Unit 13 Control systems

About the unit

In this unit pupils explore ICT systems through the scenario of designing a new water ride in a theme park. The ride must be a new concept, water based and involve some kind of boat or raft. The design of the boat is not important; the focus is on developing a ride where a number of individual boats move through a water channel safely and under control. The system could involve a feedback loop.

The pupils assess the requirements of a new ride, plan and develop a safety control system. The work provides them with the opportunity to evaluate the use of technology and reflect on its use in other situations. Pupils develop their abilities to plan, build, test, evaluate and document their use of control systems, as well as extending their skills in using sensors and control software.

Pupils might test their procedures using a variety of input and output devices, with no need to build models.

This unit is expected to take approximately 10 hours.

Where the unit fits in

This unit builds on the understanding of systems, which was established in unit 6 'Control: input, process and output' and unit 1 'Using ICT', and the specific control techniques in unit 5 'Data: designing structure, capturing and presenting data'. It provides the basis for more advanced systems design, implementation and evaluation in further year 9 units.

Expectations

At the end of this unit

most pupils will: develop, trial and refine sets of instructions to monitor and control a system, including the development of a number of procedures (with variables combined into a single system); design a system which meets identified needs; develop a presentation which demonstrates an awareness of purpose and audience, using a variety of media

some pupils will not have made so much progress and will: understand how ICT devices can be used to monitor and control external events, using sensors and software to produce sets of instructions to control events; understand that a system needs to be designed to meet specified needs; develop a presentation which records their system

some pupils will have progressed further and will: develop systems for others to use which respond to events and make appropriate use of feedback; identify advantages and limitations of the system in relation to its requirements; have used a range of techniques for collecting and combining information in a presentation to the specified audience

Prior learning

It is helpful if pupils have:

- learnt the function of, and used, simple sensors and switches
- used control software
- approached the planning of a system at a basic level
- used a presentation package

Language for learning

Through the activities in this unit pupils will be able to understand, use and spell correctly vocabulary relating to systems design, *eg procedure, module, counter, input and output, testing, documentation, algorithm.*

Resources

Resources include:

- one or more control boxes
- at least three switches per control box
- three or more sensors, with a minimum of two light sensors and one pressure sensor (depending on format of design) per control box
- a programming environment which allows the interfacing of external inputs and outputs
- presentation software
- video and/or images of theme park rides

Extension and enrichment

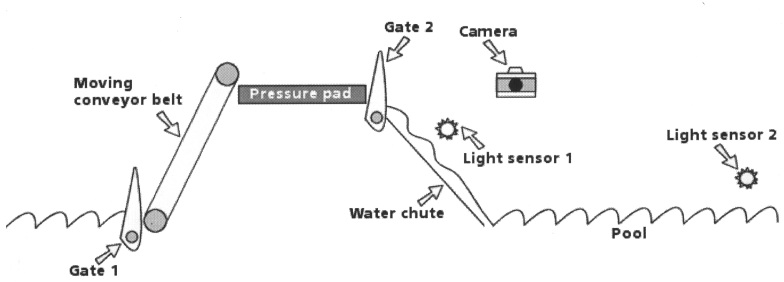
- A visit to a theme park would provide a range of opportunities for research and stimulus material. Pupils could use a digital camera to record images and video for the unit.
- Teachers could make a pre-visit to a theme park to collect video and digital images.
- Simulation and games software relating to theme parks could be made available to out-of-school clubs as useful background experiences.
- An additional activity could be the planning and construction of physical models, including ones using water flow, which could then be used in conjunction with the sensors and systems.

Task

To assess the requirements for part of a new ride, to plan and develop a safety control system and then develop a presentation to the theme park management to prove the concept.

The specific activity links to a section of a water-based ride. The section of the ride includes the following elements:

- a channel down which boats move to the start of the ride
- a control gate to allow boats into the system
- a ramp to raise the boats up to a point where they can descend by gravity
- a rest point where boats wait until the ride in front is clear
- a control gate to allow the boats to move down the water channel
- a sensor to identify when boats are at the centre of the channel and to activate a camera to take a photograph of the boat and its occupants
- a further channel which boats pass along having travelled downwards, with a sensor to identify when the boat leaves the first channel and it is safe to allow another boat to descend



Below is an example of the state table for a single boat passing through the system.

	A	B	C	D	E	F	G	H	I	J
1	Log Flume State Table									
2										
3		One Boat	Boat	Gate 1	Moving belt	Pressure pad 1	Gate 2	Light sensor 1	Camera	Light sensor 2
4	1	Boat waiting to start	Yes	Closed	Off	Nil	Closed	Off	Off	Nil
5	2	Boat accepted on ride	Yes	Open	On	Nil	Closed	Off	Off	Nil
6	3	Boat moves up hill	No	Closed	On	Nil	Closed	Off	Off	Nil
7	4	Boat reaches summit	No	Closed	On	Yes	Open	Off	Off	Nil
8	5	Boat goes down water slide	No	Closed	Off	Nil	Open	Off	Off	Nil
9	6	Boat passes camera	No	Closed	Off	Nil	Closed	Yes	Yes	Nil
10	7	Boat reaches pool	No	Closed	Off	Nil	Closed	Off	Off	Yes
11	8	End process	No	Closed	Off	Nil	Closed	Off	Off	Nil
12										

1	Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
Activity 1				
	• that control systems underlie many systems in society • that it is possible to describe systems in a structured manner using standard conventions • that many real-world systems focus on safety issues	• Lead a discussion to: – introduce the context – discuss the nature and form of some different rides – illustrate the range of issues with video – elicit a range of issues or areas where ICT can help support the effective management and safety concerns in a theme park • Following a broad conversation discuss the specific ride to be investigated and how safety on such rides is of vital importance. Either use a video to stimulate discussion of danger points and control that is required, or brainstorm the safety points and possible solutions, *eg that the boats must not catch up with each other, or be in certain sections at the same time; that there is a requirement to be able to know where the boats are, to control their movement at certain points in the system; and that there will be rules or conditions which control parts of and the whole system*. • Introduce the pupils to the specific task using a diagram of the section of the boat ride to be investigated. After an initial discussion ask pupils to work in groups to establish and describe the processes and to identify the control mechanisms required for the section of the ride.	• describe real-world systems that have underlying complex control systems • recognise that control systems exist to ensure people's safety • describe the components and relationships of the system	• The quality of the resources illustrating theme park rides is crucial to effective analysis of the issues and systems, *eg video clips of a ride would be the best*. • Some schools may be able to make use of a school visit. • Prepared criteria for evaluating rides would enable pupils to assess the rides. • There are a number of theme park simulations which could provide useful additional stimulus material for this section. • Homework could include a simple task using a worksheet, where there is a need for sense and control, which the pupils must assess using the criteria learnt during the lesson.
Activity 2				
	• that control systems can be represented diagrammatically • that algorithms can be tested using state tables • that inputs and outputs can be defined for each part of the system • the function and application of counters	• Discuss with the class the key points identified in activity 1 and any examples discovered in homework. Review the use of diagrams to represent the system flow and control, *eg a simple diagrammatic structure may suffice, although it is possible to use standard flow diagram symbols or the system used by the software in the school for sense and control*. • Provide an outline structure that all the pupils can work to and then with a large screen or overhead projector (OHP) to support the work, develop the diagram of the ride and its control mechanisms and discuss the inputs and outputs to the system. In this example the system has a number of key sections: a pond with a control gate providing access to the ride; the belt to raise the boat to the top of the system; a control gate to let boats descend by gravity; a sensor to trigger a camera and a sensor to identify when a boat leaves the main section of the ride. • Discuss and agree the final structure of the system and provide pupils with a system diagram. Ask pupils to work in pairs to begin to specify the modules, inputs, outputs and actions for each part of the system as a state table, which can then be completed for homework.	• produce a system diagram, and identify inputs and outputs for each part of the system and the principles underlying the process • test algorithms using appropriate techniques	• An effective method to support class activity would be to use an OHP or a large screen display to draw the system diagram. • It may be useful to prepare a pro forma, with correct columns and headings (and a correct system diagram) to help with the development of the state table. • Homework could be the completion of the state table for the system and a brief description of how one of the sections of the system might work in detail.

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
Activity 3			
• to translate plans into specific procedures • to implement conditions, and control constructs and counters using inputs and outputs • the need to document systems effectively • to document their procedures • to set up and test elements of the system	• Review the pupils' homework and the correct solution to the state table. Discuss with the pupils the need to extend the state table, *eg to investigate when there is more than one boat in the system to ensure that it is still safe*. • Review software and control techniques and introduce new techniques that are needed in this activity, demonstrating where necessary, and discuss their application with the pupils, *eg illustrate the development of a procedure to activate the camera switch and how it can receive input from a light sensor, and in this example the need to know when a boat has passed through a section of the ride*. • Describe and discuss the task with the pupils and identify one section, *eg the camera operation*. Ask pupils working in groups of four to describe the section carefully, identify the inputs and outputs, and generate a procedure to ensure the camera will take a picture. This can be extended by asking pupils how they will position the sensor to ensure the photograph is of the people screaming on their way down the slide. • Draw the pupils together and review their progress. Discuss and illustrate the need to document each procedure and its variables, inputs and outputs. Ask pupils to then work individually to document the procedure they have completed. • Ask pupils to work in groups to develop procedures for the remaining parts of the system, *eg for the different sections of the ride*, and the information that needs to pass between each section. • Following a class discussion on their progress, ask pupils to develop and test individual components and ensure the procedures work together.	• produce working procedures including the use of conditions, counters, inputs and outputs • document systems effectively • set up and test elements of the system	• The camera shot is the procedure with the simplest solution and provides a good starting point. Pupils should be able to select the appropriate looping construct. • Effective and timely intervention is vital to ensure pupils do not spend too long going down blind alleys and remain on task. • The provision of paper copies of the tasks and crib sheets of operators applicable to the specific software can be helpful aids. • This unit introduces the concept of documenting ICT systems and it is important to introduce the idea near the beginning of the process. It is also important to reinforce the need for documentation throughout the unit. • There might be the opportunity to collaborate with the design and technology department in the construction of a boat model, not necessarily using water. • Homework could extend the work in class or complete the planning, *eg homework could be to extend the state table to illustrate whether the system works with two or three boats*. As sections of the system are completed homework could include the production of documentation.

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
Activity 4			
• the need for evaluation and refinement to ensure systems are effective • to develop an understanding of diagnostic techniques • to test and evaluate the whole system in relation to the specified requirements	• Revise with the class the original aim of the system being designed, *eg to safely control the movement of boats in a ride and to take a photograph of the people going down the slide*. • Ask pupils to work in groups to test and evaluate their systems against the design brief. One example of a fault which could be discovered is the incorrect implementation of a counter, *eg the procedure for the end of ride section sensor may add to the counter rather than subtract, or the initial value may not be reset, resulting in no boats moving through the system*. • If the system works as specified, encourage the pupils to evaluate how realistic the system is and how it could be improved, *eg pupils might suggest there would be a number of boats: two new counters would need to be implemented to store information about the number of boats at the beginning and end of the ride. A more advanced solution might be to develop a closed loop system where the boats are returned to the start*.	• use diagnostic techniques to test systems • effectively evaluate through constructive criticism of their own systems leading to refinement as required	• It is possible to test and evaluate the system without a physical model, where the pupils simulate the movement by applying input to the sensors.
Activity 5			
• the need to develop a presentation for a specified purpose and audience • to apply and develop the facilities of a presentation package, using a mixture of media • the need for reflective evaluation of the processes and tools used • to consider the advantages and disadvantages of the specific software, peripherals and hardware employed	• Discuss with the class the purpose of the presentation, *eg to prove to the theme park's management that your ride is safe*. Ask pupils what the most appropriate software would be to complete this task and discuss the text and images that could be used. Following class discussion, decide on the software to be used, *eg a presentation package*. • Ask pupils to work in pairs to develop their presentation, incorporating appropriate text, images and screen shots, *eg an image from the control software illustrating the safety features of their procedure*. • Using the groupings from the earlier work, ask each group of four to present their findings to the class. One model for this approach would be for two of the groups to deliver the best presentation, while the other pair demonstrates the working software. • Discuss the need to evaluate the software with the class writing the advantages and disadvantages of the systems and the software using an OHP or word processor connected to a large-screen display.	• demonstrate skill in the use of a presentation package for a specific purpose and audience • use reflective evaluation skills in the evaluation of the processes and tools used	• A digital camera would be a valuable tool for pupils to record their work and incorporate images into their presentations.