Introduction to Hand Soldering Technology and Electronics

Practical Exercises

Incorporating elabtronics ledfun

Student Resource Booklet

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Acknowledgements

This manual is a compilation of materials from several sources and authors.

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Other Sources

The Microchip Technology Inc (USA) website http://www.microchip.com

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What you should know about Electricity

- Electrons form a part of every atom. Some electrons can free themselves from the atom.
- An electron is an invisible **negatively charged** sub-atomic particle.
- Because it is negatively charged an electron can move towards a positive charge.
- The force needed to move an electron is called the **E**lectro-**M**otive **F**orce *(EMF).*
- The size of the EMF can be referred to as the Potential Difference or Voltage and is measured in units called **Volts** *(symbol 'V').*
- Once the EMF is applied to the electrons and the charged electron is moving you have produced an **electric current**. *(An electric current is produced when the electrons move through a conductor).*
- The size of the electric current can be referred to as the Amperage and is measured in units called **Amps** *(symbol 'A').*
- The resistance *(electrical friction)* of a conductor is a measure of the force applied by that conductor against the flow of electrons through it.
- The size of the resistance depends on several factors, *(length, type of material, thickness, and temperature of the conductor),* and is measured in units called **Ohms** *(symbol 'R' or* Ω*).*

Electronic Pathways for Year 9 Students

Information for students

Aim

To introduce students to a "current" blend of science and technology, systems and processes via electronics, whilst developing a knowledge of components, circuit board manufacture and hand soldering skills to allow an informed choice in Year 10 when students are able to undertake both SACE and TAFE courses in this field of study.

Prerequisites

Students should have some **basic** understanding of the following topics:

- Charge and statics
- Voltage and current *(AC and DC)*
- Resistance/"Load" on a circuit
- Power sources *(cells, batteries, power packs, mains)*
- Types of circuits *(open, closed, short, series, parallel)*
- Effects of placing globes in series/parallel
- Effects of placing cells in series/parallel
- Conductors and insulators
- Switches, fuses and safety with electricity

Teaching Objectives

- Introduce basic skills and terminology associated with hand tools, soldering irons, tip care and soldering techniques.
- Component recognition, awareness of the existence of value codes and the importance of component polarity.
- Printed circuit board – purpose, recognition of layout, footprints of components and relationship to circuit diagrams.
- Basic debugging involving the simple use of multimeters.
- Develop safe working practices with electricity.
- Enhance problem-solving skills, fine motor skills, cooperative learning practices.
- Introduce female students to a wider range of science/technical experiences than has previously been available.
- Prepare students for Integrated Circuit programming in Year 10.

Where does this unit lead?

Students who **successfully** complete this unit *(they need to score at least 65%)* may apply to undertake a TAFE Hand Soldering course *(NE29)* that is run one evening a week after school for one semester, in a bus, on the Gleeson Campus. In conjunction with this the College offers a VET course *(which is SACE and TAFE courses combined to give dual accreditation – two qualifications for the one unit of work)* in electronics. This is begun in Year 10 and, if passed in Year 11, will give them formal recognition of their skills and open up many job, apprenticeship and further education opportunities in the electronics industry. South Australia will require 7,500 trained personnel by 2005 and a quarter of all University courses will be in the electronics field by 2010!

Requirements:

Consumables *(2 students' work goes in one labelled plastic lunchbox)*

Each student will need access to the following:

- Solder practice board *(in a resealable bank coin bag labelled with student's name)*
- 12 x ¼ watt resistors
- 10 cm of 0.7 – 0.9 mm tinned copper wire for staples
- 80 cm of 0.71 mm 60 / 40 multi core solder
- 5 cm of 2.0 – 2.5 mm desoldering wick
- 3 cm piece of lollipop stick
- ledfun kit *(to be kept in a resealable bag labelled with student name)*

Tools

One set between 2 students **in a pencil case** *(16 sets)*

- Soldering iron and appropriate tip *(2 types – 8 red pencil cases for white soldering irons and 8 blue pencil cases for blue soldering irons)*
- *(The tips for the blue irons have a '7' stamped on the flat inner end)*
- Sponge in a polythene bag *(larger sponge for blue irons)*
- 3 x 90 mm pliers – flat nosed, needle nosed, side cutters

One set per bench **in a large bucket** *(8 sets)*

- 4 sets of Helping hands *(with magnifying lens if required)*
- 2 multimeters
- 1 set of tweezers
- 1 set of desoldering tools *(1 solder syringe and set of hand tools in red plastic case)*
- 1 mini screwdriver set
- Soft toothbrush for cleaning circuit boards
- Chemwipes

On the trolley – as required

- 120 mm side cutters for heavy gauge wire cutting *(16 pairs)*
- Wire strippers for removing plastic coating on leads
- Distilled water for sponges
- Ethyl alcohol *(ethanol)* for cleaning flux off boards
- RMA flux for desoldering
- Magnifying lenses for helping hands *(18 with adapters fitted)*

This unit should be completed in 4-5 weeks. So don't waste time, there's a lot to do!

Getting started

Students need to be aware of the following procedures and safety matters:

WARNING

No solder, wire, links, resistors, plastic sleeving or any other *materials (especially metals)* used in connection with this unit of electronics must be allowed to go into the sink. Chemicals poured down the drain after them could result in dangerous reactions and maybe even poisonous gases being given off.
*(**Remember:** acid + metal = **hydrogen gas**)*

Cutting any wire other than soft copper, tinned copper wire, component leads or solder with the small 90 mm side cutters will ruin them instantly. Staples and paper clips are made from hardened spring steel and they must NOT be cut with these pliers.

Mains electricity *(240 volt)* will not be connected to any electronic components *(normally they run on 0 – 6 volt. More than this can cause them to explode!)*
Burning holes in the soldering stations is mega-dangerous – there are 240 volts inside!

Learn how to wind power cords around power packs and soldering irons, hold them correctly and store them safely in the correct location.
Select the appropriate pencil case of tools for the soldering iron being used. The BLUE pencil cases contain the correct larger sponge and tips for the BLUE soldering irons. If in doubt the blue soldering iron tips have a '7' stamped on the end of the tip – indicating an operating temperature of 700°F**.**

Learn how to insert the correct tip in the soldering iron, tin it when new, select correct heat setting *(on the white soldering irons this is critical and must be set at only 365°C/700°F)* and keep it clean during use. **Very importantly – remember to tin it at the end of the session just after switching off**, otherwise the casing will be damaged and the tip will go rusty and not solder properly – if at all.

Identify each of the pieces of equipment and the tools by their proper names.
Identify your own work with a permanent marker pen on the printed circuit board.
Use only distilled/demineralised water on the *sponges (sponges must be kept in sealed/folded polythene bags).*

Leave time at the end of a soldering session to cool the tip down before removing it and replacing it in the wooden block on the trolley. *(The damp sponge can do this if ou are pushed for time).*

You should try to gain experience on both types of soldering irons – remembering that they must use the correct tip for each type.

Look at the project kit at this stage and observe each of the 8 different "functions" and circuit plans. Start thinking carefully about the sort of device/game you are going to make around the kit and what resources you are going to have to gather in readiness to

make it. Use homework time to gather resources well before production dates and ensure that it is not overly complex or difficult with the possibility of missing the due date.

Your choice of function/mode can be altered if you don't like the end result just by using the de-soldering procedures you are about to learn and then changing some of the components *(resistors)* to those on another circuit plan. Consequently you should keep all the spare components issued with the kit.

In the final project make sure that all the components are correctly fitted before soldering and then check that all solder joints are sound with no sign of bridging *(short circuits)* before fitting the IC. IC's are easily damaged by reverse polarity.

Knowing how to set up and connect a multimeter safely to read current *(in series)*, voltage *(in parallel)* and resistance *(across component when disconnected from circuit and all power is off)* can be useful in fault finding, i.e. looking for open circuits, short circuits and checking battery condition.

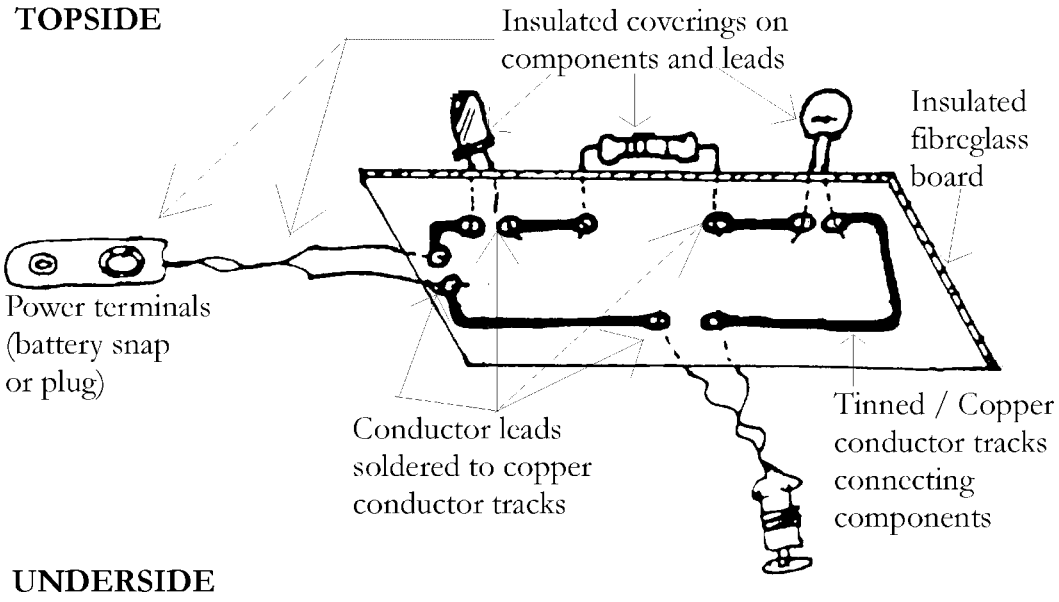
Your work will be marked as you go. **Take careful note of the points in the instructions where work needs to be presented.** You should bring the booklet with the appropriate marks page opened and ready when you present work for assessment. Please be patient and listen carefully to the feedback. Good feedback from the teacher will help you gain extra marks!

Pre-reading the instructions is a useful homework task and adds value to the time spent on practical tasks.

For more interesting facts: *Internet electronics* – www.iserve.net/~alex/lib/tutorial

Understanding printed circuit boards

When lots of components have to be joined together to make a circuit can you imagine the mess if they were all joined with wires? The simple way is to use conductive metal tracks *(usually of copper, silver, brass or gold)* glued onto a fibreglass *(insulator)* board. This is called a printed circuit board, or PCB for short.



What is solder?

Soft solder is a filler metal made from an alloy *(mixture)* of tin *(60%)* and lead *(40%)* which acts as a bonding agent during the solder process. Sometimes a little silver or antimony is added for extra strength. It conducts electricity between component leads and conducting wires or tracks on a printed circuit board. Metals get dirty and contaminated by reacting with oxygen in the air to form metal oxides. Metal oxides don't solder well, so thin coatings of metal oxides need to be cleaned off both by rubbing with light abrasives *(mechanical cleaning)* and also by chemical cleaning with methylated spirits. Final light surface oxides are cleaned by the slightly acid flux that is found in the centre of the solder, which melts onto the joint during the solder process. This flux is quite sticky and must regularly be cleaned from the board after every dozen or so solder joints are completed. It hardens if left too long. It is important never to break solder by stretching it. This thins out the flux and can make the soldering process more difficult. Cut or nip the solder to break it.

What is wetting?

Solder can only bond with metals if they are both clean and hot enough. Transferring heat to both the component lead and circuit board pad *(or land)* at the same time is achieved by contact with a wet soldering iron tip. It is very difficult to solder if the tip is dry. You need to add a little solder to the tip just before beginning the solder process. This is called tinning. Once the joint is **hot** and **wetting** takes place, solder will flow easily and quickly making a strong joint.

Tools

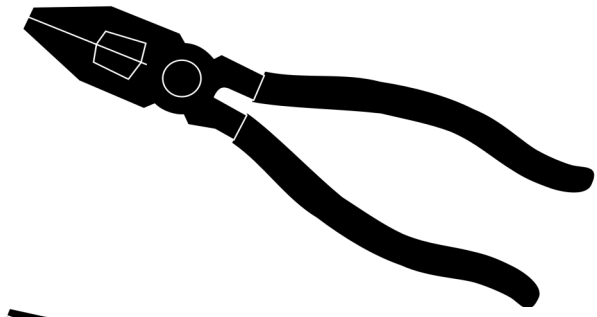
The most valuable of all the tools is your soldering iron station. It needs to be treated with care and kept clean and free from flux, solder and burn holes. The tip especially needs proper cleaning and the correct temperature setting during use.

Pliers

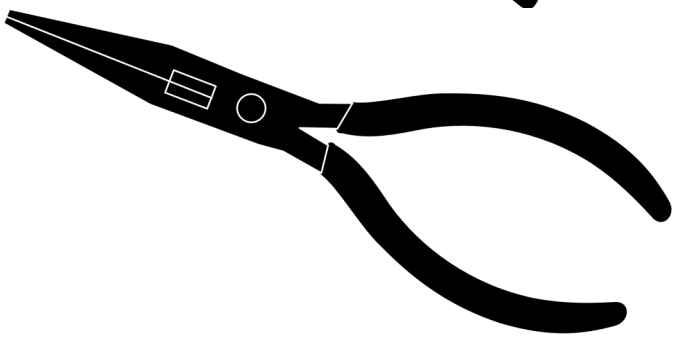
You have five in the set but will probably only use three.

- Side cutters – for use with soft metals only – **not with paper clips or staples please!**
- Flat nose – for bending and terminating most component leads.
- Needle nose or chain – these are the long ones with the completely rounded pointy ends.

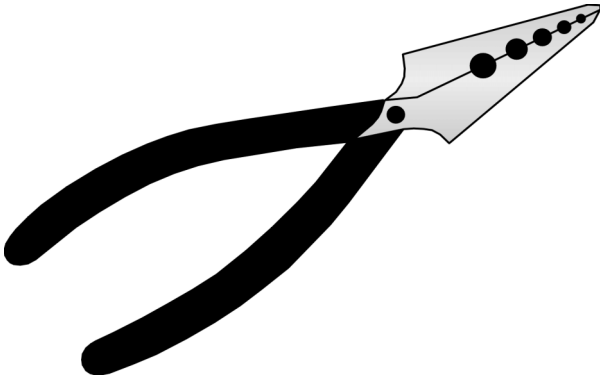
The other two *(bent nosed and long nosed have rounded ends and flat inner edges)* may be useful but can damage the leads if used inappropriately.
A letter of the alphabet engraved on the plastic handle identifies each set, which should match the letter on the pencil case.
Please make sure you keep your set together so that you always have one of each type ready for use.



Stainless steel pliers

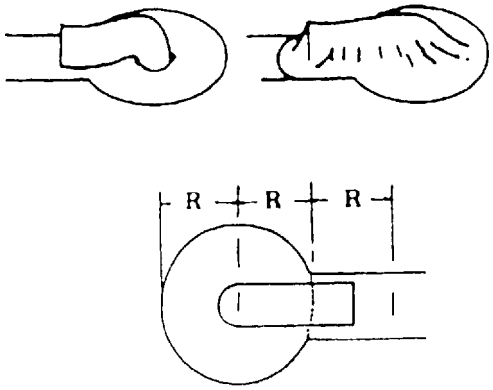


Long nosed pliers

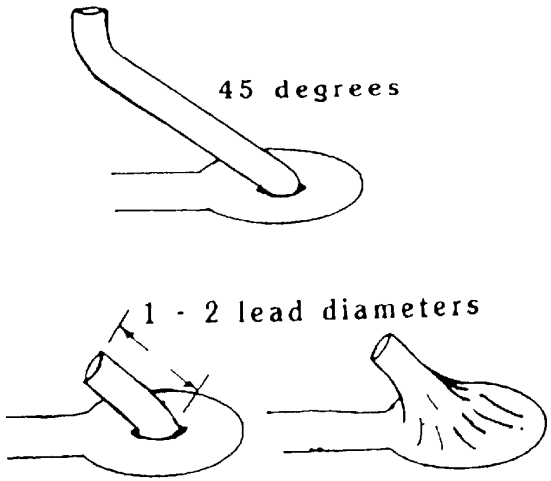


Wire cutters / strippers

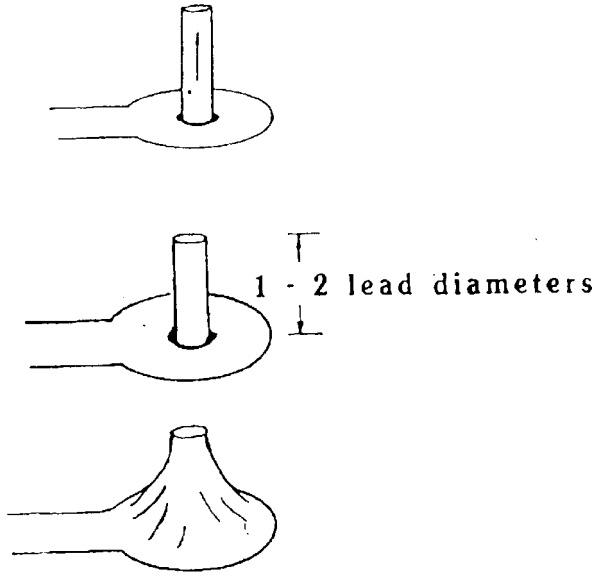
Fully clinched lead termination



Semi-clinched lead termination



Straight through lead termination

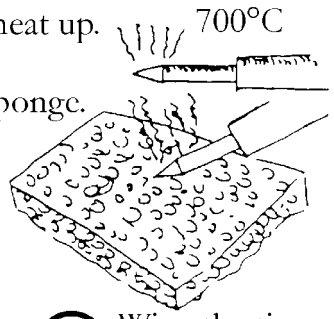


HOW TO SOLDER

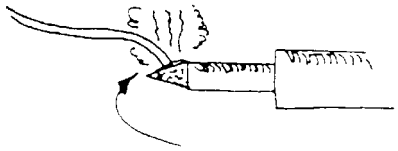
Soldering takes about <u>four seconds</u> per connection. One second to heat the joint, one second to apply solder and two seconds to allow the solder to flow. Then wait five seconds for the solder to set. Here's how it's done:

① Allow soldering iron to heat up.

② Clean the tip on a wet sponge.

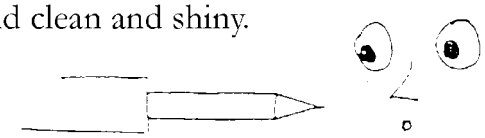


③ Feed ½ cm solder onto tip.
This is called 'tinning' the iron.

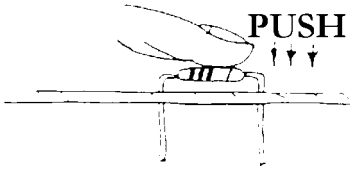


④ Wipe the tip on the sponge again.
This removes the excess solder.

⑤ The tip must be nice and clean and shiny.

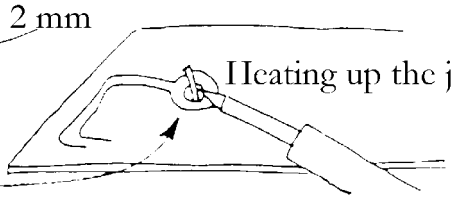


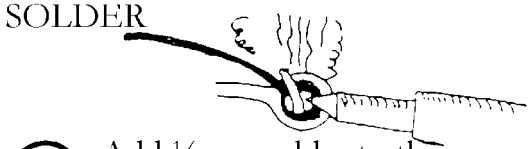
⑥ Bend leads carefully and fit a resistor onto a P.C. board and push it down firmly.



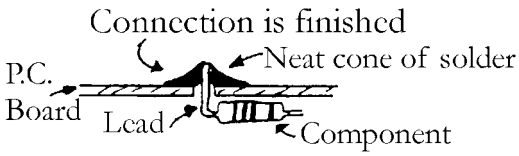
Bend the leads apart to keep the resistor in position. Cut extra lead off at about 2 mm. ⑦

⑧ Turn the board over and place the tip of the iron on the P.C. land and resistor lead. Count for about <u>one second</u>.





⑨ Add ½ cm solder to the hot lead and P.C. land. Don't move the iron!



⑩ Remove solder and count for two seconds. Remove iron. Clean the tip again. When all the joints are done clean the board of flux.

Practical Exercises

Practical Activity: Solder Practice 1

This practical activity is to introduce you to soldering practices and to enable you to experience soldering techniques. You will be loading the board with wire links and resistors, which must be correctly mounted and terminated using the fully clinched and semi-clinched lead methods, as described in the notes. Discuss the various cleaning techniques and acceptance standards with the teacher.

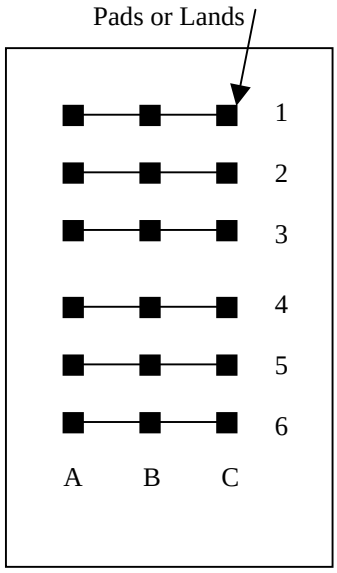
Practical Objectives

At the end of this practical activity you will be able to:

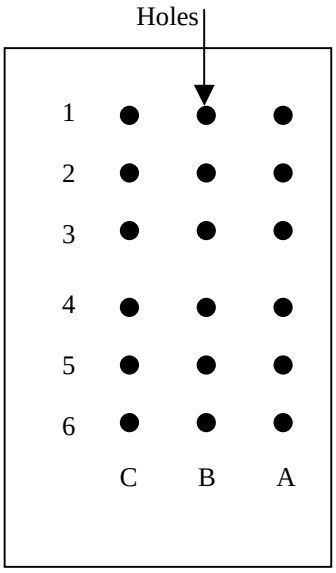
- Clean a copper clad board to the degree required to achieve reliable solder joints.
- Bend and mount on the board tinned copper wire links and resistors, in preparation for soldering.
- Terminate leads using fully clinched and semi-clinched lead terminations to specified lengths.
- Solder terminations, using the appropriate flux cored solder.
- Assess the quality of your solder terminations, and indicate to the teacher those joints that do not meet the standard as specified.

PRINTED CIRCUIT BOARD – ORIENTATION

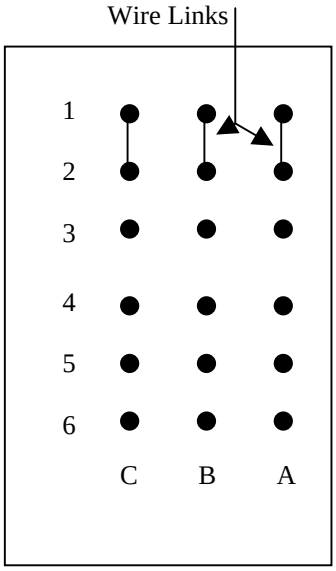
UNDERSIDE
Solder side of PCB.



TOPSIDE
Component side of PCB.



Wire links mounted and soldered to PCB.



Competency

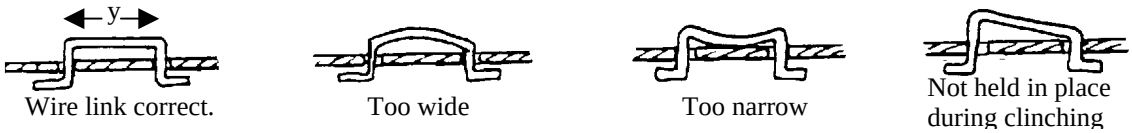
For this practical activity competency will be considered to be achieved if:

60% of all terminations you make are to the required standard.

Criteria for assessment of mounting and terminating components:

Mounting is correct if:

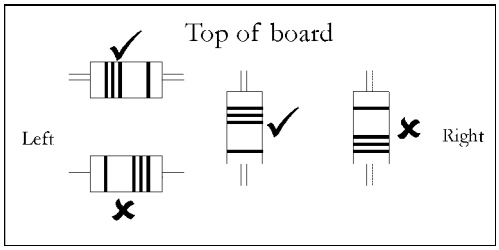
- No dings, cuts or dints in the leads – caused by rough handling with pliers.
- Shoulders bent at the correct angle.
- Width between shoulders is the correct distance for the holes in the board and the component is parallel to the board. See diagrams below for guidance.

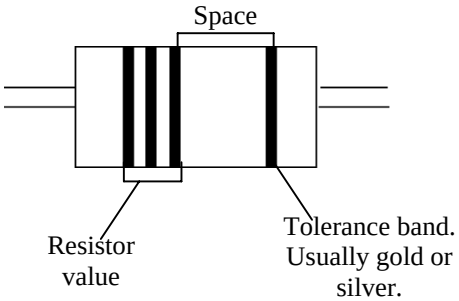


Wire link correct. Too wide Too narrow Not held in place during clinching

- There is an equal amount of lead either side of the component – the component will then be central between the holes in the board. See diagrams below for guidance.

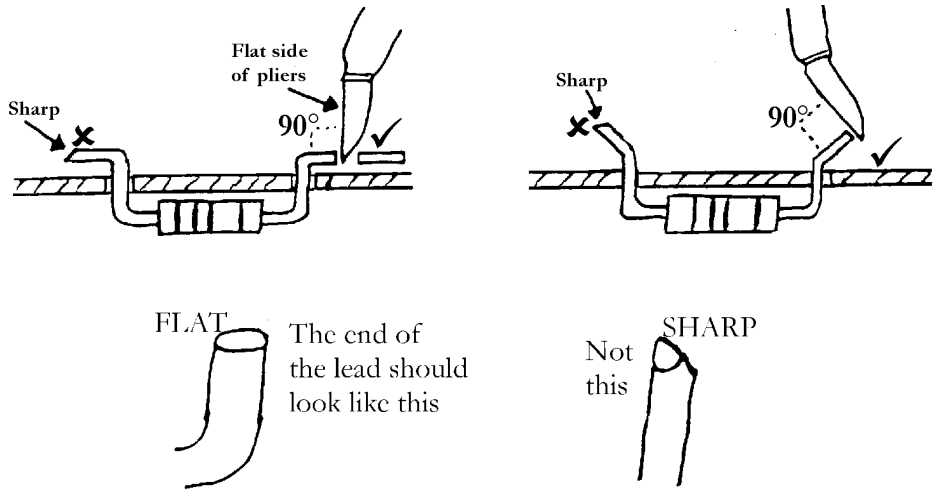
- The component is mounted the correct way for code reading. See diagrams below for guidance.





ONE MARK WILL BE TAKEN OFF FOR EACH INCORRECT CRITERION.

- Terminations are correct:
  Length *(1 – 2 lead diameters)*
  Angle
  Cut at the end – 90 degrees to the lead using the flat side of the pliers nearest the component. See diagram.



- The printed circuit board is undamaged after soldering.

Criteria for assessment of good soldering:

- Correct amount of solder – just covers the whole pad.
- Shiny finish – not crystallised from too early removal of soldering iron or spiky from late removal of solder.
- A completely bonded joint – no holes around the lead caused by lead not being heated at the same time as the pad.
- Clean solder and board *(both sides)* – free from brown sticky flux spots.
- When the pads are viewed from the **non solder side *(component side)*** of the board they should not show signs of over-heating, indicated by "measles" *(white spots where the board has separated from the solder pad)*

ONE MARK WILL BE TAKEN OFF FOR EACH INCORRECT CRITERION.

Method

Step 1: Prepare the board

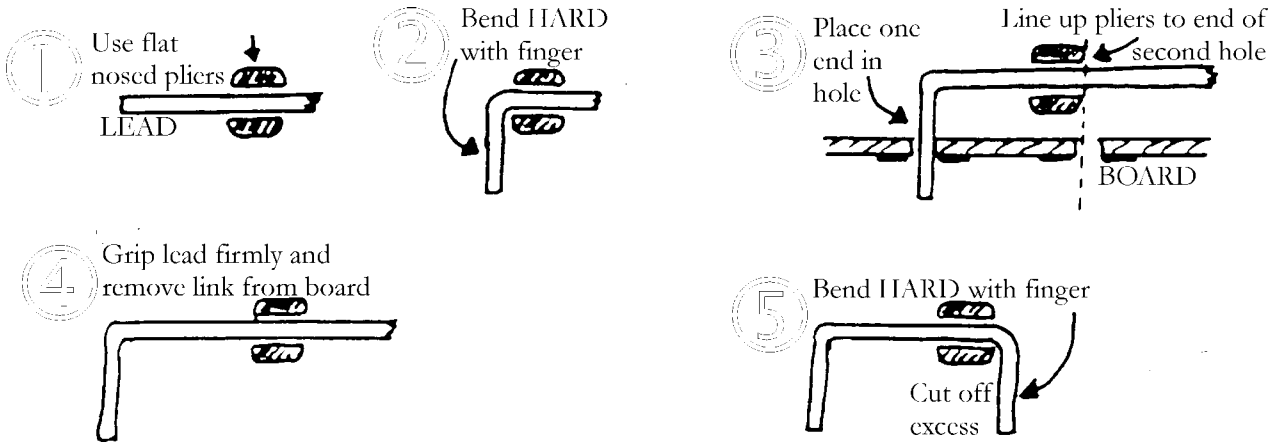
Mechanically clean the bare copper board. Follow this with a chemical clean.

Step 2: Prepare wire links

Prepare the wire links *(staples)*, bending them to the appropriate size, using flat nosed pliers. Do not use round nosed pliers as they may damage the wire.

Step 3: Mount wire links

Mount the wire links into rows 5 and 6, as shown in the diagram *(e.g. 5A-6A, 5B-6B).*



Step 4: Terminate wire links

Terminate the wire links with **fully clinched lead terminations** after a demonstration by the teacher *(see diagrams on page 9).*

Step 5: Teacher inspection

Have the teacher inspect prior to soldering. *(Take the assessment sheet 1).*

Step 6: Solder joints

Read the "How to solder" instructions on page 10. Learn the three simple steps to complete a good solder joint in **4 seconds**.

- Wet the tip and hold it on both the lead and pad for **1 second**
- Feed solder to the joint until the pad is just covered for **1 second.** Remove solder.
- Hold the soldering iron tip still on the joint for **2 seconds**. Remove the tip and don't disturb the joint while it sets.

Place your work in the alligator clips of the helping hands, solder side facing up. Each joint is to be soldered only once.

Step 7: Clean board

Chemically clean with methylated spirits and a soft toothbrush. Allow the methylated spirits to run into the sink.

Step 8: Examine and discuss work

Show the teacher and discuss acceptability/unacceptability of bends, terminations and solder joints.

ASSESSMENT SHEET 1

The project is assessed using the following assessment sheet. A grading of between excellent *(5)* and poor *(1)* is awarded for the specified items. A grade of less than good is unacceptable.

#	ITEM	Excellent	Very Good	Good	Fair	Poor
1	Bending of wire links					
2	Mounting wire links					
3	Wire link terminations					
4	Soldering wire links					
	Sub total					
	TOTAL					

Practical Activity 2: Solder Rework Techniques.

This practical activity is the first soldering rework practice. The board from previous practical activity will now be desoldered. The teacher will demonstrate this process.

Practical Objectives

At the end of this practical activity you will be able to:

- Desolder soldered terminations in row 6 using desoldering braids.
- Desolder soldered terminations in row 5 using solder syringe devices.
- Remove components from a printed circuit board without causing damage.
- Assess the bare board after desoldering, and indicate to the teacher any areas that are not to acceptable standards.

Competency

For this practical activity competency will be considered to be achieved if the assembly does not exhibit signs of measling and/or copper pads are not delaminated *(coming off the board).*

Desoldering

- Desolder row 6 using commercially available *(pre-fluxed)* wicking braids.
- Chemically clean and inspect.
- Desolder soldered terminations in row 5, using solder syringe devices.
- Remove all links, then chemically clean and inspect. ***(Remember:** TWIST don't PULL).*
- Hand into the teacher for assessment.

ASSESSMENT SHEET 2

The project is assessed using the following assessment sheet. A grading of between excellent *(5)* and poor *(1)* is awarded for the specified items. A grade of less than good is unacceptable.

#	ITEM	Excellent	Very Good	Good	Fair	Poor
1	Board cleanliness					
2	Pads undamaged					
	Sub Total					
	TOTAL					

Practical Activity 3: Solder Practice

This practical activity is to introduce you to soldering practices and to enable you to experience soldering techniques. You will be loading the board with wire links and resistors, which must be correctly mounted and terminated using the fully clinched and semi-clinched lead methods, as described in the notes. Discuss the various cleaning techniques and acceptance standards with the teacher.

Practical Objectives

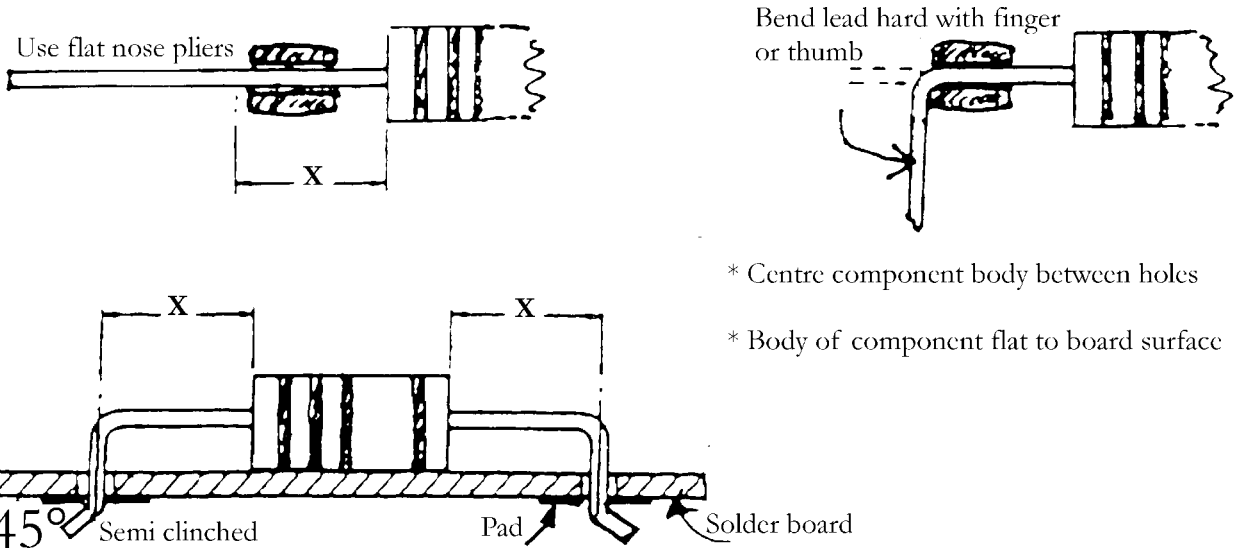
At the end of this activity you will be able to:

- Clean a copper board to the degree required to achieve reliable solder joints.
- Bend and mount on the board tinned resistors in preparation for soldering.
- Terminate leads using fully clinched and semi-clinched lead terminations to specified lengths. *(See page 9).*
- Solder terminations, using the appropriate flux cored solder.
- Assess the quality of your solder terminations, and indicate to the teacher those joints that do not meet the standard as specified.

Note: *mechanically clean the resistors (¼ W), and follow this with a chemical clean. Inspect for signs of nicks, cuts, scraps or exposed base metal (other than the cut lead end). Reject any resistors with these faults.*

Step 1: Mount resistors

Bend ¼ W resistors using standard 90°. Mount into positions indicated in rows 1 and 2.

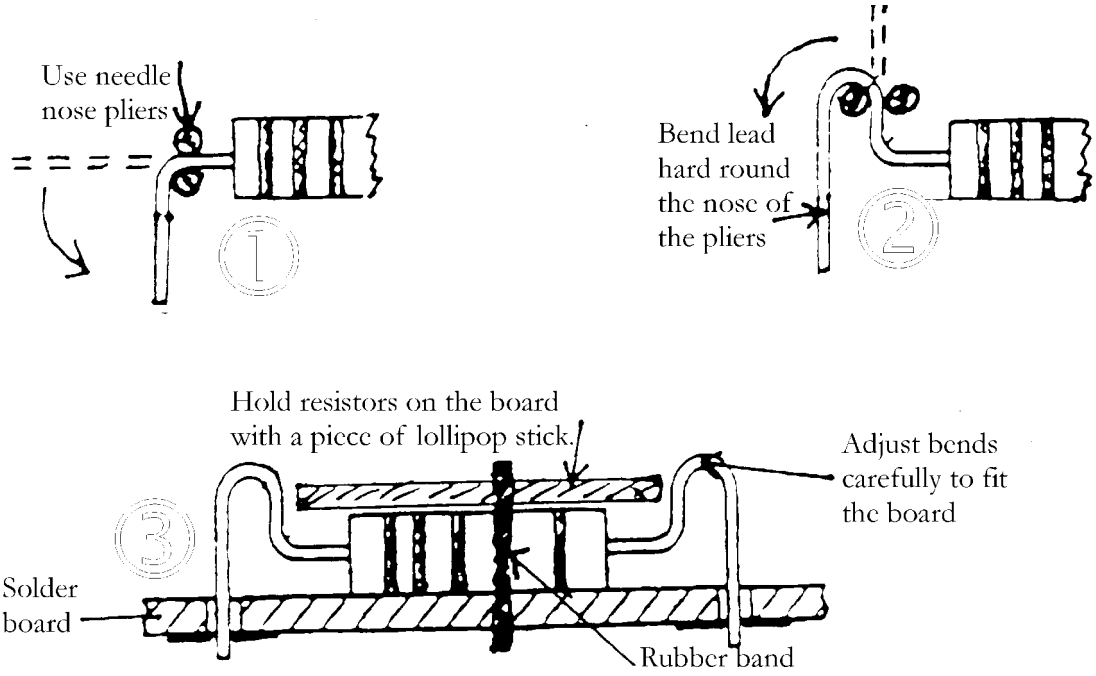


Step 2: Terminate resistors

Terminate the resistors using semi-clinched lead terminations. *(See page 11).*

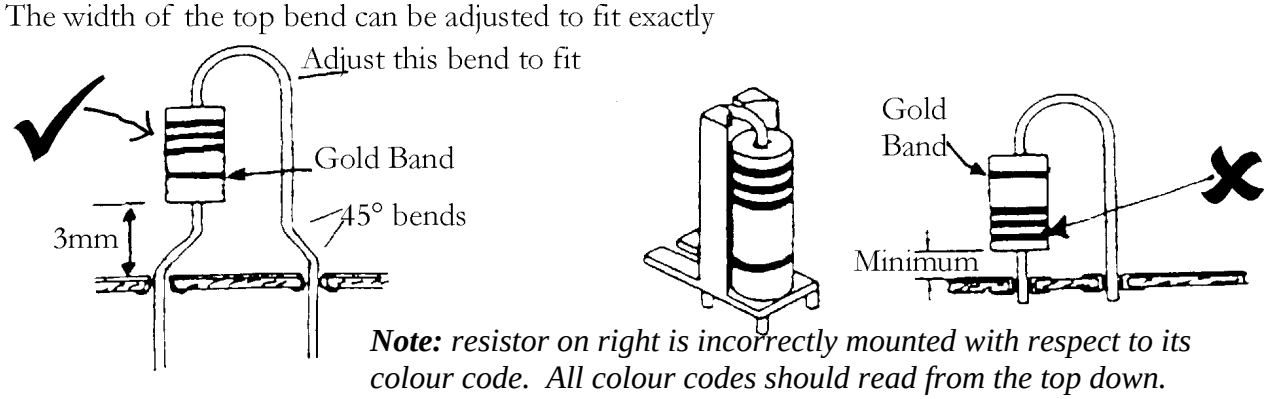
Step 3: Mount resistors

Bend resistors using Camel Back Stress Relief. Mount components into positions indicated in rows 3 and 4. Ensure they are centred between holes, and colour codes are all orientated the same way. Terminate with straight through lead terminations.



Step 4: Bend resistors

Bend resistors for vertical mounting between rows 5 and 6. ***Note:*** *There are many ways to bend upright resistors. One of the best for stress relief is shown below. This is especially useful when the holes are just too wide for the method shown.*



Note: *resistor on right is incorrectly mounted with respect to its colour code. All colour codes should read from the top down.*

Step 5: Vertically mount components

Vertically mount components and ensure component body is mounted between 0.3 – 3.0 mm above the board surface. If available, use spacers or standoffs.

Step 6: Terminate resistors

Terminate the resistors using fully clinched lead terminations.

Step 7: Confirm ready for soldering

Show the teacher. Take Assessment Sheet 3.

Step 8: Solder joints

Solder. Each joint is to be soldered only once.

Step 9: Clean board

Chemically clean and inspect

Step 10: Present work for assessment

Show the teacher. Take Assessment Sheet 3.

ASSESSMENT SHEET 3

The project is assessed using the following assessment sheet. A grading of between excellent *(5)* and poor *(1)* is awarded for the specified item. A grade of less than good is unacceptable.

#	ITEM	Excellent	Very Good	Good	Fair	Poor
1	Mounting of standard resistors.					
2	Mounting of camel back resistors.					
3	Mounting of vertical resistors.					
4	Termination of standard resistors.					
5	Termination of camel back resistors.					
6	Termination of vertical resistors.					
7	Soldering of resistors.					
8	Cleanliness					
	Sub Total					
	TOTAL: /40					

When complete, transfer all your totals for assessments 1, 2, and 3 to the assessment summary at the back of this manual.

Practical Activity: Project.

This practical activity will introduce you to assembly soldering practices. It will enable you to experience different soldering techniques. You will be required to identify and load various electronics components to a printed wiring board. These components must be correctly mounted and terminated using either the straight through or semi-clinched lead termination method. Discuss the acceptance standards with the teacher.

Practical Objectives

At the end of this practical activity you will be able to:

- Identify various electronic components.
- Clean, bend and mount on the board various electronic components using suitable bending techniques as learned in the soldering practice unit.
- Terminate leads with semi-clinched and straight through lead terminations to specified lengths.
- Solder, using the appropriate flux and solder, with respect to the specified standards.
- Assess the quality of your solder terminations and indicate to the teacher any that do not meet the prescribed standard.

Competency

For this practical activity competency will be considered to be achieved if:

- 90% of all terminations you make are to the standard taught in the soldering practice unit (a minimum of 'good' must be achieved)
- during the process that you use to solder the components to the board no copper pads are delaminated.

PROCEDURE

Component Mounting and Termination.

All components are to be mounted and inspected by the student and teacher prior to any soldering operations. Components for this board are as shown on a sample board. You are required to load the components the same as on the sample board starting with the resistors and diodes. When you complete your work take Assessment Sheet Project 1A to the teacher with your work. When soldering is complete use Project B and so on.

Building the ledfun kit – notes for Students

Aim

To construct a device/game around the ledfun project kit that will be of some use to you. The best ones in the class will automatically be entered into a Labtronics competition with great electronic kit prizes.
Start thinking right from the beginning just how you may need to have components mounted, i.e. the LED's might not even have to be soldered on to the board! Start looking for, asking about, and collecting your resources now. Don't complicate matters by going overboard *(keep it simple but do it well).* How about an electronic mousetrap that lets you know when the mouse has been caught? Or electronic snakes and ladders? Maybe an alarm for the bedroom door!

During construction there are a few essential points you should consider:

- You will need to provide three **new** good quality AA batteries to run your kit. If you get together with other students they are cheaper in bulk. You would be well advised to use a simple slide or toggle switch in your final project so that you can turn the batteries off. See if you can take one off an old broken toy, game Walkman or pocket radio – rather than spend a few cents.
- Some components are 'polarised'. This means that they have positive and negative terminals and **can only be fitted one way round.** These components include all diodes, light emitting diodes or LED's, as well as transistors and microcontroller integrated circuits *(IC's or 'chips' as they are commonly called)*, and some capacitors. Resistors are not polarised.
- Some components are very easily damaged by excess heat whilst being soldered. Transistors and integrated circuits are particularly vulnerable and need a special soldering technique, which ensures that no two leads of the same component are soldered one after the other. This permits a component to cool down.
- You will need to make special connections within the battery holder to make the unit work with only three AA cells – a bit of problem solving for you!
- You may be able to substitute different coloured LED's.
- You should ensure that the integrated circuit is not handled until you are ready to fit it in the socket because they are very susceptible to static discharge.
- If you don't like the kit you've made at the end of the unit you can rebuild it to a new plan providing you haven't damaged any of the components or tracks whilst desoldering. You do have all the components needed the make any or all of the eight circuits.
- Turn your soldering iron off, clean the tip on the sponge, add enough solder to cover the tip with a thin coating to protect it before you pack away and clean up. This allows the tip time to cool down enough to go back into the wooden block without burning it.

BEFORE YOU START:

- Capacitors and resistors especially have values coded on them and they should always be mounted in ways that clearly show their values. The capacitor code should not be obscured by the integrated circuit. **Resistor colour codes should be read from left to right or from top to bottom if mounted vertically.**
- Use camel back stress relief bends for resistors R5 and R6 only. Use standard 90° bends for everything else.
- All resistors are to be terminated with semi-clinched lead terminations to allow ease of removal at a later stage *(should you wish to change your mode)*. Use fully clinched lead termination for everything else. Cut the leads at 90° to avoid sharp edges and remember to keep the length of termination to 1.5 – 2.0 mm *(2 x lead diameter)*.
- Take your work for marking once all the components have been mounted, **before you start soldering**. This is important for marking your terminations and so that the teacher can check the polarity of your components.
- Try not to solder all the leads on one component at once. Move around the board to avoid overheating the component.
- If you would like to try your hand at cracking the resistor colour code here are your clues:
- Black = 0 Brown = 1 Red = 2 Orange = 3 Yellow = 4
- Green = 5 Blue = 6 Violet = 7 Grey = 8 White = 9
- Gold = 5% Silver = 10% None = 20%
- So the resistors that you have in your kit are 270R ± 5% - that's red, violet, brown, gold.
- What is the colour of 2k2 ± 5%? Other ways of writing 2k2 ± 5% are 2.2k ± 5%, or 2,200R ± 5% - that's red red red gold. So what colours are on a 4k7 (or 4,700R) ± 5% resistor? – Or how about 100k? What value is an orange orange red gold resistor? Now try a brown black black silver? We'll do the capacitor codes in class. Answers to this riddle are at the bottom of this page.

4,700R = 4k7 = yellow violet red gold. 100k or 100,000R =brown black yellow.
Orange orange red gold = 3,300R or 3k3. Brown black black silver = 10R ± 10%.

Kit Construction Guide

Handy Hints

Read each step completely before starting. Make sure that you understand everything that's involved.
Allow yourself plenty of time to build the kit. Set aside an area where you can work undisturbed, and can leave the kit between sessions.
Refer frequently to the assembly instructions and check each step as it is completed.

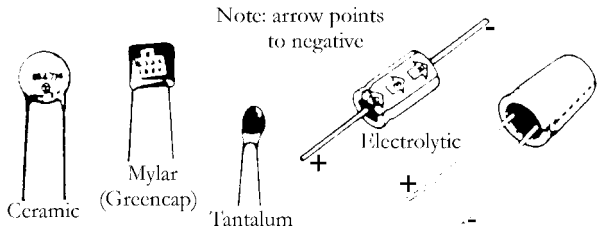
Tools You May Need

Only a minimum of tools are needed for most kits. These are:

- A 10 – 30 watt soldering iron with a 1.5 – 4 mm tip.
- A small pair of side cutters.
- A small pair of long nose pliers.
- Wire strippers or a knife.
- A few screwdrivers.
- A multimeter for testing or troubleshooting.

Soldering

Poor soldering is a major cause of kits not working. If you've never used an iron before, do some practice runs first. Get the feel of the solder flow and when to apply



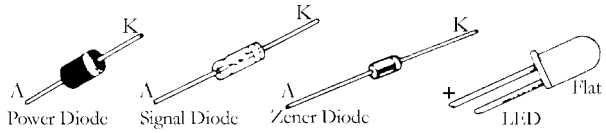
and remove the solder and the iron.
A component soldering procedure is covered in the section headed "Construction Techniques" below.

Components

Resistors

Resistors 'resist' the flow of current. They have two leads and most are small cylinders about 10 mm long with 4 or 5 coloured bands which indicate their resistance value.
Resistance is measured in ohms, abbreviated to Ω or R. Thousands are indicated by 'k', millions by 'M'. Thus a 12k resistor has a resistance of 12,000 ohms.

The colour codes for resistors used in this kit are given in the parts list. The band on one end is spaced away from the rest of the bands. This band is the last, that is, the 4th or 5th band of the code.
Some colours, such as red, brown and orange, can be difficult to distinguish from



each other so extra care may be needed when reading these colours.

Potentiometers


Trimpot

Potentiometers are variable resistors. There are two main types in kits: normal potentiometers *(often called 'pots')* which are used as controls for volume, bass, treble, speed control, etc, and 'trimpots' which are smaller devices mounted on the circuit board, used for initial adjustments and not normally adjusted once set.

Capacitors

Capacitors pass high frequency signals and impede low frequency signals. They are used to store energy, pass AC signals while isolating DC voltages, reduce noise on power supply lines, and in filter circuits.
The most common types found in kits are polyester *('greencaps' or 'mkt')*, ceramic, electrolytic and tantalum. Electrolytic and tantalum capacitors are 'polarised', that is, have a positive and negative end which must be installed in the correct direction for the circuit to work.
Capacitance is measured in Farads. This is too large a unit for most uses so various fractions are used: microFarads *(uF)* – a millionth of a Farad, nanoFarads *(nF)* – a thousandth of a microFarad, picoFarads *(pF)* – a thousandth of a nanoFarad. So 0.01uF = 10nF = 10,000pF.
Electrolytics and most tantalum capacitors are marked in uF. Some of the larger ceramic and polyester capacitors are marked in uF *(usually 0.1uF and larger)*. Smaller ceramics are usually marked in pF.
Many ceramic and mylar capacitors are marked using the IEC capacitor code, a system of three numbers and a letter giving the value, in picoFarads, and tolerance of a capacitor. The first two numbers are the significant figures, and the third the number of zeroes following *(value in picoFarads)*. The letter indicates the tolerance:
Metal = 20%, K = 10%, J = 5%. So a 123K is a 12,000pF or 12nF or 0.012uF 10% capacitor.

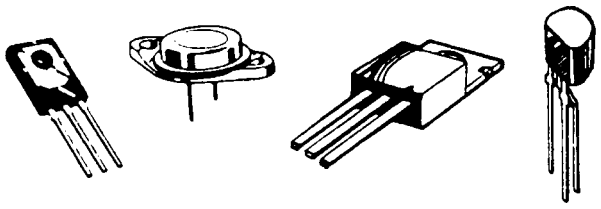
Diodes

Diodes are used to convert AC Current to DC *(rectify)*, or switch signals. Most are in the form of a black or clear cylinder 3 – 10 mm long. Diodes are also

polarised, with an anode end *(a)* and a cathode end *(k)*. The cathode is marked with a band. Always check that they are installed the right way round.
Light emitting diodes *(LEDs)* are a special type of diode which light up when current is applied. These are also polarised, and must be fed with an appropriate resistor to limit the current.

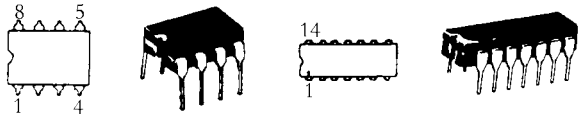
Transistors

Transistors are used to amplify and switch signals. They generally have three leads called emitter *(e)*, base *(b)*, and collector *(c)* and come in many different cases.
MOSFETs and FETs are special types of transistors, which look identical to common transistors. Their leads are called source *(S)*, gate *(G)*, and drain *(D)*. Less common, dual gate MOSFETs have 4 leads because they have 2 gates. MOSFETs can be damaged by static electricity and must be handled carefully. *(See 'CMOS ICs').*
Always check that the leads are installed in the correct positions – two transistors may look the same, but their leads could be differently orientated. The number of a transistor is usually printed on the case. Any other numbers or letters are manufacturers' codes and may be ignored.



Integrated Circuits

An integrated circuit *(IC)* is a complete circuit block in a single package. They perform a wide variety of functions – amplifying, timing, switching, counting, - the list is enormous. They are usually packaged in a dual-in-line *(DIL)* package with 8 to 40 pins.
Integrated circuit markings vary with manufacturer. For example, what is described as a '741' IC may be marked LM741CN, N741T, 741TC, MC1741CP1, or SN52741N. Notice that there is a '741' somewhere in all the numbers. The other numbers are manufacturers' codes and may be ignored, as any of these ICs would work equally well.
Integrated circuits must be installed in the correct direction as indicated in the circuit layout diagram. One end is marked with a notch or dimple for orientation.
These integrated circuits need special handling, as they are vulnerable to static electricity damage. They are packed on conductive foam shielded bags. Always install these ICs last, soldering the power pins first. Avoid touching the pins with your fingers.



Switches

Switches come in various types – toggle, rotary, paddle, micro, and are identified by the number of circuits or 'poles', that they have. This is usually given as four letters or numbers. SPST stands for Single Pole Single Throw – one pole which is either on or off. DPDT stands for Double Pole Double Throw – two separate poles, which have two 'on' positions.

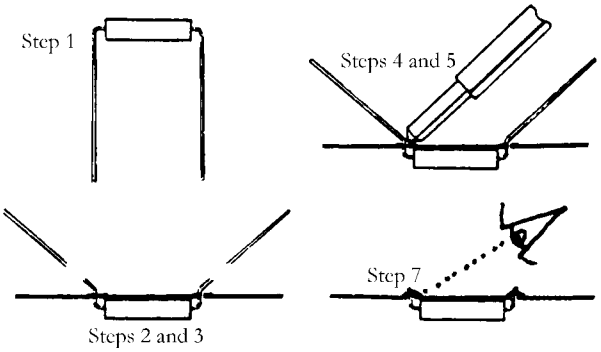
Wire and Cable

The two types of wire found in most kits are hookup wire and shielded cable.
Hookup wire is light, flexible, stranded, insulated wire in a range of colours for low voltage connections. It may be in the form of a flat 'ribbon' of twelve separate conductors joined together for easier handling.
Shielded or coaxial cable has one or more inner conductors surrounded by a twisted or braided shield. In use the outer shield is usually earthed, while the inner conductor(s) carry the signal. The earthed shield protects the inner conductors from external, electrical interference. This cable is used for radio signals and low level audio signals.

Construction Techniques

Most kits are assembled on a 'printed circuit board' *(PCB)*. This is a sheet of insulating material on which is etched the circuit layout in copper. Components are mounted on the non-copper side with their leads fed through the board and soldered to the copper tracks.

- Bend component leads to fit their PCB holes accurately, using long-nosed pliers. This allows easy, neat installation and reduces strain on the component.
- Insert leads in the correct holes and press the component down onto the board. Arrange resistors so that their colour codes can be easily read. Position capacitors so that their values can be read *(except polarised types, which must go in the direction indicated)*. If the component is polarised, check that it is installed the right way round.



- Turn the board over and bend the leads to 45°. Cut excess off.
- Hold the bit of your soldering iron against the component lead and the copper.

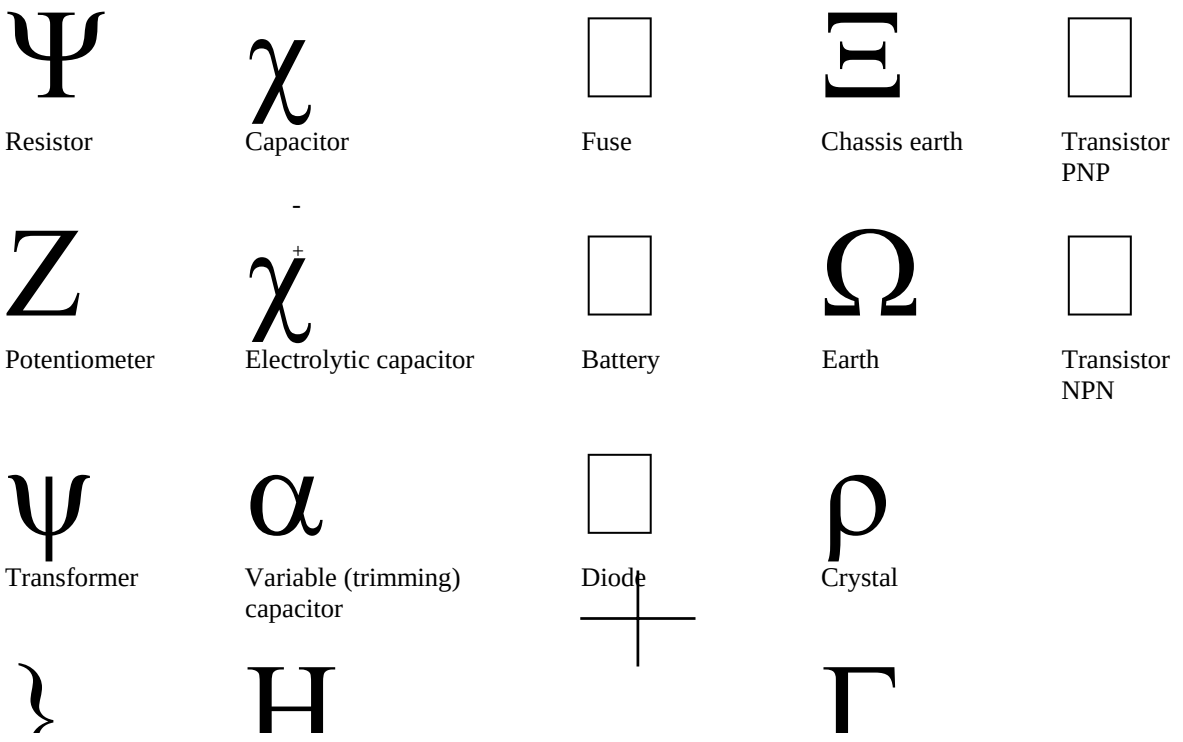
- After pre-heating for about one second apply the solder to the joint and the iron.
- When the solder has flowed across the pad remove the iron and solder.
- Inspect each joint carefully when it has cooled. The connection should be shiny and smooth. If it looks cracked or frosty, the joint is dry and must be re-done. Check for solder bridges shorting PC tracks, pinholes and cracks in the joints.
- When connecting wires to switches, potentiometers, and terminations, strip and tin them as above, put a 90° bend in the stripped end and hook it through the terminal. Do not wrap it around the terminal or it will be difficult to remove if necessary.

Troubleshooting

- If a kit doesn't work when first switched on, switch it off immediately and disconnect the power.
- Most faults in kits are due to soldering errors, or incorrectly installed parts. Faulty parts are very rare.
- Check the printed circuit board for any solder bridges or dry joints. Re-solder any that look doubtful.
- Check that all components are correctly located and that the electrolytic capacitors, diodes, transistors and integrated circuits are the right way round.
- Check all the wiring
- If no faults can be found try getting the help of an experienced person, such as your teacher or a technician.

Schematic diagram symbols

These are the commonly used symbols for components on schematic diagrams.



ledfun **8-in-1 Educational Kit**

ledfun is a kit designed at the request of high school teachers to provide an easy to construct yet fun and useful project for first time electronic construction by students.
It is intended to make electronics easy and fun so that the students maintain their interest at a high level. Hence 8 different modes have been designed to fuel the students imagination, effectively making this an 8-in-1 kit. Special care has also been taken to minimize problems for first time constructors in recognition, placement and soldering of components.

The kit contains:

- 1 PCB 7 cm x 3½ cm, tinned, solder masked and top component overlay
- 7 Red LED's
- 6 Resistors
- 1 Capacitor
- 1 Diode
- 1 Piezo Buzzer
- 1 Push Switch
- 1 Battery Holder for 3 x AA Batteries
- 1 IC Socket-8 pin
- 1 Microcontroller IC-8 pin

Modes Available

(Modes set according Mode Table - see instructions)

Mode 1: Random LEDs

On button press light chases down 6 LED's, slows and stops randomly. Buzzer clicks to a stop with the LED's and plays sound effect.

Suggestions for uses: Make up your own game, e.g. a board game with counters. Pick 1 out of 6 possible moves randomly then move according to the instructions next to that LED.

To use: Press button and release. LED's will follow each other quickly at first then randomly stop when the button is released.

Mode 2: Variable Chaser

Button press and hold time changes pattern/speed of 6 LED chaser.

Patterns (3):

- Straight Chaser – lights follow each other and then loop back to start.
- Level – lights follow each other and stay on to the end.
- Strobe – lights all flash on / off at the same time.

To use: Press button and hold – pattern will then start slow and get faster and faster, then suddenly slow again. Release the button to select the speed. Press the button and hold again for the speed of the next pattern on the list.

Mode 3: Binary countdown/alarm

A button press sets a 1 to 64 second binary timer: An alarm sounds when time is up.

Uses: Can be used as a timer, or as a doorbell, or as a security alarm. Games could be fashioned too, e.g.: like pass the parcel.

To use: Press button and hold: binary counter will count up to 64 seconds. When the required second comes up, release the button. This sets the time. Now when the button is pressed, the counter counts for the required amount of time and then sets off a visible and audible alarm for 5 seconds. Time can be set again by pressing button again.

Mode 4: Ladder / reaction timer game

Climb the 6 LED ladder if your reaction time is quick.

To use: When you hear a "ping" and an LED flashes, you must press the button quickly to keep the LED lit. The next LED up the ladder will flash and you must press the button quickly to keep it lit too – until you get to the top. Then all the LED's will flash – well done. The first LED will start again but this time it will be a bit harder. How many levels can you get? Have Fun!

Mode 5: Blinking face

7 LED face smiles and blinks randomly. Reacts to button press.

Uses: Make into a stunning pendant, broach or use as a face on a robot or a doll. You could even use it as an interesting night light for the baby.

To use: Watch the face to change different expressions and make noises. Press the button and get a reaction.

Mode 6: Doorbell/alarm

All the LEDs and the buzzer are off until a button press, then the 7 LED face blinks and smiles and alarm sounds. Makes an interesting doorbell – face turns on too and smiles while alerting you. Could be used as a "smiley face" alarm.

To use: When switch is pressed, smiley face alerts you to someone at the door with the LED face and sounds alarm.

Mode 7: Memory/sequence game

Repeat the sequence of dot/dash: 7 LED Face, happy or sad.

To use: Press button to start/release. The buzzer and an LED will produce a series of beeps and pauses, which you must repeat. The face smiles and buzzer plays a tune if you are right. The sequences get longer and harder. How many levels can you get through?

Mode 8: Dice pattern

Authentic pattern dice using 7 LED's for dots. Chases and stops randomly on button press. Use where you would use a dice. Have more fun with dice games.

To use: Press button and release. Dice "spins" more and more slowly until it stops on a number shown by an authentic dice dot pattern.

Mode Table

Mode	**270 ohm**	**LEDs**
1	None	L1 to L6
2	R4 only	L1 to L6
3	R3 only	L1 to L6
4	R3 and R4	L1 to L6
5	R2 only	L2, L4, L8 to L12
6	R2 and R4	L2, L4, L8 to L12
7	R2 and R3	L2, L4, L8 to L12
8	R2, R3 and R4	L2 to L4, L7, L9 to L11

Construction Details

Step 1: Insert resistors

Insert 270 Ohm resistors to R1, R5 and R6.
Insert 270 Ohm resistors as per mode table.

Step 2: Insert diode

Insert diode to D1, taking note of polarity.

Step 3: Insert capacitor

Insert capacitor to C1.

Step 4: Insert IC socket

Insert 8 pin DIL socket to IC1 *(terminate with semi clinched terminations to the four corner leads only and do not cut the leads).*

Step 5: Insert LEDs

Insert Red LED's as per mode table taking note of polarity. Mount the LED's between 5 and 6 mm off the board.

Step 6: Insert battery holder wires

Insert battery holder wires to BAT taking note of +ve (red) and –ve polarity.
Cut the red and black wire provided to a suitable length (if in doubt just halve it)
Strip the ends to about 3 mm and twist the wire tightly to enable tidy insertion into the holes in the board without splaying.

Step 7: Solder in buzzer

Solder wires on the back of the piezo buzzer element - one wire to the gold section and one wire to the silver section. Solder the other ends of the wires to B1 on the board.

Step 8: Solder in switch

Solder wires on the switch terminals and the other ends to S1 on the board *(any way)*.

Step 9: Solder all components

Solder the rest of the components **once only**.

Step 10: Power board

Solder a wire across one battery holder compartment. Insert 3x AA Batteries.

Step 11: Insert IC chip

Insert the IC into the DIL socket, taking note of the position of the pin one indicator.

Step 12: Complete assembly

Attach the battery holder, set up and test the unit. If you have problems, check the instructions.

Project #1A – Assembly of Project

The project is assessed using the following assessment sheet. A grading of between excellent *(5)* and poor *(1)* is awarded for the specified items. A grade of less than good is unacceptable.

#	ITEM	Excellent	Very Good	Good	Fair	Poor
1	Selected correct components					
2	Located components correctly on board					
3	Codes all visible and correct orientation					
4	Polarity of components and leads					
	Sub Total					
	TOTAL /20					

Project #1B – Mounting and Soldering

The project is assessed using the following assessment sheet. A grading of between excellent *(5)* and poor *(1)* is awarded for the specified items. A grade of less than good is unacceptable.

#	ITEM	Excellent	Very Good	Good	Fair	Poor
1	Mounting / terminating 1/8 – 1/4 W resistors					
2	Mounting / terminating capacitors					
3	Mounting / terminating diodes / LED's					
4	Mounting / terminating transistors / IC's					
5	Mounting terminals / leads / switch / buzzer / batteries					
6	Soldering on the PCB					
7	Soldering terminals / leads					
8	Assembly cleanliness					
	Sub Total					
	TOTAL /40					

ASSESSMENT SHEET

Project #1C – The Final Presentation

The project is assessed using the following assessment sheet. A grading of between excellent *(5)* and poor *(1)* is awarded for the specified items. A grade of less than good is unacceptable.

#	ITEM	Excellent	Very Good	Good	Fair	Poor
1	Chosen suitable application for module					
2	Well designed					
3	Well made					
4	Interesting to use					
5	Adequate description/ instructions for use					
	Sub Total					
	TOTAL / 25					

ASSESSMENT SHEET

Project #1D – Work Practices During Unit

The project is assessed using the following assessment sheet. A grading of between excellent *(5)* and poor *(1)* is awarded for the specified items. A grade of less than good is unacceptable.

#	ITEM	Excellent	Very Good	Good	Fair	Poor
1	Cleaned up properly					
2	Cleaned sinks, bench and floor					
3	Returned equipment to correct place					
4	No damage to any equipment					
5	Worked cooperatively throughout the unit					
	Sub Total					
	TOTAL / 25					

Student Name: Due Date: / /

Project #1 – LEDFUN

Assessment Summary:

Solder Practice 1 ☐ 20 marks
Mounting and soldering wire links

Solder Practice 2 ☐ 10 marks
Desoldering wire links

Solder Practice 3 ☐ 40 marks
Bending, mounting, terminating, and soldering resistors.

Assemble Project # 1A – LEDFUN ☐ 20 marks
Properly located, correct components/wires with correct polarity.

Solder Project # 1B – LEDFUN ☐ 40 marks
Mounting and soldering components in the kit.

Final Project # 1C ☐ 25 marks
Use the circuit board to make a useful game/device.

Safe, sensible approach to work with handtools and solder # 1D ☐ 25 marks

Total ☐ **180 marks**