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## ROBOTICS AND AUTOMATION APPRENTICESHIP (RAA)

### Book of Modules

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V11 - August 2024

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# RAA Program Structure

The proposed program comprises of 9 modules with a total FET credit value of 150. The breakdown of the FET credits by module is shown in the table below.

Module Title	NFQ Level	FET Credits
RAA Module 1: Introduction to Advanced Manufacturing and Industry 4.0/5.0 Technologies and Application	6	15
RAA Module 2: Personal & Professional Career Development	6	15
RAA Module 3: Maths for Advanced Manufacturing	6	10
RAA Module 4: Digitisation of Manufacturing Operations	6	15
RAA Module 5: Robotics Fundamentals, Operations and Automation	6	15
RAA Module 6: Industrial Systems and Operations and Workshop Skills	6	15
RAA Module 7: Robotic Programming/Simulation, System Integration and Functional Safety	6	15
RAA Module 8: Equipment Control, Automation and Actuation	6	15
RAA Module 9: Work Based Project	6	30
<b>Total FET Credits</b>		<b>145</b>

# RAA Module 1

Full Title	<b>Introduction to Advanced Manufacturing and Industry 4.0/5.0 Technologies and Application</b>		
NFQ Level	6	Start Term	
Status	Draft	FET Credits	15
Authors	RAA Consortium	Duration	

## Module Description

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 outlines the impact of Industry 4.0 and Industry 5.0 on manufacturing and economic development. It highlights the digitization of manufacturing, the adoption of new technologies, and improvements in productivity, flexibility, resource efficiency, and sustainability. Additionally, it examines Industry 5.0's emphasis on human-centric and enabling technologies.

### **Unit 2: Overview of Workshop Skills and Practices**

This unit outlines essential manufacturing methods such as turning and milling, emphasizing their critical roles in the production of parts and Units in the manufacturing process. It also introduces a practical element, demonstrating the hands-on use of these manufacturing techniques.

### **Unit 3: 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. Apprentices will be able to conduct quality checks on a process line to identify and reduce variation.

### **Unit 4: Lean Manufacturing and Assembly Systems**

This unit covers key manufacturing and assembly concepts such as production rate, capacity, and buffers, supported by industry examples and case studies. It also introduces lean methodologies, such as but not limited to Just-In-Time (JIT) and 5S, focused on minimizing waste and maximizing productivity.

### **Unit 5: Manufacturing Cost**

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

### **Unit 6: 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 7: 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 automation 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.

### **Unit 8: 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. It covers essential topics such as health and safety legislation, employer/employee responsibilities, and the correct use of personal protective equipment (PPE). The unit also addresses safety practices for manual handling, working at heights, abrasive wheels, electrical/mechanical systems, chemical handling, pharmaceutical production standards and clean room protocols. Emphasis is placed on creating a safety culture, conducting risk assessments, and managing techniques to identify and mitigate safety and environmental hazards, all in line with current Irish industrial standards.

### **Learning Outcomes**

1. Describe the evolution of advanced manufacturing and the impact of emerging technologies.
2. Explain the key workshop functions, equipment, and their application in the manufacturing process.
3. Produce components for use in a typical assembly line process.
4. Present quality control systems and the use of statistical methods for analysing, monitoring, and controlling process variation.
5. Conduct quality checks on a process line to identify and capture data relating to variations to a process.
6. Summarise key manufacturing and assembly concepts, and the importance of lean methodologies in the production process.
7. Implement lean strategies and tools to identify and reduce waste in manufacturing and assembly processes.
8. 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.
9. Explain the circular economy and the contribution of digitisation to the sustainability of the manufacturing.
10. Outline the application of Robotics Automation across Advanced Manufacturing Sectors

11. Demonstrate the fundamentals of Environmental, Health and Safety (EHS) principles, practices, legislation, regulation, and standards in advanced manufacturing.

# RAA Module 2

Full Title	<b>Personal &amp; Professional Career Development</b>		
NFQ Level	6	Start Term	
Status	<b>Draft</b>	FET Credits	
Authors	<b>RAA Consortium</b>	Duration	<b>15</b>
<b>Module Description</b>			
<p>This module will provide the apprentice 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. 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 apprentice with an understanding of the legislation and associated obligations necessary for a safe working environment and will equip the apprentice with an understanding of the characteristics of a functional safety culture.</p>			
<b>Indicative Syllabus</b>			
<p><b>Unit 1: Communications in the Professional Workplace</b></p> <p>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.</p>			
<p><b>Unit 2: Personal Development and Goal Setting</b></p> <p>Through this unit, participants will learn to recognize 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, 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.</p>			

### **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. The unit will show how to be agile and adaptable in the face of changes and challenges in the workplace. It will explore how to successfully work with remote teams, covering the adoption of a shared vision and understanding, and strategies for collaboration and problem solving.

### **Learning Outcomes**

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. Apply teamworking skills to lead and motivate others, co-operate in the delegation of tasks, setting of team goals, and adoption of a shared vision.

# RAA Module 3

Full Title	Maths for Advanced Manufacturing	Start Term
NFQ Level	6	FET Credits
Status	Draft	Duration
Authors	RAA Consortium	10

## Module Description

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 algebra, numerical methods, geometry, trigonometry, statistics, 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 apprentices will display a level of competency and application of mathematical computation necessary to realise engineering solutions as required.

At the programming planning stage in which teaching, learning and assessment strategies are being reviewed and formalised, instructors will liaise with colleagues to establish linkage whereby the application of the maths techniques may be incorporated through case studies or practical exercises.

## 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 (binomial, 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 optimize the manufacturing process.

#### **Learning Outcomes**

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 optimize the manufacturing process.

# RAA Module 4

Full Title	Digitisation of Manufacturing Operations		
NFQ Level	6	Start Term	
Status	Draft	FET Credits	
Authors	RAA Consortium	Duration	15
<b>Module Description</b>			
<p>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 apprentice with an understanding of the key technology building blocks and principles in the digital transformation of manufacturing operations.</p>			
<b>Indicative Syllabus</b>			
<p><b>Unit 1: Overview of Digitisation of Manufacturing Operations</b></p> <p>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. 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.</p>			
<p><b>Unit 2: Processes for Digitisation</b></p> <p>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 Units 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.</p>			

### **Unit 3: 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), 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 several types of microcontrollers, and the basic principles of their operation. They will also be introduced to the distinct 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 hands-on 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 implement, and debug simple microcontroller-based systems. Through a series of lectures, 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 4: 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 orientated 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 5: 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 Units 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 various 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 6: 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. 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 hands-on 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 the art in AR and VR technologies and discuss the potential for future applications.

### **Unit 7: 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.

### **Unit 8: 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.

## Learning Outcomes

1. Discuss the 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 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. Apply up to date VR/AR technologies to provide solutions to a given application
9. Show an in-depth appreciation of the benefits and challenges associated with the digitisation of manufacturing enterprises and outline strategies for their successfully application.
10. Demonstrate how to design and build Industrial Electrical Systems.

# RAA Module 5

Full Title	Robotics Fundamentals, Operations and Automation	
NFQ Level	6	Start Term
Status	Draft	FET Credits
Authors	RAA Consortium	Duration

## Module Description

This module will provide the apprentice 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 realized 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 optimizing their use. It also provides a detailed look at the different use cases, including industrial automation, assembly, welding, additive manufacturing, machine tending, palletizing and more. The unit will introduce mobile robotics, covering Mobile Logistical Robots/ Autonomous mobile robots (AMRs)/ Automated Guided Carts (AGCs)/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 diverse types of robotic axes and the DOF associated with them. It then covers motion control techniques, and the distinct types of motion control systems used in robotics. The unit then explains repeatability and the different methods used to measure and maintain it. The unit then covers drive systems, and the several types of motors used to power robotic systems. Finally, the unit covers controller systems, and the several types of controllers used in robotics. Apprentices will gain an understanding of the different Units 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 diverse types of end effectors available and their associated features, as well as the safety considerations that must be considered when using them. Finally, the unit will provide hands-on 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, program and debug robot motion, and use teach pendant to program 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 diverse 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 to use robots and cobots safely and effectively in an industrial setting.

### Learning Outcomes

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

# RAA Module 6

Full Title	Industrial Systems and Operations and Workshop Skills	
NFQ Level	6	Start Term
Status	Draft	FET Credits
Authors	RAA Consortium	Duration

## Module Description

This module is designed to equip the apprentice with the knowledge and practical hands-on skills required to operate, maintain, calibrate, troubleshoot, and upgrade industrial systems and their subsystem component. The apprentice will gain an understanding of the fundamental workings and applications of Electro Pneumatic Systems, Industrial Electrical Systems, and Industrial Mechanical Systems. Mechanical engineering principles and machining techniques, including CNC operations, will be delivered using a practical hands-on approach, enabling apprentices to operate and maintain mechanical systems effectively. Additionally, apprentices will be gaining practical experience at utilizing digital technologies such as CAD, CAM, and 3D Printing, applying these tools to modernize and optimize manufacturing processes. They will also become proficient in measurement systems and calibration, crucial for accurate system installation and maintenance. Through comprehensive training in system management and integration, apprentices will develop the ability to streamline and optimize industrial systems, ensuring reliability and efficiency. The module further provides insight into various manufacturing processes, including injection moulding, thermoforming, casting, and additive manufacturing, equipping apprentices with a broad understanding of diverse production techniques. The module will also provide the apprentice 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 distinct 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. 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 hands-on 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 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 several types of mechanical systems and their components. Topics such as mechanics of machines, machine design, fabrication, and maintenance will be covered. Practical applications such as 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 4: Technology Utilisation in Digitisation**

This unit will provide apprentices with an introduction to the use of 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 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 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 hands-on 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 maximize efficiency. The unit focuses on managing, controlling, and optimizing 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.

### **Unit 8: Summary of other key manufacturing processes**

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

- i) Injection moulding is 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.

### **Learning Outcomes**

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 Mechanical Systems.
5. Produce a Pneumatic/Electrical Schematics using a 2D CAD System
6. Produce 3D models and assemblies using SolidWorks or a similar 3D modelling package.
7. Produce a CAM program using MasterCAM or Similar package for practical use to be run on a CNC machine.
8. Design a 3D Solid model in SolidWorks or a similar 3D modelling package and produce the part on a 3D Printing machine.
9. Calibrate modern manufacturing equipment and recognise when equipment is out of calibration.
10. Outline the key principles and techniques relating to engineering workshop equipment and processes.
11. Produce small engineering parts using a range of common workshop machining equipment in a safe and effective manner.
12. Outline key manufacturing processes for component production, including injection moulding, thermoforming, sheet metal forming, casting, and additive manufacturing, and understand their applications and industry significance.

# RAA Module 7

Full Title	<b>Robotic Programming/Simulation, System Integration and Functional Safety</b>		
NFQ Level	6	Start Term	
Status	<b>Draft</b>	FET Credits	
Authors	<b>RAA Consortium</b>	Duration	<b>15</b>

## Module Description

This module will provide the apprentice with the technical understanding of how to programme robot operations in a manufacturing environment. The module will also provide the apprentice 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 relevant Functional Safety Standards.

## 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 Systems 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 hands-on 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 lectures, hands-on 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 FMS (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 Program](#) for apprentices/employers interested in pursuing these certifications which are outside the scope of the apprenticeship programme.

### **Learning Outcomes**

1. Explain how robotic programming, simulation and system integrations are used to enhance 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 using a practical example how to program and modify robotic movements using leading vendor specific and open-source programming and a teaching pendant.
4. Describe 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. State the International Safety Standard IEC 61508 and key aspects of Functional Safety Management systems.

# RAA Module 8

Full Title	Equipment Control, Automation and Actuation	
NFQ Level	6	
Status	Draft	
Authors	RAA Consortium	

## Module Description

This module will provide the apprentice with an understanding of industrial control systems and their key constituent components. The module will also provide the apprentice 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 an 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 several 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 units of Programmable Logic Controllers (PLCs). Apprentices will learn about the various inputs the distinct 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 several types of PLCs and functions. Apprentices will also gain hands-on 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 several 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 introduces the principles and applications of industrial actuation and deterministic control and operation. It 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 distinct 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 optimization. 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 optimize 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 several 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 several 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 optimize 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 several 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 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**

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. Develop and refine an industrial actuation and deterministic control system for manufacturing processes using a collaborative robot (cobot).
6. Describe key techniques and practices used to identify and resolve faults in industrial control systems and how preventive maintenance and automation can improve reliability.

# RAA Module 9

Full Title	<b>Work Based Project</b>	
NFQ Level	<b>6</b>	Start Term
Status	<b>Draft</b>	FET Credits
Authors	<b>RAA Consortium</b>	Duration <b>30</b>

## Module Description

This module will provide the apprentice with an opportunity to undertake a Work Based Project which is entirely anchored in the employer's workplace. 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 Project Brief. An Overview of the Work Based Project is contained in Appendix 1.

## Indicative Structure and Content

### Topic Selection for a Work Based Project

The Work Based Project is entirely anchored in the employer's workplace and is selected and defined with the guidance and approval of the employer. 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?

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.

## Work Based Project Scope

The Work Based 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 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.

### **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. Final report: structure and contents

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

### **Learning Outcomes**

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 Project report which demonstrates attainment of a Project Brief encapsulating a proactive approach to learning, reflection and development.

# APPENDIX 1

## ROBOTICS AND AUTOMATION APPRENTICESHIP (RAA)

### Overview of the Work Based Project

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#### 1. Introducing the Work Based Project

The Work Based 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.

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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 in order 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 AMTCE**

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.