SCOTTISH QUALIFICATIONS AUTHORITY

ELECTRONIC AND ELECTRICAL FUNDAMENTALS
Intermediate 2

Third edition – published December 1999

SCOTTISH QUALIFICATIONS AUTHORITY

NOTE OF CHANGES TO ARRANGEMENTS
THIRD EDITION PUBLISHED ON CD-ROM DECEMBER 1999

COURSE TITLE: Electronic and Electrical Fundamentals (Int 2)

COURSE NUMBER: C025 11

National Course Specification

Course Details: Core skills statements expanded

National Unit Specification:

All Units: Core skills statements expanded

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National Course Specification

ELECTRONIC AND ELECTRICAL FUNDAMENTALS (INT 2)

COURSE NUMBER C025 11

COURSE STRUCTURE

The course comprises of three mandatory units as follows:

D132 11	***Electrical Fundamentals (Int 2)***	***1 credit (40 hours)***
D133 11	***Semiconductor Applications: An Introduction (Int 2)***	***1 credit (40 hours)***
D134 11	***Combinational Logic (Int 2)***	***1 credit (40 hours)***

In common with all courses, this course includes 40 hours over and above the 120 hours for the component units. This is for induction, extending the range of learning and teaching approaches, support, consolidation, integration of learning and preparation for external assessment. This time is an important element of the course and advice on its use is included in the course details.

RECOMMENDED ENTRY

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

- Mathematics and either Technological Studies or Physics at grade 3 Standard Grade
- equivalent National units.

Administrative Information

Publication date: December 1999

Source: Scottish Qualifications Authority

Version: 03

National Course Specification: course details

COURSE Electronic and Electrical Fundamentals (Int 2)

CORE SKILLS

This course gives automatic certification of the following:

Complete core skills for the course	None
Core skills components for the course	Using Number Int 2

For information about the automatic certification of core skills for any individual unit in this course, please refer to the general information section at the beginning of the unit.

Additional information about core skills is published in *Automatic Certification of Core Skills in National Qualifications* (SQA, 1999).

National Course Specification: course details

COURSE Electronic and Electrical Fundamentals (Int 2)

RATIONALE

This course aims to introduce the candidate to electronic and electrical engineering through the study of basic electrical principles and introductory analogue and digital processing. The course will serve as a bridge to Higher Electrical Engineering, Higher Electronics or Higher Mechatronics and also be an asset in the wider scientific and engineering fields.

This course will also contribute to the general education and personal development of the candidate and in particular foster a greater technological capability. From a general education perspective this course will encourage an increased technological appreciation of what electricity is, how it may be generated and how it may be utilised to perform processing tasks.

This course introduces the candidate to the study of electronic and electrical engineering through the study of basic electrical principles and introductory electronic processing. Candidates who may find this course appropriate are those who are interested in technology and have completed a short course in the area of Technological Studies or Physics at Intermediate 1 level.

Candidates who successfully complete this course should possess a knowledge of the fundamental principles which underpin all electrical circuits and a good understanding of the two basic forms of electronic processing, namely analogue and digital. These abilities will be reflected in a candidate's ability to analyse and design simple electronic and electrical circuits. Candidates will also develop the ability to construct circuits and to analyse their performance practically using test instrumentation.

From a vocational viewpoint the course is particularly suited to those candidates whose aspirations and abilities are towards employment and/or further study in electrical, electronic and mechatronic engineering. However, it may also be of use to candidates who are considering entry into a wider engineering or scientific area where some technical electronics knowledge may be required.

The course fulfils the following aims:

- the development of an understanding of electrical circuit theory
- the development of an understanding of electronic component operation
- the development of the application of design skills when applied to simple electronic circuits
- the encouragement of each candidate's skills in communication and presentation
- the cultivation of a receptive attitude towards technological progress in the electronic and electrical industries.

National Course Specification: course details (cont)

COURSE Electronic and Electrical Fundamentals (Int 2)

COURSE CONTENT

Whilst the units in the course can be taught independently, it is the intention of the course to broaden and develop the understanding of electronic and electrical fundamentals. This will be best achieved by adopting a systems approach which will integrate the theory and practice covered in the course content. The approach will enable candidates to develop a deeper understanding of electronic and electrical engineering.

All of the course content will be subject to sampling in the external assessment. A brief description of the content of each of the three units which comprise the course follows.

SUMMARY OF COURSE CONTENT

Electrical Fundamentals (Int 2)
This unit has been designed to introduce candidates to the basic electrical engineering principles and laws. It covers the relationships between current, voltage, resistance, power and energy in a d.c. network. It also considers the factors relating to the generation of electricity as an a.c. (sinusoidal) waveform.

This unit offers a foundation for establishing electrical engineering principles and laws.

CONTENT STATEMENTS

Electrical Fundamentals (Int 2)
The content statements given in the left-hand column of the table below describe in detail what the candidate should be able to do in demonstrating knowledge and understanding. The right-hand column gives suggested contexts, applications, illustrations and activities associated with the content statements.

Knowledge and Understanding	***Contexts, applications, illustrations and activities***
1 Measure the supply current, branch currents, supply voltage, series potential differences, circuit resistance and component resistance, in a resistive d.c. network.	Laboratory exercises to confirm relationships.
2 Calculate voltages, current and resistance in simple d.c. circuits containing only resistance in series.	Tutorial supported by laboratory exercises.
3 Calculate voltages, currents (branch and total) and resistance in simple d.c. circuits containing only resistance in parallel.	Tutorial supported by laboratory exercises.

National Course Specification: course details (cont)

COURSE Electronic and Electrical Fundamentals (Int 2)

Knowledge and Understanding (cont'd)	*Contexts, applications, illustrations and activities*
4 Calculate voltages, current and resistance, in circuits composed of series and parallel resistor combinations.	Tutorial supported by laboratory exercises.
5 Know the concepts of, and the relationship between, the units of power and energy.	
6 Apply the relationships between circuit parameters and energy and power to solve problems.	
7 Perform calculations to determine power and energy dissipation in components and circuits which are composed of series and parallel resistor combinations.	Application of $P = VI$, $P = I^2R$, $P = V^2/R$ and $P = W/t$
8 State the factors required to set up permanent magnetic fields and electromagnetic fields.	
9 Recognise permanent magnetic field patterns around permanent magnets.	Practical investigations using magnets and iron filings.
10 Recognise electromagnetic field patterns around a straight current-carrying conductor.	Practical investigations.
11 Describe the interaction between magnetic fields to produce a force on a straight current-carrying conductor.	
12 State the factors which determine magnitude and direction of the force on a straight current-carrying conductor situated perpendicular to a uniform magnetic field.	
13 Perform calculations using the formula $F = BIl$.	Tutorial.

National Course Specification: course details (cont)

COURSE Electronic and Electrical Fundamentals (Int 2)

Knowledge and Understanding (cont'd)	*Contexts, applications, illustrations and activities*
14 State the factors which determine the electromotive force (e.m.f.) generated by moving a straight conductor in a magnetic field.	Practical investigations.
15 Draw a graphical production of a sinusoidal voltage waveform using the expression $e = E_{max} \sin\alpha$.	
16 Carry out calculations using the expression $e = Blu \sin\alpha$.	
17 Carry out calculation of root mean square (r.m.s.) values.	Use the formulae $E_{r.m.s.} = \frac{1}{\sqrt{2}} E_{max}$

National Course Specification: course details (cont)

COURSE Electronic and Electrical Fundamentals (Int 2)

SUMMARY OF COURSE CONTENT

Semiconductor Applications: An Introduction (Int 2)

This unit has been designed to introduce candidates to analogue electronics. It covers the analysis of diode parameters and circuits including power applications using thyristors and triacs. It also considers the analysis of amplifier circuits using discrete transistors (bipolar and field effect transistors (FET)) as well as operational amplifiers.

This section of the course provides an introduction to the basic analogue devices such as diodes and transistors along with associated applications. It also provides an introduction to operational amplifier devices and associated simple circuits. As with the other two units within this course this unit provides a good mix of theoretical and practical activities at a suitable level.

CONTENT STATEMENTS

Semiconductor Applications: An Introduction (Int 2)

The content statements given in the left-hand column of the table below describe in detail what the candidate should be able to do in demonstrating knowledge and understanding. The right-hand column gives suggested contexts, applications, illustrations and activities associated with the content statements.

Knowledge and Understanding	***Contexts, applications, illustrations and activities***
1 Investigate the operation of signal diodes, rectifiers and zener diodes.	Measurement of diode current and voltage levels.
2 Use the following terms correctly in context: a) peak inverse voltage, V_{PIV} or V_{RRM} b) maximum forward current, $I_{F(max.)}$ c) typical forward voltage drop, V_D.	Reference should be made to manufacturers' data sheets (device characteristics).
3 Describe the application of diodes for: a) rectification b) clipping c) clamping d) voltage stabilisation.	Laboratory exercises using components or preconstructed boards.

National Course Specification: course details (cont)

COURSE Electronic and Electrical Fundamentals (Int 2)

Knowledge and Understanding (cont'd)	*Contexts, applications, illustrations and activities*
4 Recognise BS symbols for the following power control devices: a) thyristor b) diac c) triac.	Candidates should study actual industrial circuit diagrams.
5 Describe the transfer characteristics of thyristors, diacs and triacs.	
6 Describe one application each for: a) thyristor b) diac c) triac.	Applications such as motor control or a light dimmer could be studied.
7 Interpret the operating conditions of single-stage resistance-loaded small-signal amplifiers. Common emitter and common source configurations only.	Measurement of circuit voltage levels. Measurement of voltages related to transistor biasing. Measurement of gain using the relationship output/input.
8 Describe the circuit operation of a single-stage resistance-loaded small-signal amplifier.	Laboratory investigations using components or preconstructed boards of common emitter and common source amplifiers.
9 Investigate the operation of simple operational amplifier circuits, limited to inverting and non-inverting amplifier configurations.	Laboratory investigations using components or preconstructed boards.
10 Explain the requirement for an offset null in an op-amp integrated circuit (IC).	Produce a voltage null at the output of an op-amp circuit.
11 Calculate the gain of an op-amp configured as an inverting or non-inverting amplifier.	Gain = $1+R_f/R_i$; Gain = $-R_f/R_i$
12 State the phase relationship between input and output for op-amps configured as inverting and non-inverting modes.	Use of oscilloscope to indicate phase difference.

National Course Specification: course details (cont)

COURSE Electronic and Electrical Fundamentals (Int 2)

SUMMARY OF COURSE CONTENT

Combinational Logic (Int 2)

This unit has been designed to introduce candidates to analogue electronics. It considers binary representation, basic logic gates and the analysis and synthesis of simple combinational circuits.

This unit offers an introduction to binary systems which is suitable for Intermediate 2. It outlines the function of basic gates and allows for simple design and construction.

CONTENT STATEMENTS

Combinational Logic (Int 2)

The content statements given in the left-hand column of the table below describe in detail what the candidate should be able to do in demonstrating knowledge and understanding. The right-hand column gives suggested contexts, applications, illustrations and activities associated with the content statements.

Knowledge and Understanding	***Contexts, applications, illustrations and activities***
1 Convert binary numbers to decimal and vice versa.	The requirement for engineers (software and hardware) to be proficient by relating to computer systems, for example memory allocation, memory maps, etc.
2 Convert from decimal, or binary, to hexadecimal and vice versa.	
3 Perform additions of binary integers.	
4 Identify the following logic gates from both their BSEN and ANSI symbols: a) 3-input AND b) 3-input OR c) NOT d) 3-input NAND e) 3-input NOR.	Industrial circuit diagrams should be used.

National Course Specification: course details (cont)

COURSE Electronic and Electrical Fundamentals (Int 2)

Knowledge and Understanding (cont'd)	*Contexts, applications, illustrations and activities*
5 Determine truth tables for the above listed logic gates from experimental measurements.	Laboratory exercises using both TTL and CMOS families.
6 Produce Boolean expressions for the above listed logic gates from experimental measurements.	Measurement of logic states. Use of logic probes and multichannel oscilloscopes.
7 Derive truth tables for assembled circuits. Circuits to contain four logic inputs, and be constructed from no more than four, 3-input gates.	
8 Construct logic circuits (containing up to four, 3-input logic gates) and verify circuit operation.	Use of TTL and CMOS ICs and manufacturers' data sheets.

ASSESSMENT

To gain the award of the course the candidate must pass all the unit assessments as well as the external assessment. External assessment will provide the basis for grading attainment in the course award.

When the units are taken as component parts of a course, candidates will have the opportunity to achieve a level beyond that required to attain each of the unit outcomes. This attainment may, where appropriate, be recorded and used to contribute towards course estimates and to provide evidence for appeals. Additional details are provided, where appropriate, with the exemplar assessment materials. Further information on the key principles of assessment is provided in the paper *Assessment* (HSDU, 1996), and in *Managing Assessment* (HSDU, 1998).

National Course Specification: course details (cont)

COURSE Electronic and Electrical Fundamentals (Int 2)

DETAILS OF THE INSTRUMENTS FOR INTERNAL ASSESSMENT

The external assessment will comprise a written examination paper. The time allocation will be 2 hours 30 minutes. The paper will comprise two sections as follows:

Section A - 50 marks
Eight to ten short answer questions will be set to assess knowledge and understanding of discrete aspects of the course content.

Candidates should attempt all questions in this section.

Section B - 50 marks
Three extended, integrated questions will be set. The questions will test the candidates' knowledge and understanding and their ability to deal with integrated course content.

Candidates should attempt two questions from this section. Each question will be worth 25 marks.

All necessary background information will be provided with the examination script in the form of data sheets or a data booklet to cover eg:

- technical details such as a range of formulae
- specification sheets for electronic components
- a range of symbols.

GRADE DESCRIPTIONS

The grade of award A, B or C will be based on the total score obtained in Sections A and B of the question paper. The descriptions below indicate the nature of the achievement which is required for the award of a grade C and a grade A in the course assessment. They are intended to assist candidates, teachers, lecturers and users of the certificate and to help establish standards when question papers are being set.

GRADE C	GRADE A
Use the appropriate knowledge, understanding and skills acquired through the study of the component units of this course with some consistency.	Use knowledge, understanding and skills which have been developed beyond those required for the basic study of the component units of this course.
Demonstrate the ability to integrate skills acquired in component units to solve problems of both a theoretical and practical nature.	Demonstrate the ability to integrate advanced skills acquired in component units to solve more complex problems of both a theoretical and practical nature.

Apply knowledge and understanding to solve problems presented in less familiar contexts.	Apply advanced knowledge and understanding to comprehensively solve complex and sometimes unstructured problems presented in a variety of contexts.

National Course Specification: course details (cont)

COURSE Electronic and Electrical Fundamentals (Int 2)

APPROACHES TO LEARNING AND TEACHING

Whilst the course is integrative in nature, some sequential teaching will be required. It is recommended that the units are approached in the following order:

1 Electrical Fundamentals (Int 2)
2 Introduction to Semiconductor Applications (Int 2)
3 Combinational Logic (Int 2).

This will ensure that concepts are encountered at the appropriate stage of the course and can be reviewed, reinforced and further developed through application within later units. Every opportunity should be taken to integrate concepts where possible.

Candidates wishing to progress to Higher Electronics, Higher Electrical Engineering or Higher Mechatronics will be required to develop abilities in Mathematics at grade 3 Standard Grade and are advised to complete appropriate units in Mathematics concurrently with this course.

The outcomes for the course would be best undertaken in the context of a series of integrated assignments which bring industrial and/or domestic perspectives. The assignments should also be differentiated to take account of varying candidate abilities. Teachers and lecturers can select the assignments according to each candidate's ability and therefore maximise the candidate's potential in learning.

It is recommended for the unit *Electrical Fundamentals (Int 2)* that Outcomes 1, 3 and 4 should be taught in a laboratory/workshop through investigative exercises. Outcome 2 should be taught through discussion and exposition.

Semiconductor Applications: An Introduction (Int 2) must be taught in a laboratory/workshop environment since it involves the operating conditions of devices in practical circuits. In all outcomes preconstructed circuits can be used as long as the candidate has access for adjustment and measurement. Alternatively components and prototyping boards may be used.

Combinational Logic (Int 2) should be taught in an area which allows access to logic devices and their corresponding data sheets. Logic tutor boards, if available, could be used in order to reduce the complexity of wiring in experimental circuits. The use of components and prototyping boards is recommended. The use of logic probes to measure logic states in circuits should be encouraged.

With reference to all three units, it would be appropriate to use computer simulation to reinforce the teaching/learning process.

National Course Specification: course details (cont)

COURSE Electronic and Electrical Fundamentals (Int 2)

SUBJECT GUIDES

A Subject Guide to accompany the Arrangements Documents has been produced by the Higher Still Development Unit (HSDU) in partnership with the Scottish Consultative Council on the Curriculum (SCCC) and Scottish Further Education Unit (SFEU). The Guide provides further advice and information about:

- support materials for each course
- learning and teaching approaches in addition to the information provided in the Arrangements document
- assessment
- ensuring appropriate access for candidates with special educational needs.

The Subject Guide is intended to support the information contained in the Arrangements document. The SQA Arrangements documents contain the standards against which candidates are assessed.

SPECIAL NEEDS

This course specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment and Certification Arrangements for Candidates with Special Needs/Candidates whose First Language is not English* (SQA, 1998).

SCOTTISH QUALIFICATIONS AUTHORITY

National Unit Specification: general information

UNIT Electrical Fundamentals (Int 2)

NUMBER D132 11

COURSE Electronic and Electrical Fundamentals (Int 2)

SUMMARY

This unit has been designed to introduce candidates to the basic electrical engineering principles and laws. It covers the relationships between current, voltage, resistance, power and energy in a d.c. network. It also considers the factors relating to the generation of electricity as an a.c. (sinusoidal) waveform.

This unit offers a foundation for establishing electrical engineering principles and laws.

OUTCOMES

1 Determine the current, voltage and resistance relationships in a resistive d.c. network.
2 Solve problems on power and energy in d.c. resistive systems.
3 Determine the relationship between the factors relating to the force acting on a current-carrying conductor situated in a magnetic field.
4 Determine the factors which relate to the generation of a sinusoidal voltage waveform.

RECOMMENDED ENTRY

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

- Mathematics and either Technological Studies or Physics at grade 3 Standard Grade
- equivalent National units.

Administrative Information

Superclass: XJ

Publication date: December 1999

Source: Scottish Qualifications Authority

Version: 03

National Unit Specification: general information (cont)

UNIT Electrical Fundamentals (Int 2)

CREDIT VALUE

1 credit at Intermediate 2.

CORE SKILLS

This unit gives automatic certification of the following:

Complete core skills for the unit	None
Core skills components for the unit	Using Number Int 2

Additional information about core skills is published in *Automatic Certification of Core Skills in National Qualifications* (SQA, 1999).

National Unit Specification: statement of standards

UNIT Electrical Fundamentals (Int 2)

OUTCOME 1

Determine the current, voltage and resistance relationships in a resistive d.c. network.

Performance criteria

(a) The determination of the relationship between supply current and branch currents in a combined series-parallel resistive d.c. network is correct.
(b) The determination of the relationship between applied voltage and the series potential differences in a combined series-parallel resistive d.c. network is correct.
(c) The calculation of the resultant resistance of a combined series-parallel resistive network is accurate.
(d) The determination of the relationship between current, voltage and resistance of a resistive d.c. network is correct.

Evidence requirements

The candidate could be given an assignment which would measure ability to determine resistance relationships and calculate currents and voltages in a resistive d.c. network. For example, the assignment could be constructed around specific tasks in which the candidates are provided with four resistors of known values, connected in a combined series-parallel configuration, suitable measuring instruments and a known d.c. supply.

The tasks would include:

- measurement of branch currents, supply current and series potential differences
- determination of the relationship between supply current and branch current
- determination of the relationship between applied voltage and series volt drops
- calculation of resultant network resistance from known resistance values
- calculation of supply current
- verification of relationship between I, V and R by comparison of the measured and calculated results.

This exercise should be carried out in conjunction with a suitably constructed observation checklist covering all practical elements of the assessment. Satisfactory achievement of the outcome will be based on results which show the relationships between quantities to be correct to within experimental tolerance.

National Unit Specification: statement of standards (cont)

UNIT Electrical Fundamentals (Int 2)

OUTCOME 2

Solve problems on power and energy in d.c. resistive systems.

Performance criteria

(a) The concepts of, and the relationships between, power and energy, are correctly stated and used.
(b) The application of the power expressions $P = VI$, $P = I^2R$, $P = V^2/R$ and $P = W/t$ is correct.
(c) The calculation of energy values from values of voltage, current, resistance and time is correct.

Evidence requirements

The candidate could be presented with short answer questions to assess the recall of knowledge and the understanding of power and energy as related to electrical systems.

The assessment could consist of 13 short answer questions to be allocated as follows:

1	Units of power: watt, kilowatt, etc.	1 question
2	Units of energy: joule, kilowatt hour etc.	1 question
3	Concept of power as the rate at which energy is dissipated.	1 question
4	Calculation of power values using appropriate expressions.	4 questions
5	Calculation of current, resistance and voltage from the power of expressions of (4).	3 questions
6	The calculation of energy values given voltage, current, resistance and time.	3 questions

Satisfactory achievement of the outcome will be based on the candidate producing nine correct responses which must include correct responses for points 1-3 (above), and two out of four for point 4, two out of three for point 5, two out of three for point 6. An incorrect response should be considered as one which shows a lack of understanding and is not caused by trivial arithmetic error.

National Unit Specification: statement of standards (cont)

UNIT Electrical Fundamentals (Int 2)

OUTCOME 3

Determine the relationship between the factors relating to the force acting on a current-carrying conductor situated in a magnetic field.

Performance criteria

(a) The production and recognition of permanent and electromagnetic fields is correctly demonstrated.
(b) The description of the principle of force acting on a straight current-carrying conductor situated perpendicular to a uniform magnetic field is correct.
(c) The calculation of the force on a straight current-carrying conductor in a magnetic field is correct.

Evidence requirements

The candidate could be presented with questions to assess the recall of knowledge and the understanding of the concepts of magnetic fields and their interaction to cause a force to act on a current-carrying conductor situated in such a field.

The assessment could consist of 12 short answer questions to be allocated as follows:

1	Elements required to set up permanent and electromagnetic fields.	2 questions
2	Recognition of permanent magnetic field patterns.	2 questions
3	Recognition of electromagnetic field patterns including that of a straight current-carrying conductor.	2 questions
4	Interaction between magnetic fields to produce a force on a straight current-carrying conductor.	2 questions
5	The factors which determine magnitude and direction of the force on a straight current-carrying conductor situated perpendicular to a uniform magnetic field.	2 questions
6	The calculation of force from the expression $F = BIl$.	2 questions

Satisfactory achievement of the outcome will be based on the candidate producing nine correct responses which must include five out of six for points 1-3 above, and three out of four for points 4-5 (above) and one out of two for point 6 (above). An incorrect response should be considered as one which shows a lack of understanding and is not caused by trivial arithmetic error.

National Unit Specification: statement of standards (cont)

UNIT Electrical Fundamentals (Int 2)

OUTCOME 4

Determine the factors which relate to the generation of a sinusoidal voltage waveform.

Performance criteria

(a) The description of the factors which determine the e.m.f. generated by movement of a straight conductor in a magnetic field is correct.
(b) The determination of the direction of generated e.m.f. in a straight conductor is correct.
(c) The application of the expression $e = Blu \sin \alpha$ to calculate the e.m.f. generated in a rotating loop of conductor is correct.
(d) The graphical production of a sinusoidal voltage waveform using the expression $e = E_{max} \sin \alpha$ is correct.
(e) The application of the expression $E_{rms} = \frac{1}{\sqrt{2}} E_{max}$ to calculate the r.m.s. value of a sinusoidal e.m.f. is correct.

Evidence requirements

The candidate could be set a structured question to test the recall of knowledge and understanding of the concepts of the generation of a sinusoidal voltage waveform.

The candidate could be given two diagrams indicating conductors each of active length l metre, moving with a constant velocity u m/s^{-1} at the perpendicular through a uniform magnetic field of flux density *B* Tesla.

Diagram (a) would show a single straight conductor in the field and Diagram (b) would show a single loop conductor mounted on a central spindle.

The candidate would be required to:

- determine the factors governing the magnitude of generated e.m.f. in a straight conductor and the relationship between them
- determine the factors governing the direction of generated e.m.f. in a straight conductor
- calculate the instantaneous e.m.f. generated in a loop conductor rotating at constant speed in a uniform magnetic field using the expression $e = Blu \sin \alpha$
- plot, on given scaled axes, a sinusoidal voltage waveform using points determined from the expression $e = E_{max} \sin \alpha$
- calculate the r.m.s. value of generated voltage from a given maximum value using the relationship $E_{rms} = \frac{1}{\sqrt{2}} E_{max}$.

Satisfactory achievement of the outcome will be based on all parts of the question being answered correctly. An incorrect response should be considered as one which shows a lack of understanding and is not caused by trivial arithmetic error.

National Unit Specification: support notes

UNIT Electrical Fundamentals (Int 2)

This part of the unit specification is offered for guidance. The support notes are not mandatory.

It is recommended that you refer to the SQA Arrangements document for the Intermediate 2 Electronic and Electrical Fundamentals course before delivering this unit.

While the exact time allocated to this unit is at the discretion of the centre, the notional design length is 40 hours.

This unit will establish a foundation of electrical engineering principles and laws. It is written for electrical craft and technician candidates but can also be used by craft and technician candidates from other technology related backgrounds.

GUIDANCE ON CONTENT AND CONTEXT FOR THIS UNIT

Appropriate units, symbols and unit-symbols should be used throughout.

Outcome 1
Essential parts of a basic circuit, i.e. source, load, conductors.
Concept of current flow round a circuit. Potential difference.
Relationship between circuit current, voltage and resistance, i.e. $I = V/R$.
Series resistive circuits, i.e. resultant resistance, voltage distribution and current.
Parallel resistive networks, i.e. resultant resistance, current distribution and voltage.
Combined series-parallel resistive networks, i.e. resultant resistance, branch currents, series potential differences, etc.

Outcome 2
Concepts of power and energy.
Units of power: watt and kilowatt, etc.
Units of energy: joule and kilowatt hour, etc.
Calculation of power in electrical systems from the expressions $P = VI$, $P = I^2R$, $P = V^2/R$ and $P = W/t$.
Calculation of voltage, current and resistance from the power expressions.
Calculation of energy using expressions $W = Pt$, $W = VIt$, $W = I^2Rt$ and $W = V^2t/R$.

Outcome 3
Elements required to set up magnetic fields.
Permanent and electromagnetic field patterns.
Factors relating to the interaction of two magnetic fields.
Concept of force acting on a current-carrying conductor situated in a magnetic field as the result of interaction between two fields.
Factors determining the magnitude and direction of the force.
Calculation of force on a straight conductor using the expression $F = BIl$.

Outcome 4

Concept of e.m.f. and its generation by the movement of a straight conductor at the perpendicular through a magnetic field.
Factors determining the magnitude of the generated e.m.f. and the direction in which it acts.
Calculation of generated e.m.f. using the expression $e = Blu$ volts.
Generation of e.m.f. by the rotation of a single loop of conductor in a magnetic field.
Generated e.m.f. at any instant as a function of sin α where α is the angle through which the loop has rotated at the given instant.
Use of the instantaneous e.m.f. expression $e = E_{max} \sin \alpha$ volts.
Statement of r.m.s. value of sinusoidal voltage as $E_{rms} = \frac{1}{\sqrt{2}} E_{max.}$

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

Laboratory investigation should be used where appropriate to determine the relationship between current, voltage and resistance, and the current and voltage distribution in resistive networks.

Exposition and discussion on power and energy with calculations to reinforce appreciation of relationships.

Concepts of force and generated e.m.f. should be verified by demonstration and/or laboratory investigation for Outcomes 3 and 4.

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Examples of instruments of assessment that could be used for each outcome are given below.

Outcome 1

The candidate could be given an assignment which measures ability to determine resistance relationships and calculate currents and voltages in a resistive d.c. network. This exercise could be carried out in conjunction with a suitably constructed observation checklist covering all practical elements of the assessment. Satisfactory achievement of the outcome would be based on results which show the relationships between quantities to be correct to within experimental tolerance.

Outcome 2

A number of short answer questions to assess the recall of knowledge and the understanding of power and energy as related to electrical systems.

Outcome 3

A number of short answer questions to assess the recall of knowledge and the understanding of the concepts of magnetic fields and their interaction to cause a force to act on a current-carrying conductor situated in such a field.

National Unit Specification: support notes (cont)

UNIT Electrical Fundamentals (Int 2)

Outcome 4
A structured question to test the recall of knowledge and understanding of the concepts of the generation of a sinusoidal voltage waveform.

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment and Certification Arrangements for Candidates with Special Needs/Candidates whose First Language is not English* (SQA, 1998).

SCOTTISH QUALIFICATIONS AUTHORITY

National Unit Specification: general information

UNIT Semiconductor Applications: An Introduction (Int 2)

NUMBER D133 11

COURSE Electronic and Electrical Fundamentals (Intermediate 2)

SUMMARY

This unit has been designed to introduce candidates to analogue electronics. It covers the analysis of diode parameters and circuits including power applications using thyristors and triacs. It also considers the analysis of amplifier circuits using discrete transistors (bipolar and field effect transistors (FET)) as well as operational amplifiers.

OUTCOMES

1 Interpret the operation of semiconductor diode circuits.
2 Outline the use of power control devices.
3 Interpret the operating conditions of a single-stage resistance-loaded small-signal amplifier.
4 Investigate operational amplifier circuits.

RECOMMENDED ENTRY

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

- Mathematics and either Technological Studies or Physics at grade 3 Standard Grade
- equivalent National units.

Administrative Information

Superclass: XL

Publication date: December 1999

Source: Scottish Qualifications Authority

Version: 03

National Unit Specification: general information (cont)

UNIT Semiconductor Applications: An Introduction (Intermediate 2)

CREDIT VALUE

1 credit at Intermediate 2.

CORE SKILLS

There is no automatic certification of core skills or core skills components in this unit.

Additional information about core skills is published in *Automatic Certification of Core Skills in National Qualifications* (SQA, 1999).

National Unit Specification: statement of standards

UNIT Semiconductor Applications: An Introduction (Intermediate 2)

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 the Scottish Qualifications Authority.

OUTCOME 1

Interpret the operation of semiconductor diode circuits.

Performance criteria

(a) The identification of operational limitations from manufacturers' data sheets is correct.
(b) The measurement and recording of diode circuit voltage levels are correct.
(c) The explanation of the circuit operation is correct.

Evidence requirements

The candidate could be set tasks which assess the ability to interpret the operation of two different semiconductor diode circuits. The candidate would be required to take measurements of diode circuit voltage levels and answer questions which relate these measurements to manufacturers' data sheets. The measurements would be recorded in a prespecified format. The candidate would also be required to maintain a logbook which would include a brief explanation of the operation of the circuits.

Satisfactory achievement of the outcome will be based on the candidate attaining all of the PCs and correctly answering the questions connected with PCs (b) and (c).

OUTCOME 2

Outline the use of power control devices.

Performance criteria

(a) Power control devices are correctly identified from their symbols.
(b) The actions of the power control devices are correctly described.
(c) Applications for power control devices are correctly stated.

Evidence requirements

The candidate could be set a structured question to test understanding of the use of power control devices.

The candidate would be given a circuit diagram(s) containing a thyristor, diac and triac which he/she would be required to identify from their symbols. The candidate would be required to describe the action of the device and a typical application for each.

Satisfactory achievement of the outcome will be based on all parts of the question being correctly answered.

National Unit Specification: statement of standards (cont)

UNIT Semiconductor Applications: An Introduction (Intermediate 2)

OUTCOME 3

Interpret the operating conditions of a single-stage resistance-loaded small-signal amplifier.

Performance criteria

(a) The measurement and recording of circuit voltage levels are correct.
(b) The measured voltages are correctly related to the biasing of the transistor.
(c) The gain of the circuit is correctly determined from measurement of input and output signals.
(d) The circuit operation is described correctly.

Note on range for the outcome

Amplifier: bipolar (common emitter) or FET (common source).

Evidence requirements

The candidate could be set a task which assesses the ability to interpret the operating conditions of a single-stage resistance-loaded small-signal amplifier. The candidate would be required to take measurements of circuit voltage levels and relate these measurements to the biasing of the transistor and gain of the amplifier and describe the overall circuit operation. The measurements would be recorded in a prespecified format.

Satisfactory achievement of the outcome will be based on all PCs being met.

National Unit Specification: statement of standards (cont)

UNIT Semiconductor Applications: An Introduction (Intermediate 2)

OUTCOME 4

Investigate operational amplifier circuits.

Performance criteria

(a) Appropriate adjustments are made to the circuit to provide a voltage null at the output.
(b) The gain of inverting and non-inverting configurations is correctly calculated from measurements taken and recorded.
(c) The phase relationship between input and output signals in inverting and non-inverting configurations is correctly recorded.

Evidence requirements

The candidate could complete practical exercises to demonstrate an ability to investigate operational amplifier circuits and explain the requirement for an offset null.

The candidate would be given two preconstructed units in which adjustments and measurements are to be made and recorded.

The exercises would be carried out in conjunction with a suitably constructed observation checklist.

Satisfactory achievement of the outcome will be based on all PCs being met.

National Unit Specification: support notes

UNIT Semiconductor Applications: An Introduction (Intermediate 2)

This part of the unit specification is offered for guidance. The support notes are not mandatory.

It is recommended that you refer to the SQA Arrangements document for the Intermediate 2 Electronics and Electrical Fundamentals course before delivering this unit.

While the exact time allocated to this unit is at the discretion of the centre, the notional design length is 40 hours.

This unit will establish a foundation of electrical engineering principles and laws. It is written for electrical craft and technician candidates but can also be used by craft and technician candidates from other technology related backgrounds.

GUIDANCE ON CONTENT AND CONTEXT FOR THIS UNIT

Safety regulations and safe working practices should be observed at all times.

- signal diodes, rectifiers and zener diodes. Manufacturers' data for peak inverse voltage, maximum forward current and typical forward voltage drop with reference to device characteristics, testing of diode and labelling of terminals using digital-meter or multi-meter
- diode applications to include rectification, clipping, clamping, voltage stabilisation
- thyristor, diac, triac
- only common emitter and common source configuration to be investigated
- only inverting and non-inverting operational amplifier configurations to be investigated
- non-inverting configuration to include voltage follower.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

This unit should be taught in a laboratory/workshop environment since it involves the operating conditions of devices in practical circuits.

In all activities preconstructed circuits should be used so that the candidate has access for adjustment and measurement.

National Unit Specification: support notes (cont)

UNIT Semiconductor Applications: An Introduction (Intermediate 2)

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Examples of instruments of assessment which could be used for each outcome are given below.

Outcome 1
The candidate could be set an assignment that would assess the ability to interpret the operation of two different semiconductor diode circuits.

Outcome 2
The candidate could be set a structured question to test understanding of the use of power control devices.

Outcome 3
The candidate could be set a task which assesses the ability to interpret the operating conditions of a single-stage resistance-loaded small-signal amplifier.

Outcome 4
The candidate could complete practical exercises to demonstrate an ability to investigate operational amplifier circuits and explain the requirement for an offset null.

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment and Certification Arrangements for Candidates with Special Needs/Candidates whose First Language is not English* (SQA, 1998).

SCOTTISH QUALIFICATIONS AUTHORITY

National Unit Specification: general information

UNIT Combinational Logic (Int 2)

NUMBER D134 11

COURSE Electronic and Electrical Fundamentals (Intermediate 2)

SUMMARY

This unit has been designed to introduce candidates to digital electronics. It considers binary representation, basic logic gates and the analysis and synthesis of simple combinational circuits.

This unit offers an introduction to binary systems which is suitable for Intermediate 2. It outlines the function of basic gates and allows for simple design and construction.

OUTCOMES

1 Perform simple binary operations.
2 Identify the function of logic gates.
3 Assemble and investigate a combinational logic circuit.
4 Solve combinational logic system problems.

RECOMMENDED ENTRY

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

- Mathematics and either Technological Studies or Physics at grade 3 Standard Grade
- equivalent National units.

Administrative Information

Superclass: XL

Publication date: December 1999

Source: Scottish Qualifications Authority

Version: 03

National Unit Specification: general information (cont)

UNIT Combinational Logic (Int 2)

CREDIT VALUE

1 credit at Intermediate 2.

CORE SKILLS

There is no automatic certification of core skills or core skills components in this unit.

Additional information about core skills is published in *Automatic Certification of Core Skills in National Qualifications* (SQA, 1999).

National Unit Specification: statement of standards

UNIT Combinational Logic (Int 2)

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 the Scottish Qualifications Authority.

OUTCOME 1

Perform simple binary operations.

Performance criteria

(a) The conversion between decimal and binary quantities is correctly performed.
(b) The conversion between decimal and hexadecimal quantities is correctly performed.
(c) The conversion between hexadecimal and binary quantities is correctly performed.
(d) The operation of binary addition is correctly performed.

Evidence requirements

The candidate could be set short answer questions to test the ability to perform simple binary operations. The test could comprise 8 short answer questions involving numbers with no more than four bits. The questions could be allocated as follows:

1 conversion 6 questions
2 addition 2 questions.

Satisfactory achievement of the outcome will be based on the candidate producing seven correct responses which must include five out of six for point 1 (above) and two out of two for point 2 (above).

National Unit Specification: statement of standards (cont)

UNIT Combinational Logic (Int 2)

OUTCOME 2

Identify the function of logic gates.

Performance criteria

(a) Logic functions are correctly identified from given BSEN 60617 and ANSI symbols.
(b) Truth tables are constructed using measurement of input/output conditions.
(c) Boolean expressions are obtained from the truth tables.

Evidence requirements

The candidate could be presented with a set of logic gates and a supply for each. He/she would then test the input/output levels for NOT function, three input OR, AND, NAND and NOR from which he/she would identify each gate and provide the truth table and Boolean expression for each.

A checklist should be devised to record the candidate's practical activities.

Satisfactory achievement of the outcome will be based on all PCs being met for each of the logic gates.

OUTCOME 3

Assemble and investigate a combinational logic circuit.

Performance criteria

(a) The assembly of a 3-input logic circuit is correct.
(b) The construction of the truth table for the assembled circuit is accurate.
(c) The Boolean expression is correctly derived from the truth table.

Evidence requirements

A diagram of a circuit with a minimum of four gates could be given to the candidate. The candidate would be required to assemble the circuit and test its operation by obtaining the truth table and deriving the Boolean expression.

A checklist would be devised to record the candidate's practical activities.

Satisfactory achievement of the outcome will be based on all PCs being met.

National Unit Specification: statement of standards (cont)

UNIT Combinational Logic (Int 2)

OUTCOME 4

Solve combinational logic system problems.

Performance criteria

(a) An accurate logic system design is produced.
(b) The assembly of the system designed is correct.
(c) The recording of the results and measurement of the system specification in the form of a truth table is accurate.

Evidence requirements

The candidate could be required to design and assemble a practical circuit for a task which would be stated by the teacher or lecturer. The task would be restricted to 3-input variables.

A checklist should be devised to record the candidate's practical activities.

Satisfactory achievement of the outcome will be based on all PCs being met.

National Unit Specification: support notes

UNIT Combinational Logic (Int 2)

This part of the unit specification is offered as guidance. The support notes are not mandatory.

It is recommended that you refer to the SQA Arrangements document for the Intermediate 2 Electronic and Electrical Fundamentals course before delivering this unit.

While the time allocated to this unit is at the discretion of the centre, the notional design length is 40 hours.

GUIDANCE ON CONTENT AND CONTEXT FOR THIS UNIT

Safety regulations and safe working practices should be observed at all times.

- Decimal, binary and hexadecimal number systems, conversion of integer decimal values to binary to hexadecimal and vice versa.
- Addition of binary integers.
- AND, OR, NOT, NAND and NOR logic gates. BSEN 60617 and ANSI gate symbols. Derivation of truth tables for each gate and the associated Boolean expression.
- TTL and CMOS integrated circuit devices, including their respective series numbers (74XX and 40XX).
- Measurement of logic states and the construction of truth tables for assembled circuits. The production of Boolean expressions derived from the truth tables.
- The design of logic circuits to solve simple practical problems. Implementation of the design. Recording of measurements from the circuits to form truth tables. Testing of the circuits to ensure compliance with the required function.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

This is an introductory unit in digital electronics. It should therefore preferably be taught in an area which allows access to logic devices and their corresponding data sheets. It is recommended that logic tutor boards be used in order to reduce the complexity of wiring circuits.

The use of logic probes to measure logic states in circuits should be encouraged. Candidates should make full use of logbooks to record circuit diagrams and measurements taken.

National Unit Specification: support notes (cont)

UNIT Combinational Logic (Int 2)

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Examples of instruments of assessment which could be used for each outcome are given below.

Outcome 1
The candidate could be set short answer questions to test the ability to perform simple binary operations.

Outcome 2
The candidate could be given a practical exercise from which he/she would identify each logic gate and provide the truth table and Boolean expression for each.

Outcome 3
The candidate could be given a practical exercise that would require the candidate to assemble a given circuit and test its operation by obtaining the truth table and deriving the Boolean expression.

Outcome 4
The candidate could be given a practical exercise that would require the candidate to design and assemble a practical circuit from a given problem. The problem would be restricted to 3-input variables and a checklist should be devised to record the candidate's practical activities.

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment and Certification Arrangements for Candidates with Special Needs/Candidates whose First Language is not English* (SQA, 1998).