team goalsetting and the delegation of tasks. It will explore how to successfully work with remote teams. The unit will show how to be agile and adaptable in the face of changes and challenges in the workplace.

Unit 6: Environmental, Health, and Safety (EHS) in Advanced Manufacturing

This unit introduces the fundamentals of Environmental, Health and Safety (EHS) principles and practices in advanced manufacturing. The unit will provide an overview of EHS in the manufacturing and industrial sectors, including an introduction to relevant standards, regulations, and best practices. The unit introduces health & safety legislation and employer/ employee responsibilities including the provision and correct use of personal protective equipment (PPE). It also focuses on safety in manual handling, working at heights, working with abrasive wheels, the use of electrical/ mechanical systems and certification requirements. Apprentices will also explore how to create a safety mindset and culture in the workplace. The unit will cover risk assessment and management techniques used to identify and mitigate potential safety and environmental hazards.

Learning Outcomes:

On successful completion of this module, learners will be able to:

1. Demonstrate the principles of effective communication, including verbal and nonverbal communication, active listening, communication styles, the use of technology / digital systems and communications within groups and remote teams.
2. Demonstrate effective technical writing in the creation of high-quality technical reports and technical documentation.
3. Demonstrate the concepts of self-awareness, self-esteem, personal responsibility, decision-making, a growth mindset, personal goal setting, resilience and motivation in the workplace.
4. Evaluate the importance of professional development within the community of practice and apply the concepts and strategies to create a personalised plan for achieving one's professional goals.
5. Apply agile methodology to one's learning and use of creative methods, design thinking and an adaptable mindset to solve problems and develop innovative ideas.
6. Demonstrate effective team working, applying the skills to lead and motivate others, co-operate in the delegation of tasks, setting of team goals, and adoption of a shared vision.
7. Demonstrate the fundamentals of Environmental, Health and Safety (EHS) principles, practices, legislation, regulation and standards in advanced manufacturing.
8. Adhere to a safety mindset and culture and apply risk assessment techniques and safe practices in manual handling, working at heights, working with abrasive wheels, and the use of electrical/ mechanical systems in the workplace.

MODULE THREE

Maths for Advanced Manufacturing

Maths for Advanced Manufacturing is a module designed to provide apprentices with the mathematical knowledge and competencies necessary for the successful implementation of advanced manufacturing processes. The module will cover topics such as the applicable arithmetic and linear algebra, calculus, numerical methods, differential equations, optimisation, and probability. It will also introduce apprentices to the advanced mathematical models used in the design and analysis of manufacturing systems. The module will provide an in-depth study of the mathematical techniques used in the design, analysis, and control of these systems while providing apprentices with the opportunity to apply their knowledge and skills in the development of real-world manufacturing applications. On completion of this module, apprentices will display a level of competency and application of mathematical computation necessary to realise engineering solutions as required.

Indicative Syllabus:

Unit 1: Arithmetic & Algebra for Advanced Manufacturing

This unit will cover the fundamentals of arithmetic and algebra for advanced manufacturing. It will cover topics such as operations, equations, polynomials, factoring, and graphing. It will also introduce the applicable rules of algebra and cover the use of algebraic techniques to solve problems related to advanced manufacturing, such as using linear equations to solve for unknowns in a system or using polynomials and vector algebra to model a manufacturing process. The unit will also provide a foundation in linear programming and optimization techniques such as the evaluation of determinants and solution of systems of simultaneous linear equations by Gaussian elimination. The unit will include examples and exercises to help apprentices gain a deeper understanding of the topics. Upon completion of this unit, apprentices will have a strong foundation in basic arithmetic and algebra for advanced manufacturing.

Unit 2: Introduction to Set Theory & Boolean Logic

This unit introduces the mathematical concepts of set theory and Boolean logic and their application in the field of advanced manufacturing. Apprentices will learn how to use these concepts to analyse and solve complex problems related to automation, robotics, and other industrial processes. Topics covered will include the basic principles of set theory (such as set notation and operations), the algebraic properties of Boolean logic, and the application of these principles in the design of logic circuits. Through a combination of lectures, tutorials, and laboratory exercises, apprentices will have a solid grounding and understanding of how to apply set theory and Boolean logic to the design and control of industrial processes.

Unit 3: The Application of Geometry and Trigonometry in Designing Advanced Manufacturing Solutions and Products

This unit will introduce apprentices to the application of geometry and trigonometry in advanced manufacturing. The unit will cover topics such as the use of trigonometric functions to calculate angles, lengths, and areas, as well as the use of geometric principles to understand the design of manufacturing components. Apprentices will also be introduced to fundamental concepts of three-dimensional space, including the use of Cartesian coordinates, vector algebra, and vector calculus. They will also gain an appreciation of sinusoidal waveforms, motion in a circle, angular velocity and acceleration. Through this unit, apprentices will gain an understanding of the importance of geometry and trigonometry in the design and manufacture of advanced products. In addition, they will learn how to apply these concepts to solve real-world problems in advanced manufacturing. The unit will include lectures, tutorials, and hands-on exercises to help apprentices gain a deeper understanding of the subject. At the end of the unit, apprentices will be able to use their knowledge to design and manufacture advanced products.

Unit 4: Application of Probability & Statistics in Advanced Manufacturing

This unit introduces apprentices to the application of probability and statistics in advanced manufacturing and the representation of data, and frequency distributions. Apprentices will be able to explain, and compute mean, mode, median quartile, range and standard deviation. It covers topics such as probability distributions (binominal, Poisson and normal), sampling techniques, hypothesis testing, regression analysis, and time series analysis. Apprentices will learn to identify and analyse data to make informed decisions in the manufacturing process. They will also learn to predict future outcomes based on data and to develop strategies for improving processes. The unit will provide apprentices with the skills to understand and apply probability and statistical techniques in the context of manufacturing industry. Additionally, the unit will explore the use of software applications for data analysis, such as SPSS and Minitab. Upon completion of the unit, apprentices will be able to analyse data and make decisions to optimise the manufacturing process.

Learning Outcomes:

On successful completion of this module, learners will be able to:

1. Solve problems in advanced manufacturing using applicable arithmetic and algebra.
2. Apply set theory and Boolean logic to the design and control of industrial processes.
3. Solve real-world problems in advanced manufacturing using geometry and trigonometry.
4. Use probability and statistical techniques to analyse data and make decisions to optimise the manufacturing process.

MODULE FOUR

Digitisation of Manufacturing Operations

This module will provide the apprentice with an understanding of the digital technologies that are transforming robotics driven manufacturing operations. The module will provide the learner with an understanding of the key technology building blocks and principles in the digital transformation of manufacturing operations.

Indicative Syllabus:

Unit 1: Overview of Digitisation of Manufacturing Operations

This unit will provide an overview of the digitisation of manufacturing operations, exploring the ways in which digital technologies are transforming the way in which manufacturing processes are conducted. It will introduce the concept of the fourth industrial revolution and explain the potential benefits this can bring for manufacturers. It will also look at the challenges associated with digitisation, such as the need for technical expertise and the potential for cyber security risks. The unit will cover the different digital technologies that can be used to digitise manufacturing processes, such as 3D printing, robotics, artificial intelligence, cloud computing, AR/VR technologies and application and the Industrial Internet of Things (IIoT). It will explain how these technologies can be used to improve efficiency, reduce costs, and increase accuracy. Finally, the unit will provide an overview of the advantages of digitising data and processes, such as improved accuracy and efficiency, cost savings, and better access to information. It will also discuss the obligations and potential risks associated with digitisation, such as data security and privacy. Participants will gain a better understanding of the potential of digitisation and be able to make informed decisions about its use in their organisation and the implications of digitisation for the future of manufacturing operations in general.

Unit 2: Technology Utilisation in Digitisation

This unit will provide apprentices with an introduction to the use of Automation, Robotics, Computer-aided Design (CAD), Computer-aided Manufacturing (CAM) and 3D Printing in the digital transformation of businesses. The unit will provide a comprehensive overview of the technologies and their applications, with a focus on the practical aspects of their use. Apprentices will learn the principles of automation, robotics, CAD and CAM, and gain an understanding of the processes and tools used to create digital designs and products including an introduction to software such as SOLIDWORKS and other similar software. They will also gain an understanding of the various 3D printing technologies and their applications. The unit will provide apprentices with the necessary skills to apply these technologies in the digitisation of businesses and will equip them with the knowledge to evaluate the best technology for a specific application.

Unit 3: Processes for Digitisation

This unit provides apprentices with an in-depth exploration of processes for digitisation, including designing the digital workflow, developing a digital manufacturing plan, implementing automation and robotics, integrating CAD/CAM systems and utilizing 3D printing. Apprentices will learn the fundamentals of designing a digital workflow, including the principles of process mapping, data flow diagrams, and the use of software tools to design and implement the workflow. Apprentices will gain an understanding of the components of a digital manufacturing plan and the process of developing a plan that is tailored to the specific needs of a given manufacturing environment. They will learn the fundamentals of automation, robotics, 3D printing and CAD/CAM systems and how they can be used to improve the design and manufacturing process. By the end of the unit, apprentices will have a thorough understanding of the processes for digitisation and the tools and techniques that can be used to improve the design and manufacturing process.

Unit 4: Overview of Microcontroller Technologies, Associated Input/Output Devices and their Practical Applications

This unit will introduce microcontroller technologies (including an overview of microcontroller and microprocessor technologies such as Arduino and Raspberry Pi), associated input/output devices such as sensors, motors, and displays, and will explore how these devices can be used to create interactive projects and their practical applications. Apprentices will learn the fundamentals of microcontroller architectures, the different types of microcontrollers, and the basic principles of their operation. They will also be introduced to the different types of input/output devices available, such as sensors, actuators, and displays, and how they can be used to interact with the microcontroller. Apprentices will be introduced to various practical applications and will gain practical experience with programming and interfacing microcontrollers with input/output devices. The unit will also cover topics such as debugging, programming languages, and development tools. At the end of the unit, apprentices should be able to design, implement, and debug simple microcontroller-based systems. Through a series of lessons, tutorials, and practical exercises, apprentices will gain an understanding of the principles of microcontroller programming and will be able to apply this knowledge to create their own projects.

Unit 5: Data Capture Tools and Analysis Techniques

This unit will introduce the tools and techniques used to capture data related to equipment in the manufacturing process. Topics covered will include the use of various data capture methods, such as barcode scanning, RFID tags, and manual data entry. The unit will also cover the use of various software tools to capture, store, and analyse data related to equipment output and performance, including asset management systems, inventory management systems, and maintenance management systems.

This unit will provide apprentices with the knowledge and skills to develop and implement data capture tools and techniques for robotics orientated manufacturing systems. The unit will provide apprentices with the ability to optimise and enhance robotics-oriented manufacturing systems. The unit will cover topics such as data collection and storage, data mining and analysis, data visualisation, data-driven decision making, and data-driven continuous optimisation and enhancements. Additionally, the unit will provide apprentices with the ability to apply these techniques to solve a variety of real-world problems. Finally, the unit will provide apprentices with the opportunity to develop a project that incorporates the data capture tools and techniques discussed in the unit.

Unit 6: IIoT technology Adoption and Applications

This unit will provide apprentices with a comprehensive overview of the Industrial Internet of Things (IIoT) and its applications in advanced manufacturing. It will cover the fundamentals of IIoT technology, including the different components of the system, the challenges and benefits of implementation, and the potential applications in advanced manufacturing. Apprentices will gain an understanding of the different communication protocols used for IIoT systems, as well as the security considerations for IIoT systems.

The unit will explore the application of IIoT in different aspects of advanced manufacturing such as data analytics, sustainability, environmental control, lean manufacturing, and bespoke production systems. It will cover the potential advantages and disadvantages of each of these areas, and the ways in which they can be used to improve the efficiency and effectiveness of manufacturing processes. The unit will also look at the potential risks and challenges associated with the adoption of IIoT in advanced manufacturing, and the strategies that can be employed to mitigate these. It will provide an overview of the legal and regulatory framework that governs the use of IIoT in the manufacturing sector.

Unit 7: Application of AR/VR in Preventative Maintenance / Equipment Troubleshooting

This unit is designed to provide apprentices with an introduction to the use of Augmented Reality (AR) and Virtual Reality (VR) technologies in the field of preventative maintenance and equipment troubleshooting. Apprentices will learn how to apply AR/VR technologies to diagnose and repair common equipment problems. Topics will include an overview of the distinct types of AR/VR technologies, their advantages and disadvantages, and the most effective ways to use them in the maintenance and troubleshooting of equipment. The unit will also cover the practical applications of AR/VR in preventative maintenance and equipment troubleshooting, including the use of AR/VR to identify and diagnose potential problems, as well as the use of AR/VR to create virtual simulations for training and troubleshooting purposes. Additionally, the unit will cover the safety considerations for working with AR/VR technologies and discuss the ethical implications of using these technologies in the workplace. Upon completion of the unit, apprentices will be able to identify and apply the appropriate AR/VR technologies for preventative maintenance and equipment troubleshooting. The

unit will demonstrate how AR and VR can be used to create interactive, immersive training simulations and provide practical experience to trainees. It will also demonstrate the use of 3D models and simulations to display and analyse equipment performance. Finally, the unit will provide an overview of the current state of AR and VR technology use and discuss the potential for future applications.

Unit 8: Implementation of a Digitisation Strategy in Manufacturing Enterprises

This unit will explore the methodologies for digitising manufacturing enterprises in the modern era. It will provide an overview of the current state of the industry, the potential benefits of digitisation, and the challenges that need to be addressed. It will cover topics such as the need for increased automation, the need for better data management, the need for more efficient supply chain management, and the need for improved customer service. The unit will also discuss the implications of digitisation on the workforce, the need for new skills and training, and the need to manage the transition. This unit will provide an in-depth exploration of the challenges associated with the digitisation of manufacturing enterprises. It will explore the cost/benefit of digitisation, from both a financial and time perspective, and the various technical challenges that must be addressed to successfully implement a digital transformation. The unit will also explore the importance of training employees in the use of new digital technologies, and the need for robust data security measures to protect sensitive information. The unit will explore the use of AI (artificial intelligence) in robotics/cobotics and will focus on the ethical use of AI in the enterprise and society. By the end of the unit, participants will have a comprehensive understanding of the challenges associated with the digitisation of manufacturing enterprises, and the strategies that can be used to overcome them.

Learning Outcomes:

On successful completion of this module, learners will be able to:

1. Discuss the of application of digitisation in industry, the challenges it presents and its implications for the future of advanced manufacturing.
2. Describe the processes and tools used to create digital designs and products and evaluate the best digital technology for specific applications.
3. Apply the processes, tools and techniques for digitisation, that are used to improve the design and manufacturing process.
4. Demonstrate the application of microcontroller and microprocessor technologies and demonstrate how to design, implement, programme and debug simple microcontroller-based systems.
5. Develop and implement data capture tools and analysis techniques to optimise and enhance a robotics orientated manufacturing system.
6. Outline the applications and challenges of IIoT and the ways in which it can be used to improve the efficiency and effectiveness of manufacturing processes.
7. Describe how to effectively use VR/AR to support industrial use case scenarios such as industrial maintenance activities.
8. Show an in-depth appreciation of the benefits and challenges associated with the digitisation of manufacturing enterprises and outline strategies for their successfully application.

MODULE FIVE

Robotics Fundamentals, Operations and Automation

This module will provide the learner with an understanding of industrial robotics, cobotics and the technical operation of robotics in advanced manufacturing operations across various business verticals such as Aerospace, Metal Fabrication, Lifesciences, Plastics, Pharma, Electronics and Food and Drink sectors. The module will examine key robotic metrics, the basics of movement geometry, axes and coordinated motion, how to build type specifications for robotics systems, robotics ecosystem and the key industry players. It will explain how to operate a robot cell compliant with robot safety regulations and how to perform operating tasks on a robot. It will discuss both existing and emerging use cases, the application of collaborative robots, which automate repetitive tasks normally carried manually.

Indicative Syllabus:

Unit 1: History of Robotics, Business Justification, New Applications, Performance Metrics and ROI

This unit will provide an overview of the history of robotics, business justification, new applications, performance metrics and return on investment (ROI). We will discuss the development of robotics from its early days to the present, and how it has been used in industry and in research. We will also explore new applications for robotics, such as in healthcare, manufacturing, and transportation. We will identify and discuss performance metrics for robotics, such as accuracy, speed, and power consumption, and how they can be used to measure the effectiveness of a particular robot. Finally, we will examine the ROI of robotics, exploring the cost savings and other benefits that can be realised from investing in robotics

Unit 2: Industrial Robotics / Cobotics use cases, processes, and integration and optimisation in manufacturing operations

This unit will introduce the use of industrial robotics and cobotics in manufacturing operations, their advantages and disadvantages, and how they can be used in a variety of applications, providing an overview of their use cases. Apprentices will learn about the processes and integration of robotics and cobotics into manufacturing operations, as well as strategies for optimising their use. It also provides a detailed look at the different use cases, including industrial automation, assembly, welding, additive manufacturing, machine tending, palletising and more. The unit will introduce mobile robotics, covering Mobile

Logistical Robots/ Autonomous mobile robots (AMRs)/ Automated Guided Carts (AGCs)/Automated Guided Vehicles (AGVs) and Delta Robots and their applications. Finally, the unit provides an in-depth look at the challenges and opportunities that come with implementing industrial robotics and cobotics.

Unit 3: Robotic Terminology, Types, Components, Systems and Type Specification

This unit is designed to introduce apprentices to the terminology, types, components, systems, and type specifications related to robotics. Apprentices will gain an understanding of the fundamental concepts of robotics, including robot anatomy, robot components, robot systems, and robot type specifications. Apprentices will learn about the diverse types of robots, such as industrial robots, service robots, and personal robots. They will also become familiar with the units that make up a robot, such as motors, sensors, and actuators.

Unit 4: Robotic Axis/DOF, Motion Control, Repeatability, Drive and Controller Systems

This unit introduces apprentices to robotic axis/degrees of freedom (DOF), motion control, repeatability, drive, and controller systems. The unit begins by introducing the different types of robotic axes and the DOF associated with them. It then covers motion control techniques and the different types of motion control systems used in robotics. The unit explains repeatability and the different methods used to measure and maintain it. The unit then covers drive systems and the different types of motors used to power robotic systems. Finally, the unit covers controller systems and the different types of controllers used in robotics. Apprentices will gain an understanding of the different components of robotic systems and how they work together to create a functioning robotic system.

Unit 5: Robotic End Effectors/Jaws/ Clamps/Suction Cups etc. and End of Arm Tooling Considerations

This unit will provide an overview of robotic end effectors, including jaws, clamps, suction cups, and other end of arm tooling considerations. It will discuss their various uses, advantages, and disadvantages, as well as the considerations that need to be considered when selecting the right end effector for a particular application. Additionally, the unit will cover the different types of end effectors available and their associated features, as well as the safety considerations that must be taken into account when using them. Finally, the unit will provide practical demonstrations of how to install and use end effectors in a robotic system.

Unit 6: Manipulating and control robotic operations using and Operator Panel and Teach Pendant

This unit provides apprentices with the skills and knowledge to manipulate and control robotic operations using an Operator Panel and Teach Pendant. Apprentices will learn how to set up and operate a robot, programme and debug robot motion, and use teach pendants to programme and debug robot motion. Upon completion of this unit, apprentices will have the skills and knowledge necessary to control and manipulate robotic operations safely and effectively.

Unit 7: Robots vision systems, peripheral equipment and associated operations e.g. pick and place

This unit covers the principles, fundamentals, and applications of vision for robots and peripheral equipment. It covers the basics of vision systems, including camera types, image processing, and programming of vision systems. The unit also covers the principles and applications of various robotic and peripheral equipment, such as pick and place robots, automated guided vehicles, and vision-guided robotic arms. It also introduces the concepts of vision-guided operations, such as object recognition, navigation, and motion control.

Unit 8: Operating, Maintaining and Troubleshooting Robots / Cobots and essential System Safety requirements.

This unit is designed to provide apprentices with the knowledge necessary to safely operate, maintain, and troubleshoot robots and cobots in an industrial setting. Apprentices will learn about the different types of robots and cobots, their components, and the safety requirements for their operation. The course will also cover system safety requirements, including the use of proper safety equipment, and the maintenance and troubleshooting of robots and cobots. Upon completion of the course, apprentices will know how use robots and cobots safely and effectively in an industrial setting.

Learning Outcomes:

On completion of this module, learners will be able to:

1. Identify and justify the uses of robots in their own manufacturing contexts
2. State the major classification/functions of robotics / cobotics and recount where they can be fittingly utilised in manufacturing operations and other sectors
3. Describe the primary use cases of industry robotics / cobotics from a technical and business perspective and outline emerging use cases and their potential impacts on manufacturing operations
4. Describe and apply the fundamentals of robotic motion
5. Define the key terminology and identify the key components of a robotic system/cell
6. Explain how to build a technical and operational specification for a robotic cell/system
7. Demonstrate a practical understanding of the operation and application of vision driven robotics operations including camera types, image processing, and programming of vision systems
8. Outline how to operate a robot / cobot safely and efficiently in an industrial environment

MODULE SIX

Industrial Systems, Operations and Workshop Skills

This module is designed to equip the learner with the knowledge and practical skills required to operate, maintain, calibrate, troubleshoot, and upgrade industrial systems and their subsystem components. The learner will gain both an understanding of the fundamental workings and applications of Electro Pneumatic Systems, Industrial Electrical Systems and Industrial Mechanical Systems. The unit will introduce mobile robotics / cobotics and the various systems used and their applications. The module will also provide the learner with the knowledge and skills required to operate effectively and safely in a modern engineering workshop.

Indicative Syllabus:

Unit 1: Introduction to Industrial Systems, Operations and Workshop Skills

This unit will provide apprentices with an understanding of the fundamentals of industrial systems, operations and workshop skills. It then introduces the different types of industrial systems such as Electro Pneumatic Systems, Industrial Electrical Systems, Industrial Mechanical Systems, and their applications in the modern industrial world. Apprentices will learn the principles of industrial systems and operations, such as the design, construction, and installation of industrial systems, as well as the use of tools and machinery. Apprentices will also gain practical experience in the use of tools and machinery in a workshop environment, including the use of welding, cutting and machining tools. Additionally, the unit will cover the principles of safety in the workshop, as well as the principles of quality control and assurance. The unit will also cover the basics of engineering drawing and reading and interpretation of schematic drawings.

Unit 2: Electro Pneumatic Skills and Application

This unit will provide apprentices with an introduction to the fundamentals of electro-pneumatic systems and their applications. Apprentices will gain an understanding of the theory and principles of electro-pneumatic systems, including components, energy transfer, and control techniques. Using laboratory exercises and practical experience, apprentices will develop the ability to design, install, operate and maintain electro-pneumatic systems. Apprentices will learn how to troubleshoot and repair these systems, as well as gain the skills necessary to design and build their own electro-pneumatic systems. Additionally, the unit will cover the safety considerations and regulations for these systems. Upon completion of this unit, apprentices will be able to demonstrate a proficient understanding of the principles of electro-pneumatic systems and their applications.

Unit 3: Industrial Electrical Skills and Application

This unit is designed to provide apprentices with an understanding of industrial electrical systems and their applications in industrial settings. It covers topics such as electrical circuits, components, and equipment; electrical safety; electrical systems; and troubleshooting and installation. It also covers topics such as wiring diagrams and electrical drawings, motor control, and electrical instruments. This unit is designed to provide apprentices with a comprehensive knowledge of industrial electrical systems and their applications in industrial settings. It will enable apprentices to gain practical skills in the installation, maintenance, and troubleshooting of industrial electrical systems, components, and equipment.

Unit 4: Industrial Mechanical Skills and Application

This unit will provide an in-depth exploration of the principles of mechanical engineering and their practical application in industrial settings. Apprentices will learn the fundamentals of mechanics, including force, motion, energy, and power. In addition, the unit will cover the design and operation of different types of mechanical systems and their components. Topics such as mechanics of machines, machine design, fabrication, and maintenance will be covered, and apprentices will gain experience in the use of CAD/CAM software and other engineering tools. Practical applications such as welding, machining, and inspection will be demonstrated, and apprentices will also explore the safety procedures and regulations associated with industrial mechanical systems. Upon completion of this unit, apprentices will have the knowledge to operate and fault-find a simple industrial mechanical system.

Unit 5: Measurement Systems and Calibration for Industrial Systems Installation and Operation

This unit will cover the principles of measurement systems and calibration, including measurement uncertainty, calibration techniques, instrumentation, and test equipment. Apprentices will gain practical experience with industrial systems installation and calibration, as well as an understanding of the safety procedures and regulations related to these tasks. The unit will also cover the principles of troubleshooting and maintenance of industrial systems, including the use of software tools to aid in the calibration process. At the end of the unit, apprentices will be able to apply their knowledge to the installation and calibration of industrial systems.

Unit 6: Industrial Systems Management and Integration

Industrial Systems Management and Integration is a unit that aims to equip apprentices with the knowledge and skills to integrate industrial systems to maximise efficiency. The unit focuses on managing, controlling, and optimising industrial systems with a particular emphasis on the integration of different technologies. The unit covers topics such as industrial system architecture, system integration and control, industrial automation, communication protocols, and the development of control systems. Apprentices will gain a fundamental understanding of industrial systems, the challenges of integration, and how to develop systems that are reliable, stable, and cost-effective. Apprentices will learn how to read and interpret schematic drawings, and how to use the information to troubleshoot and diagnose problems. The unit will also cover topics such as safety protocols, environmental regulations, and quality control. Upon completion of the unit, apprentices will have a comprehensive understanding of factory level manufacturing systems and the ability to read and interpret schematic drawings.

Unit 7: Engineering Workshop Processes, Principles and Machining Application

This unit is designed to provide apprentices with an understanding of the fundamental principles and processes of engineering workshops. The unit will provide apprentices with an understanding of the various processes, principles and decision making involved in engineering workshops, such as the use of machines, tools, and materials, and the application of these processes to the manufacture of products. The unit will also provide apprentices with an understanding of and practical skills in the principles and techniques of machining and Computer Numerical Control (CNC) machining. It will cover the types of machines, cutting tools, and materials used in machining operations and explore the different methods and techniques of machining, such as drilling, turning, milling, grinding etc. Finally, the unit will cover the safety considerations and regulations that must be followed during machining operations.

Learning Outcomes:

On successful completion of this module, learners will be able to:

1. Describe the key subsystems in a modern manufacturing system including pneumatics, electrical and mechanical.
2. Interpret engineering drawings and the symbolic representations in systems schematics.
3. Demonstrate how to design and build Electro Pneumatic Systems.
4. Demonstrate how to design and build Industrial Electrical Systems.
5. Demonstrate how to design and build Industrial Mechanical Systems.
6. Calibrate modern manufacturing equipment and recognise when equipment is out of calibration.
7. Outline the key principles and techniques relating to engineering workshop equipment and processes.
8. Produce small engineering parts using a range of common workshop machining equipment in a safe and effective manner.

MODULE SEVEN

Robotic Programming/Simulation, System Integration and Functional Safety

The module will present an overview of relevant Functional Safety Standards.

This module will provide the learner with the technical understanding of how to programme robot operations in a manufacturing environment. The module will also provide the learner with an understanding of how robots can be integrated with peripheral equipment and End of Arm Tools (EOAT's), Programmable Logic Controllers (PLC) and control systems into overall manufacturing systems and production environments. The module will also address the use of simulation environments for offline programming of robots and the optimisation of systems and robots outside of a production environment. The module will present an overview of Functional Safety and IEC 61508.

Indicative Syllabus:

Unit 1: Introduction to Robotic Programming, Simulation and System Integration

This unit will introduce the fundamentals of robotic programming, simulation, and system integration, and explores their applications in the development of robotic systems. It will introduce the key languages used in robotic programming to communicate to the PC/SBC/microcontroller/PLC inside a robot to perform a specific application using actuators and feedback from various sensors to initiate applications such as pick and place of objects, automating repeated tasks etc. It will explain the importance of simulation to create a digital representation (digital twin) to enable dynamic interaction with robotics models in a virtual environment to efficiently engineer robotics-based automated production systems prior to the commissioning phase of a project. It will set out the benefits of robotics integration in realising efficiencies in the manufacturing process with respects to production costs, material handling, shipping, inspection lines etc and in achieving consistency, accuracy, repeatability, and speed-to-market.

Unit 2: Robotic Automation

This unit will explore the fundamentals of robotics and automation technologies. It covers the basics of robotics and automation, including programming and control systems, sensors and actuators, and robotic platforms. It also introduces the concept of artificial intelligence (AI) and its applications in robotics, presenting several AI algorithms and their implementation. It will introduce apprentices to Robot

Operating Systems and Control Software and outline the function of robotic programming, including the use of sensors and actuators, the programming of motion and behaviours, and the use of algorithms for decision-making and will present the leading programming languages in use. It will conclude with an overview of the current state of robotics and automation, as well as their potential future applications.

Unit 3: Robotic Programming in Advanced Manufacturing Environments

The unit will present robotic programming in manufacturing environments including integration with peripheral equipment and End of Arm Tools (EOAT's) into the overall manufacturing systems and production environment. The unit will outline and explain the five major robotics fields of operator interface, mobility or locomotion, manipulators and effectors, programming, sensing, and perception. Apprentices will learn how to program robots to perform basic tasks, as well as more complex behaviours utilising the development software in its IDE (Integrated Development Environment). The unit also addresses topics such as system integration, debugging, and troubleshooting. It examines system crashes, fault isolation and the debugging of failures and how to develop avoidance strategies. In gaining an appreciation of robotic programming apprentices will apply their knowledge to create robotic applications. This unit will also provide apprentices with the skills necessary to carry out robot programming using the teach pendant.

Unit 4: PLC/Robotics communications protocols and integration

This unit examines the principles and techniques for integrating programmable logic controllers (PLCs) and robots into communication networks. It will provide apprentices with a comprehensive overview of the various communication protocols and integration techniques used in configuring Programmable Logic Controllers (PLCs) and robotics systems. Topics to be covered include the basics of PLC/robotics programming, communication protocols such as Ethernet, Modbus, and CANbus, the integration of PLCs and robots with other devices, and the development of custom communication protocols. Apprentices will gain practical experience designing and implementing communication systems for PLCs/robots, as well as troubleshooting and debugging existing systems. Upon completion, apprentices will have the necessary skills to effectively configure PLC/robotics communications protocols and integration. Apprentices learn to design, configure, and troubleshoot communications networks and protocols, as well as develop and implement integration solutions.

Unit 5: Principles of Robotic Simulation

This unit will provide apprentices with an understanding of the principles of robotic simulation and the use of simulation environments for offline programming of robots and the optimisation of systems and robots outside of a production environment. It will cover topics such as robotic modelling, kinematics and dynamics, motion planning and control systems. Apprentices will gain an understanding of the fundamentals of robotic simulation and will be able to develop and test robotic systems using a range of software tools. The unit will demonstrate relevance of simulation to test robotic components prior to commissioning and will profile leading simulation software.

Unit 6: Robotic System Integration

This unit will demonstrate the importance and necessity to effectively integrate different systems and applications covering topics such as system design, architecture, data structures, communication protocols, and software development. It will also discuss the integration of robotic systems into existing systems. Through classes, practical exercises, and case studies, apprentices will learn how to identify, design, and implement an integrated system and the

related safety considerations. They will also explore the challenges of system integration, such as data security, scalability, and reliability. They will learn how to identify key mistakes in system integration and how to develop avoidance strategies. The unit will review the installation and commissioning of robotic systems. The unit will also cover the factors needing consideration when selecting a System Integrator. Apprentices will gain an understanding of the importance of system integration and its role in creating a successful business environment.

Unit 7: Functional Safety

This unit will introduce the relevant International Safety Standards which requires implementation of a FSM (Functional Safety Management) system to provide an organisational framework for the development of safety-relevant electrical, electronic, and programmable safety-related systems. The unit will present the tasks and methods involved in safety management and introduce the concept of functional safety, expressed in terms of safety integrity levels (SILs). These will be placed in context, along with risk assessment, likelihood of fatality and the cost of conformance. The life-cycle approach, together with the basic outline of IEC 61508, will be explained. The unit will describe the two aspects of safety-integrity targets: quantitative targets, where the frequency of hardware failures is predicted and compared with a tolerable risk target and qualitative targets, where the occurrence of systematic failures is minimised (e.g. software errors). The unit will describe the certification and demonstration of conformance to the standard. The unit will also signpost industry certification such as the TÜV Rheinland Functional Safety Training Programme for apprentices/employers interested in pursuing these certifications which are outside the scope of the apprenticeship programme.

Learning Outcomes:

On successful completion of this module, learners will be able to:

1. Outline robotic programming, simulation and system integration and benefits they deliver in the manufacturing process
2. Describe the fundamentals of robotics and automation, including programming, control systems, sensors, actuators, robotic platforms and the application of AI.
3. Demonstrate how to programme and modify robotic movements using leading vendor specific and open-source programming and a teaching pendant.
4. Discuss how to integrate and control a robot cell using an industrial PLC and industry standard communications protocols.
5. Explain the relevance of robotic simulation and its use and outline the leading simulation software employed.
6. Describe the key steps of the system integration cycle and the factors needing consideration when selecting a System Integrator.
7. Describe the commissioning process for an integrated robotics system.
8. Outline the International Safety Standard IEC 61508 and key aspects of Functional Safety Management systems.

MODULE EIGHT

Equipment Control, Automation and Actuation

This module will provide the apprentice with an understanding of industrial control systems and their key constituent components. The module will also provide the learner with a clear understanding of how industrial controls systems are used to control, adapt, and maintain the stability of manufacturing operations. The apprentice will gain the skills necessary to approach troubleshooting these systems in a systematic manner when operational issues arise.

Indicative Syllabus:

Unit 1: Industrial Control Systems, Operations, Customisation, and Evolution in Manufacturing Environments.

This unit will present on overview of Industrial Control Systems (ICS), their history and their evolution from simple systems to complex ones. It will describe Operational Technology (OT) and the benefits/ challenges of its integration with Information Technology (IT) systems. Apprentices will learn how an ICS can refer to any device, network, or system and the associated instrumentation that is used to operate or automate common industrial processes. The unit will cover the application of ICSs and how they are used in a range of industrial sectors and in critical infrastructure industries, including energy, manufacturing, transportation, and water treatment. It will explore the types of ICSs and their components, how they vary in size and complexity, and how they are built with different industries and different tasks in mind. Finally, it will introduce the main classes of industrial control systems e.g. SCADA, DCSs, PLCs and examine how they are used and combined.

Unit 2: Programmable Logic Controllers, Inputs/Outputs, Programming Methods and Troubleshooting Techniques.

This unit is designed to provide apprentices with an understanding of the hardware and software components of Programmable Logic Controllers (PLCs). Apprentices will learn about the various types of inputs and outputs devices associated with programmable logic controllers (PLCs), as well as the various programming methods used to control them. The unit will cover topics such as digital and analogue inputs and outputs, input/output wiring and configuration, and programming techniques. It will also provide an overview of the main components to the different types of PLCs and functions. Apprentices will also gain practical experience in programming and configuring inputs and outputs in a PLC system. Upon completion of this unit, apprentices should be able to identify and configure inputs and outputs in a PLC system, as well as programme and troubleshoot PLC systems. By the end of the unit, apprentices should have a comprehensive understanding of PLCs and their associated hardware and software components.

Unit 3: Sensors for industrial systems and robotics.

This unit introduces the principles of sensors and transducers and their application in industrial systems and robotics. It covers topics such as types of sensors, sensor characteristics, sensor principles, sensor selection, signal conditioning, and sensor interfacing. The unit also discusses the various types of industrial systems and robotics, their applications, and the role of sensors in these systems. Practical applications and examples of sensors used in industry will be discussed.

The unit will introduce the primary types of light sensors used in robotics namely photoresistors and photovoltaic cells as well as the less common CCDs, phototubes, phototransistors and explain a range of other types of sensors in general use such as Temperature Sensor, Proximity Sensor, Accelerometer, IR Sensor (Infrared Sensor), Pressure Sensor, Light Sensor, Ultrasonic Sensor, Smoke, Gas and Alcohol Sensor etc. It will explain the most used sensors for industrial robots namely two-dimensional visual sensors, three-dimensional visual sensors, force/torque sensors, and collision detection sensors. On completion apprentices will have attained the knowledge and skills to design, develop and implement sensor systems in industrial and robotic systems.

Unit 4: Industrial Actuation and Deterministic Control and Operation

This unit covers topics such as the fundamentals of industrial actuation, control systems, sensing and feedback, and deterministic control. In addition, the unit will explore the types and use of actuators in industrial applications, including the selection, installation, and maintenance of actuators. Apprentices will gain an understanding of the various types of actuators, their control characteristics, and the various control algorithms and strategies used in industrial operation. The unit also covers topics such as the design of industrial actuation systems, the selection of components for industrial actuation systems, and the integration of actuation systems with other manufacturing systems. In addition, the unit provides an in-depth understanding of the principles of deterministic control, their application in manufacturing processes, and the importance of system optimisation. The unit will also include practical exercises to reinforce the concepts and principles covered. At the end of the unit, apprentices should be able to design, implement, and optimise industrial actuation and deterministic control systems in manufacturing operations.

Unit 5: Factory Cloud and Edge Compute in Industrial Control Systems.

This unit provides a comprehensive introduction to the use of cloud and edge computing in industrial control systems. It covers the fundamentals of cloud and edge architectures, cloud and edge services, and the use of cloud and edge computing in industrial control systems. The unit begins with an overview of cloud and edge computing and their differences, followed by a discussion of the advantages and disadvantages of using cloud and edge computing in industrial control systems. It then focuses on the different types of cloud and edge services available, such as Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), and Software-as-a-Service (SaaS). It also covers the different types of industrial control systems and their applications, such as process control, machine learning, and predictive analytics. The unit also covers the integration of cloud and edge computing with industrial control systems, such as the use of cloud and edge services for data storage, data processing, and communication. The unit enables apprentices to connect to cloud-based resources and to utilise them to monitor and control industrial processes in a secure and reliable manner. It provides apprentices with the knowledge and skills to develop and deploy applications that are tailored to specific industrial control needs. Additionally, it provides a platform for the analysis of data from the cloud and edge computing environment, allowing apprentices to gain insight into a variety of industrial processes. The unit provides tools and instruction for the management and maintenance of cloud and edge computing systems, showing apprentices how to optimise industrial control systems for maximum efficiency. Finally, the unit provides an overview of the security issues associated with cloud and edge computing in industrial control systems.

Unit 6: Software Tools and Developing Applications for Equipment Control and Monitoring.

This unit will provide apprentices with an introduction to the fundamentals of software development for equipment control and monitoring and discuss the importance of software development in the manufacturing process. Apprentices will learn about the different types of software tools and languages used to develop applications for controlling and monitoring equipment. The unit will cover topics such as software design, programming, debugging, and testing. The unit will cover the fundamentals of software development, including the purpose and use of different software development tools and languages. Topics discussed will include the basics of software development, such as coding, debugging, and testing, as well as more advanced topics such as object-oriented programming and software architecture. The unit will also provide an overview of the different of software development tools and languages used in the manufacturing industry, as well as the advantages and disadvantages of each. The unit will provide practical exercises and demonstrations to help apprentices understand the concepts and apply them to their own projects. By the end of the unit, apprentices should be able to develop their own applications for controlling and monitoring equipment.

Unit 7: Troubleshooting Skills and Methodologies for industrial Control Systems.

This unit will provide apprentices with a comprehensive understanding of troubleshooting skills and methodologies for industrial control systems. It will discuss the various troubleshooting techniques used to identify and resolve problems within industrial control systems. It will cover topics such as common industrial control system components and their functions, troubleshooting techniques for identifying and resolving system faults, and strategies for troubleshooting system hardware and software. It will also cover the basics of fault tree analysis and how it can be used to identify and resolve system faults. Additionally, the unit will discuss the importance of preventive maintenance and the use of automation to reduce downtime and improve system reliability. Finally, it will provide an overview of safety and security considerations when troubleshooting industrial control systems. Apprentices will learn how to identify and diagnose common problems, utilise simulation tools to evaluate system performance and identify potential issues as well as how to develop strategies to prevent future issues. The unit will also cover best practices for documenting problems, as well as how to effectively communicate with system operators and technicians. Upon completion, apprentices will have a thorough understanding of troubleshooting skills and methodologies for industrial control systems.

Learning Outcomes:

On successful completion of this module, learners will be able to:

1. Describe the various types of industrial control systems and their components and explain how they are used to operate or automate a wide range of industrial processes.
2. Identify the hardware and software components of PLC systems; configure their inputs and outputs; and show how to programme, configure and troubleshoot them.
3. Explain the key principles of industrial sensors and transducers and how they are used in industrial manufacturing and robotic systems.
4. Describe the use of cloud and edge computing in industrial control systems and how to optimise their use and avoid potential security issues in industrial control systems.
5. Design, implement, and optimise industrial actuation and deterministic control systems in manufacturing operations.
6. Outline different types of software tools and languages used to develop applications for controlling and monitoring equipment and show how to develop a simple application.
7. Discuss key techniques and practices used to identify and resolve faults in industrial control systems and how preventive maintenance and automation can improve reliability.

MODULE NINE

Work Based Capstone Project

This module will provide the learner with an opportunity to undertake a Work Based Capstone Project. This project will integrate theory and practice, enabling apprentices to gain deeper knowledge through exploring real-world challenges and problems in the workplace – and designing practical solutions to those problems. Such a project will involve an element of change management and critical thinking, requiring the apprentice to manage a project through various stages or milestones to achieve agreed objectives as set out in a Work Based Capstone Project Brief. An Overview of the Work Based Project is contained in Appendix 1.

Indicative Structure and Content:

The Work Based Capstone Project provides apprentices with a safe environment in which they can engage in experimentation, experience setbacks, acquire knowledge, develop communication skills and create outcomes. Apprentices can develop a proactive approach to learning, equipping themselves to effectively address challenges and opportunities in a real-world setting. The Work Based Capstone Project cultivates critical thinking skills, effective collaboration abilities, innovative approaches to problem-solving and an enthusiasm for learning.

The Work Based Capstone Project will require a degree of independent working by the apprentice, especially in the initial stages of scoping out suitable projects based on organisational need and strategy. While we encourage the employer mentor to help the apprentice locate a suitable project in the organisation, we expect the apprentice to take ownership early in the process and to scope out and explore the topic or issue in detail as they draft the Project Brief.

The Work Based Capstone Project is an excellent vehicle through which an apprentice can develop and practice a range of critical skills and behaviours (e.g. decision making, negotiation, communication etc) and in turn provide valuable evidence for assessment thus contributing towards the attainment of their certification.

The Work Based Capstone Project is carried out after the off-the-job learning phases are completed. It commences in month seventeen and continues for a seven-month period concluding in month twenty-three upon submission of the Final Project Report. The employer will arrange for the apprentice to carry out the Work Based Capstone Project on-the-job over a 30-week period spending one day per week on this activity supported by their Employer Mentor.

A Work Based Capstone Project 'lifecycle' will be highly dependent on the nature of the individual project and how it fits with the wider organisational planning of the employer. Work based projects allow the apprentice to demonstrate critical skills throughout the entire project life cycle. Guidelines for the Work Based Capstone Project:

- **Define:** a clear purpose or goal is defined based on a valid business problem or case. Clear objectives and deliverables are set which are aligned to strategic aims.
- **Design:** a plan of work is constructed which might include visual plans, terms of reference, assumptions and consequences, stakeholder engagement and financial plans. Controls and milestones are clearly outlined prior to the start of a project.
- **Do:** on-project activities are undertaken and there is evidence of analysis and reflection on how these contributed to the achievement of the project purpose or goals. Decisions are taken and controls utilised.
- **Review:** project delivery and outcomes are analysed and reviewed. Barriers and challenges to success, and strategies used to overcome these, are analysed.

The Work Based Capstone Project Brief

The Work Based Capstone Project Brief is a short document that describes the project and its objectives. It contains the following sections:

i) Employer name and profile

ii) Overview of the project

iii) Project Objectives

iv) Schedule

v) Controls and milestones

vi) Scope of the project

vii) Final report: structure and contents

The Work Based Capstone Project Brief will be approved by the AMTCE Project Supervisor and the Employer Mentor before commencement of the project.

Learning Outcomes:

On successful completion of this module, learners will be able to:

1. Demonstrate the capacity to complete a Work Based Project through independent working which shows practitioner knowledge, skills and competency in the robotics and automation field.
2. Apply project management approaches, critical thinking skills, effective collaboration abilities, innovative approaches to problem-solving and negotiation & communication skills.
3. Produce a Work Based Capstone Project report which demonstrates attainment of a Project Brief encapsulating a proactive approach to learning, reflection and development.

APPENDIX 1

Overview of the Work Based Project for the Robotics and Automation Apprenticeship

1. Introducing the Work Based Capstone Project

The Work Based Capstone Project integrates theory and practice, enabling apprentices to gain deeper knowledge through exploring real-world challenges and problems – and designing practical solutions to those problems. Such a project will involve an element of change management and require the apprentice to manage a project through various stages or milestones to achieve agreed objectives as set out in a Work Based Project Brief.

It provides apprentices with a safe environment in which they can engage in experimentation, experience setbacks, acquire knowledge, develop communication skills and create outcomes. Apprentices can develop a proactive approach to learning, equipping themselves to effectively address challenges and opportunities in a real-world setting. The Work Based Project cultivates critical thinking skills, effective collaboration abilities, innovative approaches to problem-solving and an enthusiasm for learning.

The Work Based Project will require a degree of independent working by the apprentice, especially in the initial stages of scoping out suitable projects based on organisational need and strategy. While we encourage the employer mentor to help the apprentice locate a suitable project in the organisation, we expect the apprentice to take ownership early in the process and to scope out and explore the topic or issue in detail as they draft the Project Brief.

The Work Based Project is an excellent vehicle through which an apprentice can develop and practice a range of critical skills and behaviours (e.g. decision making, negotiation, communication, etc.) and in turn provide valuable evidence for assessment thus contributing towards the attainment of their certification.

1.1 Duration and Extent of the Work Based Project

The Robotics and Automation Apprenticeship programme consists of four phases.

- Phase 1: Introducing Robotics & Automation
- Phase 2: Industrial and Control Systems
- Phase 3: Transversal Skills
- Phase 4: Work Based Project

The Work Based Project is carried out after the three off-the-job learning phases are completed. It commences in month seventeen and continues for a seven-month period concluding in month twenty-three upon submission of the Final Project Report. The employer will arrange for the apprentice to carry out the Work Based Project on-the-job over a 30-week period spending one day per week on this activity supported by their Employer Mentor.

1.2 The Work Based Project Brief

The Work Based Project Brief is a short document that describes the project and its objectives. It contains the following sections:

I. Employer name and profile
II. Overview of the project
III. Project Objectives
IV. Schedule
V. Controls and milestones
VI. Scope of the project
VII. Confidential employer information (if applicable)
VIII. Final Project Report: structure and contents
IX. PowerPoint Presentation: structure and contents

Some information accessed or compiled by the apprentice during the Work Based Project activity, and contained in the Final Project Report, may be deemed confidential or proprietary by the employer. Section VII of the Work Based Project Brief will set this out, if applicable, and will state the Final Project Report sharing restrictions and rules that will apply, as agreed by the AMTCE Project Supervisor and the Employer Mentor.

The Work Based Project Brief will be approved by the AMTCE Project Supervisor and the Employer Mentor before commencement of the project.

1.3 Assessment of the Work Based Project

The Work Based Project contributes a maximum of 20% of the overall marks for the award. The Project Supervisor will assess the Work Based Project by evaluating the Final Project Report, covering the project implementation and outcomes attained, against the Work Based Project Brief and the module learning outcomes as outlined below.

a) Demonstrate the capacity to complete a Work Based Project through independent working which shows practitioner knowledge, skills and competency in the robotics and automation field.

b) Apply project management approaches, critical thinking skills, effective collaboration abilities, innovative approaches to problem-solving and negotiation & communication skills.

c) Produce a Work Based Project report which demonstrates attainment of a Project Brief encapsulating a proactive approach to learning, reflection and development.

1.4 Work-based Project Parameters

a) The project will be completed by the apprentice at the employer's premises or specialist location based on the project plan

b) There will be an appropriate Employer Mentor who will oversee and support the apprentice during the project delivery

c) Apprentices will be allocated an AMTCE Project Supervisor who will support and help underpin the project with relevant theories or approaches

d) The project will be largely completed as part of the apprentice's normal working day

2. Principles Relating to the Work Based Project

2.1 Team projects and long-term projects

If the apprentice is completing a project as part of a wider project team, then they should discuss the project with the AMTCE supervisor to ascertain if the topic is appropriate and that there is sufficient scope to justify an individual project. The project must enable the apprentice to demonstrate that they have made an impact on the project and that they contributed to the definition, design and management of the project.

Similarly, the work-based project may also be part of a broader or longer-term organisational project that extends beyond the time constraints of a particular unit. Once again, in these cases the apprentice should discuss the project with their AMTCE project supervisor or unit leader. In these cases, we request apprentices to identify the 'slice' or section of the project for which they are responsible and outline their individual contribution in terms of the project definition, design, delivery and review for their particular stage of ownership.

2.2 Managing Risk and Ethical Considerations

When considering each project topic, apprentices should ensure that they have buy-in from their employer to ensure they are able to investigate, research and explore their selected topic in detail. In addition, apprentices will need to consider the ethical implications of their project as outlined below:

- The project should do no harm – which includes emotional and mental distress, and financial, social and professional standing.
- Ensure anonymity is preserved throughout by complying with your own organisation rules surrounding data and confidentiality. If in doubt check with the data controller and seek appropriate approval.

There may be some topics that will require further ethical considerations prior to any approval being granted by the AMTCE, for example, if your research for the work-based project requires participation of those under the age of 16 or adults lacking the capacity to provide consent. It is important that apprentices discuss their ideas early in order to facilitate the smooth navigation through the applicable ethical approval process.

All projects will require sign-off from an employer representative.

3. Guidelines for the Work Based Project

Throughout the programme, apprentices will be encouraged to critique and reflect on different project management approaches and methodologies.

All projects are unique, and when designing their project, apprentices will be requested to identify an approach which is suitable to their individual project requirements, conditions and management style.

Therefore, what constitutes a project 'lifecycle' will be highly dependent on the nature of the individual project and how it fits with the wider organisational planning. Work-based projects should allow the apprentice to demonstrate critical skills throughout the entire project life cycle.

- **Define:** a clear purpose or goal is defined based on a valid business problem or case. Clear objectives and deliverables are set which are aligned to strategic aims.
- **Design:** a plan of work is constructed which might include visual plans, terms of reference, assumptions and consequences, stakeholder engagement and financial plans. Controls and milestones are clearly outlined prior to the start of a project.
- **Do:** on-project activities are undertaken and there is evidence of analysis and reflection on how these contributed to the achievement of the project purpose or goals. Decisions are taken and controls utilised.
- **Review:** project delivery and outcomes are analysed and reviewed. Barriers and challenges to success, and strategies used to overcome these, are analysed.

4. Topic Selection and Project Scope

When selecting an appropriate topic for the work-based project, apprentices should first consider the emerging issues, problems and opportunities for practical improvements in their organisation.

Work-based Projects need to provide apprentices with sufficient opportunity to make a real contribution or practical improvement to their organisation or its processes, through what they do and/or learn. Therefore, projects should be substantial pieces of original work. However, apprentices should be realistic with the scope and expectations of the project when selecting a suitable topic. Asking the questions below, may assist with this process:

- What are the current issues and challenges being faced by the organisation or within the wider sector? Are there new initiatives that could be tested or processes that could be improved?
- What are the growth plans for your organisation and what would assist this growth?
- What risk factors could have an impact on business success?
- What new solutions could be implemented to solve problems that have been identified?
- Is the project suitably aligned with the level of study e.g. practical, hands-on?

5. Project Support

Apprentices are expected to take the lead on work-based projects, however the support offered by mentors and AMTCE supervisors in relation to work-based projects is outlined below.

5.1 Employer Mentor Involvement

M: Meet regularly with apprentices and plan ahead to ensure dates are scheduled for reviewing project milestones and review of deliverables.

E: Encourage apprentices through the whole project, helping them to identify barriers to success and strategies for overcoming these. Not all projects will run smoothly, and you can provide a valuable sounding for apprentices when things go awry.

N: Negotiate project topics and scope with apprentices to ensure that they link to their organisation and have clear and meaningful impact. Ensure that the complexity of the project enables the apprentice to apply knowledge and demonstrate a range of practical skills and behaviours that align with the Robotics and Automation Apprenticeship programme.

T: Target development areas and guide apprentices on resource or training information for the required knowledge, skills and behaviour gaps to be addressed.

O: Offer ongoing support and attend progress reviews and other manager and mentor information sessions to share best practice and stay up to date with requirements and developments.

R: Remind apprentices about positive time management. This is key and managing this is a skill apprentices should demonstrate as part of any project.

S: Signpost apprentices to helpful information, share knowledge and expertise in relation to the organisation and enable apprentices to gain access to relevant internal resources and information.

5.2 Project Supervisor – allocated by the Training Centre

Apprentices will be allocated an instructor by AMTCE who will act as their work-based Project Supervisor. Apprentices are encouraged to be pro-active and seek the support of their project supervisor. As part of their role supervisors will:

- Talk over ideas with apprentices
- Suggest reading materials and resources
- Help with structuring, write-up and particular unit requirements
- Agree objectives and targets
- Offer 1-to-1 supervisions for the project
- Offer remote support via telephone/ email (where appropriate)

6. A Synoptic Project

In the last eight months of the programme, apprentices will undertake the Work Based Project, which is a large-scale synoptic project, and this substantial piece of work will be assessed as a key element of the formal apprenticeship qualification.

The Work Based Project is called synoptic because it is the accumulation of the apprentices' knowledge, skills and behaviours which have been developed across the apprenticeship learning journey. Synoptic assessment is an important because it shows that apprentices have achieved a holistic understanding of their sector and that they can make effective connections between different aspects of the subject content and across the breadth of the assessment objectives in an integrated way.

The Work Based Project should be a practical and beneficial piece of work aligned to organisational plans and goals that demonstrates and develops a broad range of applied, critical and project management skills.

Due to the significance and extent of the Work Based Project, apprentices and employers are encouraged to engage in discussions about suitable projects early in the apprenticeship.

WE ARE HERE TO SUPPORT YOU AND THE APPRENTICE ON THIS EXCITING JOURNEY

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