N5 National 5 Course Specification

National 5 Practical Electronics

Course code:	C860 75
Course assessment code:	X860 75
SCQF:	level 5 (24 SCQF credit points)
Valid from:	session 2017–18

The course specification provides detailed information about the course and course assessment to ensure consistent and transparent assessment year on year. It describes the structure of the course and the course assessment in terms of the skills, knowledge and understanding that are assessed.

This document is for teachers and lecturers and contains all the mandatory information you need to deliver the course.

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Contents

Course overview

The course consists of 24 SCQF credit points which includes time for preparation for course assessment. The notional length of time for a candidate to complete the course is 160 hours.

The course assessment has two components.

Component	Marks	Scaled mark	Duration
Component 1: question paper	60	30	1 hour
Component 2: practical activity	70	n/a	See course assessment section

Recommended entry	Progression
Entry to this course is at the discretion of the centre. Candidates should have achieved the fourth curriculum level or the National 4 Practical Electronics course or National 4 Engineering Science course or equivalent qualifications and/or experience prior to starting this course.	♦ other qualifications ♦ further study, employment and/or training

Conditions of award

The grade awarded is based on the total marks achieved across all course assessment components.

Course rationale

National Courses reflect Curriculum for Excellence values, purposes and principles. They offer flexibility, provide more time for learning, more focus on skills and applying learning, and scope for personalisation and choice.

Every course provides opportunities for candidates to develop breadth, challenge and application. The focus and balance of assessment is tailored to each subject area.

Electronics brings together elements of technology, science and mathematics and applies these to real-world challenges. The course provides progression from experiences and outcomes in craft, design, engineering and graphics, and in science. It provides a solid foundation for those considering further study or a career in electronics, electrical engineering and related disciplines. The course also provides a valuable complementary practical experience for those studying engineering science, physics or other science courses.

The electronics industry is vital to everyday life in our society and plays a major role in the economy. It contributes not only to manufacturing, but to other sectors such as finance, telecommunications, material processing, oil extraction, weather forecasting and renewable energy. Within all of these sectors, a wide range of job opportunities are available for people with skills in electronics.

The National 5 Practical Electronics course provides a broad practical introduction to electronics. The course encourages candidates to become responsible and creative in their use of technologies and to develop attributes such as flexibility, enthusiasm, perseverance, reliability and confidence.

Purpose and aims

The aims of the course are for candidates to develop:

- knowledge and understanding of key concepts in electronics and apply these in a range of contexts
- a range of practical skills in electronics, including skills in analysis and problem-solving, design skills, skills in the safe use of tools and equipment, and skills in evaluating products and systems
- awareness of the importance of safe working practices in electronics
- an understanding of the role and impact of electronics in changing and influencing society and the environment

The course is mainly practical in nature. The aims of the course are developed through practical projects and investigative tasks in a range of contexts.

Who is this course for?

The course provides sufficient breadth, flexibility and challenge to meet the needs of all learners. It is particularly beneficial for those considering a career or further study in electronics, electrical engineering, physics, and related disciplines.

The course has a skills-based approach to learning. It takes account of the needs of all learners and provides sufficient flexibility to enable learners to achieve in different ways.

Course content

The National 5 Practical Electronics course has three areas of study.

Circuit design
In this area, candidates develop an understanding of key electrical concepts and electronic components. Candidates analyse electronic problems, design solutions to these problems and explore issues relating to electronics.

Circuit simulation
In this area, candidates use simulation software to assist in the design, construction and testing of circuits and systems and to investigate their behaviour.

Circuit construction
In this area, candidates gain experience in assembling a range of electronic circuits, using permanent and non-permanent methods. They develop skills in practical wiring and assembly techniques, carrying out testing and evaluating functionality.

Skills, knowledge and understanding

Skills, knowledge and understanding for the course

The following provides a broad overview of the subject skills, knowledge and understanding developed in the course:

- awareness of safe working practices in electronics
- analysing electronic problems and designing solutions to these problems
- simulating, testing and evaluating solutions to electronic problems
- skills in using a range of test equipment
- constructing electronic circuits using permanent (soldering) and non-permanent methods
- knowledge and understanding of the systems approach to electronics, including sub-systems
- knowledge and understanding of the use of concepts and principles associated with a range of electronic and electromagnetic components and circuits
- knowledge and understanding of combinational logic
- understanding of key electrical concepts — current, voltage, resistance, power, analogue/digital, capacitance, magnetic effect of current
- applying electronic knowledge and skills in a range of contexts

Skills, knowledge and understanding for the course assessment

The following provides details of skills, knowledge and understanding sampled in the course assessment:

Content and concepts
Use appropriate SI units, scientific notation and the prefixes pico (p), nano (n). micro (μ), milli (m), kilo (k), and mega (M). Use appropriate relationships to determine voltage, current, resistance or power for a resistor network supplied by a d.c. source. The network should contain a maximum of three resistors. $V = IR$ $R_T = R_1 + R_2 + \ldots$ $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$ $P = IV$ or $P = I^2R$ or $P = \frac{V^2}{R}$ Use appropriate relationships to determine voltage or resistance in a voltage divider circuit. (eg calculate the switch over voltage of an op-amp used in comparator mode). $\frac{V_1}{V_2} = \frac{R_1}{R_2}$ $V_2 = \frac{R_2}{R_1 + R_2} \times V_S$ From an oscilloscope trace of a sinusoidal or square wave determine the peak voltage and the period and frequency of the signal, given the Y-gain and time base settings. $f = \frac{1}{T}$ Identify an oscilloscope trace/signal as either analogue or digital. Describe the effect on the timing of the output waveform of changing the capacitance of a capacitor in a given circuit. State that when a current flows in a conductor there is a magnetic field in the region surrounding the conductor. State that the magnetic field can be made stronger by coiling the conductor. Describe the operation of electromechanical devices.

Circuit simulation and design
Explain the benefits of electronic circuit simulation prior to circuit construction. Identify two input logic gates from symbols. Identify two input logic gates from truth tables. Complete the truth table for an identified two input logic gate. Determine the output and intermediate logic levels of a combinational logic circuit consisting of a maximum of four inputs and a maximum of two outputs. Given a printout of a simulated circuit, identify potential faults, eg incorrect supply voltage, incorrect resistor values or wrong component orientation (test points to be included). Given a layout diagram of a circuit, identify potential faults, eg incorrect supply voltage, incorrect resistor values or wrong component orientation. Compile a pre-power up checklist for a given simulation printout, layout diagram or circuit diagram. Describe the operation of a number of simple circuits: a transistor analogue switching circuit, bi-stable switching circuit, half-adder circuit, 741 comparator. Using a block diagram, design a circuit to solve a given problem. Identify the input, process and output stages of a given circuit. Given circuit diagrams, complete IC pin-out diagrams and circuit layout diagrams. Given circuit layout diagrams, produce circuit diagrams. Determine costs of constructing circuits given component codes and component costs.

Circuit construction
Convert resistance values stated in ohms, kiloohms and megaohms into the notation used in BS1852 notation or R notation, eg 270R, 27K, 5K8, 2M7. Determine the resistance of a resistor and the tolerance in this value, given its colour code (using the convention of three colours + tolerance colour). Calculate the maximum and minimum resistances of a given resistor with a specified tolerance. Given a circuit specification and an incomplete circuit diagram, identify any missing key components and complete circuit diagrams.

Circuit construction
Identify and draw the circuit symbols for, and describe the function of, the following components (using American National Standards Institute (ANSI) and International Electrotechnical Commission (IEC) symbols): ♦ power supplies ♦ resistors (fixed, variable, LDR and thermistor) ♦ diodes ♦ capacitors (electrolytic and non-electrolytic) ♦ transistors (bipolar and n-channel enhancement MOSFET) ♦ input/output devices (switch, relay, motor, buzzer, lamp, LED, solenoid and speaker) ♦ connectors and wires ♦ fuses ♦ logic gates (AND, OR, NOT, NOR, XOR and NAND) ♦ ICs (logic gates, 7400 series or equivalent, 555 timer) ♦ op-amp circuits (741 op-amp comparator mode only) ♦ voltmeter and ammeter Select appropriate scale and range on a multimeter for measuring voltage, resistance and current. Describe the use of a logic probe and continuity tester in circuit testing. State at least two safety measures to be taken when soldering. Describe the uses of prototype board, stripboard and pcb in electronic design and construction. Describe uses for each of the following cable types: multi-strand, ribbon, co-axial or fibre-optic. State an advantage of colour coding or numbering bundled wiring. Give examples of where either colour coding or numbering is used.

Skills, knowledge and understanding included in the course are appropriate to the SCQF level of the course. The SCQF level descriptors give further information on characteristics and expected performance at each SCQF level (www.scqf.org.uk).

Skills for learning, skills for life and skills for work

This course helps candidates to develop broad, generic skills. These skills are based on SQA's Skills Framework: Skills for Learning, Skills for Life and Skills for Work and draw from the following main skills areas:

2 Numeracy

2.3 Information handling

4 Employability, enterprise and citizenship

4.2 Information and communication technology (ICT)

5 Thinking skills

5.3 Applying
5.4 Analysing and evaluating

These skills must be built into the course where there are appropriate opportunities and the level should be appropriate to the level of the course.

Further information on building in skills for learning, skills for life and skills for work is given in the course support notes.

Course assessment

Course assessment is based on the information provided in this document.

The course assessment meets the key purposes and aims of the course by addressing:

- breadth — drawing on knowledge and skills from across the course
- challenge — requiring greater depth or extension of knowledge and/or skills
- application — requiring application of knowledge and/or skills in practical or theoretical contexts as appropriate

This enables candidates to:

- apply breadth and depth of skills, knowledge and understanding from across the course to answer questions in electronics
- show that they can apply the knowledge and skills developed through the course by taking part in a practical activity which requires them to solve an appropriately challenging practical electronics problem

The course assessment has two components: a question paper and a practical activity. The relationship between these two components is complementary, to ensure full coverage of the knowledge and skills of the course.

Course assessment structure: question paper

Question paper 60 marks

The purpose of the question paper is to assess breadth, challenge and application of skills, knowledge and understanding from across the course.

The question paper also assesses inquiry skills and analytical thinking skills.

The question paper gives candidates the opportunity to demonstrate the following skills, knowledge and understanding by:

- making accurate statements
- describing information, providing explanations and integrating knowledge
- applying knowledge of electronics to new situations, interpreting information and solving problems
- selecting information
- presenting information appropriately in a variety of forms
- processing information (using calculations and units, where appropriate)
- making predictions based on evidence/information

The question paper has a total of 60 marks. This is scaled to 30 marks and is worth 30% of the overall marks for course assessment.

The question paper contains restricted and extended response questions.

The majority of marks are awarded for demonstrating and applying knowledge and understanding. The other marks are awarded for applying inquiry and analytical thinking skills.

A question paper insert containing relevant data and formulae is provided.

Setting, conducting and marking the question paper

The question paper is set and marked by SQA, and conducted in centres under conditions specified for external examinations by SQA. The question paper is 1 hour in duration.

Specimen question papers for National 5 courses are published on SQA's website. These illustrate the standard, structure and requirements of the question papers candidates sit. The specimen papers also include marking instructions.

Course assessment structure: practical activity

Practical activity 70 marks

The practical activity assesses candidates' ability to apply electronic knowledge and skills to solve an appropriately challenging practical problem, and is designed to allow candidates to demonstrate their ability to work independently.

This component allows assessment of skills which cannot be assessed through the question paper, for example circuit simulation, construction and testing.

Practical activity overview

The practical activity gives candidates an opportunity to demonstrate the following skills, knowledge and understanding:

- analysing a problem
- designing an electronic solution to the problem
- simulating a solution to the problem
- constructing a solution to the problem
- applying safe working practices
- testing the solution
- reporting on and evaluating the solution

The practical activity has 70 marks and is worth 70% of the overall marks for course assessment.

The practical activity enables clear demonstration of the application of knowledge and skills from across the course.

Guidelines for the practical activity include questions/tasks/prompts which lead candidates through the task in clear stages.

Marks are awarded for:

- analysis and design
- simulating a solution
- construction using safe working practices
- testing the solution
- reporting on and evaluating the solution

Evidence must include:

- the completed solution
- a record of progress through the activity (such as an informal log or blog produced by the candidate)
- a short report on the testing of the solution (in written, electronic or oral form)

Setting, conducting and marking the practical activity

Setting

The practical activity is:

- set by SQA; a bank of practical activities is provided, and there is choice from this bank
- set at a time appropriate to the candidate's needs

Conducting

The practical activity is:

- an individually produced piece of work from each candidate
- started at an appropriate point in the course
- conducted under some supervision and control

Full instructions for candidates are contained within each task.

The practical activity is carried out under open-book conditions, but supervised to ensure that the work presented is the candidate's own.

Marking

The practical activity has a total of 70 marks.

Marks are awarded for:

♦ analysis and design	7 marks
♦ designing and simulating a solution	7 marks
♦ construction using safe working practices	44 marks
♦ testing the solution	7 marks
♦ reporting on the solution	5 marks

Evidence is internally marked by centre staff in line with SQA's marking instructions. Marking instructions are contained within the practical activity assessment task.

The assessor may give candidates support and guidance to help them progress through each stage of the activity. Where any significant amount of support is provided, this should be reflected in the marks awarded.

The practical activity is designed to discriminate between candidates and therefore is expected to provide a wide range of marks. Stronger candidates should be able to complete the activity successfully with minimal support and guidance. Weaker candidates may not be able to complete all aspects of the activity within a reasonable time, or may require significant assistance, and so would achieve a lower mark.

Once the activity has been completed and assessed, it must not be returned to the candidate for further work to improve their mark.

All marking is quality assured by SQA.

Assessment conditions

Controlled assessment is designed to:

- ensure that all candidates spend approximately the same amount of time on their practical activities
- prevent third parties from providing inappropriate levels of guidance and input
- mitigate concerns about plagiarism and improve the reliability and validity of SQA awards
- allow centres a reasonable degree of freedom and control
- allow candidates to produce an original piece of work

Time

The practical activity is assessed in a single assessment event. Candidates should be assessed at an appropriate point, normally when they have completed most of the work in the course.

Time is required for:

- preparation for the practical activity, which could include considering exemplars and practising required skills
- carrying out the stages of the practical activity, with assessor guidance and support
- assessing the process and completed solution

Supervision, control and authentication

There are two levels of control.

Under a high degree of supervision and control	Under some supervision and control
♦ the use of resources is tightly prescribed ♦ all candidates are within direct sight of the supervisor throughout the session(s) ♦ display materials which might provide assistance are removed or covered ♦ there is no access to e-mail, the internet or mobile phones ♦ candidates complete their work independently ♦ interaction with other candidates does not occur ♦ no assistance of any description is provided	♦ candidates do not need to be directly supervised at all times ♦ the use of resources, including the internet, is not tightly prescribed ♦ the work an individual candidate submits for assessment is their own ♦ teachers/lecturers can provide reasonable assistance

The practical activity is conducted under some supervision and control.

Assessors must exercise their professional responsibility in ensuring that evidence submitted by a candidate is the candidate’s own work.

Assessors should put in place processes to authenticate evidence, ensuring that the work is the candidate's own. For example:

- regular checkpoint/progress meetings with candidates
- short spot-check personal interviews
- checklists which record activity/progress
- photographs, film or audio evidence

Resources

As this is an open-book assessment, there are no restrictions on the resources that candidates may have access to.

Reasonable assistance

Candidates must undertake the assessment independently. However, reasonable assistance may be provided prior to the formal assessment process taking place. The term 'reasonable assistance' is used to try to balance the need for support with the need to avoid giving too much assistance. If a candidate requires more than what is deemed to be 'reasonable assistance', they may not be ready for assessment or it may be that they have been entered for the wrong level of qualification.

Reasonable assistance may be given on a generic basis to a class or group of candidates, for example advice on how to develop a project plan. It may also be given to candidates on an individual basis. When reasonable assistance is given on a one-to-one basis in the context of something the candidate has already produced or demonstrated, there is a danger that it becomes support for assessment and assessors need to be aware that this may be going beyond reasonable assistance.

Candidates may seek clarification on the wording of a brief or specification or instructions for the assessment if they find them unclear. In this case, the clarification should normally be given to the whole class.

Some guidance may be provided during the analysis and design stages, but the candidate must work independently throughout the implementation, testing and evaluation stages.

Assessor input and advice on the candidate's analysis and design is acceptable in order to allow the candidate to progress to the next stages of the assessment. The assistance provided must be recorded so that the candidate's own analysis and design work can be judged/marked fairly.

As the practical activity is a summative assessment, support and guidance during implementation, testing and evaluation stages must be limited to minimal prompts and questioning, referring the candidate to the instructions provided in the assessment task. Where candidates are observed to be following unsafe working practices, the assessor must intervene.

However, some assistance may also be given during fault-finding if the candidate has already carried out appropriate tests but is still unable to diagnose faults, which may be, for example, due to faulty components rather than any shortcomings in the candidate’s construction techniques.

As part of the preparation for assessment, group work approaches can be helpful to simulate real-life situations, share tasks and promote team-working skills. However, group work is not appropriate once formal assessment has started.

Evidence to be gathered

The following candidate evidence is required for the assessment:

- the completed solution (constructed circuit or photographs and/or hard copy from simulation software)
- a record of progress through the task, including all items of evidence specified within the assessment task
- a short report on testing the solution (in written, electronic and/or oral form)
- evidence of candidate’s degree of independence and safe working (eg detailed assessor observation notes)

Evidence must be retained for quality assurance purposes.

Volume

There is no word count.

Grading

A candidate's overall grade is determined by their performance across the course assessment. The course assessment is graded A–D on the basis of the total mark for all course assessment components.

Grade description for C

For the award of grade C, candidates will typically have demonstrated successful performance in relation to the skills, knowledge and understanding for the course.

Grade description for A

For the award of grade A, candidates will typically have demonstrated a consistently high level of performance in relation to the skills, knowledge and understanding for the course.

Equality and inclusion

This course is designed to be as fair and as accessible as possible with no unnecessary barriers to learning or assessment.

For guidance on assessment arrangements for disabled candidates and/or those with additional support needs, please follow the link to the assessment arrangements web page: www.sqa.org.uk/assessmentarrangements.

Further information

The following reference documents provide useful information and background.

- National 5 Practical Electronics subject page
- Assessment arrangements web page
- Building the Curriculum 3–5
- Design Principles for National Courses
- Guide to Assessment
- SCQF Framework and SCQF level descriptors
- SCQF Handbook
- SQA Skills Framework: Skills for Learning, Skills for Life and Skills for Work
- Coursework Authenticity: A Guide for Teachers and Lecturers
- Educational Research Reports
- SQA Guidelines on e-assessment for Schools
- SQA e-assessment web page

Appendix: course support notes

Introduction

These support notes are not mandatory. They provide advice and guidance to teachers and lecturers on approaches to delivering the course. They should be read in conjunction with this course specification and the specimen question paper and/or coursework.

Developing skills, knowledge and understanding

This section provides further advice and guidance about skills, knowledge and understanding that could be included in the course. Teachers and lecturers should refer to this course specification for the skills, knowledge and understanding for the course assessment. Course planners have considerable flexibility to select coherent contexts which will stimulate and challenge their candidates, offering both breadth and depth.

The mandatory skills, knowledge and understanding may be developed throughout the course. The table below shows where there are significant opportunities to develop these in the individual topics and in the course assessment.

Mandatory skills, knowledge and understanding	Circuit design	Circuit simulation	Circuit construction	Course assessment
♦ awareness of safe working practices in electronics			✓	✓
♦ analysing electronic problems, and designing solutions to these problems	✓			✓
♦ simulating, testing and evaluating solutions to electronic problems		✓	✓	✓
♦ skills in using a range of test equipment			✓	✓
♦ constructing electronic circuits using permanent (soldering) and non-permanent methods			✓	✓
♦ knowledge and understanding of the systems approach to electronics, including sub-systems	✓			
♦ knowledge and understanding of the use of concepts and principles associated with a range of electronic and electromagnetic components and circuits	✓	✓	✓	✓
♦ knowledge and understanding of combinational logic	✓			✓
♦ understanding of key electrical concepts — current, voltage, resistance, power, analogue/digital, capacitance, magnetic effect of current	✓	✓		
♦ applying electronic knowledge and skills in a range of contexts		✓	✓	✓

Approaches to learning and teaching

An appropriate balance of teaching methodologies should be used in the delivery of the National 5 Practical Electronics course. Whole-class, direct teaching opportunities should be balanced by activity-based learning on practical tasks.

Learning should be supported by appropriate practical activities, so that skills are developed simultaneously with knowledge and understanding. Practical activities and investigations lend themselves to group work, and this should be encouraged. While working in a group is not specifically identified as one of the skills for learning, life and work for this course, it is a fundamental aspect of working in the electronics industry, and should be encouraged and developed by teachers and lecturers.

Assessment activities, used to support learning, may usefully be blended with teaching and learning activities throughout the course. For example:

- sharing learning intentions/success criteria
- using assessment information to set learning targets and next steps
- adapting teaching and learning activities based on assessment information
- boosting candidates' confidence by providing supportive feedback

Self- and peer-assessment techniques should be encouraged wherever appropriate.

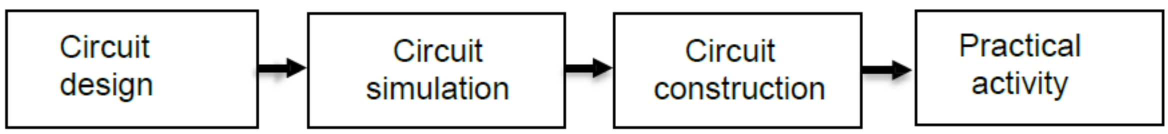
Teaching and learning activities should be designed to stimulate candidates' interest and develop:

- skills, knowledge and understanding to the standard required and to the level defined by this course specification
- the breadth of knowledge and understanding required to complete the course assessment successfully, as listed in this course specification

Sequence of delivery

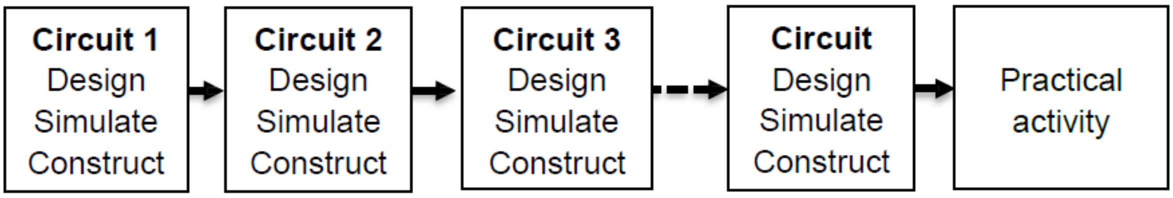
The sequence of delivery of the topics within the National 5 Practical Electronics course is at the discretion of the centre and the models suggested below exemplify possible approaches which may be developed to suit individual circumstances and resources.

Delivering topics sequentially



While it would be possible to deliver the topics in sequence (circuit design — circuit simulation — circuit construction — practical activity), this approach may not be the most natural and effective way of delivering the course, as it would not allow for integration of learning and skills. The sequence of design, simulate, construct is applicable to each circuit being developed, rather than to the overall delivery of the course.

Combined delivery of topics



In this integrated approach, the course would be designed around a series of circuits of increasing complexity (not necessarily four, as shown in the diagram).

The course could start with an introduction to general workshop safety; use of tools; the importance of following instructions carefully; maintaining a logbook or e-portfolio; and an introduction to components and concepts.

Circuit 1 could involve simple components and concepts, such as resistors and resistance. Candidates may then simulate circuits involving these components using suitable software, then they could build these circuits on prototype board.

Circuit 2 could introduce additional components, with the same pattern of activities, perhaps continuing right through to constructing permanent circuits using soldering.

As the course progresses, the degree of complexity can be gradually advanced, both in conceptual understanding and in level of skill required in circuit construction and simulation. In effect, this is a continuous loop of: theory—simulation—construction, spiralling outwards.

A useful mnemonic for the integrated approach is **DD SS BB RR**. For each circuit, the following stages can be applied:

- **Define**: the process of looking for an objective or being given an objective that can be achieved by the construction of a circuit.
- **Design**: considering the components required, how they interact and work together, and calculating values.
- **Simulate**: checking (and probably modifying) the design by simulating, using a software package.
- **Shop**: gathering or purchasing of components.
- **Build**: construction of the circuit (using permanent or non-permanent methods).
- **Bench test**: comparing the finished circuit with its simulation to check it does what it's supposed to, and identifying any faults.
- **Repair**: fixing any problems until proper function is achieved.
- **Report**: may be verbal, written, electronic, and include description, circuit diagram and/or photograph, as required.

These stages may be iterative, with a problem discovered at any stage requiring a return to an earlier stage.

Some use could be made of commercial kit projects (with circuit diagrams) where the sequence can be shortened to BBRR — build, bench test, repair, report — with the simulation and theory of their design taking place at any time during the work.

Delivery of the practical activity

As the practical activity is intended to allow candidates to apply skills, knowledge and understanding developed throughout the course, it should normally be delivered at the end of the course. However, it may be possible to begin work on the practical activity at an earlier stage, but only where it is clear that candidates have already gained the required skills, knowledge and understanding.

Distribution of time

The distribution of time between the various topics is a matter for professional judgement and is entirely at the discretion of the centre. Each topic is likely to require an approximately equal time allocation, although this may depend on candidates' prior learning in the different topic areas.

Circuit design

Sequence of delivery

The sequence of delivery and the distribution of time is a matter of professional judgement and is entirely at the discretion of the centre. Two main approaches are suggested, but other possibilities exist.

Some teachers or lecturers may prefer to consider analogue circuits first, so that candidates understand the various components required for input and output from digital circuits.

Some teachers or lecturers may prefer to cover the content by combining learning about analogue and digital circuits, for example:

1. Resistors and resistance. Power. Magnetic effect of current. Colour code, resistor notation, combining resistors in series and parallel, varying resistance and some uses.
2. Diodes. One-way current, LEDs, and some uses.
3. Transistors. NPN and PNP, transistor amplifier, use as an electronic switch.
4. Capacitors and capacitance. Storing electric charge.
5. Integrated circuits. Should include logic gates AND, OR, NOT, NAND, XOR, and NOR. Operational amplifier.
6. The systems approach. Should include: input devices, LDR, thermistor and switch; process devices, transistor switch and logic gates; output devices, LED, motor and buzzer.

Integrated approach

Either of the approaches described above can be delivered in an integrated way with the other two topics in the course. For example, when teaching about digital circuits, these can be simulated and/or constructed as part of the learning activities. Candidates will gain a richer experience by learning about concepts and components while actually constructing them on prototype board, stripboard and printed circuit boards (PCBs) in a series of practical activities. Similarly, circuits can be simulated and tested at the same time, for example investigating resistor networks on prototype boards and comparing the colour code with an actual measurement using an ohmmeter. This can then be simulated on appropriate software.

Useful resources

- Electronic components can be purchased from a range of commercial suppliers such as Rapid Electronics, RS components, Picaxe, and Velleman.
- Electronic systems kits, such as the Angus system boards (JJM Electronics), and Unilab Alpha modular kits.
- Optoelectronics College kits are a useful resource for investigating LEDs and other components.

Suitable texts for reference, include:

- *A Practical Approach to System Electronics*, Gregory, Hackett and Vincent-Smith, Longman, 1985.

- *Electronics for Dummies*: UK edition, Ross, Shamieh and McComb, John Wiley & Sons, 2009.
- *Electronics: a Systems Approach*, Dr Neil Storey, Pearson, 2017.

Suitable texts for candidates, containing relevant material on basic electrical and electronic concepts, include:

- Intermediate 1 and 2 Physics handbooks, Campbell White, Hamilton Publishing, 2003.
- Standard Grade Physics, Baillie and McCormick, Hodder Gibson, 2002.
- Standard Grade Physics, Campbell and Dobson, Nelson, 1999.

The *Virtual Physics Intermediate 1* and *Intermediate 2 Physics* **digital textbooks** by Flash Learning also contain lots of useful material and interactive activities.

The **software package** Absorb Physics has some useful notes, diagrams and quizzes on electronics.

There are many useful online videos. For example, on YouTube there are several electronic tutorials on 'expert village' and 'make'.

Various **Logic Simulators** are available, including Logic-Lab from the neuroproductions website.

Circuit simulation

Sequence of delivery

The sequence of delivery and the distribution of time is a matter of professional judgement and is at the discretion of the centre. Two main approaches are suggested, but other possibilities exist.

Delivering circuit design and circuit simulation topics sequentially

It is possible to deliver the two concepts of circuit design and circuit simulation in sequence, with the transferable skills of design being used as a basis to develop further skills in circuit construction and simulation.

Integrated approach

This topic lends itself to a more holistic delivery approach, integrated with the circuit design and circuit construction topics. In this approach, the candidate would be introduced to the software package/packages when required, to support the design process and then the construction and testing phase. This would allow candidates to experience the industrial pattern of the design, simulation and construction phases of a project.

Useful resources

Before choosing and installing software, check that the relevant specification will be compatible with your current hardware.

ECAD simulation packages

There are many electronic schematic editors and PCB layout packages available, many of them free. Many have simulation elements based on variations of SPICE and will deliver what the course requires. **ECAD list** is a website which contains links to over 60 packages of various types. The most consistent entry-level education package appears to be **Yenka** (formerly known as Crocodile Clips). This Scottish company specifically designs with an education focus and their products are used widely in Scottish centres.

An example of useful software includes **VeeCAD**, a free-to-download stripboard layout package which works in conjunction with **TinyCAD**, an open source electronic schematic editor. These may be used to assist in layout of circuits.

Circuit construction

Sequence of delivery

The sequence of delivery and the distribution of time is a matter of professional judgement and is entirely at the discretion of the centre. Two main approaches are suggested, but other possibilities exist.

Each candidate is expected to plan, construct and test several circuits during this area of the course, as these are the three main stages in circuit construction. It is therefore unlikely that a simple sequential approach is appropriate, as this would involve planning several circuits, then constructing them, then testing them.

A more appropriate approach is to develop a series of circuits of increasing complexity, building up skills with each circuit, until each candidate reaches a level where the teacher or lecturer is confident that they have reached the appropriate standard.

Each circuit would be developed through the following phases:

- planning:
  - — design
  - — simulation
  - — 'purchase' of components
- construction:
  - — breadboard try-out
  - — solder and connect
- testing:
  - — test and evaluate

Topic approach

In this approach (with all candidates constructing the same circuits) the following sequence of main topics would give opportunities to develop all of the required skills:

1 Constructing circuits on breadboard
2 Soldering and safety introduction
3 Constructing circuits on stripboard
4 Ordering components
5 Soldering small commercial PCB project or kit
6 Connection technologies

On completion of these topics, candidates should be ready to progress to the practical activity assessment task.

Useful resources

Suitably ventilated area for soldering (this depends on centre safety policy and type of soldering irons and solder used).

Safety equipment

- safety glasses (optionally, with magnification)

Tools

- soldering irons
- soldering iron stand
- wire strippers
- solder sucker
- track cutter, side cutters, end cutters
- crimp tools
- multimeters, continuity testers
- magnifying light
- breadboards
- power supplies
- oscilloscope (can be PC plug-in)
- screwdriver, pliers, etc

Consumables

- lead-free solder (ideally rosin-free)
- stripboard
- range of components
- wire, wire markers, cable ties, etc

Books

Some useful books include:

- *Electronics for Dummies*: UK edition, Ross, Shamieh and McComb, John Wiley & Sons, 2009.
- *Make: Electronics: Learning Through Discovery*, Charles Platt, Maker Media, 2009.

Component suppliers

Electronic components and kits can be obtained from wide range of suppliers, including RS components, Picaxe, Rapid Electronics and Velleman.

Safety considerations and good practice

- No mains voltage work should be attempted by candidates and they should be reminded that this course does not qualify them to work on any mains circuit.
- Candidates should not construct any kind of radio transmitter or laser.

- Candidates should be aware of the dangers of using large capacitors, transformers or high voltage circuits; suggested limit 12 V.
- Solder should be lead-free and the care of soldering irons should be covered before soldering begins.
- Candidates should have access to a cold water tap when soldering.
- Keep the soldering tip tinned.
- When soldering, candidates should have soldering iron and solder in hands, work positioned or held correctly, and have safety glasses on.
- Wire work: preparing wires for insertion on stripboard and breadboard should be practised by all candidates. Wires should lay flat on the surface, between the correct holes, with stripped ends a reasonable length. Other wire stripping should be practised with a range of wire stripping tools.

Preparing for course assessment

Each course has additional time which may be used at the discretion of teachers or lecturers to enable candidates to prepare for course assessment. This time may be used near the start of the course and at various points throughout the course for consolidation and support. It may also be used towards the end of the course, for further integration, revision and preparation and/or gathering evidence for course assessment.

Within the notional time for the course assessment, time will be required for:

- preparation for the practical activity assessment task which could include considering exemplar tasks and practising the application and integration of skills
- carrying out the stages of the practical activity, with guidance and support from teachers and lecturers
- assessing the process and completed solution
- consolidation of learning
- development of problem-solving skills

Developing skills for learning, skills for life and skills for work

Course planners should identify opportunities throughout the course for candidates to develop skills for learning, skills for life and skills for work.

Candidates should be aware of the skills they are developing and teachers and lecturers can provide advice on opportunities to practise and improve them.

SQA does not formally assess skills for learning, skills for life and skills for work.

There may also be opportunities to develop additional skills depending on approaches being used to deliver the course in each centre. This is for individual teachers and lecturers to manage.

The table below suggests opportunities to develop these skills during this course.

2 Numeracy	
2.3 Information handling	Drawing and interpreting system diagrams. Drawing and interpreting circuit diagrams.
4 Employability, enterprise and citizenship	
4.2 Information and communication technology (ICT)	Using simulation software in the design of circuits. Using software to create layouts. Using simulation software to test circuits.
5 Thinking skills	
5.3 Applying	Choosing appropriate construction methods. Applying safe working practices. Using and creating checklists to identify faults. Solving electronic problems.
5.4 Analysing and evaluating	Analysing circuit functions and explaining their operation. Fault finding in circuits. Rectifying faults in circuits. Evaluating circuit design and construction.

The course may also provide opportunities to develop or consolidate other skills for life, learning and work, including:

- reading and writing
- number processes
- working with others
- enterprise and citizenship

Administrative information

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History of changes to course specification

Version	Description of change	Date
2.0	Course support notes added as appendix.	September 2017

Note: you are advised to check SQA's website to ensure you are using the most up-to-date version of the course specification.