Scottish Certificate of Education

Standard Grade Revised Arrangements in Physics

General and Credit Levels in and after 1999

STANDARD GRADE ARRANGEMENTS IN PHYSICS

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Introduction

This document sets out the arrangements for examinations in Standard Grade Physics which have been developed in the light of a two-stage consultation exercise carried out between November 1995 and February 1997. The consultation initially sought the views of interested bodies and presenting centres on a range of alternative models for assessment of Practical Abilities in the sciences and latterly on proposed amended arrangements.

Examinations in Physics at General and Credit Levels based on these Arrangements will be offered in and after 1999.

Section 1

Aims, Course Objectives and Assessable Elements

1 Aims, Course Objectives and Assessable Elements

1 1 Aims

The Standard Grade Physics course aims to contribute to pupils' general education by helping to make sense of the physical environment through scientific enquiry and to provide a suitable basis for further study of the subject. The essence of such enquiry is problem solving, and thus in common with other sciences this course aims to develop the skills necessary to find solutions to scientific problems and through success and enjoyment to develop positive pupil attitudes.

1 2 Course Objectives

As a result of following the course, pupils should acquire:

- **knowledge and understanding** of facts and ideas, techniques and the applications of physics in society;
- skill in applying their knowledge and understanding in **problem solving**;
- **practical abilities** associated with investigations in physics;
- **positive attitudes** such as being open-minded and willing to recognise alternative points of view, prepared to show initiative and accept responsibility, interested in physics, in themselves and in their environment, and aware that they can take decisions which affect the well-being of themselves and others and the quality of their environment.

1 3 Assessable Elements

In achieving the course objectives a variety of abilities and attitudes will be developed.

These abilities are grouped into three assessable elements, namely,

A Knowledge and Understanding

B Problem Solving

C Practical Abilities.

These are described in paragraph 4 2.

The elements will form the basis for assessment and profiling of pupil performance.

The achievement of the course objectives relating to attitudes will not be formally assessed.

Section 2

The Course

2 The Course

2 1 Design of the Course

In designing this course the strategy has been to introduce physics through its impact on everyday life. The study of well-known physics applications is intended to stimulate interest and increase motivation of pupils of a wide range of ability. By progressing from the known (the application) to the unknown (the underlying principle) and by allowing repeated opportunities for reinforcement of important principles, the course reflects the best accepted teaching methods. All pupils involved should gain an understanding of some simple applications of physics. For the more able pupils, the essential concepts underlying the applications are firmly established, thus providing the necessary foundation for further study of the subject.

The course is designed to follow on from work in S1 and S2. The activities suggested in Units 1 and 2 (see Section 3), are, in most cases, equally suitable for all pupils. In later Units, however, alternative activities have been suggested to match the needs and capabilities of pupils.

The approach chosen is one in which the content is organised into Units so that traditional concepts may be encountered in a logical order. A possible sequence for teaching these Units is suggested in paragraph 2 4. The planned progression and development of physical concepts which that teaching order suggests are illustrated in Appendix I.

2 2 Course Content

The following Units have been chosen to allow pupils to achieve the objectives outlined in paragraph 1 2 above. The reasons for this selection of units are stated briefly below.

Unit 1: Telecommunication

The purpose of this Unit is to assist pupils to gain understanding of the physical principles which underlie the rapidly developing area of information technology. Among the aspects studied are radio and television reception, communication satellites and the use of fibre optics for transmitting information.

Unit 2: Using Electricity

This Unit allows pupils to gain a knowledge and understanding of the principles behind the electrical and electronic devices which they encounter in their everyday lives. Since these principles are developed further in later Units, the emphasis in this Unit is on providing a sound foundation of electrical circuit theory.

Unit 3: Health Physics

It is hoped that an awareness of the beneficial and caring face of physics will balance the negative view that physics only relates to the production of weapons of mass destruction. At the same time, this Unit is especially important as a preparation for life as it introduces pupils to the uses of ultrasonics, optics, electronics and radioactivity in medical care.

2 2 (*continued*)

Unit 4: Electronics

Developments in the field of microelectronics have revolutionised the structure of commerce and industry. This Unit attempts to familiarise pupils with developments in both digital and analogue electronics and provides further applications of the circuit theory developed in Unit 2. The associated practical activities allow pupils to investigate what "chips" can do and to recognise how they can be linked together as elements in a total system. Theoretical aspects of solid state physics are not considered appropriate at this level.

Unit 5: Transport

This Unit is similar in nature to Unit 2 in that it introduces fundamental concepts which can be developed further in later Units. The main aim is to provide a grounding in key concepts of mechanics and to relate these to everyday aspects of travel such as the use of seat belts and the stopping distances of vehicles.

Unit 6: Energy Matters

The provision of an adequate supply of energy and its careful husbanding is one of the most important problems facing a modern, highly-industrialised society. This Unit enables pupils to study energy supply and demand, the generation of electricity and the physical principles involved in conservation, especially in the domestic environment.

Unit 7: Space Physics

This final Unit endeavours to instil in pupils a sense of wonder about the vastness of the Universe and to develop an appreciation of the ways in which knowledge has been obtained about the constitution of stars. Our trips into near space provide a context in which to consider the physical basis of space travel.

Units 1, 3, 4 and 6 emphasise the applications of physics to a rather greater extent than the other Units. Units 2 and 5 are more theoretically based, concentrating as they do on the fundamental concepts of electricity and mechanics. Unit 7 has been structured to provide opportunities to revise and consolidate within a fresh topic area concepts studied earlier.

2 3 Links with other Subjects

Physics shares with Biology, Chemistry and Science the aim to develop practical and problem solving abilities. There are, however, differences in emphasis among these subjects as well as the obvious differences of content. In Physics, for example, greater demands are made on numerical skills than in the other subjects.

Physics offers a context in which mathematical skills and techniques may be applied in a relevant and meaningful way. The study of Physics, therefore, should assist in the learning of Mathematics, while acquaintance with relevant mathematical skills and techniques may help the pupil to grasp certain physical principles.

Technological Studies has important links with Physics, particularly in electronics. As with Mathematics, the two subjects should be mutually supportive, with Technological Studies being more concerned with the application and use of devices and Physics with the physical principles involved in their operation.

2 4 Sequence of the Course

The course is designed to occupy 160 hours of teaching time. A suggested teaching sequence is as follows:

- Telecommunication
- Using Electricity
- Health Physics
- Electronics
- Transport
- Energy Matters
- Space Physics.

It is recognised that this is not the only possible sequence, but where an alternative is adopted care should be taken to ensure a logical progression. For example, the Unit on Using Electricity should logically precede that on Electronics and the Unit on Space Physics is designed to round off the whole course.

2 5 The Course Units

Each of the Units is described in Section 3 under the headings of Content, Suggested Activities and Learning Outcomes.

The suggested activities have been chosen to provide opportunities to attain the course objectives but alternative activities may be used where teachers consider that their own material would be more relevant to local needs, pupil interests and teacher strengths. Links to local industries may have a place in the selection of activities.

Some of the suggested activities are underlined. A broken line indicates an activity which is intended to reinforce work done previously. A solid line indicates an activity which is appropriate to Credit Level only.

In Knowledge and Understanding, the element identified by the letter A, the learning outcomes relate to the abilities which should be developed by candidates. These learning outcomes are a compromise between a large number of specific objectives and a few general statements. The outcomes are stated using behavioural verbs.

In the description of the Units, suggested activities which offer opportunities for the development of Problem Solving abilities are identified by the letter B. Similarly, the letter C denotes activities which will lead to the development of Practical Abilities.

2 6 Practical Investigations

The course is designed to allow time for investigative work to be conducted. It is recommended that an investigative approach to practical work be taken and throughout the course pupils should be given the opportunity to develop investigative skills. Contexts relating to Health Physics and Electronics in which investigative skills may be developed are included in Section 3. Additional contexts relating to sport are given in Appendix II. Pupils and teachers are encouraged to identify other contexts where investigative skills may be acquired.

For certification purposes, evidence is required of the candidate's ability to plan and carry out a physics investigation which covers the 13 Investigative Skills Objectives described in paragraph 5 6 3. Pupils should be afforded adequate opportunity to conduct a number of such investigations.

Section 3

Units and Learning Outcomes

3 Units and Learning Outcomes

Unit 1: Telecommunication

Introduction

Since the earliest times, human beings have communicated with each other. Our ability to communicate is at the root of our civilisation and its advancement.

Historically, important methods of telecommunication were voices, drum beats and warning lights, but the range of such communication was limited. In modern times telecommunication has become a major industry encompassing telephones, radio, television, optical systems and computers amongst many other aspects. Modern telecommunication systems are available in most parts of the world and signals extend millions of kilometres into space.

Telecommunication techniques involve the practical application of many basic principles of physics. The Unit develops an understanding of some of the main properties of waves, and also describes the use of waves to transmit information.

The Unit builds on work which should be familiar from S1/S2 Science but it may be necessary to revise work in such areas as sound, light and electric circuits.

Content Outline

Section	Content
1 Communication Using Waves	Speed of Sound. Waves.
2 Communication Using Cables	Communicating with wires between transmitter and receiver. Telephone. Electrical signals in the communicating wires. Optical fibre communication. Fibres and electrical cables. Laws of reflection. Signal transmission.
3 Radio and Television	Radio: Receiver, aerial, tuner, decoder, amplifier. Television: Receiver, aerial, tuner, decoders, amplifiers, picture tube, black and white picture, colour picture.
4 Transmission of Radio Waves	Transmission and reception. Waves, wavelength, frequency band. Dish aerials, curved reflectors. Satellites. Geostationary satellite and ground stations.

Unit 1: Telecommunication

Section 1: Communication Using Waves

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Speed of sound	Measure the speed of sound in air using the relationship between distance, time and speed, eg starter pistol and delay in hearing the sound, or electronic timing.	C	1 give an example which illustrates that the speed of sound in air is less than the speed of light in air, eg thunder and lightning 2 describe a method of measuring the speed of sound in air (using the relationship between distance, time and speed) 3 carry out calculations involving the relationship between distance, time and speed in problems on sound transmission 4 state that waves are one way of transmitting signals	
Waves	Demonstrate, using "Slinky", ripple tank or computer, wavelength, speed, frequency, amplitude.	C	5 use the following terms correctly in context: wave, frequency, wavelength, speed, energy (transfer), amplitude 6 carry out calculations involving the relationship between distance, time and speed in problems on water waves	

Unit 1: Telecommunication

Section 1: Communication Using Waves (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to:	and in addition to:
	Use a list of examples which enable $v = f\lambda$ to be derived simply from the relationship between speed v, distance d and time t.	B	7 carry out calculations involving the relationship between speed, wavelength and frequency for water and sound waves	8 explain the equivalence of $f \times \lambda$ and d/t.

Unit 1: Telecommunication

Section 2: Communication Using Cables

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Communicating with wires between transmitter and receiver	Set up Morse code transmitter/ receiver, eg switch, bulb, long wires and battery. Send short Morse code message.	C	1 describe a method of sending a message using code (Morse or similar) 2 state that coded messages or signals are sent out by a transmitter and are picked up by a receiver	
Telephone	Use a pair of telephones to communicate through wires.	C	3 state that the telephone is an example of long range communication between transmitter and receiver	
	Demonstrate the energy changes in a microphone and loudspeaker.	C	4 state the energy changes *a)* in a microphone (sound → electrical) *b)* in a loud speaker (electrical → sound) 5 state that the mouthpiece of a telephone (transmitter) contains a microphone and the earpiece (receiver) contains an earphone (loudspeaker)	
Electrical signals in the communicating wires	Use an oscilloscope to examine the electrical signal patterns in the communicating wires during speech.	C	6 state that electrical signals can be transmitted along wires during a telephone communication	16 explain the electrical signal pattern in telephone wires in terms of loudness and frequency changes in the sound signal

Unit 1: Telecommunication

Section 2: Communication Using Cables (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to:	and in addition to:
			7 State that an electrical signal is transmitted along a wire at a speed >> speed of sound (almost 300 000 000 m/s)	
	Use a signal generator to identify frequency and loudness effects.	C	8 describe the effect on the signal pattern displayed in oscilloscope due to a change in *a)* loudness of sound *b)* frequency of sound	
			9 describe, with examples, how the following terms relate to sound: frequency and amplitude	
Optical fibre communications	Use an optical fibre to transmit a message, eg speech or music → amplifier → LED output → optical fibre → photodetector amplifier/loudspeaker, or Morse code transmission.	C	10 state what is meant by an optical fibre	
			11 describe one practical example of telecommunication which uses optical fibres	

Unit 1: Telecommunication

Section 2: Communication Using Cables (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to:	and in addition to:
Fibres and electrical cables	Obtain, present and discuss information on the advantages/ disadvantages of optical fibres compared to electrical cables of comparable capacity to transmit information.	B	12 state that electrical cables and optical fibres are used in some telecommunication systems	17 Compare some of the properties of electrical cables and optical fibres, eg size, cost weight, signal speed, signal capacity, signal quality, signal reduction per km
Law of reflection	Illustrate: *a)* straight line propagation; *b)* angle of incidence = angle of reflection; *c)* reversibility of rays, using ray boxes. Use a plane mirror, metal surface and a semi-circular slab (total internal reflection).	C	13 state that light can be reflected 14 describe the direction of the reflected light ray from a plane "mirror"	18 state the principle of reversibility of ray paths
Signal transmission	Demonstrate a signal transmission along a light pipe or optical fibre.		15 state that signal transmission along an optical fibre takes place at very high speed	19 describe the principle of operation of an optical fibre transmission system 20 carry out calculations involving the relationship between distance, time and speed in problems on light transmission.

Unit 1: Telecommunication

Section 3: Radio and Television

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
(a) Radio:				
Receiver	Examine and identify the main parts of a radio receiver specially built to give a simple layout, ie aerial, tuner, decoder, amplifier, loudspeaker, battery.	C	1 state that the main parts of a radio receiver are: aerial, tuner, decoder, amplifier, loudspeaker, electricity supply; and identify these parts on a block diagram	7 describe the general principle of radio transmission in terms of transmitter, carrier wave, amplitude modulation, receiver
	Complete a block diagram of a radio receiver.	C	2 describe in a radio receiver the function of the aerial, tuner, decoder, amplifier, loudspeaker and electricity supply	
Aerial	Investigate the effects of: wrapping up a radio in aluminium foil; wrapping a tape player in aluminium foil.			
Tuner	Use a mechanical vibrator and metal strips of various length to simulate tuning.	C		
Decoder	Examine a signal before and after a decoder using an oscilloscope.			
Amplifier	Examine a signal before and after an amplifier using an oscilloscope.			

Unit 1: Telecommunication

Section 3: Radio and Television (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to:	and in addition to:
(b) Television: Receiver Aerial Tuner Decoders Amplifiers	Complete a block diagram of a television receiver, ie aerial, tuner, decoders, amplifiers, TV tube for light output and loudspeaker for sound output.	B	3 state that the main parts of a television receiver are: aerial, tuner, decoders, amplifiers, tube, loudspeaker, electricity supply and identify these parts on a block diagram of a television receiver	8 describe the general principle of television transmission in terms of transmitter, carrier wave, modulation, video and audio receivers
Picture tube	Examine, eg Teltron tubes to establish *a)* electron emission *b)* electron beam *c)* deflection *d)* energy conversion in screen coating.	C	4 describe in a television receiver the function of: aerial, tuner, decoders, amplifiers, tube, loudspeaker, electricity supply	
Black and white picture	Build up line picture (from pre-numbered strips).	C	5 describe how a picture is produced on a TV screen in terms of line build-up	9 describe how a moving picture is seen on a television screen in terms of: line build-up image retention brightness variation

Unit 1: Telecommunication

Section 3: Radio and Television (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
(b) Television:				
	Observe image retention by flick book, cine film, etc.	C		
	Observe simple modulation of picture by connecting signal generator to Z input of oscilloscope.	C		
	Examine colour television screen or monitor.	C	6 state that mixing red, green and blue lights produces all colours seen on a colour television screen	10 describe the effect of colour mixing lights (red, green and blue).
Colour picture	Show colour mixing by lights or otherwise.	B		
	Obtain, present and discuss information by open book exercise on construction of colour picture tube, ie 3 guns, shadowmask.			

Unit 1: Telecommunication

Section 4: Transmission of Radio Waves

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Transmission and reception	Use model transmitter and receiver to transmit a message across the laboratory.	C	1 state that mobile telephones, radio and television are examples of long range communication which do not need cables (between transmitter and receiver) 2 state that microwaves, television and radio signals are waves which transfer energy 3 state that microwaves, television and radio signals are transmitted at very high speed 4 state that microwaves, television and radio signals are transmitted through air at 300 000 000 m/s	13 carry out calculations involving the relationship between distance, time and speed in problems on microwaves, television and radio waves
Waves, wavelength, frequency bands	Obtain, present and discuss information on different radio bands, eg UHF, VHF, Police, Coastguard, radio taxis, model aircraft. Relevant properties would include:	B	5 state that a radio transmitter can be identified by wavelength or frequency values	14 carry out calculations involving the relationship between speed, wavelength and frequency for microwaves, television and radio waves

Unit 1: Telecommunication

Section 4: Transmission of Radio Waves (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to:	and in addition to:
Waves, wavelength, frequency bands (*continued*)	frequency, wavelength, range, use, clarity, source strength, cost.			15 explain some of the differences in properties of radio bands in terms of source strength, reflection, etc
	Demonstrate diffraction using a ripple tank.	C		16 explain in terms of diffraction how wavelength affects radio and television reception
Dish aerials, curved reflectors	View suitable film or video explaining the principles of television transmission and reception.	B		
	Demonstrate the focusing effect of curved reflectors, eg visible light, infra red, microwave, sound, ultrasonic waves.	C	6 state that curved reflectors on certain aerials or receivers make the received signal stronger 7 explain why curved reflectors on certain aerials or receivers make the received signal stronger 8 describe an application of curved reflectors used in telecommunication eg satellite TV, TV link, boosters, repeaters or satellite communication	17 explain the action of curved reflectors on certain transmitters.

Unit 1: Telecommunication

Section 4: Transmission of Radio Waves (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Satellites	Obtain, present and discuss information about satellite period and height above the Earth's surface.	B	9 state that the period of satellite orbit depends on its height above the Earth	
Geostationary satellite and ground stations	Obtain, present and discuss information on intercontinental telecommunication using geostationary satellite and ground stations.	B	10 state that a geostationary satellite stays above the same point on the Earth's surface	
			11 describe the principle of transmission and reception of satellite television broadcasting using geostationary satellites and dish aerials	
	Obtain, present and discuss information from sheet giving typical signal path lengths when using satellites or space probes.	B	12 describe the principle of intercontinental telecommunication using a geostationary satellite and ground stations	

Unit 2: Using Electricity

Introduction

In a world of electrical and electronic devices, an understanding of the principles behind such devices is of great relevance within any Physics course.

It is assumed that simple d.c. electricity with bulbs and batteries will have been met in S1 and S2 and perhaps even in primary school. This Unit aims to develop further fundamental principles of electricity and it does so within the context of familiar electrical devices. An increased emphasis is placed upon the role of a.c. within the home, although the production and supply of a.c. is left until the Unit 'Energy Matters'.

The time allocation for Suggested Activities should be adjusted within each school in the light of work already covered in S1 and S2. Thus by the end of the Unit, pupils should have a knowledge and understanding of the operation of various household devices and should understand basic electrical principles – principles which are required and reinforced in later Units.

This Unit offers ample opportunity to develop practical abilities.

Content Outline

Section	Content
1 Frome the Wall Socket	Household applicances. Earth wire and safety.
2 Alternating and Direct Current	Battery and transformer. Circuit diagrams. Current and voltage.
3 Resistance	Resistance. Variable resistors and their uses. Electrical power. Lamps and heaters.
4 Useful Circuits	Series and parallel. Fault finding.
5 Behind the Wall	The mains supply. Domestic Electricity Meter.
6 Movement from Electricity	Electric motor.

Unit 2: Using Electricity

Section 1: From the Wall Socket

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	
Household appliances	Obtain information on appliances in the home (past, present and future).	B	1 describe the mains supply/battery as a supply of electrical energy and to describe the main energy transformations occurring in household appliances	
	Look at labels and connecting flexes and cables on household appliances.	B	2 state approximate power ratings of different household appliances	
			3 select an appropriate flex given the power rating of an appliance	
	Compare appliance power ratings, flexes used and plug fuses fitted.	B	4 state that fuses in plugs are intended to protect flexes	
			5 select an appropriate fuse given the power rating of an appliance	
	Revise, (do if necessary) the wiring of a 13 A plug, lampholder and extension cable.	C	6 identify the live, neutral and earth wire from the colour of their insulation	
			7 state to which pin each wire must be connected for plug, lampholder and extension socket	

Unit 2: Using Electricity

Section 1: From the Wall Socket (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to:	and in addition to:
Earth wire and safety	Carry out an experiment (with a 1.5 V cell) to demonstrate the conductivity of the human body when dry and when wet.	C	8 state that the human body is a conductor of electricity and that moisture increases its ability to conduct	
	Carry out experiments to demonstrate the importance of the earth wire as a safety device. Examine household appliances to see if an earth wire is fitted or a double insulation symbol is shown.	C	9 state that the earth wire is a safety device	13 explain how the earth wire acts as a safety device.
			10 state that electrical appliances which have the double insulation symbol do not require an earth wire	14 explain why fuses and switches must be in the live lead.
			11 draw the double insulation symbol	
	Examine drawings to identify potential hazards in the incorrect use of electrical appliances.	B	12 explain why situations involving electricity could result in accidents (to include proximity of water, wrong fuses, wrong, frayed or badly connected flexes, short circuits and misuse of multiway adaptors)	

Unit 2: Using Electricity

Section 2: Alternating and Direct Current

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Battery and transformer	Observe and compare the outputs from a battery and a low voltage a.c. supply,	C	1 state that the mains supply is a.c. and a battery supply is d.c.	
	a using an oscilloscope	C	2 explain in terms of current the terms a.c. and d.c.	
	b by their effects on various components (eg resistor, lamp, capacitor, diode).		3 state that the frequency of the mains supply is 50 Hz.	
			4 state that the declared value of the mains voltage is 230 V	9 state that the declared value of an alternating voltage is less than its peak value
Circuit diagrams	Draw circuit diagrams using appropriate symbols.	B	5 draw and identify the circuit symbol for a battery, fuse, lamp, switch, resistor, capacitor, diode and variable resistor	
Current and voltage	Revise simple electrostatic experiments.	C	6 state that electrons are free to move in a conductor	
			7 describe the electric current in terms of the movement of charges around a circuit	10 carry out calculations involving the relationship between charge, current and time

Unit 2: Using Electricity

Section 2: Alternating and Direct Current (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to: 8 use correctly the units: ampere and volt	and in addition to: 11 use correctly the unit: coulomb 12 state that voltage of a supply is a measure of the energy given to the charges in a circuit.

Unit 2: Using Electricity

Section 3: Resistance

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Resistance	Measure current and voltage in a circuit containing a resistor.	C	1 draw and identify the circuit symbols for an ammeter and voltmeter	
	Determine resistance.	C	2 draw circuit diagrams to show the correct positions of ammeter and voltmeter in a circuit	
			3 state that an increase in resistance of a circuit leads to a decrease in the current in that circuit	
	Show from experimental results that when current changes, the resistance of a resistor is approximately constant.	C	4 carry out calculations involving the relationship between resistance, current and voltage	17 state that V/I for a resistor remains approximately constant for different currents.
			5 use correctly the unit: ohm	
Variable resistors and their uses	Examine applications of variable resistors: (eg a rheostat in a model car controller and a light dependent resistor in a light sensor).	C	6 give two practical uses of variable resistors	
	Investigate how the value of resistance changes with current when a torch bulb, thermistor, or light dependent resistor are used.	C		

Unit 2: Using Electricity

Section 3: Resistance (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to:	and in addition to:
Electrical power	Measure the current when lamps (24 W, 36 W, and 48 W) and heaters are operating at their correct voltage. Hence confirm P = VI.	C	7 state that when there is an electric current in a wire, there is an energy transformation	
			8 give three examples of resistive circuits in the home in which electrical energy is transformed into heat	
			9 state that the electrical energy transformed each second = VI	
	From tables of data or experimental results show the equivalence of VI and I^2R	B	10 state the relationship between energy and power	18 explain the equivalence of VI and I^2R
			11 use correctly in context, the terms energy, power, joule and watt	
			12 carry out calculations involving the relationship between power, current and voltage	19 carry out calculations using the relationship between power, current and resistance.
Lamps and heaters	Examine tungsten filament and discharge tube lamps.		13 state that in a lamp, electrical energy is transformed into heat and light	

Unit 2: Using Electricity

Section 3: Resistance (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to:	and in addition to:
			14 state that the energy transformation in an electric lamp occurs in resistance wire (filament lamp) or gas (discharge tube)	
			15 state that a discharge tube lamp is more efficient than a filament lamp (ie more of the energy is transformed into light and less into heat)	
	Examine reflector and convector heaters. Use an ohmmeter to measure element resistance	C	16 state that the energy transformation in an electric heater occurs in resistance wire (element)	

Unit 2: Using Electricity

Section 4: Useful Circuits

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Series and parallel	Examine practical situations of series and parallel.	C	1 state a practical application in the home which requires two or more switches used in series	
	Perform experiments with lamps and switches in series and parallel. (Relate experiment to actual situations such as car side and head lights, ignition switch and brake lights).	C	2 state that in a series circuit, the current is the same at all points	9 Draw circuit diagrams to describe how the various car lighting requirements achieved
			3 state that the sum of currents in parallel branches is equal to the current drawn from the supply	
	Measure current and voltage in a circuit containing components in series and parallel.	C	4 explain that connecting too many appliances to one socket is dangerous because a large current could be drawn from the supply	
			5 state that the voltage across components in parallel is the same for each component	

Unit 2: Using Electricity

Section 4: Useful Circuits (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to:	and in addition to:
			6 state that the sum of voltages across components in series is equal to the voltage of the supply	
Fault finding	Use an ohmmeter and continuity tester to find circuit faults (eg open and short circuits)	C	7 describe how to make a simple continuity tester	
			8 describe how a continuity tester may be used for fault finding	
	Use an ohmmeter to find the combined resistance of resistors in series and parallel	C		10 to carry out calculations involving the relationships $R_T = R_1 + R_2 + \ldots$ and $1/R_T = 1/R_1 + 1/R_2 \ldots$

Unit 2: Using Electricity

Section 5: Behind the Wall

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
The mains supply	Wire up a model ring circuit.	C	1 state that household wiring connects appliances in parallel	5 describe, using a circuit diagram, a ring circuit 6 state advantages of using the ring circuit as a preferred method of wiring in parallel 7 give two differences between the lighting circuit and the power ring circuit
	Examine various fuses and circuit breakers.	C	2 state that mains fuses protect the mains wiring 3 state that a circuit breaker is an automatic switch which can be used instead of a fuse	8 state one reason why a circuit breaker may be used in preference to a fuse
Domestic Electric Motor	Use an 'energy' meter to measure energy transformed by different appliances.	C	4 state that kWh is a unit of energy	9 explain the relationship between kilowatt-hours and joules.

Unit 2: Using Electricity

Section 6: Movement from Electricity

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Electric motor	Examine commercial motors.	C	1 identify on a simple diagram of an electric motor, the rotating coil, field coil (magnet) brushes and commutator	5 state that the direction of force on a current-carrying wire depends upon the direction of current and of the field
	Perform experiments to show that a magnetic field is created by a current-carrying wire.	C	2 state that a magnetic field exists around a current-carrying wire	6 explain the operation of a d.c. electric motor in terms of forces acting on the coil and the purpose of brushes and commutator
	Examine an electric bell and relay.	C	3 give two examples of practical applications which make use of the magnetic effect of a current	7 state the reasons for the use in commercial motors of carbon brushes, multi-section commutators and field coils.
	Perform experiments to show that a current-carrying wire experiences a force in a magnetic field.	C		
	Construct a simple d.c. electric motor.	C	4 state that a current-carrying wire experiences a force when the wire is in a magnetic field	

Unit 3: Health Physics

Introduction

This is a study of the uses of physics in the field of medicine. Starting with familiar applications such as thermometers, stethoscopes and spectacles, the Unit then progresses to more modern applications such as ultrasonics, fibre optics, and to radioactivity and its applications in medicine. Electricity has many applications in the field of health and this is given due coverage.

In addition to developing the pupil's knowledge of heat, light, sound and electricity this Unit introduces aspects of radioactivity.

Content Outline

Section	Content
1 The Use of Thermometers	The use of thermometers in measuring body temperature.
2 Using Sound	The stethoscope. Ultrasonic scanning. Noise pollution.
3 Light and Sight	Refraction. Image formation. Correction of eye defects. The use of fibre optics in a cold light source in medicine.
4 Using the Spectrum	Uses of Laser, X-rays, ultra violet and infra red in medicine
5 Nuclear Radiation – Humans and Medicine	The use of radioactivity in the field of medicine. The properties of radioactivity. The effect of radioactivity on living things and the special precautions necessary in handling radioactive materials.
6 Practical Investigation	Suggested contexts for the development of investigative skills.

Unit 2: Health Physics

Section 1: The Use of Thermometers

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
The use of thermometers in measuring body temperature	Study, perhaps by way of stations, of a series of thermometers including:	C	1 state that a thermometer requires some measurable physical property that changes with temperature	
	a) liquid in glass thermometer - experiment with thermometer being removed from a hot body:		2 describe the operation of a liquid in glass thermometer	
	b) clinical thermometer – use in a similar experiment to (a): advantages, structure, etc;		3 describe the main differences between a clinical and ordinary thermometer	
	c) digital display thermometer – advantage, etc;		4 describe how body temperature is measured using a clinical thermometer	
	d) thermocouple;			
	e) liquid crystal			
	f) semiconductor sensor			
	Obtain, present and discuss information on the significance of variation in body temperature, ie use of body temperatures in diagnosis.	B	5 explain the significance of body temperature in diagnosis of illness.	

Unit 2: Health Physics

Section 2: Using Sound

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
The stethoscope	Carry out an experiment on the transmission of sound through solids, liquids and gases. Study the stethoscope (experiment and reading exercise).	C	1 state that a solid, a liquid or a gas is required for the transmission of sound.	
			2 explain the basic principles of a stethoscope as a "hearing aid"	
Ultrasonic scanning	Carry out experiments using ultrasonic transmitter and receiver.	C	3 give one example of the use of ultrasound in medicine, eg images of an unborn baby	8 explain one use of ultrasound in medicine.
	Reflection/absorption – information on:	B		
	safety of ultrasound versus X-rays:			
	applications of ultrasonics (reading exercise).			
	Investigate range of hearing experiment with signal generator and loudspeaker.	C	4 state that high frequency vibrations beyond the range of human hearing are called ultrasounds	

Unit 3: Health Physics

Section 2: Using Sound

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Noise pollution	Carry out an experiment with sound level meter. Obtain information on noise pollution.	C	5 Give two examples of noise pollution	
			6 give examples of sound levels in the range O dB - 120 dB	
	dB scale	B	7 state that excessive noise can damage hearing	
	Carry out handling information exercise on noise pollution	B		

Unit 3: Health Physics

Section3: Light and Sight

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Refraction	Reading exercise on the eye. 'Yellow spot' experiment. Carry out ray box experiments on refraction, using ray diagrams.	C	1 describe the focusing of light on the retina of the eye	
			2 state what is meant by refraction of light	
	Pupil experiments:	C	3 draw diagrams to show the change of direction as light passes from air to glass and glass to air	12 use correctly in context the terms angle of incidence, angle of refraction and normal
	rectangular block, various convex/concave lenses		4 describe the lens shapes of convex and concave	
			5 describe the effect of various lens shapes on the rays of light	
Image formation	Carry out experiments on image formation by a convex lens.	C	6 state that the image formed on the retina of the eye is upside down and laterally inverted	

Unit 3: Health Physics

Section3: Light and Sight (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to:	and in addition to:
			7 explain using a ray diagram how an inverted image can be formed on the retina	13 explain using a ray diagram how the lens of the eye forms, on the retina, an image of an object *a)* some distance from the eye *b)* close to the eye
			8 describe a simple experiment to find the focal length of a spherical convex lens	14 carry out calculations on power/focal length to find either one given the other
Correction of eye defects	Carry out experiments on long and short sight, eg using model eye.	C	9 state the meaning of long and short sight	
	Use a simulation of eye defects and their treatment.	C	10 state that long and short sight can be corrected using lenses	15 explain the use of lenses to correct long and short sight
The use of fibre optics in a 'cold light' source in medicine	Obtain, present and discuss information on the use of fibre optics in medicine (eg fibroscope). Look at fibre optics simulations and samples of optical fibres	B	11 state that fibre optics can be used as a transmission system for 'cold light'	16 explain the use of fibre optics in the endoscope (fibroscope).

Unit 3: Health Physics

Section 4: Using the Spectrum

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Use of lasers	Demonstrate laser properties using slides or actual laser.	C		
	Obtain, present and discuss information on retinal welding, birthmark removal, cholesterol removal, etc.	B	1 describe how the laser is used in one application of medicine	
Use of X-rays	Obtain, present and discuss information on the use of X-ray photographs.	B	2 describe one use of X-rays in medicine	6 describe the advantage of computerised tomography.
			3 state that photographic film can be used to detect X-rays	
Uses of ultraviolet and infrared in medicine	Obtain, present and discuss information on the uses and effects of ultraviolet and infrared.	B	4 describe the use of ultraviolet and infrared in medicine	
			5 state that excessive exposure to ultraviolet radiation may produce skin cancer	

Unit 3: Health Physics

Section 5: Nuclear Radiation – Humans and Medicine

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
The use of radioactivity in the field of medicine, eg cancer treatment tracers, gamma camera	View video on use of tracers in man and use of radiotherapy.	B	1 state that radiation can kill living cells or change the nature of living cells	
	Discussion of pupils' existing understanding of radiation.	B	2 describe one medical use of radiation based on the fact that radiation can destroy cells (instrument sterilisation, treatment of cancer)	
	Obtain, present and discuss information on the use of radioactivity in cancer treatment and in instrument sterilisation.	B	3 describe one medical use of radiation based on the fact that radiation is easy to detect	

Unit 3: Health Physics

Section 5: Nuclear Radiation – Humans and Medicine (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to:	and in addition to:
The properties of radioactivity	Demonstrate the use of Geiger Müller tube to examine range of alpha, beta, gamma rays and to simulate a tracer experiment, emphasising that extremely small quantities of radiation can be detected. (View video experiments on activity of solids, liquids, gases.)	C	4 state the range and absorption of alpha, beta and gamma radiation	
			5 state that radiation energy may be absorbed in the medium through which it passes	
			6 describe a simple model of the atom which includes protons, neutrons and electrons	
			7 state that alpha rays produce much greater ionisation density than beta or gamma rays	13 explain the term ionisation
	Demonstrate the intense ionisation caused by alpha rays.	C	8 state one example of the effect of radiation on non-living things (eg ionisation, fogging of photographic film, scintillations)	describe how one of the effects of radiation is used in a detector of radiation (eg GM tube; film badges; scintillation counters)

Unit 3: Health Physics

Section 5: Nuclear Radiation – Humans and Medicine (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to:	and in addition to:
	Study activity, radioactive decay and half-life by experiments, simulation and videos of actual experiments.	C	9 state that the activity of a radioactive source is measured in becquerels	15 describe a method of measuring the half-life of a radioactive element
			10 state that the activity of a radioactive source decreases with time	16 state the meaning of the term "half-life"
				17 carry out calculations to find the half-life of a radioactive element from appropriate data
The effect of nuclear radiation on living things and the special precautions necessary in handling radioactive materials	Obtain, present and discuss information on the effects of radiation on living things and of the precautions necessary when handling radioactive substances. (Units of activity, absorbed dose and dose equivalent.)	B	11 describe the safety precautions necessary when dealing with radioactive substances	18 state that for living materials the biological effect of radiation depends on the absorbing tissue and the nature of the radiation and that dose equivalent measured in sieverts takes account of the type and energy of radiation.
			12 state that dose equivalent is measured in sieverts	

Unit 3: Health Physics

Section 6: Practical Investigation

Some suggestions for context relating to Health Physics in which investigative skills may be developed are as follows:

- thermistor to measure body temperature;
- ramps for invalid chairs, etc;
- noise level measurement/pollution/absorption;
- survey of background radiation;
- effect of exercise on body temperature.

Alternatively this time may be used to conduct investigations based on other contexts.

Unit 4: Electronics

Introduction

In this Unit, Electronics is studied in terms of a systems approach in that the components of an electronic system are considered from the point of view of how they behave. Each system is divided into three parts: input, process and output with the physics content being confined mainly to the input and output sections.

It is assumed that pupils will have studied Unit 2: Using Electricity before starting Electronics and the latter Unit provides opportunities for reinforcing the concepts of voltage, current and resistance through applications. Other than this, the Unit stands alone and does not need knowledge from other Units in the Standard Grade Physics course.

The Unit is intended to give an overview of Electronics and includes both Digital and Analogue aspects.

There is a strong emphasis on applications and it is hoped that teachers will be able to provide many examples of electronics in action to give wider relevance to course work. Links with local industries using electronics would be very useful in this context.

Input and output devices should be studied in some detail from the point of view of energy conversions and/or electrical properties. The Unit affords opportunity for devising and constructing an electronic system to meet some identified purpose.

Content Outline

Section	Content
1 Overview	Practical systems. Input → Process → Output. Analogue/digital outputs.
2 Output Devices	Output devices producing light sound movement. Light emitting diode. 7-segment display.
3 Input Devices	Microphone, thermocouple, solar cell, thermistor, light dependent resistor, switch, voltage divider, capacitor.
4 Digital Processes	Transistor as a switch. Simple switching systems: fire alarm, burglar alarm, automatic parking light, time delay. Digital logic gates. Applications of combinational logic. Clock signals.
5 Analogue Processes	Devices containing amplifier. Amplifier gain.
6 Practical Investigation	Suggested contexts for the development of investigative skills.

Unit 4: Electronics

Section 1: Overview

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Practical systems Input → process → output	Discuss practical systems in terms of input, process and output.	C	1 state that the activity of a radioactive source is measured in becquerels	
Analogue/digital outputs	Use an oscilloscope to show the difference between analogue and digital signals	C	2 distinguish between digital and analogue outputs 3 identify analogue and digital signals from waveforms viewed on an oscilloscope	
	Discuss electronics systems, eg • electronic thermometer (digital) • radio (analogue) • computer (digital) • battery-operated cassette recorder (analogue) • stopwatch (digital).	C		
	Present and discuss information obtained from an audio-visual presentation on applications of electronics.	B		

Unit 4: Electronics

Section 2: Output Devices

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Output devices producing: light sound movement	Examine a range of output devices as used within various systems, eg LED, 7-segment display, loudspeaker, electric motor, relay, solenoid, moving coil meter.	C	1 give examples of output devices and the energy conversions involved	7 identify appropriate output devices for a given application
			2 give examples of digital output devices and of analogue output devices	
Light emitting diode (LED)	Carry out experiments to compare electrical and optical properties of filament lamp and LED.	C	3 draw and identify the symbol for LED	8 describe by means of a diagram a circuit which will allow LED to light
			4 state that LED will light only if connected one way round	
			5 explain the need for a series resistor with LED	9 calculate the value of the series resistor for LED
7-segment display	Carry out experiments with 7-segment LED display with separate switches for each segment.	C	6 state that different numbers can be produced by lighting appropriate segments of a 7-segment display	10 calculate the decimal equivalent of a binary number in the range 0000 - 1001.
	Carry out experiments with four input switches connected to a decoder/driver which is connected to a 7-segment display.	C		

Unit 4: Electronics

Section 3: Input Devices

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Microphone Thermocouple Solar cell Thermistor Light dependent resistor Switch Voltage divider Capacitor	Carry out experiments to investigate the behaviour of the input devices listed.	C	1 describe the energy transformations involved in the following devices: • microphone • thermocouple • solar cell 2 state that the resistance of a thermistor changes with temperature and the resistance of an LDR decreases with increasing light intensity 3 carry out calculations using $V = IR$ for the thermistor and the LDR 4 state that during charging the voltage across a capacitor increases with time 5 identify from a list an appropriate input device for a given application	6 carry out calculations involving voltages and resistances in a voltage divider 7 state that the time to charge a capacitor depends on the values of the capacitance and the series resistance 8 identify appropriate input devices for a given application

Unit 4: Electronics

Section 4: Digital Processes

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Transistor as a switch	Carry out experiments with transistor, batteries and LED to show switching action.	C	1 state that a transistor can be used as a switch	
			2 state that a transistor may be conducting or non-conducting, ie ON or OFF	
Simple switching systems: simple fire alarm; simple burglar alarm; automatic parking light; simple time delay in switching on LED	Carry out experiments with transistor, thermistor, LDR and charging capacitor to show that a transistor can switch LED in response to changes in temperature, light level or after a suitable delay.	C	3 draw and identify the circuit symbol for an NPN transistor	15 explain the operation of a simple transistor switching circuit
			4 identify from a circuit diagram the purpose of a simple transistor switching circuit	

Unit 4: Electronics

Section 4: Digital Processes (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to:	and in addition to:
Digital logic gates	Investigate truth tables for two-input AND and OR gates and a NOT gate using LED as state detector.	C	5 draw and identify the symbols for two input AND and OR gates, and a NOT gate	16 identify the following gates from truth tables: two-input AND two-input OR NOT (inverter).
	Use series and parallel combinations of switches to illustrate the AND and OR functions.		6 state that logic gates may have one or more inputs and that a truth table shows the output for all possible input combinations	
			7 state that high voltage = logic '1' low voltage = logic '0'	
			8 draw the truth tables for two input AND and OR gates, and a NOT gate	
Applications of combinational logic	Examine simple applications of the above gates using digital inputs, eg AND gate to start/stop a process; OR gate to combine two signals.	C	9 explain how to use combinations of digital logic gates for control in simple situations	17 complete a truth table for a simple combinational logic circuit

Unit 4: Electronics

Section 4: Digital Processes (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to:	and in addition to:
Clock signals	Examine slow (approx 1 Hz) clock signals.	C	10 state that a digital circuit can produce a series of clock pulses	18 explain how a simple oscillator built from a resistor, capacitor and inverter operates
	Use a practical device with counting capability.	C	11 give an example of a device containing a counter circuit	19 describe how to change the frequency of the clock
Counter	Apply clock signals to a 4-bit binary counter with: binary outputs to LEDs; decimal output to 7-segment display	C	12 state that there are circuits which can count digital pulses 13 state that the output of the counter circuit is in binary 14 state that the output of a binary counter can be converted to decimal	

Unit 4: Electronics

Section 5: Analogue Processes

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Devices containing amplifiers	Discuss various devices containing amplifiers.	C	1 identify from a list, devices in which amplifiers play an important part	
	Compare the effect of listening with a crystal earpiece at the input and output connections to the amplifier.	C	2 state the function of the amplifier in devices such as radios, intercoms and music centres	
Amplifier gain	Use an oscilloscope to compare a pure tone input to, and output from, an audio amplifier.	C	3 state that the output signal of an audio amplifier has the same frequency as, but a larger amplitude than, the input signal	
	Put together and use a simple transistor amplifier for use with a microphone and loudspeaker or earphone.	C	4 carry out calculations involving input voltage, output voltage and voltage gain of an amplifier	5 describe how to measure the voltage gain of an amplifier
	Measure the voltage gain of the amplifier.	C		6 state that power may be calculated from V^2/R where V is the voltage and R the resistance (impedance) of the circuit 7 state that the power gain of an amplifier is the ratio of power output to power input 8 carry out calculations involving the power gain of an amplifier

Unit 4: Electronics

Section 6: Practical Investigation

Some suggestions for contexts relating to electronics in which investigative skills may be developed are as follows.

i Construction, calibration and use of an electronic thermometer

It is expected that pupils would be provided with a suitable circuit diagram and that a major part of the investigation would centre on the calibration and use of the device for measurement of a physical quantity. The design would not be a significant aspect and the construction should occupy a minor fraction of the time available.

ii Design, construction and testing of a simple frost warning mechanism

In this case pupils would be expected to use prior knowledge to design a suitable circuit by considering input, process and output. After construction, the device should be tested to establish whether it meets adequately the required design function. Failure to meet the required function would normally be followed by suitable modifications to the original design.

In either case the task should be selected to link with earlier course work and the scope should be limited so that pupils are likely to experience reasonable success in the time available.

Alternatively this time may be used to conduct investigations based on other contexts.

Unit 5: Transport

Introduction

The aim of this Unit is to develop some understanding of the essential concepts of mechanics and to foster an awareness of how these relate to familiar aspects of transportation.

In S1/S2 pupils will have met a variety of energy forms and may have acquired the ability to recognise forces through their effects. The force of friction will have been introduced and pupils may already be familiar with a range of energy transformations. These ideas are seen as essential prerequisite knowledge and, as a consequence, some time should be allocated in this Unit, at the start of the second and third sections, to allow pupils to reinforce their understanding of these concepts. Where it is established that pupils have already developed an adequate understanding, it may be possible to bypass the activities associated with this preliminary approach to these concepts.

In the Using Electricity Unit, pupils will have been introduced to the relationship between energy, power and time and this understanding will be developed further in this Unit.

Towards the end of the Unit, pupils have the opportunity to develop a quantitative understanding of the principle of conservation of energy and to consider the energy implications of car crashes and the dependence of stopping distance on vehicle speed.

Content Outline

Section	Content
1 On the Move	Average and instantaneous speed. Performance figures for cars. Speed-time graphs.
2 Forces at Work	Recognising forces and measuring force. Friction and movement. Newton's first law of motion: seat belts. Newton's second law of motion.
3 Movement Means Energy	Energy transformations in vehicles. Power, work done, gravitational potential energy. Kinetic energy, crashes and the Highway Code. Principle of conservation of energy.

Unit 5: Transport

Section 1: On the Move

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Average speed	Measure average speeds of, for example, walking, running, bicycle and car, using stop-watch and measuring tape.	C	1 describe how to measure an average speed	
Instantaneous speed			2 carry out calculations involving the relationship between distance, time and average speed	
	Measure short time intervals and hence estimate the instantaneous speed at various times for eg a toy car.	C	3 describe how to measure instantaneous speeds	9 identify situations where average and instantaneous speeds are different
Performance figures for cars	Obtain, present and discuss information on performance figures for cars.	B	4 define the terms speed and acceleration	10 explain how the method used to measure the time of travel can have an effect on the measured value of the instantaneous speed
			5 calculate acceleration from change of speed per unit time (miles per hour per second or metres per second per second)	

Unit 5: Transport

Section 1: On the Move (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to:	and in addition to:
Speed-time graphs	Measure instantaneous speeds and acceleration as a vehicle runs down a slope for a range of angles of incline.	C		
	Draw graphs using data from the above experiment.	B	6 draw speed-time graphs showing steady speed, slowing down and speeding up	
			7 describe the motions represented by a speed-time graph	
			8 calculate acceleration, from speed-time graphs, for motion with a single constant acceleration	11 calculate distance gone and acceleration from speed-time graphs for motion involving more than one constant acceleration
				12 carry out calculations involving the relationship between initial speed, final speed, time and uniform acceleration.

Unit 5: Transport

Section 2: Forces at Work

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Recognising forces	Revise experiments on forces and their effects.	C	1 describe the effects of forces in terms of their ability to change the shape, speed and direction of travel of an object	
Measuring force	Use Newton balance to lift and pull various known masses.	C	2 describe the use of a Newton balance to measure force	
	Use the results to show that the ratio of weight to mass is approximately 10 N kg^{-1}.	C	3 state that weight is a force and is the Earth's pull on the object	12 distinguish between mass and weight
			4 use the approximate value of 10 N kg^{-1} to calculate weight	13 state that the weight per unit mass is called the gravitational field strength
Friction and movement	Carry out experiments with a balloon puck or linear air track to show the effect of "removing" friction.	C	5 state that the force of friction can oppose the motion of a body	
			6 describe and explain situations in which attempts are made to increase or decrease the force of friction	

Unit 5: Transport

Section 2: Forces at Work (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to:	and in addition to:
	Obtain and present information on or investigate friction, eg lubrication, car tyres and brakes, effectiveness of bicycle brakes wet and dry, hovercraft.	B	7 state that equal forces acting in opposite directions on an object are called balanced forces and are equivalent to no force at all	
			8 state that when balanced forces or no forces act on an object its speed remains the same	
Newton's first law of motion: seat belts	Use models and/or video to demonstrate the importance of seat belts.	B	9 explain, in terms of the forces required, why seat belts are used in cars	14 explain the movement of objects in terms of Newton's first law
Newton's second law of motion	Carry out experiments with ride-upon trolley or dynamics carts or linear air track to investigate the effects of force and mass on acceleration. (Direct readout of acceleration is recommended.)	C	10 describe the qualitative effects of change of mass or of force on the acceleration of an object	
			11 carry out calculations involving the relationship between a, F and m	15 carry out calculations using the relationship between a, F and m and involving more than one force but in one dimension only.

Unit 5: Transport

Section 3: Movement Means Energy

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Energy transformation in vehicles	If necessary, revise appropriate experiments on energy transformations	C	1 describe the main energy transformations as a vehicle accelerates, moves at constant speed, brakes and goes up or down a slope	
Power, work done, gravitational potential energy	Carry out investigations selected from: *a)* the work done by and the power of a pupil walking/running upstairs, an electric motor lifting a load; *b)* the power of a spring driven toy car as it moves up a slope; *c)* the work done at the pedals by a cyclist travelling a certain distance in each gear	C	2 state that work done is a measure of the energy transferred 3 carry out calculations involving the relation-ship between work done, force and distance 4 carry out calculations involving the relation-ship between power, work and time 5 state that the change in gravitational potential energy is the work done against/by gravity	

Unit 5: Transport

Section 3: Movement Means Energy (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to:	and in addition to:
Kinetic energy	Carry out experiments to show the dependence of kinetic energy on mass and speed.	C	6 state that the greater the mass and/or the speed of a moving object, the greater is its kinetic energy	7 carry out calculations involving the relationship between kinetic energy, mass and speed
	View audio-visual presentation on the implications of crashing a car at various speeds.	B		
Crashes and the Highway Code	Obtain from the Highway Code information to relate how thinking time and vehicle speed affect stopping distance.	B		
Principle of conservation of energy	Carry out an experiment to show, for example, loss of gravitational potential energy = gain in kinetic energy.	C		8 carry out calculations involving energy, work, power and the principle of conservation of energy

Unit 6: Energy Matters

Introduction

This Unit emphasises the importance of energy to our survival. In addition to considering some of the physical principles involved, pupils should becomr aware of wider issues concerning energy.

In the first section of this Unit, issues relating to consumption and supply of energy are considered. The opportunity is offered to consider renewable sources and to evaluate the contribution that these might make in the future. The need for conservation and for consideration of environmental issues is also involved.

The second section of the Unit concentrates on the conversion of electrical energy from the original source. A range of types of power station is considered.

The third section describes the transmission of electricity from source to consumer. A review and development of the principles involved in electromagnetic induction and a.c. is included in order to allow them to be considered in the context of the National Grid.

The final section concentrates on energy in the form of heat with particular reference to the domestic situation.

Content Outline

Section	Content
1 Supply and Demand	Main sources, relative demands, conservation issues, alternative sources, environmental issues.
2 Generation of Electricity	Fossil-fuelled power stations, hydro-electric stations, nuclear power stations, energy transformations; efficiency.
3 Source to Consumer	Induced voltage, alternating current, generators, transformers, National Grid.
4 Heat in the Home	Energy conservation in buildings, specific heat capacity, domestic applications, change of state, refrigerator.

Unit 6: Energy Matters

Section 1: Supply and Demand

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Main sources Relative demands Conservation issues	Introduction based on audio-visual presentation Obtain, present and discuss information, particularly in the form of numerical and graphical data, on: total energy supply and demand; the finite supply of fossil fuels; relative contributions from a variety of sources, eg coal, oil, gas, hydro, nuclear, other; relative demands relating to a variety of uses; relative demands in an industrial/ non-industrial society; various means of conserving energy relating to the variety of uses; combined heat and power plants.	B	1 state that fossil fuels are at present the main sources of energy 2 state that the reserves of fossil fuels are finite 3 explain one means of conserving energy related to the use of energy in industry, in the home and in transport	

Unit 6: Energy Matters

Section 1: Supply and Demand (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to:	and in addition to:
			4 carry out calculations relating to energy supply and demand	
	Handling data involving a variety of energy units, eg joule (Kilo, Mega, Giga, Tera), kilowatt-hour, tonnes of coal equivalent, Q units, therm.	B		
Renewable sources	Carry out experiments to illustrate how electricity can be obtained from renewable energy sources, eg wind, wave, solar, hydro.	C	5 classify renewable and non-renewable sources of energy	6 explain the advantages and disadvantages associated with at least three renewable energy sources.

Unit 6: Energy Matters

Section 2: Generation of Electricity

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Fossil-fuelled power stations, hydro-electric stations, nuclear power stations, energy transformations	Review, discuss and develop information relating to means of power generation.	B	1 identify from a diagram the energy transformation at each stage of: • a thermal power station • a hydro-electric power station • a nuclear power station	5 compare energy output from equal masses of coal and nuclear fuel 6 carry out calculations involving efficiency of energy transformation 7 state that energy is degraded in energy transformation
	Carry out experiments on energy transformation.	C		
	Study models and simulations relating to nuclear structure.	C	2 state that radio-active waste is produced by nuclear reactors 3 carry out calculations on energy transformation to include gravitational potential energy 4 describe the principle and give the advantages of a pumped hydro-electric scheme	explain in simple terms a chain reaction.

Unit 6: Energy Matters

Section 3: Source to Consumer

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Induced voltage, alternating current, generators	Carry out demonstrations, eg: wire moving between magnet poles; moving magnet and coil; model dynamo and galvo; model dynamo (a.c. form); bicycle dynamo and lamp.	C	1 identify circumstances in which a voltage will be induced in a conductor 2 identify on a given diagram the main parts of an a.c. generator	8 explain from a diagram how an a.c. generator works 9 state the main differences between a full-size generator and a simple working model
	Carry out experiment to investigate the factors affecting the size of the induced voltage.	C		10 state the factors which affect the size of the induced voltage, ie field strength, number of turns on the coil, relative speed of magnet and coil
Transformers	Investigate voltages induced in coils wound on iron cores.	C	3 state that transformers are used to change the magnitude of an a.c. voltage	11 explain why a transformer is not 100% efficient

Unit 6: Energy Matters

Section 3: Source to Consumer (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to:	and in addition to:
	Investigate the relationship between V_p, V_s, and turns ratio of a transformer.	C	4 describe the structure of a transformer 5 carry out calculations involving the relationship between V_s, V_p, n_s, n_p	12 carry out calculations on transformers involving input and output voltages, turns ratio, primary and secondary currents and efficiency
National Grid	Demonstrate model power lines.	C	6 state that high voltages are used in the transmission of electricity to reduce power loss 7 describe qualitatively the transmission of electrical energy by the National Grid system	13 carry out calculations involving power loss in transmission lines

Unit 6: Energy Matters

Section 4: Heat in the Home

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Energy conservation in buildings	Use a computer simulation on home heating.	B	1 use the following terms correctly in context: • temperature • heat • Celsius	
	Investigate various ways of reducing heat loss in the home.	C	2 describe two ways of reducing heat loss in the home due to: • conduction • convection • radiation	
			3 state that heat loss in a given time depends upon the temperature difference between the inside and the outside of the house	
			4 state that the same mass of different materials requires different quantities of energy to raise their temperature of unit mass by one degree	

Unit 6: Energy Matters

Section 4: Heat in the Home (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to:	and in addition to:
Specific heat capacity	Investigate the relative effectiveness of different materials (eg water, aluminium, copper, brick) to store heat.	C	5 carry out calculations based on practical applications involving heat, mass, specific heat capacity and temperature change	10 use the principle of conservation of energy to carry out calculations on energy transformations which involve temperature change eg: $ItV = E_h = cm\Delta T$
Domestic applications	Measure the efficiency of an electric kettle.	C		
Change of state	Demonstrate the cooling effect of liquid evaporating.	B	6 give examples of applications which involve a change of state, eg refrigerator or picnic box cooler	11 carry out calculations involving specific latent heat.
	Measure the specific latent heat of vaporisation of water.	C	7 use the following terms correctly in context: • specific heat capacity • change of state • latent heat of fusion • latent heat of vaporisation	
	Investigate the melting point of a solid (eg stearic acid cooling curve).	C		

Unit 6: Energy Matters

Section 4: Heat in the Home (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to:	and in addition to:
	Investigate the relative effectiveness of materials (eg ice, picnic box coolant) to release or take in latent heat.	C	8 state that a change of state does not involve a change of temperature	
			9 state that energy is gained or lost by a substance when its state is changed	

Unit 7: Space Physics

Introduction

The aim of this Unit is to review, consolidate, and (particularly for the more able pupil) extend some important physics concepts by considering applications of physics in the context of astronomy and spaceflight.

The first section gives the opportunity to revise earlier work on refraction of light, lenses and image formation (Unit 3), and to extend this to include the effects of aperture and image formation with a magnifying glass. Spectroscopy relates to aspects of colour and leads on to a treatment of the electromagnetic spectrum where the various parts of the spectrum, previously met as separate entities in Units 1 and 3, are linked together.

Section 2 begins with a treatment of rockets and Newton's third law, which is introduced for the first time. The topic of launch vehicles provides an opportunity to revise (and extend) the use of Newton's second law. The topic "Gravity and weightlessness" allows for revision of acceleration and weight met in Unit 5 and builds on this to consider the relationship between weight, mass and gravitational field strength. Mechanics concepts are further developed in the topic "Artificial satellites and projectiles". A treatment of the effects of friction on spacecraft gives the opportunity to revise aspects of heat energy from Unit 6.

Content Outline

Section	Content
1 Signals from Space	Astronomical terms. Refracting telescope. Spectroscopy, invisible signals (the electromagnetic spectrum).
2 Space Travel	Rockets. Interplanetary flight. Gravity and weightlessness. Artificial satellites and projectiles. Re-entry.

Unit 7: Space Physics

Section 1: Signals from Space

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Astronomical term	View the night sky, and an audio-visual presentation on solar system, stars, etc	B	1 use correctly in context the following terms: moon, planet, sun, star, solar system, galaxy, universe 2 state approximate values for the distance from the Earth to the Sun, to the next nearest star, and to the edge of our galaxy in terms of the time for light to cover these distances	11 use correctly in context the term light-year
Refracting telescope	Construct and use a refracting "astronomical" telescope.	C	3 draw a diagram showing the main features of a refracting telescope (objective, eyepiece, light-tight tube) 4 state that the objective lens produces an image which is magnified by the eyepiece	12 draw a ray diagram to show the formation of an image by a magnifying glass 13 explain why the brightness of an image depends on the diameter of the objective
Spectroscopy	Use a prism to produce a visible spectrum.	C	5 state that different colours of light correspond to different wavelengths 6 list the following colours in order of wavelength: red, green, blue 7 state that white light can be split into different colours using a prism	

Unit 7: Space Physics

Section 1: Signals from Space (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to:	and in addition to:
	Use a direct vision spectroscope to examine line and continuous spectra.	C	8 state that the line spectrum produced by a source provides information about the atoms within the source	
	Examine spectra of various elements and stars, and, using simplified spectra, identify elements present in a star.	B		
Invisible signals	Use a variety of devices to detect radiations associated with different parts of the electromagnetic spectrum (eg ultraviolet, infrared, microwaves, radio).	C	9 state that there exists a large family of waves with a wide range of wavelengths which all travel at the speed of light	14 classify as members of the electromagnetic spectrum the following radiations: gamma rays, X-rays, ultraviolet, visible light, infrared, microwaves, TV and radio
	Revise and consolidate earlier references to electromagnetic radiation in Units 1 and 3.	B	10 state that telescopes can be designed to detect radio waves	15 list the above radiations in order of wavelength (and frequency)
	Obtain information about radio telescopes.	B		16 give an example of a detector for each of the above radiations
	Examine a radio telescope image of part of the sky and compare it with an optical photograph.	B		17 explain why different kinds of telescope are used to detect signals from space.

Unit 7: Space Physics

Section 2: Space Travel

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	Credit Level
			Pupils should be able to:	and in addition to:
Rockets	Carry out experiments with, for example, balloons, sparklet bulbs, water rockets.	C	1 state that a rocket is pushed forward because the "propellant" is pushed back	10 state that Newton's Third Law is: "If A exerts a force on B, B exerts an equal but opposite force on A"
	Carry out other "pairs of forces" experiments.	C	2 explain simple situations involving the rule: A pushes B, B pushes A back	11 identify "Newton pairs" in situations involving several forces
	Establish that the product of mass and speed is the same for both of two trolleys in "explosions". This lays the foundation for the concept of momentum.	C	3 carry out calculations involving thrust, mass, and acceleration	
	Obtain information about a variety of launch vehicles.	B		
Interplanetary flight	View audio-visual presentation on use of rocket motors during flight and manoeuvring.	B	4 explain why a rocket motor need not be kept on during interplanetary flight	

Unit 7: Space Physics

Section 2: Space Travel (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to:	and in addition to:
Gravity and weightlessness	Measure the acceleration due to gravity for different masses (using, for example, an accelerometer).	C	5 state that the force of gravity near the Earth's surface gives all objects the same acceleration (if the effects of air resistance are negligible)	12 explain the equivalence of acceleration due to gravity and the gravitational field strength
			6 state that the weight of an object on the moon or on different planets is different from its weight on Earth	13 carry out calculations involving the relationship between weight, mass, acceleration due to gravity and/or gravitational field strength including situations where g is not equal to 10 N kg^{-1}.
	Obtain information on weightlessness and free-fall.	B	7 state that objects in free fall appear weightless	14 use correctly in context the following terms: mass, weight, inertia, gravitational field strength, acceleration due to gravity
	Obtain and present information on applications of "weightlessness" in space.			15 state that the weight of a body decreases as its distance from the Earth increases

Unit 7: Space Physics

Section 2: Space Travel (*continued*)

Content	Suggested Activities	Elements B, C	Element A (Knowledge and Understanding): Learning Outcomes	
			General Level	**Credit Level**
			Pupils should be able to:	and in addition to:
Artificial satellites and projectiles	Carry out projectile experiments (qualitative only at General Level). Use computer simulation of projectile motion.	C	8 explain the curved path of a projectile in terms of force of gravity	16 explain how projectile motion can be treated as two independent motions and solve numerical problems using this method
	Use computer simulation of "Newton's Thought Experiment" (varying speed and height).	C		17 explain satellite motion as an extension of projectile motion
Re-entry	Carry out experiments involving frictional heating.	C	9 state that an effect of friction is the transformation of E_k into heat	18 carry out calculations involving the relationships $E_h = cm\Delta T$, $W = Fd$ and $E_k = \frac{1}{2} mv^2$.
	Obtain information concerning re-entry temperatures, melting points, and the design of re-entry vehicles	B		

Section 4

Elements, Abilities and Assessment Methods

4 Elements, Abilities and Assessment Methods

4 1 Introduction

Assessment has an important contribution to make to the teaching and learning process and is an essential component in the planning of any course. Its procedures should be reliable, valid, easy to understand, simple to implement and not unduly time consuming. Assessment for the purpose of certification is described in Section 5.

4 2 Elements and Abilities

The groups of abilities which comprise each element are detailed below.

A Knowledge and Understanding

Pupils should demonstrate Knowledge and Understanding by their ability to:

- recall facts and terms, symbols, quantities, models, principles, techniques;
- give examples of the application of physics principles in society;
- use terms, relationships, quantities and units correctly;
- give descriptions of models, methods and applications;
- explain ideas.

B Problem Solving

Pupils should demonstrate skills of problem solving by their ability to:

- select and present relevant information;
- process information which involves the use of calculations;
- evaluate experimental procedures;
- draw and justify conclusions and make predictions from given information;
- use principles to explain phenomena and scientific applications.

C Practical Abilities

Pupils should demonstrate their ability to:

- carry out practical techniques;
- plan and carry out investigations.

4 3 Assessment Methods

Assessment can be carried out using a variety of methods, including:

- objective questions
- short answer questions
- extended answer questions
- practical tests
- practical investigations.

The first three methods are most appropriate for the assessment of abilities within the Knowledge and Understanding and Problem Solving elements and the last two for the assessment of Practical Abilities.

Section 5

Assessment for Certification

5 Assessment for Certification

5 1 Introduction

Assessment has an important contribution to make to the teaching and learning process. Assessment is also used for the purposes of certification and this is the concern of this section.

5 2 Assessment Scheme

The assessment of pupil performance in the three elements – Knowledge and Understanding, Problem Solving and Practical Abilities – will be carried out with reference to the Extended Grade Related Criteria defined for each of these elements (see Section 6).

A grade for attainment in each element will be recorded on the Certificate together with an overall grade for the course derived from the mean of the element grades with a weighting of 2:2:1 in favour of the externally assessed elements. For Physics, element grades will be awarded on the scale 5 to 1, Grade 1 denoting the highest performance. Grade 6 is not available for an element, but may be gained as an overall award. Grade 7 is available (see 5 3 and 5 4 below).

There will be external and internal assessment.

Knowledge and Understanding and Problem Solving will be assessed externally by a single written paper at each Level. Presenting centres will be required to submit to the Scottish Qualifications Authority (SQA), by 31 March of the year of the examination, estimate grades for each candidate for Knowledge and Understanding and for Problem Solving. The teacher should determine the estimate grades on the basis of the candidate's work. Estimates may be used by the SQA for its internal procedures, including such cases as absence from external examinations, adverse circumstances and appeals. In these cases, evidence in support of these estimates should be retained by centres for submission to the SQA.

Practical Abilities will be assessed internally. These assessments will be externally moderated.

The assessment scheme in summary is as follows:

Element	*Type of Assessment*
Knowledge and Understanding Problem Solving	External
Practical Abilities	Internal with external moderation

5 3 Presentations for External Papers

All candidates will be required to be presented at both Levels, but it is emphasised that they are not obliged to attempt both papers. They should, however, be made aware that, other than as the result of an appeal, candidates taking the General paper alone will have only Grades 3, 4, 5 and 7 open to them in Knowledge and Understanding and Problem Solving. For candidates taking only the Credit paper, the grades available in these elements will be 1, 2 and 7.

Candidates who attempt both papers will be given the better of the two grades achieved for each of Knowledge and Understanding and Problem Solving. Performance at one Level will **not** be taken into account in grading at the other Level.

5 4 Grade 7 and No Overall Award

For any element, Grade 7 will indicate that the candidate has, in the element concerned, completed the course but has not demonstrated achievement of any specified level of performance as defined by the Grade Related Criteria.

The SQA will regard the submission of an estimate grade for an externally assessed element as evidence that the course has been completed in that element.

Candidates who have not complied with the assessment requirements in any element (eg due to unauthorised absence from the external examination) will be deemed not to have completed the course, in that element. Such candidates **will not receive a grade** for that element and hence **will not receive an overall award** for the subject. In such cases, however, if a grade is gained for any other element, that grade will be recorded on the Certificate.

5 5 External Assessment

An examination paper in Knowledge and Understanding and Problem Solving will be set at each of General and Credit Levels. The papers will be designed to assess the achievement of the Course Objectives relating to these two elements. The full range of course Units will be examinable. The context of, and the standard of performance required in, the questions will be appropriate to the Level to which each paper relates.

The General paper, assessing Grades 4 and 3, will be of 1½ hours' duration. The number of marks will be approximately equally distributed between Knowledge and Understanding and Problem Solving. Knowledge and Understanding will be assessed by multiple-choice items, numerical direct-answer and short-answer questions and extended-answer questions. Problem Solving will be assessed mainly by extended-answer questions. Units of physical quantities will be written out in full. In this paper, Grade 5 may be awarded to candidates who narrowly fail to meet the criteria for General Level.

The Credit paper, assessing Grades 2 and 1, will be of 1¾ hours' duration. The types of question will be similar to those of the General paper, but there may be a greater proportion requiring extended answers. The solidus notation will be used for describing the units of physical quantities in questions in the Credit Level paper.

There will be no choice of questions in either paper and the division and distribution of questions assessing each element in both papers will be at the discretion of the examiners and may vary from year to year.

Marks will be allocated to each question and a total mark obtained. The two grades associated with each element at each Level will be distinguished by setting two cut-off scores. The lower score (in the region of 40-50%) will reflect a satisfactory overall standard of performance, the upper score (in the region of 70-80%) a high overall standard of performance.

5 6 Internal Assessment of Practical Abilities

5 6 1 Introduction

Throughout the Units of this course there are suggested activities and involvement in these activities should lead to achievement of the course objectives.

As stated in 4 2, the abilities which comprise the element Practical Abilities are:

a) carrying out practical techniques;

b) planning and carrying out investigations.

Assessment of Practical Abilities may take place at any time during the course after the candidates have had the opportunity to develop the abilities in which performance is being assessed: suggested activities and Practical Investigations offer opportunities for the assessment of the Practical Abilities element.

5 6 2 Carrying Out Practical Techniques

This ability is assessed by monitoring the candidate's success in carrying out eight prescribed techniques. These techniques, the conditions under which each should be demonstrated (the specification) and the criteria which must be satisfied for certification purposes are set out in the table overleaf.

5 6 2 *(continued)*

Technique	Specification	Criteria for Assessment
The candidate is able to: 1 measure the speed of a moving object;	The candidate uses a light-gate to measure the instantaneous speed of an object as it moves down a slope. A length of card is fixed to the object. The length of the card is measured by the candidate. The object is released from a reference line on the slope so that it passes through the light-gate which is positioned at a second reference point on the slope. The time for the card to pass through the light-gate is measured electronically. The instantaneous speed of the object at the second reference point is calculated by the candidate.	The candidate produces written results and arrives at a value of the instantaneous speed within + or - 10% of the teacher's measurement.
2 measure the approximate focal length in order to select a particular convex lens from a box containing five different lenses;	The candidate is presented with a box containing five unmarked converging lenses covering a range of focal lengths from 50 mm to 500 mm. The candidate is asked to identify by measurement a lens of specified focal length.	The candidate correctly measures the focal length and selects a lens of specified focal length.

5 6 2 *(continued)*

Technique	Specification	Criteria for Assessment
The candidate is able to: 3 measure the angle of incidence and the angle of refraction of a ray of light going from plastic or glass into air;	The candidate is provided with a ray-box, a protractor and a plastic or glass semi-circular block. The candidate sets up a ray-box on a sheet of paper and directs a non-divergent ray of light at the curved surface of the semi-circular block so that the ray passes through the centre of the block and emerges from the plane surface. *The direction of the incident ray and the position of the glass block are previously drawn on the sheet of paper by the teacher.* The candidate draws the normal and the direction of the refracted ray on the sheet of paper. The angle of incidence and the angle of refraction are then measured from the sheet of paper using the protractor.	The candidate draws the normal, measures the angle of incidence and the angle of refraction and records values which are within + or – 2 degrees of the teacher's measurements.
4 detect an open or a short circuit in an electric circuit;	The candidate is supplied with three circuit boards each with three similar lamps in lampholders and connected in series. Each circuit board has a different fault. One has an open-circuited lead, another an open-circuited lamp and the other a short-circuited lampholder.	The candidate correctly identifies the fault on each board and its location.
5 measure current in and voltage across an electrical component;	The candidate is presented with an assembled series circuit comprising a d.c. supply, resistor and a lamp. The circuit components are on mounts with terminals. The candidate is given a suitable d.c. ammeter and voltmeter (or multimeter).	The candidate measures the current in the circuit, and the voltage across either the resistor or the lamp and arrives at values within ± 5% of those measured by the teacher.

Technique	Specification	Criteria for Assessment
The candidate is able to: 6 connect an oscilloscope to an a.c. supply and measure the peak voltage;	The candidate is given the following apparatus: signal generator, oscilloscope, calculator, connecting leads. The oscilloscope is set by the teacher as follows: *a)* brightness and focus correctly adjusted; *b)* X-shift and Y-shift centred; *c)* X-gain minimum, Y-gain minimum amplification; *d)* stability adjusted for 1 kHz *e)* input *f)* Sync - internal, Trig -auto; *g)* time-base on lowest setting. The signal generator is set as follows: *a)* frequency at 1 kHz; *b)* voltage such as to give a wave-form that is just discernible when the oscilloscope is set as described above. The oscilloscope and signal generator have been switched on previously, but are not connected to each other. The candidate must not adjust the signal generator, but will require to adjust the time-base and the Y-gain controls, and use the Y-gain calibration scale to calculate the voltage. Different candidates are asked to measure different voltages.	The candidate must adjust the time-base and Y-gain controls, measure the peak voltage and arrive at a value within ± 5% of that measured by the teacher.

Technique	Specification	Criteria for Assessment
The candidate is able to: 7 set up and adjust a voltage divider circuit to produce a specified voltage;	The candidate is given a low voltage supply, eg cell, battery; a suitable linear potentiometer and a suitable d.c. voltmeter or multimeter. The components are supplied on mounts with terminals. No connections are made between any of the components. The candidate is not provided with a circuit diagram.	The circuit must be correctly assembled as a voltage divider circuit and the voltmeter must read 1.0 V ± 0.1 V.
8 wire up correctly a mixed series and parallel circuit, given the circuit diagram.	The candidate is supplied with 2 cells, 2 lamps, a resistor, a suitable d.c. ammeter or multimeter, a switch, connecting leads and a circuit diagram. The components are presented with no connections made between them. The components are on mounts with 4 mm sockets. The circuit diagram shows the two cells, the switch, the resistor, all in series, and in series with these components is a parallel arrangement of the two lamps. The value of the resistor is such that the lamps will light.	The circuit must be set up as shown in the diagram presented to the candidate and, when switched on, allow the current to be measured.

Each candidate should be assessed on **all** of the eight techniques listed above, the assessment being carried out during ongoing classwork or in specific practical tests. **Candidates who on a particular occasion are unable to carry out a technique should be assessed again on another day until the teacher is satisfied that the candidate can carry out the technique or is unlikely to benefit from further opportunities**. A score of 2 marks should be awarded by the teacher for each technique successfully demonstrated by the candidate. Where the candidate is unsuccessful in demonstrating a technique, zero marks should be awarded for that technique. A total of 16 marks are available for carrying out Practical Techniques.

5 6 3 Planning and Carrying Out Investigations

This ability is assessed in terms of the extent to which Investigative Skills objectives are achieved by the candidate in the course of planning and carrying out a practical investigation. The Investigative Skills objectives are grouped under four headings, as follows:

i Generative Skills (G);
ii Experimental Skills (E);
iii Evaluation Skills (Ev);
iv Recording and Reporting Skills (RR).

Two investigations, each covering all of the Investigative Skills objectives should be submitted for the purpose of assessment for certification. At least one of the investigations must involve a continuous variable.

The Investigative Skills objectives, together with the related assessment criteria and mark allocations for Standard Grade Physics, are set out in paragraph 5 6 6 below.

5 6 4 Structure of Investigations

It is important that Investigations carried out for certification purposes provide opportunities for candidates to demonstrate **all** of the thirteen identified skills objectives and are structured in a way which allows the teacher and an external moderator readily to identify in the evidence generated those parts which relate to the individual objectives. It is equally important that the degree of structuring of the Investigation is not so great that the candidate receives an excessive amount of support. The Investigation Booklet issued by the SQA must be used for all investigations conducted for the purposes of assessment for certification.

5 6 5 Conduct of Investigations

The following comments give guidance on the permissible limits of support which may be offered by teachers during an investigation which is being assessed for certification purposes.

It is expected that, at the outset of the investigation, teachers will stimulate class or group discussion. Subsequent to the dicussion, candidates must work individually throughout the remainder of the investigation. However, if the candidate is unable to meet the criterion for G1, the teacher should give assistance to enable the candidate to proceed but will not award the mark allocated to this Objective. In the case of a candidate who identifies a relevant investigable aspect which cannot be investigated within the constraints of the school situation the candidate should be directed to other alternatives without penalty. Should a candidate fail to meet a criterion associated with Objective G2, G3 or G4, it is permissible for the teacher to intervene and give sufficient support to enable the candidate to proceed, but the mark allocated **to the relevant criterion** will not be awarded.

After the generative phase (Objectives G1, G2, G3 and G4) candidates must be left to pursue the investigation **independently**. Teacher intervention in the post-generative phase is permitted only when the candidate fails to adopt standard, safe laboratory practice. In such a case, the mark allocated to the criterion for Objective E1 is forfeited.

Investigations for certification purposes must be carried out and written up by the candidate in class time.

5 6 6 Assessment Scheme for Planning and Carrying Out Investigations

Assessment of achievement of Investigative Skills objectives is undertaken by applying the following assessment scheme to evidence generated by the candidate in conducting practical investigations. The scheme identifies the criteria which must be satisfied for the purposes of assessment for certification. For each of the criteria, one mark should be awarded where the requirements of the criterion are satisfied. If the criterion is not satisfied, zero marks should be awarded. The mark allocation for an investigation is 24. A total of 48 marks is therefore available for planning and carrying out investigations.

5 6 6 *(continued)*

Investigative Skills Objective The candidate should be able to:		Assessment Criteria and available marks	Marks Total
G1	demonstrate understanding of the problem posed;	Following group discussion, the candidate individually identifies and records an investigable aspect of the problem (1,0)	1
G2	state the aim of the investigation;	Clearly identifies the aim of the investigation in terms of the two relevant variables (1,0)	1
G3	articulate a testable hypothesis;	Articulates a testable hypothesis in terms of the two relevant variables; this should be directional if a continuous variable is chosen (1,0)	1
G4	suggest a broad strategy to adopt;	The strategy gives sufficient detail by description and/or diagram to indicate: *a)* how the chosen independent variable will be altered (1,0) *b)* that the candidate has considered what will have to be measured (1,0)	2
E1	adopt appropriate and safe procedures;	*a)* Adopts appropriate and safe procedures (1,0)	1
E2	identify the independent variable to be used and alter it over a suitable range;	*a)* Provides a working definition of the independent variable (1,0) *b)* Alters the independent variable over an appropriate range taking account of a suitable number of types or values (1,0)	2
E3	control all relevant variables as necessary;	*a)* Makes a written statement of the variables which need to be actively controlled by the candidate (1,0) *b)* Controls these variables in practice (1,0)	2
E4	make valid, reliable measurement of the dependent variable;	*a)* Uses a valid method of measuring the dependent variable (1,0) *b)* Evidence is provided of a form of repeat/replicate testing which improves the reliability of the results or a valid written justification is given for not repeating/replicating measurements (1,0)	2
RR1	tabulate results with appropriate headings and units of measurement;	*a)* Values (or types) with appropriate headings for independent, dependent (and any derived) variable are entered in the table (1,0) *b)* Appropriate units or their correct abbreviations are entered in the table (1,0)	2

5 6 6 *(continued)*

Investigative Skills Objective The candidate should be able to:		Assessment Criteria and available marks	Marks Total
RR2	present the results on a graph or chart;	*a)* produced (1,0) *b)* Both axes have appropriate labels and units (1,0) *c)* Plots all the points/bars accurately (1,0) *d)* Draws line/curve of best fit or joins up the points as appropriate when the independent variable is continuous **or** draws a bar chart when independent variable is not continuous (1,0)	4
Ev1	draw a valid conclusion inter-relating the appropriate variables;	Draws a conclusion which interrelates the appropriate variables or states that no firm conclusion can be drawn (1,0)	1
Ev2	use results to evaluate the original hypothesis;	Confirms hypothesis if appropriate **or** refutes hypothesis and replaces it with appropriate substitute **or** states that no conclusion can be drawn (1,0)	1
RR3	describe how the investigation was carried out.	The description includes: *a)* a labelled diagram and/or statement of the apparatus used; (1,0) *b)* an account of the procedure adopted to measure the dependent variable; (1,0) *c)* an account of how the independent variable was altered; (1,0) *d)* an indication of how variables which were the investigator's responsibility to control were kept constant (1,0)	4

5 6 7 Recording of Assessment of Practical Abilities

An Assessment Record should be used to record the outcome of the assessment of Practical Abilities. The Assessment Record should provide a summary of the candidate's attempts at the eight prescribed techniques and the mark out of 16 attained. The Record should also give the candidate's total mark out of 48 for planning and carrying out investigations and the breakdown of the marks attained for each of the Investigative Skills objectives. In addition, the total mark and the overall grade for Practical Abilities (see paragraph 5 6 9) should be included. An exemplar of an Assessment Record is given in Appendix III.

The SQA will provide presenting centres annually with details of the arrangements for the submission of internal assessments of Practical Abilities for all candidates.

5 6 8 Evidence of Attainment of Practical Abilities

Evidence of a candidate's attainment of Practical Abilities should comprise a summary, as described in paragraph 5 6 7, of the candidate's attempts to demonstrate the ability to carry out practical techniques. In addition, the evidence should include the candidate's written work from two practical investigations each of which covers the thirteen Investigative Skills objectives listed in paragraph 5 6 6.

The two best practical investigations should be used as evidence for certification purposes. At least one of the two investigations must involve a continuous variable. The conditions for the structure and conduct of investigations specified in paragraphs 5 6 4 and 5 6 5 respectively must be met and the investigations must be assessed in accordance with the assessment scheme described in paragraph 5 6 6. The candidate's written work for the two practical investigations should be marked and totalled, and must give a clear indication of the mark awarded for each of the Investigative Skills objectives.

For each candidate, the evidence from the two best practical investigations should be retained by the centre for possible submission to the SQA for the purposes of moderation of the centre's internal assessments.

5 6 9 Grade for Practical Abilities

The grade awarded for Practical Abilities is determined by totalling the candidate's mark for carrying out practical techniques and the marks for the two best investigations. The total mark is then compared with the marks ranges in the table below and the corresponding grade awarded.

Marks Range	Grade
64 - 55	1
54 - 46	2
45 - 39	3
38 - 30	4
29 - 19	5

Candidates for whom there is evidence in support of at least one of the two abilities (ie carry out practical techniques and plan and carry out practical investigations) and who achieve fewer than 19 marks should be awarded a Grade 7 for Practical Abilities.

5 6 10 Moderation of Internal Assessments

To ensure the uniform application of the Extended Grade Related Criteria for Practical Abilities, each year a sample of presenting centres will be required to submit to the SQA evidence in support of internal assessments for a sample of candidates. Where a centre's internal assessments cannot be confirmed, the centre will be required to carry out re-assessment as necessary.

Section 6

Grade Related Criteria

6 Grade Related Criteria

6 1 Definition

Each of the three elements comprises a number of abilities in which performance is measured. Grade Related Criteria (GRC) are descriptions of candidates' performance in these abilities. Direct comparisons are not made between the performance of one candidate and another.

6 2 Application of GRC

For each element, GRC are defined at two Levels of performance: General and Credit. Two grades are distinguished at each Level, Grades 4 and 3 at General Level and Grades 2 and 1 at Credit. Grade 5 is available for candidates who narrowly fail to reach the standard of performance required for Grade 4. Grade 7 will be awarded to candidates who have completed the course but have not fulfilled the requirements for Grade 5 or better. Grade 6 will not be available for an element.

6 3 Types of GRC

Summary GRC are broad descriptions of performance. They are published as an aid to the interpretation of the profile of attainment by candidates, parents, employers, and other users of the Certificate.

Extended GRC are more detailed descriptions of performance. They are intended to assist teachers in making their assessments for each element and to be used by examiners when conducting external assessment.

6 4 Illustration of Terms

The definitions of the terms "element", "ability" and "Grade Related Criteria" can be made clearer by an example. Within the element of Problem Solving a candidate is expected to demonstrate the ability "to select and present relevant information".

At General Level, this ability is recognised by the candidate being able to "select relevant information from sources which use terms and ideas specified by the learning outcomes and present this information in a meaningful form". This statement is the standard of performance expected of a pupil at General Level and is therefore one of the Extended GRC for General Level.

At Credit Level, the standard of performance expected with regard to this same ability requires the candidate to "select relevant information from sources which use terms and ideas not necessarily specified by the learning outcomes and present this information in a meaningful and complete form". This behaviour is considered more difficult to demonstrate and is therefore associated with the Extended GRC for Credit Level.

6 5 Knowledge and Understanding – Summary GRC

General Level (Grades 4, 3)

The candidate has demonstrated knowledge and understanding of facts, ideas, terminology, simple generalisations and some related applications of physics in society.

Credit Level (Grades 2, 1)

The candidate has demonstrated knowledge and understanding of complex facts, ideas, terminology, theoretical generalisations and related applications of physics in society.

6 6 Problem Solving – Summary GRC

General Level (Grades 4, 3)

In familiar situations, the candidate has demonstrated ability to extract information and present it in a meaningful form; to process information in order to solve simple problems, evaluate experimental procedures and draw conclusions; and to make predictions and use the principles of physics in order to explain phenomena and applications.

Credit Level (Grades 2, 1)

In situations which may be unfamiliar, the candidate has demonstrated ability to extract information and present it in a meaningful and complete form; to process information in order to solve complex problems and to evaluate, and suggest improvements in, experimental procedures; to justify conclusions and predictions; and to use the principles of physics in order to give a complete explanation of phenomena and applications.

6 7 Practical Abilities – Summary GRC

General Level (Grades 4, 3)

The candidate has demonstrated ability to carry out a range of practical techniques and to conduct investigations in physics with a degree of competence.

Credit Level (Grades 2, 1)

The candidate has demonstrated ability to carry out a wide range of practical techniques and to conduct investigations in physics with a high degree of competence.

6 8 Descriptions of Grades

These describe performance within Levels. They apply to each element.

Grade 5 Judged by the criteria for General Level, the candidate has demonstrated a significant but not satisfactory overall standard of performance..

Grade 4 The candidate has met the criteria for General Level, demonstrating a satisfactory overall standard of performance.

Grade 3 The candidate has met the criteria for General Level, demonstrating a high overall standard of performance.

Grade 2 The candidate has met the criteria for Credit Level, demonstrating a satisfactory overall standard of performance.

Grade 1 The candidate has met the criteria for Credit Level, demonstrating a high overall standard of performance.

6 9 Knowledge and Understanding – Extended GRC

	Abilities	General Level (Grades 4, 3)	Credit Level (Grades 2, 1)
a	*Recall facts and terms, symbols, quantities, models, principles and techniques.*	The candidate has demonstrated these abilities by attaining a majority of the General Level learning outcomes.	The candidate has demonstrated these abilities by attaining a majority of the General and Credit Level learning outcomes.
b	*Give examples of the application of physics principles.*		
c	*Use terms, relationships, quantities and units correctly.*		
d	*Give descriptions of models, methods and applications.*		
e	*Explain ideas.*		

Descriptions of grades are given in **6 8**.

6 10 Problem Solving – Extended GRC

	Abilities	General Level (Grades 4, 3)	Credit Level (Grades 2, 1)
		The candidate has demonstrated these abilities by being able to:	The candidate has demonstrated these abilities by being able to:
a	*Select and present relevant information.*	select relevant information from sources which use terms and ideas specified by the learning outcomes and present this information in a meaningful form;	select relevant information from sources which use terms and ideas not necessarily specified by the learning outcomes and present this information in a meaningful and complete form;
b	*Process information which involves the use of calculation.*	apply a relationship and perform a calculation accurately to solve a problem;	apply a relationship or relationships in sequence and perform a calculation accurately, making appropriate use of significant figures, to solve a problem;
c	*Evaluate experimental procedures.*	comment on the validity of experimental procedures closely related to the activities of the course;	comment on experimental procedures with regard to validity and improvements;
d	*Draw and justify conclusions and make predictions from given information.*	draw a valid conclusion and/or make a prediction from given information relating to the General Level learning outcomes;	draw a valid conclusion and/or make a prediction from given information not necessarily specified in the learning outcomes, and provide some justification;
e	*Use principles to explain phenomena and applications of physics.*	use principles relating to the General Level learning outcomes to give a meaningful explanation of phenomena and applications of physics	use principles relating to the General and Credit Level learning outcomes to give a meaningful and complete explanation of phenomena and applications of physics.

Descriptions of grades are given in **6 8**.

6 11 Practical Abilities – Extended GRC

	Abilities	General Level (Grades 4, 3)	Credit Level (Grades 2, 1)
		The candidate has demonstrated these abilities by being able to:	The candidate has demonstrated these abilities by being able to:
a	*Carry out practical techniques*	carry out a proportion of the prescribed physics techniques;	carry out a high proportion of the prescribed physics techniques;
b	*Plan and carry out investigations*	achieve a proportion of the Investigative Skills objectives in conducting physics investigations.	achieve a high proportion of the Investigative Skills objectives in conducting physics investigations.

Descriptions of grades are given in **6 8**.

Appendices

Appendix I

Concept Development

The development of physical concepts is of fundamental importance in any Physics course. However, the content of this course is not structured in the traditional way, but is organised into Units based mainly on an applications approach organised through themes such as Health Physics and Telecommunication. Such an approach is designed to promote learning by stimulating interest and enthusiasm and by being more obviously relevant to the pupil. A further outcome is that it allows repeated opportunities to encounter important topics, thus enabling reinforcement of earlier ideas.

The planned progression of physics concepts through the course is represented in the following tables.

Wave Properties

Unit 1 Section 1	SPEED of sound
Unit 1 Section 1	FREQUENCY, AMPLITUDE of sound, oscilloscope traces
Unit 1 Section 1	WAVELENGTH, FREQUENCY in ripple tank
Unit 1 Section 2	$v = f\lambda$ water and sound waves
Unit 1 Section 3	SPEED, FREQUENCY, WAVELENGTH radio and TV (including $v = f\lambda$)
Unit 1 Section 3	DIFFRACTION ripple tank, radio
Unit 1 Section 4	REFLECTION plane mirror and internal reflection ($i = r$)

The Electromagnetic Spectrum

Unit 1 Section 3	RADIO AND TV transmission, reception; speed, wavelength and frequency; diffraction
Unit 1 Section 3	COLOUR colour mixing (red, green, blue)
Unit 1 Section 5	RADIO, MICROWAVES focusing effects with curved mirrors
Unit 3 Section 4	X-RAYS, ULTRAVIOLET AND INFRARED uses in medicine
Unit 3 Section 5	γ-RAYS properties, uses in medicine
Unit 7 Section 1	VISIBLE SPECTRUM dispersion, colour and wavelength, spectroscopy
Unit 7 Section 1	THE ELECTROMAGNETIC SPECTRUM the family of waves and detectors

Kinematics

Unit 1 Section 5	REFLECTION focusing with curved mirrors

Unit 3 Section 2	FREQUENCY of sound, range of hearing, ultra sound

Unit 3 Section 3	REFRACTION ray box experiments, lenses

Unit 7 Section 1	REFRACTION telescope, ray diagrams for virtual images

Unit 1 Section 1	SPEED, FREQUENCY, WAVELENGTH electromagnetic spectrum

Unit 1 Section 1	SPEED speed of sound = distance/time

Unit 1 Section 3	SPEED speed of radio, TV signals

Unit 5 Section 1	AVERAGE SPEED measurement, calculations

Unit 5 Section 1	INSTANTANEOUS SPEED methods of measurement

Unit 5 Section 1	ACCELERATION measurement and calculation

Unit 5 Section 1	SPEED-TIME GRAPHS calculating, drawing and interpreting distance gone and acceleration

Unit 7 Section 1	SPEED speed of light, light-year

Unit 7 Section 2	ACCELERATION measurements of acceleration due to gravity

Radioactivity and the Nucleus

Unit 3 Section 5	α, β, γ RADIATION range, absorption
Unit 3 Section 5	IONISATION
Unit 3 Section 5	RADIOACTIVE DECAY half-life, becquerel
Unit 3 Section 5	BIOLOGICAL EFFECTS OF RADIATION dose equivalent, sievert
Unit 6 Section 1	NUCLEAR ENERGY compared with other sources
Unit 6 Section 2	NUCLEAR POWER STATIONS energy changes, fission chain reactions, waste products

Electromagnetism

Unit 2 Section 6	MAGNETIC EFFECT OF CURRENT practical applications
Unit 2 Section 5	FORCE ON A CONDUCTOR d.c. motor
Unit 4 Section 2	OUTPUT DEVICES loudspeaker, meters, relays
Unit 4 Section 3	INPUT DEVICE microphone
Unit 6 Section 3	ELECTROMAGNETIC INDUCTION generators
Unit 6 Section 3	TRANSFORMER transmission lines

Electric Circuits

Unit 1 Section 1	CURRENT in telephone wires
Unit 2 Section 1	CURRENT in flexes, cables and appliances
Unit 2 Section 2	ELECTRICAL SUPPLY a.c. and d.c.
Unit 2 Section 2	CIRCUIT DIAGRAMS
Unit 2 Section 2	CHARGE, CURRENT AND VOLTAGE coulomb, ampere, volt
Unit 2 Section 3	RESISTANCE including $R = V/I$
Unit 2 Section 3	POWER including $P = VI$ and $P = I^2R$
Unit 2 Section 4	SERIES AND PARALLEL CIRCUITS current, voltage, equivalent resistance
Unit 2 Section 5	DOMESTIC ELECTRIC CIRCUITS fuses, circuit breakers, ring circuit
Unit 4	VARIOUS APPLICATIONS IN ELECTRONICS

Electronics

Unit 1 Section 1	OSCILLOSCOPE to examine electrical signals in wires
Unit 1 Section 3	RADIO components, block diagram
Unit 1 Section 3	AMPLIFIER use in radio
Unit 1 Section 3	TELEVISION block diagram, picture tub
Unit 4 Section 1	ANALOGUE AND DIGITAL identifying signals by oscilloscope
Unit 4 Section 2	OUTPUT DEVICES LED loudspeaker, relays
Unit 4 Section 3	INPUT DEVICES microphone, thermocouple, solar cell, capacitor
Unit 4 Section 4	DIGITAL PROCESSES transistor switch, logic gates, clock signals
Unit 4 Section 5	ANALOGUE PROCESSES audio amplifier

Force and Motion

Unit 5 Section 2	FORCES effects of forces, the newton
Unit 5 Section 2	FRICTIONAL FORCES effects on motion
Unit 5 Section 2	NEWTON'S FIRST LAW seat belts
Unit 5 Section 2	NEWTON'S SECOND LAW $F = ma$ from experiments
Unit 7 Section 2	NEWTON'S THIRD LAW pairs of forces experiments
Unit 7 Section 2	APPLICATIONS OF NEWTON'S SECOND LAW to rocket vehicles, etc
Unit 7 Section 2	NEWTON'S FIRST LAW space flight

Energy

Unit 2 Section 1	ENERGY TRANSFORMATION in electrical appliances
Unit 2 Section 3	ENERGY AND POWER joule, watt $P = VI$ and $P = I^2R$
Unit 5 Section 3	ENERGY TRANSFORMATION in cars and bicycles
Unit 5 Section 3	WORK DONE AND POWER *work done* = energy transformed *work done* $= F \times d$; $P =$ *work done/t*
Unit 5 Section 3	GRAVITATIONAL POTENTIAL ENERGY E_p = work done against/by gravity
Unit 5 Section 3	KINETIC ENERGY $E_k = \frac{1}{2}mv^2$
Unit 5 Section 3	CONSERVATION OF ENERGY $mgh = \frac{1}{2}mv^2$
Unit 6 Section 1	ENERGY SUPPLIES supply and demand, variety of sources, units

Gravity, Projectiles and Satellites

Unit 1 Section 5	SATELLITES orbits, uses in telecommunication
Unit 5 Section 2	WEIGHT as force of gravity*:* $w = mg$ (on Earth)
Unit 5 Section 3	GRAVITATIONAL POTENTIAL ENERGY gain in E_p = work done against gravity
Unit 6 Section 2	GRAVITATIONAL POTENTIAL ENERGY calculations
Unit 7 Section 2	ACCELERATION DUE TO GRAVITY measuring for different masses
Unit 7 Section 2	GRAVITATIONAL FIELD STRENGTH related to acceleration
Unit 7 Section 2	WEIGHTLESSNESS effects and applications
Unit 7 Section 2	PROJECTILES experiments and calculations
Unit 7 Section 2	SATELLITES as an extension of projectiles

Energy

Unit 6 Section 2	ENERGY TRANSFORMATION in power stations ($E_p \rightarrow E_k$ calculations)
Unit 6 Section 2	EFFICIENCY of power stations
Unit 6 Section 2	DEGRADATION OF ENERGY in energy transformations
Unit 6 Section 3	EFFICIENCY of transformers
Unit 6 Section 4	HEAT calculations involving ItV, E_h and $cm\Delta T$
Unit 6 Section 4	LATENT HEAT calculations
Unit 7 Section 2	FRICTIONAL HEATING calculations

Appendix II

Suggested Contexts for the Development of Investigative Skills - Sport

Speed Records

Accurate timing is an essential part of many sports. Discuss the advantages and disadvantages of using a manually operated stop-watch for timing, say a 100 metres race. Devise, set up and describe a fully automatic method of timing such an event. Compare the reading obtained using your automatic method with those measured on a manually operated stop-watch and discuss your results.

High Dives

How does the speed at which a diver strikes the water vary with the height from which he dives? Design an experiment to find how the speed of a falling body varies with height and plot a graph of your results. Suggest other sports involving a similar relationship.

Maximum range of throw

At what angle should an athlete throw a ball to achieve the maximum range? Devise and describe a simulation experiment to find the answer. Suggest a theoretical answer to the problem and state what assumptions you have to make. Suggest why the theoretical solution is not the best in practice for the discus, hammer, javelin and shot. In what other sports is similar information needed?

Bouncing balls

i How does the "bounce" of a squash ball change with temperature? Devise a way of finding out and present your results visually. Suggest a reason for the change. Find out how the change affects play and what action is taken by the players.

ii Test a number of different balls for their "bounce" on a soft and on a hard surface. Design and describe your method and record your results on a suitable visual display. Calculate the percentage loss of energy when each ball bounces once on each surface. Suitable balls: squash, tennis, golf, cricket, hockey, table tennis, croquet, skittles, snooker, football, volleyball, netball, basketball.

Skiing

Why do skis slide over snow? How can frictional forces on skis be reduced? Why does a dry ski slope cause the skis to wear quickly? Devise experiments to investigate the factors affecting frictional forces and report on your results.

Parachuting

Why does a parachute fall at a roughly constant speed? Make a polystyrene sphere fall through water at a constant speed by adding plasticine to it. Build a model parachute and investigate how it falls through the air. Discuss the forces acting on a parachute and explain its rate of fall.

Boating

Why does a boat float? Why do life-jackets keep people afloat? Devise an experiment to study floating bodies and find a way of predicting whether or not a particular object will float. Discuss flotation in terms of the density of the body and the density of the liquid.

Diving and ballooning

What makes a diver rise to the surface? Build a model diver (eg from a lemonade bottle, ball-pen cap and length of copper wire) and determine why the "diver" rises and falls. Find out what conditions are needed to make an underwater object rise to the surface. Explain what makes a hot air balloon or an airship rise against the pull of gravity.

Trampolining and jumping

i When a gymnast who is trampolining wants to be projected vertically upwards, where should her centre of gravity be situated with respect to her feet just as she leaves the trampoline? Build a plasticine (or other) "gymnast" and determine its centre of gravity with its arms and legs bent to different positions. Now build a model trampoline and solve the problem.

ii Explain in terms of centre of gravity how a high jumper or pole vaulter clears his maximum bar height by altering his body position.

iii Explain the importance of balance, stability and the position of the body's centre of gravity in some other sports (eg athletics, boxing, diving, horse riding, skiing, wind surfing ...).

Appendix III

Exemplar Assessment Record for Practical Abilities

Standard Grade Physics

Assessment Record for Practical Abilities

School _____

Name _____Class _____

a) **Carry out Practical Techniques** (16 Marks)

Technique No	Date, Pass/Fail			
1				
2				
3				
4				
5				
6				
7				
8				

Total Mark for Practical Techniques	16

b) **Plan and Carry Out Investigations** (48 Marks)

Investigation	Date	G1	G2	G3	G4	E1	E2	E3	E4	RR1	RR2	Ev1	Ev2	RR3	Total Mark
*															24
															24
	Total														24

Total Mark for the two best investigations	

* At least one investigation must involve a continuous variable

Summary

Ability	Mark	Total Mark for Practical Abilities
a) Carry out practical techniques	16	64
b) Plan and carry out investigations	48	

Practical Abilities Grade

Appendix IV

(append to Arrangements issued August 1997)

Assessment of Practical Abilities

Standard Grade Biology, Chemistry, Physics and Science

In August 1997 SQA issued revised arrangements for the assessment of Practical Abilities in all of the science subjects specified above. These revised arrangements were implemented for the first time in 1999.

Following central moderation of the internal assessment of these subjects, SQA has decided that the following additional guidance should be provided to centres. **This additional guidance does not change any requirements of the published Arrangements documents and should be read in conjunction with these documents.**

General Comments

1 The assessment of candidate performance is carried out with reference to the Extended Grade Related Criteria (EGRC) that are included in Arrangements documents. Across the science subjects, the EGRC for Practical Abilities at Foundation, General and Credit Levels detail requirements for *both* techniques and investigations. In addition, the Summary GRC for Practical Abilities confirm that both techniques *and* investigations are required at all levels.

To be awarded any grade other than 7 in Practical Abilities, candidate evidence must be consistent with the EGRC and so must cover **both techniques and investigations**. For example, to be awarded any grade between 1 and 6 for Practical Abilities in Standard Grade Science, in achieving the minimum mark specified in the Arrangements document, candidates must:

- carry out at least one practical technique
  and
- achieve at least one Investigative Skill objective.

All of the Arrangements documents for science Standard Grades include statements of the type:

> "Candidates for whom there is evidence in support of at least one technique or investigation and who achieve an overall total of less than X marks should be awarded a Grade 7 for Practical Abilities."

These statements apply only to the award of Grade 7. A small number of schools have inferred, incorrectly, that these statements also apply to the award of grades other than 7. As indicated above, this inference is consistent neither with the EGRC nor the Summary GRC.

A candidate who attempts neither techniques nor investigations will be deemed not to have completed the course in the Practical Abilities element. Such a candidate will not receive a grade for this element and hence will not receive an overall grade for the subject.

2 **To comply with the EGRC**, investigations undertaken by candidates **must** be relevant to the subject eg investigation of:

- the period of a pendulum is inappropriate for Chemistry or Biology candidates
- lathering is inappropriate for Physics candidates.

Science candidates may undertake an investigation in any science subject. All candidates should have a clear understanding of the science content of their investigations.

3 Investigations carried out for certification purposes **must** provide opportunities for candidates to demonstrate **all** of the thirteen skills objectives. During the generative phase it is in order for the teacher to direct candidates away from trivial or other investigations that will not permit candidates to demonstrate particular skills. For example a candidate might want to investigate the rate of reaction of copper with dilute acids. This would result in a graph where all of the points would be on one of the axes. This investigation is not appropriate for certification purposes as it would not permit the candidate to demonstrate skills in relation to criteria *a*, *c* and *d* of objective *RR2*. The candidate should be directed to alternatives **without penalty**.

4 The booklets supplied by SQA must be used. No change is permitted to the text of the booklets, or to the sequence. The following modifications **are permitted**:

- addition of school or class details to the front page
- reproduction in A4 or other format
- alteration of font size
- highlighting the boxes for marks awarded by direct observation
- photocopying graph paper into the booklet.

5 To facilitate assessment and moderation, candidates should provide evidence in the appropriate places in the Investigation Booklet. For example, evidence relevant to criterion *G1* should normally be written in the space following instruction number 1. Where marks are awarded for evidence written elsewhere in the booklet, this must be clearly recorded by the assessor.

6 Candidates should be encouraged to avoid the use of the term 'amount' where other terms, eg mass, volume, weight, are more appropriate. Use of 'amount' usually results in loss of marks, as responses are misleading and/or ambiguous.

7 At least one investigation must have a continuous independent variable to ensure that all candidates have the opportunity to draw a line graph.

8 To aid moderation, the teacher should indicate briefly in the booklet why a candidate has not been awarded marks for one or more of the criteria *G1*, *G2*, *G3* or *G4*. Similarly, the teacher should indicate briefly why marks dependent on direct observation (criteria *E1*, *E3b* and *E4a*) have not been awarded.

Investigative Skills Objective		Criterion	Wording in Investigation Booklet	Additional Guidance
The candidate should be able to:				
G1	demonstrate understanding of the problem posed;	Following group discussion, the candidate individually identifies and records an investigable aspect of the problem.	1 Having thought about the problem and talked about it with others in your class, write down the factor which you are going to investigate.	Where the dependent variable is given, the candidate must give an independent variable that is to be investigated. Where neither variable is given, the candidate could give **either** an independent or a dependent variable eg: • concentration of acid or rate of reaction • light intensity or number of seeds germinating • length of pendulum or period. A list of variables is not required. Candidates who make a list must indicate the variable they have chosen to investigate. If the candidate is *unable to meet this criterion*, the teacher should give assistance to enable the candidate to proceed but should *not award the mark* allocated to this objective. In the case of a candidate who identifies a relevant investigable aspect *that cannot be investigated within the constraints of the school situation* the candidate should be directed to alternatives **without penalty**. **Note:** The term 'constraints of the school situation' applies to any circumstance that would prevent the candidate from completing the investigation eg necessary equipment is not available, equipment that is available is insufficiently sensitive, length of school period is too short etc…

Investigative Skills Objective		Criterion	Wording in Investigation Booklet	Additional Guidance
The candidate should be able to:				
G2	state the aim of the investigation;	Clearly identifies the aim of the investigation in terms of the two relevant variables.	2 What is the aim of your investigation?	**Both** the independent and dependent variables must be mentioned eg to find out how: • *light intensity* affects the *germination* of seeds • the *length* of pendulum affects the *period* • the *concentration* of an acid affects *rate of reaction.* Candidates can use their own words – ie they do not have to use precise scientific terms to meet this criterion.
G3	articulate a testable hypothesis;	Articulates a testable hypothesis in terms of the two relevant variables; this should be directional if a continuous variable is chosen.	3 What is your hypothesis? (What do you expect to happen?)	Where a discontinuous variable is used, candidates should not be penalised for using the word 'change' eg the following are acceptable: • I expect voltage to change when I use electrodes made of different metals. • I expect height of rebound to change when I use different surfaces. When a continuous variable is used the direction of change **must** be mentioned eg I expect: • *more* seeds to germinate as temperature rises • current to *increase* as voltage increases. If the candidate is *unable to meet this criterion*, the teacher should give assistance to enable the candidate to proceed but should *not award the mark* allocated to this objective.

Investigative Skills Objective		Criterion	Wording in Investigation Booklet	Additional Guidance
The candidate should be able to:				
G4	suggest a broad strategy to adopt;	The strategy gives sufficient detail by description and/or diagram to indicate:	4 Describe briefly how you are going to carry out your investigation.	
		a) how the chosen independent variable will be altered.		*a)* It is not sufficient for candidates to say what they are going to change; they **must** state how they are going to effect the change eg I will change • the voltage … by adding more batteries/by turning the voltage control on the power supply. ('by using a power supply' on its own is insufficient as many common power supplies have a single output voltage) • the temperature … by heating with a bunsen burner/water bath • light intensity … by putting one seed tray in a cupboard, one beside a window and one in a shaded part of the room. In each case the text after the ellipsis is essential. For investigations where candidates are provided with prepared samples of the independent variable (eg acids of different concentrations), they should indicate that they are using a different sample for each test.
		b) that the candidate has considered what will have to be measured.		*b)* Candidates do not require to state how they intend to measure the dependent variable. It is sufficient for candidates to state that they intend to measure it eg I will: • measure the volume of gas given off • measure the current • count the number of seeds that germinate. Where the independent variable requires to be measured, candidates should also state that they intend to measure this variable.

Investigative Skills Objective		Criterion	Wording in Investigation Booklet	Additional Guidance
The candidate should be able to:				
E1	adopt appropriate and safe procedures;	*Adopts appropriate and safe procedures. (Mark awarded by teacher observation)*	7 You should now carry out your investigation in a safe way.	**Both** appropriateness and safety are essential. Thus the mark allocated to this objective should not be awarded if the procedures followed by candidates: • do not allow successful completion of the investigation eg inappropriate method of measuring either variable • put themselves or anyone else at risk.
E2	identify the independent variable to be used and alter it over a suitable range;	*a)* Provides a working definition of the independent variable. *b)* Alters the independent variable over an appropriate range taking account of a suitable number of types or values.	5 State clearly what you are going to change. 8 Make a table of your results.	*a)* The candidate must refer to the **independent** variable. *b)* The minimum number of types of values must be **appropriate to the investigation.** While a minimum of three values will be appropriate in many investigations, this number would be insufficient for others. For example, the three pairs of values below could be obtained by candidates investigating *either* the variation of range with angle of projection (smooth curve with maximum at 45°) *or* variation of current with voltage (straight line through the origin for ohmic circuit). *Variable 1* 10 20 30 *Variable 2* 3.2 6.4 8.8 These three points on their own are insufficient to establish the relationship between these variables.

Investigative Skills Objective		Criterion	Wording in Investigation Booklet	Additional Guidance
The candidate should be able to:				
E3	control all the relevant variables as necessary;	*a)* Makes a written statement of the variables which need to be actively controlled by the candidate. *b)* *Controls these variables in practice.*	6 What variables are you going to keep the same?	*a)* The statement should include all variables that **must** be controlled by the candidate to ensure that the results of the investigation are valid. For example, if maintaining a constant temperature is crucial to the investigation, temperature must be included in the statement. However, if small variations in laboratory temperature do not have a significant effect on the measurements made, the candidate need not include temperature in the list. A candidate who omits any variable that must be controlled should not be awarded this mark. *b)* Candidates must **actively** control all of the variables included in their lists.
E4	make valid, reliable measurement of the dependent variable;	*a)* *Uses a valid method of measuring the dependent variable.*	7 You should now carry out your investigation in a safe way. Use the space below to note results or for rough notes.	*a)* Candidates must use a valid method to measure the dependent variable. (The method used by the candidate to measure the independent variable is irrelevant to this criterion. However, a candidate using an invalid method for measuring the independent variable would not be awarded the mark allocated to objective *E1*.)

Investigative Skills Objective		Criterion	Wording in Investigation Booklet	Additional Guidance
The candidate should be able to:				
E4 *(cont)*		*b)* Evidence is provided of a form of repeat/ replicate testing which improves the reliability of the results **or** a valid written justification is given for not repeating/ replicating measurements.	8 Make a table of your results.	*b)* In addition to taking more than one reading of the same measurement, repetition/replication may involve: • simultaneous experiments eg planting many seeds at the same time • measuring multiples eg the time for 10 swings of a pendulum. Pooling of results is not permitted. The purpose of replication is to **improve the reliability** of the results. Thus a candidate who calculates an average incorrectly should not be awarded the mark allocated to this criterion. Normal constraints of the school situation, eg insufficient apparatus, cost, length of period etc. are **not** valid justifications for repeat/replicate testing not being carried out. Candidates should have been directed to other investigable aspects without penalty (see comments for objective *G1*).
RR1	tabulate results with appropriate headings and units of measurement;	*a)* Values (or types) with appropriate headings for inde-pendent, dependent (and any derived) variable are entered in the table. *b)* Appropriate units or their correct abbreviations are entered in the table.	8 Make a table of your results.	*a)* Data must be presented in clearly discernible rows and columns. Headings should be clear and appropriate. Candidates should be encouraged to use a ruler when drawing tables. However, candidates should not be penalised for omitting table lines. Data errors, should be penalised, eg where it is apparent that the candidate has recorded incorrect readings for either variable. *b)* Units are required for **both** the independent and dependent variables. The units may appear in the table headings or in the body of the table. Where a table includes repeated measurements and an average value the units do not need to be repeated for each heading or entry eg: *Reading 1* *Reading 2* *Reading 3* *Average reading (units)* would be acceptable for one variable.

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The candidate should be able to:				
RR2	present the results on a graph or chart;		9 On square ruled paper or graph paper draw a graph or a chart based on your results. Staple the square ruled paper or graph paper to your booklet.	During the generative phase it is in order for the teacher to direct candidates away from investigations that will not permit the candidates to demonstrate these skills (see general comment 3 on page 114).
		a) A graph or chart of suitable size and scale is produced.		*a)* The decision about *suitability* of size of a graph should relate to the quality of the communication, ie does the graph communicate findings clearly? A graph that is difficult to read or interpret does not meet this criterion. Numerical scales must rise in equal increments (eg 0, 2, 4, 6, 8 ... **not** 0, 2, 5, 11, 23 ...).
		b) Both axes have appropriate labels and units.		*b)* Any error in labelling or units should be penalised *unless* the candidate has already been penalised for the error under criterion *RR1a* or *RR1b*. Line graph scales do not need to begin at zero. However, candidates using such scales will have to exercise great care when drawing conclusions. For bar charts, the y-axis should begin at zero.
		c) Plots all the points/bars accurately.		*c)* Plotting either average values or all replicates is acceptable. The points plotted should be consistent with the data in the table produced by the candidate. Incorrect data (penalised under criterion *RR1a*) plotted correctly should not be penalised again here.

Investigative Skills Objective		Criterion	Wording in Investigation Booklet	Additional Guidance
The candidate should be able to:				
RR2 *(cont)*		*d)* Draws line/curve of best fit or joins up the points as appropriate when the independent variable is continuous **or** draws a bar chart when independent variable is not continuous.		*d)* A line/curve of best fit must be drawn where this is appropriate eg in physics investigations. Joining of points with a series of straight lines should be accepted only if this is appropriate to the investigation. Inappropriate extrapolation should be penalised eg straight line extended well beyond highest/lowest values without supporting data. Vertical solid lines (spikes) should be penalised in line graphs. In a bar chart adjacent bars may be separate or touching. Candidates should be encouraged to use bars of equal width and to avoid using spikes.
Ev1	draw a valid conclusion inter-relating the appropriate variables;	Draws a conclusion which inter-relates the appropriate variables or states that no firm conclusion can be drawn.	10 What conclusion can you draw from your results?	The conclusion should relate to the aim of the investigation (*G2*) and should reflect the findings. It should be more than a simple restatement of the results. acceptable: "The higher the temperature the more seeds germinated." not acceptable: "Half the seeds germinated at 5°C and all the seeds germinated at 25°C." Where a valid conclusion can be made that is directional, the direction of change must be included in the candidate's conclusion. acceptable: "The longer the pendulum string the greater the period." unacceptable: "The period of the pendulum changes as the string gets longer." Candidates do not have to use precise scientific terms to meet this criterion ie candidates may answer in their own words.

Investigative Skills Objective		Criterion	Wording in Investigation Booklet	Additional Guidance
The candidate should be able to:				
Ev2	use results to evaluate the original hypothesis;	Confirms the hypothesis if appropriate **or** refutes hypothesis and replaces it with appropriate substitute **or** states that no conclusion can be drawn.	11 What can you say about your hypothesis? (Circle A or B or C below. If your circle B complete the sentence.) A My hypothesis in part 3 is correct. B My hypothesis in part 3 should be changed to … C My results do not allow me to choose A or B.	If the candidate is unable to meet the criterion for skill objective *G3*, the teacher should give assistance so that the candidate has an opportunity to gain the mark for objective *Ev2*. Where this is the case the teacher should record an appropriate comment on page 2 in the candidate's investigation booklet.

Investigative Skills Objective		Criterion	Wording in Investigation Booklet	Additional Guidance
The candidate should be able to:				
RR3	describe how the investigation was carried out.	The description includes: *a)* a labelled diagram and/or statement of the apparatus used; *b)* an account of the procedure adopted to measure the dependent variable; *c)* an account of how the independent variable was altered; *d)* an indication of how variables which were the investigator's responsibility to control were kept constant.	12 Describe clearly how you set up and carried out your investigation.	*a)* Key apparatus must appear in the text or in a labelled diagram. A list of apparatus is not required. *b)* This account should describe the procedure actually used by the candidate. *c)* This account should describe the procedure actually used by the candidate. The procedure used may be different from the procedure indicated for objective *G4* eg a candidate may have planned to change temperature using a bunsen burner but may actually have used an immersion heater. *d)* Candidates should indicate how they controlled **all** of the variables specified in their statement for criterion *E3a*. Some of the information required may be communicated by a clearly labelled diagram eg diagram could show that temperature was controlled by immersion of apparatus in crushed ice.