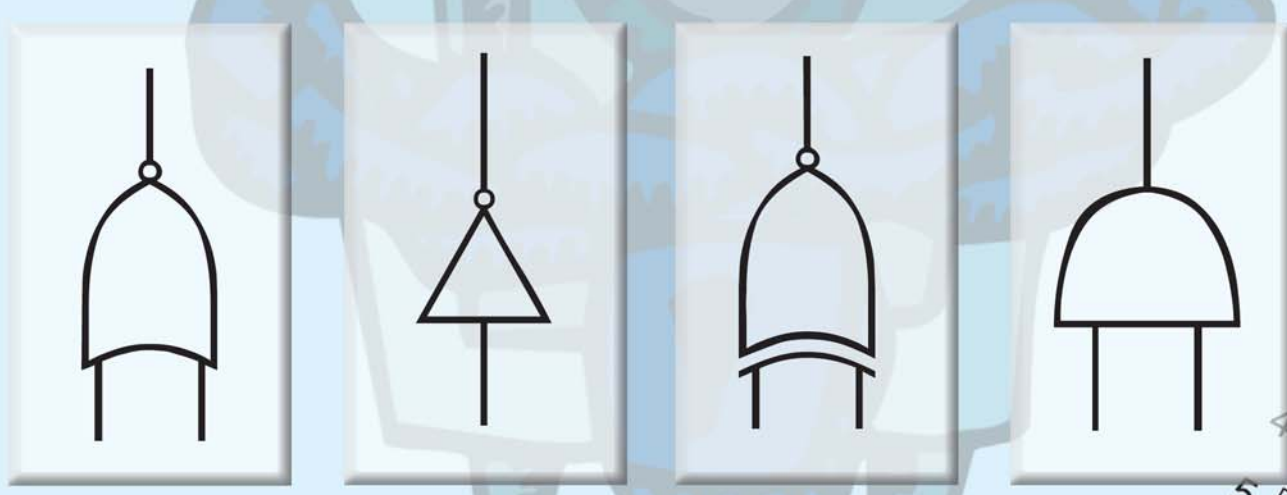
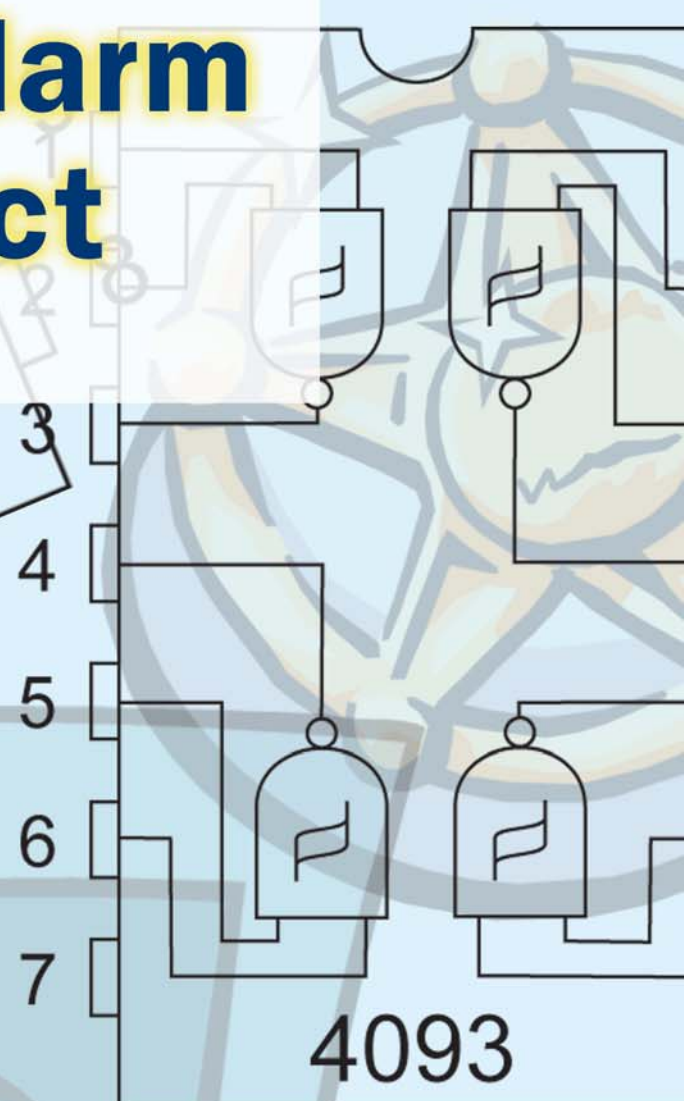
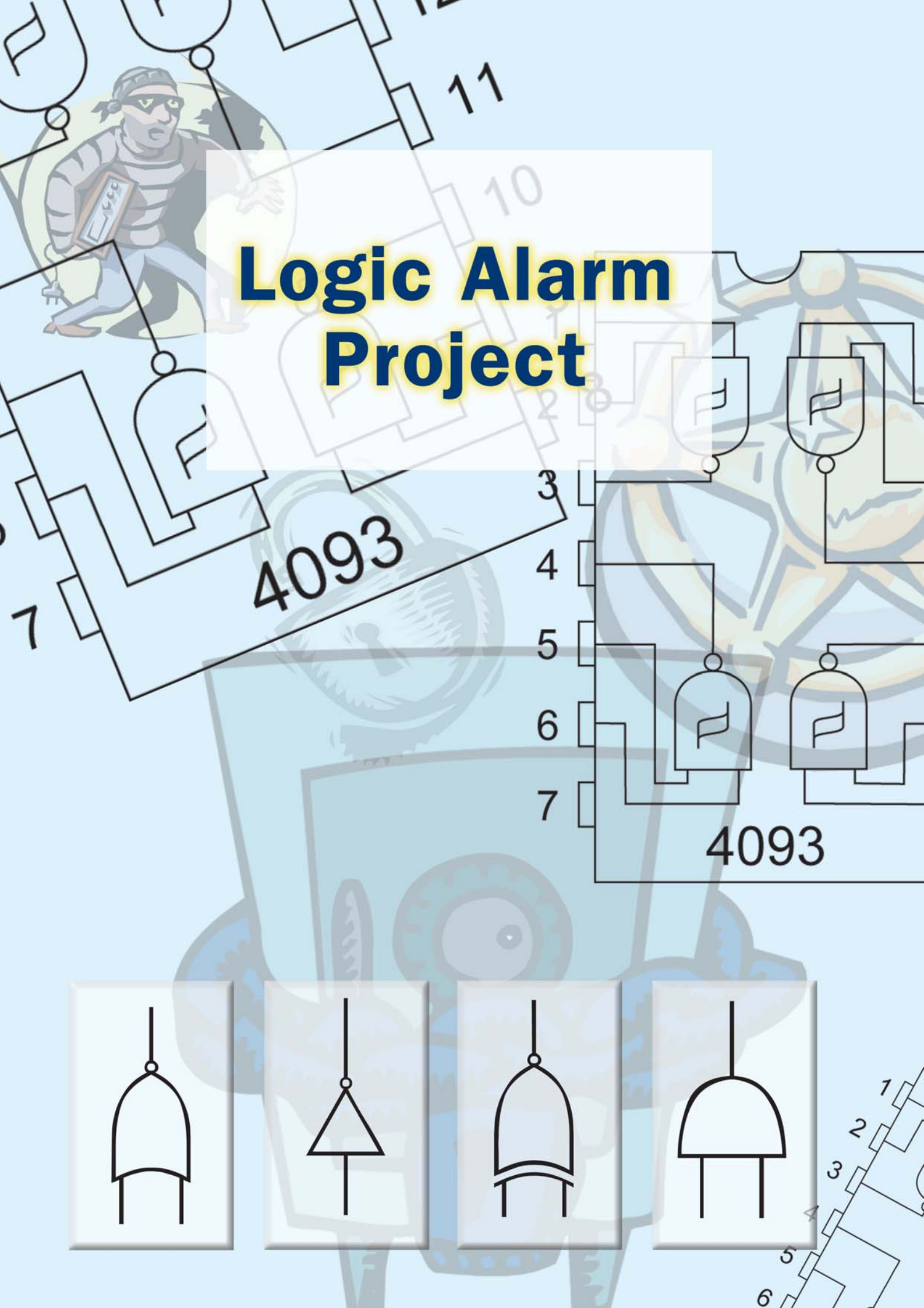


Logic Alarm Project



PROJECT INTRODUCTION



The project you are about to undertake will provide you with an introduction on how to tackle a project at GCSE level. This material will guide you through the design process. When you reach your final year at GCSE you will be able to apply some of the information gained along with the experience you have built up to help you solve your own design problems.

When you are given a problem to solve, it is important to break it up into a number of smaller activities. This allows you to make sure that you have covered all the important aspects that might affect the design.

There are many different models of how to solve a design problem. They all offer guidance to help focus your work in the most effective way to solve the problem. It may not be possible to follow the design process in strict order. Frequently you will need to conduct further research whilst you are developing your ideas.

Whichever design process you choose to follow, it is important that you record your thoughts so that those assessing your work can see how you have developed your ideas and reached your solution.

PROBLEM OUTLINE:

The first stage in the design process is to clearly establish what the problem is that you are going to solve. Your teacher or the examination board might provide the problem outline. If you come up with your own, it is important that you are interested in the problem and have some idea about how you are going to tackle it.

An electronics company wishes to market a low cost alarm targeted at protecting personal belongings.

DESIGN BRIEF:

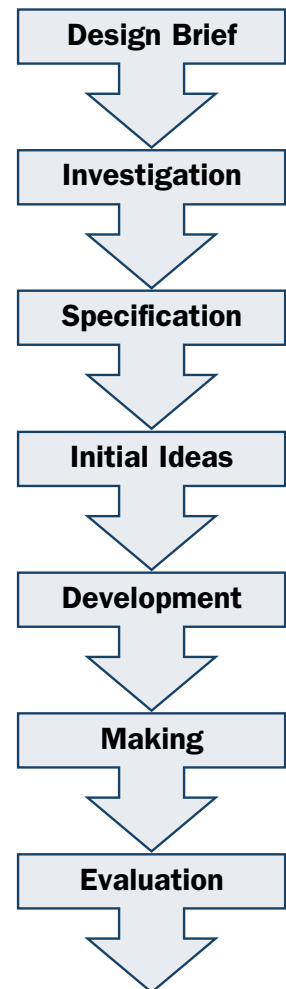
The design brief is a summary statement that clearly states the aim of the design project and in a few words states the kind of thing that is needed. The statement should give your design work a clear focus without applying restrictions.

“Design an electronic alarm” is a vague sentence that does not help the designer to isolate the problem to be solved. “Design a personal alarm” is a more specific statement that will help the designer focus on the problem to be solved. A clear design brief should include the following information:

- What the product is to be used for:
- Who is likely to be using it:
- Where the product is likely to be used:

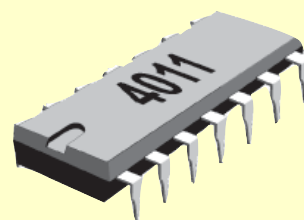
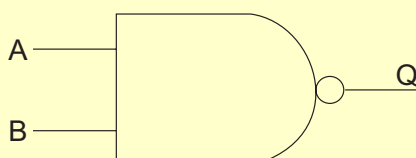
The design brief gives the designer a statement from which they can conduct their initial research to build up background knowledge about the problem.

The design brief is normally written as a paragraph. You should refer back to your design brief during the project to check that your ideas are developing in the right direction.



TASK

Write a design brief for your Alarm project



INVESTIGATION & RESEARCH

Investigation and research are important aspects of your project. The collection and analysis of essential information will help build your experience and thus help you solve the problem effectively.

Research often takes place throughout the project and it is important to keep a record to show the information you have considered. It is also important to include analysis of your information so that you understand its relevance to the design.

You can undertake research in a variety of ways:

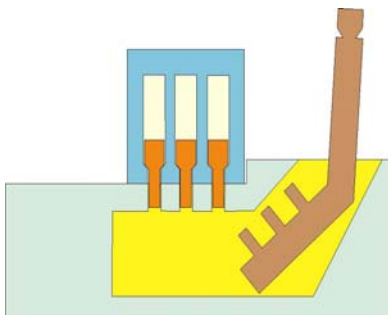
- Collect articles/images from books, specialist magazines, brochures and catalogues.
- Visit shops that stock similar items.
- Talk or write to experts for advice or information.
- Make simple models to test your ideas.
- Disassemble existing products to find out how they work.
- Use the Internet to search for information.



SECURITY

Methods for protecting property have been around for thousands of years. The first locks were invented by the Egyptians around 2000 BC and were made from wood. Today with the aid of electronics, methods of protecting our property are now more sophisticated.

Electronics has allowed us to expand the number of situations to which an alarm can be applied. As a result alarms are now commonly used in a variety of situations that affect our everyday life.



At home we can protect our houses with sophisticated entry alarms. Whilst smoke alarms now offer us a reliable method of detecting fires early and as a result have saved many lives. You are about to design an alarm, which is targeted on a particular market.

Your research and evaluation of existing products will need to be comprehensive and systematic. To be successful you will need to look closely at what other designers and manufacturers are producing.



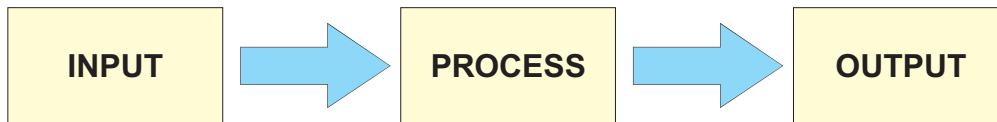
TASKS

1. Make a list of possible research sources available to you to help you build up background information into personal alarms.
2. For one of the sources you have identified, collect the information and present your findings, taking care to include analysis of the data.
3. Students use a variety of bags to carry their personal belongings around with them whilst at school. Survey the types of bags people carry.



SYSTEMS DESIGN

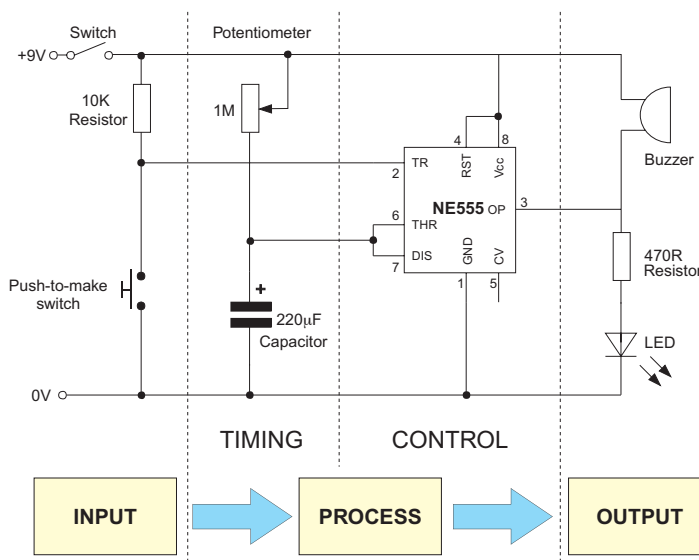
Designers of electronics will often use a systems approach to help them design a new product. A systems design uses a series of small linking circuits to solve a problem.



The above block diagram is often used to represent a system

The designer's first task is to break the design problem up into a series of blocks, each block represents a part of the circuit with a specific function to perform. The designer then designs each block in the circuit using components. The advantage of designing a circuit in this way is that it allows the designer to build and test each section of the circuit. As a result, it makes it easier for the designer to find any problems.

Most circuits can be broken up into three blocks, input, process or control, and output. The input section in the circuit normally reacts to changes in the environment, for example, an increase in temperature or light level. The process or control section will react to the input and then, depending on how it has been designed, alter the output by switching it on or off.



The diagram of a NE555 monostable circuit shows how a system diagram relates to a circuit diagram.

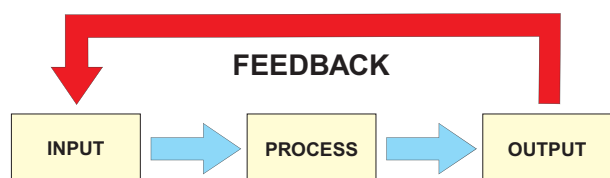
The input to the system is from the push-to-make switch. The process or control section of the circuit is the delay provided by the variable resistor and capacitor linked to the NE555 timer. The output is the buzzer and LED, which indicates when the timer is operating and when the timing period is over.

FEEDBACK

The system described above is an example of an open-loop system. Changes to the input through the system, cause the output to change. The system is limited because the input is not affected by the output.

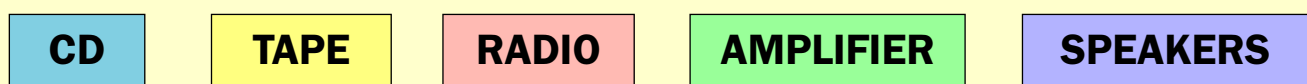
By providing feedback from the output we can influence the input, changing the way the circuit behaves. As a result, if the output is incorrect the input circuit can change to correct it.

Cruise control in a car uses feedback to alter the car's speed. If the car is travelling faster than the set speed, the feedback will reduce the amount of fuel to the engine and therefore slow the car.



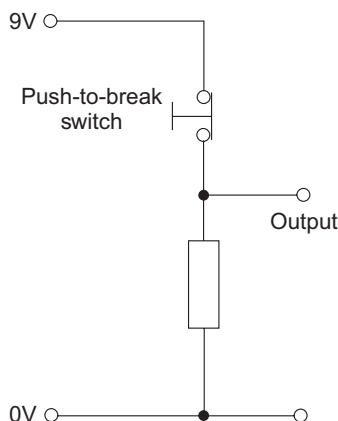
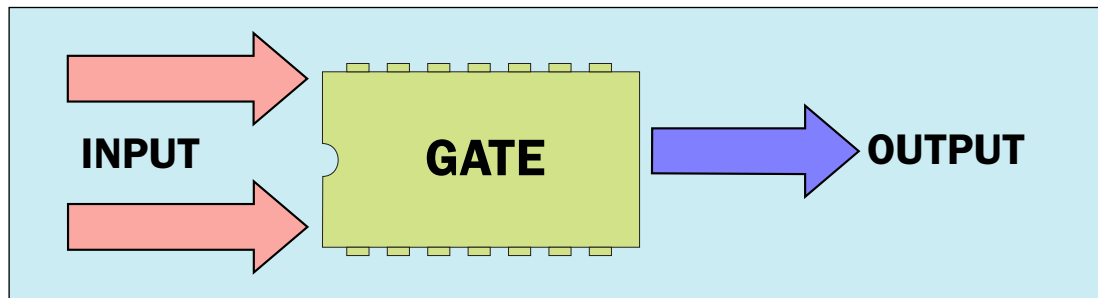
TASK

Draw a simple diagram using the blocks provided to represent how the sections of a home audio system relate to each other. The arrows should indicate the flow of data.



LOGIC GATES

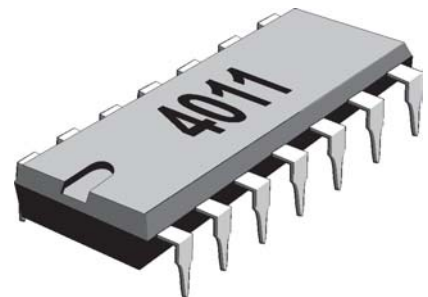
Logic gates are integrated circuits, which have digital inputs and outputs. A single IC may contain several logic gates. The logic gates use symbols to represent their functions.



Logic gates are digital switches that open and close to set input conditions. The diagram to the left shows the operation of a NOT gate. When the push to break switch is pressed, the output is connected via the resistor to 0V.

By releasing the switch, the output is connected to 9V through the switch. Pressing the switch changes the output between 0V and 9V.

When the output is at 0V it is called Low or Logic 0. When the output changes to 9V it is called High or Logic 1



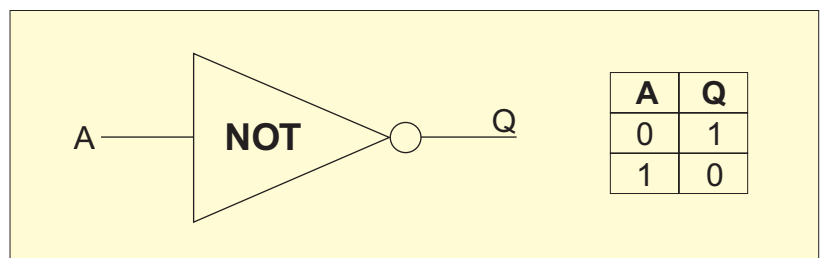
TRUTH TABLES

Truth tables are necessary to help us map all the inputs and outputs from a logic gate or circuit. Truth tables show the range of inputs alongside the corresponding outputs. 1 is used to denote High and 0 to represent Low.

NOT (4069 or 7404)

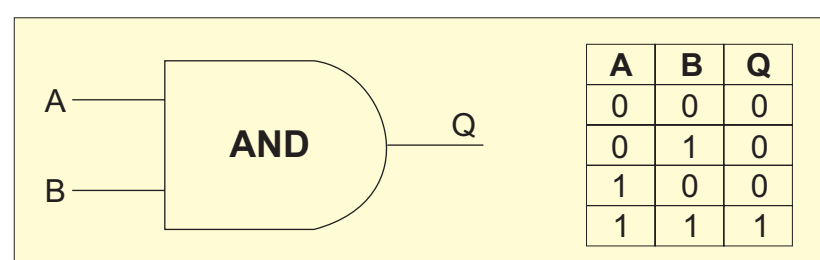
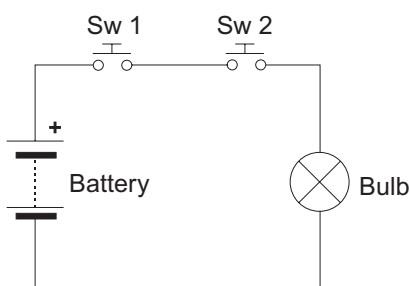
NOT gates are frequently called inverters. They only have one input.

When the input A is at logic 1 then the output will be opposite 0. The output always inverts the input.



AND (4081 or 7408)

The operation of the AND gate can be simulated by the circuit below. The bulb will only light if both switches are pressed together. The gate gives logic high only when both inputs are high. If either or both of the inputs are low then the output will be low.



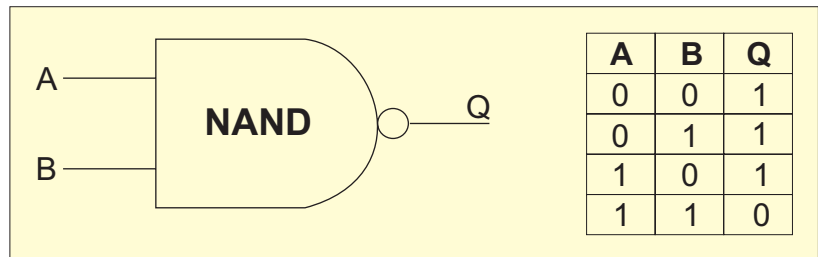
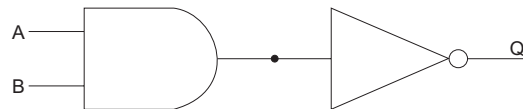
LOGIC GATES

NAND (4011 or 7400)

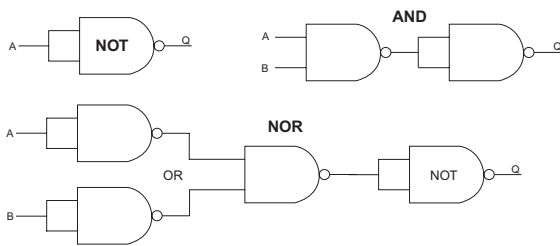
The NAND (Not AND) gate is an AND gate that has the output inverted. The symbol uses the AND symbol followed by the inverter or NOT symbol.

The NAND truth table outputs are the opposite of an AND gate.

NAND gates were the first gates to be manufactured as ICs. They were popular because you can construct all the other gates from NANDs.

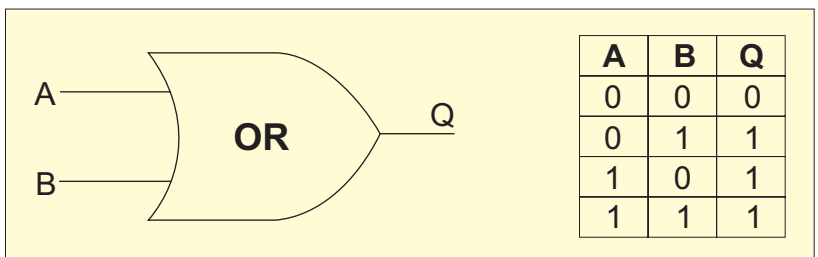
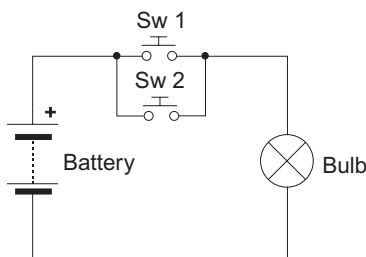


Being able to build other gates from NANDs is very useful to designers. It means that if a circuit only requires a few gates, they can all be made from NAND gates combined to form other gates. This also has the advantage to manufacturers that they only have to buy one type of gate and as a result can purchase them in bulk and negotiate larger discounts from suppliers.



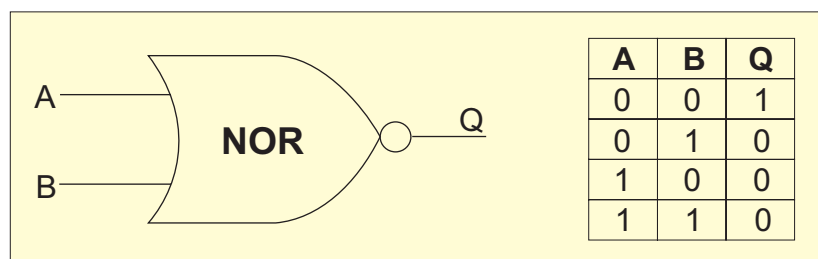
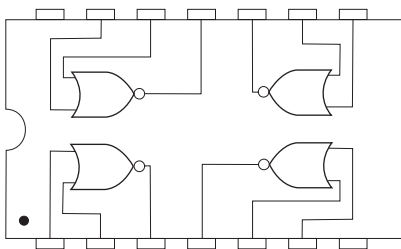
OR (4071 or 7432)

The OR gates output will be high unless both of the inputs are low. In the diagram below, if either Sw1 OR Sw2 are pressed the output will be high.



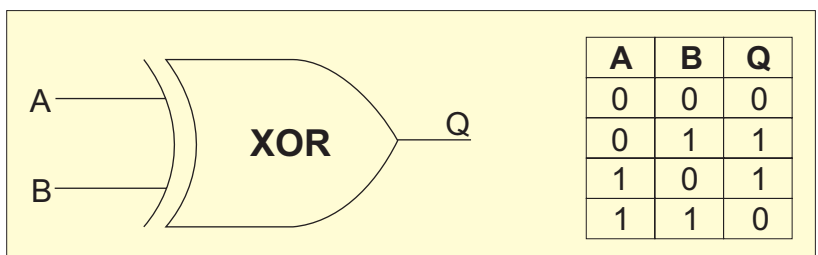
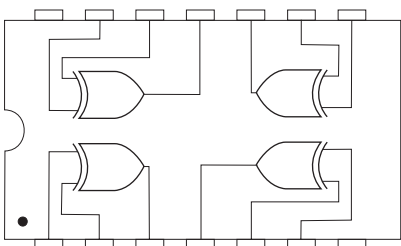
NOR (4001 or 7402)

The NOR (Not OR) gate operates the same as an OR with its output inverted by a NOT gate. The truth table outputs for the NOR gate are opposite those for an OR gate.



XOR (4070 or 7486)

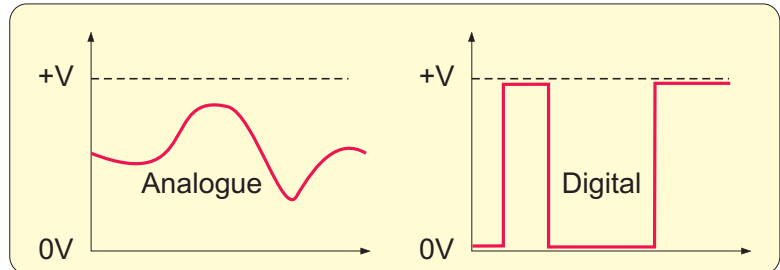
The XOR (exclusive OR) gate is a special form of OR gate. If either of the inputs is high, its output is high. If both inputs are high then the output will be low.



ANALOGUE AND DIGITAL SIGNALS

A radio volume control is an example of an analogue control. Turning the volume control alters the sound level. Switching a light on and off is an example of digital control. In a digital circuit inputs and outputs that are either on or off.

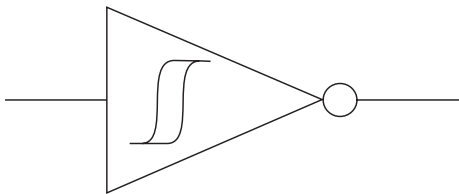
Sensors such as LDRs or Thermistors provide analogue outputs. Their resistance will vary according to changes in light or temperature levels. However, to use these signals in a digital circuit they need to be converted. This is what is called analogue to digital (A/D) conversion.



TASK

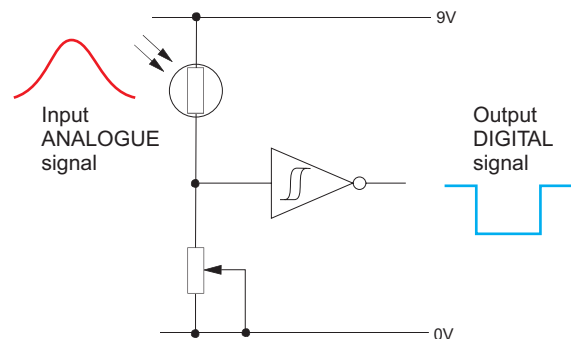
1. List the advantages and disadvantages of using the analogue and digital outputs on a hi-fi system
2. Name three other examples of where analogue and digital outputs are used.

SCHMITT TRIGGERS

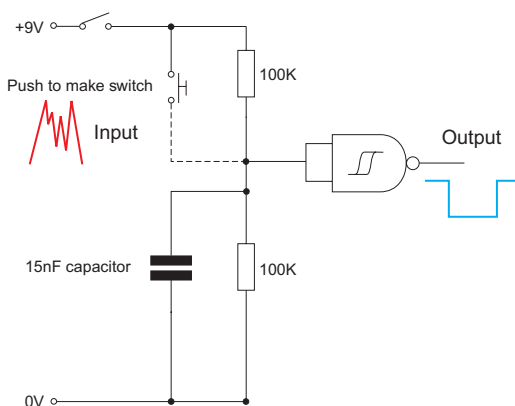


When connecting an analogue signal to digital, designers will often use a Schmitt Trigger in the circuit. An analogue signal contains many small fluctuations. These can be very confusing to a digital circuit, since it thinks each is a new instruction. The Schmitt trigger provides a clean signal into a digital circuit from an analogue sensor. The Schmitt trigger acts as an interface between the two types of circuit.

The diagram to the right shows a Schmitt Trigger used to convert an analogue signal into a digital signal. As the light level falling on the LDR changes so does its resistance. This analogue signal is then fed into the Schmitt trigger, which cleans up the signal to produce a clear digital signal. By feeding the analogue signal through the Schmitt trigger the signal has also been inverted.



SWITCH DE-BOUNCING



When two switch contacts are very close together, current can jump the small gap. This occurs just before and after switch contact is made. This condition is called switch bounce and can cause problems in digital circuits. The spikes in the input signal cause the digital circuit to think more contacts have made.

In the logic alarm circuit the first NAND gate on the IC has been connected so that it behaves like a Schmitt trigger, removing the unwanted spikes that are produced by the switch contacts and providing a clean digital output.

TASK

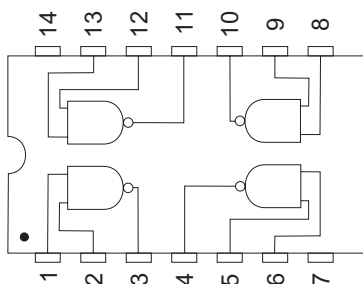
1. The Schmitt trigger inverts the signal from the LDR in the circuit above. Show with the addition of a few extra components how you could overcome this problem.

LOGIC ICs

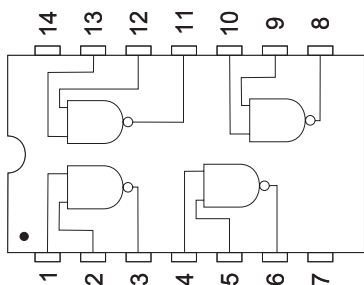
TTL and CMOS are the two main types of integrated circuits used for designing logic circuits. TTL stands for Transistor Transistor Logic and can be found in the Rapid Electronics catalogue as the 7400 and 74LS series ICs, whilst CMOS stands for Complementary Metal Oxide Semiconductor and are called the 4000, 74HC or 74HCT series ICs.

CMOS has the advantage that it will work directly from a standard 9V battery. The disadvantage of CMOS is that it can be damaged by a static charge on the input pins. TTL offers the advantage that it is less sensitive to static electricity and can tolerate higher currents. However, TTL chips do require a stabilised 5V supply, which adds extra cost to the circuit.

CMOS 4011 NAND



TTL 7400 NAND



ADVANTAGES

- Operates from a range of power supplies
 - 4000 3V to 15V
 - 74HC 2V to 6V
 - 74HCT 4.5 to 5.5V
- They consume little current
- High source current
- Has a high fan out (50)

DISADVANTAGES

- They are sensitive to damage from static electricity
- Unused inputs need connecting to either the positive or negative supply

ADVANTAGES

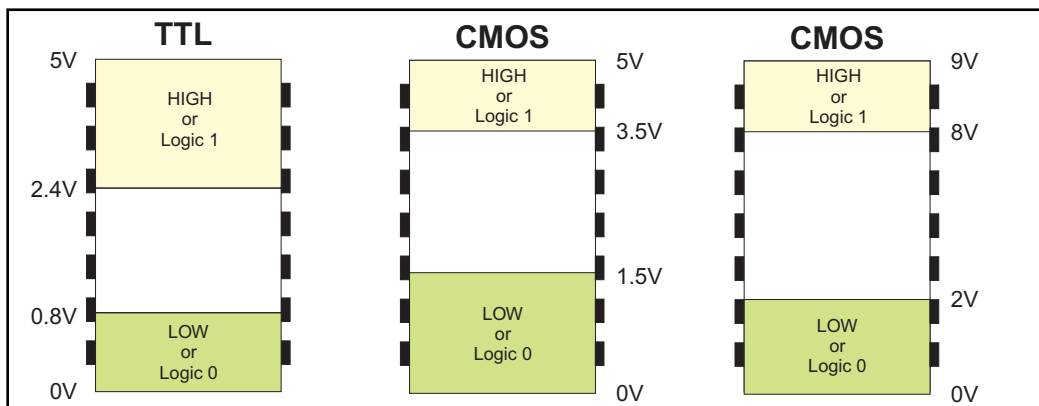
- Very fast switching speed
- Not sensitive to static electricity
- Unused inputs can be left unconnected

DISADVANTAGES

- Requires a stabilised 5V supply
- Use more current than CMOS ICs
- Has limited fan out (10)

LOGIC LEVELS

The logic high and low levels vary between the two types of logic ICs. The input voltage that is used to change the logic level is called the threshold voltage. It can be seen from the diagram below that this varies depending upon the IC used and the supply voltage. For TTL any input voltage above 2.4V will create high or logic 1. For CMOS the threshold voltage for high or logic 1 rises to 3.5V. When running a CMOS IC from a 9V battery the threshold voltage for high or logic 1 will rise to 8V.



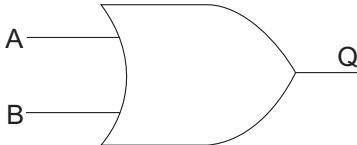
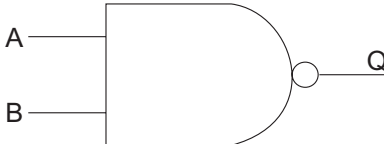
TASK

What type of logic IC would you use in the following design situations:

1. You needed to connect a large number of ICs together to create your circuit
2. You want to operate your circuit directly from a 9V PP3 battery.

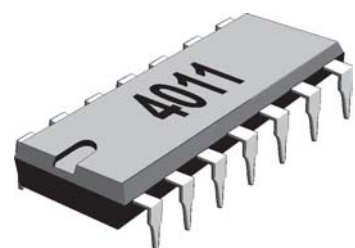
LOGIC GATE TEST

Complete the chart below by naming the gates and filling in the missing symbols and truth tables.

GATE NAME	LOGIC SYMBOL	TRUTH TABLE															
NOT		<table><tr><th>A</th><th>Q</th></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr></table>	A	Q													
	A	Q															
		<table><tr><th>A</th><th>B</th><th>Q</th></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td><td>1</td></tr></table>	A	B	Q	0	0	0	0	1	0	1	0	0	1	1	1
A	B	Q															
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0	1	0															
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A	B	Q															
XOR		<table><tr><th>A</th><th>B</th><th>Q</th></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr></table>	A	B	Q												
	A	B	Q														

NAME.....

SCORE.....



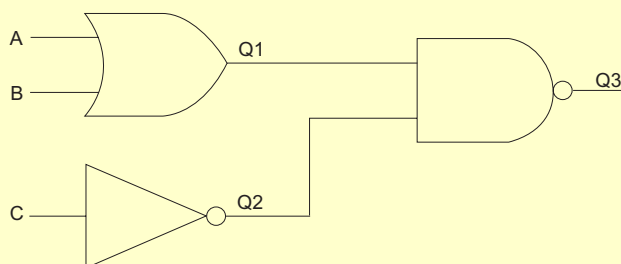
COMBINATIONAL LOGIC

Combinational logic involves using more than one type of gate to solve a logic problem. Designers are often faced with a situation in which they have a set pattern of input conditions in order to achieve an output.

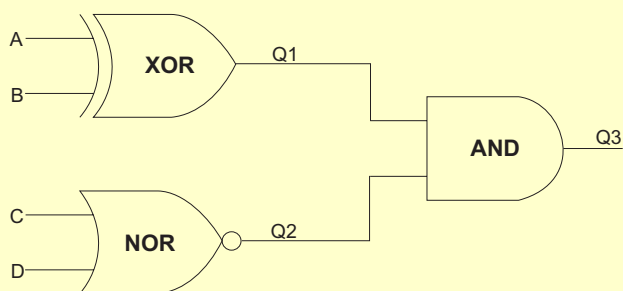
We can use Boolean algebra to solve complex logic problems. To help identify what happens to the output of these more complex combinational circuits we can use a larger scale truth table to map the outputs.

TASK

Complete the truth tables for the following combinational logic circuits.



Write down the table line numbers for 0 output from the above circuit.

[illegible]

Write down the table line numbers for Q3 output to give logic 1.

[illegible]

STARTING TO DESIGN

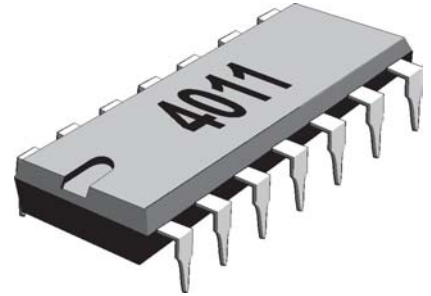
SPECIFICATION

Once you have established a clear understanding of the problem by conducting research, you are now in a position to write a specification. A specification is a detailed list of features that the final design must do. A good specification will list the important features in order of importance.

A specification would normally be written as a series of bullet points e.g.

- The alarm circuit must operate from a PP3 9V battery.

Specifications are an important part of designing because they provide a checklist against which you can review your ideas as you are working. They also give you something against which to evaluate your ideas and your finished product.



TASK

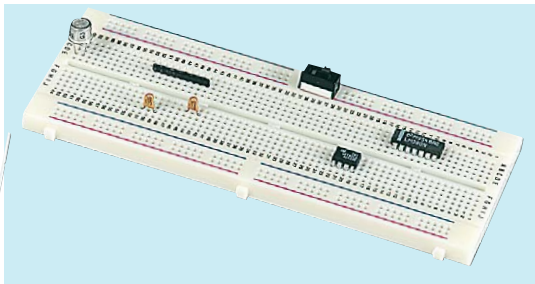
Write a specification for your Alarm.

- Make a list of all the features you need to include in the design.
- Place them in the correct order of importance.



INITIAL IDEAS

When you start to design, you will need to break the problem down into a number of sections. Initially this will be the circuit and case. Try to use the systems approach when designing your electronic circuits. You need to show that you have considered a range of circuit ideas for the INPUT, PROCESS and OUTPUT sections of your design.



You should try to develop a wide range of different ideas. Some of the ideas you will discard, others you will refine and develop at a later stage.

During your initial ideas it is important to model and test your designs. Prototype boards or computer simulation allow you to test your circuit ideas.

Write short comments next to your designs. These will prove useful when you come to develop your ideas.

Remember it is important to refer back to your design brief and specification. These will help you decide which ideas to develop further.

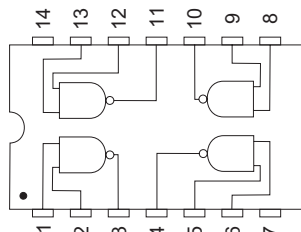
COMMUNICATION OF IDEAS

Effective communication of your design ideas is important. Good communication will help you understand and explain your ideas to others.

You should try to use a variety of presentation techniques to express your ideas. Not all drawings need to be formal. In the early stages use quick sketches and notes to record your ideas.

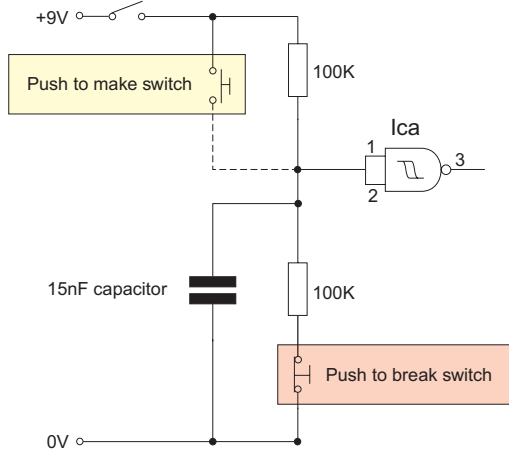
Colour helps to enhance your design sketches. Try using colour to highlight those designs you are interested in developing further. This will help the assessor follow the progression of your ideas.

When designing, don't be afraid of experimenting with new presentation techniques to enhance your designs.



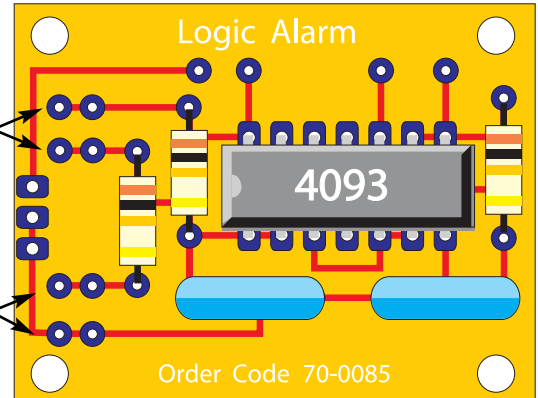
INPUT IDEAS

The diagrams below show that the Logic Alarm can be triggered by either the make, or break contacts. The PCB is provided with two sets of each contact. Your alarm can be triggered by any combination of contacts. For example, you could use a tilt switch attached to the make contacts so that if anyone tilts the alarm it will go off, whilst also using a wire loop between the break contacts so that if anyone disconnects the wire the alarm will be activated.



Make contacts

Break contacts



TASK

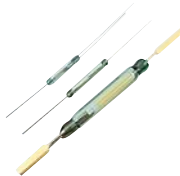
The Logic Alarm can be triggered by either a break or make in the circuit as described above. Using the Rapid Electronics catalogue, design how your alarm circuit is to be triggered. Include annotations with your drawings to help explain your ideas.

The following extracts taken from the Rapid Electronics catalogue will help you identify suitable sensors to incorporate into your design.

Refer to latest version for up-to-date pricing and more comprehensive selection of sensors.

Reed switches

A comprehensive range of rhodium contact miniature reed switches available in a variety of styles and contact ratings. See **60-0560** for suitable magnets.



Technical specification									
Case code	A	B	C	D	Case code	A	B	C	D
1	36	10	2.0	0.4	5	55	18.5	2.6	0.5
1A	46	15	2.54	0.6	6	55	18.5	2.6	0.7
2	55	14	2.3	0.5	7	70	36	5.6	2.5
3	52	14	2.6	0.5	8	79	52	5.4	2.5
4	55	14	2.2	0.35					

A = Overall length
B = Glass length
C = Diameter
D = Lead diameter

Type	Contacts	Case code	Contact rating (VA) max.	Switching current (A) max.	Switching voltage (V) AC max.	Pull in range (AT)	Order code
Micro	SPST	1	1.0	0.1	24	10-30	60-0520
Submin.	SPST	2	10.0	0.5	100	15-35	60-0522
Submin.	SPDT	3	3.0	0.2	30	15-30	60-0524
Submin.	SPDT	4	20.0	1.0	150	15-30	60-0526
Miniature	SPST	1A	10.0	0.5A	140	14-23	60-0515
Miniature	SPST	6	40.0	2.0	440	30-50	60-0528
Compact	SPDT	7	60.0	1.0	400	40-80	60-0530
Compact	SPST	8	120.0	3.0	1500	75-95	60-0532

Type	Order code	1+	25+	100+	500+
Micro SPST	60-0520	0.65	0.57	0.48	0.43
Submin. SPST	60-0522	0.50	0.40	0.34	0.30
Submin. SPDT	60-0524	2.05	1.68	1.50	1.33
Submin. SPDT	60-0526	4.75	3.99	3.41	2.99
Miniature SPST	60-0515	0.32	0.27	0.23	0.21
Miniature SPST	60-0528	0.65	0.57	0.48	0.43
Compact SPDT	60-0530	7.10	6.20	5.20	4.63
Compact SPST	60-0532	2.25	1.93	1.64	1.45

Miniature magnets

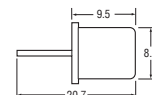
A range of miniature magnets to suit our range of reed switches.

Length (mm)	width (mm)	depth (mm)	Order code	1+	25+	100+	500+
12.7	3.2	1.6	60-0560	0.25	0.18	0.15	0.13
19.0	3.2	3.2	60-0540	0.53	0.42	0.32	0.29
28.0	4.8	4.8	60-0542	0.95	0.74	0.58	0.54
25.4	6.4	6.4	60-0544	1.60	1.26	1.02	0.96

Mercury vibration switch

Assemtech Europe

A switch specially developed for detection of vibration or motion enclosed in a metal housing which is tin plated for ease of soldering. The switch can be mounted at any angle and contacts are closed by vibration or motion of the switch. An inert gas infill and hermetic seal protects the switch contacts from the atmosphere and ensures long life and reliability in a wide range of normal and harsh environments. Applications include robotics, sensing devices and automotive alarm systems. **Assemtech type CM14-4D**



Technical specification

Contacts Single pole normally open
Contact rating 0.25A 250V AC
Operating temperature range -40° to +260°C

	Order code	1+	25+	100+	500+
Vibration switch	78-0765	2.10	1.75	1.55	1.45

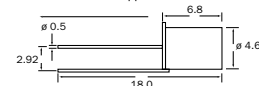
Linear acceleration switch

Assemtech Europe

The switch is fitted with a spring loaded contact which closes when the switch detects shock or acceleration above stated activation levels. Contact will open again when activation levels decrease. Applications include impact sensing, automotive crash and motion systems. Sealed contacts.



Direction of travel for acceleration applications



Technical specification

Activation level 5.0 ± 1.5G
Switching voltage (max.) 24V AC
current (max.) 0.25A
capacity (max.) 5VA
Contact resistance 100 max.
Operating temperature -20° to +85°C
Assemtech type ASLS5.0

	Order code	1+	10+	50+
Acceleration switch	78-1495	4.75	4.15	3.57

Mercury tilt switch

Assemtech Europe

A miniature mercury tilted switch encapsulated in a sealed nickel plated steel package designed for horizontal mounting. Normally open contacts close on 5° change from horizontal position. **Assemtech type CM1320-0.**

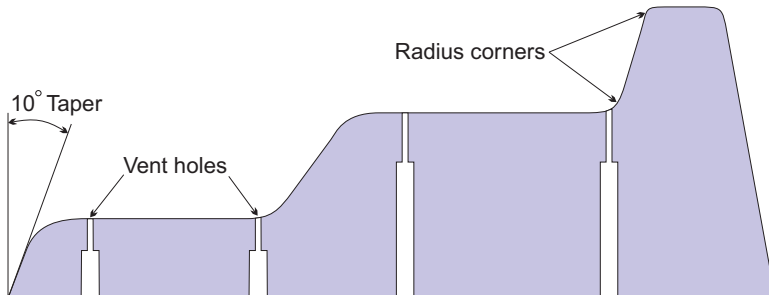


	Order code	1+	25+	100+	500+
Mercury switch	78-0770	1.25	1.03	0.90	0.82

CASE DESIGN

There are a variety of methods of containing your electronic products. The choice will depend on your design requirements.

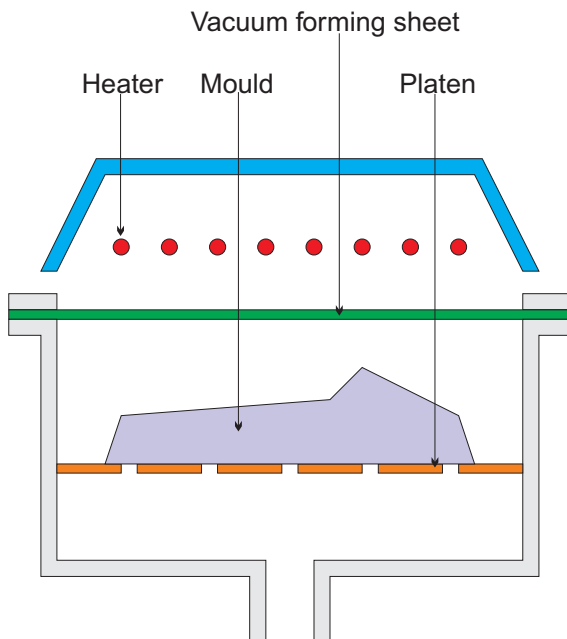
Vacuum forming is an ideal method for creating cases to hold your electronic products. High impact Polystyrene or ABS make good case moulding materials. The first stage is to design and make a mould.



There are a number of important features that need to be included to make a good mould design:

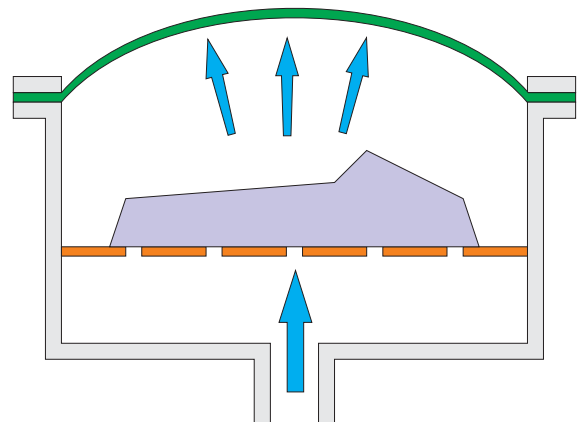
1. The mould sides must be tapered to allow the mould to be removed.
2. Vent holes need to be drilled to help draw the plastic when the vacuum is created.
3. There should be no undercuts, which will prevent the moulding being removed from the mould.
4. The mould needs a high standard of finish. Any marks will appear on the surface of the moulding.

VACUUM FORMING PROCESS



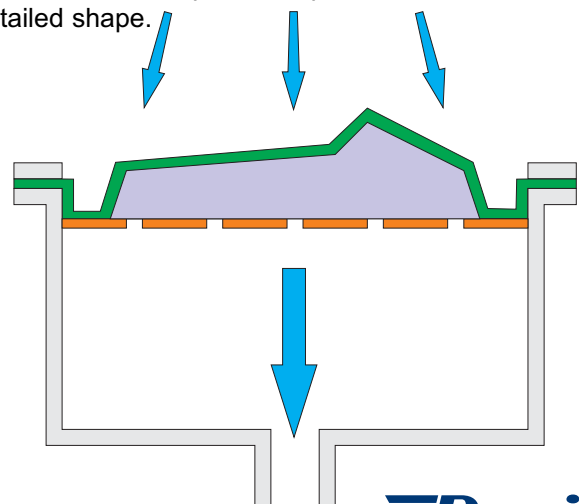
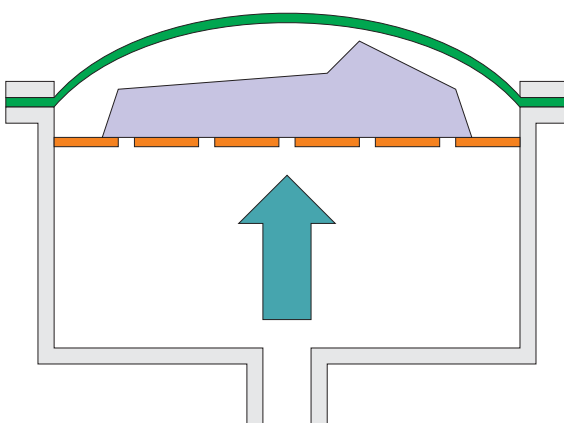
The vacuum forming sheet is first clamped into position around its edge by an airtight seal. The sheet is then heated from above by the radiant heaters in the machine hood.

When the sheet becomes soft and pliable, between 150° - 170° the heating hood is removed.



When the sheet is pliable and the heater has been removed, air is blown in under the sheet to stretch it. This is done to reduce the tinning on the moulding. The platen is now raised into the blown sheet.

The air is then drawn from under the moulding, creating a vacuum. The atmospheric air pressure above then forces the pliable sheet plastic over the mould taking up its detailed shape.



CASE DESIGN

MANUFACTURED CASES

There are a large number of manufactured cases that can be used to contain your prototype circuits. These are available in a variety of materials and styles.

ABS enclosures



A range of cases specifically designed for pocket-size electronic equipment. Manufactured from ABS with textured matt finish. **30-1960** and **30-1965** incorporate battery compartments which will accept two AA cells or one PP3 battery. All types (except the smallest which clips together) are screwed together via screws held in the base of the box. **30-3255** and **30-3265** have louvered panels, ideal for applications using speakers, buzzers and microphones.

Length (mm)	Width (mm)	Height (mm)	Order code	1+	25+	100+
58	35	16	30-1950	0.85	0.75	0.65
90	56	23	30-1955	1.05	0.90	0.80
90	56	23	30-3255	1.20	1.15	1.05
100	60	30	30-1960	2.05	1.75	1.55
109	70	40	30-1965	2.55	2.15	1.90
121	55	31	30-3260	1.60	1.55	1.40
121	55	31	30-3265	1.70	1.65	1.50

Miniature ABS boxes

A range of miniature ABS boxes in black matt surface finish which simply snap fit together. Rounded edges enabling the boxes to be used in hand held applications.

Teko



Length (mm)	Width (mm)	Height (mm)	Order code	1+	25+	100+
56	31	24	30-1900	1.20	1.05	0.95
80	56	24	30-1905	1.20	1.10	1.00
131	66	30	30-1910	1.90	1.70	1.60

Hand held cases

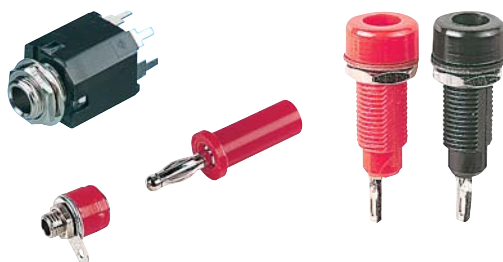
Two hand held cases with battery compartments, ideal for portable equipment. The battery compartments have removable lids and can accommodate a single PP3 battery. The cases are moulded in ABS with the two halves being held together by screws, supplied. The bottom case has moulded-in bosses for easy installation of PCB and hardware. Colour: black.



Length (mm)	Width (mm)	Height (mm)	Order code	1+	25+	100+
145	61	28	30-0285	2.10	1.78	1.57
190	81	34	30-0290	2.95	2.50	2.18

CIRCUIT FIXTURES

Taken from the Rapid Electronics catalogue, the following components are useful to help secure your circuit board into a case and provide connections.



The pillers below will help secure the circuit board into the case.



TASK

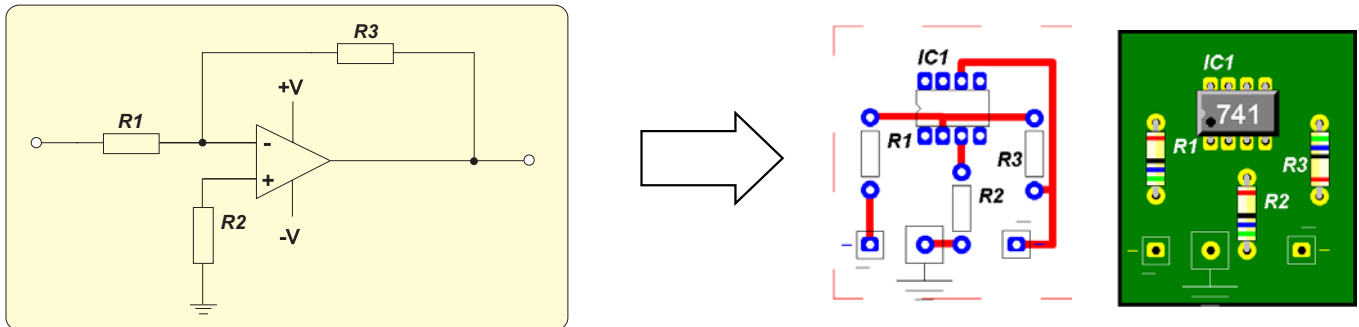
1. Measure all the separate components that are going to make up your Logic Alarm e.g. switch, circuit board, battery, etc. Work out the optimum space needed to contain the circuit.
2. Draw a series of initial ideas for a vacuum formed case to hold the Logic Alarm. Think carefully about the following:
 - a. How the circuit is to be held in the case.
 - b. How much space is required to house the circuit.
 - c. How to gain access to change the battery.

Present your ideas as a series of sketch ideas, highlighting those you feel are the most interesting with colour.

3. Use the Rapid Electronics catalogue to select a suitable case for your Logic Alarm circuit giving reasons for your selection.

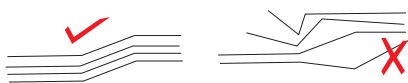
PCB DESIGN

An important part of the design process is transferring your circuit diagram into a printed circuit board or PCB.



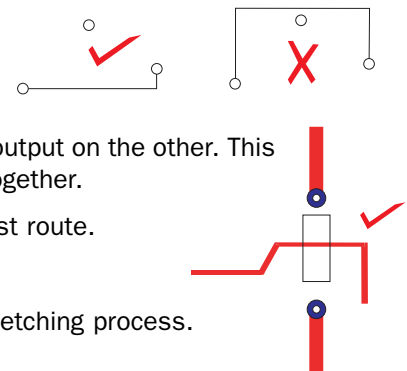
Careful planning of the component layout is important if your transfer from circuit diagram to PCB layout is to be successful. Use the following rules to guide your design:

- Ensure that tracks are not too close together and that they do not cross.
- Try to place tracks and components in a line or at right angle to each other.

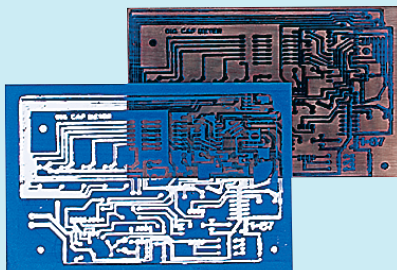


- Place input on one side of the board and output on the other. This will make it easier to keep connections together.
- Try to connect components by the shortest route.

- You should aim to avoid using wire links to jump over tracks.
- Do not make the tracks too thin since they may become damaged during the etching process.



1. ARTWORK



You can either lay out your design on paper or use a computer. Using a computer has many advantages. The software will ensure that the components are accurately positioned and are the correct size.

A number of software packages allow you to draw circuit diagrams that can then be converted directly into basic PCB designs. This gives you the added advantage of ensuring that all the connections are made.

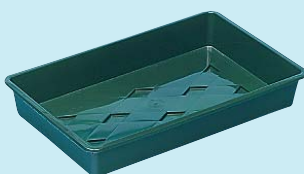
When you have finished your design you need to print it out and photocopy it onto acetate sheet. You need to take care of the acetate sheet since it is easy to damage the image.

2. ETCHING

The acetate artwork sheet is then placed in an ultraviolet light box and a photosensitive PCB board placed over the design. Take care when closing the lid to ensure the lid to ensure that they do not move. The exposure normally takes a few minutes and depends upon the type of board used and the strength of the ultraviolet box. Use a small piece of board to test the exposure time needed.



3. DEVELOPING



The photosensitive board should then be developed. Take care when placing the board into the developer by wearing protective clothing. The tray should be agitated so that the solution continually passes over the board. This should be done until the circuit image can be clearly seen on the copper surface. When complete, remove the board and rinse thoroughly.



4. ETCHING

The next stage in the production process is to place the board into a bubble etch tank that contains a solution of heated ferric chloride. The tank also contains a pump that generates bubbles, which help agitate the solution over the board. Depending on the quality of the solution the board will normally take 10 minutes to etch. Again care needs to be taken when retrieving the board, protective clothing, goggles and gloves should be worn.

5. CLEANING

If you have laid out your design with an etch resist pen then you will need to clean the board with an abrasive block before soldering. Try to leave the photo resist covering the copper tracks since it will provide protection.



6. DRILLING

Holes should be centre marked for accurate drill location. Holes are normally drilled with a 1mm bit. Take care not to move the work whilst drilling as this may break the fragile drill bit.

7. COMPONENT PLACEMENT

Place and solder low profile components such as resistors and IC holders first, taking care to bend the connecting wires so as not to damage the components. For heat sensitive components use pliers to hold them whilst soldering to act as heat sinks. Remember to use IC holders that allow easy removal of the IC if it becomes damaged.

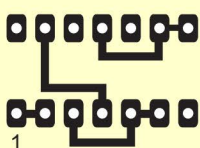
8. SOLDERING

Place the soldering iron against the leg of the component and the track. Heat them for a few seconds, then place the solder on the junction for just enough time for the solder to melt and join the component to the track. Finally remove any excess component below the joint.

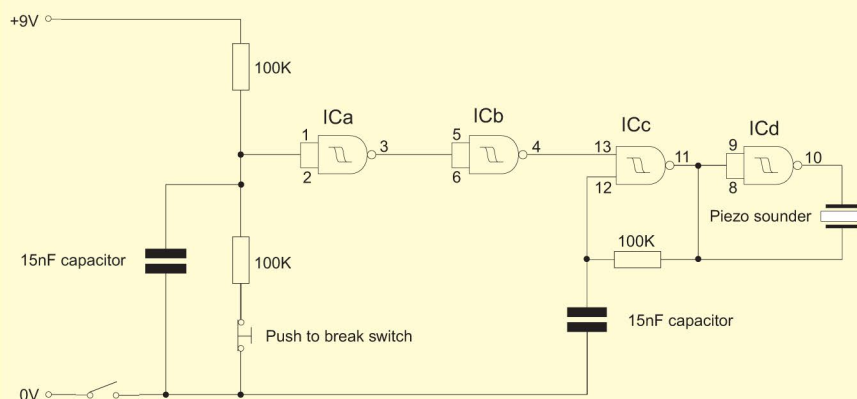
TASK

The circuit diagram below is for the logic alarm. Use this diagram to help you complete the PCB circuit layout.

1. Start by positioning the IC
2. Make the connections between the pins of the IC



3. Then place on the other components, remembering to try and group inputs and outputs



Your aim should be to produce a design that allows for easy placement and soldering of components whilst being economical in your use of printed circuit board.

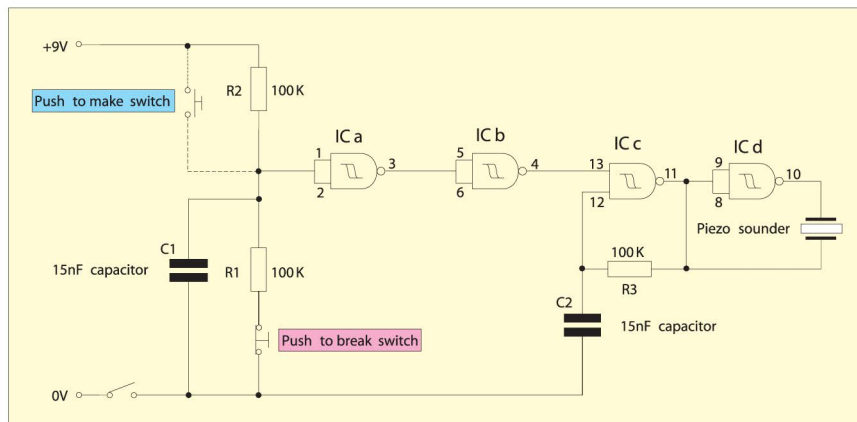
CIRCUIT CONSTRUCTION

The circuit can be divided into two sections. The first section is a voltage sensitive latch. The second half is an astable multivibrator. When the power is turned on, the voltage applied to the input of the logic gate ICa rises to 4.5 Volts. This causes ICb to go high and remain at that level.

When the push-to-make switch is pressed, the voltage between the resistors goes high and output latches low and the astable will be activated, sounding the alarm.

The alarm cannot be reset by closing the switch again. The alarm has latched on. Resetting can only be achieved by resetting the power supply.

The spare NAND gates are used on the IC to produce an astable multivibrator to oscillate the piezo transducer and thus produce the alarm sound when triggered.

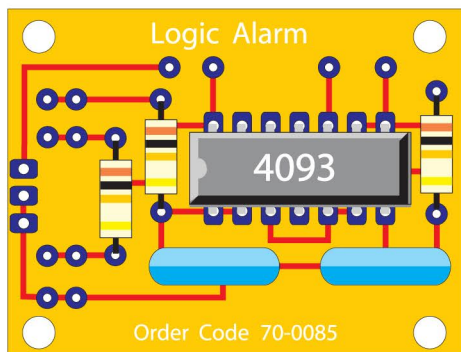


CONSTRUCTION OF CIRCUIT

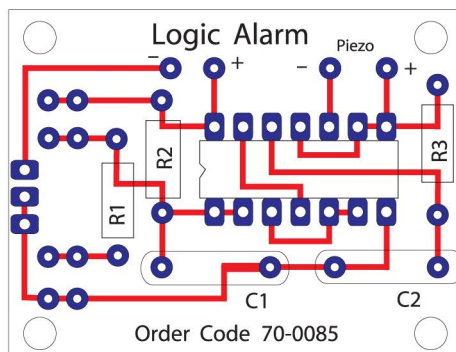
You will need to collect together the following equipment before you start construction of your circuit:

- Soldering equipment set
- Printed circuit board
- Components:
 - IC 4093, 14 pin IC holder, three 100K resistors (brown, black, yellow)
 - Ultra-miniature slide switch, two 15nF capacitors, piezo sounder
 - PP3 battery clip, method of triggering alarm circuit, e.g. push-to-break switch

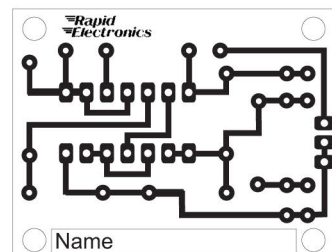
Component side



Transparent view



Track view



PROCEDURE FOR CIRCUIT CONSTRUCTION

1. Solder the resistors in place.
2. Solder the capacitors in place.
3. Solder the piezo sounder onto the circuit board.
4. Solder the switch onto the circuit board.
5. Solder the IC holder in place.
6. Solder the battery clip in place.
7. Connect your method of triggering the alarm to the circuit, taking care to use the correct set of pads.
8. Place the 4093 chip into the holder, making sure to insert it the correct way round.

EVALUATION

Evaluation is an important part of the design process. It is used by designers to check that they have produced an effective design with all the features they identified in the specification. When you are evaluating a product you are trying to find out both its good and poor features.

Your own opinions are important, but you must also get some other people's opinions as well. They may notice qualities you are not aware of.



TASK

Evaluate your Alarm project by establishing if it meets your specification.

Look at your specification and write down in the boxes below two features to establish the quality of your Alarm.

1.

2.

TASK

Show with the aid of sketches and annotations how an aspect of your final alarm design could be improved.

PROGRESS DIARY

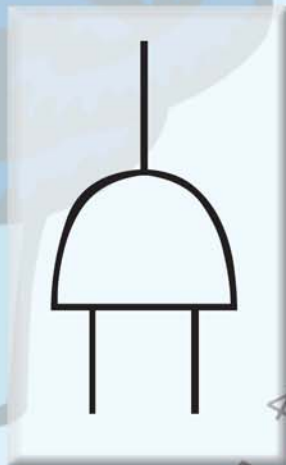
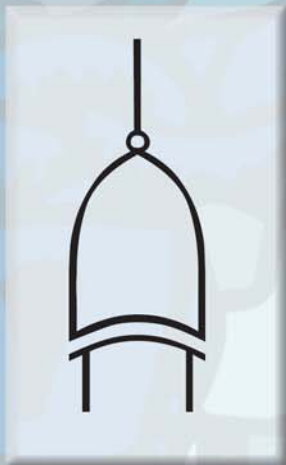
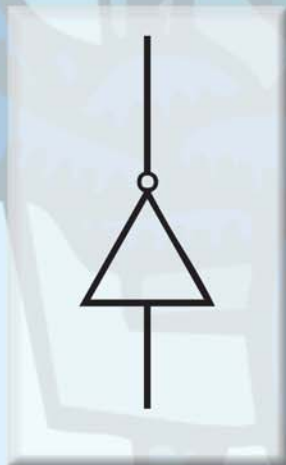
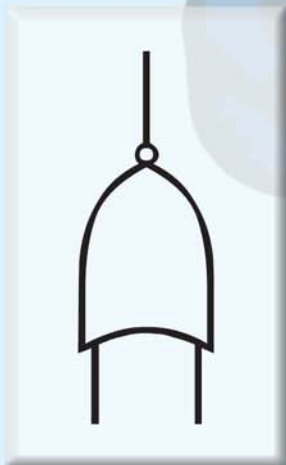
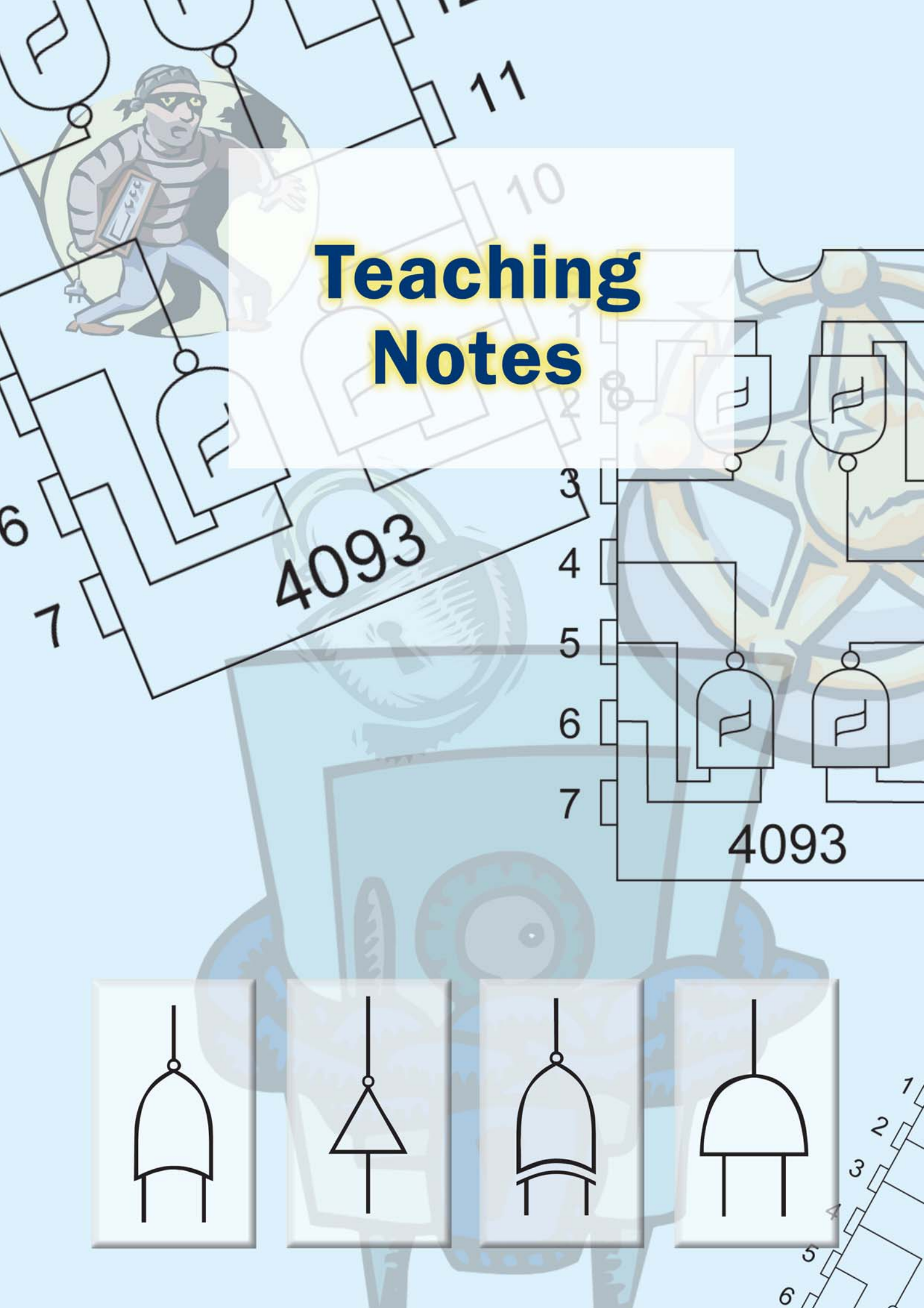
Each week, write a short paragraph about the work you have done. As well as commenting on good aspects of the lesson, try to comment on work that has not gone so well, or that you did not fully understand.

When designing, it is also important to think ahead. Write down in the second section what work you anticipate doing next week on your project. This will give you experience when planning your own projects.

Week 1	TODAY_____
	NEXT LESSON
Week 2	TODAY_____
	NEXT LESSON
Week 3	TODAY_____
	NEXT LESSON
Week 4	TODAY_____
	NEXT LESSON
Week 5	TODAY_____
	NEXT LESSON
Week 6	TODAY_____
	FINAL COMMENT

Teacher comments:

Teaching Notes



TEACHER INFORMATION

INTRODUCTION

The Logic Alarm is intended to introduce students to logic circuit design. The project is designed for Y10 students following electronics based courses. Emphasis has been placed on covering key features of examination syllabuses through a series of structured exercises. The project also offers them the opportunity to design a real product at the end of the course.

A key feature of the teaching material is that in addition to providing a student resource, it also contains detailed teacher support notes for guidance. The teaching pack has been designed to be **photocopied**. A number of the activity sheets can be used in isolation from the project. Included in the material are a series of structured homework assignments to support the work in class.

A series of lesson plans have been included based on teacher experience. However, the detailed project organisation will depend upon timetable, facilities and student needs.

The practical work should be possible in a typical secondary based workshop.

AIMS AND OBJECTIVES

The project is to design and make a small alarm that can be used in a variety of situations. The project will enable students to experience the design and manufacture of logic based electronic circuits.

CONCEPTS:

- Logic.
- Design and manufacture.
- Evaluation.

OBJECTIVES:

Pupils should be able to:

- Identify design situations where the alarm circuit could be used.
- Identify a suitable sensor for triggering the alarm.
- Design and build combinational logic circuits.
- Design and make PCBs for the circuit.
- Design and manufacture suitable casings to contain their designs.

SCIENCE OPPORTUNITIES:

- The selection of materials based on properties that make them suitable for use in security environment.

MATHS OPPORTUNITIES:

- Calculation of the costs of alternative input circuits.
- Accurate measurement and marking out.
- Binary arithmetic.

IT OPPORTUNITIES:

- Use of simulation software to develop and test circuit ideas.
- Graphic packages to help generate design ideas.
- CAD to generate PCB layout

ART & DESIGN:

- Drawing and presentational techniques to help represent design ideas.

LESSON PLANS

WEEK 1 INTRODUCTION TO DESIGN SITUATION

Aim:

- Introduction situation.
- Investigate use of personal alarms and identify suitable areas for focus work.
- Write Design Brief.

Student:

- Investigate alarm situations.
- Write design brief.

Teacher:

- Help identify suitable areas for an alarm design through background discussions.
- Assist in the writing of the design brief.
- Advice on organisation of information gained from alarm activity sheet.

Demonstrations:

- A range of small scale alarms e.g. case, personal.
- Investigation of bags found in the class.

Resources:

- Examples of alarms (if available).
- Example of a completed Alarm project.
- "Project introduction" sheet.
- "Investigation & Research" information and activity sheet.
- Access to Library/books/Internet for research information.

Homework:

- Research possible design situations for use of an alarm.
- Selected questions from "Investigation & Research" sheet.
- Diary record.

WEEK 2 CIRCUIT THEORY

Aim:

- Develop concept of system design.
- Develop concepts of logic gates to control decisions.
- Understand the concepts of digital and analogue signals.
- Make decisions as to which type of IC to use.
- Experiment with building electronic circuits.

Student:

- Testing variety of logic circuits.
- Questions based on activity sheets.

Teacher:

- Introduction to concept of system design.
- Introduction to logic gates.
- Discussion on TTL vs CMOS.
- Guidance on building and testing circuits.
- Assistance with work on activity sheets.

Demonstrations:

- Construction of circuits.
- How to set-up logic ICs

Resources:

- "System design" activity sheet.
- "Logic gates" activity sheet.
- "Analogue & Digital signals" activity sheet.
- Electronic components for testing.

Homework:

- Selected questions from activity sheets.
- Diary record.

LESSON PLANS

WEEK 3 CIRCUIT DEVELOPMENT

Aim:

- Establish specification.
- Generate initial ideas for triggering alarm.
- Develop graphical communication and presentation skills.

Student:

- Write specification.
- Establish range of initial ideas for triggering alarm circuit.

Teacher:

- Discuss specification.
- Guide students through generation and development of ideas.
- Advice on presentation techniques and layout of work.

Demonstrations:

- Variety of presentation techniques suitable for communicating ideas in GCSE project work.
- Methods of triggering alarm.

Resources:

- "Starting to design" activity sheet.
- "Input ideas" activity sheet.
- Drawing materials.
- Selection of input sensors and switches to trigger alarm.

Homework:

- Completion of unfinished design work.
- Diary record.

WEEK 4 MANUFACTURING

Aim:

- Review of safe working practices in the workshop.
- Design and production of PCBs.
- Students to start manufacturing Alarm project.

Student:

- Manufacture Alarm project.

Teacher:

- Go through safety in the workshop with students based on equipment to be used.
- Discuss the design and manufacture of PCBs.
- Provide assistance to students to start manufacturing alarm.

Demonstrations:

- Review soldering.
- Manufacturing a PCB

Resources:

- Student: • Class set for five students, order code **70-0075** which includes:
 - IC 4093 – 14 pin IC holder – three 100k resistors (brown, black, yellow)
 - Ultra-miniature slide switch – two 15nF capacitors – piezo sounder – Battery clip
- Class set of five printed circuit boards (pre-drilled, order code **70-0085**).
- PP3 battery (order code **18-1020**)
- Soldering tools.
- 50mm solid core wire.
- Workshop tools.

Homework:

- PCB design exercise.
- Diary record.

LESSON PLANS

WEEK 5 CASING MANUFACTURER/ASSEMBLY (This section will need additional time if students are to manufacture their own case designs).

Aim:

- Complete construction of alarm circuit.
- Assemble Alarm.
- Examine alternative methods for casing circuit.

Student:

- Complete any unfinished circuit construction.
- House circuit in case.

Teacher:

- Provide support to help students finish the soldering of their PCB.
- Assist students in the fitting of their circuits into the case.
- Examine alternative methods of case construction

Demonstrations:

- How to assemble circuit into case.
- Vacuum forming.

Resources:

- Examples to use in demonstrations for assembly of circuit into case.
- Cases for students.
- Vacuum forming machine, suitable mould and sheet material.
- Workshop tools for cutting, shaping and finishing.

Homework:

- Selected TASK questions from “Case design” information sheet
- Diary record.

WEEK 6 EVALUATION

Aim:

- Completion of Alarm assembly.
- Evaluation of Alarm project and student progress.

Students:

- Completion of project assembly.
- Evaluation against specification.
- If sufficient time – Extension exercises based on extended logic theory.

Teacher:

- Help with final project assembly.
- Discussion on important feature to include in project evaluations.
- Guidance on extension activity.
- Demonstrations:
- Project evaluation exercise.

Resources:

- “Evaluation” activity sheets.

Homework:

- Diary record and final project evaluation.
- Extension activity.

NATIONAL CURRICULUM 2000

DESIGN AND TECHNOLOGY

Programme of Study Key Stage 4

During Key Stage 4 pupils take part in design and make projects that are linked to their own interests, industrial practice and the community. Projects may involve an enterprise activity, where pupils identify an opportunity, design to meet a need, manufacture products and evaluate the whole design and make process. Pupils use ICT to help with their work, including computer-aided design and manufacture (CAD/CAM) software, control programs and ICT-based sources for research. They consider how technology affects society and their own lives, and learn that new technologies have both advantages and disadvantages.

KNOWLEDGE SKILLS AND UNDERSTANDING

Developing, planning and communicating ideas

1. Pupils should be taught to:

- a. Develop and use design briefs, detailed specifications and criteria.
- b. Consider issues that affect their planning.
- c. Design for manufacturing in quantity.
- d. Produce and use detailed working schedules, setting realistic deadlines and identifying critical points.
- e. Match materials and components with tools, equipment and processes, taking account of critical dimensions and tolerances when deciding how to manufacture the product.
- f. Be flexible and adaptable in responding to changing circumstances and new opportunities.
- g. Use graphic techniques and ICT, including computer-aided design (CAD), to generate, develop, model and communicate design proposals.

Working with tools, equipment, materials and components to produce quality products

2. Pupils should be taught to:

- a. Select and use tools, equipment and processes effectively and safely to make products that match a specification.
- b. Use a range of industrial applications when working with familiar materials and processes.
- c. Manufacture single products and products in quantity, applying quality assurance techniques.
- d. Use computer-aided manufacture (CAM) in single item production and in batch or volume production.
- e. Simulate production and assembly lines, including the use of ICT.

Evaluating processes and products

3. Pupils should be taught to:

- a. Check design proposals against design criteria, and review and modify them if necessary as they develop their product.
- b. Devise and apply tests to check the quality of their work at critical points during development.
- c. Ensure that their products are of a suitable quality for intended users [for example, how well products meet a range of considerations such as moral, cultural and environmental] and suggest modifications that would improve their performance if necessary.
- d. Recognise the difference between quality of design and quality of manufacture, and use essential criteria to judge the quality of other people's products.

NATIONAL CURRICULUM 2000

DESIGN AND TECHNOLOGY

Programme of Study Key Stage 4

Knowledge and understanding of materials and components

4. Pupils should be taught:

- a. How materials are cut, shaped and formed to specified tolerances.
- b. How materials can be combined and processed to create more useful properties, and how these changed materials are used in industry.
- c. How materials are prepared for manufacture and how pre-manufactured standard components are used.
- d. About a variety of finishing processes, and why they are important for aesthetic and functional reasons.
- e. That to achieve the optimum use of materials and components, they need to take into account the relationships between material, form and intended manufacturing processes.

Knowledge and understanding of systems and control

5. Pupils should be taught:

- a. The concepts of input, process and output, and the importance of feedback in controlling systems.
- b. How control systems and sub-systems can be designed, used and connected to achieve different purposes
- c. How feedback is incorporated into systems
- d. How to analyse the performance of systems.

Breadth of study

6. During the key stage, pupils should be taught the knowledge, skills and understanding through:

- a. Product analysis
- b. Focused practical tasks that develop a range of techniques, skills, processes and knowledge
- c. Design and make assignments, which include activities related to industrial practices and the application of systems and control.

