Higher National Unit specification

General information

Unit title: Electricity and Magnetism (SCQF level 7)

Unit code: H93L 34

Superclass: RC

Publication date: July 2015

Source: Scottish Qualifications Authority

Version: 02

Unit purpose

This Unit is designed to enable learners to understand key aspects of electricity and magnetism. Learners will also develop practical skills in techniques relevant to electricity and magnetism. The Unit is suitable for learners studying at HNC level, and will provide the necessary underpinning knowledge and skills to enable progression to further study of electricity and magnetism at HND level or to seek employment in science based industries.

Outcomes

On successful completion of the Unit the learner will be able to:

1 Describe and apply properties of electric fields.
2 Explain and apply properties of magnetic fields.
3 Apply properties of RC and RL circuits.
4 Perform a practical experiment related to electricity and magnetism.

Credit points and level

1 Higher National Unit credit at SCQF level 7: (8 SCQF credit points at SCQF level 7)

Recommended entry to the Unit

Entry is at the discretion of the centre, however it is recommended that learners should have experience of Physics and Mathematics at Higher level.

Higher National Unit specification: General information (cont)

Unit title: Electricity and Magnetism (SCQF level 7)

Core Skills

Achievement of this Unit gives automatic certification of the following Core Skills component:

Complete Core Skill	None
Core Skill component	Critical Thinking at SCQF level 6 Using Number at SCQF level 6

There are also opportunities to develop aspects of Core Skills which are highlighted in the Support Notes of this Unit specification.

Context for delivery

If this Unit is delivered as part of a Group Award, it is recommended that it should be taught and assessed within the subject area of the Group Award to which it contributes.

The Assessment Support Pack (ASP) for this Unit provides assessment and marking guidelines that exemplify the national standard for achievement. It is a valid, reliable and practicable assessment. Centres wishing to develop their own assessments should refer to the ASP to ensure a comparable standard. A list of existing ASPs is available to download from SQA's website **www.sqa.org.uk/sqa/46233.2769.html.**

Equality and inclusion

This Unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence.

Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**.

Higher National Unit specification: Statement of standards

Unit title: Electricity and Magnetism (SCQF level 7)

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

Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the Knowledge and/or Skills section must be taught and available for assessment. Learners should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion.

Outcome 1

Describe and apply properties of electric fields.

Knowledge and/or Skills

- Electric field strength and gravitational field strength
- Coulomb's Inverse Square Law
- Electric field strength around a point charge and a system of charges
- Electric potential around a point charge and a system of charges
- Potential difference and electric field strength in a uniform electric field
- Motion of charged particles in uniform electric fields: linear accelerators, oscilloscope deflecting plates
- Millikan's Oil Drop experiment
- Electron volt unit of energy

Outcome 2

Explain and apply properties of magnetic fields.

Knowledge and/or Skills

- Ferromagnetism
- Tesla unit
- Magnetic field pattern around a moving charge in a straight wire and a solenoid
- Left hand grip rule
- Magnetic induction at a distance from a long current carrying wire
- Force on a current carrying wire in a magnetic field
- Hall Effect
- Fleming's Right Hand Rule
- Applications of magnetic induction: the electric motor

Outcome 3

Apply properties of RC and RL circuits.

Knowledge and/or Skills

- Capacitor combinations in series and parallel
- Capacitors in dc circuits: the time constant for an RC circuit
- Capacitors in ac circuits: capacitive reactance
- Inductors in dc circuits: self-inductance of a coil, Lenz's Law
- Inductors in ac circuits: inductive reactance
- Energy stored in capacitors and inductors
- Applications of capacitors
- Variation of capacitive and inductive reactance with frequency

Outcome 4

Perform a practical experiment related to electricity and magnetism.

Knowledge and/or Skills

- Electricity and magnetism experiment
- Working safely, within current health and safety regulations
- Consistent and accurate results
- Recording observations and results
- Evaluation skills
- Result analysis and conclusions

Higher National Unit specification: Statement of standards (cont)

Unit title: Electricity and Magnetism (SCQF level 7)

Evidence Requirements for this Unit

Written and/or oral recorded evidence for Outcomes 1−3 should be assessed using a holistic closed-book assessment under supervised conditions. The assessment will use a sampling approach to the Knowledge and/or Skills as detailed below. It is recommended that the assessment be completed within 90 minutes. Learners can only have access to the *SQA Databook for HN Physics* or any suitable replacement when sitting the assessment.

Written and/or oral recorded evidence for Outcome 4 should be assessed by production of a full laboratory report, or by completion of an appropriate pro forma. An assessor's observation checklist could be used to record performance evidence of the practical experiment.

Outcome 1

The assessment will sample five of the eight Knowledge and/or Skills items. Learners will not have prior knowledge of which items are being assessed. Those items which are not sampled must be covered in the alternative (re-sit) assessment.

Where an item is sampled, a learner's response will be judged satisfactory where the evidence shows that the learner can:

- Describe the similarity between the electric field strength and the gravitational field strength equations.
- Apply Coulomb's Inverse Square Law to perform calculations to determine the resultant electrostatic force between 2 or 3 point charges in fixed positions.
- Perform calculations to determine the electric field strength around a point charge or a system of charges.
- Perform calculations to determine the electric potential around a point charge or a system of charges.
- Apply the properties of potential difference and electric field strength in a uniform electric field to perform calculations to determine the force, acceleration or time of motion of a stationary particle placed within the field.
- Describe the two dimensional motion of a moving charged particle as it enters a uniform electric field.
- Perform calculations related to Millikan's Oil Drop experiment.
- Use the electron volt as a unit of energy.

Higher National Unit specification: Statement of standards (cont)

Unit title: Electricity and Magnetism (SCQF level 7)

Outcome 2

The assessment will sample five of the nine Knowledge and/or Skills items. Learners will not have prior knowledge of which items are being assessed. Those items which are not sampled must be covered in the alternative (re-sit) assessment.

Where an item is sampled, a learner's response will be judged satisfactory where the evidence shows that the learner can:

- Explain ferromagnetism.
- Describe and apply the Tesla unit.
- Describe the magnetic field pattern around a moving charge in a straight wire and a solenoid.
- Apply the Left hand grip rule to determine direction of field patterns.
- Apply $B = \frac{\mu_0 I}{2\pi r}$ to perform calculations to determine the magnetic induction at a distance from a long current carrying wire.
- Apply $F = IlBsin\theta$ to perform calculations to determine the force on a current carrying wire in a magnetic field.
- Describe the Hall Effect.
- Apply Fleming's Right Hand Rule to determine the relative directions of current, magnetic field and force of a current carrying conductor in a magnetic field.
- Explain an application of magnetic induction.

Outcome 3

The assessment will sample five of the eight Knowledge and/or Skills items. Learners will not have prior knowledge of which items are being assessed. Those items which are not sampled must be covered in the alternative (re-sit) assessment.

Where an item is sampled, a learner's response will be judged satisfactory where the evidence shows that the learner can:

- Perform calculations to determine the total capacitance for a series or parallel combination of capacitors.
- Perform calculations to determine the time constant for a capacitor in an RC circuit.
- Perform calculations to determine the capacitive reactance.
- Apply Lenz's Law to solve a problem.
- Perform calculations to determine the inductive reactance.
- Perform calculations to determine the energy stored in a capacitor or an inductor.
- Describe an application of capacitors.
- Describe variation of capacitive and inductive reactance with frequency.

Higher National Unit specification: Statement of standards (cont)

Unit title: Electricity and Magnetism (SCQF level 7)

Outcome 4

Learners will perform one practical experiment, the content of which will be related to Outcomes 1−3. A learner's response will be judged satisfactory where the evidence shows that the learner can achieve all of the following:

- Follow instructions to perform an experiment related to electricity and magnetism.
- Work in a safe manner regarding current health and safety regulations.
- Achieve consistent and accurate results.
- Record experimental observations and results clearly and accurately.
- Evaluate validity of results in terms of sources of and values of experimental errors.
- Analyse results correctly and state valid conclusions.

An assessor observation checklist will be used to record the learner's performance of the practical work in line with given instructions and health and safety requirements.

Learners may report results either by production of a full laboratory report, or by completion of an appropriate pro forma. Where a pro forma approach is deployed, the pro forma will not present information or assistance to the learners on how to correctly perform calculations, analyse experimental results or experimental errors. Learners will be expected to perform such activities independently on the basis of the experimental data.

Where a learner does not perform an assessed practical experiment to the required standard, they will be given the chance to either reattempt the same practical experiment, or to undertake a different practical experiment of similar complexity. Where a laboratory report or pro forma does not meet required standard, then the learner will be given a single opportunity to re-draft. If the required standard is still not attained, then an alternative practical experiment will be set.

Higher National Unit Support Notes

Unit title: Electricity and Magnetism (SCQF level 7)

Unit Support Notes are offered as guidance and are not mandatory.

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

Guidance on the content and context for this Unit

This Unit is intended as part of the framework for HNC/D Applied Sciences but may be suitable for inclusion in other HN Science awards. It is designed to develop the theoretical and practical aspects of electricity and magnetism.

Outcome 1 — Describe and apply properties of electric fields

- The similarity between electric field strength $E = \frac{F}{Q}$, with gravitational field strength $g = \frac{F}{m}$.
- Use Coulomb's Inverse Square Law $F = \frac{1}{4\pi\varepsilon_o} \cdot \frac{Q_1 \cdot Q_2}{r^2}$ to calculate the resultant electrostatic force between 2 or 3 point charges in fixed positions.
- Use $E = \frac{Q}{4\pi\varepsilon_o r^2}$ to calculate the electric field strength around a point charge.
- Use $V = \frac{Q}{4\pi\varepsilon_o r}$ to calculate the electric potential around a point charge.
- Determine the electric field strength and electric potentials for a system of charges, including an electric dipole. Use $V = Ed$, and $E_w = qV$ to calculate potential difference and electric field strength in a uniform electric field.
- The motion of charged particles in uniform electric fields, including electron gun, linear accelerators (used in radiotherapy) and oscilloscope deflecting plates.
- Describe and explain Millikan's Oil Drop experiment, which determined the charge on an electron. Show $mg = QE$, but $E = V/d$, therefore $Q = mgd/V$. Carry out computer simulations of Millikan's Oil Drop experiment that led to the quantisation of charge. Carry out calculations on Millikan's Oil Drop experiment, using $mg = QE$, and $Q = mgd/V$.
- Use the electron volt unit of energy.

Higher National Unit Support Notes (cont)

Unit title: Electricity and Magnetism (SCQF level 7)

Outcome 2 — Explain and apply properties of magnetic fields

- Ferromagnetism, where magnetic dipoles align resulting in the material being magnetised.
- Use the Tesla unit correctly.
- Magnetic field patterns around a bar magnet, a current carrying wire and a solenoid.
- Use the Left hand grip rule to determine the direction of magnetic field patterns, magnetic field strength, forces, magnetic induction and applications.
- Carry out calculations of magnetic induction at a distance from a long current carrying wire using $B = \frac{\mu_0 I}{2\pi r}$.
- Carry out experiments, using a Hall probe, to show that the Force on a current carrying conductor varies with current and length and calculate the force using $F = IlBsin\theta$.
- Describe the Hall Effect.
- Apply Fleming's Right Hand Rule to determine the relative directions of current, magnetic field and force of a current carrying conductor in a magnetic field.
- Applications of magnetic induction, including the electric motor.

Outcome 3 — Apply properties of RC and RL circuits

- Determine the total capacitance for series and parallel combinations of capacitors.
- Current and voltage in charging and discharging RC circuits and determine the time constant for the circuit.
- Show $Xc = V/I$, and show variation of capacitive reactance with frequency $Xc = 1/2\pi fC$.
- Inductors in dc circuits; self-inductance and Lenz's Law $\varepsilon = -LdI/dt$.
- Inductive reactance $X_L = V/I$ and $X_L = 2\pi fL$
- Energy stored in an inductor is $E = \frac{1}{2} LI^2$, and Energy stored in a capacitor = ½ QV = ½ CV^2.
- Applications of capacitors in circuits: smoothing ac signals, tuning, RC filters, blocks dc signals.
- A comparison of X_L and X_c variations with frequency.

Outcome 4 — Perform a practical experiment related to electricity and magnetism

Guidance on suitable practical experiments for assessment purposes is given elsewhere in this document. However, it is envisaged that learners will also participate in a range of other practical experiments which will both develop their laboratory skills and support the theory covered in Outcomes 1−3.

In carrying out such activities, learners should follow Good Laboratory Practice (GLP) and carry out or be familiar with the risk and Control of Substances Hazardous to Health (COSHH) assessments on all procedures undertaken. Opportunities should be taken to develop awareness of the sources of experimental error and of the accuracy of measurements, with quantification of errors where possible.

Higher National Unit Support Notes (cont)

Unit title: Electricity and Magnetism (SCQF level 7)

Guidance on approaches to delivery of this Unit

It is recommended that Outcomes 1−3 be taught in order. It is envisaged that laboratory work and demonstrations will feature across the delivery of each of the Outcomes, and that the assessed practical experiment for Outcome 4 will be undertaken in a similar timeframe to the underpinning theory.

It is advisable to encourage a learner-centred, participative and practical approach. Practical work should be backed up with problem solving and related to real life applications.

It is envisaged that delivery of Outcome 1 could commence with a comparison of electric field strength and gravitational field strength. Learners could then be introduced to Coulomb's Inverse Square Law before applying it to 2 or 3 point charges in fixed positions. Delivery could then focus on calculating electric field strength and electric potential around a point charge and a system of charges before covering electric field strength and potential difference in uniform electric fields. The motion of charged particles in uniform electric fields, for a range of applications, could then be delivered. Millikan's Oil Drop experiment could then be introduced via computer simulations with learners carrying out calculations using $mg = QE$ and $Q = mgd/V$. Outcome 1 could continue with an explanation of the electron volt as a unit of energy, before using it in calculations. During delivery learners should be encouraged to research practical applications, eg medical linear accelerators (linacs), LHC at CERN.

Outcome 2 covers magnetism, and could commence with a description of ferromagnetism and the unit of magnetic field strength. Demonstrations of field patterns around a bar magnet, current carrying wire and a solenoid could then be covered before introducing the Left hand grip rule. Delivery should include a discussion of magnetic field strength, magnetic induction and applications. Learners could then use $B = \frac{\mu_0 I}{2\pi r}$ to solve problems in magnetic induction in a current carrying wire, before applying $F = IlBsin\theta$. Delivery could then focus on a discussion of the Hall Effect and an explanation of Fleming's Right Hand Rule in order that it be applied to the Hall Effect. Outcome 2 could continue with a discussion of applications of magnetic induction.

Outcome 3 covers RC and RL circuits, and could commence with calculations involving the total capacitance in series and parallel combinations of capacitors. Delivery could then focus on current and voltage in charging and discharging capacitors in RC circuits, determining time constant, and the effect of magnitude of R, demonstrate $\tau = RC$. These topics lend themselves to practical work, perhaps using dataloggers. Variation of capacitive reactance with frequency should then be covered, and this could be an assessed experiment for Outcome 4. Lenz's Law could then be introduced before applying it to solve problems. Practical exercises could be used to cover variation of inductive reactance with frequency, before moving on to compare, by graph, inductive reactance and capacitive reactance variation with frequency. Outcome 3 could continue with a discussion of applications of inductors and capacitors in circuits, eg smoothing ac signals, tuning circuits, passive and active filters, induction cookers, electromagnetic braking.

It is envisaged that Outcome 4 will be delivered alongside the theoretical based Outcomes 1−3. A range of practical experiments could be utilised to both support understanding of the underlying theory and to prepare learners for undertaking the assessed practical experiment.

Higher National Unit Support Notes (cont)

Unit title: Electricity and Magnetism (SCQF level 7)

Aspects suitable for experimental investigation might include variation of capacitive or inductive reactance with frequency, time constant of an RC or RL circuit, and current in RL circuits.

Guidance on approaches to assessment of this Unit

Evidence can be generated using different types of assessment. The following are suggestions only. There may be other methods that would be more suitable to learners.

Outcomes 1−3 could be assessed by a single holistic closed-book assessment with an appropriate cut-off score that covers the minimum sampling requirements as detailed in the Evidence Requirements. Assessment should be carried out in supervised conditions, and it is recommended to last for 90 minutes. Learners can only have access to the *SQA Databook for HN Physics* or any suitable replacement when sitting the assessment.

Where evidence of Outcomes 1−3 is assessed by sampling, the whole of the content listed in the Knowledge and/or Skills must be taught and available for assessment. Learners should not know in advance the items on which they will be assessed, and different items should be sampled on each assessment occasion. Any items not sampled in the first assessment, must be included in the alternative (re-sit) assessment.

In Outcome 4 learners are required to undertake one assessed practical experiment, the content of which will be related to Outcomes 1−3. Examples of suitable experiments are given below. However, this list is not prescriptive, and other practical experiments of similar complexity may be used by the centre.

Suitable practical experiments for Outcome 4 are:

- Variation of capacitive or inductive reactance with frequency
- Time constant of an RC or RL circuit
- Current in RL circuits

Assessed practical activities will usually be performed individually. However, there may be some activities that are suitable to be undertaken in pairs or small groups. If this is the case then the assessor should ensure that all participants are actively involved and are able to adequately demonstrate the required skills.

An exemplar instrument of assessment with marking guidelines has been produced to indicate the national standard of achievement at SCQF level 7.

Centres are reminded that prior verification of centre-devised assessments would help to ensure that the national standard is being met. Where learners experience a range of assessment methods, this helps them to develop different skills that should be transferable to work or further and higher education.

Unit title: Electricity and Magnetism (SCQF level 7)

Opportunities for e-assessment

E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA's qualifications is available at **www.sqa.org.uk/e-assessment**.

Opportunities for developing Core and other essential skills

The delivery and assessment of this Unit will provide learners with the opportunity to develop the Core Skill of *Numeracy* at SCQF level 6, and *Information and Communication Technology (ICT)* at SCQF level 5.

***Numeracy* — Using Number at SCQF level 6**

Learners will be required to solve complex problems, involving several stages, and requiring a number of sustained complex calculations.

***Information and Communication Technology (ICT)* — Providing/Creating Information at SCQF level 5**

Learners may make effective and appropriate use of ICT packages to produce a laboratory report in an appropriate format. Packages used will likely include word processing and spreadsheets.

This Unit has the Critical Thinking component of Problem Solving and the Using Number component of Numeracy embedded in it. This means that when candidates achieve the Unit, their Core Skills profile will also be updated to show they have achieved Critical Thinking at SCQF level 6 and Numeracy at SCQF level 6.

History of changes to Unit

Version	Description of change	Date
02	Core Skills Components Critical Thinking and Using Number at SCQF level 6 embedded.	July 2015

General information for learners

Unit title: Electricity and Magnetism (SCQF level 7)

This section will help you decide whether this is the Unit for you by explaining what the Unit is about, what you should know or be able to do before you start, what you will need to do during the Unit and opportunities for further learning and employment.

This is a 1 credit Unit at SCQF level 7, which you are likely to be studying as part of the first year of an HNC/HND Science programme. Before progressing to this Unit, it would be beneficial to have experience of Physics and Mathematics at Higher level, where you will have studied underpinning knowledge of electricity.

On successful completion of this Unit you should be able to:

1 Describe and apply properties of electric fields.
2 Explain and apply properties of magnetic fields.
3 Apply properties of RC and RL circuits.
4 Perform a practical experiment related to electricity and magnetism.

Outcome 1

In Outcome 1 you will learn about static electricity; studying electric field strength, and using Coulomb's Inverse Square Law to study forces between point charges and system of charges. You will also study induction and Millikan's Oil Drop experiment.

Outcome 2

In Outcome 2 you will learn about ferromagnetism, and you will study magnetic field patterns around various objects. You will use the Left hand grip rule to determine the directions of magnetic fields, and you will carry out calculations of magnetic induction at a distance. You will also apply Fleming's Right Hand Rule to determine relative directions of current, force and magnetic fields, and you will study applications of magnetic induction.

Outcome 3

In Outcome 3 you will learn about total capacitance of series/parallel combinations of capacitors. You will study series circuits containing combinations of resistors, capacitors and inductors, and you will cover capacitive and inductive reactance and its variation with frequency. You will determine timer constants of RC and RL circuits, and you will learn about practical applications of capacitor and inductor circuits.

Outcome 4

In this Outcome you will undertake a practical experiment, based on the content of Outcomes 1−3.

During this practical work, you will also be expected to develop good laboratory practices as well as improve your skills of manipulation, observation and measurement. You will be encouraged to develop safe working practices and to strive constantly to improve the accuracy and reliability of your results. The reporting and analysis of experimental data is an important aspect of the practical sessions.

General information for learners

Unit title: Electricity and Magnetism (SCQF level 7)

Assessment

For Outcomes 1 to 3 you will take a closed-book, end of Unit assessment.

Outcome 4 will be assessed after you have learned the necessary practical skills, and will take the form of one practical experiment, for which you will report your results either in a full laboratory report, or by completion of a pro forma report.

Core Skills

You will have opportunities to develop the Core Skill of *Numeracy* at SCQF level 6, and *Information and Communication Technology (ICT)* at SCQF level 5.