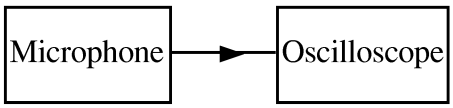
PHYSICS
Intermediate 1
Electronics

ACTIVITY 1

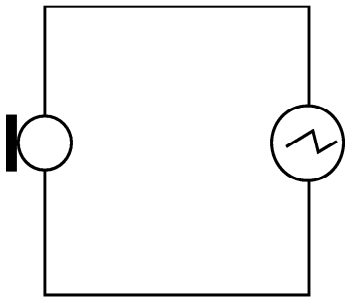
Title: The Microphone.

Aim: To study the function of a microphone.

Apparatus: Microphone, oscilloscope.



Block Diagram



Circuit Diagram

Instructions

- Connect the microphone to the input terminals of the oscilloscope.
- Adjust the controls of the oscilloscope so that there are clear patterns produced when you make various sounds into the microphone.
- Hold the microphone near your mouth and say the letter "A" for about 5 seconds and watch the pattern you see on the oscilloscope.
- Try speaking different letters of the alphabet and watching for the difference in the oscilloscope pattern.
- What energy change takes place in a microphone?
- Is the microphone an input device or an output device?

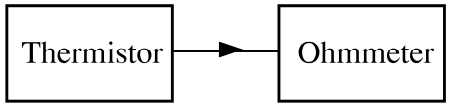
ACTIVITY 2

Title: The thermistor.

Aim: To study the function of a thermistor.

Apparatus: Thermistor, ohmmeter.

Circuit Diagram



Block Diagram

Instructions

- Connect the ohmmeter leads to both ends of the thermistor.
- Copy the following table.

Temperature	Resistance (Ω)
cold	
hot	

- Record the resistance of the thermistor; this is when it is cold.
- Warm the thermistor by holding it in your fingers. Hold it until the reading on the ohmmeter stops changing.
- Record the resistance of the thermistor; this is when it is hot.
- Compare the resistance of the thermistor when it is hot and cold.
- Is the thermistor an input device or an output device?

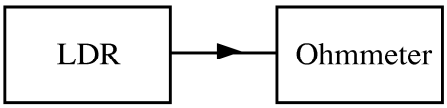
ACTIVITY 3

Title: The Light Dependent Resistor (LDR).

Aim: To study the function of a LDR.

Apparatus: LDR, ohmmeter

Circuit Diagram



Block Diagram

Instructions

- Connect the ohmmeter leads to both ends of the LDR.
- Construct a table to record your results using the following headings:

  Light level **Resistance (Ohms)**

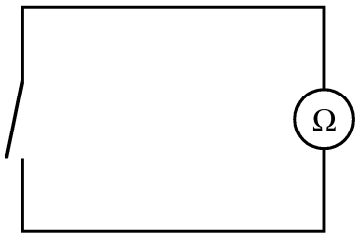
- Record the resistance of the LDR; this is in the light.
- Cover the LDR.
- Record the resistance of the LDR; this is in the dark.
- Compare the resistance of the LDR in light and in dark.
- Is the LDR an input device or an output device?

ACTIVITY 4

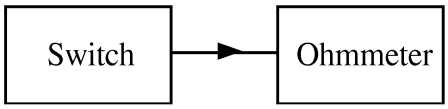
Title: The Switch.

Aim: To study the function of a switch.

Apparatus: Variety of switches, labelled A, B and C, ohmmeter.



Circuit Diagram



Block Diagram

Instructions

- Connect the ohmmeter leads to both ends of switch A.
- Copy the following table.

Switch	Resistance (Ohms) open (off)	Resistance (Ohms) closed (on)
A		
B		
C		

- Record the resistance of the switch; this is the switch open (off).
- Operate the switch - this will depend on the type of switch used.
- Record the resistance of the switch; this is the switch closed (on).
- Repeat with switches B and C.
- Compare the resistance of switches when open and when closed.
- Is the switch an input device or an output device?

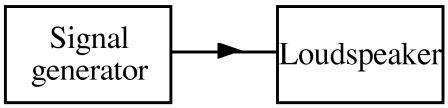
ACTIVITY 5

Title: The Loudspeaker.

Aim: To study the function of a loudspeaker.

Apparatus: Loudspeaker, signal generator.

Circuit Diagram



Block Diagram

Instructions

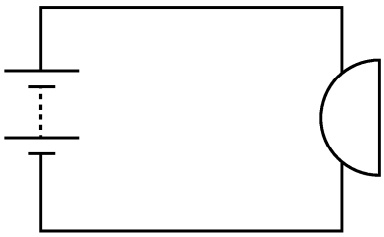
- Connect the loudspeaker to the signal generator.
- Set the output to 5 Hz; this is low frequency. Gradually increase the frequency control of the signal generator until you can hear a tone.
- Describe the movement of the speaker cone and the sound which is produced.
- Set the output of the signal generator to 8 kHz; this is high frequency.
- Describe the movement of the speaker cone and the sound which is produced.
- Compare the sound produced and movement of the cone at low and high frequencies.
- What is the energy change in the loudspeaker?
- Is the loudspeaker an input device or an output device?

ACTIVITY 6

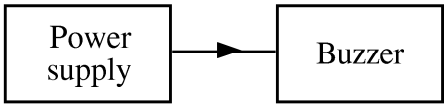
Title: The Buzzer.

Aim: To study the function of a buzzer.

Apparatus: Buzzer, battery (minimum 4.5 V) or power supply.



Circuit Diagram



Block Diagram

Instructions

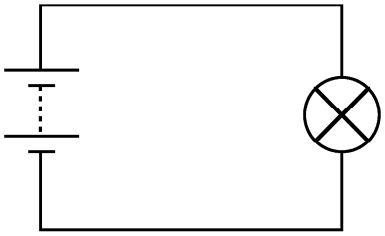
- Connect the buzzer ensuring that the positive terminal of the battery is connected to the positive terminal of the buzzer.
- Describe the sound produced.
- Describe which way the buzzer has to be connected in the circuit to allow it to work.
- What energy change takes place in the buzzer?
- Is the buzzer an input device or an output device?

ACTIVITY 7

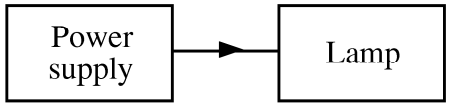
Title: The Lamp.

Aim: To study the function of a lamp.

Apparatus: Lamp, battery (4.5 V) or power supply.



Circuit Diagram



Block Diagram

Instructions

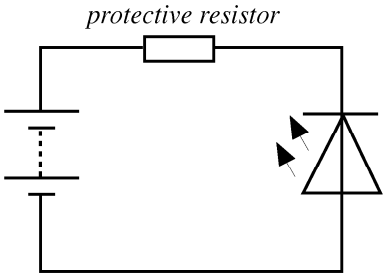
- Connect the lamp to the battery.
- Describe the brightness of the lamp.
- What energy change takes place in the lamp?
- Is the lamp an input device or an output device?

ACTIVITY 8

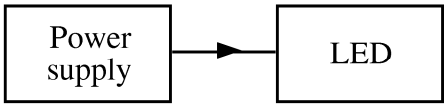
Title: The Light Emitting Diode (LED).

Aim: To study the function of a LED.

Apparatus: LED and protective resistor, battery (3 V) or power supply.



Circuit Diagram



Block Diagram

Instructions

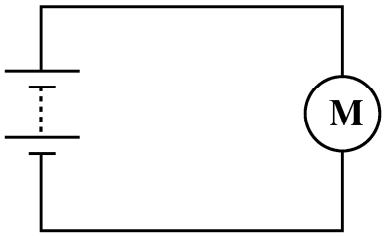
- Connect the LED ensuring that the negative terminal of the battery is connected to the negative terminal of the LED (flat side).
- Describe the brightness of the LED.
- What energy change takes place in the LED?
- Is the LED an input device or an output device?

ACTIVITY 9

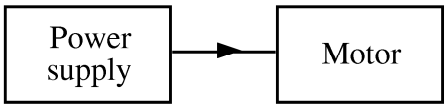
Title: The Motor.

Aim: To study the function of a motor.

Apparatus: Motor, battery (minimum 4.5 V) or power supply.



Circuit Diagram



Block Diagram

Instructions

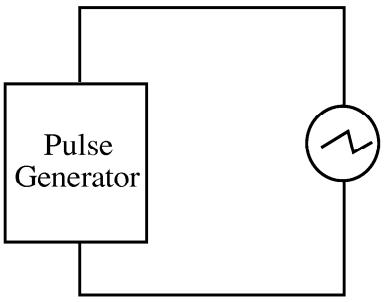
- Connect the motor to the battery.
- Describe the motion of the motor.
- What energy change takes place in the motor?
- Is the motor an input device or an output device'?

ACTIVITY 10

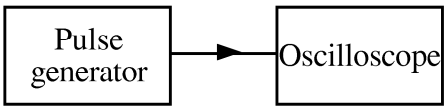
Title: Digital Signals.

Aim: To study digital signals using an oscilloscope.

Apparatus: Pulse generator and power supply, oscilloscope.



Circuit Diagram



Block Diagram

Instructions

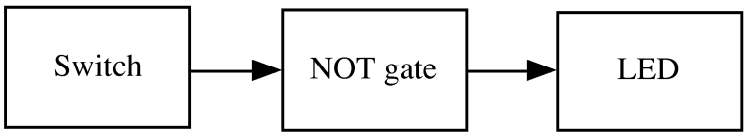
- Connect the power supply to the pulse generator.
- Connect the oscilloscope to the output of the pulse generator.
- Adjust the time-base control of the oscilloscope until a steady trace is obtained.
- Draw the trace.
- Keep the controls on the oscilloscope constant. Increase the frequency of the pulse generator and obtain a new steady trace.
- Draw the new trace.
- Compare the two traces looking for features which are the same. Write a conclusion about the nature of digital signals.

ACTIVITY 11

Title: The NOT gate.

Aim: To determine the truth table for a NOT logic gate (Inverter).

Apparatus: Power supply, NOT gate, LED indicator, switch.



Block Diagram

Instructions

- Construct the system shown in the block diagram above.
- Note the LED state with the switch off.
- Put the switch to the **on** position.
- Note the state of the LED.
- Copy and complete your **own** truth table for the NOT gate.

Remember: off → low → logic 0
on → high → logic 1

NOT Gate Truth Table

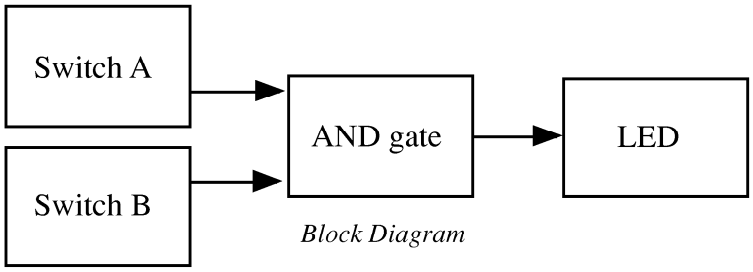
Input	Output
low (0)	
high (1)	

ACTIVITY 12

Title: The AND gate.

Aim: To determine the truth table for an AND logic gate.

Apparatus: Power supply, AND gate, LED indicator, switches (2).



Block Diagram

Instructions

- Construct the system shown in the block diagram above.
- Note the LED state with both switches off.
- Put only switch B to the **on** position. Note the state of the LED.
- Put only switch A to the **on** position. Note the state of the LED.
- Put switches A and B to the **on** position at the same time. Note the state of the LED.
- Copy and complete your **own** truth table for the AND gate.

AND Gate Truth Table

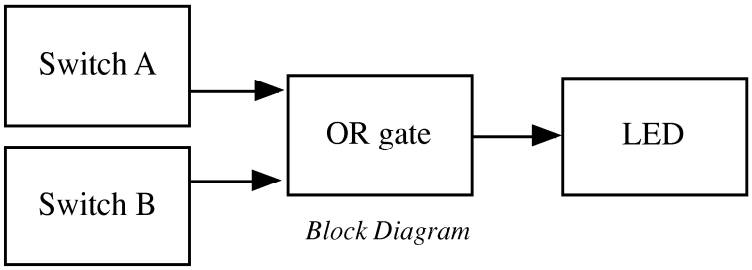
Input A	Input B	Output
low (0)	low (0)	
low (0)	high (1)	
high (1)	low (0)	
high (1)	high (1)	

ACTIVITY 13

Title: The OR gate

Aim: To determine the truth table for an OR logic gate.

Apparatus: Power supply, OR gate, LED indicator, switches (2).



Block Diagram

Instructions

- Construct the system shown in the block diagram above.
- Note the LED state with both switches off.
- Put only switch B to the **on** position. Note the state of the LED.
- Put only switch A to the **on** position. Note the state of the LED.
- Put switches A and B to the **on** position at the same time. Note the state of the LED.
- Copy and complete your **own** truth table for the OR gate.

OR Gate Truth Table

Input A	Input B	Output
low (0)	low (0)	
low (0)	high (1)	
high (1)	low (0)	
high (1)	high (1)	

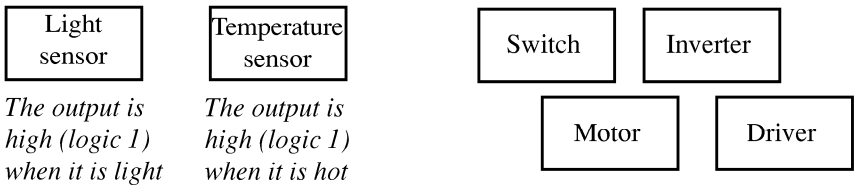
ACTIVITY 14 **Outcome 3** ✔

Temperature control

The problem

People in an office find that it gets too hot in the summer.
An electronic system is required to turn on the motor of a fan when it is too hot.

Subsystems available



Other sensors and logic gates are available.

Instructions

- Select appropriate subsystems.
- Draw a block diagram of your system.
- Assemble the subsystems in the correct order.
- At room temperature, turn the dial on the sensor unit so that the output is just off.
- Test the system.
- Ask your teacher or lecturer to check your system.
- Complete the report page.

ACTIVITY 15

Outcome 3 ✔

Getting a farmer up

The problem

At certain times of the year a farmer would like an alarm to wake him up when it gets light.
He would like his alarm to sound only when it gets light and he has switched it on.

Subsystems available

Light sensor	Temperature sensor	Switch	Inverter	Driver
The output is high (logic 1) when it is light	*The output is high (logic 1) when it is hot*	*The output is high (logic 1) when the switch is on*		

AND gate	Buzzer

Other sensors and logic gates are available.

Instructions

- Select appropriate subsystems.
- Draw a block diagram of your system.
- Assemble the subsystems in the correct order.
- Put the switch in the on position.
  In daylight, turn the dial on the sensor unit so that the output is just on.
- Test the system.
- Ask your teacher or lecturer to check your system.
- Complete the report page.

ACTIVITY 16 **Outcome 3** ✔

Security Lights

The problem

A shop has had a number of break-ins at night time.
An electronic system is required to make a light come on when it gets dark.

Subsystems available

Light sensor	Temperature sensor	Lamp	Inverter	Driver
The output is high (logic 1) when it is light	*The output is high (logic 1) when it is hot*	OR gate	Fan	

Other sensors and logic gates are available.

Instructions

- Select appropriate subsystems.
- Draw a block diagram of your system.
- Assemble the subsystems in the correct order.
- In daylight, turn the dial on the sensor unit so that the output is just off.
- Test the system.
- Ask your teacher or lecturer to check your system.
- Complete the report page.

ACTIVITY 17

Outcome 3 ✔

Keeping watch

The problem

Many outdoor lamps are also security devices.
An electronic system is required which lights a lamp when heat is detected during the hours of darkness.

Subsystems available

Light sensor	Temperature sensor	Lamp	Inverter	Driver
The output is high (logic 1) when it is light	*The output is high (logic 1) when it is hot*			

OR gate	AND gate	Buzzer

Other sensors and logic gates are available.

Instructions

- Select appropriate subsystems.
- Draw a block diagram of your system.
- Assemble the subsystems in the correct order.
- At room temperature, cover the light sensor and turn the dial on the temperature sensor until the output is just off.
- Test the system.
- Ask your teacher or lecturer to check your system.
- Complete the report page.

ACTIVITY 18 **Outcome 3** ✓

Camping out

The problem

Jimmy likes to play in his tent in the garden but his mum worries about him being too cold.
An electronic system is required to sound a buzzer in the house if gets too cold. Include a switch to allow Jimmy to call his mum in an emergency.

Subsystems available

Light sensor	Temperature sensor	Switch	Inverter	Driver
The output is high (logic 1) when it is light	*The output is high (logic 1) when it is hot*	*The output is high (logic 1) when the switch is on*	AND gate	Buzzer
			OR gate	

Other sensors and logic gates are available.

Instructions

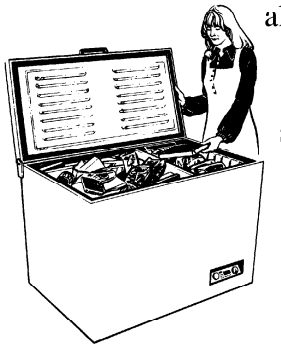
- Select appropriate subsystems.
- Draw a block diagram of your system.
- Assemble the subsystems in the correct order.
- Put the switch in the on position.
  Warm the temperature sensor and turn the dial so that the output is just off.
- Test the system.
- Ask your teacher or lecturer to check your system.
- Complete the report page.

DESIGN PROBLEMS

These design problems require you to use the knowledge you have gained about all aspects of the course. They are not required for assessment. They are just for fun.

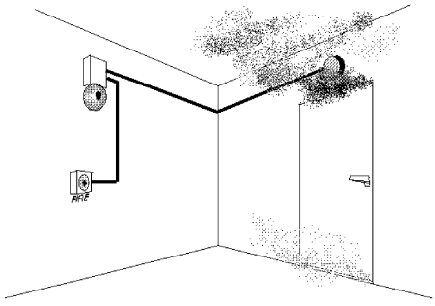
1 A City Council is having problems with birds perching on the ledges of buildings and messing the pavements. Design a system which makes a sound to scare away a bird if it lands on two trip wires (connected to switches).

2 A freezer food shop is worried about people leaving the freezer doors open allowing the temperature of the food to increase. This could allow germs to contaminate the food making it unfit to eat.



Design a system which lights a lamp above the freezer if someone leaves the lid up or if it gets too warm inside.

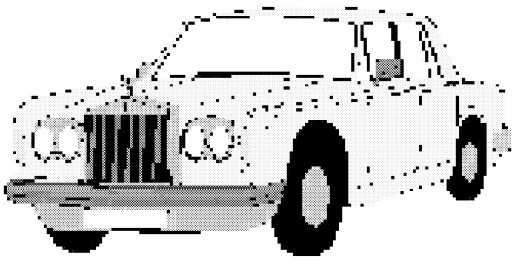
3 Modern buildings have a double alarm system to control fire.



A motor drives a pump which sprays water whenever it gets too hot or if there is smoke present.

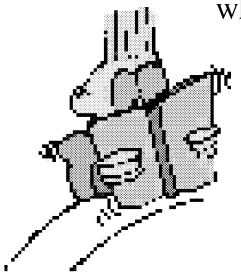
Design a system which will drive the pump motor when it gets too hot or if there too much smoke to let light reach a sensor.

4 Some luxury cars have sidelights which come on automatically when it gets dark.



Design a system which automatically lights the sidelight lamps if it is dark. Include a master switch to allow the sidelights to be turned on for parking.

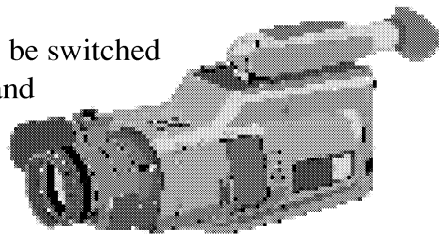
5 Sam likes to sit up in bed at night reading (usually horror stories). His parents don't mind him reading but they don't like him being awake when they are asleep.



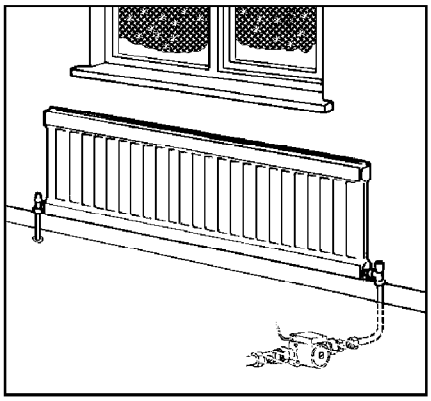
Design a system which will only allow Sam's bedroom light to be switched on at night if his parents' light is on. Sam should be able to operate his light during the day if he wants to.

6 Some modern camcorders do not allow operation of the record mode unless there is a tape inserted and the lens cap is removed.

Design a system which allows the motor to be switched on only if there is a tape in the camcorder and light can enter the lens.



7 The pump motor in an automatic heating system is designed to be on all the time day or night unless it gets too hot in the daytime.



Design a system which drives the pump motor constantly except when it is hot during the day.

INPUT, PROCESS AND OUTPUT

Electronic Systems

When something is made up of lots of parts which are put together to do a job, it is called a system.

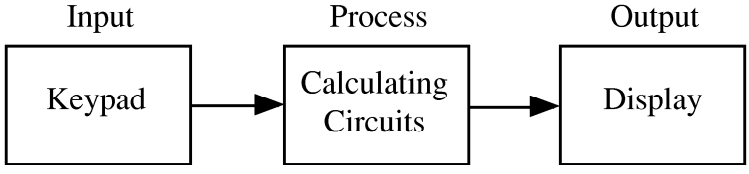
When the parts are electronic components the system is called an electronic system. Electronic systems can do lots of jobs. The type of job will depend on the components used to make the system. A calculator is an example of an electronic system.

Every electronic system has three main sections - called sub-systems. These are called the input, the process and the output.

Subsystem	What it does
Input	Detects some type of energy. For example: light, heat, sound and changes it to elecrical energy. This is then passed to the process subsystem
Process	Changes the electrical energy from the input so that the system can do its job. This is then passed on to the output subsystem.
Output	Converts the electrical energy from the process subsystem into another type of energy which can be used. For example: heat, light, movement.

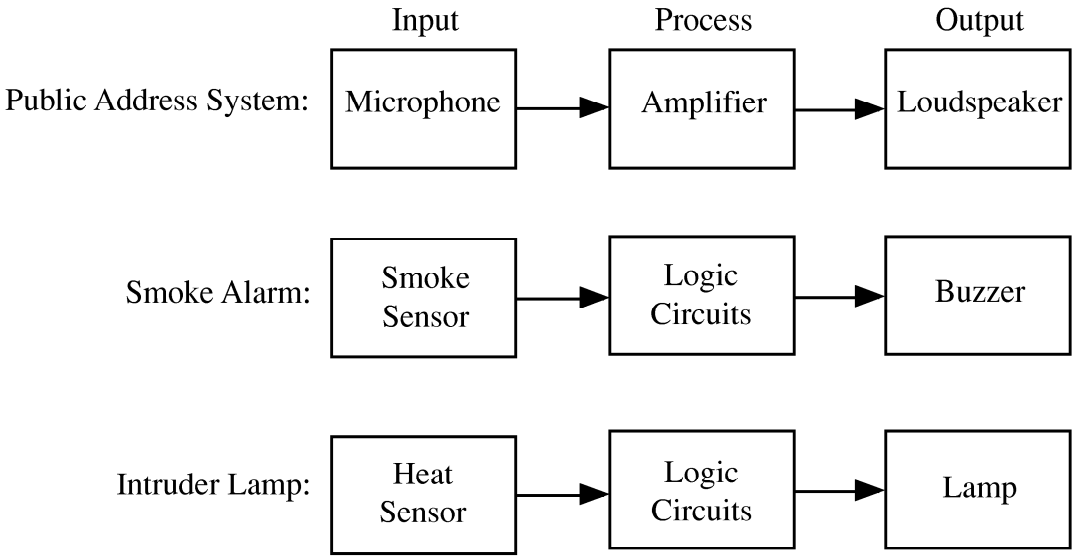
Block Diagrams

A block diagram is an easy way to draw a system. Instead of drawing a complicated diagram showing all the components, we draw a box or block to take the place of the input, process and output subsystems. Each block is labelled so that we know what is.



The block diagram for a calculator is shown above. Any subsystem can be further broken down to smaller and smaller subsystems - down to the actual components if required.

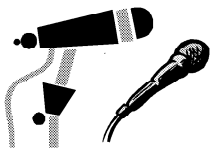
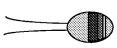
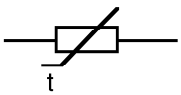
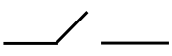
Block diagram examples



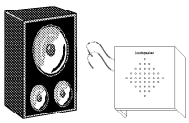
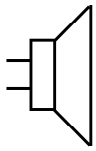
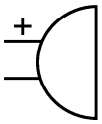
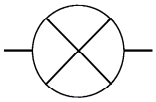
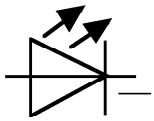
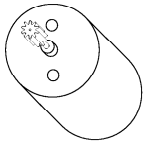
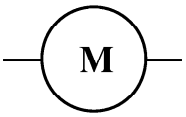
Input and Output Devices

Input subsystems contain a device which changes some form of energy into electrical energy. Output subsystems contain a device which changes electrical energy into some other form.

Input Devices

Device	*What it looks like*	*Circuit Symbol*	*How it Works*
Microphone			The inside of the microphone vibrates exactly the same way as the sound waves. This makes identical electrical waves.
Thermistor			The resistance of the thermistor changes as the temperature changes.
Light Dependent Resistor *(LDR)*			The resistance of the LDR decreases as the light level gets brighter.
Switch			Moving the switch from one setting to the other makes or breaks the circuit.

Output devices

Device	*What it looks like*	*Circuit Symbol*	*Energy Change and How it Works*
Loudspeaker			Electrical energy → Sound energy *Electrical waves make vibrations inside the loudspeaker producing sound waves.*
Buzzer			Electrical energy → Sound energy *A voltage across the buzzer makes it sound. The buzzer just switches sound on or off.*
Lamp			Electrical energy → Light energy *A voltage across the lamp makes it light. The greater the voltage, the brighter it gets.*
Light Emitting Diode (LED)	—		Electrical energy → Light energy *A voltage across the LED makes it light. LEDs are used to indicate when something is on or off.*
Electric Motor			Electrical energy → Kinetic energy *A voltage across the motor makes it turn. The greater the voltage, the faster it turns.*

Examples of input and output applications

Application	Device	Reason
Output of a radio.	Loudspeaker	The output should be sound waves.
Input of an automatic lamp.	LDR	The LDR will change resistance when the brightness changes.
Input of a heating controller.	Thermistor	The thermistor will change resistance when the temperature changes.
Output of a fan.	Motor	The motor will turn the blades of the fan.

DIGITAL LOGIC GATES

Digital Signals

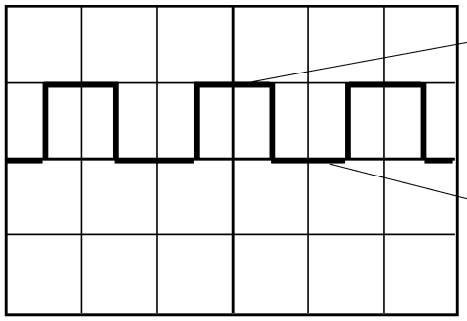
Digital signals are either on or off.

An "off" signal has a zero voltage (called "low").

An "on" signal has a non-zero voltage (called "high").

The "off" signal; low state is given the name "logic 0" (most often just "0").
The "on" signal; high state is given the name "logic 1" (most often just "1").

An oscilloscope can show logic states since it measures the high and low voltages.



Oscilloscope trace showing a digital logic signal which is changing from 1 to 0 several times.

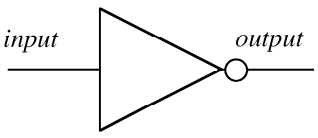
Logic Gates

Digital logic gates are used to combine or change digital electronic signals. There are three basic types of logic gate called the NOT gate (sometimes called an inverter), the AND gate and the OR gate.

The NOT gate

This is the simplest gate. It has one input and one output. The output is always the opposite of the input.

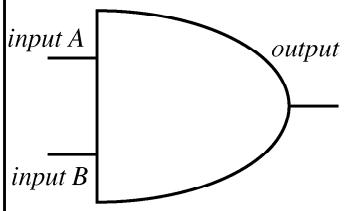
<table>
<tr><th>Logic gate</th><th>Symbol</th><th>How it Works</th></tr>
<tr><td>NOT gate

(Inverter)</td><td> 
</td><td>The NOT gate changes the input signal to the opposite state.

NOT Truth table:
<table>
<tr><th>Input</th><th>Output</th></tr>
<tr><td>high
(1)</td><td>low
(0)</td></tr>
<tr><td>low
(0)</td><td>high
(1)</td></tr>
</table></td></tr>
</table>

The AND gate

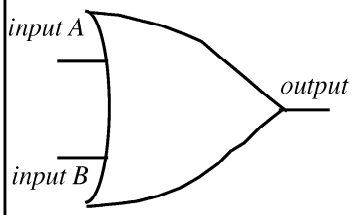
The AND gate has two inputs and one output. The output of the AND gate is always at logic 0 unless both the inputs are at logic 1 when the output becomes logic 1 as well.

<table>
<tr><th>Logic gate</th><th>Symbol</th><th>How it Works</th></tr>
<tr><td>AND gate</td><td> 
</td><td>The AND gate combines the input signals so that the output is only 1 when both inputs are 1.

AND Truth table:
<table>
<tr><th>Input A</th><th>Input B</th><th>Output</th></tr>
<tr><td>low (0)</td><td>low (0)</td><td>low (0)</td></tr>
<tr><td>low (0)</td><td>high (1)</td><td>low (0)</td></tr>
<tr><td>high (1)</td><td>low (0)</td><td>low (0)</td></tr>
<tr><td>high (1)</td><td>high (1)</td><td>high (1)</td></tr>
</table></td></tr>
</table>

The OR gate

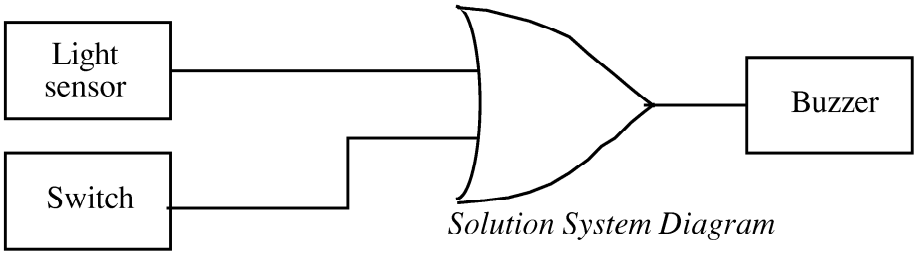
The OR gate has two inputs and one output. The output of the OR gate is always at logic 1 unless both the inputs are at logic 0 when the output becomes logic 0 as well.

<table>
<tr><th>Logic gate</th><th>Symbol</th><th>How it Works</th></tr>
<tr><td>OR gate</td><td> 
</td><td>The OR gate combines the input signals so that the output is 1 when either input is 1.

OR Truth table:
<table>
<tr><th>Input A</th><th>Input B</th><th>Output</th></tr>
<tr><td>low (0)</td><td>low (0)</td><td>low (0)</td></tr>
<tr><td>low (0)</td><td>high (1)</td><td>high (1)</td></tr>
<tr><td>high (1)</td><td>low (0)</td><td>high (1)</td></tr>
<tr><td>high (1)</td><td>high (1)</td><td>high (1)</td></tr>
</table></td></tr>
</table>

Logical Solutions

1 Donnie's dad wants to be wakened if he gets up at night. Design a system to sound a buzzer if Donnie switches on his light or if he stands on a mat. (A switch is under the mat.)



Solution System Diagram

How it works

Light Sensor

Dark	Light
low	high

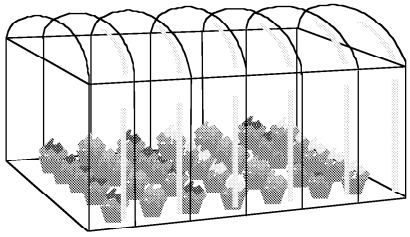
When the light is turned on, the light sensor output is high. This causes the OR gate output to go high which sounds the buzzer.

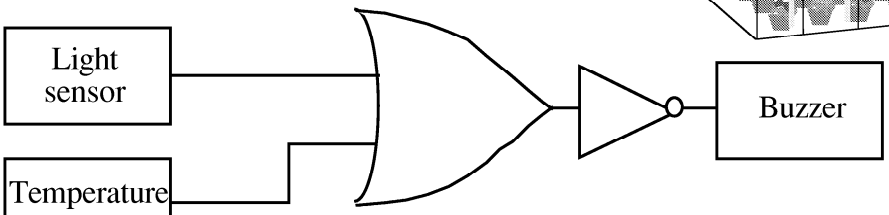
Switch

Open	Closed
low	high

When the switch under the mat is pressed, it closes - making its output high. This causes the OR gate output to go high which sounds the buzzer.

2 A tomato grower wants to protect his delicate plants which are in his greenhouse. Design a warning system to sound a buzzer if it gets too cold during the night (dark).





Solution System Diagram

How it works

Light Sensor

Dark	Light
low	high

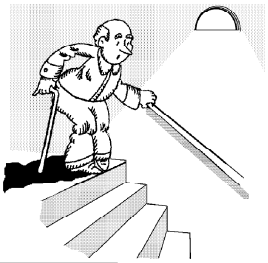
The buzzer can only switch on when the output from the NOT gate is high. Therefore the output from the OR gate must be low.

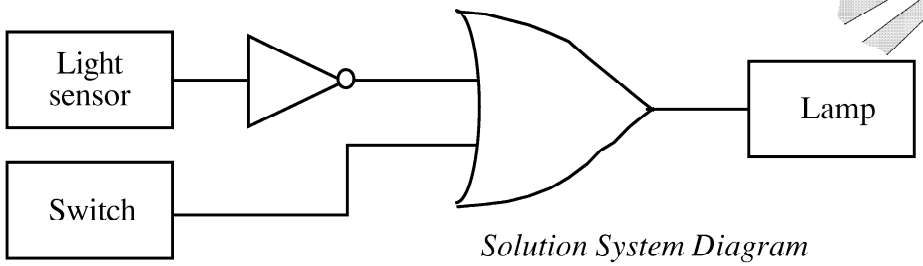
Temperature Sensor

Cold	Warm
low	high

The OR gate output can only be low if both the inputs are low. This means it must be both dark and cold as well.

3 Grandad can't use the stair light switch easily since he got his walking stick. Design a system which will switch on the stair light automatically when it gets dark. There must be a manual switch as well.





Solution System Diagram

How it works

Light Sensor

Dark	Light
low	high

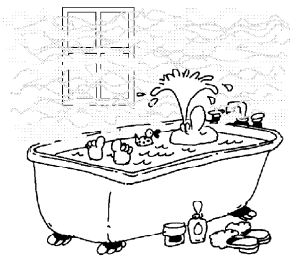
When it is dark, the light sensor output is low which is changed to high by the NOT gate. This causes the OR gate output to go high which lights the lamp.

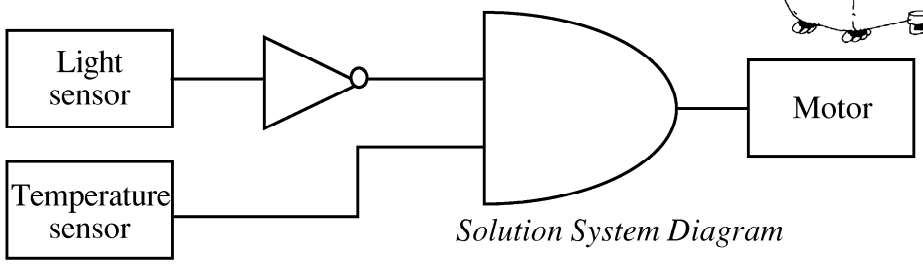
Switch

Open	Closed
low	high

When the switch is closed, its output is high. This causes the OR gate output to go high which lights the lamp.

4 Design a system for a bathroom to switch on a fan motor when the bathroom gets so steamy, the light from the window is blocked. The fan must only come on when it is hot as well as steamy.





Solution System Diagram

How it works

Light Sensor

Dark	Light
low	high

When it is steamy, it gets dark, the light sensor output is low which is changed to high by the NOT gate. When it gets too hot the output from the temperature sensor is high.

Temperature Sensor

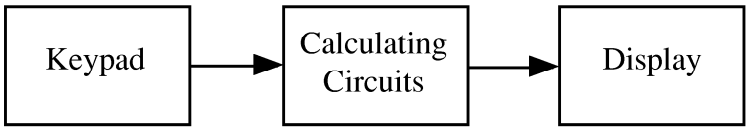
Cold	Warm
low	high

Only when it is hot and steamy at the same time will both inputs of the AND gate be high to make the output high to turn the motor.

ELECTRONICS: PROBLEMS

1. Describe what is meant by an electronic system. Give two examples.

2. The block diagram for a calculator is shown below. Copy the block diagram and identify the input, process and output subsystems.



3. Draw a block diagram of the following systems. Identify the input, process and output subsystems in each case.

   (a) A public address system
   (b) A smoke alarm
   (c) An automatic porch light (lamp lights when it gets dark)
   (d) An automatic fan (fan operates when it gets too warm)
   (e) A radio

4. What is sensed by each of the following input devices?

   (a) microphone
   (b) thermistor
   (c) light dependent resistor
   (d) switch

5. What can change the resistance of a thermistor?

6. State how the resistance of a light dependent resistor changes with light level.

7. Describe an experiment you would perform to determine how the resistance of a thermistor changes with temperature.

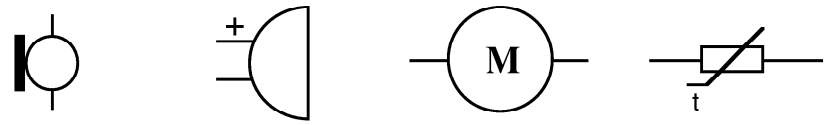
8. Describe an experiment you would perform to determine how the resistance of a light dependent resistor changes with light level.

9. Describe how you would use an oscilloscope to examine the output signal from a microphone. Describe what is seen on the oscilloscope screen.

10. Describe the energy changes which take place in the following output devices:
    loudspeaker, buzzer, lamp, light emitting diode (LED), electric motor.

11. Study the circuit symbols below. In each case:

(a) name the device
(b) state whether it is an input or output device
(c) state the energy changes in the device
(d) give an example of where it could be used.

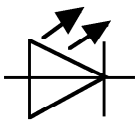


device 1

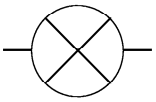
device 2

device 3

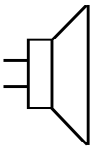
device 4



device 5



device 6



device 7

device 8

12. In the applications below identify which of the above devices would be suitable. Give a reason for the choice of each device.

(a) Output of a radio
(b) Input of an automatic lamp
(c) Input of a heating controller
(d) Output of a fan
(e) Output of an electronic timer
(f) Input of cassette recorder - recording subsystem
(g) Output of a cassette recorder - drive subsystem
(h) Output of a cassette recorder - play back subsystem.

13. Describe what is meant by a "digital signal".

14. Draw an oscilloscope trace of a digital signal.

15. Draw the symbol for the following logic gates:

(a) NOT gate or Inverter
(b) AND gate
(c) OR gate.

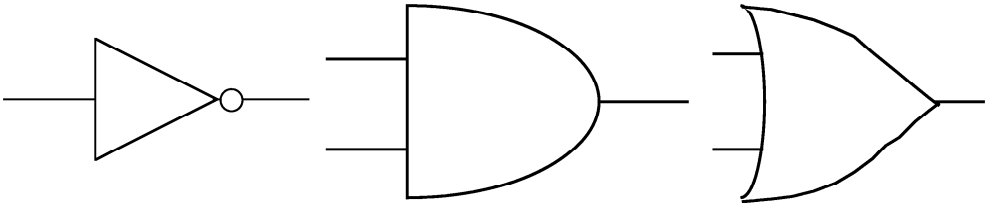
16. The following is a truth table for a logic gate.

Input	Output
0	1
1	0

(a) Name the logic gate.
(b) Explain in terms of voltage levels, what is meant by the "1"s and "0"s.

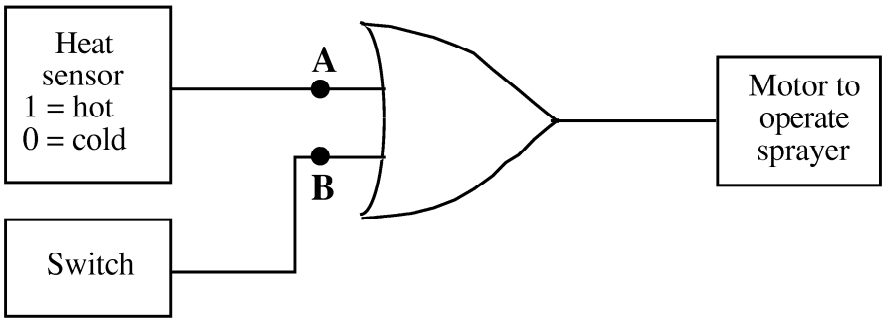
17. For each of the logic gates shown below:

(a) Name the gate
(b) Draw the truth table
(c) Describe the operation of the gate in words.



Gate 1 *Gate 2* *Gate 3*

18. The system below is designed to allow water to be sprayed on to plants if the air becomes too hot **or** the gardener switches the sprayer on.



(a) Identify the logic gate used in the system.
(b) The gardener switches the sprayer on. What is the logic level at B?
(c) What input device could be used in the heat sensor?