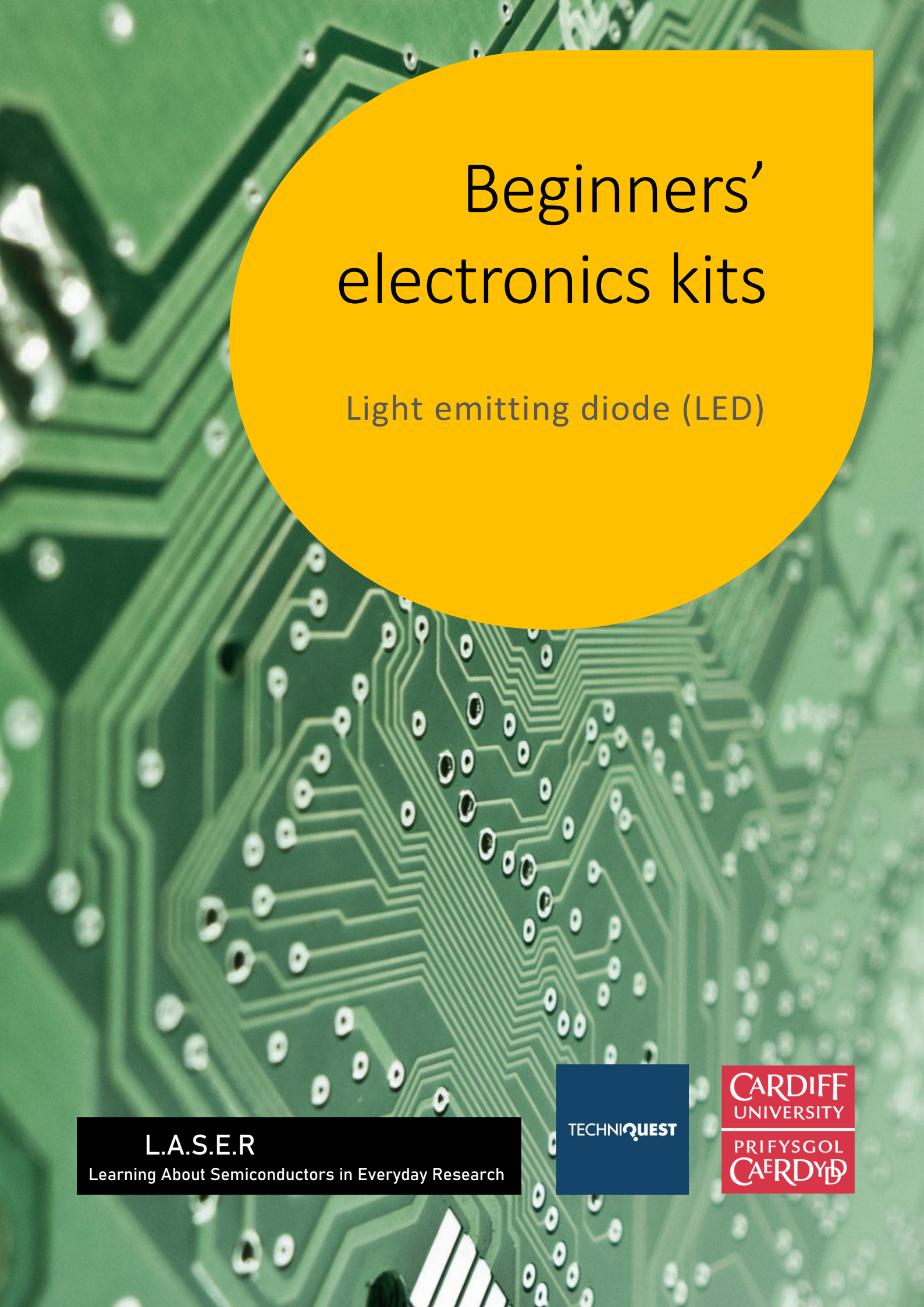

Beginners' electronics kits

Light emitting diode (LED)

L.A.S.E.R
Learning About Semiconductors in Everyday Research

TECHNIQUEST

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

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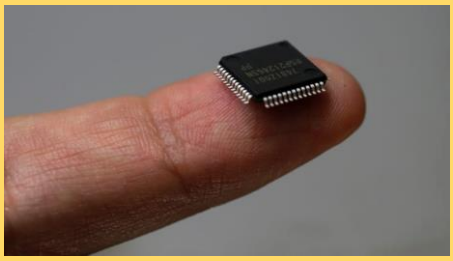


Today's tech means we can make semiconductor devices tiny!

One of the labs in Cardiff Uni, they're called cleanrooms because they can't have any contaminants in them that will affect our experiments.

About LASER

LASER is a small research group led by passionate physicists who all share the same vision; to spread awareness and appreciation for semiconductor physics. The aim is to make semiconductor physics accessible for KS3 students who wouldn't ordinarily study it unless they undergo a degree in physics. To us this seems ridiculous since semiconductors have shaped our everyday lives for over 70 years!

Why are Semiconductors Important?

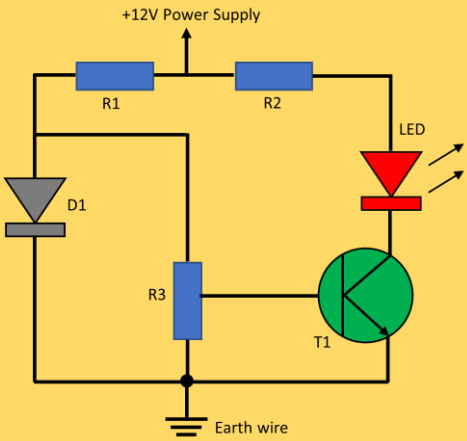
You might not know it, but semiconductors are all around you! From mobile phones to microwaves, semiconductors are everywhere, and their importance cannot be overstated. Think for a second about all the encounters you've had with electronic devices in the last 24 hours, we can guarantee that all of them have been made with semiconductor materials. Without semiconductors, none of the devices we take for granted would exist. How then would you heat up your food?

Semiconductor Research at Cardiff University

Here at Cardiff University, we are at the forefront of cutting-edge semiconductor research. Exciting new research is happening all the time looking at how we can make technology more accessible for the world. Current research is looking into new ways to understand how light interacts with stuff, this is called 'photonics'. As well as this, Cardiff has departments looking at nanotechnology which is basically technology the size of atoms!

Also, with funding from the Welsh government, Cardiff has founded the Institute of Compound Semiconductors which has brought hundreds of jobs to people in Wales making it the place to be for anything semiconductor related!

Instructions



This is the '*circuit diagram*' for what we will be making in this project. Don't worry if it looks really complicated, you'll be able to put it together easily with this instruction manual.

This is an example of the modular aspect of the kit, notice how you can snap together individual parts of the circuit.

About our Kits

Our LED kits teach basic engineering, electronics, and circuitry concepts by using building components with a modular design to assemble electronic circuits on a simplified electronics breadboard (a construction base for designing electronic circuits). The resulting project functions like the printed circuit that you'd find in any electronic circuit. Each circuit component is easily recognizable by its colour and diagram on the front of the component as well as its description in this manual (see parts list below).

List of Parts

1 x power supply (12V battery) **3** x resistor **1** x red LED **14** x wire blocks

1 x transistor **1** x diode **1** x base **1** x willing parent/guardian to help you!

Resistor (R1, R2 & R3): a small part of a circuit that is designed to provide a specific amount of resistance in an electrical circuit. Resistance is an essential part of any circuit; you'll use resistors in just about any circuit you make!

LED: a semiconductor device that emits light when you pass current through it. Light is made when the particles that carry current (known as electrons and holes) combine in the semiconductor material. They can last ages and are more durable than normal bulbs.

Transistor (T1): a semiconductor device that can be used to control and/or change the flow of electrical signals in an electrical circuit.

Diode (D1): another semiconductor device (they're everywhere!) that essentially acts as a one-way switch for electrical current. It allows current to flow in one direction in the circuit but not the other.

Don't worry if these ideas are new to you/you can't quite get them yet, we will be able to help you out in our Techniquest workshop!

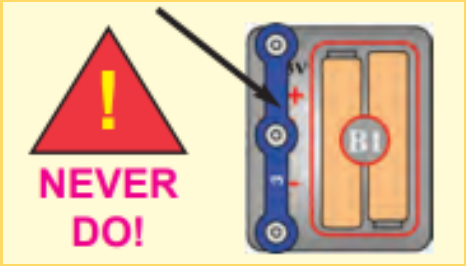
Instructions

How the Kits Fit Together

Using the circuit diagram on the previous page as a template, the circuit can be made by fixing in the modular circuit parts on the base as they appear in the circuit diagram. To power the circuit, you can use the 12V power cable provided to give the necessary current to power the circuit components.

Each of the circuit components, including the wire blocks, are encased in plastic to make sure they're safe for use by any age. To fix these to the base simply push in until you hear a 'click' and that's all there is to it! Components can be stacked on top of each other to ensure the circuit fits into the boundaries of the base. An example component is shown below. The component to the left is the LED used in the circuit, its labelled with the circuit symbol to make it easy to identify. A summary of the other parts is as follows: The base functions like the printed circuit boards found in most electronic products. It is a platform for mounting parts and wires (though the wires are usually "printed" on the board). The blue snap wires are just wires used to connect other components, they are used to transport electricity and do not affect circuit performance. They come in different lengths to allow orderly arrangement of connections on the base grid. The LED is a light emitting diode and may be thought of as a special one-way light bulb. In the "forward" direction (indicated by the "arrow" in the symbol) electricity flows if the voltage exceeds a turn-on threshold (about 1.5V); brightness then increases. A high current will burn out the LED, so the current must be limited by other components in the circuit. LEDs block electricity in the "reverse" direction. Resistors, such as the 100Ω resistor, "resist" the flow of electricity and are used to control or limit the electricity in a circuit. Increasing circuit resistance reduces the flow of electricity.

Safety



This is an example of a short circuit. Even if you add more blue snap wires to this loop it is still a short circuit since it is still a low resistance pathway.

Dos and Don'ts of building circuits

You must be careful not to create 'short circuits' (very low resistance paths across the battery) as this can damage components. Only connect the circuit in the configuration found on page 2. Some other important guidelines are below:

ALWAYS USE EYE PROTECTION WHEN EXPERIMENTING ON YOUR OWN.

ALWAYS include at least one component that will limit the current through a circuit, such as the speaker, lamp, whistle chip, ICs (which must be connected properly), motor, photoresistor, or resistor.

ALWAYS use the LED and switches in conjunction with other components that will limit the current through them. Failure to do so will create a short circuit and/or damage those parts.

ALWAYS disconnect your power supply immediately and check your wiring if something appears to be getting hot.

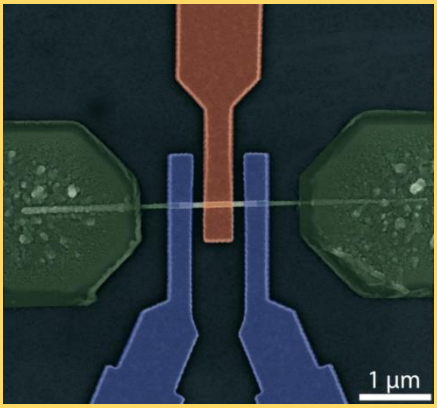
ALWAYS check your wiring before turning on a circuit.

ALWAYS connect ICs using configurations given in the projects or as per the connection descriptions for the parts.

NEVER connect to an electrical outlet in your home in any way.

NEVER leave a circuit unattended when it is turned on.

Behind the Scenes



This is a modern-day transistor, like those you'd find in your phone or computer. They have to be made very small to fit in your phone, so scientists have a big challenge to make them small enough. The one in the picture is 1um meaning its 0.000001m big, this is smaller than the size of a human hair!

How do the Kits Work?

The basic principle of working of the temperature sensors is the voltage across the diode terminals. If the voltage increases, the temperature also rises, followed by a voltage drop between the transistor terminals of base and emitter in a diode. The type of circuit made here is ideal to monitor the level of charge in the 12V batteries used for this project. The working of this circuit depends on the 'biasing' of the base terminal of the transistor T1. What this means is the transistor is configured with some initial operating conditions. A bias circuit is then the portion of the device which supplies this steady 'pre-configured' current.

When the voltage of the battery is more than 9 volts, then the voltage on base-emitter terminals will be the same. This keeps both transistors and LED off. When the voltage of the battery reduces below 9V due to utilization, the base voltage of the T1 transistor falls while its emitter voltage remains the same. At this stage, the base terminal of the T1 transistor becomes +ve and turns ON. Current is then discharged through the LED.

Physics of LEDs

Light-emitting diodes (LEDs) and lamps produce light when a current flows through them in the forward direction. LEDs use semiconducting material to produce light and colour. Many materials for LEDs are based on gallium (Ga in the periodic table) such as gallium phosphide (GaP) and gallium nitride (GaN). Layers of semiconductor material undergo a process called 'doping' which intentionally adds impurities to the semiconductor material. When a current is applied to this material, the impurities added combine with the semiconductor material. When they combine, they release energy in the form of light. We call this process 'recombination'. We can make LEDs of different colours of LED based on the amount of energy released in this recombination process; more energy means the LED will be blue, less energy means it will be red!

Techniquest Trip

You can find Techniquest in Cardiff Bay near the Wales Millennium Building. More informati0n can be found on the Techniquest website at techniquest.org

What Will the Day Involve?

Shortly after receiving your kits, you'll be invited to Techniquest in Cardiff to attend an interactive day learning about semiconductors. You will be given talks by students studying for their PhD so they will be able to answer any questions you have about your kits and the wider world of semiconductor physics. As well as this we will run a short workshop for those that struggled to make their circuit and who need a little bit of extra help to understand how they work. Parents are also encouraged to attend too so that they can also gain appreciation for the technology they use every day.

Please don't forget your LED kit when you come to Techniquest as they will become part of an interactive exhibit. The plan is to connect all your circuits together to make a Welsh Dragon that will be activated by changing the temperature of their housing. We look forward to welcoming you to Techniquest and can't wait to see what you've built!

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