Light Up The World

Lighting up the World

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ACGC
Alberta Council for Global Cooperation

LIGHTING UP THE WORLD - TEACHERS' NOTES

INTRODUCTION

The project is based around the issue of providing light for people in developing countries, who do not have access to electricity. Light Up The World in an international development organisation based in Calgary, Canada and is used throughout the project as an example of this type of work in action in the real world. Students will be required to investigate the context, design and manufacture a sustainable lighting system and write/present a technical project report similar to that produced by Electrical and Electrical Engineers in industry.

Included in the online pack is a PowerPoint containing student activities, guidelines for writing a project report, a student template for the report, this set of teachers' notes and a careers education tagging sheet.

TIMESCALES AND TARGET YEAR GROUP

The author recognises that different schools will operate different timetables with different lesson timings. Therefore the student activities have not been broken into specific lesson timings but instead presented as tasks for the individual teacher to adapt to his/her school and classes. The target year group for the activities is grade 9 student, but again the individual teacher may deem it appropriate to adapt for other year groups depending on their school and ability of their students.

Light Up The World

Light Up the World (LUTW) is a non-profit organisation founded by Dr. David Irvine-Halliday, a Professor in Electrical Engineering at the University of Calgary, who after some initial work in Nepal officially created the organisation in 2002.

LUTW provides solar-powered, LED (Light Emitting Diode) based lighting systems for people in developing countries where there is no access to electricity. Lighting systems are typically powered by solar electric energy. These lighting systems use a fraction of the energy often consumed by incandescent lighting.

The organisation has a strong emphasis on helping to raise educational standards and improve literacy, and its first projects in Nepal were developed to provide light so that school students could read at night. There is also an emphasis on providing clean and safe lighting to replace the kerosene oil lamps typically used in developing nations. These lamps provide serious health issues and are a huge fire risk if they fall or are knocked over.

The website www.lutw.org contains information about the organisation, current projects, contact details and a media section containing videos and images from past and present work.

KEY PEOPLE

It is key that students gain an insight into how projects are conducted by engineers in the real world. Therefore they should be introduced to the types of terms used in companies and industry.

The teacher will act as the students' manager, who provides support at appropriate times, supervises their work and expects regular progress updates for the students. However just as in real life, the manager has a number of projects to manage, and as such should not always be the students' first port of call for support.

The other students in the class are each individual student's colleagues, and just as in a real industrial project students should be encouraged to consult their colleagues for advice before going to their manager.

LEARNING OBJECTIVES

By the end of this module students should be able to:

- Design and manufacture a solid state, sustainable lighting system for people in a country with no access to electricity.
- Describe the benefits of White LEDs (WLEDs) in comparison to kerosene oil lamps and incandescent lighting.
- Calculate appropriate resistor values to protect LEDs used in the lighting system.
- Use software to design, model and simulate their lighting system circuit.
- Develop a printed circuit board layout for their lighting system.
- Use soldering equipment to assemble and test their PCB.
- Design and manufacture an appropriate housing for the lighting system.
- Write and present an industrial style technical report detailing what they have learnt during the project.
- Discuss the personal skills and qualities that they have used in the project, and how these might relate to future career choices.

STUDENT ACTIVITIES

The activities to be completed by students are provided in the PowerPoint presentation that is a part of this resource pack. Each activity is described, along with guidance for delivery below:

ACTIVITY 1 – LIGHTING UP THE WORLD

This slide presents the design brief for the project that students are to undertake. Students are to design and manufacture a sustainable, solid state lamp that could be used by a child in a developing country, where there is no access to electricity.

The teacher should show students the video 'The Man Who Lit up the Mountains' (http://lutw.org/Videos), which details the early work of Light up the World in Nepal. Students could discuss, possibly in the form of a class discussion lead by the teacher, the problems faced using kerosene oil lamps in the homes of the people shown. These problems include the health risks of using smoke emitting lamps and the fire hazard that they provide.

Students could use a simple video editing tool such as Windows Movie Maker, to make and present a short video highlighting these issues and what they think the possible solutions might be.

A ‘client’ profile detailing a 12 year old Nepali boy is given to help establish a context for the students. This can be used or adapted as required by the teacher.

ACTIVITY 2 – HOW BIG IS 1.4 BILLION?

This slide is intended to stimulate discussion regarding the scale of the problem of people having no access to electricity. Students can shade on a paper copy how much of the globe that they think two billion people covers, or make use of an interactive whiteboard to do the same.

The teacher can then reveal that 1.4 billion covers about quarter of humanity, and use as a basis for further discussion with students. For example, how might the lives of children in these countries differ from those in this country? What sorts of things that we take for granted will they have no access to? The children in Nepali mountain villages will not have laptops, wireless internet or ipods!

ACTIVITY 3 – POWERING YOUR PRODUCT

Students will need to select a power source for their product and should be introduced to, and have the opportunity to research alternatives to main electricity such as solar, wind and hydro energy. They should consider the advantages and disadvantages of each as part of their design work.

If cost allows each student could implement one such power supply within their lighting system (i.e. the lamp could have a solar panel integrated within the design). However if cost prevents this, students could instead use rechargeable batteries and the class teacher could purchase one or two solar, hydro or wind charging systems that students can use when the batteries require re-charging.

Parallels could be drawn to Light up the World, who have set up similar schemes, where a family within a village charges a small amount of money for other villagers to charge their lighting system batteries when they run low.

ACTIVITY 4 – LIGHT SOURCES

It is important that students are given the opportunity to perform the types of calculations that engineers undertaking similar projects would need to take. It is also important that students understand the benefits of solid state LED lighting compared with more traditional incandescent lighting.

Students should read the table given on this activity slide and shown below.

Lighting Type	Power consumption (W)	Intensity (lumens)	Efficiency (lumens/W)
Kerosene Wick Lamp	n/a	10	0.1
White LED (WLED)	0.1	3	30
Filament Lamp	3	10	3
Filament Lamp	40	400	10
Fluorescent Tube	15	600	40

They should observe that kerosene oil lamps are extremely inefficient compared to just about every other form of alternative lighting.

Although fluorescent tubing is still more energy efficient that solid state White LEDs (WLEDs), this is likely to change in the near future as more efficient diodes are produced. In addition LEDs last much longer and are far more rugged having a plastic, rather than glass outer casing, and so would still be a better solution for the environment that they are to be used in. It would be useful to discuss these points with students.

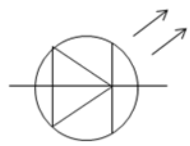
Students should find that the difference in energy efficiency of White LEDs (WLEDs) compared to a) kerosene wick lamps, b) 3 Watt filament lamps and c) 15 Watt fluorescent tubes from the table is:

- + 29.9 lumens/W
- + 27 lumens/W
- 10 lumens/W

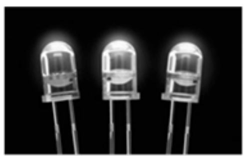
Students can also perform a simple calculation to find out how many WLEDs would provide an equivalent or better light intensity than 3 a Watt lamp (bulb). A 3W bulb has a light intensity of 10 lumens. Three WLEDs would give 9 lumens, and four WLEDs would give 12 lumens.

ACTIVITY 5 – LIGHT EMITTING DIODES

Light Emitting Diodes (LEDs) are components that produce a light output signal when a current flows through them. They have two legs (anode and cathode) and have to be connected the right way around in a circuit.



Circuit Symbol



Different coloured LEDs

Students should think about the number of different applications that use LEDs. They should also be able to discuss the advantages of using Hi-bright WLEDs instead of incandescent lighting. WLEDs are more energy efficient, use much less electricity, are more rugged and have a much longer lifespan.

ACTIVITY 6 – RESISTORS

Resistors are used to control the flow of current in a circuit. Resistor values are measured in ohms, named after the German scientist. The greater the value, the less current can flow through the resistor. This is the resistance of the resistor. LEDs usually require a resistor connected in series with them to prevent them from being damaged by too much current.

This activity provides an opportunity for students to calculate an appropriate resistor values for the power supply voltage, and also to work out the colours of this required resistor based on the resistor colour code. It should be explained to students that these are the sorts of calculations that engineers working in this field would need to carry out to ensure that LEDs are protected effectively, and that any mistakes could lead to the failure of the lighting systems. Out in the field this could be expensive and costly, which is undesirable for a charity with limited funds.

Students should use Ohm's Law: Voltage (V) = Current (I) x Resistance (R)

Therefore, Resistance (R) = Voltage (V) / Current (I)

Voltage V = 5 – 2 = **3 V**

Current I = 20mA = **0.02 A**

So, R = 3 / 0.02 = **150 R**

Using the Resistor Colour Code Table:

First number = 1 = Brown (band 1)

Second number = 5 = Green (band 2)

Number of zeros = 1 zero = Brown (band 3)

Therefore a **150R resistor** would have the colours **brown, green and brown**.

ACTIVITY 7 – CIRCUIT SIMULATION

Wherever possible students should have the opportunity to model and test their ideas using appropriate software. This would require access to ICT for this activity. Testing in this way models the industrial experience, where circuits are developed and tested extensively using software to minimise the chance of costly errors at the manufacturing stage.

Common examples of software that could be used are Circuit Wizard and Yenka (Crocodile Technology).

ACTIVITY 8 – DEVELOPING A PRINTED CIRCUIT BOARD (PCB)

Teachers may feel confident enough for students to design and subsequently manufacture their own PCB, or to keep production and fault finding manageable they may wish to use a standard board for all students. Students however should still be given the opportunity to at least design their own PCB using appropriate software.

Higher ability students could also edit the track and pad sizes for optimum use of the copper board and ease of soldering during manufacture.

Some software, such as Circuit Wizard, allows existing circuit simulations to be imported directly into a PCB layout.

ACTIVITY 9 – CASE DESIGN

Students should consider how the product will be cased. Each school will have different access to tools, materials and equipment, so it has been left for the teacher to decide how this part of the project might be tackled. Students should consider the environment in which the product is to be used, and how to make the product rugged and reliable.

Although this is presented as a separate activity, it is expected that students will be encouraged to think of the product as a whole throughout the design process, and consider how it might be cased at the same time as designing the PCB.

ACTIVITY 10 – MANUFACTURING YOUR LAMP

Students will require access to basic soldering equipment to assemble their PCB. They will need to be briefed on safety issues regarding the use of soldering irons and side cutter/wire strippers. Similar demonstrations of tools and equipment required to create the housing will also need to be made.

A useful resource to support students is a soldering comic which can be found and downloaded at this link http://img.skitch.com/20100219-pmcq2auhgiwj1imwd2p8rg8sju.jpg .

ACTIVITY 11 – WRITING A PROJECT REPORT

This is the key summative assessment piece for the module. Students will be expected to write an industrial style report detailing the work that they have done in the project, and also present their main findings to their line manager (teacher) and senior manager.

Guidelines on how to write the report can be found as part of this pack, and the teacher should discuss these guidelines with the students before they begin writing the report. It is important to emphasise that this is the way that projects are presented by engineers in the real industrial world, and it is the main way that findings are shared with the wider engineering community.

A guide on how marks and grades might be allocated is also included in the guidelines. These are linked to grades, which can, if the teacher feels it appropriate, be used to give students an early experience of the kind of grading that they will encounter at a later date.

ACTIVITY 12 – SKILLS AND QUALITIES

This activity encourages students to think about the types of skills and qualities that they have used in this project and how that might relate to engineering careers in the future. It is to take the form of a business meeting which will give students the experience of how a meeting is run in an industrial setting.

Students will need to be separated into groups of three by the teacher. It is recommended that they are give between ten and twenty minutes to discuss the items on the agenda, and then time to present their discussions to the class and prepare their meeting minutes. Students can select the chairman, scribe and spokesperson for the group. The teacher will need to explain what these roles will involve in advance of the meeting taking place.

USEFUL WEBSITES

Below are websites which may aid delivery of the unit of work or form the basis of additional activities for students:

http://www.lutw.org - Official Light up the World website.

http://www.futuremorph.org/scienceandmaths/#/humanitarian-engineer - Website for charity called Engineers Without Borders, which places engineering students in developing countries to help them with a range of projects.

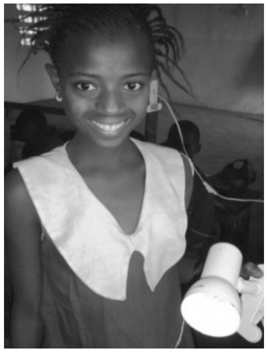
http://practicalaction.org/ - Practical Action works with poor communities to help them choose and use technology to improve their lives for today and generations to come.

http://img.skitch.com/20100219-pmcq2auhgiwj1imwd2p8rg8sju.jpg - Free 'how to solder' comic book style resource.

Lighting up the World

Solid state sustainable lighting for the developing world

Photo: Illuminated orphanage in Tibet, 2008 (www.lutw.org)



Lighting up the World

Light Up The World is an **international development organisation** that creates **sustainable lighting systems** for people in **developing countries,** where there is little or no **access to electricity**. You will undertaking a project similar to that which their **engineers** carry out on a regular basis.

Design Brief:

Your task is to **design and manufacture** a **sustainable**, **solid state lamp** that could be used by a child in a **developing country** (see **client profile** on the next page), where there is **no access** to **mains electricity**.

You will also need to produce a **project report** and deliver a **presentation** showing what you have **learnt** during the project.

INITIAL TASKS:

1)Watch the video **'The Man who Lit up the Mountains'** about the foundation of Light up the World: http://lutw.org/Videos
2)What are the problems for the villagers shown when using **kerosene wick lamps** as a light source?
3)Use **Windows MovieMaker** to make a **short film** highlighting some of these issues and what the **solutions** might be. Use **www.lutw.org** to help.

‘Client’ Profile

“My name is Mahesh and I am 12 years old. I live in **Nepal** which is a country on the Himalayan mountains near India, Bangladesh and China.

During the day I go to school but at night I find it hard to study because **we have no electricity for lighting**, so I have to work in the dark. We do have **kerosene oil lamps** but these do not give us much light and are very smoky.

An **electric light** that could be powered by battery or something like the sun would be brilliant for me. It would help me to **study** much better and pursue my dreams of becoming a doctor or an engineer.”

Key People

There are a number of **key people** who you can make use of for **help and support**, and who will also expect you to **report back** to them a various points during the project.

Key People:

Colleagues: These are your **classmates** and your first port of call for any **questions** or help that you might need during the project. You should always use your colleagues for support **before** going to your line manager.

Manager: This is your **teacher**. Your **manager** will provide help and support and expect you to **report back** to them at appropriate times during the project. However, you should not aim to **over-use** your line manager as they will be very busy managing a number of different projects.

How Big is 1.4 Billion?

Over **1.4 billion people** in the whole world have no access to **electricity.** How much of the world map do you think that this covers?

Powering your Product

You will need to decide how your lighting device is going to be **powered**. Remember that the people who will use your product have **no access** to **power lines for electricity**. If your product is to be **battery powered**, you will need to think about how the batteries will be **recharged**.

TASKS:

1)Use www.lutw.org to **investigate** what sort of **power supplies** Light Up The World has used to power its **lighting products** for people in developing countries.

2)Make a list of possible methods of powering your product and discuss their **advantages** and **disadvantages** for the **environment** in which they will be used.

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Light Sources

Lighting Type	Power consumption (W)	Intensity (lumens)	Efficiency (lumens/W)
Kerosene Wick Lamp	n/a	10	0.1
White LED (WLED)	0.1	3	30
Filament Lamp	3	10	3
Filament Lamp	40	400	10
Fluorescent Tube	15	600	40

Many people in **developing countries** rely on **kerosene wick lamps** for lighting. These do not give out much light, are extremely smoky and bad for peoples' health.

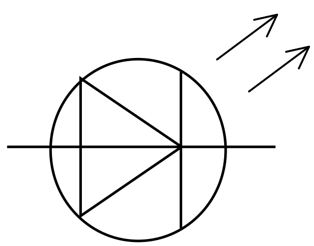
The table on the left shows the **power consumption** (Watts) , **light intensity** (lumens) and **efficiency** (lumens/W) of Kerosene lamps and some possible **electrically powered** alternatives.

TASKS:

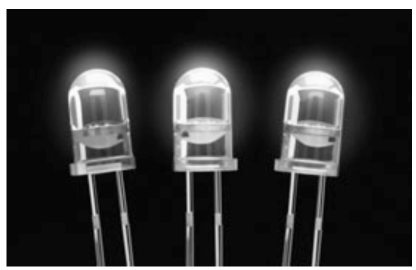
1) Which out of the **alternatives** to Kerosene lighting is the most energy efficient?
2) What is the **difference** in **energy efficiency** of White LEDs (WLEDs) compared to:
    a) Kerosene Wick Lamps
    b) 3 Watt Filament Lamp
    c) 15 Watt Fluorescent Tube
3) Calculate the **number of White LEDs** (WLEDs) you would need to give the same or higher **light intensity** in lumens as a **3W light bulb**. What about a **40W bulb**?

Light Emitting Diodes

Light Emitting Diodes (LEDs) are components that produce a **light output signal** when a **current** flows through them. They have two legs **(anode and cathode)** and have to be connected the right way around in a circuit. This means that they are **polarised**.



Circuit Symbol



Different coloured LEDs

LEDs come in a range of **colours** and **sizes** including white (WLEDs).

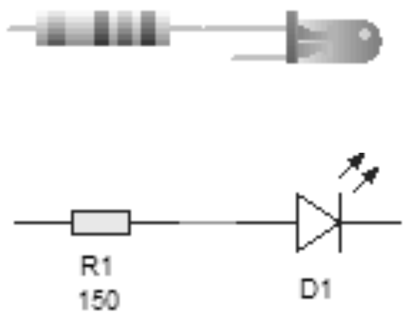
TASKS:

1)Complete a **spider chart** or **thought shower** listing as many different products that use LEDs as you can.

2)What are the **advantages** of using **WLEDs** for **lighting** over traditional bulbs?

Resistors

Resistors are used to **control** the **flow of current** in a circuit. Resistor **values** are measured in **ohms**, named after a German scientist. The **greater** the **value**, the **less current** can flow through the resistor. We call this value the **resistance** of the resistor.



LEDs usually require a resistor connected in **series** with them to prevent them from being **damaged** by too much current.

TASKS

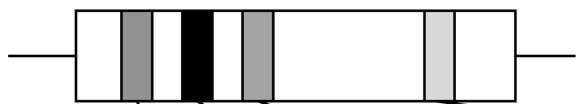
1)Calculate the **value of resistor** you would need to **protect** an LED if the power supply is **5V**, the LED uses **2V** and the LED draws a **current** of **20mA (0.02A).**

HINT: Use V (voltage) = I (current) x R (resistance)

2)The value of a resistor is found using a **colour code**. There are four **coloured bands** round the resistor which give the **resistance** and **“tolerance”** (accuracy) of the resistor.

Using the **resistor colour code** on the next page work out the **colours** that would be present on a resistor of the value that you calculated in **task 1**.

Resistor Colour Code

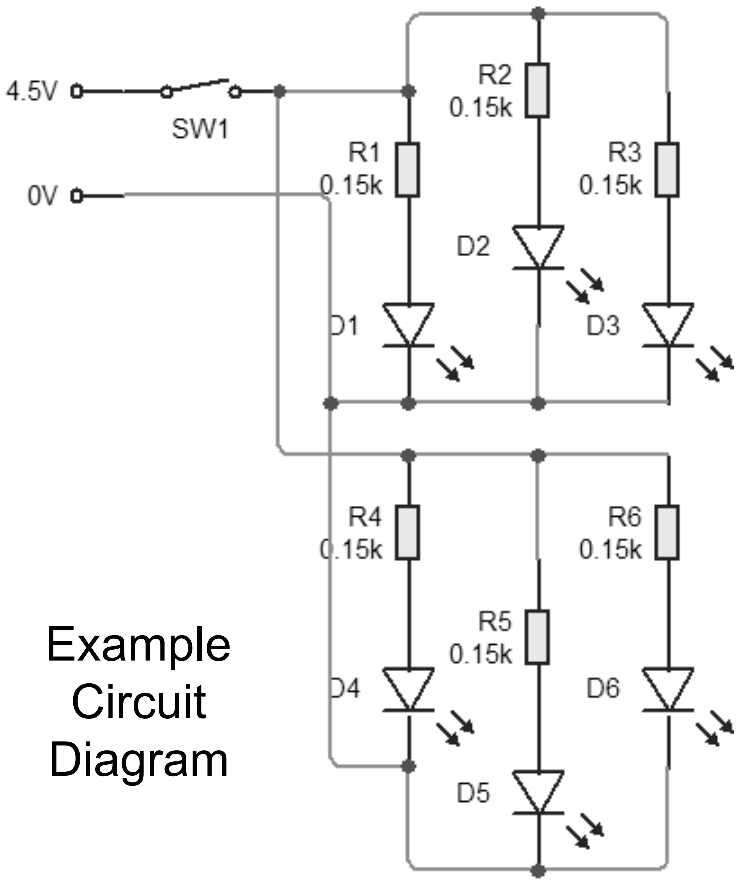


Fourth Band
Tolerance is a measure of how close the resistance is expected to be to its marked value. Silver means + or - 10%, gold means + or - 5%

The Resistor Colour Code

Colour	First Band	Second Band	Third Band
Black	0	0	None
Brown	1	1	0
Red	2	2	00
Orange	3	3	000
Yellow	4	4	0000
Green	5	5	00000
Blue	6	6	000000
Violet	7	7	_
Grey	8	8	_
White	9	9	_

Circuit Simulation



Example Circuit Diagram

Electrical and Electronic Engineers often use **software** to try out circuit ideas to see how they might work **before** they make them.

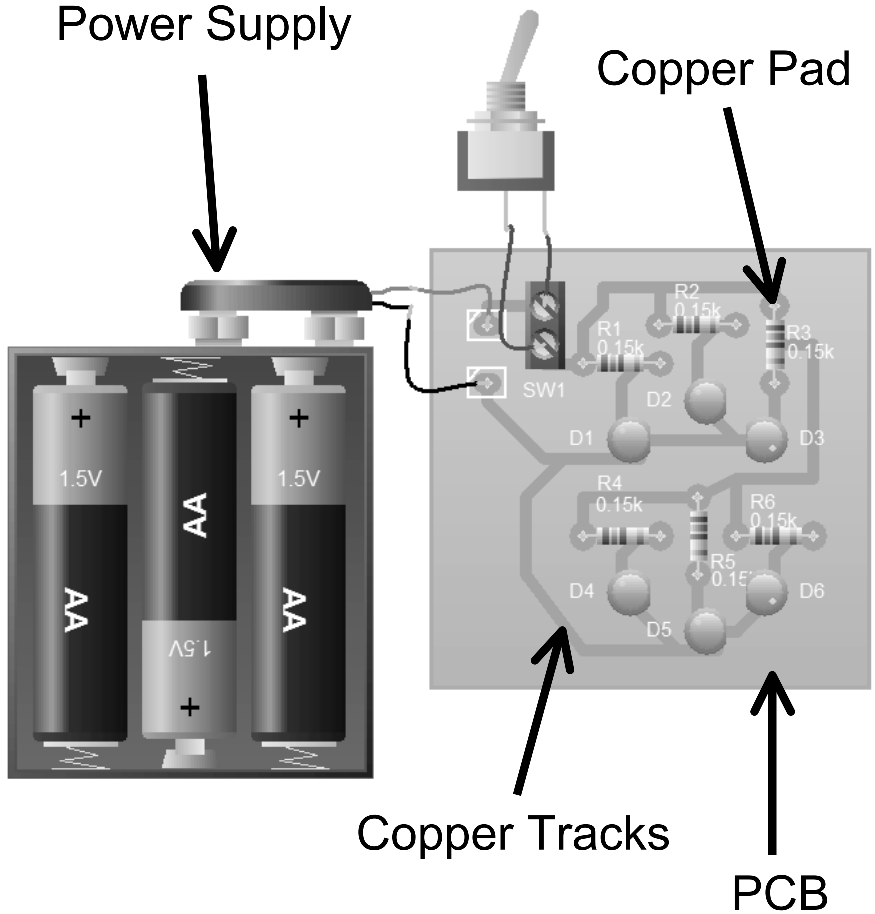
This can save time and money as any mistakes in the circuit design are identified early in the **design process**, and before any **real components** have been used. This is called **circuit simulation**.

TASKS:

1)Using a **circuit design software package** that you have access to, draw a **circuit diagram** of your proposed circuit design for your LED lamp.

2)Test how this would work. Are there any **changes** that you need to make?

Developing a PCB



A **Printed Circuit Board** (PCB) is the most common method of assembling a **permanent circuit**. PCBs usually have a plastic side and a side with copper tracks to link the **components** together.

Software can be used to develop a PCB. Some software packages allow the designer to import a **circuit diagram** that they have already simulated into a **PCB layout**.

TASKS:

1)Using a **circuit design software package** that you have access to, develop a **PCB layout** for your circuit.
2)Try to make the PCB as **compact** as possible so as not to **waste materials**.
3)You may need to **alter** the size of the **copper pads** and **tracks**. Larger pads may make **soldering** easier when you come to **assemble** your circuit.

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Casing the Product

Your circuit will need to be housed in an appropriate **casing** to protect it. Remember that the **environment** in which it is going to be used will mean that it will need to be **rugged** and **hardwearing**.

TASKS:
Design the **housing** for your circuit. You will
need to consider:

a) What **materials** you are going to use.
b) If you are using **batteries**, how they will be **accessed** for **re-charging.**
c) Where the **on/off switch** and **LEDs** will be located.
d)How the PCB will be **securely fitted** to the case.

Manufacturing your Lamp

You are now ready to **assemble your PCB** and **manufacture** your lamp. Your **line manager** will demonstrate **soldering** and the safe use of other machines at your disposal.

TASKS:

1)Using your **PCB layout** as a guide, select and place your **components** into the correct positions on your PCB.

2)Solder the **components** in place (you may need to add **flying leads** for some components depending on your design). Be especially careful to place **LEDs** and **battery leads** the **right way around**.

3)Test your circuit and check for any **faults** (dry joints, solder bridges etc) if it does not work.

4)Begin assembly of your **case**. Your **line manager** will tell you what **machines** and **equipment** you will have access to.

Writing a Project Report

Knowing how to write a **clear project report** is useful because it is an important way that other people can **learn about** what has been done. It is the normal way projects are **presented by engineers in industry**.

Quite often engineers also have to **show their findings** to their **peers** and **managers** and **answer questions** about what they have learnt.

TASKS:

1)Write a **technical report** detailing **what you did**, **who it was for** and what **went well/what you could improve**. Use the **project report guidelines** sheet to help you. Your report should be completed **electronically** on the **report template document** provided.

2) Prepare a **short presentation** (no more than 5 minutes) showing the **key findings** of your report. You will be required to present this to your **line manager** and **senior manager** as part of the **project assessment**.

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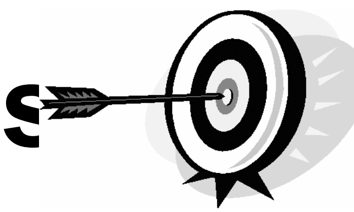
Skills and Qualities



Organisations such as Light up the World don't just look for people who are good at electronics and engineering to work for them; they also want people with the right **personal skills** and **qualities** to do the job well.

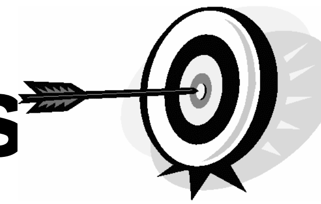
TASK:

For this activity you will be working in **groups of three** in the style of a **business meeting**. One person will **chair the discussion**, one person will **scribe** (write down the findings) and one person will be the **spokesperson** (feedback to the rest of the class at the end).

TOPICS FOR YOUR MEETING (AGENDA):

1)Decide who is going to be **chairman**, **scribe** and **spokesperson**.
2)What do you think is the **difference** between a **skill** and a **personal quality?**
3)List the **skills** and **qualities** that you think you have used in this project. Use the **example sheet** provided to help you.
4)Choose **three skills** and **three qualities** that you think would the most **important** to an organisation such as Light up the World.
5)Discuss **why** you have chosen these and **feedback** to the class.
6)Prepare a set of **meeting minutes** outlining what you have discussed.

Skills and Qualities



A **personal quality** is something that makes you who you are as a person:

Examples of Personal Qualities:

§ I am polite
§ I am trustworthy
§ I am friendly
§ I am well mannered
§ I am enthusiastic
§ I am confident
§ I am caring
§ I am sociable

A **personal skill** is something that you are good at or can do well:

Examples of Skills:

§ Reading and writing
§ Making decisions
§ Problem solving
§ Presenting information
§ Speaking in public
§ Using ICT
§ Working to a deadline
§ Working with numbers