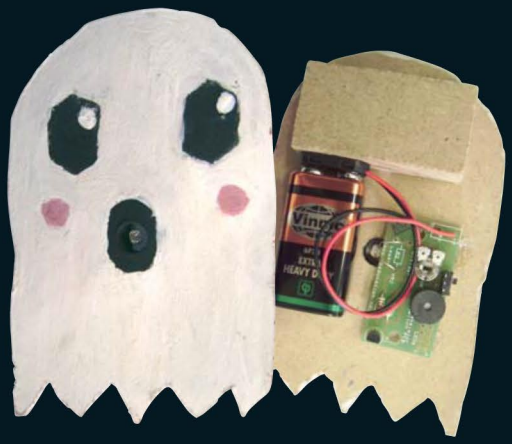
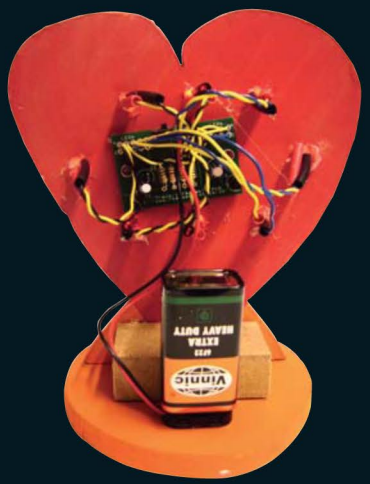
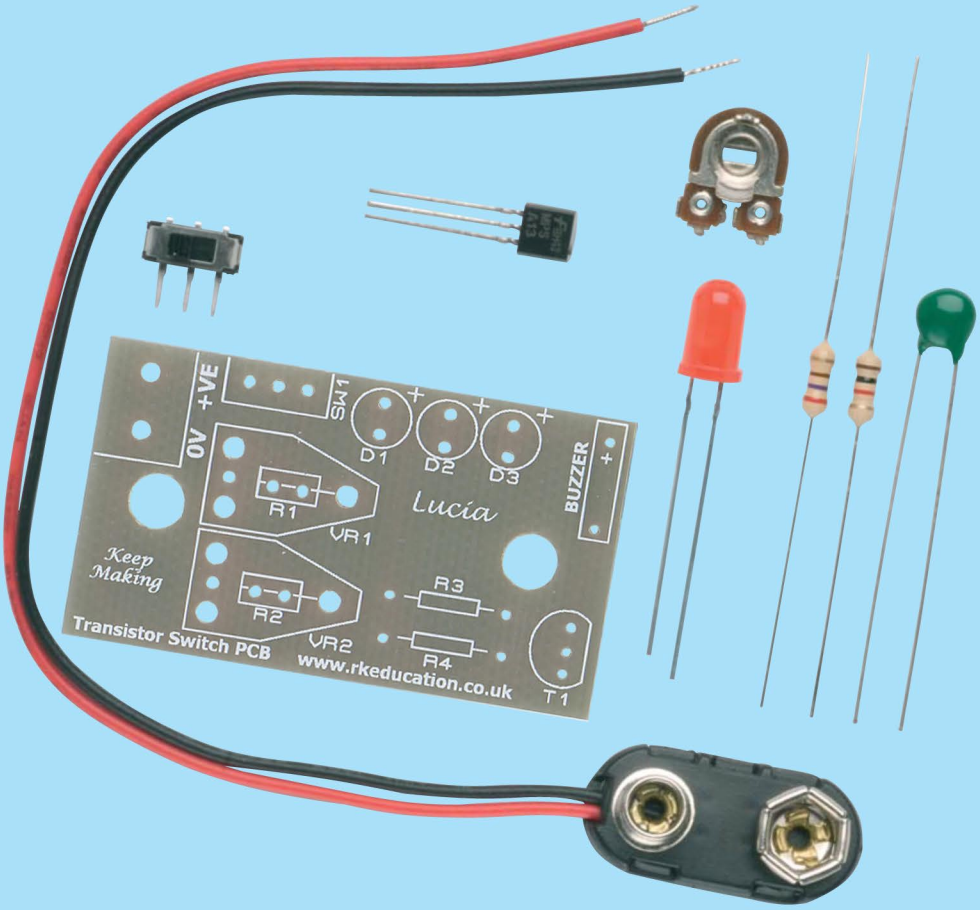
Transistor switch nightlight

KEY STAGE 2,3&4







Rapid

Class and teaching notes for:

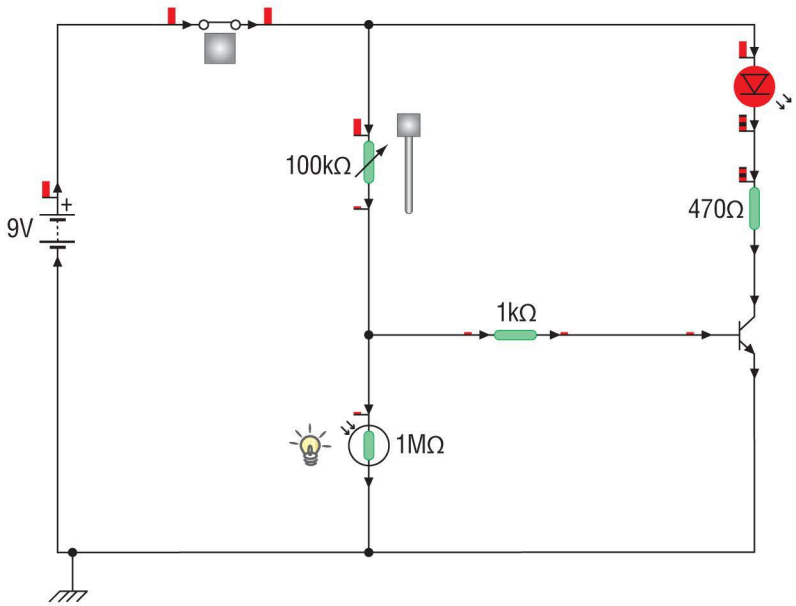
Transistor switch nightlight	70-6024
Transistor switch nightlight with temperature sensor	70-6025

Circuit construction – transistor switch nightlight

The circuit diagram on the right is the circuit for your nightlight. It is called a transistor switch circuit and it uses an LDR to detect changes in light levels. When it is dark the transistor switches on and this switches on the LED.

When the LDR is dark it has a very high resistance which cause the base of the transistor to rise above 0.6V, this is enough to turn on the transistor and LED. When it is light the LDR has low resistance and this turns off the transistor and LED.

The circuit can also be used as a light detector, moisture sensor or temperature sensor.



Construction of circuit

You will need to collect the following equipment before you start soldering your circuit:

- Soldering iron and stand
- Damp sponge
- Solder wire
- Side cutters
- Pliers
- Components: T1 – MPSA13 transistor

  R3 – 470R resistor (yellow, violet, brown)

  R4 – 1K resistor (brown, black, red)

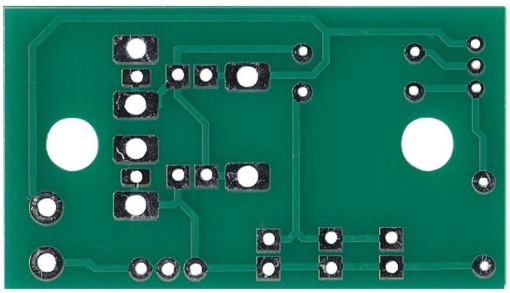
  R2 – LDR

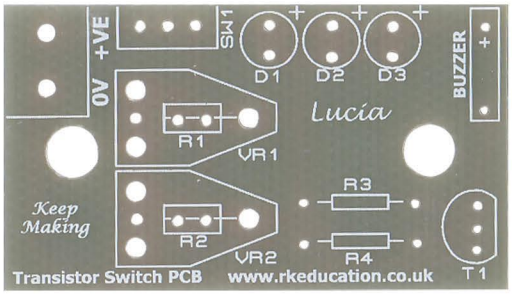
  R1 – 100k preset resistor or 47k resistor (yellow, violet, orange)

  SW1 – Power switch

  Battery – Battery clip

  LED





Procedure for construction

1. Solder the resistors into your PCB, take care to insert the correct resistor into the correct place, if in doubt ask your teacher. When soldering be sure to heat the area sufficiently but not too much as it will damage the PCB.
2. If you are using a preset resistor solder this in place.
3. Solder the transistor in place, be careful as the transistor legs are close together, be sure not to connect the legs together as this will stop the nightlight working. When inserting it do not force it down too far.
4. Solder the LDR in place, when inserting it into the PCB do not force it down too far.
5. Solder your power switch in place
6. Solder your battery clip in place
7. Solder your LED into the PCB, if you have attached flying leads insert these, be sure to get the LED the correct way round, remember the long and short legs …

Case design

There are lots of different ways that you can construct a case for this project but a very simple and effective way is to make it from two pieces of MDF that are cut to shape, attached together and decorated.

Below are three examples:

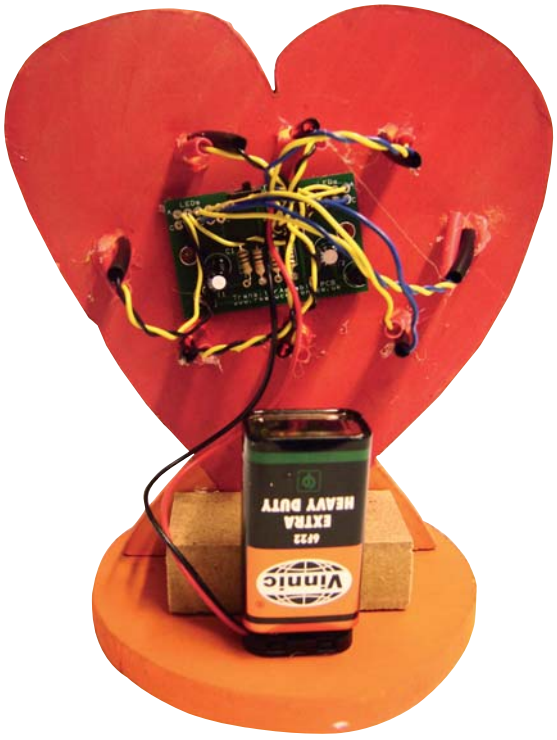
They have been constructed using two pieces of MDF 15 x 15cm with a thin 3mm piece for the upright background and a thicker 6mm piece for the base. They have been glued together using a supporting piece of MDF and PVA glue.

For your case you should create three different designs using A4 plain paper. On each piece of paper draw 2 boxes 15 x 15cm, 1 on each side. In one box draw the base and in the other the background. Be sure to decorate your designs and add labels where necessary e.g. show the location of your LEDs, also evaluate each design against your specification and state what is good and bad about the design and why you think it would appeal to the user.

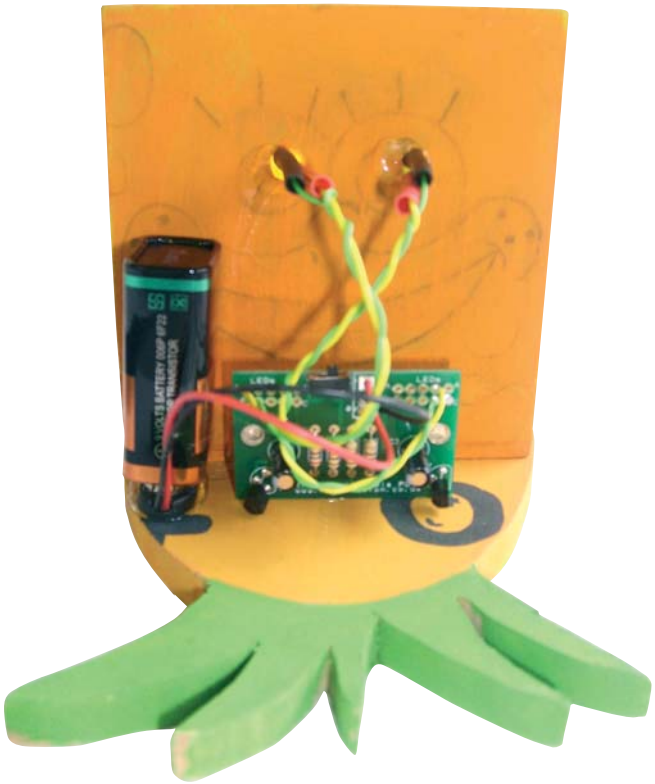
Select a final design that you will build into your final product. State your reasons for the choice you have made.

Extension task: draw your final design in 3D

An example can be seen on the next page showing the back and front view of the product:



Case construction



This has been constructed using two pieces of MDF 15 x 15cm with a thin 3mm piece for the upright background and a thicker 6mm piece for the base. They have been glued together using a supporting piece of MDF and PVA glue.

Procedure:

Remember to always aim for a high quality finish!

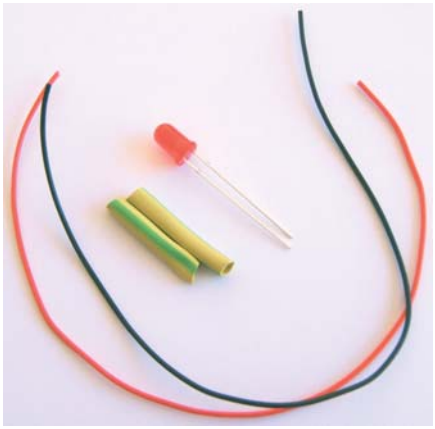
1. Draw your base design outline onto your piece of MDF
2. Cut the outline using the tools and method shown by your teacher, paying close attention to health and safety at all times
3. Finish the edges of your base, using, for example, glasspaper and/or files
4. Draw your background design outline onto your piece of MDF
5. Cut the outline using the tools and method shown by your teacher, paying close attention to health and safety at all times
6. Finish the edges of your base using, for example, glasspaper and/or files
7. Drill the hole or holes for your LEDs using a pillar drill. Remember to use the correct sized drill bit and above all pay close attention to health and safety
8. Begin to decorate your product. You may need to do this over more than one lesson or finish it for homework. Protect your work surfaces and do not allow your work to dry onto newspaper
9. When you have finished decorating, glue your base and background together using PVA glue and a small MDF block. Allow a minimum of one hour for the glue to dry, and several hours to fully set
10. Glue the PCB to the small MDF block using a hot glue gun
11. Glue the battery clip to the back of the product using a hot glue gun
12. If necessary glue the LEDs in place

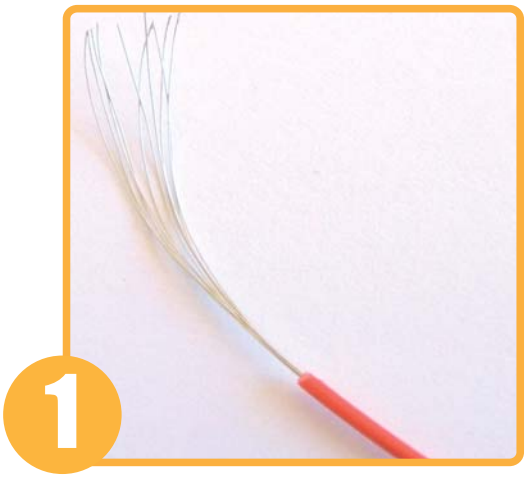
Construct an LED with flying leads

This method is also suitable for constructing push to make switches with flying leads.
You may attach your LEDs to your project using flying leads, if this is the case then use this method.
This example uses multi core wire, you may also use single core.

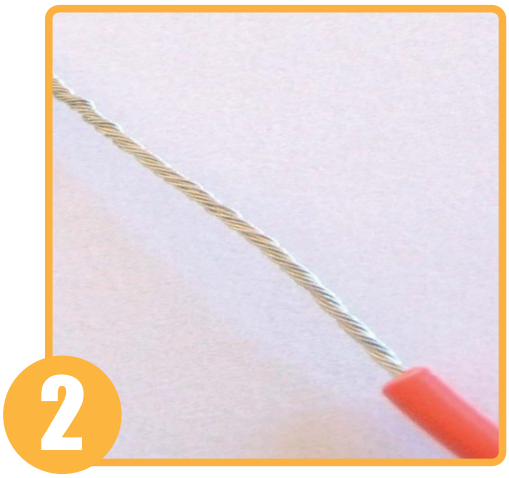
You will need to collect the following equipment before you start soldering your circuit:

- Soldering iron and stand
- Damp sponge
- Solder wire
- Side cutters
- Pliers
- Wire strippers
- Red and black wire
- Rubber tubing
- LEDs
- LED tester

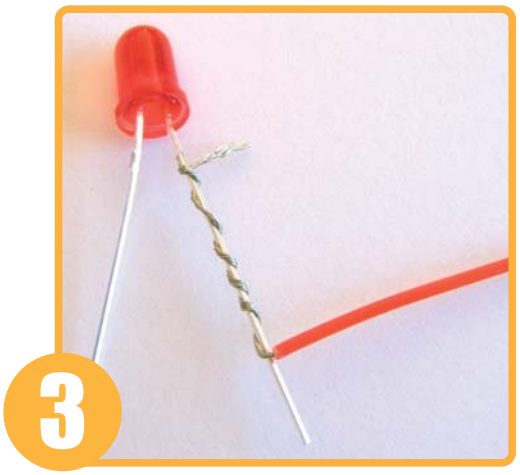




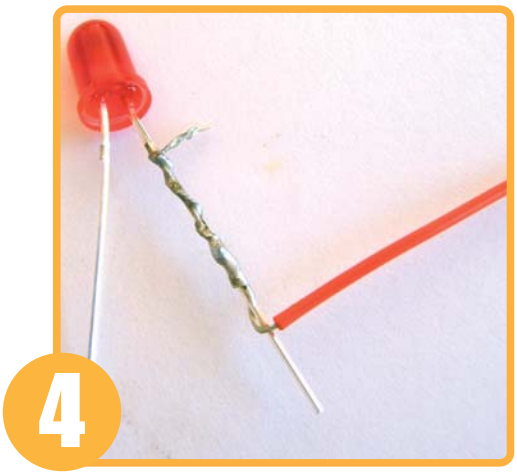
Strip wire using wire strippers



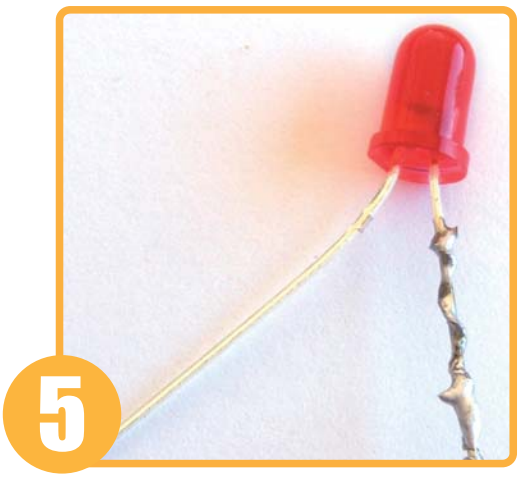
Twist the wire between your finger and thumb to stop fraying



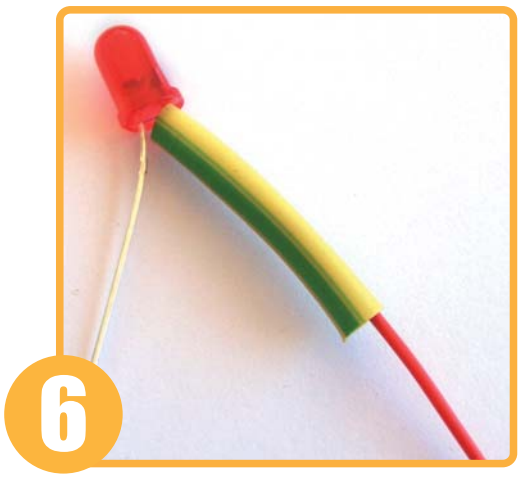
Wrap around the LED leg, remember the long leg, use pliers to help



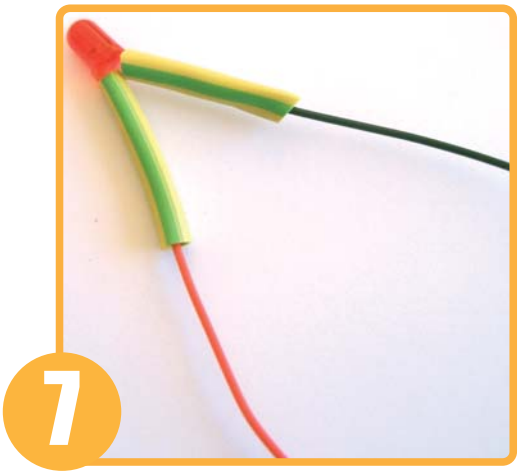
Solder



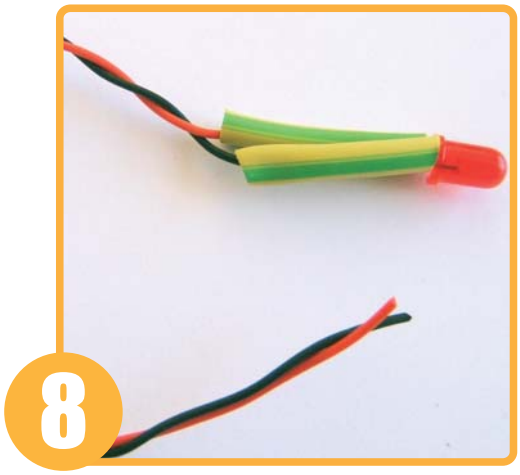
Trim with cutters



Cover with rubber tube



Repeat for other leg



Twist together

Tip

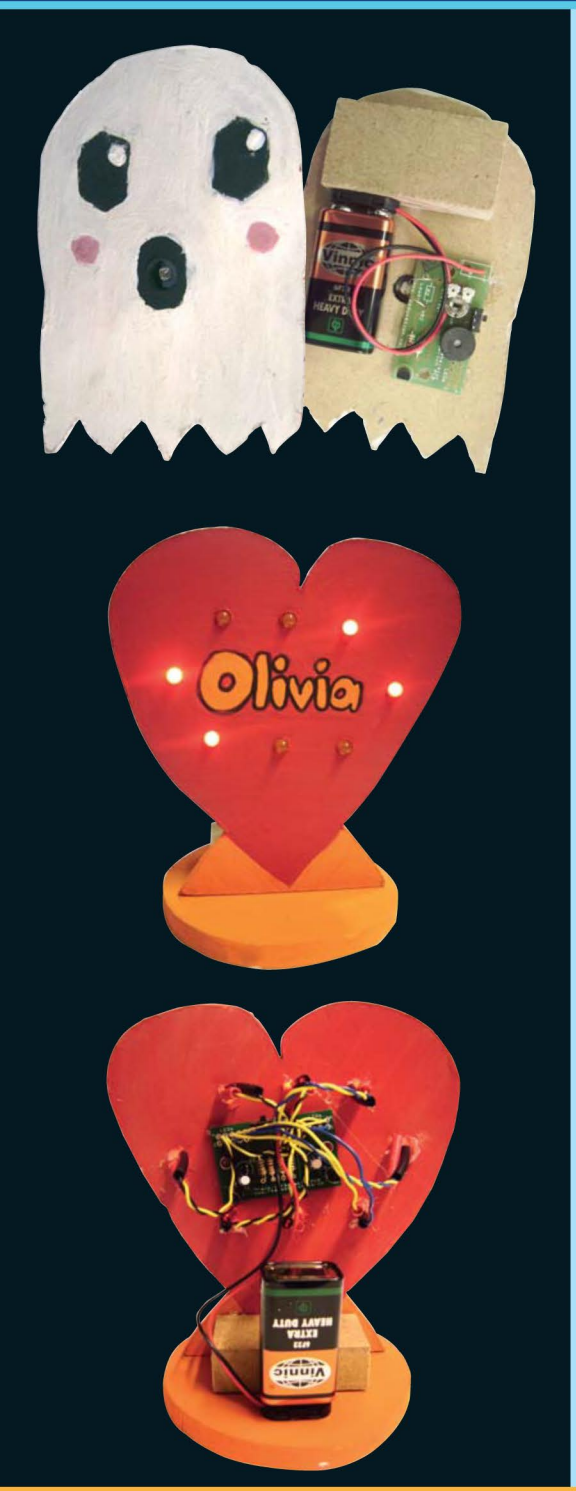
When you have finished, wrap some masking tape around the leg and write your name on it; this will avoid your LEDs getting mixed up with those of other pupils.

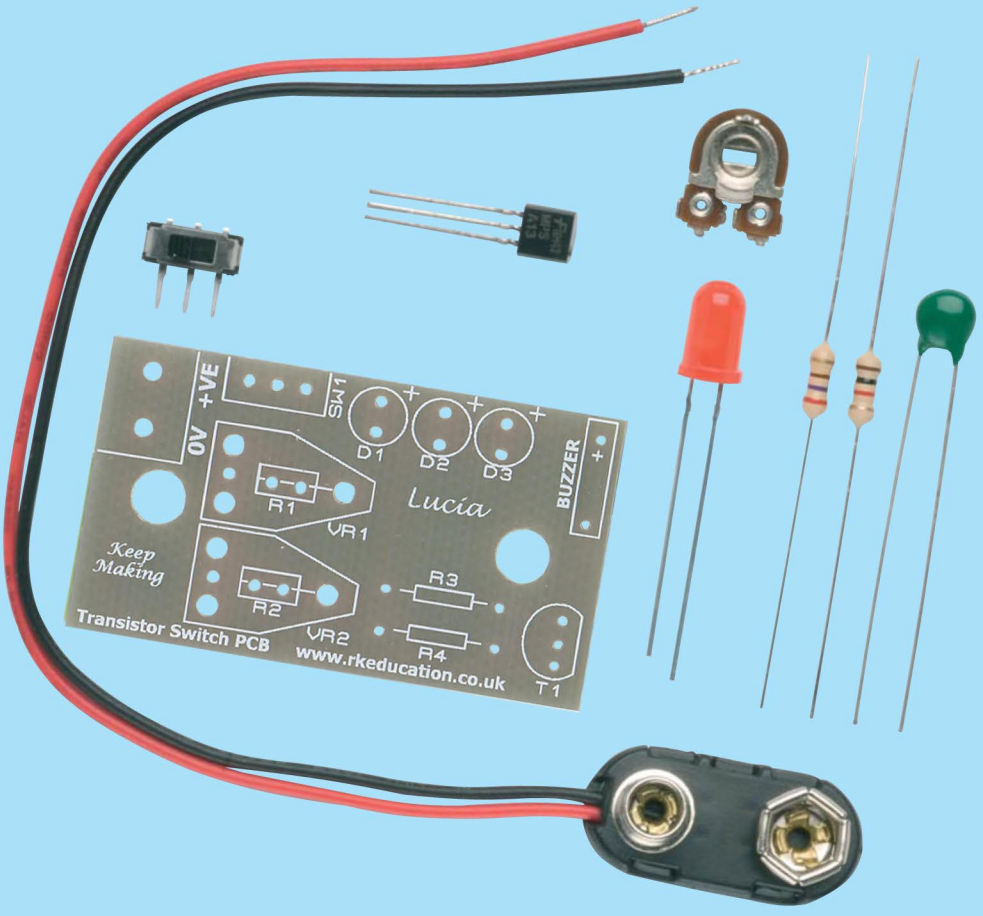
Homework

Produce a storyboard that shows how to make an LED

Teacher Notes

Transistor switch nightlight





Rapid

Teacher notes

Introduction

The aim of this seven week (two hour lessons) project is to design and manufacture an electronic nightlight that lights up in the dark and turns off in light conditions. The project will introduce or reinforce the use of resistors, transistors, LEDs, thermistors and sound outputs. Students will learn about various aspects of electronics including the systems approach, components and circuit diagrams as well as product design. They will learn new practical skills i.e. soldering and develop existing graphics and RMT skills.

This is a rough guide and the time needed for each activity will vary between schools and groups. These notes are based on experience with year 8 groups of approximately 20 students of mixed ability and gender in an average state school. The lessons are broken up into seven, two hour, sessions.

The project is primarily aimed at **Key Stage 3** students but is also excellent for **Key Stage 2** where suitable facilities exist. It is also applicable for **Key Stage 4** students, as the transistor switch circuit is an important part of the syllabus and a popular subject for exam questions.

An excellent way of helping students understand the electronics is by using the training system. It allows students to change various components, input and output and therefore is an effective way of prototyping. It is also very good for exam revision as the circuit is very similar to exam questions asked in the past.

If you have any comments to make about the project and notes, or you would like to contribute, then please contact us.

Aims and objectives

The project is to design and make an electronic nightlight. The project will enable students to experience the design and manufacture of simple electronic circuits.

CONCEPTS:
- Electronic circuits
- PCB design
- Design and manufacture
- Model making
- Evaluation

OBJECTIVES:
Pupils should understand:
- The need to investigate the background to a problem
- How to select appropriate components to build simple electronic circuits
- How to select appropriate tools and materials
- The importance of planned manufacture
- The need to build models to evaluate design ideas
- How to improve a product by evaluation

SCIENCE OPPORTUNITIES:
- Understanding of circuit theory
- Resistance/Ohms law
- The working of the voltage divider
- The transistor as a switch

MATHS OPPORTUNITIES:
- Accurate measurement and marking out

IT OPPORTUNITIES:
- Use of Crocodile Clips to develop and test circuit ideas
- Graphic packages to help generate design ideas
- PCB design and production

OTHER OPPORTUNITIES:
- Product styling

Week 1

Introduction and Investigation

Aim:
- Review safety in a workshop, state safety rules as a group
- Introduction to project, show previous examples
- Explain the different skills they will be learning – Electronics, PCBs etc
- Write design brief and design specification

Teaching input:
- Discuss the project with the class
- The importance of product evaluation in the design process
- Teach about briefs and specs, their use in industry and importance, use examples such as mobile phones, electrical goods, games machines, cars and other things with which they are familiar
- Teach about designing products that are fit for purpose and aiming products at particular consumer groups

Student:
- Discuss and record workshop safety rules
- Evaluate several electronic products – the aim of this is to understand the key components of an electronic product – PCB + components, battery, switches, wiring, case etc
- Discuss as a class
- Learn about briefs and specs, their use in industry and importance
- Research existing and similar products using, for example, the internet or catalogues; produce an image board in small groups
- Design Brief – maybe give them it – e.g. Design and make an electronic nightlight, the sensitivity must be adjustable
- Specification – discuss as a class

Resources:
- Examples of existing practical outcomes
- Examples of image boards
- Access to ICT or product catalogues
- A range of old electronic products to evaluate

Homework:
- Bring £1.50 (suggestion) to pay for the project
- Diary record

Week 2

Designing the nightlight

Aim:
- Design the nightlight - concentrate on fitness for purpose and target audience
- Produce a 3D model
- Evaluate designs

This is a suggestion; modify to suit your requirements –
- Build with an MDF base and an MDF background which has been shaped and decorated and drilled to accommodate LED(s) – 5, 8 or 10mm, the PCB will be behind the background, as will the battery – PP3

Teaching input:
- Explain what is required using examples of previous work or a teacher's example. A good way to do this is to cut the base from a piece of MDF 15 x 15cm and use a small block as a stand at the back, glue together with PVA
- Produce an example design and display using an OHP or on the whiteboard

Week 2 continued on next page

Continued

Week 2

Student:
The designs can be produced by students drawing a 15 x 15cm box and drawing the design inside it. It must be pointed out that the design cannot be too small or just the square they started with. Around the design the students should put labels and underneath evaluate the design stating who it would be for, a particular person or group. They should produce at least three designs and explain why they have picked their final choice.

The next stage would be to produce a 3D model. Depending on how long the designing takes this could be done in class and/or as homework. If it is done for homework then a cereal box could be used.

Resources:
- Drawing resources
- Card for 3D models
- Examples of previous work

Homework:
- Finish designs and 3D model
- Diary record

Week 3

Manufacturing the base and background

Aim:
- Manufacturing the base and background
- Decorating the base and background

Teaching Input:
- Review health and safety
- Provide assistance to students during practical

Resources:
- Each student will need a piece of 3mm MDF 15 x 15cm for the background and a piece of MDF 15 x 15cm for the base
- Access to tools
- Access to paints

Demonstration:
- Demonstrate to the students how to cut and finish MDF bases and backgrounds with appropriate tools paying close attention to H&S
- Demonstrate how to use a pillar drill to drill the holes for the LED(s) paying close attention to H&S

Student:
- Students to cut and finish their backgrounds with a coping saw and glass paper. Make sure the room is well ventilated
- Students to drill the holes for the LEDs
- Students to decorate their backgrounds

Homework
- If not completed during lesson finish decorating at home or during lunch/break/after school
- Diary record

Week 4

Electronics

There is quite a lot in this lesson and it may be that some elements are omitted. If you have the facilities available a good idea is to concentrate on Crocodile Clips and Real PCB.

Aims:
- Introduction to electricity and electronics – current and voltage
- Power supplies – mains, solar, wind, sea, batteries, parallel and serial
- Introduction to the Systems approach – systems have an input, process and output, relate to examples they are familiar with, e.g. microwave oven

Week 4 continued on next page

Continued

Week 4

Teaching input:
- Discuss the lesson aims with the class and use Q&A to reinforce

Student:
- Worksheet – Identify Input, Process and Output components on a worksheet, stronger students can state the function of the components by using research material, class books, wall charts etc.
- Discuss as a group
- Introduce the electronic circuit with a worksheet – this could be constructed using Crocodile Clips
- The first task if for students to identify the various components and suggest their function
- Go through the answers with the group then give an explanation of the circuit and how it works
- Introduction to PCBs and Q&A – what they are, what they are made of and why, where they are found, how they are made etc. This maybe a good opportunity to do a demo of how to make a PCB using a workshop etch tank – if possible. This is also a good opportunity to introduce Real PCB or an alternative PCB design package and allow students to design a PCB of their own, this could be reinforced using a worksheet where students identify mistakes in a PCB design

Resources:
- Worksheets
- ICT facilities including Crocodile Clips and Real PCB
- Examples of components
- PCB examples
- Etch facilities

Demonstration:
- Using Crocodile Clips and Real PCB
- Producing a PCB in an etch tank – there are some good resources for this on the Rapid website

Homework:
- Apply the systems approach to a household appliance, differentiate by ability, the more able to do a more complex appliance, the less able a simpler.

OR
- Worksheet, for example identify mistakes on PCB designs
- Diary record

Week 5

Soldering

Aim:
- Introduction to soldering
- Students start soldering

Teaching input:
- Q&A session, what is solder? why these materials? why solder? etc.
- Discuss health and safety
- Discuss quality issues

Demonstration:
- Demonstrate soldering, insert component securely, bend legs back a little, heat the area including the leg for 5 seconds, apply a small amount of solder, take solder away, take iron away – aim for a neat 'mountain' of solder around the leg, it is very important that soldering is not rushed and that legs do not touch as this will cause a short circuit – there are some good resources on the Rapid website

Student:
- Activity – Start soldering
- This will depend on the individual teacher as to how it is organised. It may be that one component is soldered at a time; each student doing the same. Students may be given the component list, and components, and be allowed to complete the task independently

Week 5 continued on next page

Continued

Week 5

The LED(s)
How this is done will depend on the final outcome. If wires need attaching to the LED these steps may be followed. Remember long leg is +ve.

Cut a length of red wire
Strip about 2cm of the plastic sleeving
Twist to stop fraying
Wrap around the longer leg
Apply a thin coat of solder
Snip off any excess wire
Insulate with rubber tubing/heat shrink
Repeat with black wire for shorter leg

Resources:
- Soldering equipment
- Tools

Homework:
- Storyboard on how to solder or make LEDs with wires (6 steps), this helps reinforce the skill as it would be likely they will solder again in the future in D&T

OR
- LED worksheet – identify 10 things at home that contain an LED
- Diary record

Week 6

Finish Soldering and Assemble Product

Aim:
- Finish soldering
- Finish any other practical work
- Construct final product
- Test

Teaching input:
- Discuss with Q&A quality control and testing
- Discuss test sheets
- Help students as required

Student:
- Finish all practical work
- Students to produce a test sheet
- Test circuit using test sheet and adjust the sensitivity with a variable resistor (if used), LEDs should turn on in the dark

Resources:
- Access to tools

Homework:
- Diary record

Week 7 begins on next page

Week 7

Evaluation

Students who have unfinished practical work should complete any and assemble final product

Aim:
- Evaluation

Teaching input:
- Discuss the importance of evaluation in design and technology

Student:
- Produce a detailed production plan of their project
- Evaluate their work
- Complete any unfinished work
- Put folders into order
- Students may complete a test based on the project – this may be set as homework

Resources:
- Worksheets
- Test sheet
- Access to tools

Homework:
- Diary record
- Complete test