Nelson Thornes
Distance Learning

AS Electronics

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Nelson Thornes

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AS ELECTRONICS
Contents

ELECTRONICS AS

AWARDING BODY: AQA

SUBJECT CODE: 1431

INTRODUCTION

DISTANCE LEARNING

You are about to start on your Electronics AS course this year and you are going to be studying Electronics using a distance learning technique. There are several parts to distance learning and it is probably best if you spend a few minutes reading through the following points to familiarise yourself with the method by which you are going to study Electronics this year.

- Package

  The first part of any distance-learning course will be a distance-learning package consisting of printed material. You are reading the first page of the distance-learning package at the moment, and the content of this course will be explained to you a little later on.

- Video Conferencing

  The second major part of any distance learning process is contact with your tutor, and this contact will be largely by a videoconference on a timetabled time, regularly for an hour once per week. The tutor will explain the topics to you, will give you certain tasks to perform, and will expect you to do a certain amount of work to be carried out during the next week.

- Text book

  The third part of distance learning involves the use of the course textbook. There are two different course textbooks - whichever one you have, follow the references for that during the course. Read the specified pages when you are asked to, and attempt any questions that follow. Be ready to discuss any problems you have had with this at your next videoconference.

- Practical Work

  The fourth part of distance learning involves you carrying out regular practical work. For this, you will have the “Hands On” equipment in the flight case and you will be guided through practical work using it. You will be asked to collect results from the practicals you are doing, and report these back to your tutor.

- Handing in Your Work

  Every theory topic is followed by a series of questions to be completed in your own time. Most topics also have practical work associated with them, followed by a series of practical questions based on what you have done. You will complete a grid containing all your answers and send this to your tutor. Your work will be marked and the results given back to you at the next tutorial if possible. Your work is also archived so that your tutor can assess your progress.
  Your week's work is not complete until this is done.

- Visits

  There will also be a programme of tutor visits. Your tutor will come and visit you in school to discuss with you, first of all in the first term, setting up the course, to explain to you what you have to do in order to be successful, and to give out any materials that you will need. There will also be another visit to be arranged later on in the year. In this way your tutor will be able to keep in touch with you on a personal level.

In general, distance learning is successful for students who:

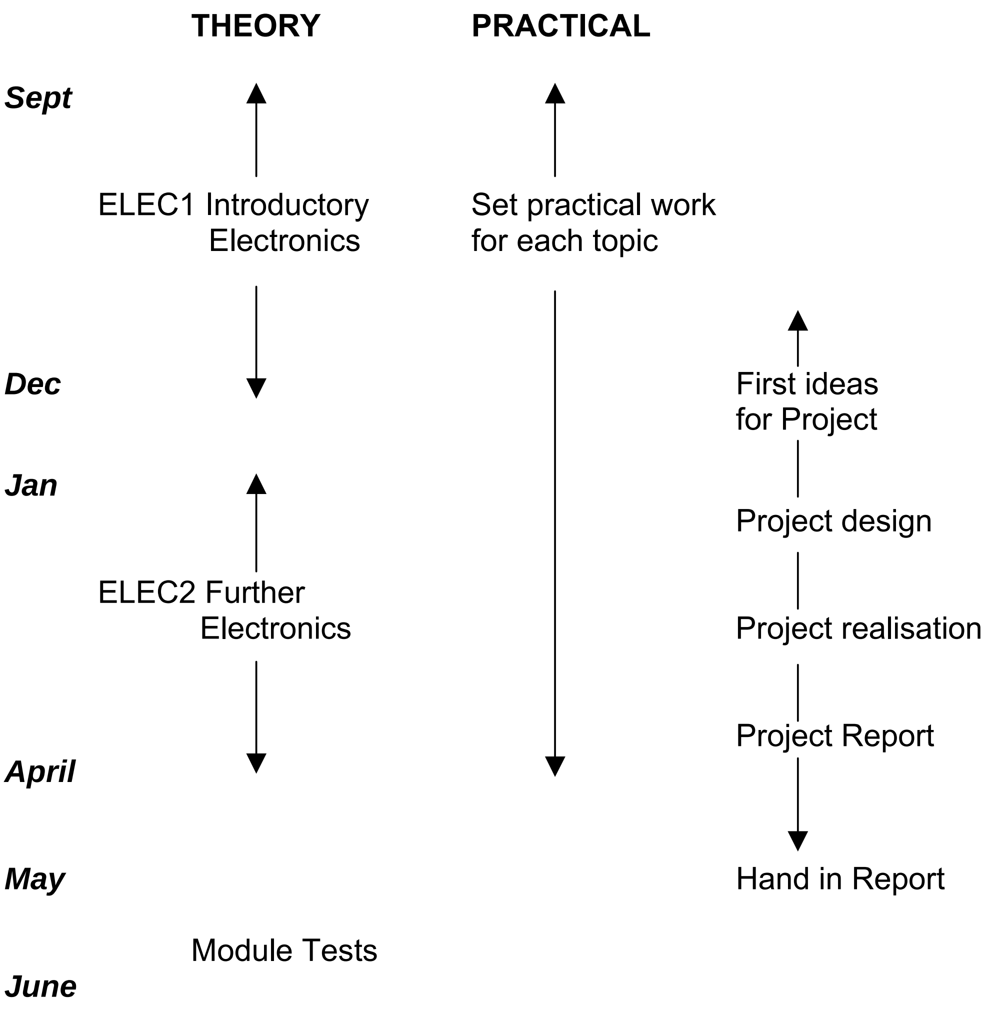
- **take part in the regular video conferences**
- **read the distance learning package**
- **follow the practicals**
- **use the support text book wisely wherever asked to**
- **e- mail or post their work on time.**

A lot of this will be more familiar to you in a few weeks time when you have had a chance to make a start on your Electronics course with your tutor.

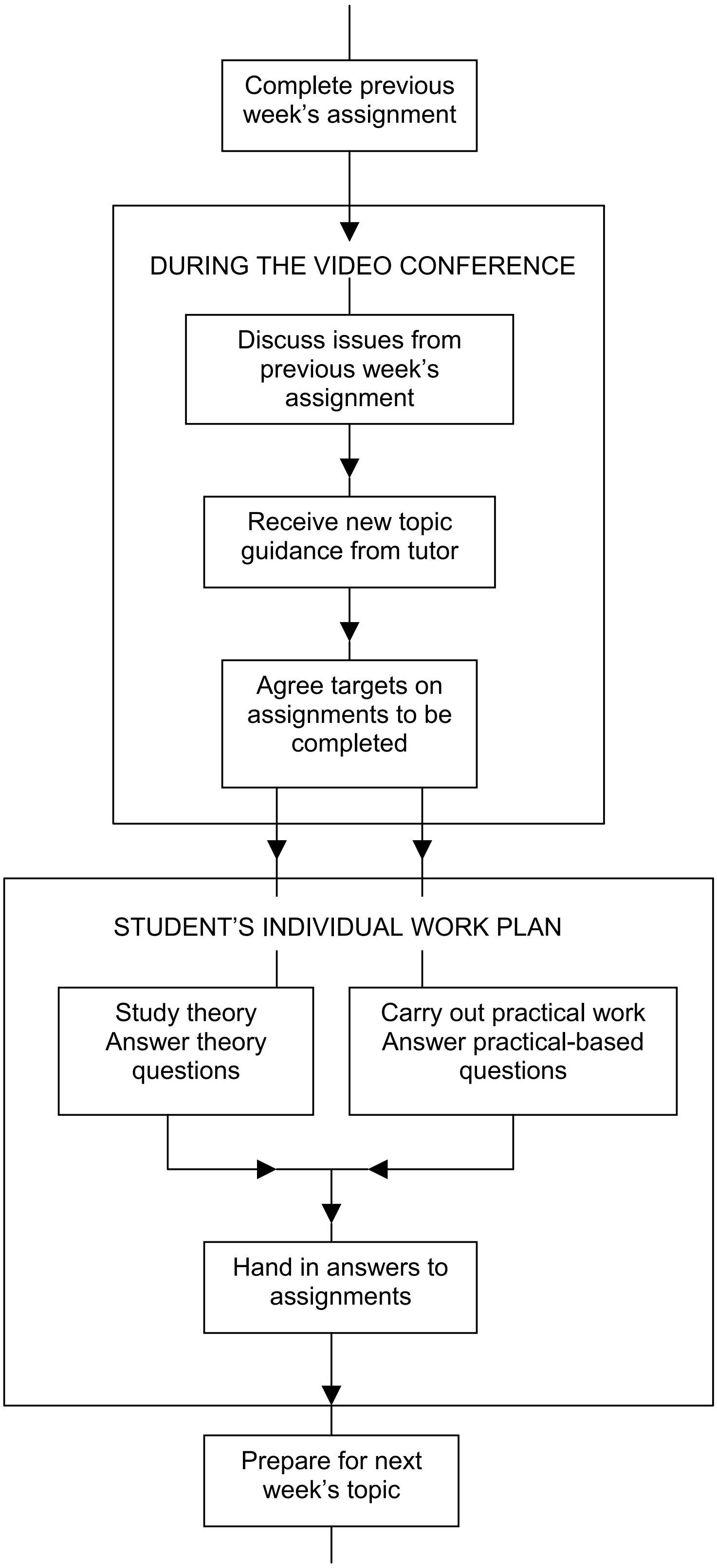
ELECTRONICS AS

This year you will be studying two separate theory modules and you will be undergoing one practical coursework assignment in the form of a project.

The first theory module, ELEC1 is called ‘Introductory Electronics’. That will take approximately the first term to complete, after which time you should be able to begin to think about a suitable title for your project. There will, of course, be a guidance package on this coursework given to you at the right time. In January, module ELEC2 entitled ‘Further Electronics’ will be started, and this will continue until early April, when you will then concentrate on finishing your project and its report. After this you will begin preparation for the Module Tests in May/June.



A Typical Week on a Distance Learning Course



ELEC1 Introductory Electronics

This section is a **complete list** of all the topics covered in **ELEC1**.

The boxes are for you to use as a checklist to confirm you have completed **all the work**. When you have completed a topic, indicate this by writing in the box the **page number(s)** where you have found the relevant theory on that topic. In this way you will build your own index that will be useful when you come to revise for the Module Test.

ELEC1 is found in section 3.1 of the specification.

Section No.	***Topic***	***Skills***	Page
1	**System Synthesis**	Systems consist of inputs, processes, outputs and possibly feedback.	
		Analyse and design systems.	
		Complex system diagrams	
		Systems with several inputs	
2	**Basic Electrical Calculations**	Voltages in circuits	
		Ohms Law calculations	
		Power calculations	
		Resistors in series and/or parallel	
		Resistors in practice	
3	**Diodes**	Silicon diode basics	
		LEDs	
		Zener diodes	

4	**Transducers**	LDRs	
		Thermistors	
		Voltage dividers	
5	**Transistors**	npn transistors	
		MOSFETS	
		Using transistors as switches	
6	**Output devices**	Electromagnetic relays and solenoids	
		Diode protection	
		Buzzers	
		Motors	
7	**Operational Amplifier**	Basics	
		Input and output behaviour	
		The comparator	
8	**Logic Gates**	Identify and use different logic gates	
		Truth tables	
		Combinations of gates	
		Boolean Algebra	

9	**Design and Simplification of Combinational Logic Systems**	Design a logic system from a truth table or a description	
		Simplification using Boolean Algebra or a Karnaugh Map	
		Convert logic systems into NOR or NAND gates only	
		Explain the operation of combinational logic systems	

INTRODUCTORY ELECTRONICS

Section 1 : SYSTEM SYNTHESIS

AIMS: ***This section will help you to:***

- Investigate the systems approach to Electronics ☐
- Analyse system diagrams ☐
- Design your own system diagrams ☐
- Represent complex systems in terms of subsystems ☐
- Name systems that make use of several sensors ☐

Tick the boxes when you have achieved each aim.

READING:

AQA syllabus support booklet for Introductory Electronics

This will help you throughout the course and it should be downloaded so you have continual access to it, read pages 7 – 9. ☐

'Electronics Explained' by M. W. Brimicombe

Read pages 21- 23 about digital systems ☐

Tick the boxes when you have completed each task.

Electronic Systems

Any Electronic system can be broken down into smaller parts called **subsystems**.

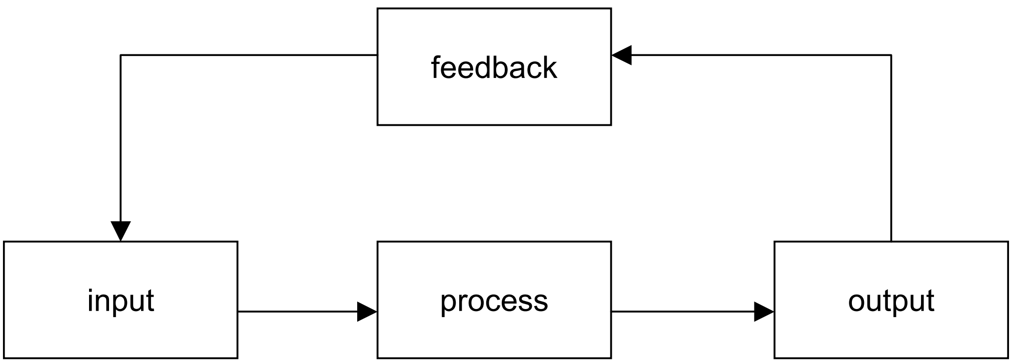
Subsystems can be:

- **Inputs**
- **Processes**
- **Outputs**

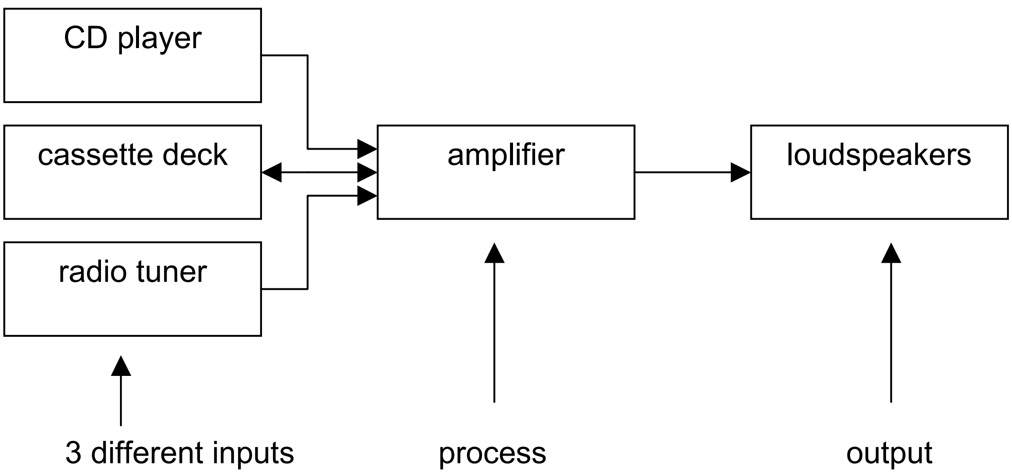
Some systems have:

- **Feedback** (but not in simple systems)

A general system diagram would look like this:



An audio hi-fi system makes a good example to show how to apply this in practice:



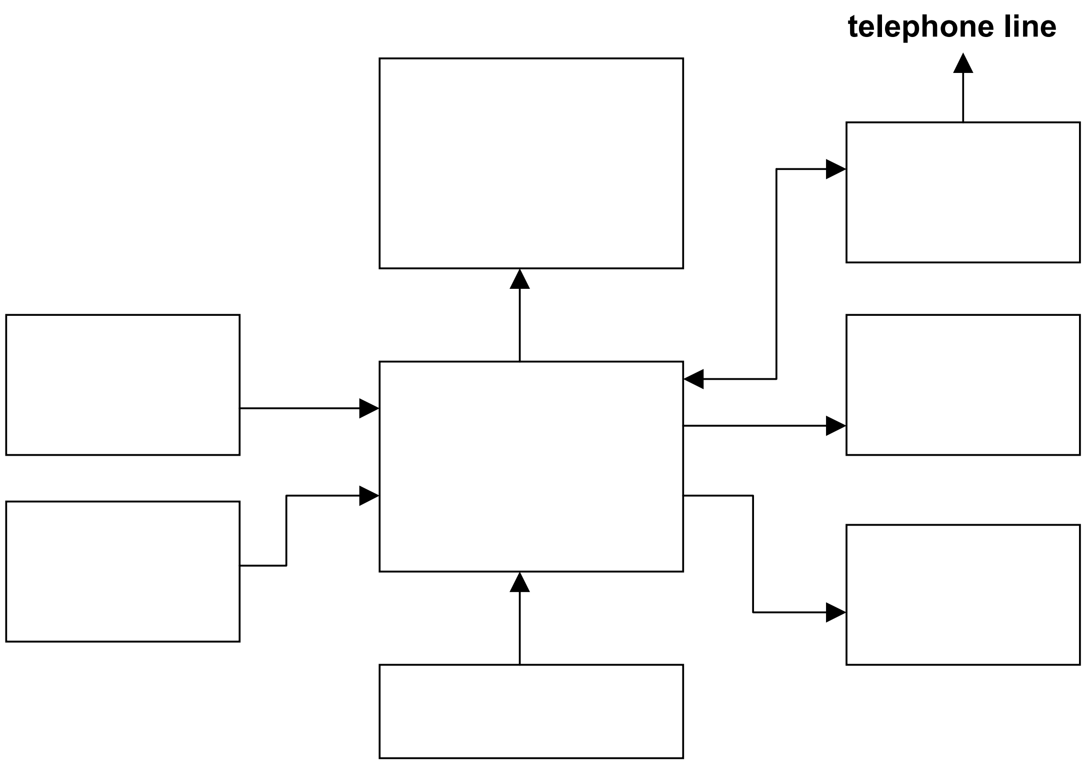
Complex Systems 1

A more complex system could be a Personal Computer (PC). At the simplest level a PC has a:

Keyboard		System box	
Monitor		Loudspeakers	
Printer		Modem	
Mouse		Scanner	

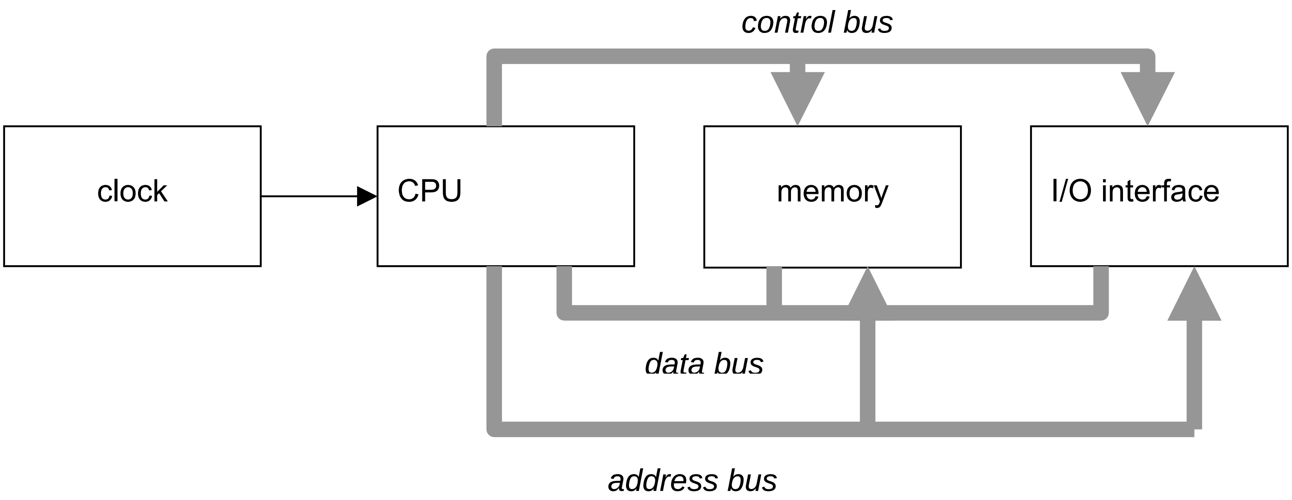
Label each box above to describe what type of subsystem it is (input, process, or output). (You may have a problem in deciding which type of subsystem to label the modem.)

Complete the diagram below by using the subsystem names above to show how they work together in a PC.



Complex Systems 2

Any one of the subsystems in the PC system diagram can itself be broken down further. The system box is the computer, based on a microprocessor system, shown below:



Use your reference material to find out more about this system.

What is a CPU?

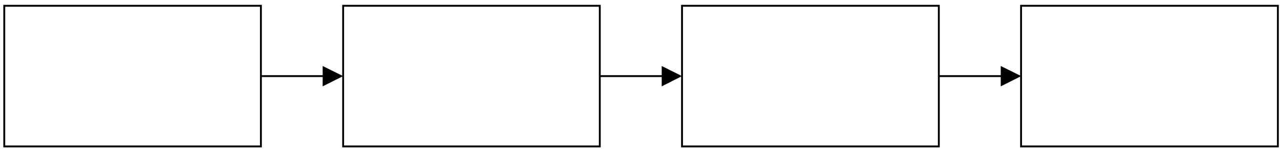
What is an I/O interface?

What is a bus?

Find out what the single arrowed lines between subsystem boxes represent, and the difference between these and the bus structures drawn on the diagram of the microprocessor.
Write this down in the box below.

Designing your own system diagrams 1

Most street lamps come on automatically when it gets dark. You have a lamp, a relay to control the lamp, a light sensor and a process stage to produce an output for the relay when it is dark.
Complete the system diagram for this below:



Input subsystems

The input subsystems you will need to be familiar with include sensors for: (the numbers will be used in the questions at the end)

1	light (LDR)	2	heat (thermistor)
3	touch (switch)	4	magnetism
5	humidity	6	sound (microphone)

Processes

These include:

1	amplifiers	2	analogue to digital converters
3	comparators	4	drivers
5	logic	6	memory
7	pulsers	8	timers
9	relays		

Output subsystems

These include:

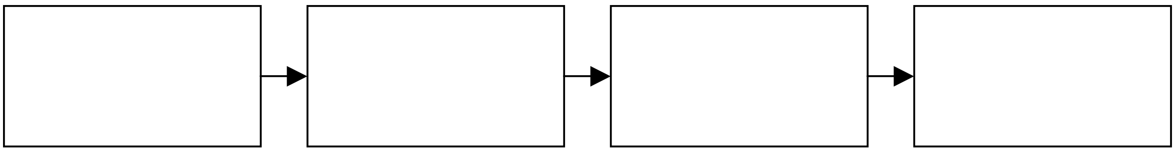
1	lamps	2	LEDs
3	loudspeakers	4	buzzers
5	heaters	6	solenoids
7	motors	8	ultrasonic transducers

Designing your own system diagrams 2

To help you develop the skill to design your own systems (using the subsystems listed on the previous page), attempt the following two design tasks:

Design Tasks

1 An electronically controlled room heater is needed, design a system diagram for this using a comparator to compare the room temperature with the required temperature, and a driver to switch on a heating device, as your process stages:



2 Design an automatic porch light that switches on a lamp when it gets dark. You will need the same process stages as in the heater, plus an extra one the will reverse the signal (remember that you want the lamp to switch on when the sensor detects darkness).

That is all there is to system design, no need to worry about what is inside each subsystem, what it does is more important at this stage. You will be building simple systems like these in the practical section that follows.

READ THE FOLLOWING CAREFULLY:
Health and Safety Precautions:
Proper Use of the 'Hands On' Electronics Kit

This kit contains electronic components and tools that are to be used only as directed. Used safely, no harm should come to the user if the following rules are strictly adhered to:

- Circuits assembled from these components should only be powered up from the 9V battery when they are complete, and have been checked.
- Do not build or adjust any circuit with the battery connected.
- Use only the recommended 9V battery to power all circuits (do not use any other power source). The 9V battery has been chosen to avoid the possibility of large currents flowing, causing overheating.
- The tools should only be used in connection with the Practicals described in the booklet.
- Care should be exercised when cutting and stripping wires, particularly if wire fragments could fly off when wires are cut.
- Eye protection should be worn and the open face of the cutters should face away from yourself and others.
- The screwdrivers are necessarily sharp at their blade ends and undue force should not be used on them as there is danger of puncture wounds being inflicted.
- Wire ends (including component leads and meter probes) are also sharp, and care should be exercised when handling them.
- The multimeters should not be used for any electrical measurements other than those indicated in the Practicals.

UNDER NO CIRCUMSTANCES ARE THE MULTIMETERS OR ANY OTHER COMPONENTS OR TOOLS TO BE CONNECTED DIRECTLY OR INDIRECTLY TO THE MAINS ELECTRICAL SUPPLY.

Please sign and date the tear-off strip below to show you have read, understood, and agree to abide by these instructions. You may begin the practical work only when you have done so.

Hand the signed and dated form to your tutor on the first visit.

✂ ……………………………………………………………………………………………….

Health and Safety Precautions:
Proper Use of the 'Hands On' Electronics Kit

I have read and understood the Health and Safety Precautions and I agree to be bound by them. Nelson Thornes Distance Learning will accept no responsibility for damage or injury howsoever caused.

Signature ………………………………………………… **Date** …………………………

Name ………………………………………………………

School …………………………………………………….

Before you start the practicals

Before you start, check the contents of the ***equipment case*** against the list given later. This will help you familiarise yourself with the locations of the parts you will need at each stage.

Pay particular attention to the double-sided ***parts organiser box***, and check the diagrams included later to find the location of the various components within the box. To avoid spilling the contents, make sure the lid is closed on both sides before turning it over to access each of the sides.

The Equipment Case

The Parts Organiser Box

Contents of AS 'Hands On' Kit

1 equipment case	1 wire stripper	1 screwdriver set
2 multimeters	1 side cutter	4 wire packs
1 x 610 resistor kit	1 long-nose pliers	1 jump wire kit
1 x 120 capacitor kit	1 combination pliers	4 bread boards
1 x 40 LED kit	1 microphone	Carrying strap

1 Parts Organiser Box containing:

Op-amps:

2 x 741
4 x TL081

Transistors:

2 x BC108
2 x BC548
4 x 2N2219
4 x 2N2222A
4 x BC635
1 x BC141
1 x 2N4033
2 x HUF75337

Potentiometers:

1 x 10k panel mounting
4 x 10k
4 x 50k
4 x 100k
4 x 250k

Logic ICs:

4 x 4001
4 x 4011
4 x 4013
4 x 4017
4 x 4029
4 x 4049
4 x 4071
4 x 4081

LEDs:

2 x green LED
2 x red LED

Diodes:

4 x IN4001
4 x IN4148
24 x zener diodes

Miscellaneous:

4 x battery boxes
4 x 9V batteries
6 x 555 timer
4 x LDR
4 x thermistor
230 x resistors
28 x polarised capacitors
36 x polyester capacitors
8 x ceramic capacitors
1 x stripboard
1 x 6V buzzer
1 x DC buzzer
1 x loudspeaker
1 x piezo speaker
1 x relay
1 x reed relay

Plan of Side 1 of Parts Organiser Box:

relays	logic ICs
zener diodes	batteries, battery boxes, stripboard, loudspeaker

Plan of Side 2 of Parts Organiser Box:

potentiometers	transistors	LEDs	rectifier diodes	resistors
buzzers	polyester capacitors	electrolytic capacitors	ceramic capacitors	thermistors
555 timers	op-amps	BC635 transistors	2N2219 & 2N2222 transistors	LDRs

Maplin Components Order list

Component	Order No.	Price (£)	Component	Order No.	Price (£)
case	GL34M	29.99	HUF75337	UE47B x 2	2.98
GCSE kit	GT66W	19.99	TL081	RA70M x 4	1.56
meters	N20AX x 2	9.98	555	QH66W x 4	1.16
610R kit	FA08J	7.99	Jumper kit	FS65V	8.99
CAP kit	N68BT	7.99	breadboards	FD32K x 4	39.96
LED kit	RS37S	7.99	batt boxes	L90AN x 4	3.96
LDR	N47AY x 4	3.96	9V alk batts	L46AL x 4	7.96
Therm 15k	FX22Y x 4	1.96	cutter/str	FT44X	4.99
4001	QX01B x 4	1.56	sidecut	RL85G	2.99
4011	QX05F x 4	1.56	plierLN	RL84F	2.99
4013	QX07H x 4	1.96	combpli	RD99H	2.99
4017	QX09K x 4	3.96	screwd	RR34M	1.99
4029	QW20W x 4	1.96	microphone	CJ15R	6.99
4049	QX21X x 4	1.96	reed relay	JH12N	0.99
4071	QW43W x 4	1.56	relay	FM91Y	1.49
4081	QW48C x 4	1.96	DC buzz	CR34M	1.29
4.7Z	QF45Y x 4	0.28	spkr	VC86T	1.99
5.1Z	QF46A x 4	0.28	pzt spch	YU83E	0.49
5.6Z	QF47B x 4	0.28	pot 10k	UHO3D x 4	0.76
6.2Z	QF48C x 4	0.28	pot 50k	N42BR x 4	0.76
6.8Z	QF49D x 4	0.28	pot 100k	UH06G x 4	0.76
7.5Z	QF50E x 4	0.28	pot 250k	N43BR x 4	0.76
2N2219	N46AC x 4	3.16	wire blk	BL85G	0.99
2N2222A	UH54J x 4	2.36	wire blu	BL86T	0.99
BC635	N56AC x 4	0.60	wire red	BL92A	0.99
BC141-10	QB38R	0.49	wire yel	BL95D	0.99
2N4033	N10AF	0.79			

Section 1 Practical: System Synthesis

PROJECT 1: Make a lamp switch on when it gets dark

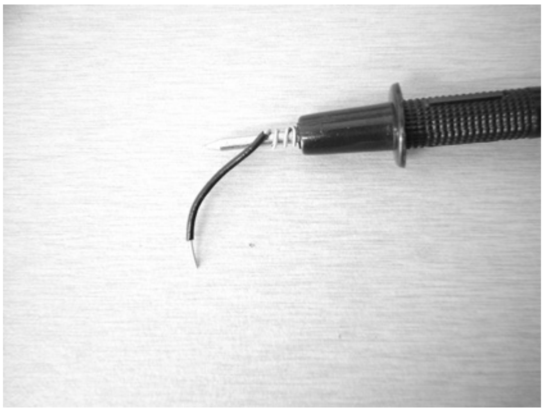
(a) Before you can make even the simplest system, you should investigate the components that make up its subsystems. The first system you are going to make is one to turn on a lamp in the dark. This relies for its action on an LDR (light dependent resistor). Your first step is to investigate the behaviour of the LDR under different lighting conditions.

You will need:

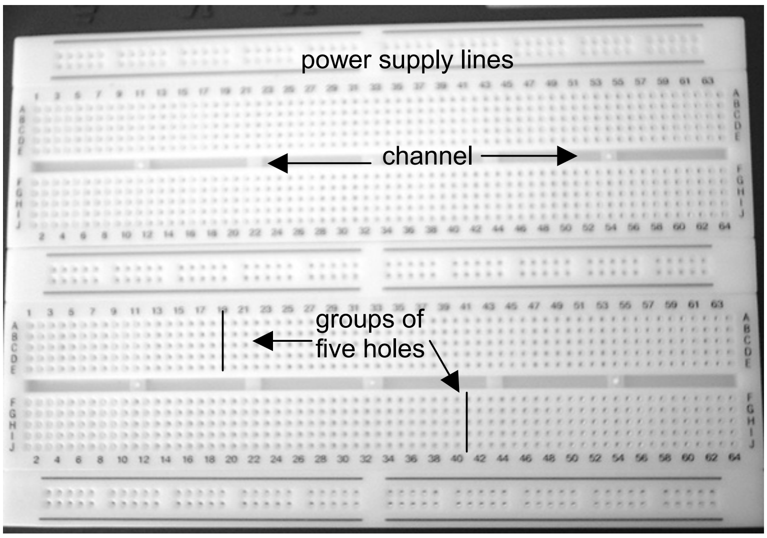
- an LDR
- multimeter and leads
- breadboard
- 2 wires (stripped and attached to the multimeter)
- leads (as shown below)

1. First, add these wires to the meter probes. Cut two 5cm lengths of wire, one from the red pack and the other from the black pack. Strip 5mm of insulation from one end and 20 – 30mm from the other (see photograph below).

2. Wind the longer stripped end of each wire in a tight spiral around each meter lead probe tip, slide this off and pull the spiral out slightly. When you push this back onto the probe tip it will be a tight fit. You now have probes that will plug directly into the breadboard (see photograph below).

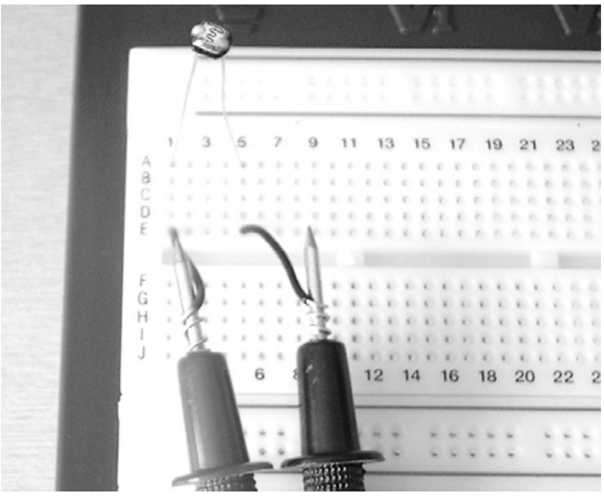


3. On the breadboard, note the red and blue lines of holes. These will be used later for power supply connections. Each numbered group of 5 holes, A – E and F – J are separately connected and isolated from each other numbered group. The channel in the centre of each breadboard is where integrated circuits are located. The arrangement of connections is shown below:



(b) **Investigate the LDR**

1. Plug the LDR leads into A1 and A5. Plug your multimeter wire probes into E1 and E5 – this simply connects the multimeter across the LDR.



2. Your multimeter has 5 ranges that will measure resistance. It uses its internal battery to send a small current through a component connected to it, and calculates the resistance of the component. The value marked on the case for each range is the maximum resistance it can measure when switched to that range. The ranges are:

- 200 Ω (the meter actually goes up to 199.9 Ω)
- 2000 Ω
- 20 kΩ
- 200 kΩ
- 2000 kΩ (2 MΩ)

If you select too low a range, the meter will show this by displaying a single 1 on the left of the screen - move the range switch up.

If the meter reads 0.00, you have either got no resistance at all, or the range switch is set too high – move it down a range and try again.

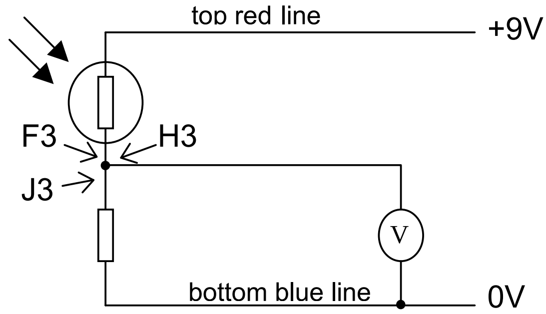
The Multimeter on its 20kΩ range

3. Use your multimeter to measure the resistance of the LDR in varying lighting conditions. Complete the table below with your results.

Light level	Resistance (Ω)
Bright sunlight	
Overcast	
Room light	
In shadow	
As dark as possible	

(c) **Investigate the voltage divider circuit**

1. Build this circuit:

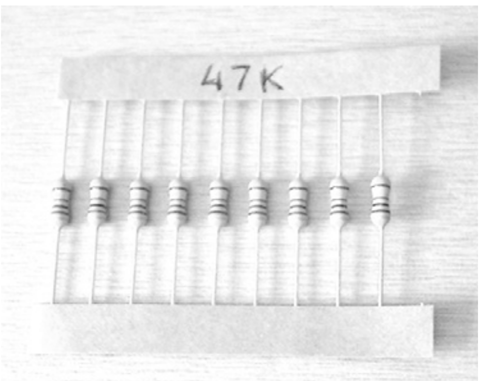


Your second step is to place the LDR in series with a fixed resistor to make a voltage divider circuit as shown above. The theory for this is covered later, but for now, this will enable the LDR to act as an input sub-system to give out a signal voltage related to the light level.

In addition to the requirements in (a) you will need:

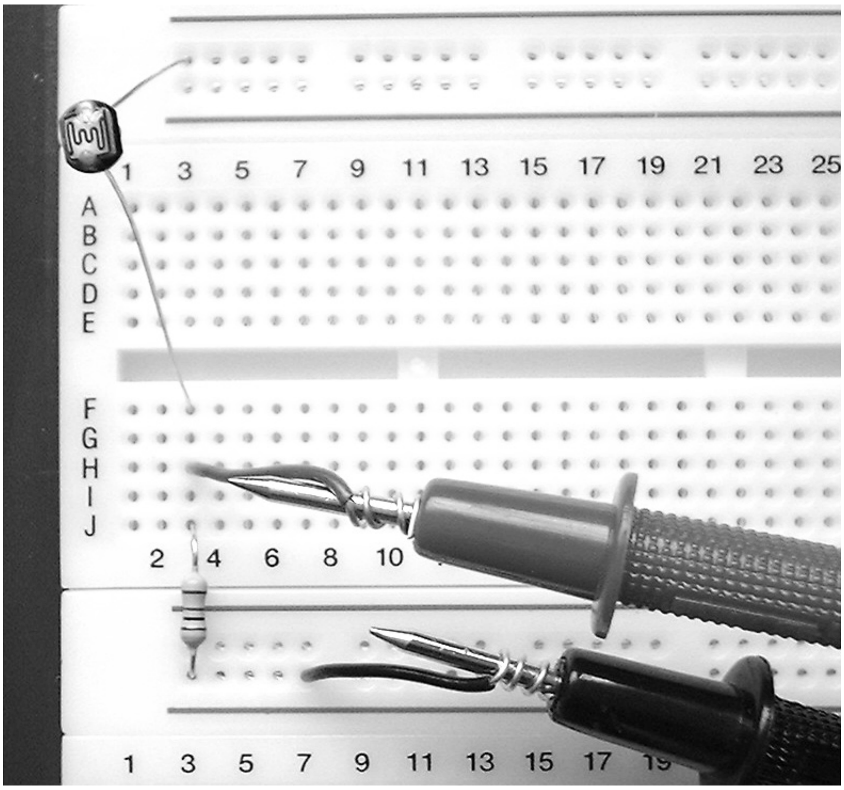
- 9V battery in switched battery box, (remove the crosshead screw, insert a 9V battery and replace the screw, make sure the switch on the box is off).
- 47kΩ resistor, use the colour code to identify it, then use the wire cutters to clip it out of the strip, and mark the strip 47kΩ (to help in identifying resistors, mark all the strips as you use them for the first time).

Strip of 47kΩ resistors



2. The LDR is plugged in between the leftmost hole on the top red line and F3. The resistor goes from J3 (so it connects to the LDR), to the bottom blue line. (Keep to red for positive and blue for 0V in all your work.) The red voltmeter probe goes into H3 and the black probe to the blue line.
   The battery should be in its switched box, its red lead should be plugged into the right hand side of the red line (above A31) and the black lead to the right hand side of the blue line (below J31).

The LDR circuit



Switch the multimeter on to the 20V range and switch on the battery.

3. Record the voltage output signal from your circuit under the same lighting conditions as before. Complete the table below with your results.

Light level	Output voltage (V)
Bright sunlight	
Overcast	
Room light	
In shadow	
As dark as possible	

4. You have now made and investigated the input subsystem. Remove the multimeter probes. Leave the resistor, LDR and battery box in place for a later part of this practical and switch off the battery.

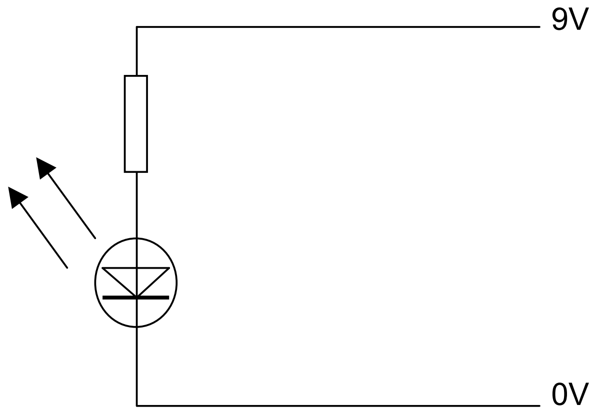
(d) **Investigating the output subsystem**

1. The output for your system is going to be an LED. LEDs must always have a suitable series resistor (again, this will be explained later). You will need an LED and a1 kΩ resistor

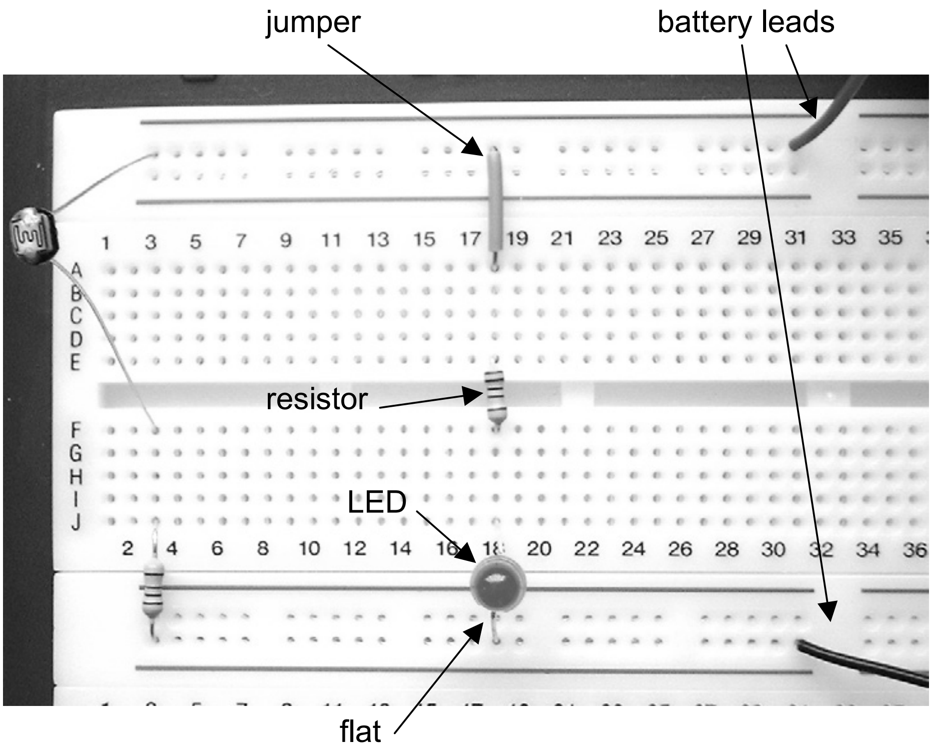
   Identify the cathode (negative connection) of the LED by finding the shortest lead, or the lead nearest the ‘flat’ on the lower rim of the LED body.

2. Connect the LED cathode to the blue line below J18, its other lead going to J18. Connect the 1 kΩ resistor (don’t forget to mark the strip from which you removed the resistor) from F18 to E18 across the channel. Complete the circuit using a jumper wire link from A18 up to the top red line.

You have now completed the circuit, which is shown below in diagram form, as is a photograph of the completed circuit (note the components from the previous circuit on the left).



The LED circuit



3. Switch on the battery – hopefully you will observe the LED lighting.

4. Use your multimeter on its 20V range to measure the voltages across the LED and resistor separately.

Voltage across LED	V
Voltage across resistor	V

Leave the LED in place, remove the resistor and jump wire link.

(e) **Adding the process stage**

1. You are going to add a process stage called an **inverter**. It will convert a low voltage from the light sensor into a high voltage capable of switching on the LED and so make a light come on in the dark.

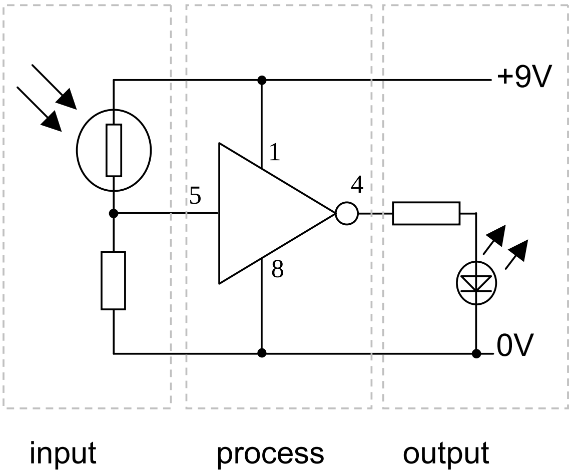
2. You will need:

- a 4049 IC
- jumper wires

in addition to the components from the earlier stages.

3. Build the circuit on the following page onto the breadboard. The LDR, 47 kΩ resistor and LED, are already in place, as is the battery. Make sure the battery is off.

The complete system



4. Plug the IC across the channel from E9, F9 to E16 F16.The mark on the IC between pins 1 and 16 should be on the left, so that pin 1 is in hole F9.

   Wire the +9V line to pin 1 on the IC (the Vss or positive power pin) by connecting a jumper wire from the red line down to G9. (This has been done with two jumper wires on the photo, joined by using D5 and E5.)

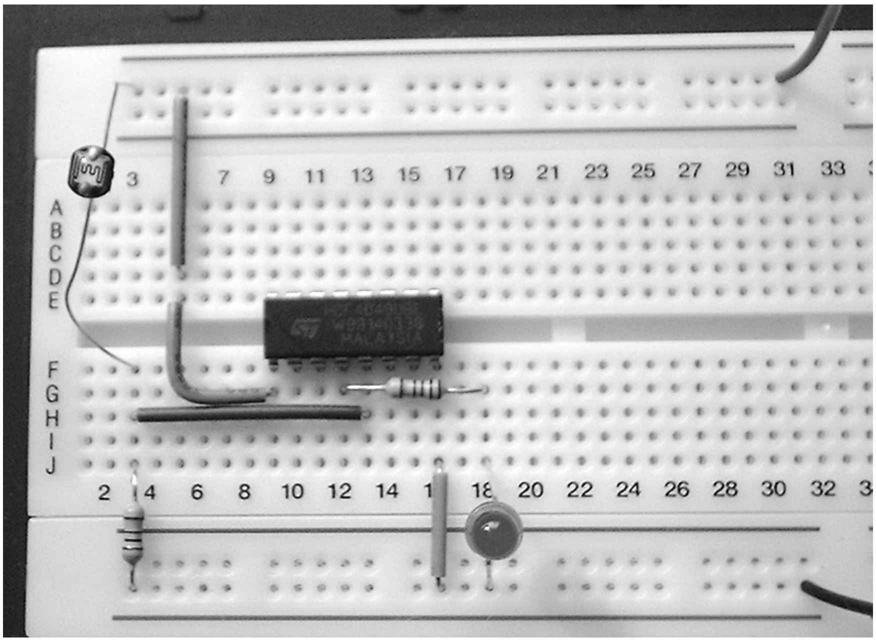
   Use another jumper wire to connect pin 8 of the IC (the 0V or ground pin) to 0V, wire it from J16 to the blue line below.

   Connect the input subsystem into one of the IC's inverter inputs, (pin 5). To do this, connect a jumper wire from H3 to H13.

   Finally, use the 1 kΩ resistor to connect the output of the inverter (pin 4) to the LED. To do this, connect the resistor from G12 to G18.

5. Check your wiring carefully with the photograph below and switch on.

The complete system



6. Find the lighting conditions needed to make the LED light up.

Lighting conditions to light LED	

Switch off.

7. Remove the 47 kΩ LED resistor and replace it with a 10 kΩ resistor. What change do you notice in the behaviour of your circuit?

Changing to a 10 kΩ resistor	

Further Work:

Swap the positions of the LDR and its resistor, so that the resistor goes to +9V (you may need a jumper wire to connect the resistor and the LDR) and the LDR goes to 0V. How does your system's behaviour change?

Change in behaviour	

PROJECT 2: Make a lamp switch on at a high temperature

Investigate the input sensor

(a) This system uses a thermistor (a temperature-dependent resistor) as its input sensor. Look back to the previous project to remind yourself how you investigated the LDR, and use the same technique to investigate the thermistor.

You will need:

- thermistor (in the parts organiser, box near the LDRs)
- multimeter and probes
- breadboard

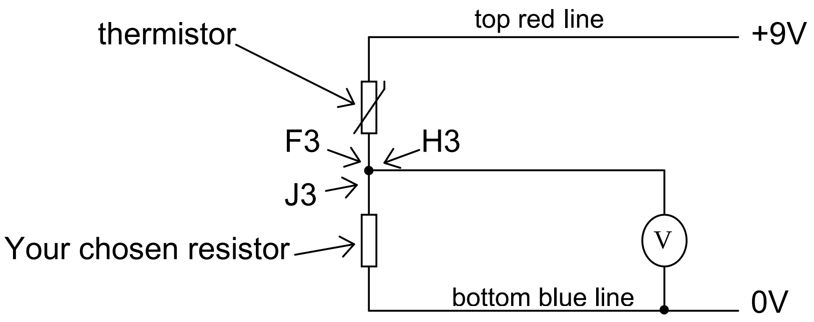
Subject the thermistor to a range of temperatures using the multimeter to measure its resistance at each point. (If you have access to a thermometer you may be able to measure the exact temperature.) Any aerosol spray will reduce the temperature of the thermistor if sprayed for one second.

Temperature	Resistance (Ω)
Aerosol spray	
Room temperature	
Warm fingers	

(b) The second step is to place the thermistor into a voltage divider circuit, as you did previously. In addition to the requirements in (a), you will need:

- 9V battery in its box
- a resistor of as close to the value of resistance of the thermistor at room temperature that you found in the table above.

Build this circuit:



Follow the steps from the previous system to build this circuit and investigate the range of output voltages from this subsystem.

Temperature	Output Voltage (V)
Aerosol spray	
Room temperature	
Warm fingers	

(c) **Making the complete system**

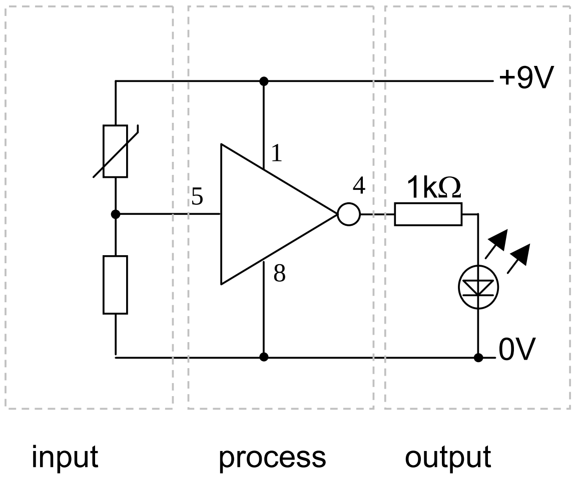
1. Since you have already investigated the LED and its resistor as an output subsystem, go straight on to building the complete system.

   You will need the following in addition:

   - LED
   - 1 kΩ resistor
   - 4049 IC
   - jumper wires

2. Build this circuit onto the breadboard. Make sure the battery switch is off at all times until you have checked the circuit and are ready to observe your system working.

The complete system



3. Find the conditions under which your LED lights up.

Temperature	LED
Aerosol spray	
Room temperature	
Warm fingers	

4. Exchange the positions of the thermistor and its resistor. How does the system behave now?

Temperature	LED
Aerosol spray	
Room temperature	
Warm fingers	

5. Describe the action of your system.

Section 1 Theory questions

1 What do the lines between sub-system boxes represent?

A: wires, B: electric current, C: information flow, D: none of these

For the next questions use the following codes, input = a, process = b, output = c.

What type of sub-system is?

2 a loudspeaker

3 a microphone

4 an amplifier

5 a LED

6 a comparator

7 What sequence of sub-systems did you use for the street lamp system on page 13? Write down the numbers of the sub-systems from the lists on the same page in the order that they are employed in the system.

8 What sequence of sub-systems did you use for the room heater system on page 14? Use the numbering system from page 13.

9 What sequence of sub-systems did you use for the porch light system on page 14? Use the numbering system from page 13.

10 Design an "intercom" system that would enable speech to be sent from one location in school to another.

Enter this using the numbering system from page 13.

Section 1 Practical Questions

Now find answers to the following questions from your practical work.

1.	LDR resistance in bright sunlight	Ω
2.	LDR resistance as dark as possible	Ω
3.	Output voltage in bright sunlight	V
4.	Output voltage as dark as possible	V
5.	Voltage across LED	V
6.	Lighting conditions to make LED light up	
7.	Resistance of thermistor when warmed	Ω
8.	Resistance of thermistor when cooled	Ω
9.	Output voltage when warmed	V
10.	LED lights up when thermistor is …..	