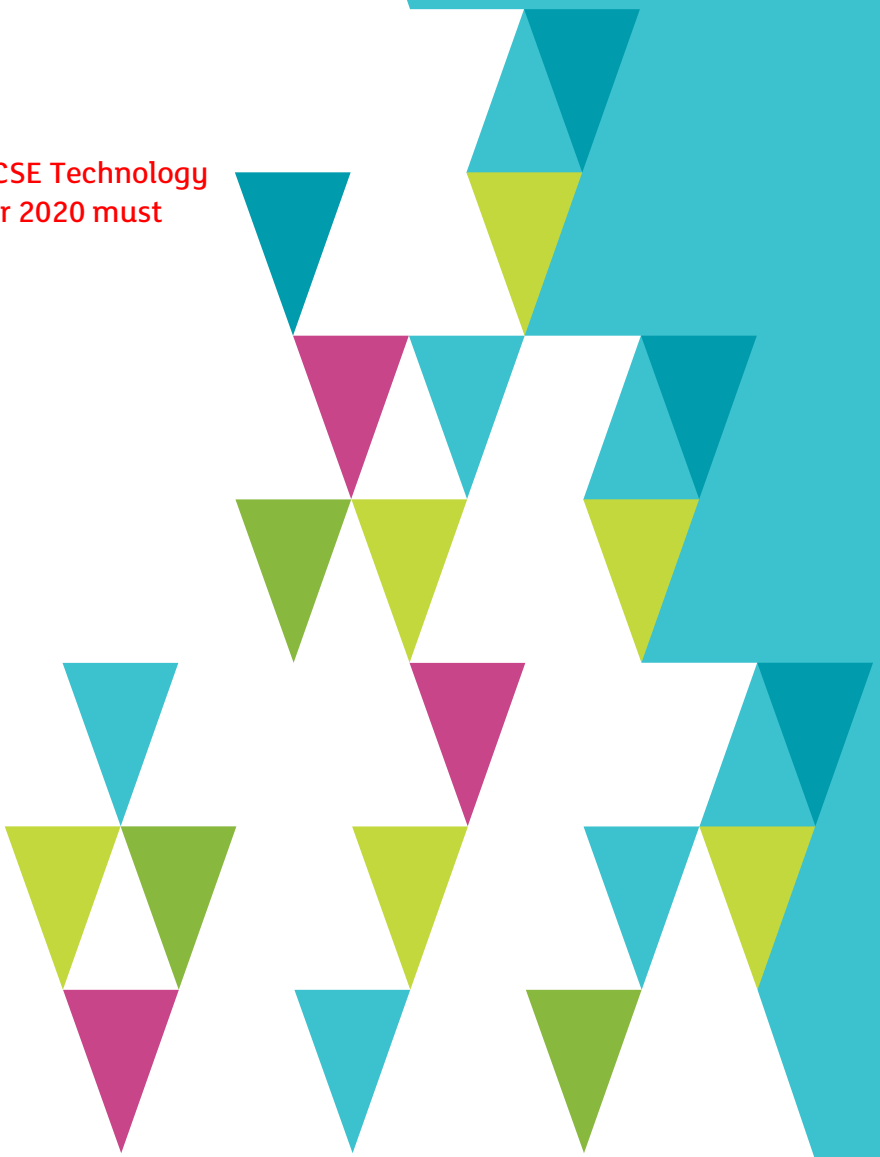
GCSE

Rewarding Learning

CCEA GCSE Specification in

Technology and Design

Students commencing study of the GCSE Technology and Design specification in September 2020 must follow this specification.



For first teaching from September 2020
For first assessment in Summer 2021
For first award in Summer 2022
Subject Code: 8900

Contents

Subject Code 8900
QAN 603/0771/7

This specification is available online at www.ccea.org.uk

1 Introduction

This specification sets out the content and assessment details for our GCSE course in Technology and Design. We have designed this specification to meet the requirements of:

- Northern Ireland GCSE Design Principles; and
- Northern Ireland GCE and GCSE Qualifications Criteria.

First teaching is from September 2020. We will make the first award based on this specification in Summer 2022.

This specification is a unitised course. The guided learning hours, as for all our GCSEs, are 120 hours.

The specification supports the aim of the Northern Ireland Curriculum to empower young people to achieve their potential and to make informed and responsible decisions throughout their lives, as well as its objectives:

- to develop the young person as an individual;
- to develop the young person as a contributor to society; and
- to develop the young person as a contributor to the economy and environment.

If there are any major changes to this specification, we will notify centres in writing. The online version of the specification will always be the most up to date; to view and download this please go to www.ccea.org.uk

1.1 Aims

This specification aims to encourage students to:

- use imagination and develop skills of creativity and critical analysis through making links between existing solutions, technological knowledge and the principles of good design;
- communicate design ideas and decisions using a range of media and techniques;
- use a broad range of materials, components and technologies, as well as practical skills, to develop and produce high quality, imaginative and functional prototypes;
- consider aesthetic, technical, economic, environmental, ethical and social dimensions when engaged in design and making;
- consider the costs in the making and marketing of products;
- apply health and safety procedures to ensure safe working practices;
- analyse and develop existing products and develop practical solutions to needs, wants and opportunities, recognising their impact on quality of life;
- develop decision-making skills through individual and collaborative working;
- apply appropriate technology and design terminology;
- understand that designing and making reflect and influence cultures and societies, and that products have an impact on lifestyle; and
- combine skills with knowledge and understanding in order to make quality products.

1.2 Key features

The following are important features of this specification.

- It offers opportunities to build on the skills and capabilities developed through the delivery of the Northern Ireland Curriculum at Key Stage 3.
- It allows students to develop transferable skills, which will benefit them in vocational training and employment.
- It makes students aware of creative, engineering and manufacturing industries.
- It incorporates product design, and systems and control.
- It encourages students to be creative, innovative and prepared to take design risks.
- It makes students aware that high quality design and technology are important.
- It makes students aware that many modern day innovations are developed from existing and historical solutions.
- It is accompanied by planning frameworks and student guides to support teachers and students.
- It has broad cross-curricular links.

1.3 Prior attainment

Students do not need to have reached a particular level of attainment before beginning to study this specification.

1.4 Classification codes and subject combinations

Every specification has a national classification code that indicates its subject area. The classification code for this qualification is 8900.

Please note that if a student takes two qualifications with the same classification code, schools, colleges and universities that they apply to may take the view that they have achieved only one of the two GCSEs. The same may occur with any two GCSE qualifications that have a significant overlap in content, even if the classification codes are different. Because of this, students who have any doubts about their subject combinations should check with the schools, colleges and universities that they would like to attend before beginning their studies.

2 Specification at a Glance

The table below summarises the structure of this GCSE course.

Content	Assessment	Weightings	Availability
Unit 1: Technology and Design Core Content	External written examination 1 hour 30 mins Students answer **10** questions from a core area of study.	25%	Summer from 2020
Unit 2: Optional Areas of Study	One of three optional written examinations 1 hour 30 mins Students choose **one** of **three** options: A. Electronic and Microelectronic Control Systems; or B. Mechanical and Pneumatic Control Systems; or C. Product Design. Students should select the option that reflects the area of Technology and Design they have studied.	25%	Summer from 2021
Unit 3: Design and Manufacturing Project	Controlled assessment Students complete a design project comprising a design portfolio and an associated manufacturing task. Teachers mark the design project, and we visit centres to carry out moderation.	50%	Summer from 2021

Students must take at least 40 percent of the assessment (based on unit weightings) at the end of the course as terminal assessment.

3 Subject Content

We have divided this course into three units. The content of each unit and the respective learning outcomes appear below. Students must complete Unit 1: Technology and Design Core Content and Unit 3: Design and Manufacturing Project. Students must also complete **one** of the **three** options from Unit 2: Optional Areas of Study. Students studying this GCSE Technology and Design Specification should be familiar with the symbols specified in Appendix 3.

3.1 Unit 1: Technology and Design Core Content

This unit is **compulsory**. It comprises designing, manufacturing, electronic control systems, mechanical control systems, pneumatic systems and control, and computer control systems.

Designing

Content	Learning Outcomes
1.1 Design and communication	Students should be able to: • demonstrate understanding that the design process may contain some or all of the following: – design opportunity; – research; – brief; – specification; – idea generation and development; – manufacture; and – testing and evaluation; • apply the design process; • discuss and analyse the design process; • analyse products to understand the relevance of ergonomics and aesthetics to product design; • demonstrate understanding that the design process is non-linear; and • analyse and use the following methods of communication: – freehand sketching; – presentational drawings; – working drawings; – mood boards; – physical mock-ups/models; and – computer-aided design (CAD) virtual modelling.

Manufacturing

Content	Learning Outcomes
1.2 Materials and their general physical, aesthetic and structural characteristics	Students should be able to: • demonstrate understanding of the main properties and applications of the following plastics: – thermosetting plastics (melamine, polyester resin, epoxy resin and urea formaldehyde); and – thermoplastics (acrylic, polyvinyl chloride (PVC), acrylonitrile butadiene styrene (ABS), nylon and rigid polystyrene); • demonstrate understanding of the main properties and applications of the following woods: – hardwoods (mahogany, beech and oak); – softwoods (pine and cedar); and – manufactured boards (plywood, medium density fibreboard (MDF), chipboard and veneered manufactured boards); • demonstrate understanding of the main properties and applications of the following metals: – ferrous metals and alloys (mild steel, carbon steels and stainless steel); and – non-ferrous metals and alloys (aluminium, brass and copper); • demonstrate understanding of the use of alloying to produce different properties and working characteristics; • demonstrate awareness of graphene and provide some examples of its properties and its potential use; and • demonstrate understanding of the following heat treatments: – annealing; – normalising; – hardening; and – tempering.

Content	Learning Outcomes
1.3 Tools and processes	Students should be able to: • demonstrate understanding of the main features and applications of the following tools and processes: – deforming (vacuum forming, line bending and metal folding); • use and demonstrate understanding of the main features and applications of the following: – saws (tenon saw, coping saw, scroll and hacksaw); – drills (pillar drill, cordless drill and hand drill); – drill bits (flat bit, forstner bit, countersunk bit and hole cutter); – hammers (claw, pin and ball pein); – handplane; – wood chisel; – tools for marking out (pencil, steel rule, engineer's square, sliding bevel, odd-leg callipers, try square, scriber, centre punch, spring dividers, marking knife, marking gauge, bradawl and engineer's markers blue); – files (flat, round and half-round profile); – bandfacer/linisher; – pedestal polisher; – milling machine; and – lathe (wood and metal); • demonstrate understanding of accuracy and tolerance when using tools and processes; and
1.4 Appropriate methods of joining	• demonstrate understanding of the main features and applications of the following permanent joining methods: – soft soldering, brazing and welding; – wood adhesives; – wood joints (butt, mitre, dowel and housing); – riveting, including pop riveting; and – joining techniques for plastics.

Content	Learning Outcomes
1.4 Appropriate methods of joining (cont.)	Students should be able to: • demonstrate understanding of the main features and applications of the following semi-permanent joining methods: – nuts, washers and bolts; – machine screws; – self-tapping screws; – woodscrews (countersunk and round-head); and – knock-down fittings;
1.5 Production methods	• demonstrate understanding of the wasting, fabrication and joining of: – metals; – plastics; and – woods;
1.6 Moulds, jigs and fixtures	• demonstrate understanding of the main features and applications of the following items used in the manufacturing process: – moulds; – templates; – jigs; and – fixtures;
1.7 Finishing techniques	• demonstrate understanding of how to prepare metal, wood and plastic prior to applying a suitable finish; • demonstrate understanding of the main reasons for applying a suitable finish to the following, taking account of function, aesthetics and environment: – metals (painting, polishing, dip coating and galvanising); – woods (painting, varnishing and applying preservative stains); and – plastics (polishing); and
1.8 Smart materials	• demonstrate understanding of smart materials, with specific reference to thermochromic pigments and self-cleaning glass.

Content	Learning Outcomes
1.9 Health and safety **1.10 CAD and CAM**	Students should be able to: • identify and understand the common health and safety symbols in Appendix 3 and the use of appropriate personal protective equipment; • identify and understand potential hazards in products, activities and environments; • demonstrate understanding of the main advantages and disadvantages of using CAD and computer-aided manufacture (CAM); and • demonstrate understanding and application of the process of CAD and CAM.

Electronic control systems

Content	Learning Outcomes
1.11 Construction techniques **1.12 Input–process–output** **1.13 Units and measurements**	Students should be able to: • identify the tools, equipment and process required to produce a printed circuit board (PCB) when using computer numeric control (CNC) or chemical production; • design and analyse electronic circuits and demonstrate understanding of the reasons for using PCBs; • analyse and describe electronic systems with reference to input–process–output; • give examples of electronic control systems; and • apply and demonstrate knowledge and understanding of the units we use to measure: – current (amps and milliamps); – voltage (volts and millivolts); and – resistance (ohms, kilohms and mega-ohms).

Content	Learning Outcomes
1.13 Units and measurements (cont.)	Students should be able to: • apply an understanding of electrical units to measure voltage, current and resistance; • perform calculations based on Ohm's law using: V = I × R ;
1.14 Electrical components	• identify the components below by their circuit symbols and physical appearance: – batteries (single cell and multi-cell); – resistors; – variable resistors; – light dependent resistors (LDRs); – thermistors (limited to negative temperature); – diodes; – thyristors; – transistors (NPN); – buzzers; – light-emitting diodes (LEDs); – bulbs; – motors; and – potentiometer; • identify the circuit symbols for earth and ac supply; • identify the circuit symbols for a voltmeter and an ammeter; • select appropriate components to meet the requirements of a circuit diagram; • draw circuit symbols and demonstrate knowledge and understanding of the components;
1.15 Electronic conductors and insulators	• demonstrate knowledge and applications of the use of conductors, semi-conductors and insulators; and • identify and give examples of materials that are conductors, semi-conductors and insulators.

Content	Learning Outcomes
1.16 Resistors	Students should be able to: • demonstrate knowledge and understanding of the term resistance and the use of resistors in electronic circuits; • use the colour coding system to identify values and tolerance levels of individual resistors – tolerance levels limited to 5% and 10%; • calculate the resistance of two or more resistors in series, using: $R_t = R_1 + R_2 + \ldots + R_n$;
1.17 Switches	• identify the following switches by their circuit symbols and physical appearance: – reed; – push-to-make switch (PTM); – single pole, single throw (SPST); and – single pole, double throw (SPDT); • identify the following switches by their physical appearance: – toggle; – microswitch; – rocker; – membrane; and – slide; • draw the above symbols and demonstrate knowledge and understanding of the switches; • select appropriate switches to meet the requirements of a circuit diagram; • demonstrate understanding of the action of these switches by recognising and selecting according to their application;
1.18 Potential dividers	• demonstrate knowledge and understanding of how a potential/voltage divider is used to control voltage in a circuit (no calculation required); and • draw and interpret circuit diagrams containing a potential/voltage divider.

Content	Learning Outcomes
1.19 LEDs **1.20 Thyristors** **1.21 Transistors** **1.22 Safety**	Students should be able to: • use LEDs in circuits; • demonstrate knowledge and understanding of the use of current-limiting resistors to protect LEDs (no calculation required); • outline the function and application of thyristors in circuits; • identify the gate, anode and cathode from a circuit diagram or symbol; • outline the function and application of an NPN transistor as a switch; • identify the base, emitter and collector from a circuit diagram or symbol; and • recognise potential hazards when producing electronic circuits with breadboards and PCBs.

Mechanical control systems

Content	Learning Outcomes
1.23 Construction techniques **1.24 Input–process–output**	Students should be able to: • design and analyse mechanical systems (which can use kits, working and/or virtual models, and products that use resistant materials and discrete components); • demonstrate awareness of the advantages and disadvantages of each of the above construction methods; • describe and analyse mechanisms with reference to input–process–output; and • identify and give examples of mechanical control applications.

Content	Learning Outcomes
1.25 Types of motion	Students should be able to: • recognise and analyse examples of the following types of motion: – rotary; – linear; – oscillating; and – reciprocating;
1.26 Mechanical components	• identify the following components by their circuit symbols and physical appearance: – wheel and axle; – gears; – cams; – followers; – levers; – belts; – pulleys; and – shafts; • draw the above symbols and demonstrate knowledge and understanding of the components; • select appropriate components to meet the requirements of mechanical systems; • evaluate the mechanical components listed when they are used in mechanical systems;
1.27 Levers	• apply knowledge and understanding of the following: – load; – effort; and – fulcrum; • draw and interpret diagrams of first, second and third class levers; and • recognise and give examples for each of the three classes of lever.

Content	Learning Outcomes
1.28 Power transmission	Students should be able to: • demonstrate understanding of the main features and applications of the following: – simple gear trains (maximum three gears); – toothed, round and V-belt systems; – chain and sprocket; and – idler gears; • demonstrate understanding of how gear systems can be used to change speed and/or direction of rotation; • perform calculations including simple gear trains and simple belt drives; • calculate simple gear ratios (limited to three gears) using: $\text{Gear ratio of a simple gear train} = \frac{\text{number of teeth on driven gear}}{\text{number of teeth on driver gear}}$ $\text{VR} = \frac{\text{Diameter of Driven}}{\text{Diameter of Driver}}$
1.29 Cams and followers	• apply knowledge and understanding of the following types of cams and followers: – eccentric; – pear; – heart; – knife; – roller; and – flat; and
1.30 Safety	• recognise potential hazards when building and using mechanical control systems.

Pneumatic systems and control

Content	Learning Outcomes
1.31 Input–process–output	Students should be able to: • describe and analyse pneumatic systems and control with reference to input–process–output; • identify and give examples of pneumatic control systems applications;
1.32 Cylinders	• identify a single acting cylinder (SAC) by its physical appearance and circuit symbol; • sketch the SAC and insert it in a circuit diagram; • use SACs (limited to two in any system); • demonstrate understanding of the terms instroke and outstroke; • analyse circuit diagrams that use SACs (limited to two in any system);
1.33 Valves	• identify the following by their circuit symbols: – exhaust; and – pressure source; • identify a 3/2 valve by its physical appearance and circuit symbol; • sketch the symbol for a 3/2 valve; • explain the function of a 3/2 valve in a circuit diagram; • identify the following types of actuator symbol for a 3/2 valve: – roller trip; – push button; – plunger; and – lever; and • select an appropriate method of operation of a 3/2 valve in a circuit diagram.

Content	Learning Outcomes
1.34 Logic and AND/OR	Students should be able to: • identify a shuttle valve in an OR circuit; • sketch the symbol for a shuttle valve; • explain the use of a shuttle valve; • connect two 3/2 valves with a single acting cylinder to create an AND or an OR circuit;
1.35 Speed control	• identify a unidirectional flow regulator in a circuit; • use a unidirectional flow regulator to incorporate speed control into a system; • describe how a flow regulator is used for speed control;
1.36 Construction	• design, draw and construct pneumatic systems using discrete components; • analyse pneumatic circuits and systems; and
1.37 Safety	• recognise the potential hazards when designing, drawing and constructing pneumatic control systems using discrete components.

Computer control systems

Content	Learning Outcomes
1.38 Input–process–output **1.39 Flowcharts**	Students should be able to: • describe and analyse computer control systems with reference to input–process–output; • identify and give examples of computer control applications; • demonstrate knowledge and understanding of the use of flowcharts; and • draw and name flowchart diagrams to describe a sequence of events, using the symbols for: – START/STOP; – OUTPUT; – DECISION; – WAIT; and – feedback loops. *(Only generic flowcharts should be produced. Only the flowchart symbols that appear in Appendix 3 should be used.)*

3.2 Unit 2: Optional Areas of Study

Students must select **one** of the following **three** options:

- **Option A: Electronic and Microelectronic Control Systems**; **or**
- **Option B: Mechanical and Pneumatic Control Systems**; **or**
- **Option C: Product Design**.

This unit includes synoptic assessment building on the content of Unit 1. This encourages students to develop their understanding of the subject as a whole.

Option A: Electronic and Microelectronic Control Systems

Content	Learning Outcomes
2.1 **Systems and control**	Students should be able to: • demonstrate understanding of input, process and output and the importance of feedback in control systems;
2.2 **Electronic concepts and Ohm's law**	• identify polarised and non-polarised capacitors by their circuit symbols; • show that they understand and can explain the use of polarised and non-polarised capacitors; • select appropriate capacitors to suit applications; • apply and demonstrate knowledge and understanding of the units used to measure capacitance: – farads; – microfarads; – nanofarads; and – picofarads; • demonstrate understanding of the relationship between current, voltage and resistance; • perform calculations based on Ohm's law using: $V = I \times R$;
2.3 **Printed circuit boards**	• design a printed circuit board (PCB) from a circuit diagram by placing components, tracks and pads appropriately; and • amend designs to reflect changes in circuit diagrams, to improve on existing designs or to correct errors.

Content	Learning Outcomes
2.4 **Use a multimeter**	Students should be able to: • demonstrate how to connect a generic digital multimeter to measure voltage, current and resistance; • calculate the expected values for a generic digital multimeter connected in a circuit;
2.5 **Resistors**	• explain the meaning of the term resistance; • draw and interpret circuit diagrams containing resistors; • draw and interpret circuit diagrams containing resistors in series; • draw and interpret circuit diagrams containing resistors in parallel; • use given data and information to calculate the resistance of two resistors in parallel, using: $\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2}$ or $R_t = \frac{R_1 \times R_2}{(R_1 + R_2)}$ • compare the E12 and E24 series of preferred values; • determine the nearest preferred value of a resistor using the E12 and E24 series; • demonstrate knowledge and understanding of tolerance and perform relevant calculations (tolerance limited to 5% and 10%); • show that they understand and can explain the use of current-limiting resistors to protect light-emitting diodes (LEDs); and • calculate values of current-limiting resistors.

Content	Learning Outcomes
2.6 Thyristors	Students should be able to: • explain the use of a thyristor as a latching switch; • draw and interpret circuit diagrams containing thyristors in switching circuits; • explain the operation of circuits containing electronic components including thyristors;
2.7 The NPN transistor	• demonstrate knowledge and understanding that a switch on voltage for an ideal transistor is 0.6V at its base (we accept 0.6V⩽V⩽0.8V); • draw and interpret circuit diagrams containing transistors in switching circuits; • explain the operation of circuits containing electronic components including transistors;
2.8 Inputs	• demonstrate knowledge and understanding of the difference between analogue and digital signals; • draw and interpret analogue and digital voltage/time graphs; • demonstrate understanding of the properties of the following analogue input devices: – light dependent resistors (LDRs); – thermistors (limited to negative temperature coefficient); – moisture sensors; and – variable resistors; and • draw and interpret circuit diagrams containing the above analogue input devices.

Content	Learning Outcomes
2.8 **Inputs (cont.)**	Students should be able to: • demonstrate understanding of the use of the following switches: – reed; – push-to-make switch (PTM); – single pole, single throw (SPST); – single pole, double throw (SPDT); – toggle; – microswitch; – rocker; – membrane; and – slide; • draw and interpret circuit diagrams containing the above switches;
2.9 **Outputs**	• demonstrate knowledge and understanding of the use of the following output devices in circuits: – motors; – solenoids; – bulbs; – buzzers; – relays; – LEDs; and – 7-segment displays; • draw and interpret circuit diagrams containing the above output devices;
2.10 **Potential dividers**	• demonstrate knowledge and understanding of the use of variable resistors to adjust sensitivity in a potential/voltage divider; • perform calculations using: $V_{out} = \frac{R2}{(R1 + R2)} \times V_{in}$ • draw and interpret circuit diagrams containing a potential/voltage divider.

Content	Learning Outcomes
2.11 Semiconductor diodes	Students should be able to: • demonstrate understanding and explain that an ideal diode conducts when a voltage of 0.6V is applied in the forward-biased direction (we accept $0.6V \leqslant V \leqslant 0.8V$); • draw and interpret circuit diagrams containing diodes; • show that they understand and can explain the use of a reverse-biased diode in parallel with an inductive load in a relay coil, solenoid or motor in order to protect against back electromotive force (emf);
2.12 Relays	• show that they understand and can explain the use of a relay as an electrically operated switch (SPST relay); • draw and interpret circuit diagrams in which a relay is used for switching secondary circuits, for example to use with motors and solenoids;
2.13 Integrated circuits	• show that they understand and can explain the use of dual-in-line (DIL) integrated circuits and identify pin one;
2.14 Timers	• demonstrate knowledge and understanding of the function and use of a 555 timer integrated circuit to provide astable and monostable outputs; • interpret output waveforms for 555 astable and monostable circuits; • perform calculations using: Period $T = \frac{1}{f}$ • perform calculations for the output of an astable circuit using a 555 timer, using: Frequency (Hz) $f = \frac{1.44}{(R_1+2R_2)C}$ • perform calculations for the output of a monostable circuit using a 555 timer, using: Time $T = 1.1 \times C \times R$

Content	Learning Outcomes
2.15 **Time constant**	Students should be able to: • show that they know, understand and can explain the relationship between capacitance and resistance in relation to time, when selecting components for timers; • perform calculations using: Time Constant $T = R \times C$
2.16 **Digital signals and counting**	• demonstrate and understand that 1 represents a 'high' voltage level and 0 a 'low' voltage level; • demonstrate an understanding of binary and use it in counting; • convert decimal numbers in the range 0 to 255 into binary and vice versa;
2.17 **Flowcharts**	• draw flowchart diagrams which include: – count; – compare; – macro; – do macro; – end; – increments; – decrements; and – expression; • analyse a given product scenario and produce the appropriate flowchart; and • analyse a given flowchart. *(Only generic flowcharts should be produced. Only the flowchart symbols that appear in Appendix 3 should be used.)*

Content	Learning Outcomes
2.18 Microcontrollers (PICs)	Students should be able to: • show that they understand and can explain the use of microcontrollers (programmable interface controllers (PICs)) within control; • identify a PIC by its circuit symbol; • discuss the use of PICs in robotic control; • draw and explain flowcharts to implement control situations using a PIC; • use bit patterns in flowcharts to show the states of input and output devices; • design and interpret circuits which incorporate a PIC with digital inputs and digital outputs; • demonstrate knowledge and understanding of the need for amplification in order to drive some output devices from a PIC; *(Only generic flowcharts should be produced. Only the flowchart symbols that appear in Appendix 3 should be used.)*
2.19 Robotics	• give examples of where robots are used in society; • describe and analyse the reasons for using robots to assist humans; and • identify and explain the basic control systems used to produce robotic movement.

Option B: Mechanical and Pneumatic Control Systems

Content	Learning Outcomes
2.20 Systems and control **2.21 Mechanical products** **2.22 General concepts**	Students should be able to: • demonstrate understanding of the importance of feedback in controlling systems; • identify mechanical components within mechanical products and systems; • demonstrate understanding of the factors influencing the choice of components; • design mechanical systems to achieve a desired outcome, justifying their choice of components; • interpret sketches, diagrams and photographs of mechanical products and components; • explain and apply the following terms/concepts: – load; – effort; – fulcrum; – mechanical advantage; – velocity ratio; and – efficiency; • interpret sketches, diagrams and photographs of mechanical systems that contain the above terms/concepts; • perform calculations involving the above terms/concepts; and • explain and perform calculations using: $\text{Efficiency (\%)} = \left(\frac{\text{mechanical advantage}}{\text{velocity ratio}}\right) \times 100$ $\text{Mechanical advantage} = \frac{\text{load}}{\text{effort}}$ $\text{Velocity ratio} = \frac{\text{distance moved by effort}}{\text{distance moved by load}}$

Content	Learning Outcomes
2.23 Transmission of motion using gears	Students should be able to: • identify and apply the following types of gears in mechanical systems: – spur; – bevel; – worm and wormwheel; and – rack and pinion; • recognise the following by their symbols: – worm and wormwheel; – jockey pulley; – meshed gear; – bevel gear; – threaded bar; – rack and pinion; and – snail cam; • select the appropriate gear systems for practical applications, justifying their choice; • recognise a compound gear train by its symbol; • explain simple and compound gear trains (limited to four gears); • explain and perform calculations involving simple and compound gear transmissions (using a maximum of four gears) for: – velocity ratio; – gear ratio; and – transmission speeds; • show that they understand and can explain the use of an idler gear in a mechanical system; and
2.24 Pulley systems	• show that they understand and can explain the use of pulley systems in lifting systems (limited to three pulleys).

Content	Learning Outcomes
2.25 Other transmission systems	Students should be able to: • show that they understand and can explain the factors influencing the choice of: – flat belts; – toothed belts; and – sprockets and chains in mechanical systems; • explain how the belts listed can be tensioned; • explain the use of jockey pulleys;
2.26 Conversion of motion	• sketch, describe and compare simple cams and common followers (limited to knife, roller and flat); • show that they understand and can explain the conversion of rotary motion to reciprocating motion, using the following cams: – eccentric; – pear; – heart; and – snail; • show that they understand and can explain the conversion of rotary motion to reciprocating motion and vice versa, using the following mechanisms: – crank and slider; and – rack and pinion; • show that they understand and can explain the use of screw threads to transmit motion; • show that they understand and can explain the use of ratchet and pawl mechanisms; and • interpret diagrams associated with the above mechanisms.

Content	Learning Outcomes
2.27 Levers and linkages	Students should be able to: • complete calculations involving moments of forces; • show that they understand and can explain the use of bell crank levers and parallel linkages in mechanical products; • interpret diagrams associated with levers and linkages;
2.28 Pneumatic products	• identify pneumatic components within pneumatic products and systems and show understanding of the factors influencing the choice of components; • design pneumatic systems to achieve a desired outcome, justifying their choice of components; • interpret sketches, diagrams and photographs of pneumatic products and components;
2.29 Pneumatic principles	• demonstrate understanding of the relationship between the force of a piston in a cylinder, its bore diameter and air pressure: Force (N) = pressure × area ($F = P \times A$) where pressure is measured in N/mm^2 ($0.1N/mm^2$ = 1 bar) and area is measured in mm^2; • perform calculations using the above relationship; • understand and calculate the cross-sectional area (CSA) of a cylinder;
2.30 Cylinders	• identify a double acting cylinder by its physical appearance and circuit symbol; • demonstrate familiarity with the use of double acting cylinders (limited to two per system); and • design and interpret pneumatic circuit diagrams which use double acting cylinders.

Content	Learning Outcomes
2.31 Bidirectional and unidirectional flow control valves	Students should be able to: • design and interpret pneumatic circuit diagrams that make use of the following flow control valves: – unidirectional (one-way restrictor valve); and – bidirectional (two-way restrictor valve);
2.32 Valves and actuators	• design and interpret pneumatic circuit diagrams that make use of a 3/2 valve and/or a 5/2 valve to produce controlled motion for semi-automatic and automatic circuits with the following actuators: – lever; – push button; – roller trip; – plunger; and – pilot; • explain, recognise and use the above components in pneumatic circuits;
2.33 Time delay	• show that they understand and can explain the use of a reservoir and flow regulator to create a time delay; • interpret pneumatic circuit diagrams that incorporate time delays; • sketch and incorporate time delays into pneumatic circuit diagrams;
2.34 Automatic reciprocation	• design and interpret pneumatic circuits with positional feedback to activate a pilot air operated 5/2 valve, controlling two double acting cylinders (DAC) incorporating speed control;
2.35 Robotics	• give examples of where robots are used in society; • describe and analyse the reasons for using robots to assist humans; and • identify and explain the basic control systems used to produce robotic movement.

Option C: Product Design

Design and innovation

Content	Learning Outcomes
2.36 Design process	Students should be able to: • demonstrate knowledge and understanding of key aspects of the design process; • analyse key aspects of the design process;
2.37 Roles of the client, user, designer and maker	• analyse the main roles of the client, user, designer and maker and how they interact in: – commissioning; – design; – manufacture; and – evaluation of a product;
2.38 Product analysis, ideas generation and development	• generate initial ideas through: – disassembly of existing products; – thought showers; – user experience and/or trips; – initial rough sketches (concept sketches); – computer-aided design (CAD) modelling; – physical mock-ups/models; and – initial prototypes; • discuss and analyse the above techniques; • develop innovative concepts; • analyse whether a product is fit for purpose; • evaluate a product against detailed specification criteria; and • improve current solutions by a process of development and modification.

Content	Learning Outcomes
2.39 Communication techniques	Students should be able to: • consider and discuss the benefits of a CAD package; • analyse and use the following visual features in product design: – line, shape and form; – texture; – colour; and – proportion;
2.40 Ergonomics and anthropometrics	• demonstrate understanding of the relationship between people and products; • consider ergonomics when designing; • analyse how product design is influenced by the relationship between product and user; • consider anthropometrics when designing; • analyse how product design is affected and influenced by anthropometric data;
2.41 Form and function	• apply and discuss the issues associated with form versus function in product design when: – form follows function (is functionality the primary driver in the design solution?); and – function follows form (are aesthetics the primary driver in the design solution?); and
2.42 Designers	• analyse the work of the following designers: – Edward Barber and Jay Osgerby; – Philippe Starck; and – Bethan Gray.

Manufacturing practices

Content	Learning Outcomes
2.43 Scale of production and commercial viability	Students should be able to: • compare and discuss the advantages and disadvantages associated with the following types of production: – one-off/jobbing; – batch; – mass; and – continuous; • discuss the main features, advantages and disadvantages of the following in the manufacturing process: – in-line assembly; – flexible manufacturing systems; and – just-in-time manufacture; • discuss the main features, advantages and disadvantages of the following: – standardised components; – assemblies; – bought-in components; and – sub-contracting; • understand and discuss the main characteristics of quality assurance and quality control; • discuss the use and value of sample testing and tolerances;
2.44 Planning for production	• draw and analyse a Gantt chart; • calculate direct costs (labour and materials costs); • understand, interpret and be able to use fractions, decimals and percentages; • understand, interpret and be able to use data tables, charts and graphs; • calculate overhead costs (when given as a set percentage of labour costs); and • calculate total manufacturing costs (direct costs plus overhead costs).

Content	Learning Outcomes
2.45 Manufacturing processes	Students should be able to: • demonstrate and describe the main features and applications of the following: – reforming (injection moulding, die casting and extrusion); and – deforming (blow moulding, laminating and press/compression moulding); • outline and explain the use and application of the following: – circular saw; – band saw; – jigsaw; – sander; and – planer;
2.46 Computerised manufacture	• outline and explain the use and application of the following: – computer numerical control (CNC) routers; – milling machines; – lathes; – laser cutters; and – 3D printers; • discuss the main benefits of CAD and computer-aided manufacture (CAM) in the production process; • apply CAD and CAM in product manufacture; • give examples of where robots are used in society; and • describe and analyse the reasons for using robots to assist humans.

Materials, components and fabrication

Content	Learning Outcomes
2.47 Selection of materials	Students should be able to: • select and discuss materials and surface finishes on the basis of a product's: – intended use; and – properties; • identify and demonstrate awareness of commonly available shapes and cross sections: – sheet; – bar; – tube; – angle; – U-shaped channel; and – I-shaped sections; • calculate area, including cross-sectional area, for a given material;
2.48 Wood, metal and plastic	• give reasons for the selection and use of the most appropriate materials (wood, metal or plastic) for a given product;
2.49 Joining materials	• demonstrate understanding of the main features and applications of the following permanent wood joints: – comb; – biscuit; – dovetail; – mortice and tenon; and – lap; • identify and describe the joining processes for: – wood; – metal; and – plastics; and • use the most appropriate joining processes in the design, manufacture and fabrication of a product.

Content	Learning Outcomes
2.50 Smart materials and composites	Students should be able to: • discuss the reasons for using the following in product designs: – smart materials (shape memory alloy (nithinol) and polymorph); and – composites (glass reinforced plastics (GRP) and carbon fibre).

Market influences

Content	Learning Outcomes
2.51 Marketing	Students should be able to: • discuss the difference between needs and wants in relation to a product; • discuss and analyse new or improved products, considering: – growth in consumer demand (market/demand pull); and – advances in technology which stimulate new design (technology push); • analyse and draw conclusions of market research from the following data sources: – interviews; – surveys; – questionnaires; and – the internet; • discuss the life cycle of a product and identify features associated with each of the following: – inception; – introduction; – growth; – maturity; and – decline; and • analyse the life cycle curve of a product.

Content	Learning Outcomes
2.52 **The global marketplace and production**	Students should be able to: • discuss the impact of globalisation on design and manufacture, for example: – variations in labour costs; – availability of raw materials; – moral issues in outsourcing production; – transportation costs; and – environmental costs.

Social responsibility of product design

Content	Learning Outcomes
2.53 **Risk assessment**	Students should be able to: • identify and discuss the following terms associated with risk assessment: – potential hazards; – personal safety; and – prevention;
2.54 **Product safety**	• outline the need for the independent testing and labelling of products: – British Standards Institution (BSI) and Kitemark; – European CE; and – international ISO;
2.55 **Energy efficiency and recycling**	• discuss the environmental benefits of recycling and the design of products that can be recycled; • discuss how the design of products can reduce wastage of materials; • discuss and design products that can be easily maintained and repaired; and • give and analyse examples of products that have built-in obsolescence.

3.3 Unit 3: Design and Manufacturing Project

This unit is **compulsory** for all students and carries a weighting of **50%** of the full qualification. It is marked out of 100. It has a time guidance of approximately 40 hours. The project allows students to demonstrate their ability to design and manufacture a product.

We issue **two** themes each year, in January of the first year of study. Centres select the theme that is better suited to their needs.

Design portfolio

The design portfolio should be a maximum of **ten** A3 sheets on one side only or equivalent. All text must be size 12. All titles should not exceed size 16. Students may present the portfolio in an electronic format.

Students should understand that the design process is **non-linear** and creativity should be evident throughout the process.

The design portfolio is an integral part of the design project. Each design project will have its own characteristics and relevant processes, but all design portfolios should include the following:

- a chosen theme and design brief;
- a description and understanding of the design opportunity/problem;
- research and analysis of products and/or target market groups (TMGs) as appropriate to the design opportunity/problem;
- freehand sketching and computer-aided design (CAD) – these must be in all design portfolios;
- specifications which identify key design criteria;
- an appropriate range of freehand concept sketches;
- an appropriate range of graphical techniques;
- clear and succinct annotation;
- evidence of creative thinking, problem solving and decision-making;
- the development of the concept(s) using freehand sketches and/or CAD/computer modelling;
- information on how the proposed solution may perform/improve, considering function, form, size, ergonomics, safety and sustainability, as appropriate;
- manufacturing and assembly details of the proposed solution;
- evidence of a physical model/mock-up to aid development of the proposed solution;
- working drawing(s) showing all the necessary details for the manufacture of the key parts; and
- evidence of testing and evaluation of the final solution, to include appropriate modifications.

Quality of written communication is assessed throughout the portfolio.

Manufacturing

The manufactured solution should be functional and appropriately presented.

Students should understand that the design process is **non-linear** and creativity should be evident throughout the process.

The solution should have:

- scaled physical model(s) which relate(s) to and convey(s) a clear understanding of the final solution, proportion, form and function;
- evidence of the function and form of the prototype;
- appropriate materials and fabrication techniques;
- evidence of skills, precision, quality of manufacture, finish and attention to detail;
- evidence of working under test conditions;
- evidence of safety having been taken into account in its final construction and use;
- evidence of templates, patterns, jigs and formers, where appropriate, to assist in production; and
- evidence of creativity.

Students demonstrate design capability, creativity and innovation, using hand and computer numerical control (CNC) manufacturing skills, where appropriate, in the production and outcome of all models and the final prototype.

Learning outcomes for Unit 3

Students are assessed on how they demonstrate the learning outcomes that follow. See **Appendix 2** for the controlled assessment marking criteria for this unit.

Content	Learning Outcomes
3.1 Design opportunity	Students should be able to: • clearly identify and analyse a design opportunity or a problem in relation to the selected theme; • identify and analyse key elements of the design opportunity/problem; and • develop an initial clear design brief.

Content	Learning Outcomes
3.2 Research and analysis **3.3 Specification** **3.4 Concepts and analysis** **3.5 Development of proposed concepts**	Students should be able to: • apply research and analytical skills that show clear connections to the design opportunity/problem and initial design brief; • identify and analyse key design features of existing solutions and/or target market needs; • produce a final design brief; • produce a relevant, detailed specification that identifies key design features sufficient for the development of an appropriate solution; • produce and analyse initial concept sketches appropriate to their chosen design theme; • use a range of freehand graphical techniques to communicate concepts, including 2D/3D sketches, symbols, diagrams, flowcharts and sectional and exploded views; • include clear and succinct annotation; • develop the design concept(s) using freehand/ presentation sketch(es) and computer modelling techniques, as appropriate; • use annotation to analyse the development of the design concepts; and • illustrate, develop and analyse how the proposed concepts may perform or can be improved upon, using relevant annotation.

Content	Learning Outcomes
3.5 Development of proposed concepts (cont.)	Students should be able to: • consider the use of the following, as appropriate: – creativity; – calculations; – circuit simulations; – electronic breadboard modelling; – function; – form; – size; – ergonomics; – safety; – sustainability; – materials; – processes; and – assembly;
3.6 Modelling and testing	• produce one or more physical models/mock-ups to an appropriate scale (including photographic evidence in the design portfolio if they wish); • test and modify the outcome or solution and modify again as necessary;
3.7 Drawings for manufacture	• produce scaled working drawing(s) of the final solution and/or its key component(s) to enable the prototype to be manufactured; • produce drawings that conform to British Standards Institution (BSI) standard;
3.8 Manufacture	• manufacture a prototype to meet all the requirements of the design; • show capability in manufacturing skills, demonstrating quality of finish, accuracy and attention to detail;
3.9 Evaluation	• test the prototype; • produce an evaluation that demonstrates reflective thought about whether the prototype is fit for purpose; and • suggest how the prototype could be developed and modified.

4 Scheme of Assessment

4.1 Assessment opportunities

For the availability of examinations and controlled assessment, see Section 2.

This is a unitised specification; candidates must complete at least 40 percent of the overall assessment requirements at the end of the course, in the examination series in which they request a final subject grade. This is the terminal rule.

Candidates may resit individual assessment units once before cash-in. The better of the two results will count towards their final GCSE grade unless a unit is required to meet the 40 percent terminal rule. If it is, the more recent mark will count (whether or not it is the better result). Results for individual assessment units remain available to count towards a GCSE qualification until we withdraw the specification.

4.2 Assessment objectives

There are **three** assessment objectives for this specification. Candidates must:

AO1 recall, select and communicate their knowledge and understanding of technology and design in a range of contexts;

AO2 apply skills, knowledge and understanding, including quality standards in a variety of design contexts, and plan and carry out investigations and making tasks involving an appropriate range of tools, equipment, materials and processes; and

AO3 analyse and evaluate evidence, design proposals and outcomes, make reasoned judgements and present conclusions and recommendations.

4.3 Assessment objective weightings

The table below sets out the assessment objective weightings for each assessment component and the overall GCSE qualification.

Assessment Objective	Unit Weighting (%)			Overall Weighting (%)
	External Assessment		Controlled Assessment	
	Unit 1	Unit 2	Unit 3	
AO1	10	10	10	30
AO2	10	10	20	40
AO3	5	5	20	30
Total Weighting	25	25	50	100

4.4 Quality of written communication

In GCSE Technology and Design, candidates must demonstrate their quality of written communication. They need to:

- ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
- select and use a form and style of writing that suit their purpose and complex subject matter; and
- organise information clearly and coherently, using specialist vocabulary where appropriate.

Quality of written communication is assessed in responses to questions and tasks that require extended writing.

4.5 Reporting and grading

We report the results of individual assessment units on a uniform mark scale that reflects the assessment weighting of each unit. We determine the grades awarded by aggregating the uniform marks that candidates obtain in individual assessment units.

We award GCSE qualifications on a grade scale from A* to G, with A* being the highest. The nine grades available are as follows:

Grade	A*	A	B	C*	C	D	E	F	G

If candidates fail to attain a grade G or above, we report their result as unclassified (U).

5 Grade Descriptions

Grade descriptions are provided to give a general indication of the standards of achievement likely to have been shown by candidates awarded particular grades. The descriptions must be interpreted in relation to the content in the specification; they are not designed to define that content. The grade awarded depends in practice upon the extent to which the candidate has met the assessment objectives overall. Shortcomings in some aspects of candidates' performance in the assessment may be balanced by better performances in others.

Grade	Description
A	Candidates recall, select and communicate detailed knowledge and thorough understanding of technology and design, including their wider effects. They apply detailed knowledge, understanding and skills in a wide range of situations to plan and carry out investigations and tasks to a high standard. They test their solutions, working safely and with a high degree of precision. They analyse and evaluate the evidence available, reviewing and adapting their methods when necessary. They present information clearly and accurately, making reasoned judgements and presenting substantiated conclusions.
C	Candidates recall, select and communicate sound knowledge and understanding of technology and design, including their wider effects. They apply knowledge, understanding and skills in a range of situations to plan and carry out investigations and tasks effectively. They test their solutions, working safely and with precision. They review the evidence available, analysing and evaluating some information clearly and with some accuracy. They make judgements and draw appropriate conclusions.
F	Candidates recall, select and communicate knowledge and understanding of basic aspects of technology and design, including their wider effects. They apply limited knowledge, understanding and skills to plan and carry out simple investigations and tasks, with an awareness of the need for safety and precision. They modify some aspects of their approach in the light of progress. They review their evidence and draw basic conclusions.

6 Guidance on Controlled Assessment

6.1 Controlled assessment review

We will replace our controlled assessment tasks every year to ensure that they continue to set an appropriate challenge and remain valid, reliable and stimulating.

6.2 Skills assessed by controlled assessment

Teachers must assess the following skills through controlled assessment:

- independent learning;
- communication (evidenced in the design portfolio);
- creative design and problem solving;
- design and make capability; and
- analytical and evaluative capability associated with processes, products and solutions.

6.3 Level of control

Rules for controlled assessment in GCSE Technology and Design are defined for the three stages of the assessment:

- task setting;
- task taking; and
- task marking.

6.4 Task setting

The level of control for task setting is **high**. This means that we set the task. We provide **two** themes in January of the first year of study. Centres **must** submit the completed task for Unit 3 in May of candidates' final year.

Centres have the opportunity to contextualise the controlled assessment task to suit their specific circumstances.

We will provide centres with guidance on how to complete and submit the task.

6.5 Task taking

For Unit 3, the level of control for task taking is **medium**.

Areas of Control	Detail of Control
Authenticity	• Candidates may carry out research outside of the classroom. • Candidates **must** complete their manufactured product within the classroom/workshop environment under supervision. • Candidates may complete their portfolio within and outside the classroom environment, but teachers **must** be able to authenticate all work as being the candidates' own. • Teachers **must** ensure that candidates acknowledge and reference any ideas and sources used.
Feedback	• Teachers **must** guide and supervise candidates in relation to the following: – monitoring progress; – preventing plagiarism; – ensuring compliance with health and safety requirements; – ensuring work is completed in accordance with the specification requirements; and – ensuring work can be assessed in accordance with the procedures and marking criteria. • Candidates **should** reach their own conclusions. • Teachers **must** record any support or guidance they give to candidates on the Candidate Record Sheet and mark their work appropriately.
Page Limit	• Candidates **must** produce a design and manufacturing project. • The **design portfolio** should be a maximum of **ten A3 sheets** (one side only or equivalent). All text **must** be size 12. All titles should not exceed size 16. • Candidates may present the portfolio in an electronic format. • Candidates **must** submit their completed work in May of their final year of study.
Collaboration	• Candidates must submit their **own** individual responses; however, this work may be informed through discussion and/or working with others.

Areas of Control	Detail of Control
Resources	• Candidates should be able to access and use the necessary resources available to the centre. • Centres with limited resources or with candidates who need to use special equipment **must** contact us for advice on how to proceed before offering this course to their candidates. • Candidates **must** reference all resources that they access and use.

6.6 Task marking

The level of control for task marking is **medium**. Teachers mark the controlled assessment task using assessment criteria that we provide. They should use professional judgement to select and apply the criteria in each successive mark band appropriately and fairly to candidates' work. Half marks should **not** be used. Teachers should follow a 'best fit' approach when selecting a candidate's mark, making allowance for balancing strengths and weaknesses in each response.

Teachers must ensure that the work they mark is the candidate's own. For up-to-date advice on plagiarism, or any kind of candidate malpractice, see *Suspected Malpractice in Examinations and Assessments: Policies and Procedures* on the Joint Council for Qualifications website at www.jcq.org.uk

6.7 Internal standardisation

Centres with more than one teaching group must carry out internal standardisation of controlled assessment tasks before submitting their marks to us. This is to ensure, as far as possible, that each teacher has applied the assessment criteria consistently when marking assessments. Centres may need to adjust an individual teacher's marking:

- to bring assessments into line with those of other teachers in the centre; and
- to match the standards established at the agreement trial.

If marks do change, centres must amend the total/final mark on their Candidate Record Sheet.

6.8 Moderation

Centres must submit their marks to us by May in any year. We may adjust centres' marking to bring the assessment of the candidates' work into line with our agreed standards.

We issue full instructions each year on:

- our moderation procedures;
- which samples we require; and
- the deadlines for submitting marks.

Teachers and centre staff may contact us at any stage if they require advice, assistance or support relating to any aspect of controlled assessment.

6.9 Drafting/Redrafting

Teachers must not correct candidates' work in detail and return it to them to write up a fair copy. Responsibility for drafting a piece of work towards completion lies entirely with the candidate. Once a candidate has submitted the controlled assessment and it has been awarded a mark, that mark is final. The candidate may not carry out further work.

See Appendix 1 for a glossary of controlled assessment terms. For more details, see the Joint Council for Qualifications document *Instructions for Conducting Controlled Assessments*, available at www.jcq.org.uk

7 Curriculum Objectives

This specification builds on the learning experiences from Key Stage 3 as required for the statutory Northern Ireland Curriculum. It also offers opportunities for students to contribute to the aim and objectives of the Curriculum at Key Stage 4, and to continue to develop the Cross-Curricular Skills and the Thinking Skills and Personal Capabilities. The extent of the development of these skills and capabilities will be dependent on the teaching and learning methodology used.

7.1 Cross-Curricular Skills at Key Stage 4

Communication
Students should be able to: • communicate meaning, feelings and viewpoints in a logical and coherent manner, *for example discussing the main effects that historical influences and trends can have on the design of a product, or discussing the issues associated with form versus function when designing products;* • make oral and written summaries, reports and presentations, taking account of audience and purpose, *for example using some of the following methods of communication when producing a design folder based on a pre-set design brief: discussion, freehand sketching, formal presentation drawings, working drawings, mood boards, designing and analysing printed circuit boards, photography, physical modelling, computer modelling and CAD*; • interpret, analyse and present information in oral, written and ICT formats, *for example drawing and interpreting circuit diagrams containing components, analysing given product scenarios and producing appropriate flowcharts, and drawing and interpreting graphs of analogue and digital voltages against time*; and • explore and respond, both imaginatively and critically, to a variety of texts, *for example engaging in initial ideas through user trips, concept sketches, disassembly of products and improving current solutions by a process of development and modification*.

Using Mathematics
Students should be able to: • use mathematical language and notation with confidence, *for example using units (such as µf, nf, mm and m) appropriately, understanding and interpreting fractions, decimals and percentages, manipulating formulae (for example Ohm's law) and representing calculations clearly*; • use mental computation to calculate, estimate and make predictions in a range of simulated and real-life contexts, *for example:* – *determining the probability of finding a successful solution through effective research and planning;* – *calculating variations in labour costs; and* – *identifying the required materials and processes needed to realise a design;* • select and apply mathematical concepts and problem-solving strategies in a range of simulated and real-life contexts, *for example communicating their planning, calculations, measurements, solutions, data handling and evaluations using appropriate mathematical notation, techniques and language, given the purpose of the design and outcome*; and • interpret and analyse a wide range of mathematical data, *for example interpreting product life cycle charts and planning for production*.
Using ICT
Students should be able to make effective use of information and communications technology in a wide range of contexts to access, manage, select and present information, including mathematical information, *for example applying CAD, CNC and CAM in product manufacture; producing, drawing and analysing Gantt charts; using computer modelling and CAD; designing and analysing printed circuit boards; and developing skills and expertise using 2D and 3D design software, programming and control software.*

7.2 Thinking Skills and Personal Capabilities at Key Stage 4

Self-Management
Students should be able to: • plan work, *for example producing production plans, a portfolio and practical outcomes*; and • set personal learning goals and targets to meet deadlines, *for example planning the design and development of the portfolio and manufactured solutions to meet deadlines using Gantt charts and flowcharts*.

Working with Others
Students should be able to: • learn with and from others through co-operation, *for example engaging in creative discussion with peers and teachers to develop design ideas*; and • listen actively to others and influence group thinking and decision-making, taking account of others' opinions, *for example continuously evaluating, modifying and improving on design developments in their portfolio and in the production of a manufactured solution*.
Problem Solving
Students should be able to: • identify and analyse relationships and patterns, *for example analysing how product design is influenced by the relationship between product and user*; • propose justified explanations, *for example selecting appropriate systems for practical applications*; • reason, form opinions and justify their views, *for example giving reasons for selecting and using appropriate materials and solutions*; • analyse critically and assess evidence to understand how information or evidence can be used to serve different purposes or agendas, *for example explaining the main features of copyrights, trademarks and patents;* • analyse and evaluate multiple perspectives, *for example analysing the work of modern designers*; • weigh up options and justify decisions, *for example designing systems to achieve a desired outcome and justifying chosen components and solutions*; and • applying and evaluating a range of approaches to solve problems in familiar and novel contexts, *for example analysing a design problem and using an appropriate design process to make the solution*.

Although not referred to separately as a statutory requirement at Key Stage 4 in the Northern Ireland Curriculum, **Managing Information** and **Being Creative** may also remain relevant to learning.

8 Links and Support

8.1 Support

The following resources are available to support this specification:

- our Technology and Design microsite at www.ccea.org.uk and
- specimen assessment materials.

We also intend to provide:

- past papers;
- mark schemes;
- Chief Examiner's reports;
- Principal Moderator's reports;
- planning frameworks;
- support visits;
- support days for teachers;
- agreement trials;
- a resource list; and
- exemplification of examination performance.

8.2 Examination entries

Entry codes for this subject and details on how to make entries are available on our Qualifications Administration Handbook microsite, which you can access at www.ccea.org.uk

Alternatively, you can telephone our Examination Entries, Results and Certification team using the contact details provided.

8.3 Equality and inclusion

We have considered the requirements of equality legislation in developing this specification and designed it to be as free as possible from ethnic, gender, religious, political and other forms of bias.

GCSE qualifications often require the assessment of a broad range of competences. This is because they are general qualifications that prepare students for a wide range of occupations and higher level courses.

During the development process, an external equality panel reviewed the specification to identify any potential barriers to equality and inclusion. Where appropriate, we have considered measures to support access and mitigate barriers.

Reasonable adjustments are made for students with disabilities in order to reduce barriers to access assessments. For this reason, very few students will have a complete barrier to any part of the assessment. Learners with a physical disability may be limited in the range of designing and making contexts they can use, but this should not pose a barrier to assessment. For example, students may use CAD/CAM

for the making process, and practical assistants may be used to support students with physical disabilities in this process. Students with a visual impairment may find elements of the assessment difficult, such as graphics; however, there should be no additional barriers to assessment.

It is important to note that where access arrangements are permitted, they must not be used in any way that undermines the integrity of the assessment. You can find information on reasonable adjustments in the Joint Council for Qualifications document *Access Arrangements and Reasonable Adjustments*, available at www.jcq.org.uk

8.4 Contact details

If you have any queries about this specification, please contact the relevant CCEA staff member or department:

- Specification Support Officer: Nuala Tierney
  (telephone: (028) 9026 1200, extension 2292, email: ntierney@ccea.org.uk)

- Subject Officer: Judith Ryan
  (telephone: (028) 9026 1200, extension 2133, email: jryan@ccea.org.uk)

- Examination Entries, Results and Certification
  (telephone: (028) 9026 1262, email: entriesandresults@ccea.org.uk)

- Examiner Recruitment
  (telephone: (028) 9026 1243, email: appointments@ccea.org.uk)

- Distribution
  (telephone: (028) 9026 1242, email: cceadistribution@ccea.org.uk)

- Support Events Administration
  (telephone: (028) 9026 1401, email: events@ccea.org.uk)

- Moderation
  (telephone: 9026 1200, extension 2236, email: moderationteam@ccea.org.uk)

- Business Assurance (Complaints and Appeals)
  (telephone: (028) 9026 1244, email: complaints@ccea.org.uk or appealsmanager@ccea.org.uk).

Appendix 1

Glossary of Terms for Controlled Assessment Regulations

Term	Definition
Component	A discrete, assessable element within a controlled assessment/qualification that is not itself formally reported and for which the awarding organisation records the marks May contain one or more tasks
Controlled assessment	A form of internal assessment where the control levels are set for each stage of the assessment process: task setting, task taking, and task marking
External assessment	A form of independent assessment in which question papers, assignments and tasks are set by the awarding organisation, taken under specified conditions (including detailed supervision and duration) and marked by the awarding organisation
Formal supervision **(High level of control)**	The candidate must be in direct sight of the supervisor at all times. Use of resources and interaction with other candidates is tightly prescribed.
Informal supervision **(Medium level of control)**	Questions/Tasks are outlined, the use of resources is not tightly prescribed and assessable outcomes may be informed by group work. Supervision is confined to: • ensuring that the contributions of individual candidates are recorded accurately; and • ensuring that plagiarism does not take place. The supervisor may provide limited guidance to candidates.
Limited supervision **(Limited level of control)**	Requirements are clearly specified, but some work may be completed without direct supervision and will not contribute directly to assessable outcomes.

Term	Definition
Mark scheme	A scheme detailing how credit is to be awarded in relation to a particular unit, component or task Normally characterises acceptable answers or levels of response to questions/tasks or parts of questions/tasks and identifies the amount of credit each attracts May also include information about unacceptable answers
Task	A discrete element of external or controlled assessment that may include examinations, assignments, practical activities and projects
Task marking	Specifies the way in which credit is awarded for candidates' outcomes Involves the use of mark schemes and/or marking criteria produced by the awarding organisation
Task setting	The specification of the assessment requirements Tasks may be set by awarding organisations and/or teachers. Teacher-set tasks must be developed in line with awarding organisation specified requirements.
Task taking	The conditions for candidate support and supervision, and the authentication of candidates' work Task taking may involve different parameters from those used in traditional written examinations. For example, candidates may be allowed supervised access to sources such as the internet.
Unit	The smallest part of a qualification that is formally reported May comprise separately assessed components

Appendix 2

Assessment Criteria and Mark Bands for Unit 3: Design and Manufacturing Project

Appendix 2

Assessment Criteria and Mark Bands for Unit 3: Design and Manufacturing Project

Design Thinking, Analysis and Specification								
Assessment Objectives	Mark Band 1: **Limited**	Mark Range	Mark Band 2: **Satisfactory**	Mark Range	Mark Band 3: **Good**	Mark Range	Mark Band 4: **Excellent**	Mark Range
	Relevant material is poorly organised and presented with a lack of clarity and coherence.		Relevant material is sufficiently organised and presented with some clarity and coherence.		Relevant material is well organised and presented with a good degree of clarity and coherence.		Relevant material is succinct, well organised and presented with a high degree of clarity and coherence.	
AO1 AO2 AO3 Total (10)	**Candidates may require considerable guidance to:** • choose a design theme and explore possibilities; • engage with a design theme and produce a limited design brief; and • produce a limited problem analysis and specification.	(1–2)	**Candidates may require some guidance to:** • choose a design theme and explore possibilities; • engage with a design theme and produce a satisfactory design brief; and • produce a satisfactory problem analysis and specification.	(3–5)	**Candidates may require little guidance to:** • choose a design theme and explore possibilities; • engage with a design theme and produce a good design brief; and • produce a good problem analysis and specification.	(6–8)	**Candidates work independently to:** • choose a design theme and explore possibilities; • engage with a design theme and produce an excellent design brief; and • produce an excellent problem analysis and specification.	(9–10)
Award zero marks for work not worthy of credit.								

Concepts and Analysis								
Assessment Objectives	Mark Band 1: **Limited**	Mark Range	Mark Band 2: **Satisfactory**	Mark Range	Mark Band 3: **Good**	Mark Range	Mark Band 4: **Excellent**	Mark Range
	Relevant material is poorly organised and presented with a lack of clarity and coherence.		Relevant material is sufficiently organised and presented with some clarity and coherence.		Relevant material is well organised and presented with a good degree of clarity and coherence.		Relevant material is succinct, well organised and presented with a high degree of clarity and coherence.	
AO1 AO2 AO3 Total (15)	**Candidates may require considerable guidance to:** • develop initial design concepts that make use of a range of limited freehand graphical techniques; the freehand concept sketches should show evidence of limited creative thinking and analysis; and • produce basic annotation showing limited knowledge and understanding of the potential solution.	(1–4)	**Candidates may require some guidance to:** • develop initial design concepts that make use of a range of satisfactory freehand graphical techniques; the freehand concept sketches should show evidence of satisfactory creative thinking and analysis; and • produce satisfactory annotation showing satisfactory knowledge and understanding of the potential solution.	(5–7)	**Candidates may require little guidance to:** • develop initial design concepts that make use of a range of good freehand graphical techniques; the freehand concept sketches should show evidence of good creative thinking and analysis; and • produce good annotation showing good knowledge and understanding of the potential solution.	(8–11)	**Candidates work independently to:** • develop initial design concepts that make use of a range of excellent freehand graphical techniques; the freehand concept sketches should show evidence of excellent creative thinking and analysis; and • produce excellent annotation showing detailed knowledge and understanding of the potential solution.	(12–15)
Award zero marks for work not worthy of credit.								

Development of Proposed Concepts: Modelling and Testing								
Assessment Objectives	Mark Band 1: **Limited**	Mark Range	Mark Band 2: **Satisfactory**	Mark Range	Mark Band 3: **Good**	Mark Range	Mark Band 4: **Excellent**	Mark Range
	Relevant material is poorly organised and presented with a lack of clarity and coherence.		Relevant material is sufficiently organised and presented with some clarity and coherence.		Relevant material is well organised and presented with a good degree of clarity and coherence.		Relevant material is succinct, well organised and presented with a high degree of clarity and coherence.	
AO1 AO2 AO3 Total (25)	**Candidates may require considerable guidance to:** • develop creative design thinking using limited freehand/presentation sketches and/or computer modelling techniques; • illustrate, develop and analyse how the solution may perform, using limited annotation and having considered a range of appropriate factors; and • develop limited working drawing(s) showing the necessary details to enable the prototype to be manufactured.	(1–6)	**Candidates may require some guidance to:** • develop creative design thinking using satisfactory freehand/presentation sketches and/or computer modelling techniques; • illustrate, develop and analyse how the solution may perform, using satisfactory annotation and having considered a range of appropriate factors; and • develop satisfactory working drawing(s) showing the necessary details to enable the prototype to be manufactured.	(7–12)	**Candidates may require little guidance to:** • develop creative design thinking using good freehand/presentation sketches and/or computer modelling techniques; • illustrate, develop and analyse how the solution may perform, using good annotation and having considered a range of appropriate factors; and • develop good working drawing(s) showing the necessary details to enable the prototype to be manufactured.	(13–18)	**Candidates work independently to:** • develop creative design thinking using excellent freehand/presentation sketches and/or computer modelling techniques; • illustrate, develop and analyse how the solution may perform, using excellent annotation and having considered a range of appropriate factors; and • develop excellent working drawing(s) showing the necessary details to enable the prototype to be manufactured.	(19–25)

Development of Proposed Concepts: Modelling and Testing (cont.)								
	Candidates may require considerable guidance to: • produce scaled physical model(s) or mock-up(s) of the potential solution which convey(s) limited understanding of the product's form and function; and • produce limited evidence of testing the model(s) or mock-up(s) to check if it is a feasible proposal to manufacture, and modify as necessary.		**Candidates may require some guidance to:** • produce scaled physical model(s) or mock-up(s) of the potential solution which convey(s) satisfactory understanding of the product's form and function; and • produce some evidence of testing the model(s) or mock-up(s) to check if it is a feasible proposal to manufacture, and modify as necessary.		**Candidates may require little guidance to:** • produce scaled physical model(s) or mock-up(s) of the potential solution which convey(s) good understanding of the product's form and function; and • produce good evidence of testing the model(s) or mock-up(s) to check if it is a feasible proposal to manufacture, and modify as necessary.		**Candidates work independently to:** • produce scaled physical model(s) or mock-up(s) of the potential solution which convey(s) excellent understanding of the product's form and function; and • produce excellent evidence of testing the model(s) or mock-up(s) to check if it is a feasible proposal to manufacture, and modify as necessary.	
Award zero marks for work not worthy of credit.								

Development of Proposed Concepts: Manufacture								
Assessment Objectives	Mark Band 1: **Limited**	Mark Range	Mark Band 2: **Satisfactory**	Mark Range	Mark Band 3: **Good**	Mark Range	Mark Band 4: **Excellent**	Mark Range
	Relevant material is poorly organised and presented with a lack of clarity and coherence.		Relevant material is sufficiently organised and presented with some clarity and coherence.		Relevant material is well organised and presented with a good degree of clarity and coherence.		Relevant material is succinct, well organised and presented with a high degree of clarity and coherence.	
AO1 AO2 AO3 Total (40)	**Candidates may require considerable guidance to:** • manufacture a prototype, which should include the candidate's own templates, jigs and formers as appropriate and be based on the final evaluated scaled physical model(s) or mock-up(s): – giving limited consideration to function, form, innovation and creativity; – using appropriate materials and fabrication techniques; – demonstrating a limited level of skill and precision; and – producing a limited outcome with consideration given to quality of finish.	(1–10)	**Candidates may require some guidance to:** • manufacture a prototype, which should include the candidate's own templates, jigs and formers as appropriate and be based on the final evaluated scaled physical model(s) or mock-up(s): – giving satisfactory consideration to function, form, innovation and creativity; – using appropriate materials and fabrication techniques; – demonstrating a satisfactory level of skill and precision; and – producing a satisfactory outcome with consideration given to quality of finish.	(11–20)	**Candidates may require little guidance to:** • manufacture a prototype, which should include the candidate's own templates, jigs and formers as appropriate and be based on the final evaluated scaled physical model(s) or mock-up(s): – giving good consideration to function, form, innovation and creativity; – using appropriate materials and fabrication techniques; – demonstrating a good level of skill and precision; and – producing a good outcome with consideration given to quality of finish.	(21–30)	**Candidates work independently to:** • manufacture a prototype, which should include the candidate's own templates, jigs and formers as appropriate and be based on the final evaluated scaled physical model(s) or mock-up(s): – giving excellent consideration to function, form, innovation and creativity; – using appropriate materials and fabrication techniques; – demonstrating an excellent level of skill and precision; and – producing an excellent outcome with consideration given to quality of finish.	(31–40)

Development of Proposed Concepts: Manufacture (cont.)								
	Candidates may require considerable guidance to: • produce innovative solutions, which show potential for further development.		**Candidates may require some guidance to:** • produce innovative solutions, which show potential for further development.		**Candidates may require little guidance to:** • produce innovative solutions, which show potential for further development.		**Candidates work independently to:** • produce innovative solutions, which show potential for further development.	
Award zero marks for work not worthy of credit.								

Evaluation								
Assessment Objectives	Mark Band 1: **Limited**	Mark Range	Mark Band 2: **Satisfactory**	Mark Range	Mark Band 3: **Good**	Mark Range	Mark Band 4: **Excellent**	Mark Range
	Relevant material is poorly organised and presented with a lack of clarity and coherence.		Relevant material is sufficiently organised and presented with some clarity and coherence.		Relevant material is well organised and presented with a good degree of clarity and coherence.		Relevant material is succinct, well organised and presented with a high degree of clarity and coherence.	
AO1 AO2 AO3 Total (10)	**Candidates may require considerable guidance to:** • produce an evaluation of the prototype that demonstrates a limited level of reflective thought, including: – fitness for purpose; – testing against the specification and making evaluative comments; and – suggesting valid modifications, using sketches where appropriate.	(1–2)	**Candidates may require some guidance to:** • produce an evaluation of the prototype that demonstrates a satisfactory level of reflective thought, including: – fitness for purpose; – testing against the specification and making evaluative comments; and – suggesting valid modifications, using sketches where appropriate.	(3–5)	**Candidates may require little guidance to:** • produce a detailed evaluation of the prototype that demonstrates a good level of reflective thought, including: – fitness for purpose; – testing against the specification and making evaluative comments; and – suggesting valid modifications, using sketches where appropriate.	(6–8)	**Candidates work independently to:** • produce a detailed evaluation of the prototype that demonstrates an excellent level of reflective thought, including: – fitness for purpose; – testing against the specification and making evaluative comments; and – suggesting valid modifications, using sketches where appropriate.	(9–10)
Award zero marks for work not worthy of credit.								

Appendix 3

Symbols and Safety Signs

Appendix 3

Symbols and Safety Signs

Students studying this GCSE Technology and Design Specification should be familiar with the symbols below.

The symbols are presented under the following categories:

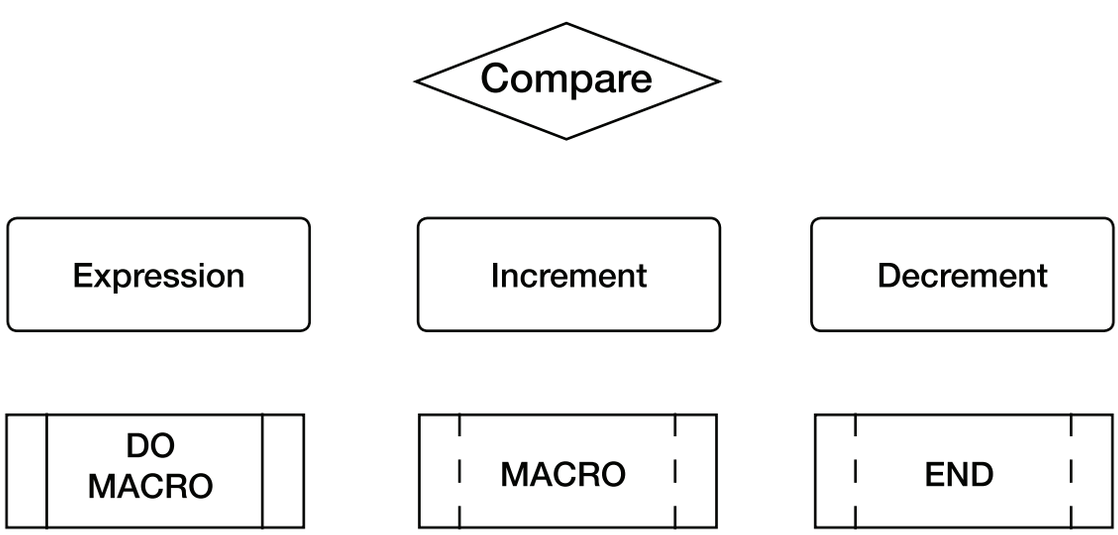
Flowchart Symbols
Electronic and Microelectronic Control symbols
Mechanical Control symbols
Pneumatic Control symbols
Standards Symbols
Safety Signs

Flowchart Symbols

Units 1 and 2A

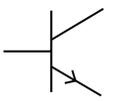
In order to avoid problems due to variations between computer control packages, only the following generic flowchart symbols will be used in examinations.

Units 2A only

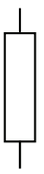


Electronic and Microelectronic Control Symbols

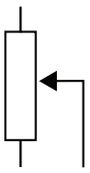
Units 1 and 2A



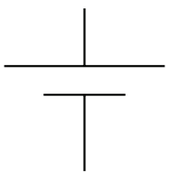
NPN transistor



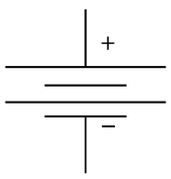
Resistor



Potentiometer



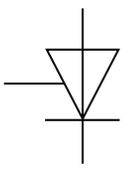
Single cell (Battery)



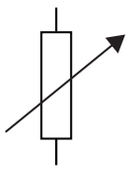
Multi cell (Battery)

Push-to-make switch

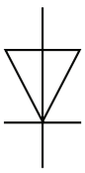
Reed switch



Thyristor

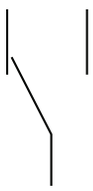


Variable resistor

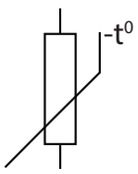


Diode

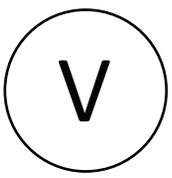
SPST switch



SPDT switch

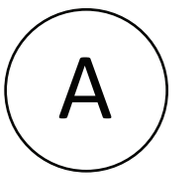


Thermistor (negative temp coefficient)

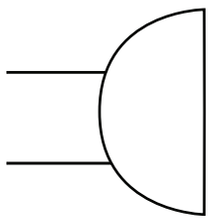


Voltmeter

ac supply

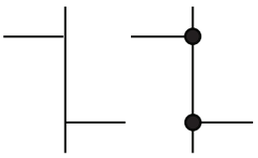


Ammeter

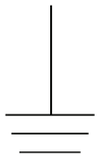


Buzzer

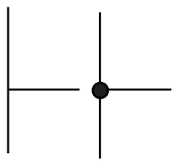
Terminal



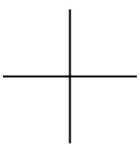
Double junction



Earth

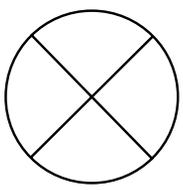


Junction of conductors

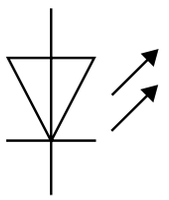


Crossing of conductors with no electrical connection

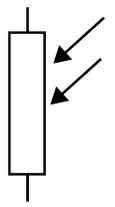
Electronic and Microelectronic Control Symbols (cont.)



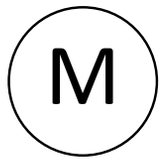
Bulb



Light-emitting diode

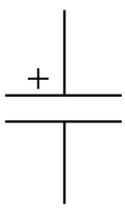


Light-dependent resistor

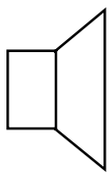


Motor

Units 2A only

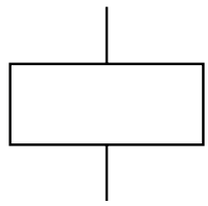


Polarised capacitor

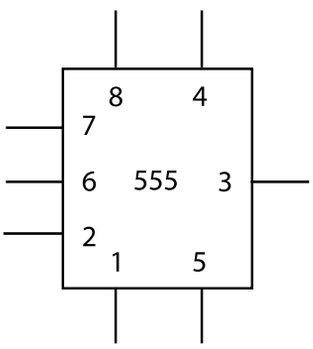


Loudspeaker

Relay make contact spring return

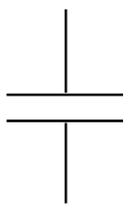


Relay coil

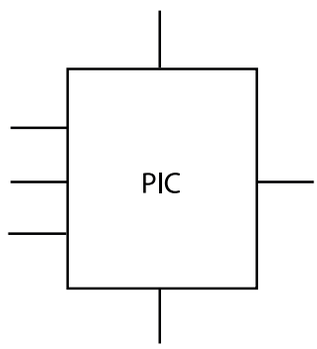


555 Timer

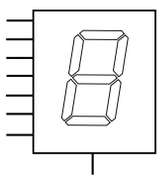
Moisture sensor



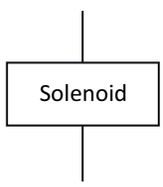
Capacitor



Microcontroller (PIC)



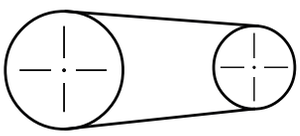
Seven Segment display



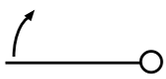
Solenoid

Mechanical Control Symbols

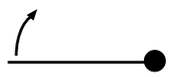
Units 1 and 2B only



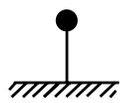
Belt and Pulley



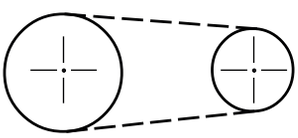
Lever



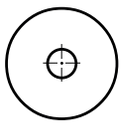
Pivoted lever



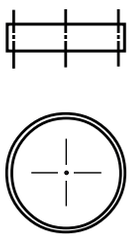
Fixed pivot



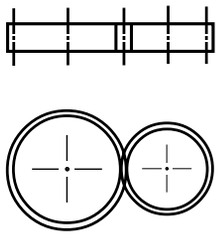
Sprocket and chain



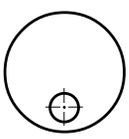
Wheel and Axle



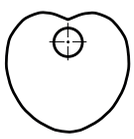
Gear



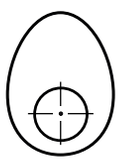
Meshed gear



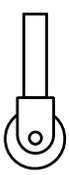
Eccentric cam



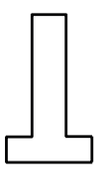
Heart-shaped cam



Pear-shaped cam



Roller follower

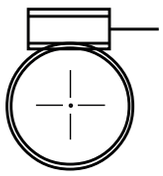


Flat follower

Knife follower

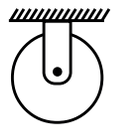
Mechanical Control Symbols (cont.)

Unit 2B only

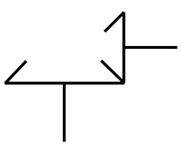


Worm and wormwheel

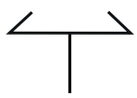
jockey pulley



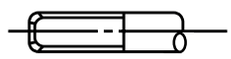
Single pulley



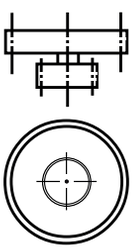
Meshed bevel gear



Bevel gear

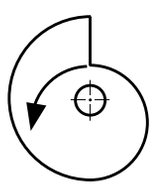


Threaded bar



Compound gear

Rack and pinion



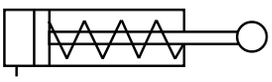
Snail cam

Pneumatic Control Symbols

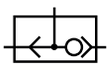
Units 1 and 2B

Exhaust

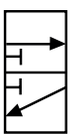
Pressure source



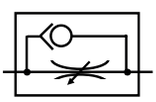
Single acting cylinder (SAC)



Shuttle valve



3/2 Valve



Unidirectional flow restrictor

Spring return

Method of Operation

Plunger

Roller trip

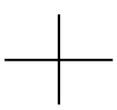
Push button

Lever

Flow Lines and Connections

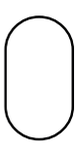
Working line, return and feed line

Pipeline junction

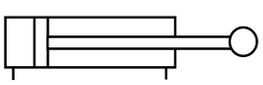


Pipeline not connected

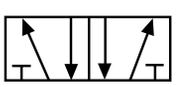
Units 2B only



Reservoir



Double acting cylinder (DAC)



5/2 Valve

Pilot/Signal

Pilot pressure

Bidirectional flow restrictor

Standards Symbols

Units 2C only

British Standards

Conformité Européene

ISO

Safety Signs

Units 1, 2A, 2B and 2C

Safety signs identify the dangers they warn against. Safety signs are divided into four categories:

Hazard Signs
Prohibition Signs
Mandatory Signs
Safe Condition Signs

Hazard Signs

Hazard signs indicate a specific source of potential harm. Examples are:

Explosive

Flammable

Corrosive

Acute toxicity

Hazardous to the environment

Health hazard
Hazardous to the ozone layer

Gas under pressure

Electrical

Prohibition Signs

Prohibition signs indicate behaviour that is forbidden. The prohibited activity is represented in black on white, with a red circle and diagonal stripe superimposed.

Examples:

Do not run

No eating or drinking

Mandatory Signs

Mandatory signs identify a particular course of action that must be taken. They are represented in white on a solid blue circle. Examples:

Wear eye protection

Wear hand protection

Use welding mask

Use face shield

Safe Condition Signs

Safe condition signs indicate the presence of a safety facility and are usually represented in white on a solid green square. Examples:

First aid

Emergency eyewash

The sign used to indicate the location of an emergency stop button is represented in white on a solid red square:

Emergency stop button