

Unit 9D Using control for electronic monitoring

Focus: control

About the unit

The main aim of this unit is for pupils to learn how to apply and combine their understanding of electronic control and product design control when designing and making.

In this unit, pupils tackle a design and make assignment (DMA) on the theme ‘Taking care’, in which they bring together their knowledge and understanding of electronics, product design and modelling to meet a specific and appropriate purpose and produce an electronically controlled sensing device that includes feedback.

Pupils gain the knowledge, skills and understanding they need to carry out the DMA successfully through product evaluation activities and focused practical tasks. They:

- understand the design features and operation of electronic control sub-systems
- identify the need for and constraints on the development of electronic systems
- design, model and test simple electronic circuits
- design printed circuit board (PCB) masks and use them to create a PCB, if appropriate
- combine circuit and product design to produce a high-quality electronic product
- design and model potential products to show what they will look like and to confirm that they are appropriate for their intended purpose

There are also opportunities for pupils to:

- design a user interface for an electronic product that suits its purpose and intended user(s)
- produce a user guide for their product

Where the unit fits in

This unit is expected to take 12–19 hours.

This is one of three units that focus on control: one in year 7 on using electrical and mechanical control to control a display; one in year 8 on programming a computer-based controller when using control for security; and this one in year 9 on designing and making electronic circuits for control when using control for electronic monitoring. (There is an option to introduce microcontrollers in year 9.) These units ensure progression in understanding a range of control technologies and their use in designing and making.

It is expected that pupils in all years will go beyond simply ensuring that control technologies work, to designing, modelling and making products that incorporate the control aspects. In this unit, there is a particular focus on product design issues with pupils designing a complete product that incorporates electronics. There are opportunities to develop pupils’ skills in both resistant materials and textiles. If you choose not to teach this unit, then plan to include the essential activities identified by the symbol ■ as part of another unit.

Teachers may find it helpful to use the unit as an end-of-key-stage project, to bring together pupils’ knowledge of different technical areas and introduce them to the quality of work required for GCSE. If this unit is used towards the end of year 9, pupils should be able to complete more of the optional activities.

Expectations

At the end of this unit

most pupils will: draw on and use their understanding of systems and control; draw on and use their understanding of feedback; draw on and use their understanding of electronics; produce a working product prototype, drawing on and using their understanding of product design; work with a range of tools, equipment, materials, components and control elements, including electronic components, taking full account of their characteristics; produce a finished electronic product that works as planned and evaluate it using appropriate techniques, taking into account the needs of the final user

some pupils will not have made so much progress and will: use systems and control ideas in their designing and making; use feedback in their designing and making; use electronics in their designing and making; design and make a working product prototype, using product design ideas; evaluate a finished electronic product in use

some pupils will have progressed further and will: use a wider range of input, process and output elements and include a microcontroller, if possible, to provide functional sophistication; apply a detailed understanding of the user’s product requirements, tailoring their end product closely to the user’s needs; make an electronic product that is original, made with precision, and evaluated against a broad range of criteria relating to the product’s purpose

Prior learning

It is helpful if pupils have:

- modelled, designed and constructed simple electrical control circuits that include switches and outputs in parallel and series, protection of LEDs and reversing control of motors
- designed computer-controlled systems that control a range of output devices and monitor a range of input signals
- implemented designed computer-controlled systems so that they respond to real signals and control real devices

Pupils should have gained the above knowledge, skills and understanding in years 7 and 8, through unit 7D ‘Using control to control a display’ and unit 8D ‘Using control for security’, or similar projects.

Language for learning

Through the activities in this unit, pupils will be able to understand, use and spell correctly words relating to:

- product design, *eg user interface, ergonomic, aesthetics, sustainability, environmental impact, maintenance*
- electronic control elements and their assembly, *eg system, sub-system, systems diagram, signal, function, input, process, output, sensor, actuator, high, low, printed circuit board, PCB, ultraviolet, expose, etch, solder, flux, soldering iron, current, voltage, meter, multimeter*

Reading – through the activities pupils could:

- appraise texts quickly and effectively for their usefulness
- evaluate how effectively information is presented in whole texts, web pages, databases, etc

Writing – through the activities pupils could:

- organise content into complete text with the relationships between points/paragraphs clearly signalled, *eg therefore, nevertheless*
- understand the effect of different aspects of formality, *eg passive verbs, third person, abstract nouns*
- use punctuation correctly to clarify and emphasise meaning for a reader, *eg full stops, commas, brackets, semicolons, dashes*

Resources

Resources include:

- electronic design equipment, *eg simulation software, electronic systems kits for modelling, PCB design software*
- electronic construction equipment, *eg connection blocks*
- PCB manufacturing equipment, *eg UV exposure, etching, cleaning, drilling equipment*
- soldering equipment, *eg irons, stands, solder*
- a wide range of electronic components, including sensors and actuators, *eg light, temperature, pressure and magnetic sensors, switches, buzzers, lamps, LEDs, solenoids, motors, piezoelectric sounders*
- product design and manufacturing equipment, *eg for vacuum forming, blow moulding, CAD/CAM (computer-aided design and manufacture)*
- computers for graphic design and output, a printer and vinyl cutter
- if available, an embedded (microcontroller) control system and a computer or other means of programming it, *eg*
 - *KidsChip from Data Harvest*
 - *PIC Logicator from Economatics*
 - *Chip Factory from the Technology Enhancement Programme*
 - *Basic Stamp from the Technology Enhancement Programme*
- useful websites, *eg*
 - *www.howstuffworks.com*
 - *www.dtonline.org*
 - *www.users.dircon.co.uk/~doctron*
 - *www.o2.org/tools*

Future learning

Pupils could go on to further work on systems and control at key stage 4, in particular:

- 5a) the concepts of input, process and output, and the importance of feedback in controlling systems, including:
- (i) how control systems and sub-systems can be designed, used and connected to achieve different purposes
 - (ii) how feedback is incorporated into systems
 - (iii) how to analyse the performance of systems

(Extracts from the D&T key stage 4 programme of study)

Out-of-school activities and homework

Pupils could:

- carry out a survey of electronic products in their home
- research situations in which people care for someone or something, and think about opportunities to develop electronic devices that support such care

Links with other subjects

- Science: links with unit 9I ‘Energy and electricity’, unit 9L ‘Pressure and moments’.
- ICT: producing graphics, using CAD/CAM, electronic modelling, computer control.
- Mathematics: gathering and interpreting data, simulating and modelling, making systems diagrams.
- English: discussing and reporting on research findings, producing a user guide, drawing up specifications, producing plans.

Pupils should learn:

Pupils:

DESIGN AND MAKE ASSIGNMENT (DMA)

- to design a product that brings together their knowledge and understanding of a range of technologies, including computer control, to meet a specific purpose, by applying the knowledge, skills and understanding they developed during the product evaluation activities and focused practical tasks

Set the pupils a DMA that requires them to bring together their knowledge, skills and understanding of electronics with product design and modelling to meet a specific and appropriate purpose.

Example

This example DMA has been written so it can be copied and given directly to pupils. Further details and contexts can be added, as appropriate.

Taking care

Electronic products are everywhere, *eg in greetings cards, toys, safety devices, domestic devices*. Some of these products are well designed and easy to use; others are less well made or are difficult to use because of their poor user interface. A good electronic product needs a high-quality and well-designed electronic circuit, and a casing to protect the circuit and make the product easy to use.

Design an effective and attractive electronic product that could be used to care for someone or something, *eg to control a pet's environment and keep it comfortable, or to help a parent check that a baby's bath water is the right temperature*.

Think carefully about how to design the product so that it is suitable for its intended use, how the system will communicate with the user, and how the user will communicate with the system. If you have time, produce a simple user guide that describes what the product does, how it should be used, and how it should be cared for and maintained, *eg how to change the batteries*.

- research the background to the setting, seeking the opinions of potential users of the product and using the information they collect to inform their own designing
- draw up a detailed design specification for an electronic product, in a setting that they choose, specifying criteria, *eg aesthetics, technical function, usability, reliability, maintenance, quality, health and safety implications*
- carry out preliminary product and electronic modelling to explore and test their thinking and correct their working before deciding on a final proposal
- use a sequence of drawings, including PCB designs, to clarify and communicate detail before making
- make a compact casing that houses the product's components effectively

Some pupils can also be expected to:

- write a simple user guide for the product*

Language for learning when writing a user guide

- Ask pupils to look back at their earlier work on reviewing product documentation and to think about the effect of different kinds of formality in this type of writing.

Pupils should learn:

Pupils:

PRODUCT EVALUATION

Organise a range of activities that give pupils an opportunity to:

- examine, describe and evaluate how electronics are used in sensing products
- explore situations in which electronic devices could usefully enhance the care of someone or something
- explore the use of feedback in products
- explore and evaluate the working of a range of electronically controlled devices, including those that incorporate embedded computer control
- examine some of the values issues, in particular environmental issues, that are raised by the development of electronic systems

■ to recognise and understand product design features and the operation of electronic control sub-systems in products, *eg to sense a signal, provide a signal*

■ Ask the pupils to investigate a range of electronic devices, *eg electronic toys*, examining the user interface, how the circuitry is packaged, the input and output devices, and instructions for use and maintenance. Put this work in context by discussing with the pupils:

- the wide range of electronic products available
- what needs they meet
- how these needs were met before electronic systems were available
- how easy electronic products are to use
- the environmental issues raised by electronic products

Extension: some pupils may also use their findings to help them prepare to write a user guide (for the DMA).

■ to identify the need for, and constraints on, electronic systems that support care in a range of contexts, *eg young children, elderly people, pets, plants*

■ Discuss with the pupils situations in which care for someone or something is needed and talk about the opportunities for developing electronic devices to support such care.

■ to consider the range of opportunities for sensing, signalling and control provided by electronic systems, *eg environmental signals, environmental control*

■ describe and explain features of a product's design, the electronic systems used, and their functional purpose in an electronic system

■ evaluate the effectiveness of product documentation

■ describe the possibilities for improving care in a given situation, listing the advantages and disadvantages of each

■ suggest approaches to using electronics to improve care in a given situation, listing the advantages and disadvantages of each

Language for learning when reviewing product documentation

- Ask pupils to work in pairs to evaluate the documentation that accompanies an electronic product in terms of:
 - readability
 - clear sequence of information
 - relationship of text to diagrams or pictures
 - ease of use
 - safety issues
 - overall rating for usefulness
- Ask each pair of pupils to produce a flip chart summary of their evaluation, with subheadings and bullet points, for classroom display (this could be a 10-minute task). Class discussions can build on this work and lead to the identification of general criteria for an effective user guide.



Health and safety – care should be taken to ensure that pupils assess immediate risks when carrying out product evaluation activities, *eg pupils should be reminded about the dangers of mains electricity and instructed not to attempt to unplug or take apart domestic appliances*. Clear information should be given and activities supervised if products have sharp edges or pointed elements. Electrical equipment should be tested at least every 12 months, *eg PAT (Portable Appliance Test)*

■ essential activities

○ optional activities

Learning objectives

Pupils should learn:

- to identify some important issues, *eg environmental issues, running costs*, that result from introducing electronic systems
- to consider the constraints on the design of electronic systems that result from the setting, *eg low cost, ease of use, ease of maintenance*

Possible teaching activities

- Ask the pupils to make a list of electronic products in their home and to note:
 - what they are for
 - how easy they are to use
 - their initial and running costs
 - how important they are to the family's life

Learning outcomes

Pupils:

- identify and describe benefits and costs that might arise from using electronics to improve care
- identify why particular approaches to care have been used for practical reasons

Points to note**FOCUSED PRACTICAL TASKS (FPTs)**

These practical tasks should focus on the knowledge, skills and understanding outlined in 'About the unit'. They should give pupils an opportunity to practise any new skills they will need during the DMA.

- to design, model and test simple electronic circuits

- Show the pupils how to design and model electronic circuits, *eg model and test circuits using system kits or another physical prototyping system; use computer simulation to model and test electronic circuits.*

- design, model and test simple electronic circuits, *eg sensing circuits, timing circuits*

- to design PCB masks and use them to create a PCB

- Show the pupils how to design and make PCBs, *eg use PCB design software to translate system-based prototypes or simulated circuits into a PCB mask, and produce a PCB from the mask using photo etching.*

- design, etch and drill their own PCB

- to design and model potential products, to show what they will look like and to confirm that they are appropriate for their intended purpose
- that an electronic circuit is just one aspect of a high-quality electronic product

- Set up activities that give the pupils an opportunity to carry out product design and modelling for an electronic product, working to realistic constraints, *eg modelling novel designs for a palmtop computer.*

- create a design for their product and model it in 3-D to verify its appropriateness against criteria
- include product considerations in their electronic designing

- about sequential and continuous control, and understand the differences between them
- how to draw meaningful systems diagrams and understand their relationship to control systems

- Set up activities that give the pupils an opportunity to explore a range of different control systems and use systems diagrams to show how the control system operates, *eg set up electronic systems using a systems electronics kit and draw systems diagrams; construct a system circuit based on a systems diagram.*

- classify simple control systems, *eg traffic lights, a thermostat*
- use systems diagrams to describe a variety of control systems

■ essential activities

○ optional activities

Learning objectives

Pupils should learn:

- about feedback, and how to use systems diagrams to illustrate the difference between systems with and without feedback
- to use systems diagrams to help them to design electronic control systems
- to design a user interface for an electronic product that suits its purpose and intended user(s)

Possible teaching activities

- Set up activities in which the pupils explore feedback systems, identifying the difference between 'open loop' systems in which the output signals do not affect the input signals, and 'closed loop' systems in which the input signals are affected by the output signals, eg
 - set up systems with and without feedback using a systems electronics kit, and draw systems diagrams to show the presence or absence of feedback
 - draw the systems diagrams for existing products, showing the presence or absence of feedback
- Ask the pupils to use systems diagrams in the design of electronic systems. This could be linked to the first activity above in the FPTs section, ie to design and model simple electronic circuits, eg by providing design briefs for a range of electronic products that involve the pupils expressing a design as a systems diagram and modelling the design using a systems kit.
- Set up activities in which the pupils design a user interface for a range of electronic products with different constraints. This could be linked to the third activity above in the FPTs section, ie product design and modelling for an electronic product, eg designing an innovative user interface for a palmtop computer designed for a child, an elderly person or someone with a disability.

Learning outcomes

Pupils:

- use systems diagrams to describe the difference between a system with feedback and one without, eg the difference between cooking on a barbecue and in a modern oven with a thermostat
- design and model electronic control systems with the help of systems diagrams, eg sensing circuits, timing circuits
- design and implement a suitable user interface for an electronic product

Points to note

■ essential activities

○ optional activities