MQF Level 7

AE7-01-21

Master of Science in Mechanical Engineering and Sustainable Technology

Course Specification

Course Description

This course covers modern technologies and will prepare the learner for the fast-developing area of engineering. It provides the foundations that will underpin ongoing professional development, preparing graduates for further study or for a career in an engineering related field or in other areas where the range of skills and knowledge acquired is needed or desirable. The learners will receive advanced study in both the theoretical and the practical aspects of engineering that builds on previous knowledge and experience. The learner will be given the opportunity to gain skills in the major engineering functions that will allow him to work in a senior technical or project management role within industry.

This course also covers subjects connected to industrial ecology. The learner is introduced to tools and knowledge that will enable them to apply technology in a more sustainable way.

The learner will be provided with modern academic and workshop facilities including specialist mechanical laboratory support run by qualified technicians, IT laboratories and a state-of-the-art technical library. Manufacturing facilities including CNC machining, 3D printing and rapid prototyping systems will also be made available.

Programme Learning Outcomes

At the end of the programme the students are able to;

1. *Evaluate critically problems and use professional skills and knowledge in the systematic development of complex engineering systems;*
2. *Communicate effectively with other science and engineering professionals and the wider global community using a wide range of communication technologies;*
3. *Understand the engineering fundamentals needed to generate a solution appropriate to the social, political, international, economic and environmental contexts in which they are applied;*
4. *Plan and execute a research project, applying relevant methodologies and knowledge;*
5. *Understand sustainable technologies, their components and interactions between the components.*

Entry Requirements

- Relevant degree;
- Applicants may be asked to sit for an interview

Current Approved Programme Structure

Unit Code	Unit Title	ECTS	Year
ETMEC-708-2104	Engineering Management	8	1
ETMEC-708-2105	Computational Fluid Dynamics	8	1
ETMEC-708-2106	Engineering Design & Manufacture	8	1
ETMEC-710-2107	Power & Propulsion Systems	10	1
ETMEC-710-2108	Low Carbon and Renewable Energy Systems	10	1
ETMEC-708-2109	Applied Materials and Corrosion	8	1
ETMEC-708-2112	Structural Analysis	8	1
ETMEC-708-2110	Quality Engineering	8	2
ETMEC-706-2111	Project Management	6	2
ETMEC-706-2113	Research Methods	6	2
ETMEC-740-2114	MSc Project	40	2
	Total ECTS	**120**	/

Unit: ETMEC-708-2104 Engineering Management

Unit level (MQF): 7
Credits: 8

Unit description

This study unit will introduce the learner to engineering management in the context of an organisation. The dynamically changing social, business and economic environment organisations live in, and the constant internal and external issues organisations face, make engineering management instrumental for an organisation to fulfil its mission and achieve its vision. This study unit aims at developing the required fundamental skills for engineering managers to be able to manage interrelated parts of the organisation's business in order to achieve its goals and objectives.

The engineering manager's functions of planning, organising, staffing, leading and controlling in different organisational complexity settings will be explored. This study unit will make the learner more aware that management is not simply common sense. Effective engineering management requires a combination of managerial, interpersonal and technical skills. Internationally recognised management system standards, which are widely used in private and public sector organisations, will be introduced to the learner. These standards present requirements related to organisational contextual analysis, leadership, planning, support, operations, performance evaluation and improvement.

The lectures will cover concepts, theories and frameworks to equip the learner with enhanced engineering management knowledge and skills. The study unit will focus on the contextual analysis of an organisation in an environment experiencing an accelerated rate of change; business strategy and planning aspects; organization structure and resource management; evidence-based decision making; performance management; and the control process. The core aspects and challenges of engineering management presented in this study unit will make the learner more prepared in terms of the ability to be a key player in sustaining and improving organisational performance.

Learning Outcomes

Upon completing the unit, learners should be able to:

1. *Discuss the management process, including the functions, role and skills of managers at different business levels in diverse organisational complexity settings.*
2. *Understand the concept of an organisation and describe the organisational context with a view to international aspects, workplace diversity, business ethics, environmental protection and social responsibility, amongst others.*
3. *Conduct a critical evaluation of the implications of management theories, and the use of tools and frameworks, whilst adapting them to implement the most appropriate solution depending on the management context.*
4. *Implement qualitative and quantitative techniques for evidence-based decision making, problem solving and planning.*
5. *Assess emerging technologies for effective engineering management aimed to enhance the performance of foreword looking organisations.*

Unit: ETMEC-708-2105 Computational Fluid Dynamics

Unit level (MQF): 7
Credits: 8

Unit description

This unit will introduce the student to the computational fluid dynamics (CFD) techniques and tools for modelling, simulating and analysing practical engineering problems related to renewable energy, with hands on experience using commercial software packages used in industry.

The unit is mainly bisected into four sections:

Introduction to CFD & thermo-fluids: introduction to the physics of thermo-fluids, governing equations (continuity, momentum, energy and species conservation) and state of the art computational fluid dynamics including modelling, grid generation, simulation, and high performance computing, case study of an industrial problem and the physical processes where CFD can be used,

Computational engineering exercise: specification for a CFD simulation, requirements for accurate analysis and validation for multi scale problems, introduction to turbulence & practical applications of turbulence models, introduction to turbulence and turbulent flows, traditional turbulence modelling,

Advanced turbulence modelling: introduction to Reynolds-averaged Navier-Stokes (RANS) simulations and large-eddy simulation (LES),

Practical sessions: offshore, process and motorsport energy problems involving flow around objects with various aerodynamic bodies (a variety of streamlined and bluff bodies) will be solved employing the widely used industrial flow solver software FLUENT. These practical sessions will cover the entire CFD process including grid generation, flow solver, analysis, validation and visualisation.

Learning Outcomes

On completion of this unit the learner will be able to:

1. *Analyse the relevance and application of CFD & fundamental principles of thermo-fluids dynamics.*
2. *Explain turbulence & practical applications of turbulence models.*
3. *Discuss the importance and application of advanced turbulence modelling (RSM) and (LES) and (DES) Models to solve complex dynamic engineering problems.*
4. *Apply commercial industrial CAD and mesh software to draw and mesh both 2D and 3D parts.*
5. *Apply commercial industrial solver and post-CFD software to solve and simulate CFD 2D and 3D case studies related to real engineering problems.*

Unit: ETMEC-708-2106 Engineering Design and Manufacture

Unit level (MQF): 7
Credits: 8

Unit description

This unit will introduce the student to Engineering Design & Manufacture. This means that the student will be able to advance his/her technical skills in industry prototyping design processes. This unit will also introduce the student to the workshops available at MCAST.

This unit is divided into four sections:

The first part of this unit will aid the student to improve his/her design thinking and creativity. By experiencing it individually, it will help the student to move forward and make use of collaborative innovation as well. The student will be able to understand the value and use of prototyping for innovation together with other firms and workmates.

The second part will be an introduction to Technology Readiness Levels (TRLs): Technology Readiness Levels (TRLs) is a method for understanding the maturity of a technology during its acquisition phase. TRLs allow engineers to have a consistent datum of reference for understanding technology evolution, regardless of their technical background. This will teach the student how to identify and write good requirements for design.

The third part of the unit will be specifically on hands-on use of professional CAD/CAE software: CAD stands for Computer Aided Design, which refers to using a computer to visualize a product idea. CAE stands for Computer Aided Engineering, which is the analysis of the designed visualization. In short, the difference between CAD and CAE can be put this way: CAD is for designing a product and CAE is for testing and simulating it.

Also the student will have the opportunity to improve his/her design skills through workshops by learning how to sketch, make use of CAD-CAM, doing specific tasks using Mechatronics, and build components using 3D printing.

The last part of this unit will assist the student to get knowledge of advanced materials and processes such as smart materials, nano and micro technologies and considering also additive manufacturing. Additive manufacturing uses data Computer Aided Design (CAD) software or 3D object scanners to direct hardware to deposit material, layer upon layer, in precise geometric shapes. It’s another way how to describe 3D printing. As its name implies, additive manufacturing adds material to create an object. By contrast, when you create an object by traditional means, it is often necessary to remove material through milling, machining, carving, shaping or other means.

Learning Outcomes

Upon completing the unit, learners should be able to:

1. *Identify, analyse and evaluate user needs and technical considerations to write good design requirements for a new product, service or system.*
2. *Apply and evaluate critically industrial best practice tools and techniques for converting an idea into commercially viable solutions.*
3. *Develop and build reliable proof of concept prototypes, using design practice methods and agile innovation techniques.*
4. *Evaluate knowledge of advanced materials and processes appropriate for a new product service or system.*

Unit: ETMEC-710-2107 Power and Propulsion Systems

Unit level (MQF): 7
Credits: 10

Unit description

This unit is aimed to enhance learners' knowledge on the application, modelling and control of state-of-the-art technology applied to propulsion systems. Various systems will be reviewed including Internal Combustion Engines, Electric and Hybrid Drives which cater for the majority of propulsion systems in industrial applications.

A numerical analysis will be carried out on the fundamental relations for power, energy and fuel consumption in propulsion systems. This analysis will include the identification of energy losses, vehicle propulsion operating modes and fuel consumption prediction. The unit also covers the application of Internal Combustion Engines in propulsion systems. The losses associated with the mechanical components typically used with this type of engine are analysed, and their effects on fuel consumption studied. Given the rise of electric and hybrid-based propulsion, the unit provides a detailed analysis of such drives with a review of Direct Current, Asynchronous and Synchronous Machines. The energy storage devices used in conjunction with such drives are also studied

The modelling of both steady-state and dynamic conditions for electromechanical systems applied to propulsion is to be carried out in this unit using computer-aided software solutions. Learners will be carrying out this work through an open-ended, problem-based approach which is intended to assess the performance of designated propulsion systems for different operating points.

Learning Outcomes

Upon completing the unit, learners should be able to:

1. *Discuss the basic concepts of Power, Energy and Fuel Consumption in Propulsion Systems.*
2. *Appraise the application of Internal Combustion Engine to Propulsion Systems.*
3. *Appraise the application of Electric and Hybrid Drives to Propulsion Systems.*
4. *Model mathematically a Mechanical, Electrical or Hybrid System for a designated Propulsion System.*

Unit: ETMEC-710-2108 Low Carbon and Renewable Energy Systems

Unit level (MQF): 7
Credits: 10

Unit Description

Renewable energy is becoming an increasingly important component of the world's energy supply as the threat of global warming continues to rise. There is a need to reduce the cost of this renewable energy and a future challenge to deal with the strain intermittent power sources like renewables place on the power grid.

The future for our planet has become increasingly stark over the past decade. Global mean temperature and carbon dioxide concentration in the atmosphere continue to rise at alarming rates. The Intergovernmental Panel on Climate Change (IPCC) has repeatedly increased their degree of certainty that human beings are contributing to or are the primary cause of these changes.

While the consequences of the already high concentrations of CO_2 in the atmosphere will not fully manifest themselves for decades, some would argue that we are already observing the effects, with 15 of the warmest 16 years on record occurring in the last 15 years.

The last two years have each subsequently been the warmest years on record and projections of the upcoming years are on pace to overtake the record again. The threat of global warming is too great to neglect taking immediate and substantial action. Renewable energy is one of several resources that can be employed to reduce the CO_2 intensity of energy production around the world. Solar energy in particular is the most abundant of these resources (7,500 TW potential), dwarfing the current annual world energy consumption (17 TW). Solar has also proven to be a promising alternative to traditional fossil fuel power. In many locations, solar is becoming a cost competitive alternative to fossil fuel-based generation and installed solar capacity has been growing exponentially worldwide.

Buildings are one of the main sources of carbon emission. Minimization of carbon emission from new and existing buildings is vital for the abatement of climate change. Recent research on buildings has shown great interest in the development of strategies and technologies to lower the carbon emission of buildings. Buildings that are designed and engineered to have low levels of carbon emission are called low-carbon buildings.

As the proportion of renewables and nuclear generation increases, alternatives to the use of flexible fossil-fuelled generation as a means of balancing the electricity system will become increasingly valuable. Numerous energy storage technologies for storing electricity are under development to meet this demand, and as the cost of storage is reduced through innovation, it is possible that they could have an important role in a low-carbon energy system. However, this depends on the costs and benefits relative to the sharing of these electricity imbalances through greater interconnection, demand-side electricity response and wider energy system storage.

Based on this introduction, this unit aims to understand how novel energy storage technologies might be integrated into the energy system in the future to reduce CO_2 emissions. In doing so, this unit focuses on: (i) the current renewable-energy technologies, mainly underlying the processes involved, (ii) the ‘Waste to Energy’ philosophy / circular-economy, (iii) carbon footprint, and (iv) energy storage methods for ‘Sustainable Energy’ systems.

Learning Outcomes

On completion of this unit the learner will be able to:

1. *Discuss technological methods that promote and shape the future of*
2. *Differentiate between the technologies and processes involved in Renewable Energy Technologies*
3. *Discuss in depth the ‘Waste to Energy’ philosophy*
4. *Assess carbon footprint of goods and services and define the future technologies for carbon capturing*
5. *Analyse Energy Storage methods for ‘Sustainable Energy’ systems*

Unit: ETMEC-708-2109 Applied Materials and Corrosion

Unit level (MQF): 7
Credits: 8

Unit description

This unit will provide the student with the knowledge and understanding of the corrosion processes that occur on structural materials and the impact on their mechanical performance.

This unit is divided into four sections:

The first part of this unit will give an introduction of mechanical testing in order to develop stress strain curves such as: Tensile test, Bending test, Buckling test and Shear test.

In the second part the student will be able to understand the corrosion monitoring techniques using electro-chemical methodologies and electron microscopy.

Also the student must learn and get knowledgeable about corrosion mechanisms including effects of underlying material composition and processing, galvanic corrosion, pitting and crevice corrosion, mechanical interactions, microbial corrosion, corrosion of welds, stress corrosion cracking, hydrogen embrittlement and effects of H_2S, and high temperature corrosion.

The last part of this unit will be specifically on corrosion control: plants, cathodic protection, corrosion resistant alloys, corrosion monitoring and control by design.

Learning Outcomes

Upon completing the unit, learners should be able to:

1. *Evaluate the impact of corrosion on the mechanical responses of structural materials and the impact of inhibition techniques on extending life.*
2. *Evaluate critically analysis and corrosion monitoring techniques to select appropriate methodologies.*
3. *Analyse materials and processes to recommend alternative engineering solutions.*
4. *Discuss the role of codes and standards.*

Unit: ETMEC-708-2110 Quality Engineering

Unit level (MQF): 7
Credits: 8

Unit description

This unit teaches Quality Engineering concepts and tools. The learner will cover the essential information about quality systems, auditing, product and process control and design, quality methods and tools, applied statistics, SPC, and Design of Experiments. It is a unit intended to enhance the engineering expertise and effectiveness as a Quality Engineer with this comprehensive introduction to key quality engineering concepts and tools critical to success in the field of Quality Engineering today.

It is divided in three sections, starting off with an introduction to the basic quality management principles and the relationship of the quality engineering to the quality systems. In this introduction the use of statistical tools and their importance in studying processes is presented. This will enable the learner to understand process capability and the use of statistical process control to monitor processes.

The learner is then introduced to the generation of acceptance sampling plans and identify and use the correct technical quality tools. These will be presented in context with multiple case studies from industry. This will instil in the learner the required discipline to incorporate quality technology in design, customer-supplier relationships, reliability, availability and maintainability (RAM), materials control, measurement, auditing, quality costs and document control within a quality system.

Finally, the learner will be applying problem-solving tools and basic statistical concepts to process control and process capability plans, acceptance sampling and attribute controls. This will lead to the core of this unit which deals with quantitative methods and tools for quality engineering. This core area is divided in collecting and summarizing data, quantitative concepts, probability distributions, statistical decision making, relationships between variables, statistical process control, process and performance capability and design and analysis of experiments.

Learning Outcomes

Upon completing the unit, learners should be able to:

1. *Understand how a quality system is essential for effective management and leadership.*
2. *Describe how a quality system is instrumental for effective product and process design and also process control.*
3. *Identify which quantitative method or tool best fits for monitoring specific quality objectives.*
4. *Pan and organise a design-of-experiment for effective analysis and/or optimisation of a process.*

Unit: ETMEC-706-2111 Project Management

Unit level (MQF): 7
Credits: 6

Unit description

This study unit will present the student with relevant project management principles, processes, tools and techniques essential for the effective and efficient execution of projects. Organisations are constantly faced with changing internal and external issues, and projects are means through which regulatory, legal or social requirements can be met; stakeholder requests or needs can be satisfied; business or technological strategies can be implemented or changed; and products, processes or services can be created, improved or fixed. This study unit will equip the student with knowledge and skills, as well as tools and techniques, to enable the achievement of project requirements.

The context of an organisation influences its ongoing operations and business strategies. Successful organisations respond intelligently to these changes in order to ensure optimal performance. Projects provide means for organisations to implement relevant and well-studied non-routine endeavours aimed at taking opportunities available and control risks. Effective project management helps individuals, groups, and public and private organisations to achieve their goals and objectives on time, on budget and meeting the desired quality standards.

This study unit will focus on the initiating, planning, executing, monitoring, controlling, and closing project management process groups. The judicious use of project management information systems will be covered, as well as put into practice for the relevant process groups.

The lectures will present concepts, theories, tools and techniques to develop the knowledge and skills of the engineering student in the field of project management. Project management concepts will be introduced in the context of the enterprise environmental factors. The study unit will improve the student's prospects to continue strengthening project management skills by understanding the role and the essential competences of the project manager. Key project management knowledge areas related to project integration, scope, schedule, cost, quality, resources, communications, risk, procurement and stakeholders will also be introduced. Effective and efficient project management requires the determination of the most appropriate combination of processes, inputs, tools, techniques, outputs and life cycle phases. The core project management concepts presented in this study unit will enhance the student's ability to adapt the application of the acquired knowledge and skills for each project.

Learning Outcomes

Upon completing the unit, learners should be able to:

1. *Discuss the importance and relevance of effective and efficient project management to organisations.*
2. *Assess the environment in which projects operate, characterised by internal and external factors.*
3. *Analyse the factors that contribute to the success and failure of a project.*
4. *Apply the appropriate project management processes, tools and techniques to help organisations achieve their goals and objectives.*
5. *Use project management information systems judiciously to enhance efficiency, whilst ensuring that information can be retrieved in a timely manner by relevant stakeholders.*

Unit: ETMEC-708-2112 Structural Analysis

Unit level (MQF): 7
Credits: 8

Unit description

This unit will provide the student with an understanding of pertinent issues concerning the use of engineering materials and practical tools for solving structural integrity and structural fitness-for-service problems.

The unit is structured in four parts:

The first part of this unit will be an introduction by considering different structural design philosophies. These are the working stress method (WSM) or allowable stress design (ASD), ultimate load method (ULM) and the limit state method (LSM).

In the second part the student will get the knowledge about fatigue crack initiation and fracture mechanics. This will be done by considering the derivation of elastic energy release rate, G and the fracture toughness, K. Also this part will consider the linear elastic fracture mechanics (LEFM) and elastic plastic fracture mechanics (EPFM), and the evaluation of fracture mechanics parameters; the stress intensity factor (K) and the crack tip opening displacements (J/CTOD). By learning the theory of fracture and crack propagation, the student will have the opportunity to conduct fracture toughness testing and analysis in order to determine and analyse the critical fracture parameters such as K_{IC} and J_{IC}. At the end of this part the student will be able to understand creep deformation and crack growth.

In the third part of this unit the student will be asked to conduct different non-destructive tests such as: visual test, x-ray test, dye penetrate test, ultrasonic wave test, magnetic particle test, fluorescent test, and radiography test. These tests will help the student to understand the importance of inspection reliability.

The last part of this unit will focus on defect assessments, fatigue and fracture mechanics of welded components and fracture of composites. This will lead the student to understand more about corrosion engineering.

Learning Outcomes

Upon completing the unit, learners should be able to:

1. *Assess fitness-for-service issues and propose appropriate structural integrity solutions.*
2. *Judge the current component life assessment procedures and distinguish their limitations in aspects of structural integrity.*
3. *Develop a critical and analytical approach towards the engineering aspects of structural integrity.*
4. *Assess confidently the applicability of the tools of structural integrity to new problems and apply them appropriately.*

Unit: ETMEC-706-2113 Research Methods

Unit level: 7
Credits: 6

Unit description

The scope of this unit is to provide learners with the necessary skills to propose, analyse and present an engineering research project diligently. In this unit, the learners will be guided through the process of carrying out a literature review. This will be based on the identification of reputable sources mainly from journals, conference proceedings and academic textbooks. Learners will be trained to assess the relevance of publications within the context of their research work in an efficient manner.

The unit will also instruct learners in writing project proposals according to a given research framework with consideration of common issues such as ethics, safety, budget and project timelines. The proposal writing stage will also include summarising research in a previously undertaken literature review to highlight the relevance of the proposed project within a given scientific or engineering field.

Given the applications of statistical analysis in engineering projects, the learners will also be processing scientific data using statistical software packages. Such training will be provided in the form of theoretical outlines, followed by practical tasks on actual data.

The unit also focuses on the communication of scientific results in written and oral form. The learners will be guided to write a scientific paper following a given template. This document can be either a review paper or documentation of new results. The task will focus on good practices in writing scientific documents which include appropriate document formatting, referencing, presentation of graphical data and adequate syntax. The learners will also be required to reflect and respond to reviewer comments which is an integral part of the peer-review process of scientific publication.

Learning Outcomes

Upon completing the unit, learners should be able to:

1. *Perform a literature review for a given area of research.*
2. *Write a research proposal for an engineering project.*
3. *Analyse scientific data using statistical software packages.*
4. *Write a scientific paper for publication using a given template.*
5. *Present and defend scientific and engineering results in a technical presentation.*

Unit: ETMEC-740-2114 MSc Project

Unit level (MQF): 7
Credits: 40

Unit description

The scope of this unit is to guide the learners towards identifying an engineering challenge relevant to the programme of study of this course and implement suitable technical solutions. The MSc Project requires a preliminary literature review to be carried out at the proposal stage, which is to be further developed during the project. The literature review should be used to enhance the learner's knowledge about the chosen engineering challenge itself and the relevant solutions recommended in the scientific literature. Learners should aim to replicate, critique and possibly provide alternative methods to those documented in the literature.

In the MSc project, the learner should include any relevant mathematical computations and modelling necessary to provide an engineered solution. Derivations obtained from scientific works or textbooks should be repeated and validated before being used in the design stage. Learners are encouraged to process data analytically using software packages with embedded statistical functions.

Given that the engineering challenge has been identified and researched, learners should propose a dissertation study based on the knowledge and skills developed within the MSc course. The dissertation can either be solely theory based or combining both theory and practical aspects. Design solutions are to be backed up by relevant literature, mathematical analysis, modelling and simulation. While learners are encouraged to apply practical solutions to given problems, these should always be justified and preferably referenced from appropriate technical documents.

All the research work and results are to be compiled with a dissertation written according to a specified template. The thesis should cater to readers with appropriate engineering expertise, such that theoretical or practical solutions considered below the level of this course should be omitted. The work presented should be in line with the MSc regulations of the institution in terms of format, referencing and length. These regulations are to be provided as an appropriate set of guidelines at the beginning of the project.

The learners are to present their work in the form of an oral presentation at the end of the project. The presentation should highlight the theoretical aspects, solutions, results and possible improvements associated with the research project. The learner is to finally justify and defend his work in front of a technically competent board.

Learning Outcomes

Upon completing the unit, learners should be able to:

1. *Perform a detailed literature review in the area of study chosen.*
2. *Present adequate mathematical-based calculations or models used in the research.*
3. *Design and implement engineering solutions to overcome the designated challenge.*
4. *Write a dissertation which documents research work carried out and results obtained in the project.*
5. *Present and defend the results of the research project in an oral presentation.*