



Gurukul Technicals Institute

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FREE EBOOK

HARDWARE, NETWORKING AND REPAIR

Soldering for Beginners

Make strong, clean solder joints on wires and circuit boards

INSIDE THIS BOOK

- Soldering safety first
- Tools and materials
- Setting up your bench and tinning the tip
- Soldering through-hole parts step by step
- Good joints and bad joints
- ...and 5 more chapters, practice questions and a glossary

Beginner

Students of electronics, robotics and repair (with adult supervision for younger students)

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Soldering for Beginners

Learn to solder safely and well. You will set up a bench, tin the iron's tip, solder parts onto a circuit board, join wires with heat-shrink, tell good joints from bad ones, remove parts with wick and pump, try surface-mount parts and build a first LED project on a perfboard. Younger students should always work with an adult.

WHO IT IS FOR	Students of electronics, robotics and repair (with adult supervision for younger students)
LEVEL	Beginner
SUBJECT AREA	Hardware, networking and repair
WHAT IS INSIDE	10 chapters, practice questions with answers, and a glossary

HOW TO USE IT

Read one chapter at a time and try the examples as you go: on a computer, at your workbench or in your notebook. The boxes give tips, safety points and short activities. When you finish, test yourself with the practice questions and check your answers at the end. Words you may not know are explained in the glossary.



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What you will find inside

1	Soldering safety first	4
2	Tools and materials	6
3	Setting up your bench and tinning the tip	8
4	Soldering through-hole parts step by step	9
5	Good joints and bad joints	11
6	Joining wires and using heat-shrink	13
7	Desoldering with wick and pump	15
8	Surface-mount (SMD) basics	17
9	Your first project: an LED on a perfboard	19
10	Caring for your iron and troubleshooting	21
	Practice questions	23
	Answers	24
	Glossary	25

Soldering safety first

Soldering joins metal parts using a soft metal called **solder**, melted by a hot tool called a **soldering iron**. When the solder cools, it holds the parts together and lets electricity flow between them. Almost every electronic device, from a phone to a robot, is held together by solder joints.

Anyone can learn to solder. But the tip of the iron is far hotter than a cooking pan, so safety comes first, before you even switch on.

SAFETY

Students in middle school, and any beginner, should solder only with an adult or teacher watching. The adult should check the bench, the iron and the cable before the iron is switched on.

Burns

The tip of a soldering iron usually works at around 300 to 400 °C. Even after you switch it off, it stays hot enough to burn for several minutes.

- Hold the iron like a pen, by the **handle** only.
- Always put it back in its **stand** when it is not in your hand. Never lay it on the table.
- Never touch the tip or the metal shaft to see if it is hot.
- **Never try to catch a falling iron.** Step back and let it fall, then pick it up by the handle.
- Keep the cable away from the hot tip, because the tip can melt through its covering.
- Tie back long hair, and keep loose sleeves and dupattas away from the bench.

Eyes

Wear **safety glasses**. Melted solder can spit, and the cut-off leg of a part can fly up.

Fumes and ventilation

The smoke you see when soldering comes mainly from **flux**, a cleaning chemical inside the solder wire. It irritates the eyes, nose and throat, and breathing it day after day can cause breathing problems such as asthma.

- Work in a room with an open window or a fan.
- Use a small fan or a **fume extractor** (a fan with a filter) to draw the smoke away from your face.
- Do not lean straight over the joint.

Lead and washing hands

Some solder contains **lead**, a metal that is poisonous if it gets into your body. At soldering temperatures very little lead goes into the air; the danger is from lead on your hands reaching your mouth.

- Use **lead-free** solder where you can, especially in a school or at home.
- Never eat, drink or touch your face while soldering.
- **Wash your hands with soap and water** after every session.

Fire and the mains cable

Keep paper, plastic bags and cloth away from the iron. Work on a surface that heat cannot damage. The iron plugs into a wall socket, which is normal. But never open the iron, and never repair its cable or plug yourself; a damaged iron goes to an adult to be replaced.

REMEMBER

If you burn yourself, hold the burn under cool running water for 20 minutes and tell an adult. Do not put ice, butter or toothpaste on a burn. Large or deep burns need a doctor.

EXAMPLE

Before the first soldering class in a robotics lab in Jaipur, the teacher walks round every bench. She checks that each iron sits in a stand, that no cable crosses the front of the bench, that the windows are open and that every student has safety glasses on.

Tools and materials

You can start soldering with a few simple tools. You do not need costly ones.

The soldering iron

- A **pencil iron** is a simple iron with a fixed heat, often rated about 25 W to 35 W for electronics work. It is cheap and fine for learning.
- A **temperature-controlled iron** has a dial to set the tip temperature. It heats faster, keeps its heat better and makes good joints easier.
- A **soldering station** is a temperature-controlled iron with a separate base that holds the controls and often the stand.

The **tip** is the part that touches the work. A small **chisel tip**, shaped like a flat screwdriver, passes heat well and suits beginners. A **conical tip** has a fine point for small work.

The stand

A **stand** is a metal holder that keeps the hot iron safe between joints. Most stands have a tray for a **sponge** or a coil of **brass wool**, used to wipe the tip clean.

Solder wire

Solder for electronics is a thin wire with **flux** inside its core, called **flux-cored** or **rosin-core** solder. When the solder melts, the flux flows out first and cleans the metal so the solder can stick.

Type	What it contains	Melts at about
Tin-lead (60/40 or 63/37)	Tin and lead	183 to 190 °C
Lead-free	Mostly tin, with a little silver or copper	217 to 227 °C

Lead-free solder needs a slightly hotter iron and a little more patience, but it is the safer choice. A diameter of about 0.8 mm suits most work; thinner wire, such as 0.5 mm, is better for small parts.

SAFETY

Never use plumbing solder or acid flux on electronics. Acid keeps eating the metal and wrecks the circuit over time.

Flux

Extra **flux** comes as a paste, a liquid or a pen. A little flux helps when a joint is old, dull or hard to make. Some flux must be cleaned off afterwards; "no-clean" flux can be left.

Tools for removing solder

- **Desoldering wick**, also called braid: a flat strip of fine copper wires that soaks up melted solder.
- **Desoldering pump**, also called a solder sucker: a spring-loaded tube that sucks up melted solder.

Holding and cutting tools

Tool	Use
Helping hands	A stand with crocodile clips, often with a magnifier, to hold the work
Side cutters	Cut wire and trim the legs of parts
Wire stripper	Remove the plastic covering from wire
Tweezers	Hold small parts, especially surface-mount parts
Heat-shrink tubing	Plastic tube that shrinks with heat to cover joints

EXAMPLE

Kabir, a class 9 student in Lucknow, starts with a basic kit: a 25 W pencil iron with a stand, lead-free solder, a strip of wick, side cutters, a wire stripper and safety glasses. In this example the whole kit costs him about ! 700. He adds a temperature-controlled iron later, once he solders every week.

TRY THIS

Lay out your tools on the bench and name each one aloud with its use. Read the label on your solder wire and find out whether it is tin-lead or lead-free.

Setting up your bench and tinning the tip

Take five minutes to set up your bench before you switch on. A well-arranged bench is safer and easier to work at.

Setting up the bench

1. Choose a firm table near an open window or fan, with good light.
2. Put down a heat-proof mat, a ceramic tile or a thick wooden board.
3. Place the stand on the side of your writing hand, at the back of the bench, so you never reach across the hot iron.
4. Run the cable behind the bench, not across the front where an arm could catch it.
5. Dampen the sponge with a little water, then squeeze it. It should be damp, not dripping. A wet sponge cools the tip too much and makes the solder spit.
6. Put on your safety glasses.

Setting the temperature

On a temperature-controlled iron, a common starting point is about 320 to 350 °C for tin-lead solder and about 350 to 380 °C for lead-free. Follow the manual for your iron. Hotter is not better: too much heat burns the flux before it can work, damages parts and wears out the tip.

A pencil iron has no dial. Give it a few minutes to reach full heat; solder touched to the tip should melt at once.

Tinning the tip

Tinning means coating the tip with a thin, shiny layer of solder. A tinned tip passes heat into the joint quickly. A dry, black tip does not, however hot it is.

1. Switch on the iron and let it heat up fully.
2. Touch the end of the solder wire to the tip. It should melt and flow over the tip within a second.
3. Turn the iron slowly so the working end of the tip is coated all round.
4. Wipe the tip lightly on the damp sponge or poke it into the brass wool.

5. Look at it. A good tip is bright and silver. If it is still dull, add a little more solder and wipe again.

Do this when the iron is new, at the start of each session, and whenever the tip looks dull.

REMEMBER

Wipe, then tin, then work. Before every joint, wipe the tip clean. Before switching off, leave a small blob of solder on the tip. The blob protects it from the air while it cools.

Brass wool or sponge

Brass wool cleans the tip without cooling it and does not spit, so many people prefer it. A damp sponge works well too. Do not use plain steel wool or sandpaper, which scratch away the tip's protective coating.

EXAMPLE

Priyanka, in Bhopal, cannot get her solder to stick to anything. Her tip is black. Her teacher shows her how to melt fresh solder onto it and wipe it on brass wool, repeating until the tip turns silver. After that, every joint flows easily.

TRY THIS

Tin the tip of your iron, then let it sit in the stand for five minutes without wiping. Look at the colour. Wipe and re-tin it, and notice how quickly a dull tip becomes bright again.

CHAPTER 4

Soldering through-hole parts step by step

Most parts in kits are **through-hole** parts: their wire legs, called **leads**, go through holes in a circuit board. On the underside, each hole has a ring of copper called a **pad**. A good joint joins the lead and the pad into one solid, shiny piece.

Preparing

1. Make sure the pads and leads are clean and bright. Old, dull parts may need a dab of flux.
2. Push the part through its holes from the top of the board, the side without copper on most simple boards.
3. Bend each lead slightly outwards underneath, so the part does not fall out when you turn the board over.
4. Turn the board over and hold it in the helping hands, pads facing up.

Making the joint

The secret is to **heat the joint, then feed in the solder**. The pad and the lead must both be hot enough to melt the solder by themselves.

1. **Wipe the tip** on the sponge or brass wool.
2. **Touch the tip** so it presses against the pad and the lead together. Hold it there for about one to two seconds.
3. **Feed solder** into the joint, on the side opposite the tip, where the lead meets the pad. Do not melt it on the tip and drip it on.
4. Let just enough solder flow to cover the pad and climb a little up the lead. This takes about a second.
5. **Take the solder away first**, then lift the iron straight up a moment later.
6. **Keep still**. Do not move the board or the part for a few seconds while the solder hardens.

The whole joint takes about three to four seconds.

Trimming the leads

When the joint has cooled, cut the spare length of the lead just above the top of the joint with side cutters. Hold the free end, or cover it with a finger, so it does not fly into someone's eye.

SAFETY

Cut-off ends are sharp and fly a long way. Wear safety glasses and point the cutters down, at the bench, away from people.

Which order to solder

Solder the lowest parts first, such as resistors and diodes, then taller ones like capacitors and LEDs, and connectors last. Each part then rests flat on the board while you work.

Some parts, such as LEDs, transistors and chips, can be damaged by too much heat. Make their joints quickly, and if a part has several legs, let it cool for a few seconds between them.

EXAMPLE

Imran is soldering resistors onto a practice board in Patna. His first joints look like grey lumps because he melted the solder on the tip and carried it to the board. When he heats the pad and lead first and feeds solder into the joint, the solder flows into neat, shiny cones.

TIP

Count quietly: "One, two" with the tip on the joint, "three" while you feed solder, "four" as you lift the iron. Counting stops you from hurrying or overheating.

TRY THIS

On a scrap board, solder ten resistors in a row. Number each joint and judge it using the next chapter. Your tenth joint should look far better than your first.

CHAPTER 5

Good joints and bad joints

Looking carefully at your joints, with a magnifier and good light, is the fastest way to improve.

What a good joint looks like

- The solder is **smooth** and **shiny**. Lead-free solder looks a little duller, like satin, and that is normal.
- It is shaped like a small **cone** or **volcano**, with sides that curve inwards.

- It covers the whole pad and joins it smoothly to the lead.
- You can still see the shape of the lead inside the solder.

When solder flows smoothly over a metal and sticks to it, we say it has **wetted** the metal. A good joint is well wetted on both the pad and the lead.

Common faults

Fault	What it looks like	Cause	Fix
Cold joint	Dull, grey, grainy or lumpy	Not enough heat; solder did not flow	Reheat with a touch of flux
Disturbed joint	Frosty or cracked surface	Part moved while the solder cooled	Reheat and keep still
Too much solder	A big round ball	Fed in too much solder	Remove some with wick
Too little solder	Pad not fully covered, gap round the lead	Stopped feeding too soon	Add a little solder
Solder bridge	Solder joining two pads	Too much solder, pads close together	Drag the tip between pads, or use wick
Not wetted	Solder sits as a ball on the lead, not on the pad	Pad dirty or not heated	Clean, add flux, heat the pad
Overheated	Brown burnt flux, pad lifting off	Iron held on too long	Work faster; ask for help with a lifted pad

A **cold joint** is one of the most common faults. It may work at first and then fail when the device is shaken or warms up. Faults that come and go are often cold joints.

A **solder bridge** is dangerous for a circuit because it joins two points that should be separate. It can make a part work wrongly or short a battery.

A **lifted pad** is a pad whose copper has peeled away from the board after too much heat or force. It can sometimes be repaired with a small wire, but it is better avoided.

REMEMBER

A joint that looks right usually is right. A joint that looks wrong is wrong, even if the circuit happens to work today.

DID YOU KNOW

Electronics factories follow written standards that show, with pictures, what an acceptable joint looks like. Inspectors judge a joint by its shape, just as you are learning to do, because the shape shows how well the solder wetted the metal.

EXAMPLE

Anjali's line follower robot in Pune works on the table but stops when it bumps into a wall. Under a magnifier she finds a dull, grainy joint on one motor wire. She reheats it with a little flux until it flows smooth and shiny, and the robot keeps running even after bumps.

TRY THIS

Swap practice boards with a friend. Find one example of each fault in the table on each other's boards, then repair it together.

CHAPTER 6

Joining wires and using heat-shrink

Robots, battery packs and repairs all need wires joined to each other or to switches, motors and battery leads. A soldered wire joint, covered with heat-shrink, is strong and neat.

Stripping and tinning a wire

1. Strip about 5 to 10 mm of plastic covering from the end of each wire, using the right hole of the wire stripper so the copper strands are not cut.
2. Twist the strands of each wire tightly together.
3. **Tin** each wire: hold the hot tip under the twisted strands and touch solder to the top. The solder soaks into the strands. Stop as soon as they are coated; a tinned wire should still look like wire, not like a blob.

Joining two wires

1. **Slide on the heat-shrink first.** Cut a piece about 2 to 3 cm long and push it onto one wire, well away from the joint, so the heat does not shrink it early.
2. Bend each tinned end into a small hook. Hook them together and squeeze them closed with pliers.
3. Hold the wires in the helping hands. Heat the joint and feed in a little solder until it flows through both wires.
4. Let it cool without moving.
5. Slide the heat-shrink over the joint so it covers all the bare metal.

Shrinking the tube

Heat-shrink tubing is plastic tube that shrinks when heated. Many kinds shrink to about half their width. Choose a size that slides easily over the joint but becomes tight after shrinking.

Use a **hot-air gun**, which blows very hot air, and keep it moving all round the tube until it grips the joint. An adult should supervise this, because the gun's nozzle and the air both get very hot. Do not use a matchstick or lighter flame, which can burn the tube and the wire.

SAFETY

Hot-air guns and freshly shrunk tube stay hot for some time. Put the gun down only on its stand or a heat-proof surface, nozzle away from you.

Soldering a wire to a terminal

To join a wire to a switch, a motor or a battery holder:

1. Tin the wire and tin the terminal.
2. Pass the wire through the hole in the terminal, or hold it against it.
3. Touch the iron to both for a moment until the solder melts and joins them.

Work quickly on motors and switches. Their plastic parts can melt if you hold the iron there too long.

TIP

Do not tin the ends of wires that go into **screw terminals**. Solder slowly squashes under the pressure of the screw, and the connection can work loose. Twist the strands neatly instead.

EXAMPLE

Harsh is wiring a battery holder to a switch for his robot car in Indore. He slips heat-shrink onto the red wire, tins both wires and the switch terminal, solders the joint, and shrinks the tube with a hot-air gun while his father watches. The joint is strong and no copper shows.

TRY THIS

Join two pieces of wire end to end, cover the joint with heat-shrink, and then pull the two ends firmly. A good joint does not move.

CHAPTER 7

Desoldering with wick and pump

Desoldering means removing solder so you can take out a part, fix a bad joint or clear a hole. Everyone needs to desolder sometimes, so practise it on scrap boards.

Using desoldering wick

Wick is a flat braid of fine copper wire, usually soaked in flux. Melted solder is pulled up into the braid, much as water soaks into a cloth.

1. Choose wick about as wide as the pad.
2. Lay the end of the wick flat on the joint.
3. Press the hot tip on top of the wick, over the joint.
4. Wait a second or two. The solder melts and flows into the braid, which turns silver.
5. Lift the iron and the wick away **together**. If you lift the iron first, the wick can stick to the board as the solder cools.
6. Cut off the used, silver part of the wick and throw it away.

SAFETY

Wick gets just as hot as the iron. Hold it by its plastic holder or a long free end, never close to the joint.

Using a desoldering pump

A **desoldering pump** is a tube with a spring-loaded plunger and a heat-resistant nozzle.

1. Push the plunger down until it locks.
2. Heat the joint with the iron until the solder melts.
3. Bring the nozzle right up to the melted solder, moving the iron aside just enough to make room.
4. Press the release button. The plunger springs back and sucks up the solder.
5. Push the plunger again over a bin to empty the pump.

If some solder remains, add a little fresh solder and try again. Fresh solder mixed with the old helps it melt and flow.

Removing a part

When every joint is clear, the part should come out with a gentle push or pull. **Never force it.** If it sticks, a joint still holds it; clean that joint again. Pulling hard tears the pads off the board.

For a two-legged part, another way is to heat one joint and gently rock the part, then heat the other joint and rock it back, a little at a time.

TIP

If a part is already dead, cut its legs on the top of the board first. Then remove each leg separately from below. This protects the pads, because you never have to heat several joints at once.

REMEMBER

Wick is best for cleaning flat pads and removing small amounts of solder. A pump is best for clearing holes. Many technicians use both on the same job.

EXAMPLE

Deepa, a mobile repair student in Kochi, practises on an old radio board. She removes ten resistors with the pump and wick. After cleaning each hole, she fits new resistors in the same place, proving the pads were not damaged.

TRY THIS

On a scrap board, remove three parts using only wick, then three using only the pump. Which was faster, and which left cleaner pads?

CHAPTER 8

Surface-mount (SMD) basics

Look inside a mobile phone and you will see hundreds of tiny parts with no wire legs at all. These are **surface-mount devices**, or **SMD** parts. They sit on flat pads on the surface of the board instead of going through holes.

SMD parts make devices small and light. They are harder to solder by hand, but the basics are easy to learn.

Sizes

Small SMD resistors and capacitors are named by size codes. Many of these codes come from inches: **1206** is about 3.2 mm × 1.6 mm, and **0805** is about 2.0 mm × 1.25 mm. Phone boards use far smaller sizes. Beginners should start with 1206 or 0805 parts on a practice board.

Reading an SMD resistor

Many SMD resistors carry a three-digit code. The first two digits are the value and the third is the number of zeros. An **R** marks a decimal point.

Code	Value
103	10 followed by three zeros = 10,000 Ω (10 kΩ)
472	47 followed by two zeros = 4,700 Ω (4.7 kΩ)

Code	Value
4R7	4.7 Ω

Tools for SMD work

- A fine conical tip or a small chisel tip
- Fine-pointed tweezers
- Thin solder, about 0.5 mm or less
- Flux, which matters even more on tiny joints
- A magnifier or a bright lamp with a magnifying lens

Soldering a two-pad part

1. Add a little flux to both pads.
2. Melt a small amount of solder onto **one** pad only.
3. Hold the part with tweezers so it lies across both pads.
4. Touch the iron to the tinned pad. The solder melts and the part's end settles into it. Take the iron away and keep holding the part still for a moment.
5. Check that the part is straight. If not, reheat that pad and adjust it.
6. Solder the other end in the normal way: tip on the pad and the part's end, then feed a little solder.
7. If the first end looks poor, touch it again with a little fresh solder.

Chips with many legs

For a chip with many legs, the same idea works. Tack down two legs at opposite corners, check that every leg sits on its pad, then solder the rest one by one. Any bridges between legs can be cleared with wick and flux.

DID YOU KNOW

Phone repair technicians often use a **hot-air station**, a tool that blows air hot enough to melt solder under a chip. Hot air can burn skin and blow tiny parts away, so it is an advanced skill learnt under a trained teacher.

SAFETY

Tiny parts get very hot and stay hot. Use tweezers, never fingers, and keep your face back from the joint.

EXAMPLE

Sameer, in a mobile repair class in Hyderabad, practises with 0805 resistors on a practice board. At first the parts stick to his iron and jump away. Once he tins only one pad first and holds the part with tweezers, he places twenty resistors neatly in an hour.

CHAPTER 9

Your first project: an LED on a perfboard

Now put your skills together. You will build a small circuit that lights an LED from a 9 V battery, on a **perfboard**: a board full of holes with a separate copper pad round each hole. Because the pads are separate, you make the connections yourself, using the parts' own leads and solder.

SAFETY

This project uses only a 9 V battery. Ask an adult to supervise the soldering. Never connect anything in this project to the mains.

Parts

Part	Details
Perfboard	A small piece, about 5 cm × 5 cm
LED	One red LED, 5 mm
Resistor	470 Ω , ¼ W (yellow, violet, brown, gold)
Battery	9 V battery with a snap connector (red and black wires)
Switch (optional)	A small slide switch

Why 470 Ω ?

An LED must have a resistor in series, or too much current flows and the LED burns out. A red LED needs about 2 V, so about 7 V is left across the resistor. Current = voltage $\div$ resistance = $7 \div 470$, which is about 0.015 A or 15 mA. That is a safe current for a standard 5 mm LED.

The circuit in words

Battery positive $\rightarrow$ (switch) $\rightarrow$ resistor $\rightarrow$ LED long leg (**anode**) $\rightarrow$ LED short leg (**cathode**) $\rightarrow$ battery negative.

The LED's cathode side usually has a **flat edge** on its rim, and its leg is shorter.

Building it

1. **Plan the layout.** Draw it in your notebook first. The resistor and LED go on the plain side of the board, with the resistor's right-hand lead in the hole next to the LED's long leg.
2. **Solder the resistor.** Push it through, bend the leads outwards and solder both joints. Do not trim the leads yet.
3. **Solder the LED.** Push it through with the long leg in the hole next to the resistor's right-hand lead. Solder it quickly, because LEDs dislike heat.
4. **Join the resistor to the LED.** Underneath, bend the resistor's right-hand lead flat against the LED's long leg, solder them together and trim the spare ends.
5. **Add the battery snap.** Tin the wire ends. For strength, thread both wires down through one spare hole and up through another, so a pull on the wires does not reach the joints. Push the red wire's end through the hole next to the resistor's left-hand lead, bend the lead against it underneath, solder and trim. Join the black wire to the LED's short leg in the same way. If you use a switch, cut the red wire and solder the switch between the two ends, with heat-shrink over each joint.
6. **Inspect.** Check every joint with a magnifier. Look for bridges between neighbouring pads.
7. **Test.** Clip on the battery. The LED should light.

If it does not light

Check	How
LED the wrong way round	Look at the flat edge and the leg lengths
A bad joint	Look again with a magnifier; reheat dull joints
A broken path	Use a multimeter's continuity test along each connection
Flat battery	Measure it with a multimeter

EXAMPLE

Neha builds the project in Kolkata. In this example her parts cost about ₹ 40, not counting the battery; prices in your area will differ. Her LED stays dark at first. She finds the LED's flat edge on the wrong side, desolders it with wick, turns it round, and it lights at once.

TRY THIS

Add a second LED of another colour with its own 470 Ω resistor, joined to the same battery wires. Both should light together.

CHAPTER 10

Caring for your iron and troubleshooting

A well-cared-for iron and tip last a long time and make every joint easier. A neglected tip turns black, refuses solder and must be replaced.

Daily care

- **Keep the tip tinned.** A thin coat of solder protects it from the air. A bare tip at full heat goes black quickly.
- **Wipe often,** on a damp sponge or in brass wool, before each joint.
- **Turn the iron off or down** during breaks. Tips wear out fastest when they sit hot with nothing to do.
- **Leave a blob of solder** on the tip when you switch off.

- **Let it cool in the stand** before you put it away.

Things never to do

- Do not file or sand the tip. Most tips have a thin protective coating, and once it is scraped off, the tip soon wears away.
- Do not use the tip as a lever or a screwdriver.
- Do not press hard on a joint. Heat flows through the solder on the tip, not through force.
- Do not tap the iron on the bench to knock off solder; wipe it instead.
- Do not change a tip while it is hot unless the iron's manual says how.

Reviving a black tip

If a tip is black and solder will not stick, heat it, rub it in brass wool, and at once melt fresh flux-cored solder onto it. Repeat a few times. A small tin of **tip tinner**, a paste made for this job, works even better. If nothing helps, the tip needs replacing.

Checking the cable

Before each session, look along the iron's cable. If the covering is melted, cut or cracked, do not use the iron. Give it to an adult. Never tape or repair it.

Troubleshooting

Problem	Likely cause	What to do
Solder will not melt or stick to the tip	Iron not hot enough, or tip black	Wait for full heat; brass wool, fresh solder or tip tinner
Solder balls up and rolls off	Pad dirty or not heated	Add flux; heat the pad and lead together
Joints dull and grainy, or the circuit fails when tapped	Cold or cracked joints	Inspect with a magnifier; reheat with a touch of flux
Solder joins neighbouring pads	Too much solder	Drag the tip between pads; use wick
Pad peels off the board	Too much heat or force	Shorter heating; ask your teacher about repair

Problem	Likely cause	What to do
Solder spits	Sponge too wet	Squeeze the sponge out more
Heat-shrink shrank too early	Placed too near the joint	Slide it further away next time
LED dead after soldering	Overheated or fitted backwards	Check the direction; solder faster next time

REMEMBER

Most soldering problems come from a dirty tip, too little heat or too little patience. Wipe, tin, heat the joint, feed the solder, keep still.

EXAMPLE

Vikram looks after the soldering bench in a school lab in Mysuru. Each Friday he checks every cable, re-tins every tip, squeezes out every sponge and replaces any wick that is used up. In a whole term, not one iron needs a new tip.

CHECK YOURSELF

Practice questions

1. Why should you never try to catch a falling soldering iron?
2. What mainly causes the smoke when you solder, and how do you protect yourself from it?
3. Why must you wash your hands after soldering?
4. What is the first aid for a small burn from a soldering iron?
5. What does the flux inside solder wire do?
6. Why does lead-free solder need a slightly hotter iron?
7. Why should the sponge be damp and not wet?
8. What does tinning the tip mean, and why is it done?
9. In a through-hole joint, what two things must the tip touch at once?

10. Where should you feed the solder: onto the tip or into the joint?
11. Which do you take away first, the solder or the iron?
12. Describe a good solder joint.
13. What does a cold joint look like, and how do you fix it?
14. What is a solder bridge, and how can you remove it?
15. When joining two wires, why must you slide on the heat-shrink first?
16. Why should you not tin wire ends that go into screw terminals?
17. Why must you lift the iron and the wick away together?
18. What is the value of an SMD resistor marked 472?
19. In what order do you solder a two-pad SMD part?
20. Why does the LED in the first project need a 470 Ω resistor?
21. How can you tell an LED's cathode?

ANSWER KEY

Answers

1. The tip and shaft are hot enough to burn badly; stepping back and letting it fall is safer.
2. Mainly the flux. Work with an open window or fan, draw the smoke away and do not lean over the joint.
3. Solder may contain lead, which is poisonous if it reaches your mouth from your hands.
4. Hold it under cool running water for 20 minutes and tell an adult; never use ice, butter or toothpaste.
5. It cleans the metal as the solder melts, so the solder can flow and stick.
6. It melts at a higher temperature, about 217 to 227 °C, compared with about 183 to 190 °C for tin-lead.
7. A wet sponge cools the tip too much and makes the solder spit.
8. Coating the tip with a thin layer of solder; a tinned tip passes heat into the joint quickly.
9. The copper pad and the lead of the part.

10. Into the joint, on the side opposite the tip.
11. The solder first, then the iron a moment later.
12. Smooth and shiny (satin for lead-free), shaped like a small cone with inward-curving sides, covering the whole pad, with the lead's outline visible.
13. It is dull, grey, grainy or lumpy. Reheat it with a touch of flux until the solder flows smoothly.
14. Solder that joins two pads that should be separate. Drag the tip between the pads or soak up the extra with wick.
15. Once the wires are soldered, the tube cannot be fitted over the ends.
16. Solder slowly squashes under the screw's pressure, so the connection can work loose.
17. If the iron is lifted first, the solder cools and the wick sticks to the board.
18. 47 followed by two zeros: 4,700 Ω , or 4.7 k Ω .
19. Tin one pad, place the part and reheat that pad to fix it, then solder the other end, then touch up the first end if needed.
20. To limit the current: about $(9 - 2) \div 470 = 0.015$ A, or 15 mA, which is safe for the LED.
21. Its leg is shorter and the rim has a flat edge on that side.

WORD LIST

Glossary

Anode

the positive leg of an LED or diode.

Cathode

the negative leg of an LED or diode, often marked by a flat edge or band.

Chisel tip

a soldering tip shaped like a flat screwdriver.

Cold joint

a dull, grainy joint where the solder did not flow properly.

Desoldering

removing solder to take out a part or fix a joint.

Desoldering pump

a spring-loaded tool that sucks up melted solder.

Flux

a chemical that cleans metal so solder can flow and stick.

Fume extractor

a fan with a filter that draws soldering smoke away.

Heat-shrink tubing

plastic tube that shrinks when heated, used to cover joints.

Lead

a wire leg of an electronic part; also a poisonous metal found in some solder.

Lifted pad

a copper pad that has peeled away from a board.

Pad

a small area of copper on a circuit board where a part is soldered.

Perfboard

a board with holes, each with its own separate copper pad.

SMD

surface-mount device, a part soldered onto pads on the surface of a board.

Solder

a soft metal that melts at a low temperature to join metal parts.

Solder bridge

solder that joins two pads that should be separate.

Soldering iron

a hand tool with a hot tip used to melt solder.

Soldering station

a temperature-controlled iron with a separate control base.

Through-hole

a part whose leads go through holes in the board.

Tinning

coating a tip or a wire with a thin layer of solder.

Tip tinner

a paste used to clean and re-tin a blackened tip.

Wetting

solder flowing smoothly over a metal and sticking to it.

Wick

a copper braid that soaks up melted solder.



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