Unit 4003: Engineering Science I

Unit Code: J/651/0710

Level: 4

Credits: 15

Introduction

Engineering is a discipline that uses scientific theory to design, develop, or maintain structures, machines, systems, and processes. Engineers are therefore required to have a broad knowledge of the science that is applicable to the industry around them.

This unit introduces students to the fundamental laws and applications of the physical sciences within engineering and how to apply this knowledge to find solutions to a variety of engineering problems.

Among the topics included in this unit are: international system of units, interpreting data, static and dynamic fundamentals, fluid mechanics and thermodynamics, material properties and failure, A.C./D.C. circuit theories, and electromagnetic principles and properties.

On successful completion of this unit, students will be able to interpret and present qualitative and quantitative data using computer software, calculate unknown parameters within mechanical and electrical systems, explain a variety of material properties, and use electromagnetic theory in an applied context.

Learning Outcomes

By the end of this unit students will be able to:

LO1 Examine scientific data using both quantitative and qualitative methods

LO2 Apply the fundamentals of mechanical engineering systems

LO3 Explore the characteristics and properties of engineering materials

LO4 Analyse applications of A.C./D.C. circuit theorems, electromagnetic principles, and properties.

Essential Content

LO1 **Examine scientific data using both quantitative and qualitative methods**

Quantitative research methodologies and methods:

Descriptive Research

Survey Research

Correlational Research

Quasi-experimental Research Design

Experimental Research

Relevant methodologies and methods.

Qualitative research methodologies and methods:

Grounded theory

Ethnographic

Narrative research

Historical

Case studies

Phenomenology

Relevant methodologies and methods.

The scientific method:

Question

Research

Hypothesis

Experiment

Data Analysis

Conclusion and Communication.

Interpreting data:

Investigation using the scientific method to gather appropriate data

Test procedures for physical (destructive and non-destructive) tests and statistical tests that might be used in gathering information

Summarising quantitative and qualitative data with appropriate graphical representations and appropriate use of an international system of units

Exploring the usage of quantitative and qualitative data in engineering applications specific to occupation/sector (e.g., manufacturing, operations, space systems, aeronautical engineering, etc.)

Using software to analyse data

Using presentation software to present data to an audience.

LO2 **Apply the fundamentals of mechanical engineering systems**

Static and dynamic fundamentals:

Units, scalars and vectors, two-dimensional force systems, and moment (torque) and couple

Representing loaded components with space and free-body diagrams

Equilibrium in two dimensions, distributed forces, the centre of mass, and centroids

Calculating support reactions of beams subjected to concentrated and distributed loads

Newton's laws of motion, one-dimensional particle kinematics, one-dimensional particle kinetics, D'Alembert's principle, and the principle of conservation of energy

Application of fundamentals and industrial case studies.

Fluid mechanics and thermodynamics:

Fluid definition and properties

Definition of pressure, hydrostatic pressure, and basic equations, manometry, application and calculations, Archimedes' principle

Flow characteristics and definitions, introduction to ideal fluid flow

Continuity of volume and mass flow for an incompressible fluid

Bernoulli's equation

Thermodynamic properties, temperature, the zeroth law of thermodynamic and pressure, system and control volume, processes, and cycles

Energy and energy transfer, and heat and work transfer: definitions, units, and sign convention

Ideal gas and equation of state, internal energy, enthalpy, and specific heats of ideal gas

The first law of thermodynamics.

LO3 **Explore the characteristics and properties of engineering materials**

Engineering materials:

Material properties, classifications, and testing

Atomic structure of materials and the structure of metals, polymers, and composites

Phase diagrams and analysis

Mechanical and electromagnetic properties of materials.

Material failure:

Destructive and non-destructive testing of materials

The effects of static, dynamic, and impact loading on a material

Degradation of materials and hysteresis.

Material selection:

Desired application

Working conditions

Manufacturability and assembly considerations

Cost and availability

Environmental impact and sustainability

Chemical and Physical properties.

LO4 **Analyse applications of A.C./D.C. circuit theorems, electromagnetic principles, and properties**

D.C. circuit theory:

Ohm law, Kirchhoff's voltage and current laws

Voltage, current, resistance, power, and energy in D.C. networks composed of resistors, capacitors, and inductors.

Exploring circuit theorems (Thevenin, Norton, Mesh, Superposition, Maximum power transfer).

A.C. circuit theory:

Waveform characteristics in a single-phase A.C. circuit

Odd and even harmonics

$V_{max}Sin(\omega t \pm \alpha)$

AC circuit analysis using Kirchhoff's laws

RLC circuits; Impedance, reactance, admittance, phasors, Q factor, bandwidth, and resonance in RLC circuits.

Magnetism:

Characteristics of magnetic fields and electromagnetic force

The principles and applications of electromagnetic induction, self and mutual induction, solenoid, relay, transformer, motors, and generators

Single and three-phase power, AC and DC motor and control.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Examine scientific data using both quantitative and qualitative methods		
P1 Examine at least three quantitative research methods. **P2** Examine at least three qualitative research methods.	**M1** Apply the scientific method within an engineering context that requires both quantitative and qualitative research methods.	**D1** Analyse scientific data employing both quantitative and qualitative methods, and using appropriate software and justified graphical representations.
LO2 Apply the fundamentals of mechanical engineering systems		
P3 Determine the support reactions of a beam carrying a combination of a concentrated load and a uniformly distributed load. **P4** Apply Archimedes and Bernoulli's principles in contextual engineering applications. **P5** Determine the ideal gas properties during a process.	**M2** Determine unknown forces by applying d'Alembert's principle to a free-body diagram.	**D2** Analyse thermodynamic systems with ideal gas by using the first law of thermodynamics.

Pass	Merit	Distinction
LO3 Explore the characteristics and properties of engineering materials		
P6 Explore the structural properties of metals and non-metals with reference to their material properties. **P7** Explain the types of degradation found in metals and non-metals.	**M3** Review elastic and electromagnetic hysteresis in different materials.	**D3** Analyse metals and non-metals for a given engineering application and fully justify the materials chosen.
LO4 Analyse applications of A.C./D.C. circuit theorems, electromagnetic principles, and properties		
P8 Calculate currents, voltages, and power in D.C. circuits with more than one power source. **P9** Use software to produce complex waveforms combining two or more sinusoidal waveforms. **P10** Analyse problems on series and parallel RLC circuits with A.C. theory in creating solutions.	**M4** Explain the principles and applications of electromagnetic induction in at least three electrical devices and machines.	**D4** Evaluate different circuit theorems used to solve DC and AC circuit theory problems.

Recommended Resources

Note: See HN Global for guidance on additional resources.

Print Resources

Ashby M.F., Shercliff H., and Cebon D. (2023) *Introduction to Materials Science and Engineering: A Design-Led Approach.* 1st Ed. Butterworth-Heinemann.

Ashby M. F. and David R. H. J. (2012) *Engineering materials 1: an introduction to properties, applications, and design*. 4th Ed. Elsevier.

Bird J. (2012) *Science for Engineering*. 4th Ed. London: Routledge.

Bolton W. (2006) *Engineering Science*. 5th Ed. London: Routledge.

Callister Jr. W.D. and RETHWISCH D.G. (2019*) Callister's Materials Science and Engineering*. 10th Ed. Global Edition. Wiley.

Cengel Y. (2019) *Thermodynamics: an engineering approach SI*, 9th Ed. McGraw Hill.

Cengel Y. (2017) *Fluid Mechanics: Fundamentals and Applications*. 4th Ed. McGraw Hill.

Hayt W. H. (2023) *Engineering Circuit Analysis ISE.* 10th Ed. McGraw Hill.

Hibbeler R. C. (2017) *Engineering mechanics: Statics.* 14th Ed. Pearson.

Hibbeler R. C. (2016) *Engineering mechanics: dynamics.* 14th Ed. Pearson.

Schobeiri M. T. (2010). *Fluid mechanics for engineers: a graduate textbook*. Springer Science & Business Media.

Tooley M. and Dingle L. (2012) *Engineering Science: For Foundation Degree and Higher National*. London: Routledge.

Journals

Note: Example journals listed below provide a broad range of articles related to unit content and those relevant for the qualification. Staff and students are encouraged to explore these journals and any other suitable journals to support the development of academic study skills, and subject specific knowledge and skills as part of unit level delivery.

Applications in Engineering Science

Engineering Reports

International Journal of Engineering Science

International Journal of Engineering Technology and Scientific Innovation

International Journal of Mechanical Sciences

Links

This unit links to the following related units:

Unit 4009: Materials, Properties and Testing

Unit 4002: Engineering Design

Unit 4092: Engineering Science II