National Unit Specification: general information

UNIT Circuit Element Principles (SCQF level 6)

CODE F5H8 12

SUMMARY

This Unit introduces candidates to the principles of the basic electrical circuit elements of resistance, self inductance, mutual inductance and capacitance at SCQF level 6. Candidates will be provided with opportunities to develop their knowledge and understanding of each of the elements in terms of their fundamental concepts and the laws of physics which govern them. Candidates will also be provided with knowledge of the Units of each element and be given opportunities to calculate the values of these quantities.

This Unit is suitable for candidates wishing to embark upon a career in electrical and/or electronic engineering or wishing to progress to further/more advanced studies. It is also relevant to candidates studying other branches of engineering, science or technology, requiring knowledge of electrical circuit elements. Candidates will be able to apply the skills gained to a wide range of electrical, electronics and related subjects in order to further their knowledge in this area.

This Unit may form part of an National Qualification Group Award or may be offered on a free-standing basis.

OUTCOMES

1 Apply the principles relating to the electrical resistance of a circuit
2 Apply the principles relating to the self inductance of a circuit.
3 Apply the principles relating to the mutual inductance of circuits
4 Apply the principles relating to the capacitance of a component.

Administrative Information

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National Unit Specification: general information (cont)

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RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following, or equivalent:

- Standard Grade Physics — Credit Level
- Standard Grade Technological Studies — Credit Level
- Standard Grade Mathematics — Credit Level
- NQ Unit *Electrical Principles* at SCQF level 6

CREDIT VALUE

1 credit at SCQF level 6 (6 SCQF credit points at SCQF level 6*).

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

CORE SKILLS

There is no automatic certification of Core Skills in this Unit.

This Unit provides opportunities for candidates to develop aspects of the following Core Skill:

- Numeracy (SCQF level 6)

These opportunities are highlighted in the Support Notes of this Unit Specification.

National Unit Specification: statement of standards

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Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit Specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA.

OUTCOME 1

Apply the principles relating to the electrical resistance of a circuit.

Performance Criteria

(a) State correctly that the electrical resistance of a circuit is a measure of its ability to oppose current flow through when an e.m.f. is applied to it.
(b) Identify correctly the physical properties of a material which determines its electrical resistance at constant temperature.
(c) Identify correctly electrical conducting and insulating materials in terms of their resistivity values.
(d) Calculate correctly the electrical resistance of a material in terms of its physical properties.
(e) State clearly that the temperature co-efficient of resistance of a material is a measure of the relationship between its resistance change per degree change in temperature and its resistance value at the initial temperature.
(f) Calculate correctly the electrical resistance of an electrical conductor in terms of its temperature change and temperature co-efficient of resistance at 0°C.

OUTCOME 2

Apply the principles relating to the self inductance of a circuit.

Performance Criteria

(a) State correctly that the self inductance of a circuit is a measure of its ability to induce a voltage in itself when its magnetic flux changes.
(b) Identify correctly the physical properties of a circuit which determine its self inductance.
(c) Calculate correctly the self inductance of a circuit in terms of its physical properties.
(d) State correctly Lenz's Law in relation to induced voltage.
(e) Calculate correctly the e.m.f. induced in a circuit due to the rate of change of its magnetic flux.
(f) Calculate correctly the e.m.f. induced in a circuit due to the rate of change of its current.

National Unit Specification: statement of standards (cont)

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OUTCOME 3

Apply the principles relating to the mutual inductance of circuits.

Performance Criteria

(a) State correctly that the mutual inductance between two circuits is a measure of the ability to induce an e.m.f. in one circuit due to a change of current in the other.
(b) Calculate the e.m.f induced in one mutually coupled circuit due to the rate of change of current in the other.
(c) Identify correctly the physical factors which determine the mutual inductive coupling between two circuits.

OUTCOME 4

Apply the principles relating to the capacitance of a component.

Performance Criteria

(a) State correctly that capacitance is the ability of a component to store electrical charge when a difference of potential exists between its plates.
(b) Identify correctly the physical properties of a capacitor which determine its capacitance.
(c) Calculate correctly the capacitance of a two-plate capacitor in terms of its physical properties.
(d) Calculate correctly the electric charge stored in a capacitor in terms of its capacitance and the potential difference between its plates.
(e) Calculate correctly the electric charge stored in a capacitor in terms of its average charging current and the charging time.

EVIDENCE REQUIREMENTS FOR THIS UNIT

Evidence is required to demonstrate the candidates have achieved all Outcomes and Performance Criteria.

Written and/or recorded oral evidence should be produced to demonstrate that the candidate has achieved all the Outcomes and Performance Criteria.

Outcomes may be assessed on an individual basis, as combinations of Outcomes (eg Outcomes 2 and 3 together) or as a single assessment covering all four Outcomes. Regardless of which approach is taken total assessment time should not exceed 2 hours and 30 minutes. Assessment(s) should be conducted under controlled, supervised, closed-book conditions in which candidates should not be allowed to bring any notes, handouts, textbooks or any other relevant materials into the assessment. Candidates may use a scientific calculator during assessment(s).

With regard to Outcome 1:
- the physical properties of length, cross-sectional area and resistivity should be identified
- three electrical conductors and three electrical insulators should be identified

- electrical resistance in terms of physical properties should be calculated using the equation $R = \rho l/a$ Ohm. Where ρ = resistivity, l = length, a = cross sectional area electrical resistance in terms of temperature change should be calculated using the equation $R = R_o (1 + \alpha\Delta t)$ Ohm. Where R_o = resistance a 0°C, α = temperature co-efficient of resistance at 0°C, Δt = temperature change from 0°C.

With regard to Outcome 2:

- the physical factors of length, cross-sectional area, absolute permeability, and number of conductor turns should be identified.
- self inductance in terms of physical properties should be calculated using the equation $L = N2\mu a/l$ Henry. Where N = number of turns, μ = absolute permeability, a = cross-sectional area of magnetic field, l = length of magnetic field.
- induced e.m.f. should be calculated using the equations $e = -Nd\Phi/dt$ Volt and $e = -LdI/dt$ Volt. Where N = number of conductor turns, $d\Phi$ = change in magnetic flux, dI = change in circuit current, dt = time taken for the flux or current change.

With regard to Outcome 3:

- mutually induced e.m.f. should be calculated using the equation $e_1 = -MdI_2/t$ Volts. Where e_1 = e.m.f. induced in circuit 1, M = mutual inductance, dI_2 = current change in circuit 2, t = time taken for current change.
- the physical factors which affect mutual inductive coupling should be identified as the proximity of the inductive circuits, the magnetic fringing of the coupling arrangement.

With regard to Outcome 4:

- the physical properties of distance between plates, cross sectional area and absolute permittivity should be identified.
- capacitance in terms of physical properties should be calculated using the equation $C = \varepsilon a/d$ Farads. Where ε = absolute permittivity, a = cross sectional area of electrostatic field, d = distance between plates.
- electric charge should be calculated using the equations $Q = CV$ and $Q = It$ Coulomb. Where C = capacitance, V = voltage between plates, I = average charging current, t = charging time.

National Unit Specification: support notes

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This part of the Unit Specification is offered as guidance. The support notes are not mandatory. While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours.

GUIDANCE ON THE CONTENT AND CONTEXT FOR THIS UNIT

This is an optional Unit within the National Qualification Group Award in Electrical Engineering at SCQF level 6. The Unit is one of a series of Units in the area of Electrical Principles but may also be offered as a free-standing Unit. Other Units in this series include:

Electrical Principles at SCQF level 5
Electrical Principles at SCQF level 6
Single Phase and Three Phase Principles at SCQF level 6
Electrostatics and Electromagnetics at SCQF level 6
Electronic Network Analysis at SCQF level 6

This Unit introduces candidates to the basic electrical circuit elements of resistance, self inductance, mutual inductance and capacitance at SCQF level 6 and is suitable for candidates wishing to gain basic knowledge in this area and is of particular relevance to candidates undertaking the Unit *Electrical Principles* at SCQF level 6 and the Unit *Electrostatics and Electromagnetics* at SCQF level 6. This Unit is suitable for candidates wishing to embark upon a career in electrical and/or electronic engineering or wishing to progress to further/more advanced studies. It is also suitable for candidates studying other branches of engineering, science or technology, requiring knowledge of electrical circuit elements.

There may be opportunities to integrate the delivery of this Unit with some of the other electrical principles Units in the National Certificate in Electrical Engineering. For example, it may be possible to link some of the subject matter in this Unit to that taught in the Unit *Electrostatics and Electromagnetics* (SCQF level 6).

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

This Unit should be delivered in a practical or laboratory environment by a combination of lectures, demonstrations and practical exercises. It is recommended that the Outcomes are delivered in the sequence stated in the Unit.

In delivering the Unit, Centres should encourage candidates to develop a sound knowledge and understanding of the basic circuit elements of resistance, self inductance, mutual inductance and capacitance since an understanding of the principles underpinning these elements is essential to the wider development of knowledge and understanding within electrical engineering.

Tutors should relate these principles to practical examples so that the relevance of each element to electrical engineering practice is clearly seen, however practical applications of these elements should not be included in any assessments.

Candidates should be encouraged to conduct internet searches to gather information which will reinforce their knowledge and understanding of the various circuit elements.

National Unit Specification: support notes (cont)

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OPPORTUNITIES FOR CORE SKILL DEVELOPMENT

Numeracy skills will be naturally enhanced in this Unit, with the focus on circuit element principles and the practical interpretation and application of number and graphics. Candidates have to work confidently with complex numerical and graphical concepts, carrying out a number of sustained calculations to determine solutions to problems. Formative activities should be designed to develop accuracy and confidence and to relate principles to practical electrical engineering contexts.

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Opportunities for the use of e-assessment

E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by information and communications technology (ICT), such as e-testing or the use of e-portfolios or e-checklists. Centres which wish to use e-assessment must ensure that the national standard is applied to all candidate evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. Further advice is available in *SQA Guidelines on Online Assessment for Further Education (AA1641, March 2003), SQA Guidelines on e-assessment for Schools (BD2625, June 2005)*.

Formative assessment exercises involving candidates in solving problems related to the application of principles for the resistance, self inductance, mutual inductance and capacitance elements of a circuit will play an important role in building candidate knowledge, understanding and confidence of Unit content.

The suggested approach to summative assessment in this Unit is as follows:

Outcomes 1:
An assessment paper comprising a balance of short answer, restricted response, and structured questions lasting 45 minutes. The assessment should be conducted at a single assessment event and be conducted under controlled, supervised, closed-book conditions in which candidates should not be allowed to bring any notes, handouts, textbooks or any other relevant materials into the assessment. Candidates may use a scientific calculator during assessment(s).

Outcomes 2 and 3:
A combined assessment paper comprising a balance of short answer, restricted response, and structured questions lasting 1 hour. The assessment should be conducted at a single assessment event and be conducted under controlled, supervised, closed-book conditions in which candidates should not be allowed to bring any notes, handouts, textbooks or any other relevant materials into the assessment. Candidates may use a scientific calculator during assessment(s).

Outcomes 4:
An assessment paper comprising a balance of short answer, restricted response, and structured questions lasting 45 minutes. The assessment should be conducted at a single assessment event and be conducted under controlled, supervised, closed-book conditions in which candidates should not be allowed to bring any notes, handouts, textbooks or any other relevant materials into the assessment. Candidates may use a scientific calculator during assessment(s).

National Unit Specification: support notes (cont)

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CANDIDATES WITH DISABILITIES AND/OR ADDITIONAL SUPPORT NEEDS

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering alternative Outcomes for Units. Further advice can be found in the SQA document *Guidance on Assessment Arrangements for Candidates with Disabilities and/or Additional Support Needs* **(www.sqa.org.uk)**.