Electrical Safety

Introduction

This chapter is all about working safely with electrical circuits. Not only is this more than desirable in a practical situation, but it can also part of the Electronics curriculum. In the vast majority of cases, a good dose of common sense is all that is necessary.

Electrical current has two main effects on the human body:

1. A large current can cause burns due to ohmic heating. In normal domestic situations it is unlikely that large currents will flow through the body due to the high resistance of the skin. High frequency currents tend to travel over the surface of a conductor (called the skin effect) and so skin burns can be caused by contact with high power transmitting antennae at radio frequencies - not very likely in a school setting but worth being aware of, none the less. However, burns can easily occur when conductors, such as wires, pass large currents and get hot. Indirect burns due to other components getting hot is a genuine hazard.

2. A small current flowing through the body can interfere with the nervous system that controls muscle response. The muscles in the body can cease to respond meaning that it can be hard to let go of a live connection and then, fairly quickly, the heart muscles may cease to function leading to death. A current of only a few tens of milliamps can be lethal, the actual value depending on the individual concerned. A.C. is also more dangerous than D.C.

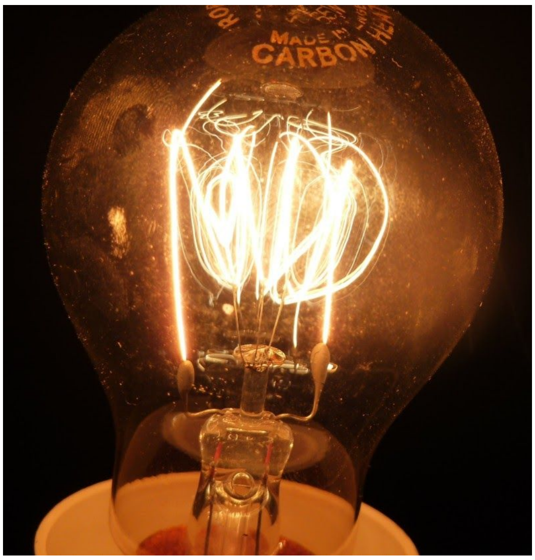
Note: An electric shock is what you get when current passes through the body. Electrocution is when the effect of the electric shock is fatal (either deliberately or accidentally) being derived from "electric" and "execution". Electrocution is often used incorrectly to describe an electric shock that is not fatal.

Electric Shock

As stated above, an electric shock can result in:

- A victim receiving an electric shock being unable to control their muscle function. In the worst case scenario this might mean that the muscles in the hand contract and the victim grips the live electrical connection being unable to let go with the result that things get rapidly worse. If you have to touch something that you suspect may be live, touch it with the back of the hand so that the natural reflex reaction pulls you hand away ... but better still, don't touch it in the first place.
- The victim being thrown away from the live electrical connection. If you are up a ladder or in some other exposed position, this involuntary spasm can result in a fall and subsequent injury. The reaction to receiving an electric shock can be quite violent and uncontrolled and increases the possibility of injury.
- The victim losing consciousness and dying as the muscles of the heart/chest stop working correctly. This is most likely when the electrical current through the body passes through the chest, from one hand to another for instance. The entry and exit points of electrical current have a significant influence on the outcome of an electric shock. It may be urban myth but in the days when televisions contained high voltage components, TV repair men would work with just one hand in the TV set so that, if they got a shock, current didn't flow through the chest.

Ohmic Heating



Ohmic heating occurs when a current passes through any conductor that has resistance. Electrical energy is transferred to thermal energy and the conductor has to dissipate this energy. In simple terms, when current flows through a wire, the wire gets hot. The energy transferred each second depends on the potential difference across the conductor and the current through the conductor. However, current and potential difference are related and so it is usual to just talk about the current. The energy transferred per second when a current (I) passes through a conductor of resistance (R) is given by I^2R

Ohmic heating is extremely useful in many domestic appliances such as toasters, electric cookers, kettles, hair-dryers, hot water heaters, fan heaters, electric fires etc ... and of course, conventional light bulbs where a thin tungsten filament glows white hot. Ohmic heating, particularly in light bulbs is not very efficient but it is very simple. In other cases, ohmic heating is undesirable, leading to an unacceptable 'loss' of electrical energy. In power distribution networks, low currents of just a few amps are used to reduce the heating effect in the power cables - this requires the use of very high voltages.

In a domestic situation, wiring inside the walls of a house can get hot and cause a house fire. The picture shows the wiring in a ceiling space that was overloaded and caused a fire damaging roof beams etc - luckily this fire was controlled and the damage repaired

An extreme example of ohmic heating is when lightning strikes a conductor and a massive current flows for a very short time. The picture shows a Eucalyptus tree that has been blown apart by a lightning strike. The heating effect of the current flowing in the tree vapourised the water in the wood turning it in to high pressure steam, the force of which was enough to blow the tree apart. It is the rapid heating of the air through which a lightning strike flows that causes the thunder we hear. People have survived lightning strikes, often because they were soaking wet and the current travelled over the wet surface causing skin burns but not the sort of damage the tree suffered.

Dangers of Capacitors

High Voltage CapacitorCapacitors are electrical components that store electrical charge and electrical energy.

They can store energy and charge, at potentially a very high voltage, even after the power supply has been disconnected. The energy stored can be lethal and so a large value capacitor should always be treated with caution! The picture shows a 25μF 1000v capacitor. It would probably kill you if you touched it when it was fully charged ... can you tell if it is charged?

Electrolytic capacitors can explode if connected the wrong way round or if the supply voltage exceeds the maximum working voltage of the capacitor. In extreme cases the explosion can be very sudden and quite catastrophic.

Transformers

Isolating transformerTransformers are used to convert a high a.c. voltage to a lower, safer a.c. voltage. Transformers provide a safe, lower voltage for project work. Transformers are covered in more detail in the section about power supplies.

A slightly different use of transformers is in the bathroom. An isolating transformer is used to provide a safe mains voltage for toothbrushes and shavers etc. The voltage from an isolating transformer is not reduced, it is still 230v, but it is isolated from the actual mains ... there is no actual electrical connection to the live and neutral. The result is that touching either of the contacts of an isolating transformer is not hazardous ... touching both contacts is still dangerous though. This makes use in the bathroom safer because one contact could be connected to the user, via moisture etc, and the user would not get an electric shock. However, if no isolating transformer were used, any contact with the live wire would always result in an electric shock.

Hazards in the Electronics Lab

There is not a definitive list of hazards in the Electronics lab, or any science lab, and so common sense is always necessary. Some of the possible hazards include:

- Hot soldering irons
- Hot glue guns
- Etching tank, drill and UV light source used for pcb production
- Misuse of tools such as wire cutters
- Trailing wires and cables
- Stools, bags and water on the floor
- Burning/over-heating components
- Fire due to ohmic heating due to excessive current
- Noise and light hazards
- Sharp objects
- Electrocution
- You, or others working near you

Working Safely

Electronics at school level is essentially a safe subject as high voltages and large currents are not used. However, there is always the potential for things to go wrong and safety in the working area can be improved by:

- Only working with supervision i.e. with another person present
- Knowing how to summon help and deal with an emergency
- Carrying out a risk assessment of the proposed activity
- Considering environmental factors such as the presence of water
- Working with the power supply turned off
- Understanding how to use apparatus and construct circuits before commencing with the practical work
- Checking that polarised components such as capacitors, semiconductors and integrated circuits are inserted correctly before turning on the supply voltage
- Not touching or dismantling apparatus or circuits with which you are not 100% familiar
- Being aware that some components (capacitors and inductors) can store energy even after the power supply is disconnected
- Being aware of all the possible hazards associated with a science lab e.g. trip hazards etc

In an Emergency

If somebody is suffering an electric shock:

- Call for help - make sure somebody else is aware of the situation before trying to help the victim
- Disconnect the person from the supply or disconnect the supply at source - This must not put you in danger of receiving an electric shock otherwise all you have done is doubled the problem. Use an insulated implement such as a broom handle to help if necessary
- Administer first aid if necessary (and if you know how, which you should) … or place victim in the recovery position and stay with them until help arrives
- Report the incident

Website

http://www.pfnicholls.com/Electronics/safety.html