National Qualifications
Revised Standard Grade Arrangements in Technological Studies

General and Credit Levels in and after 2003

August 2007

SCOTTISH QUALIFICATIONS AUTHORITY

NOTE OF CHANGES TO ARRANGEMENTS
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COURSE TITLE	Technological Studies (Standard Grade)
COURSE NUMBER:	4040 01
	Change to section 7.5 to clarify that candidates are expected to be able to extract information from the Data Booklet and use it to solve problems in an unfamiliar context.

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Introduction

The Standard Grade Technological Studies course was first introduced in 1988. There have however been no significant changes to the content of the course despite the many advances in technology that have taken place since then. Additionally, there has been a significant drop in the number of candidates taking the subject at a time when industry is in great need of technologists.

This document sets out the arrangements for external assessment which have been developed in light of national consultation exercises carried out between April 1999 and December 2000. The new course should do much to improve perceptions of the subject and the educational experience of pupils. It is hoped that the number of presentations will increase as a result.

This document supersedes the 1990 Arrangements in Technological Studies (updated). The external examination in Technological Studies, at General and Credit levels, based on these arrangements will take place in and after 2003.

1 Rationale

One of the most obvious features of contemporary societies is the rapidity and the pervasive influence of technological change. Indeed the pace of technological developments and its impact on peoples' circumstances and the environment have never been more marked.

As an industrial trading nation it is important that the significant role played by technology in the generation of employment and the creation of wealth is widely recognised. To maintain and improve the economic standing of the country among the other industrialised nations, there is a continued need to attract young people into the technology and technology-related professions and activities.

The knowledge, understanding and skills developed in technological studies will provide a basis for further study in technology. The course enables students to better understand the role and impact of technology on the world in which they live. It also provides opportunities for candidates to develop core skills (including communication, numeracy, information technology and problem solving) which are essential in everyday life and in the workplace.

The overall purpose of technological education should be to develop technological capability in young people. Technological capability encompasses understanding of appropriate concepts and processes; the ability to apply knowledge and skills by thinking and acting confidently, imaginatively, creatively and with sensitivity; the ability to evaluate technological activities, artefacts and systems critically and constructively.

The aims of technical education are especially realised though the design, make, evaluate sequence of processes. It is important that pupils gain direct experience of the design process and are involved in defining the problem to be solved and make decisions about what should be produced in achieving a solution. These are stimulating activities which develop and reinforce pupils' creativity, reasoning and personal skills.

Standard Grade Technological Studies offers students the opportunity to meet with and engage in modern technologies at first hand and, in doing so, seeks to inspire positive attitudes to careers in technology. The course is designed to build upon technology within Environmental Studies in 5-14 and provides clear progression to National Qualifications in a range of technology and engineering courses at 16+ in schools and further education colleges.

2 Aims, Objectives and Core Skills

2.1 The Aims of Technical Education

The development of young people's technological capability is a major aim of technical education. As defined in *A Framework for Technology Education in Scottish Schools* (Scottish Consultative Council on the Curriculum (SCCC) 1994), technological capability involves:

- the understanding of appropriate concepts and processes
- the ability to apply knowledge and skills by thinking and acting confidently, imaginatively, creatively and with sensitivity
- the ability to evaluate technological activities, artefacts and systems critically and constructively

The aims of technical education are realised though the *design, make, evaluate* sequence of processes. It is important that pupils gain direct experience of the design process and are involved in defining the problem to be solved and make decisions about what should be produced in achieving a solution. These are stimulating activities which develop and reinforce pupils' creativity, reasoning and personal skills.

Many pupils now experience these activities in their primary schools, following implementation of the 5-14 National Guidelines. In S1/S2, pupils should build on their prior learning as they arrive at design solutions through negotiation and group discussion. They can also develop a range of appropriate manufacturing and evaluating skills.

In S3/S4, pupils can specialise in one or more of the technical subjects and through progressively sophisticated processes, develop their own designs, illustrations, models or systems. In S5/S6, further progression includes a greater emphasis on knowledge and understanding of industrial and commercial contexts, and closer relevance to higher education.

2.2 The Context of Technical Education

Technical education combines the exploration and development of ideas with their expression in visual and material forms. In addition to developing pupils' technological and creative capabilities, with relevant knowledge and understanding, it offers a wide range of contexts within which pupils:

- learn how to control or modify the environment to meet defined needs
- develop skills and judgement in the selection and use of resources, including raw materials, technological equipment and information technology
- gain the ability to interpret commercial and technical ideas using a variety of media
- acquire a systematic approach to solving problems and making decisions
- develop critical thinking and the ability to evaluate the quality and effectiveness of products and systems
- develop skills in teamwork.

2.3 Technological Studies

Technological Studies provides candidates with the opportunity to appreciate and experience modern technology at first hand and develop informed attitudes to society's use of technology. The Standard Grade Technological Studies course, seeks to develop positive attitudes to and a continuing interest in, careers within technology.

2.4 Course Aims

The Standard Grade Technological Studies course is designed to build upon technology within Environmental Studies in 5-14 and provides clear progression to National Qualifications in a range of technology and engineering courses at 16+ in schools and further education colleges.

The principal aims of the Standard Grade Technological Studies course are to develop:

- **knowledge and understanding** of facts, concepts and ideas, and comprehension of techniques and applications of technology in society
- skills in applying knowledge and understanding in technological **reasoning and numerical analysis**
- techniques to solve technological problems by applying knowledge, understanding and skills in a purposeful way through the **application of technology**.

2.5 Course Objectives

Pupils having completed the Standard Grade course in Technological Studies should be able to:

- Understand and implement the systems approach to problem solving and decision making in a technological system
- Know and understand appropriate terminology, facts, concepts and processes associated with technological systems
- Understand and apply control techniques in a range of technological systems
- Carry out calculations to verify and measure the operation of a technological system
- Communicate information in written, oral and graphical form
- Solve technological problems through structured technological activities
- Develop skills in critical thinking, planning and organising and reviewing and evaluating through technological activity
- Select, interpret and apply technological information
- Understand the impact of technology on society and the environment.

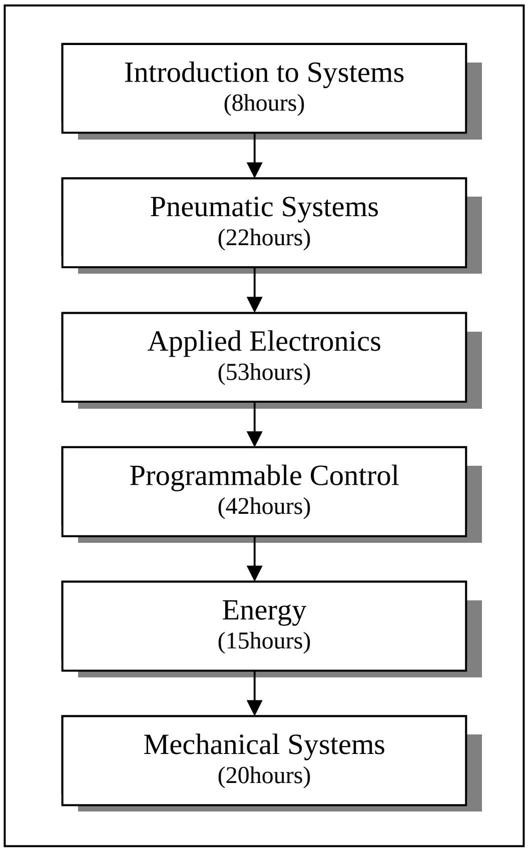
2.6 Core Skills

For information about the automatic certification of core skills for this course, please refer to the SQA publication '*Automatic Certification of Core Skills in National Qualifications*'.

3 The Course

3.1 Areas of Study

The two-year course will be offered at General and Credit level only and will cover the six areas of study shown below. The recommended course length is 160 hours. It is suggested that the course is taught in the order shown, as this will allow for relevant integration of topics as the course progresses. The recommended order also allows for students to develop their ability in mathematics as this underpins the work in both Energy and Mechanical Systems. Included in the nominal hours is time to perform the internal assessment and prepare for the external examinations.



The indicative content for each of the six topics is detailed in Section 5 under the headings ‘Course Topic and Content’ and ‘Context’. The suggested learning and teaching approach for the course is given in Section 4.

The course is externally assessed in three elements, namely:

- Knowledge and Understanding (KU)
- Reasoning and Numerical Analysis (RNA)
- Application of Technology (AT).

Information on course assessment is given in Section 6 ‘Assessment for Certification’. The assessment parameters for the course are detailed in Section 7. ‘Grade Related Criteria’.

4. Learning and Teaching Approach

Technological Studies is an exciting subject, which allows the candidates' interest and curiosity to be simulated. Throughout the teaching of this course the stimulation of candidates' interest and curiosity should be a prime objective.

An appropriate balance of teaching methodologies should be used in the delivery of the course. Whole-class, direct teaching opportunities should be balanced by activity-based learning on practical tasks. It is recommended that clear presentations on the tasks, materials and resources to be used involve the teacher and pupils in demonstrating systems and in asking and answering questions about the systems and sub systems demonstrated. Where applicable, computer assisted learning and computer simulation should be employed.

The content of this course and its assessment parameters are clearly defined and described in this document. The associated support materials give a further indication of the level of study to be undertaken in each of the three elements. As in the original course, the systems approach is central to the development of pupils' knowledge, understanding and skills. Constant reference to this approach should be made throughout the teaching of the course. Pupils should develop the ability to use this approach and the appropriate terminology and diagrams in their problem solving activities.

Knowledge and understanding is developed throughout the course with a greater emphasis given to whole class or large group activity and direct teaching. Pupils should still be exposed to a range of activities which are challenging and involve the practical use of equipment and devices. However, a greater proportion of these activities should now be teacher led. These activities should be sharply focussed and result in clear demonstrations of technological principle and practice. Whenever possible, simulations should be employed to assist pupils to test their work before constructing practical solutions.

Pupils' reasoning and their ability to analyse systems should be encouraged through the set coursework. The use of question sessions during and after teacher led demonstrations should be used to impart knowledge and understanding and to develop pupils' ability to analyse and reason. Homework, a regular feature of the course, should be used to revise and reinforce pupils' knowledge and understanding and develop their ability to apply numerical analysis and reasoning. It should also improve pupils' abilities to develop and use research skills and answer written examination questions.

The application of technology requires pupils to apply the problem solving process to solve a given technological problem. Pupils should be prepared for this task, in the first case, by experiencing teacher-led examples of the application of technology. This opportunity should be used to familiarise pupils with the structure and assessment requirements of the *Application of Technology* assignments as given by SQA.

In order to further develop the problem solving skills pupils will, as part of their coursework, require opportunities to apply knowledge and understanding, simulate, construct and then evaluate solutions to problems. This may include the application of such things as rules, methods, concepts, principles, laws and theories. The learning outcomes in this area require a higher level of comprehension than those of knowledge and understanding.

In teaching this course every opportunity should be taken to make full use of the information communication technology available within the school. The recommended sequence of tuition is shown in 3.1. This sequence enables the integration of the topics towards the end of the course to help pupils retain their knowledge of earlier topics taught while working on a new area. It also takes account of the growing body of scientific and mathematical knowledge that the pupil will accrue as they progress through Standard Grade, by building the most scientific and mathematical aspects of the course into the second year of study.

To ensure high standards of achievement, it is important to ensure that pupils are well informed about the nature and content of this course and what is expected of them. Pupils should receive a brief induction to the course. A good pace of learning should be maintained by ensuring that good value is obtained from the class-time available. Simulation and construction should be used, where possible, to reinforce the concepts and theory associated with each topic. To make the best use of time, however, consideration should be given to the use of pre-built models and test rigs. Regular assessment of coursework, with clear guidance given to pupils on how performance can be improved, is essential if the pupils are to develop the appropriate standards of attainment.

4 Course Topics, Content and Context

The following tables contain a list of indicative content for the course laying out the parameters for assessment, as well as an outline of the suggested context in which the content should be applied. More information on the depth of treatment of the content for examination purposes can be found in section 7.8.

Course Topic and Content	Context
Systems Introduction to the systems approach The Universal System System diagrams Sub-systems Boundaries Open/closed loop Feedback – manual/automatic Error detection	Most manufactured products are designed on the basis of the Universal System i.e. an input, a process and an output. This section is fundamental to the success of the whole course as systems, and the systems approach, permeate throughout all the other sections. Teachers should ensure that candidates have a firm grasp of these principles. The ability to analyse a system and list inputs and outputs is reviewed. Open and closed systems are introduced and candidates will be expected to produce relevant diagrams showing boundaries, feedback loops and error detection symbols.

Course Topic and Content	Context
Pneumatics Introduction to the use of pneumatics considering the advantages and disadvantages of using compressed air as a source of energy in terms of cost, energy consumption and safety. Compressed air as energy source Safety Systems analysis of pneumatic components and circuits Symbols (correct notation/ports/main air/pilot air/exhausts) Valves 3/2 and 5/2 Valve actuators Single and double acting cylinders Devices - tee piece shuttle valve restrictor (including unidirectional) reservoir manifold Concepts - force/pressure/area relationship AND/OR control (combinational) Sequential control Time delay Terms - outstroke/instroke/positive/negative	Pneumatics are used in many industrial applications e.g. in lifting loads or in the form of tools, as well as in everyday situations such as operating bus or train doors or its use in dentists drills. It therefore provides good examples of operational control types and methods. Throughout this section, the subject should be teacher-led with candidates asked to complete a series of problem solving activities, based on pneumatic systems. Wherever possible learning and teaching should be contextualised in industrial and commercial applications. Candidates should gain an understanding of the benefits of using compressed air to power and control devices and be aware of the costs behind producing this type of energy. Safety precautions when using compressed air should be emphasised and industrial uses should be discussed. Candidates should be able to interpret pneumatic systems from circuit diagrams, recognise and identify appropriate symbols, draw block and circuit diagrams and construct and evaluate pneumatic systems from given specifications. Candidates should be aware of how pneumatics can be interfaced with electronic/programmable control (e.g. using solenoids actuator, reed and micro-switches). Related calculations should be carried out where required.

Course Topic and Content	Context
Applied Electronics Current Voltage drop - simple cell, multi-cell battery, voltage supply unit Resistors - colour coding/ fixed and variable Input switches - toggle slide key tilt rocker push button reed Switch operation - single pole single throw double pole single throw single pole double throw double pole double throw Components - capacitors LEDs - output display device diodes - applications of use (circuit protection) Simple series, parallel and combined circuits (building and computer simulation) Simple circuit analysis and calculation using Ohm's and Kirchhoff's laws Calculation of electrical power Analogue/digital input signals	In a world of electrical and electronic devices, an understanding of the principles behind such devices is of great relevance to pupils studying technology. The systems approach to electronics (input, process and output) will be used with component-based electronics as the main focus of the topic. Systems boards will only be used to verify or exemplify the basic concepts or introductory work on discrete components. This topic deals with concepts, which are applied in other areas of the course, and thus offers opportunities for integration of content. Teachers should ensure that there is a balance between direct teaching and practical activities. The ability to handle Ohm's and Kirchhoff's laws is required when working with resistor networks. The voltage divider circuit should be introduced at component-based level. Transistor switching and its application in allowing analogue inputs to drive analogue and digital outputs is now included. Combinational logic systems should be studied with pupils being expected to design and construct systems for given specifications. These systems may be based on transistor control of combinational logic applications. In addition to developing a component-based understanding of the operation of electronic devices, practical capabilities should be developed by using electronic components and/or pre-built models. Computer simulation should be used to allow candidates to test their solutions prior to actually building them. **Note: Simulation is required to be performed in the internal assessment element of the course.**

Course Topic and Content	Context
Applied Electronics (continued) Input transducers - bead thermistor LDR reed switch micro switch Operational characteristics of input transducers (graphs, data sheets) Variable resistor (potentiometer) Circuit sensitivity - sensing (inversion light/dark) Systems boards - Inputs - push switch magnetic switch light sensor temperature sensor moisture sensor Process - latch transducer driver comparator AND, OR, NOT, NAND, NOR (logic functions and corresponding truth tables) Output - bulb buzzer relay unit motor	

Course Topic and Content	Context
Applied Electronics (continued) Transistors - npn (common emitter mode/bipolar) - saturation (0.7V) Transistors as a switch Use of relay to switch on high voltage/current circuit Output transducers - relay (solid state, reed and electro/mechanical) dc motor bulb LED Integrated circuits - combinational logic - 555 astable timer Boolean expressions from truth tables Combinational logic and output Boolean statements Truth table from logic diagram and vice versa Truth table from specification Use of computer simulation to evaluate solutions	

Course Topic and Content	Context
Programmable Control Introduction to microcontrollers Principles of operation of control systems (uses and advantages) General layout of a microcontroller system Knowledge of the terms: RAM, ROM, ALU, EEPROM, I/O port, bus and clock BASIC stamp system Graphical methods to produce - system, block and circuit diagrams Binary and decimal number systems Conversion from one number system to the other Input signals from analogue and digital devices - bead thermistor, LDR, reed and micro-switch Controlling output devices - Relay (solid state, reed and electro/mechanical) dc motor, bulb, buzzer, solenoid and LED Use of flowcharts as the basis of a structured, top down approach to programming (using appropriate symbols supplied) Use an appropriate sub-set of PBASIC language Writing programs in the high level language - PBASIC which should include inputs, outputs, loops and time delays Setting simple loops: looping through a sequence or program 'N' times and looping continuously Controlling simple mechatronic devices using a microcontroller Construct simple control routines with up to 3 inputs and 3 outputs.	As technology advances at an ever increasing rate, more and more examples of computer control are being seen in industrial, commercial and domestic applications. Therefore, it is important that the course allow the opportunity to experiment with the hardware used in this form of control as well as being able to provide an understanding of the principles behind computer control. Candidates working through this topic will be required to have a basic knowledge of a microcontroller and should be able to name and describe what each sub-system does. Candidates should be expected to use binary and they should be competent in converting numbers from binary to decimal and vice versa. Candidates should be expected to interpret information from a given specification, complete systems diagrams and construct flow charts. Candidates should be introduced to a high level programming language (PBASIC) and write control sequences to control mechatronic devices. The knowledge gained in *Applied Electronics* and *Pneumatics* will be applied, with analogue inputs and solenoid actuated valves as outputs thus allowing further integration of coursework. Candidates will be given a sub-set of instructions in PBASIC and use this in constructing their solutions. **Note: with the exception of "sensor" all commands will be PBASIC rather that the extended form.**

Course Topic and Content	Context
Energy Existing energy sources (renewable and non-renewable) Energy needs in everyday society and the need for energy conservation Problem solving using energy formulae to calculate potential, kinetic, heat and electrical energy Calculation of power and work done Describe and calculate transformation of energy in a simple system Energy audits Efficiency	Energy is a finite resource with conservation and alternative energy sources becoming important to both industrial and domestic users. The purpose of this topic is to emphasise the importance of energy in relation to society. Candidates should be able to quantify and be aware of the wider issues concerning energy. Forms of energy should be discussed and the need for conservation should be emphasised. Candidates should be able to recognise and measure energy forms and calculate energy transformations. The need for an energy audit should be clearly understood, along with its use in seeking to improve the overall efficiency of a system. Candidates should be able to analyse energy conversions and transformations and apply this analysis to an energy audit of a system.

Course Topic and Content	Context
Mechanical Systems Motion – linear reciprocating rotary oscillating Equilibrium and reaction forces Moment of a force Torque Friction Efficiency Motion conversion using the following devices levers and linkages belt drives chain drives spur and bevel gears simple and compound gears rack and pinion cam and follower crank and slider worm and wheel worm and nut ratchet and pawl	Throughout industry and commerce there are many examples of products that use a variety of mechanical systems. For example, transmission systems operate using gearboxes and linkages to transfer motion from the original drive system to different output devices. Candidates should be introduced to a range of mechanisms, all of which can be used to convert motion. They should be able to describe the operation and performance of these mechanisms and be able to describe how to adjust their input and output conditions. Candidates should have an understanding of the four types of motion. Candidates should understand the concept of equilibrium and should be able to apply the principle of moments to simple beams and levers. Rotary systems should be studied with pupils understanding how to calculate torque and be able to discuss the effects of friction on rotating parts and its effect on the overall efficiency of the mechanism. Related calculations should be carried out.

6 Assessment for Certification

6.1 Introduction

Assessment has an important evaluative contribution to make to the process of learning and teaching. It is also used for the purposes of certifying awards and this is the main focus of this section.

Performance is assessed in each of the three elements of Standard Grade Technological Studies: that is

- Knowledge and Understanding (KU)
- Reasoning and Numerical Analysis (RNA)
- Application of Technology (AT).

Assessment is carried out with direct reference to the Extended Grade Related Criteria defined for each of these elements (see Section 7). The Extended Grade Related Criteria are particularly important as they set the assessment parameters for the subject.

6.2 Assessable Elements

Each of the elements of Standard Grade Technological Studies represents a distinct cognitive domain. The nature, scope and depth of the assessment parameters for each element is detailed in the Extended Grade Related Criteria. The taxonomies used in the Extended Grade Related Criteria reflect the element they apply to. A description of the cognitive domains for each element follows:

- ***Knowledge and Understanding***

  Knowledge is defined as the remembering of previously learned material. This may involve the recall of a wide range of material, from specific facts to complete theories. Candidates should demonstrate the ability to recall and describe common terms, specific facts and basic concepts.

  Understanding is defined as the ability to grasp the meaning of material. This may be shown by translating material from one form to another, by interpreting material (explaining or summarising) and by predicting consequences or effects. Candidates should demonstrate the ability to understand facts and principles interpret charts and graphs, estimate future consequences implied in data and justify methods and procedures.

- ***Reasoning and Numerical Analysis***

  Identification of this element recognises that more than Knowledge and Understanding is needed to solve technological problems. Also required is the ability to break down material into its component parts so that its structure may be understood. This may include the identification of parts, analysis of the relationships between parts, and recognition of the principles involved.

- ***Application of Technology***

  Application refers to the ability to use learned material in new and concrete situation. This may include the application of such things as rules, methods, concepts principles, laws and theories. Application of Technology has been included in the course to reflect the requirement for students to apply knowledge, understanding and skills in a purposeful way in order to solve problems in a technological environment.

A grade for attainment in each element will be recorded on the award 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 Standard Grade Technological Studies, 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 6.2 and 6.3).

For any element, grade 5 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.

Knowledge and Understanding and Reasoning and Numerical Analysis will be assessed externally by a single written examination question paper at each Level. Presenting centres will be required to submit to the SQA estimate grades for each candidate for Knowledge and Understanding and for Reasoning and Numerical Analysis.

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.

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.

The Application of Technology assignment will be internally assessed and externally moderated.

The assessment scheme in summary is as follows:

Elements	Internal Assessment for Certification	External Moderation	External Assessment
Knowledge and Understanding	-	-	Grade awarded in external examination
Reasoning and Numerical Analysis	-	-	Grade awarded in external examination
Application of Technology	Yes	Internally derived AT Assignment grades must be available for submission to SQA by 31 March in the year of examination.	-

6.3 External Assessment

External assessment will be carried out by means of examination papers and central moderation of a centre's internally assessed grades for a Application of Technology assignment.

6.3.1

Examination papers in Knowledge and Understanding and Reasoning and Numerical Analysis will be set at General and Credit Levels. The examination papers will be designed to assess the achievement of the Course Objectives with direct reference to the extended grade related criteria for each level. The context and the standard of the performance required in the questions will be appropriate to the level to which each paper relates.

General paper (assessing grades 4 and 3):

- Time duration 1 hour 15 minutes
- Marks will be evenly distributed between the Knowledge and Understanding and Reasoning and Numerical Analysis elements
- Grade 5 may be awarded to candidates who narrowly fail the external assessment for General Level after consideration of the overall cut-off percentages for each element.

Credit paper (assessing grades 2 and 1):

- Time duration 1 hour 30 minutes
- Marks will be evenly distributed between Knowledge and Understanding and Reasoning and Numerical Analysis.

Candidates will be expected to attempt all questions.

6.3.2 Internal Assessment and Central Moderation of Application of Technology

To achieve a grade for the Application of Technology element candidates will undertake a single structured assignment, chosen by the centre, from a bank of nationally set problems in Applied Electronics or Programmable Control. Centres must ensure that these assignments are conducted under appropriate conditions and are completed by the individual candidate during class time.

The assignment should take approximately 3-5 hours to complete. SQA will provide presenting centres with a detailed structure for the assignment along with assessment guidance.

For assessment purposes candidates must:

1. Complete systems diagrams to analyse the given problem
2. Produce a specification from the given brief
3. Generate a possible solution to the given problem
4. Select and justify the use of appropriate devices/components
5. Perform a computer simulation of the proposed solution
6. Develop/build and test the proposed solution
7. Evaluate the solution against the specification.

6.4 Central Moderation of Internal Assessments

Moderation is the process by which SQA ensures that national standards are applied to internal assessment. Central moderation is the process by which selected centres are called upon to submit their marked and graded internal assessments of Application of Technology to SQA for scrutiny.

6.5 Presentations for External Examination Papers

Candidates should be presented at both General and Credit Levels. However, it is emphasised that they are not obliged to attempt both papers and candidates should be made aware that (other than as the result of an appeal) taking the:

- General paper alone will only allow grades 3, 4, 5 and 7 to be open to them in the 'Knowledge and Understanding' and 'Reasoning and Numerical Analysis' elements

- Credit paper alone will only allow grades 1, 2 and 7 to be open to them in the 'Knowledge and Understanding' and 'Reasoning and Numerical Analysis' elements.

Candidates who attempt both papers will have grades 1,2,3,4,5 and 7 available to them.

6.6 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 (e.g. 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 award certificate.

7 Grade Related Criteria

7.1 Definition

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

7.2 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.

7.3 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 the 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 in identifying targets for course construction, and by examiners when conducting external assessment.

7.4 Knowledge and Understanding - Summary GRC

General Level (grades 4, 3)
The candidate has demonstrated knowledge of technological facts, complex concepts and the functions and applications of simple devices; and knowledge and understanding of relevant technological terms and basic concepts.

Credit level (grades 2, 1)
The candidate has demonstrated knowledge of an extensive range of technological facts and the functions and applications of combinations of complex devices; and knowledge and understanding of relevant technological terms and complex concepts.

7.5 Reasoning and Numerical Analysis - 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; and to evaluate technological systems and draw conclusions; and to reason and apply appropriate knowledge and understanding to solve simple problems.

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; and to evaluate and suggest improvements to technological systems to justify conclusions; and to reason and apply appropriate knowledge and understanding to solve complex problems.

In particular candidates are expected to be able to extract information from the Data Booklet and use it to solve problems in an unfamiliar context.

7.6 Application of Technology - Summary GRC

General Level (grades 4, 3)
The candidate has demonstrated ability to analyse a problem, establish a specification; to present, simulate, develop/build and test a solution; and to evaluate it against the original specification with some degree of teacher support.

Credit Level (grades 2, 1)
The candidate has demonstrated ability to analyse a problem, establish a specification; to present, simulate, develop/build and test a solution; and to evaluate it against the original specification offering suggestions for improvements to the system with minimal teacher support.

A detailed description of each grade, and the assessment parameters at General and Credit levels, will be given in Application of Technology assessment guidance documentation issued by SQA.

7.8 Knowledge and Understanding, Reasoning and Numerical Analysis and Application of Technology Extended GRC

The tables below describe the breakdown by level of each topic and the associated assessable elements. The areas shaded in grey outline the typical problem solving performance associated with the coursework Application of Technology.

Topic	Suggested activities	General level	Element	Credit Level	Element
Systems		**Candidates should be able to:**		**and in addition to level General candidates should be able to:**	
The systems approach	Introduction to the systems approach.	Recognise that systems have an input, process and output.	RNA		
The Universal system	Complete tasks that require pupils to construct system diagrams.	Identify inputs and outputs and complete systems diagrams (including boundaries).	RNA		
System diagrams	Study open and closed loop control systems (manual and automatic).	Draw block and system diagrams representing open loop systems.	RNA	Distinguish between open and closed loop control.	RNA
Sub-systems				Describe the difference between manual and automatic closed loop systems.	KU
Boundaries					
Open/closed loop				Explain the purpose of a feedback loop in a system diagram.	KU
Feedback – manual/ automatic				Draw diagrams of manual and automatic closed loop systems.	RNA
Error detection				Recognise the use of error detection in closed loop control systems.	KU
				Explain the use of error detection in closed loop control systems.	KU

Topic	Suggested activities	General level	Element	Credit Level	Element
<u>Pneumatic Systems</u>		**Candidates should be able to:**		**and in addition to General level candidates should be able to:**	
Compressed air as energy source	Teacher led account of the uses of compressed air to control devices including its benefits and limitations.	Outline the benefits and limitations of using compressed air as an energy source.	KU		
Safety	Teacher led instruction of the safe use and operation of pneumatic systems.	Outline the safe use and operation of pneumatic systems.	KU		
Hardware- description and symbols Valves 3/2 and 5/2 Actuators Single and double acting cylinders	Teacher led description and pupil activities in recognition of appropriate pneumatic symbols. Teacher led demonstration to construct and evaluate pneumatic circuits to meet a given specification.	Name, recognise the symbols and describe the operation of the following: Air - main, pilot, exhaust, tee piece Cylinders – single and double acting. Valves – 3/2, 5/2 and shuttle. Valve actuators – push button, roller, plunger, lever, solenoid, spring return and pilot. Distribution – compressor and manifold. Speed control – restrictor and unidirectional restrictor	KU	Name, recognise the symbols and describe the operation of the following: Cylinders – magnetic piston Valve actuators – roller trip and diaphragm Time delay – reservoir Air bleed circuits	KU
Devices - Tee piece Shuttle valve Restrictor (including unidirectional) Reservoir Manifold		Complete block and circuit diagrams using correct symbols and appropriate connections from a given specification or problem (see appendix for pneumatic symbols).	RNA	Draw block and circuit diagrams using correct symbols and appropriate connections from a given specification or problem.	RNA

Topic	Suggested activities	General level	Element	Credit Level	Element
Pneumatic Systems cont.		**Candidates should be able to:**		**and in addition General level candidates should be able to:**	
AND/OR control in combination Sequential control		Complete circuit diagrams using correct symbols and appropriate connections for an AND/OR circuit with a maximum of three 3/2 valves.	RNA	Use appropriate terminology to explain the action and describe the sequence of a pneumatic system.	RNA
Concepts - Force/pressure/ area Terms – outstroke/ instroke, positive and negative position	Calculate force, pressure and area.	Carry out calculations involving force, pressure and area (positive direction only)	RNA	Calculations for an in-stroking piston (effective areas of underside of piston) Force = pressure x area $F=P \times (\pi D^2/4 - \pi d^2/4)$ or $F=P \times (\pi R^2 - \pi r^2)$ Diameter = $\sqrt{4A/\pi}$ Calculate and select appropriate cylinder diameters. (*In questions of this nature the formulae will be given*).	RNA

Topic	Suggested activities	General level	Element	Credit Level	Element
<u>Applied Electronics</u> ***Electronic sub-system boards***		**Candidates should be able to:**		**and in addition to General level candidates should be able to:**	
Systems approach	Review the systems approach.	Apply simple systems analysis to electronic systems.	RNA		
Input/output devices:	Complete tasks that require pupils to construct systems diagrams.	Complete block and system diagrams of simple electronic systems.	RNA		
Light, moisture and temperature sensors	Problem solving activities which make use of the sub-systems boards listed.	Describe the difference between analogue and digital signals.	KU		
Input voltage unit.		Complete diagrams showing how a motor can be driven from a separate power supply using a relay.	RNA		
Light dependent resistor.				When using analogue transducers (LDR/ thermistor). Describe the relationship between input conditions, resistance, voltage and current.	KU
Reed and push switches					
Bulb, buzzer.					
Motor and relay					
Solenoid.					

Topic	Suggested activities	General level	Element	Credit Level	Element
<u>Applied Electronics</u> ***Sub-system boards cont.***		**Candidates should be able to:**		**and in addition to General level candidates should be able to:**	
Process devices:	Perform tasks to investigate the behaviour and uses of process devices.	Draw and identify symbols for an Inverter, AND, OR, NAND and NOR gates (2 input).	KU	Complete truth tables for three input combinational logic systems.	RNA
Logic gates (Inverter, AND, OR, NAND, NOR).	Investigate truth tables for two and three input logic gates.	Complete truth tables for the Inverter, AND, OR, NAND and NOR gates.	KU	Construct logic diagrams and truth tables (maximum of 3 inputs)	RNA
		Complete truth tables for two input combinational logic systems.	RNA	Produce combinational logic diagrams from truth tables	RNA
Latch Inverter		Apply the convention High voltage = 'logic 1' low voltage = 'logic 0'	KU		
Comparator. Transducer driver.		Explain the use and application of a switch unit, light sensor, temperature sensor, moisture sensor, latch, comparator, transducer driver, buzzer, lamp, d.c. motor and solenoid (including actuating 3/2 valve).	KU	Differentiate between positive and negative edged triggered devices (*for examination purposes – positive edge latches will be used).*	KU

Topic	Suggested activities	General level	Element	Credit Level	Element
Applied Electronics ***Discrete components***		**Candidates should be able to:**		**and in addition to General level candidates should be able to:**	
Circuit diagrams	Draw circuit diagrams using appropriate symbols.	Draw and identify the circuit symbols for a battery; switch; resistor; variable resistor; LDR; thermistor; LED; motor; lamp; ammeter and voltmeter.	KU	Draw circuit diagrams.	RNA
d.c. networks	Build and test resistive d.c. networks.	Complete circuit diagrams.	RNA		
Resistance	Measure voltage and resistance in a d.c. network.	Identify the correct position of a multimeter in a circuit to measure voltage and current.	KU		
Ohms law	Determine voltage, current and resistance.	Identify resistor values using colour-coding charts.	RNA		
Electrical power.	Examine household/ workshop appliances to gain an awareness of power ratings, power dissipated and power consumed	Carry out calculations involving the relationship between resistance, voltage and current. (Ohms law)	RNA		
		Carry out calculations using the formulae (P = VI).	RNA		
Series, parallel and combined circuits.	Build and test series, parallel and combined with d.c. circuits.	For any circuit calculate voltage, current and resistance involving a maximum of 3 resistors 2 of which can be in parallel.	RNA	For any circuit calculate voltage, current and resistance involving a maximum of 5 resistors 3 of which can be in parallel.	RNA

Topic	Suggested activities	General level	Element	Credit Level	Element
<u>Applied Electronics</u>		**Candidates should be able to:**		**and in addition to General level candidates should be able to:**	
Discrete components cont.	Construct fixed and variable voltage dividers	Explain the principal operation of a fixed voltage divider.	KU	Explain the principal operation of a variable voltage divider using an analogue input transducer as the sensor	KU
Voltage dividers.	Measure, resistance, input and output voltages from a voltage divider.	Complete diagrams for a fixed voltage divider.	RNA	Complete diagrams for a variable voltage divider.	RNA
		Recognise that a fixed voltage divider can be used to generate a signal.	KU	Recognise that a variable voltage divider can be used to generate a varying signal.	KU
				Explain how to invert the system by moving the sensor.	KU
Variable resistors and their use as part of a voltage divider.	Examine applications of variable resistors (speed control, adjust light/temperature levels in a voltage divider).	Carry out calculations to determine resistor values and output voltage from a fixed voltage divider.	RNA	Carry out calculations to determine resistor values and output voltage from a variable voltage divider, which uses analogue transducers.	RNA
	Demonstrate the function of fixed and variable voltage dividers using analogue transducers (light, heat and temperature).	Interpret and extract information from given graphs and charts (LDR, thermistor).	RNA		
Transistor as a switch	Build a transistor circuit showing the transistor being used as a switch.	Recognise a transistor circuit diagram controlled from a voltage divider.	KU		
		State that a transistor saturates at 0.7V.	KU		

Topic	Suggested activities	General level	Element	Credit Level	Element
Applied Electronics ***Discrete components cont.***		**Candidates should be able to:**		**and in addition to General level candidates should be able to:**	
Current limiting resistors LED's Diodes	Construct and test electronic control circuits using voltage dividers, transistors, relays and output transducers.	Describe why diodes are used in electronic systems for component protection.	KU	Explain the use of current limiting resistors used in conjunction with LED's. Explain how a transistor (in conjunction with a voltage divider) can be used to provide a switching action.	KU KU
Relays		Describe the function of a relay in an electronic circuit.	KU	Explain the operation of an electronic control circuit which includes a variable voltage divider, transistor, relay and output transducer.	RNA
555 timer configured as an astable	Investigate the use of the 555 timer and construct a circuit involving the timer IC.			Complete circuit diagrams including the 555-astable timer IC *(for examination purposes candidates will not be expected to reproduce a timer circuit diagram).*	RNA
Boolean Expressions	Study use of Boolean expressions to solve problems from given truth tables.			Develop Boolean expressions from truth tables with up to three inputs *(for examination purposes there will be no more than 2 output conditions ON for the construction of a Boolean expression).*	KU
Applications of combinational logic	Problem solving activities using simple combinational logic devices (Inverter, AND, OR, NAND, NOR gates).	Complete logic diagrams or truth tables to meet a written specification (maximum 3 inputs).	RNA	Develop a truth table from a description, construct truth tables from logic diagrams, draw logic diagrams from truth tables (maximum of 3 inputs).	RNA

Topic	Suggested activities	General level	Element	Credit Level	Element
<u>Applied Electronics</u> ***Discrete components cont.***		**Candidates should be able to:**	RNA	**and in addition to General level candidates should be able to:**	
Integrated circuits (AND, OR, NOT, NAND, NOR).	Connect an IC to a power supply. Study the development and use of the IC.	Complete pin out diagrams for simple logic problems (maximum of two I.C's).		Draw complex combinational logic circuits and complete pin out diagrams (maximum of three I.C's). Identify the differences between the TTL and CMOS family of I.C's.	RNA KU
Data Sheets.	Perform tasks in wiring up solutions to simple problems.	Identify and select appropriate I.C's from a data sheet.	KU		
Problem solving activities		Analyse, develop a specification, generate a solution, select suitable components, complete a circuit diagram, simulate, construct, build and test a solution and complete an evaluation for the given problems.			AT

Topic	Suggested activities	General level	Element	Credit Level	Element
<u>Programmable Control</u>		**Candidates should be able to:**		**and in addition to General level candidates should be able to:**	
Microcontroller control systems	Discuss the use of microcontrollers in commercial and industrial applications.	Identify the use of microcontrollers in commercial and industrial applications	KU		
		List advantages and disadvantages of using programmable control systems.	KU		
		Identify and explain the following terms: ALU, RAM, ROM, clock and bus.	KU	Identify and explain the following terms: I/O port and EEPROM.	KU
Stamp controller *Inputs* thermistor LDR Reed switch Micro switch Variable resistor *Outputs* Relay d.c. motor Bulb/LED Buzzer, Solenoid 3/2 valve	Perform tasks by using the Stamp Controller to control mechatronic devices.	Complete diagrams to show input connections to the Stamp controller and output connections from the Stamp controller.	RNA		
Number systems Binary /Decimal.	Perform written tasks to assist pupils in their understanding of the two number systems			Covert decimal to binary and vice versa.	RNA

Topic	Suggested activities	General level	Element	Credit Level	Element
Programmable Control cont.		**Candidates should be able to:**		**and in addition to General level candidates should be able to:**	
Flowcharts	Demonstrate the use of flowcharts as the basis of a structured top down approach to programming.	Identify and use the correct symbols (from a given list) to construct flow charts showing solutions to simple control programs.	RNA		
PBASIC: Inputs/outputs	Use the high level language PBASIC to control mechatronic devices.	Identify and use a given sub set of instructions in PBASIC to write control programs.	RNA	Write programs in PBASIC to control: up to and including 3 inputs and 3 outputs.	RNA
Loops Time delays		Write programs in PBASIC to control: up to and including 2 inputs and 2 outputs. Write programs in PBASIC to perform: Time delays Continuous loops.	RNA RNA	Write programs in PBASIC to perform: Loops (N times).	RNA
Speed and positional control (pulse width modulation)		Describe how to control d.c. motor (only to be on or off).	KU	Describe how to control the speed and direction of a d.c. motor.	KU
Problem solving activities		Analyse, develop a specification, generate a solution, select suitable devices, complete a flow chart simulate, develop and test a solution on a pre-built model and complete an evaluation for the given problems.			AT

Topic	Suggested activities	General level	Element	Credit Level	Element
Energy		**Candidates should be able to:**		**and in addition to General level candidates should be able to:**	
Main sources.	Discuss existing forms of energy sources (oil, gas, nuclear and coal).	Explain the need for energy conservation.	KU		
Environmental issues and conservation.	Discuss environmental effects of using energy and the need for conservation.	List examples of non-renewable energy sources.	KU		
Alternative.	Discuss how electricity can be obtained from renewable energy sources (wind, wave, solar and hydro etc).	List examples of alternative energy sources.	KU	Explain the advantages and disadvantages associated with at least three alternative energy sources.	KU
Energy types: Potential. Kinetic. Electrical. Heat.	Investigate practical applications that involve the energies listed.	Carry out calculations involving the energies listed. $E_p = mgh$ $E_k = ½mv^2$ $E_e = ItV$ $E_h = Cm\Delta T$	RNA		
Power/work done.	Discuss the terms power and work done.	Explain that power is the rate of energy per second and that work done is a measure of the amount of energy transferred.	KU		
		Carry out calculations using $P = {}^{E}/_{t}$ and $W = Fs$.	RNA		

Topic	Suggested activities	General level	Element	Credit Level	Element
Energy cont.		**Candidates should be able to:**		**and in addition to General level candidates should be able to:**	
Transformation.	Discuss the types of energy transformations that take place in systems.	Identify the main energy transformations that take place in a simple system.	RNA		
Energy audits.	Discuss that energy cannot be lost but can be divided into useful energy and energy lost and that to quantify these energies an energy audit can be performed.	Complete an energy audit on a simple system showing input and output energies and main energy losses	RNA	Quantify energy losses by carrying out calculations to determine the input and output energies.	RNA
Efficiency.	Examine how to calculate efficiency and how no machine can be 100% efficient.	State reasons why the efficiency of machines is always less than 100%.	KU	Carry out calculations to determine efficiency. Efficiency = energy out/energy in	RNA

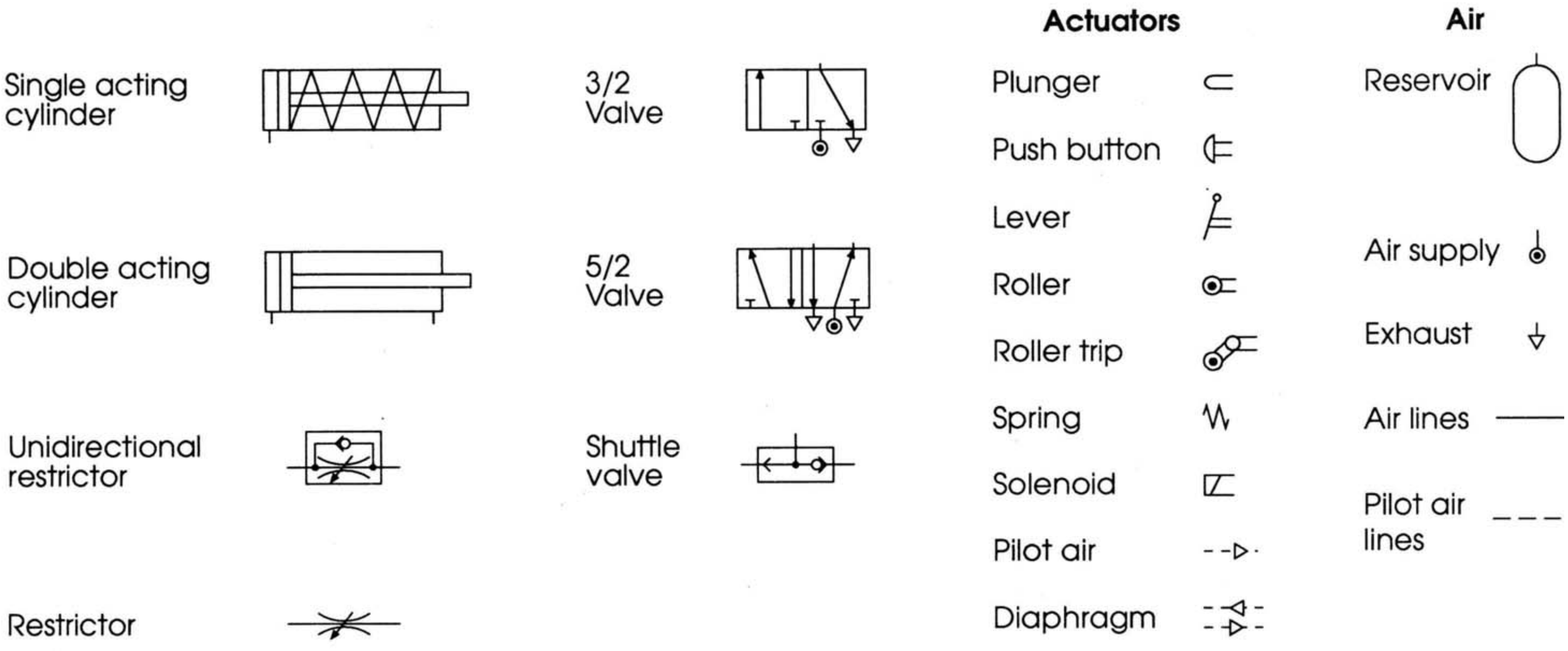
Topic	Suggested activities	General level	Element	Credit Level	Element
Mechanical Systems		**Candidates should be able to:**		**and in addition to General level candidates should be able to:**	
Equilibrium and reaction forces.	Discuss the concept of equilibrium (a body in equilibrium is balanced)				
Moment of a force.	Examine the application of the principle of moments.	Carry out calculations using the Principle of Moments (ΣMoments = 0).	RNA	Describe the operation of force multipliers.	KU
		Carry out calculations to determine force, distance and reactions (forces at 90°).	RNA		
Free body diagrams		Represent force systems by using free body diagrams	RNA		
Friction	Discuss the effects of friction.	Describe methods of utilising friction (brakes, belt drives etc)	KU		
		Describe methods of reducing friction.	KU		
Motion	Discuss the four types of motion.	State and describe the four main types of motion (linear, reciprocating, rotary and oscillating).	KU		
Torque	Examine the application of torque.	Carry out calculations to determine torque.	RNA		

Topic	Suggested activities	General level	Element	Credit Level	Element
<u>Mechanical Systems cont.</u>		**Candidates should be able to:**		**and in addition to General level candidates should be able to:**	
Levers and linkages,	Examine the principles and study the operation and uses of mechanical systems.	Identify devices and describe the operation of motion converters (see devices listed).	KU	Carry out calculations to determine input/output ratios in mechanical systems (force and speed).	RNA
Belt drives,		Complete systems diagrams for mechanical devices identifying correct input and output motions.	RNA	Identify advantages and disadvantages of given mechanical systems.	KU
Chain drives,					
Spur and bevel gears,		Recognise the convention for representing belt, chain drives and gearing systems.	KU	Describe how to adjust the performance of given mechanical systems.	KU
Gear Systems,		Complete belt, chain and gearing system diagrams.	RNA		
Rack and pinion,		Explain the use of idler gears.	KU		
Cam and follower,		Explain why a tensioner is used in belt/chain drive, and describe how to reverse direction on a belt drive.	KU		
Crank and slider,		Carry out calculations on simple gear trains to calculate input and output speeds.	RNA	Carry out calculations on compound gear trains.	RNA
Worm and worm wheel,					
Worm and nut,					
Ratchet and pawl.					
Efficiency.	Discuss the term efficiency in context to mechanical systems.	Explain why the efficiency of a machine can never be 100%.	KU		

7.9 Application of Technology - Extended GRC

The table below details the assessment of Application of Technology. This will be applied to the candidate's written work in relation to a nationally set problem assignment. As part of the external assessment, the Application of Technology report will be internally graded and externally moderated.

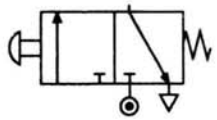
Assessment Activity		General Level	Credit Level
		Candidates should be able to:	**and in addition to General level candidates should be able to:**
AT1	Create appropriate system diagrams to analyse a given problem.	Complete system diagrams identifying inputs, outputs, sub-systems and show the links between them.	Identify the inputs, outputs, sub-systems, system boundary, error detection and feedback loops, where appropriate.
AT2	Produce a specification from a given brief.	Extract criteria from a given brief to create a specification for the given problem.	Create a specification detailing the system requirements.
AT3	Generate a possible solution to a given problem.	Complete a circuit diagram or flow chart to represent a solution.	Produce a circuit diagram or flow chart to represent a solution.
AT4	Select and justify the use of appropriate components to meet the specification	Name the appropriate devices or components to be used in a solution to the given problem.	Justify the selection and use of the devices or components to be used in a solution.
AT5	Use computer simulation software.	Select, position and connect appropriate components to represent a solution to a given problem.	Use software to simulate the operation of the solution.
AT6	Develop/build and test a solution.	Develop/build and test a solution against the criteria.	Develop/build and test a solution and describe how well it satisfied the criteria.
AT7	Evaluate the solution.	Evaluate the solution against the criteria.	Evaluate in the solution against the specification.



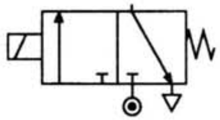
Valves should be named to give a clear indication of the type of valve and the method of operation.

For example

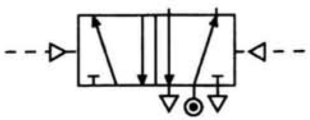
3/2 valve Push button Spring return



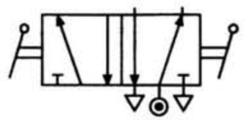
3/2 valve Solenoid Spring return



5/2 valve Pilot Pilot

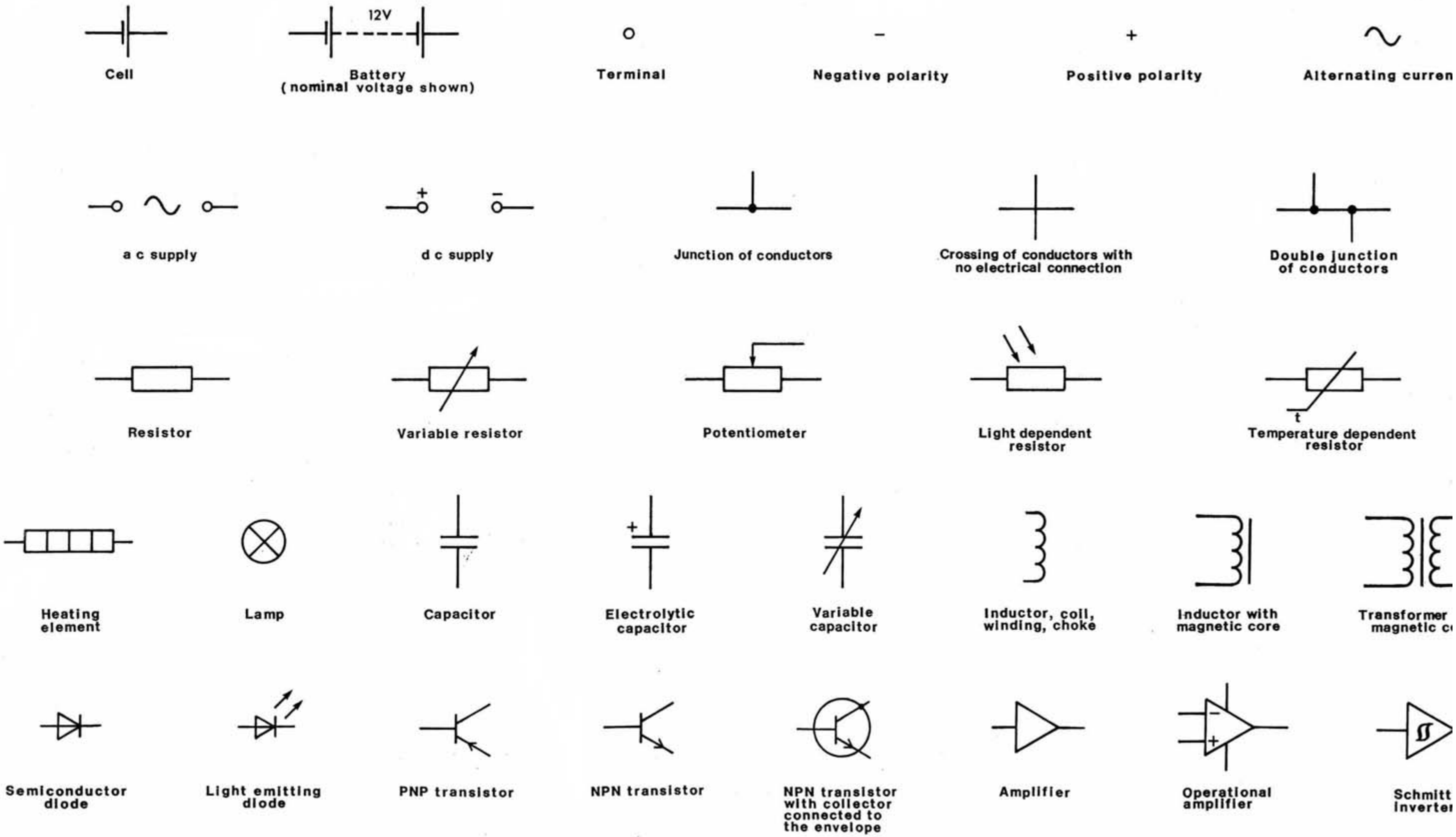


5/2 valve Lever Lever

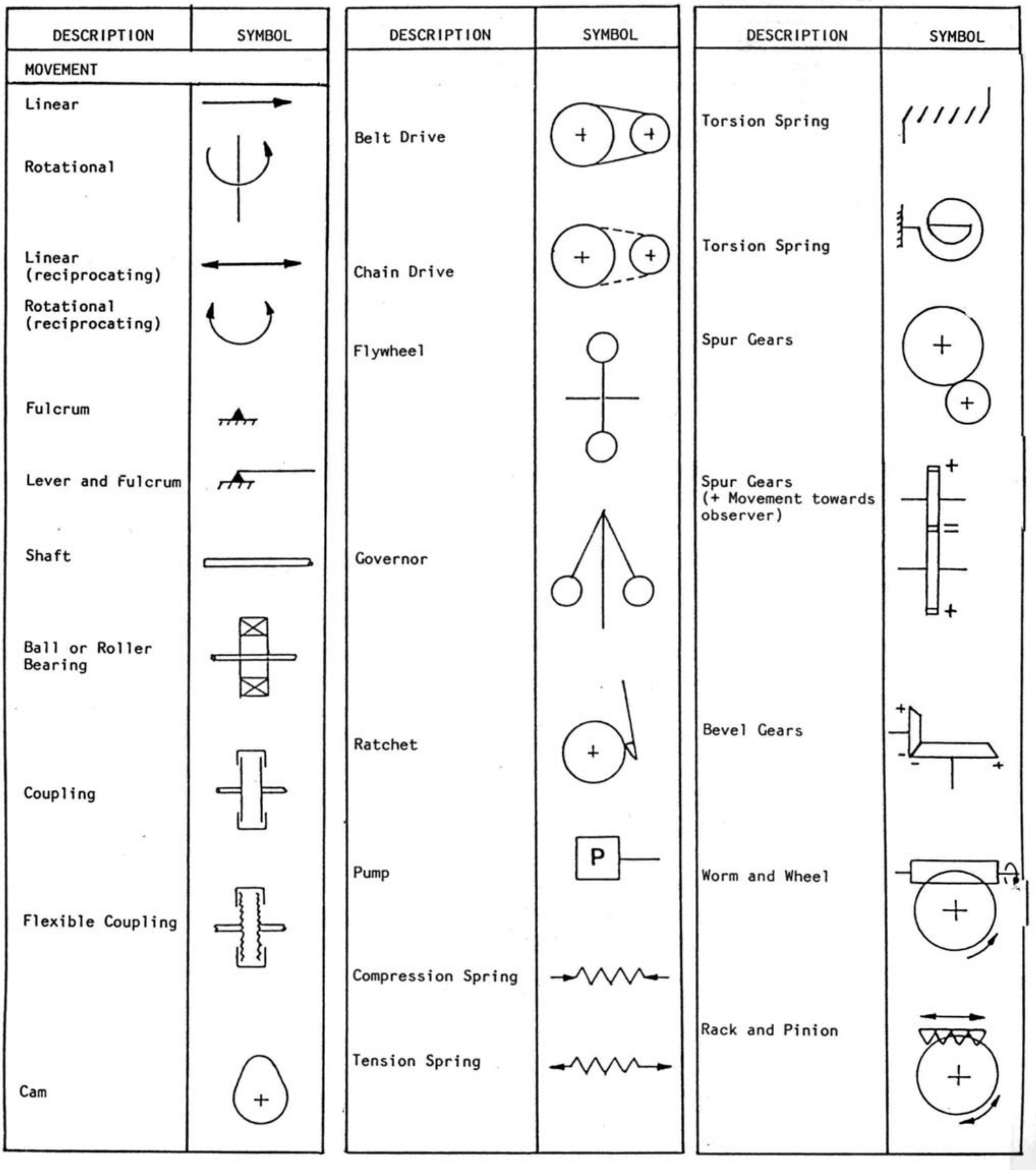


Electrical and Electronic Graphical Symbols

(Issued by the Scottish Examination Board in connection with examinations in Engineering, Physics and Technological Studies)



MECHANISMS


DESCRIPTION
SYMBOL
MOVEMENT
Linear
Rotational
Linear (reciprocating)
Rotational (reciprocating)
Fulcrum
Lever and Fulcrum
Shaft
Ball or Roller Bearing
Coupling
Flexible Coupling
Cam
DESCRIPTION
SYMBOL
Belt Drive
Chain Drive
Flywheel
Governor
Ratchet
Pump
P
Compression Spring
Tension Spring
DESCRIPTION
SYMBOL
Torsion Spring
Torsion Spring
Spur Gears
Spur Gears (+ Movement towards observer)
Bevel Gears
Worm and Wheel
Rack and Pinion