THE BOOK OF -COSPLAY LIGHTS-

GETTING STARTED WITH LEDS

BY SVETLANA QUINDT

Author
SVETLANA QUINDT

DEAR READER,

Welcome to my fourth book and thank you for supporting my work with your purchase! It means a lot to me! I also want to say thank you for staying with me for so long. Four books already, wow! If you followed my entire series up to this point you've already read about how to create bad-ass looking cosplay armor with Worbla, how to paint your finished pieces to make them look real as well as building props and weapons for your costumes. But maybe you've already asked yourself: What will I do when it's getting really dark at a convention? So dark that people cannot even see all that hard work you've put into creating your outfit anymore. Do not worry! There is a way to help you.

Let me *illuminate* the possibilities!

Since I live in a country where days in winter don't get more than what feels like about 2-3 hours of sunlight, I was forced to find ways to make my costume look cool even during the evening. LEDs are the perfect way to achieve that! Maybe you want your gems to shine, maybe you want to have glowing eyes, or an illuminated blade – there are countless opportunities to improve your costumes with awesome lights! And despite the common fear that a lot of math and other formulas are required or that it's too complicated to wrap yourself in batteries, cables, switches and LEDs – I can assure you: It's really really simple. Believe me - if I had known how easy all this is, I would have dressed myself like a cosplay Christmas tree years ago! But I also understand that it can sound intimidating as well. When you search for LED tutorials online you always see many formulas, technical drawings and all that other complicated sounding stuff! Luckily, it's easier than it seems at first. I will try to explain all you need in a down-to-earth and understandable manner. My goal is not to sound smart, but for you to understand what is actually happening. Here we go!

Allow me to introduce myself:

I'm Svetlana Quindt or Kamui as most of you know me by and I come from the beautiful (if sunlight lacking) country of Germany. In 2003 I discovered cosplay as a truly wonderful and creative hobby. Since then I specialized in armor and prop making and made that my full time job. Many of you may have found this book through my tutorials which I love to share all over the Internet. Cosplay is a community that grows by sharing experiences from every member and because I learned so much from others, I want to give something back in return.

About this volume:

Cosplay is a quite a creative hobby, no question. You craft, you sew, you experiment, you cry, fail, but then succeed or just go completely crazy with one of your always way to ambitious projects - no matter if something explodes in your workspace or if your emotions go completely wild. As an artist you always search for the next challenge: When a new project is done - often after weeks upon weeks of hard work – and every problem is solved, you finally lean back in your chair, take a deep breath and put your legs up on the table. Then suddenly inspiration hits you square in the face and brings along new ideas, new challenges and new problems, ready to be solved all over again! It's an amazing feeling to be honest.

The reason why you've bought this book is probably because you want to enter the world of shiny things! Cool light effects like glowing gemstones, mystical pulsing blades or just the weird idea to cosplay a moving Christmas tree at the next con. And I can help you with that!

Luckily you're in for a treat! Experimenting with LEDs is super rewarding! Despite the fact that I was quite scared of trying out electronics and had to overcome years of fear of high-school physics and mathematics I am so glad that I've tried it out and so will you!

First a friendly reminder:

I'm not an engineer, nor a math teacher and I've never professionally studied what I'll explain to you here. I learned everything from tutorials and my own experiments. Like always, there is no right or wrong solution to your problems. It's my own way to build something and that's what I like to share with you. You will surely find something odd or even discover better solutions for the same problems as you progress with your own experiments, which is a great thing! Share your knowledge with the world and help the community to grow. That's what I try to do with every book!

And before we start: Note that this book is written for cosplayers. Or better, it's written for myself five years ago when I was scared of electronics and LEDs. This is not a full blown book on electronics theory; we're just going to use the basics (and trust me, anyone can learn them – I did, and you can, too!). I promise you to explain everything you need to know to turn your costume into a radiant pillar of light – not more or less. If you want to learn electrical engineering, grab a book about that! I just try to keep it simple, helpful and inspiring! So here we go!

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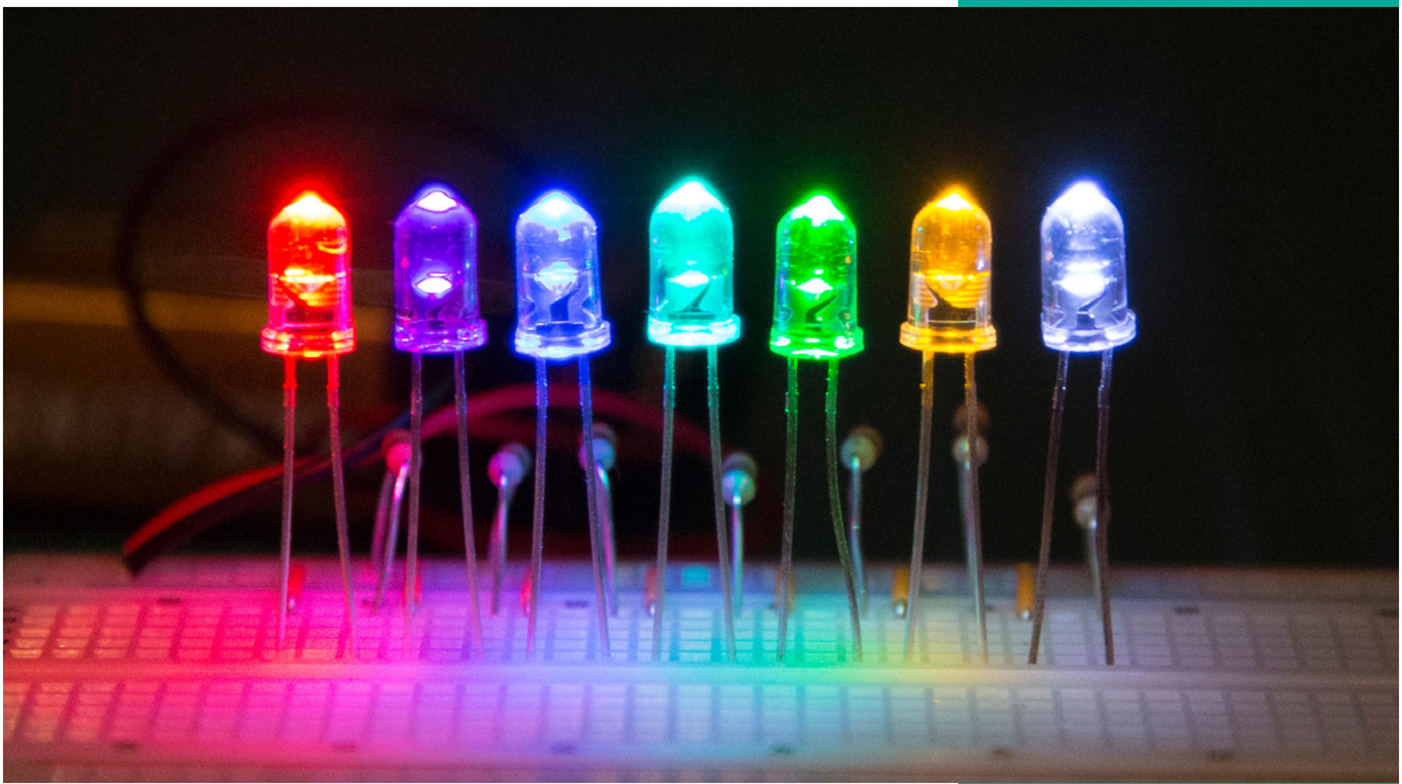
Content

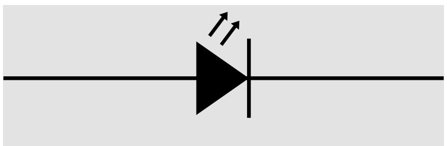
The wonderful world of LEDs

LEDs are everywhere: In traffic lights, in your TV remote, in your electric toothbrush. They tell you when your handheld is running low on battery, or shine green or blue to tell you that everything is okay. They also are in costumes! Like Worbla they sneak their way into more and more conventions and help making it all look more awesome at night! And hopefully when you're at the end of this book, you want to wrap yourself in a blinking and shining LED carpet. But first things first, what exactly are these so called LEDs?



What is an LED?

LEDs are electronic elements that transform electrical energy into light. Isn't that cool? LEDs or "ell-ee-dees" are in fact short for "Light Emitting Diode" and have the following symbol in most electronic schematics:



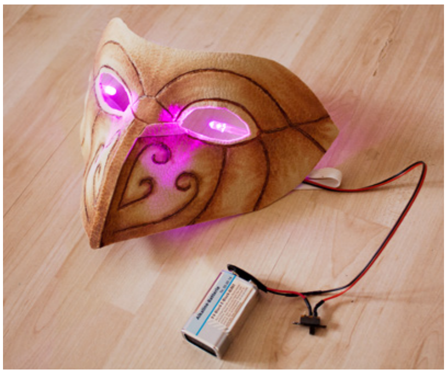
Unlike regular light bulbs, common LEDs require a lot less power and won't get hot since they are much more energy efficient. They can be extremely bright for their size and super easy to work with. So they're just perfect for all the fancy costume work we have in mind!

Note:

There are so many different LEDs, batteries, cables and switches that it all can seem a bit intimidating at first - but don't worry. We'll concentrate on what we really need to make shiny costumes and I promise you will love them by the end of my book. Just look how pretty they glow! So cute!

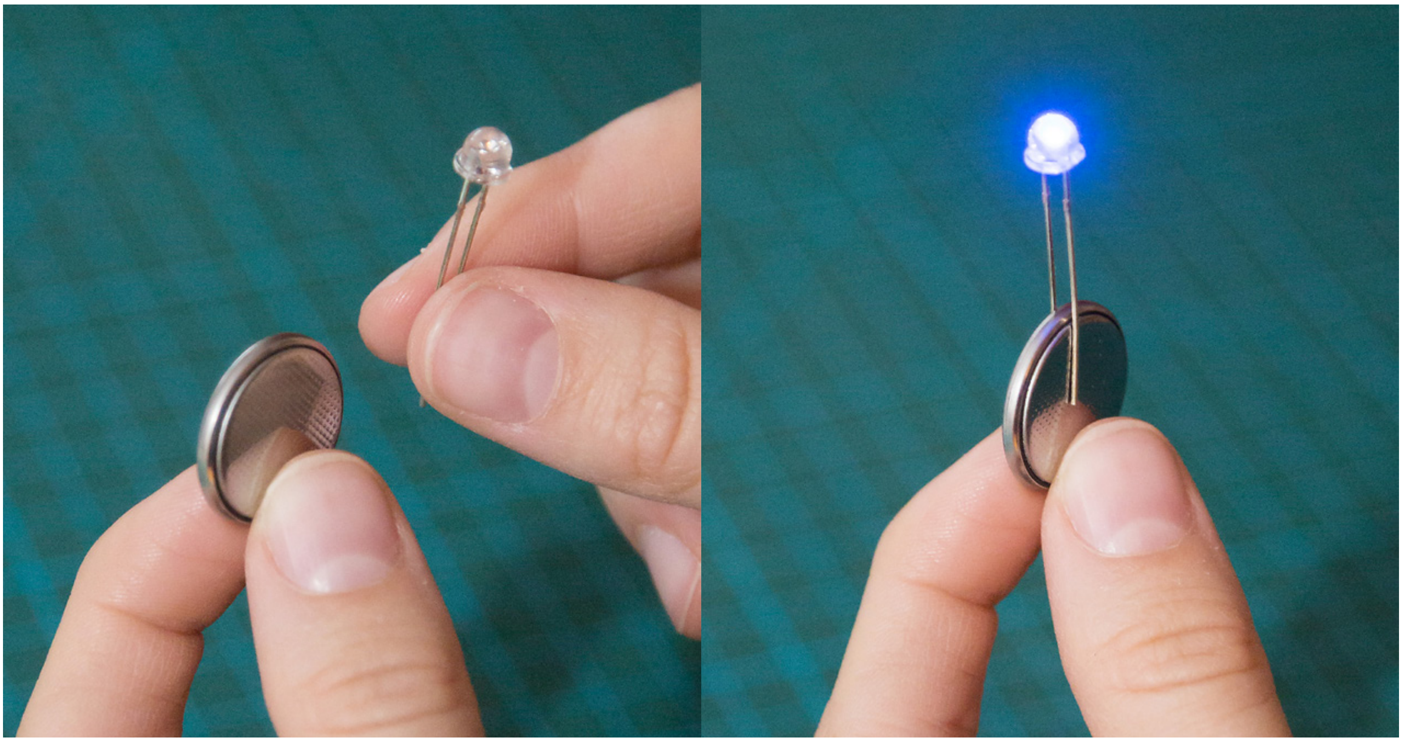
What to expect.

Electronics theory can get a little tricky, and the following pages will cover a few formulas, calculations, and some of the technical stuff you may remember from school. But don't worry, I'll keep it short and simple. Plus: Just keep in mind how cool LEDs are! There is not that much you need to learn, but the results of your new skills will be awesome! Be prepared to turn night into day!



Let us start at the beginning.

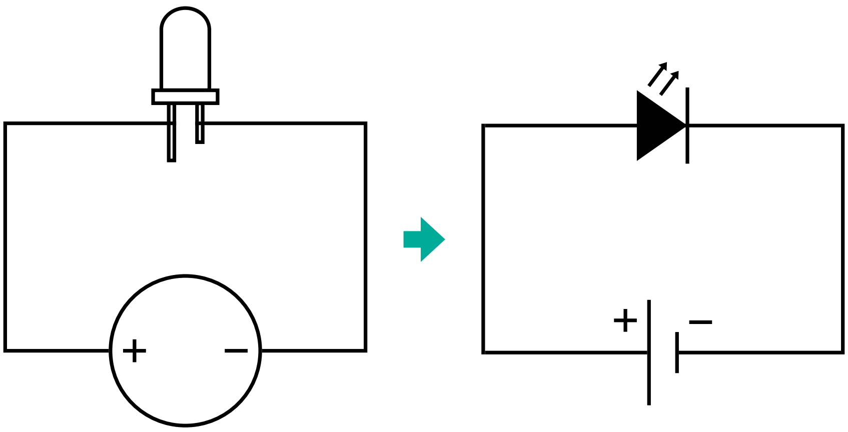
All you need to have a working circuit is a basic LED and a power source like a little 3V button cell battery - no wires, switches or even soldering is required yet. If you now simply slide the LED over the battery you'll notice it will immediately start glowing - how does it work?



To put it simply, the tiny legs of the LEDs each have a positive and a negative pole and so does the battery. If these poles get in contact with the corresponding poles of the battery, the electrical energy in the battery will start flowing trough the LED and light it up. It won't work the other direction however. Positive must always go to positive and negative must always go to negative. Poles like to stay together! So this is all you need to make a light glow. Now think about what you want to add to that. You want to make the circuit longer? Add longer wires. Want to turn the lights on and off? Add a switch! Wire will connect your parts and a soldering iron will „glue" it all together. And that's pretty much all you need!

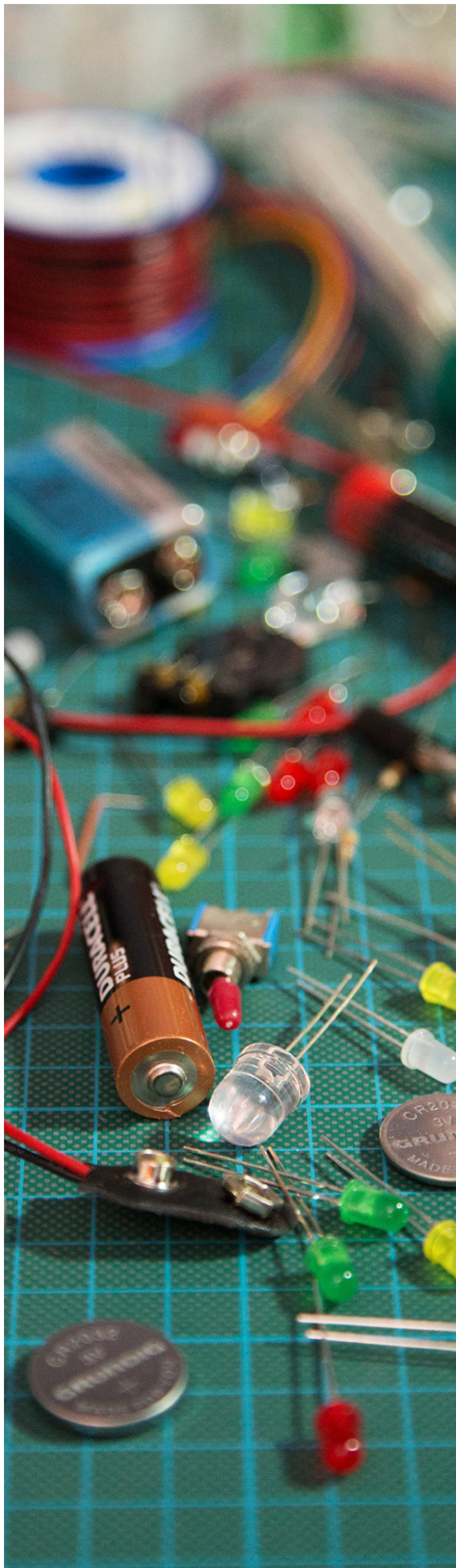
If we transform our super simple LED experiment from above to a circuit plan it would look a lot like the plan below (minus the cables of course).

As LEDs and batteries come in a nearly infinite variety of shapes and sizes, we simplify our drawings with a schematic circuit like this:



Of course there is a huge range of LEDs with different brightnesses, colors, sizes and shapes you can chose from. Luckily those you need are pretty easy to wire, very bright and compared to others pretty cheap. So they're perfect for our costumes!

How to tell which leg is positive and which is negative? If you look closely the legs have different lengths: The long one tells you it's for positive (called anode), the short one for negative (called cathode). Once you connect both legs to the right pole of the battery, the LED will light up. However don't be afraid. You won't damage the LED if you place it on the wrong pole - it just won't light up. So if your circuit doesn't work, the most common reason could be this problem. Once in a long while a LED will come along that does not have a long and a short leg. In that case Google is your friend to help you finding the poles.

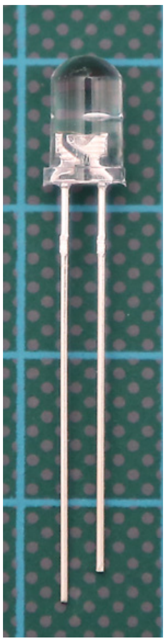


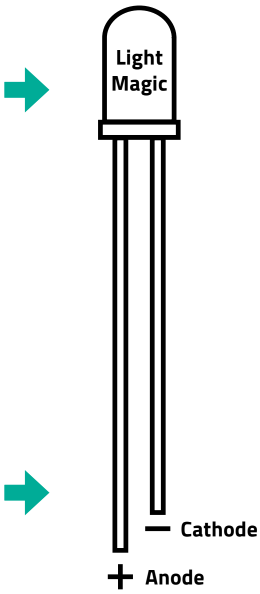
So try to remember:

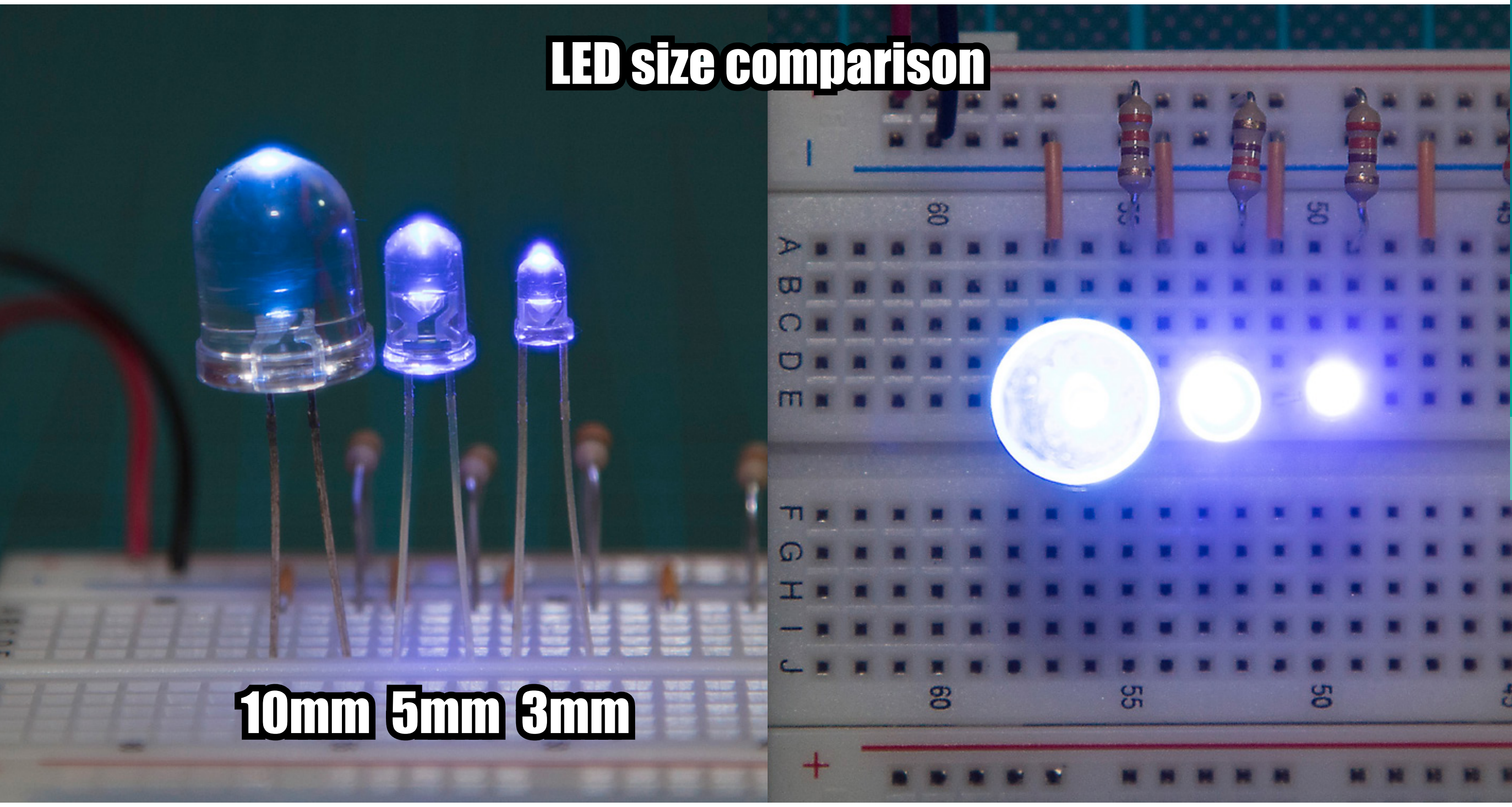
1. Know the poles! Short leg to negative and long leg to positive and you're good to go. LEDs allow energy to only flow into one direction. No power, no light. This also means that you can't break the LED if you're swapping the poles - it just won't light up.

2. More light needs more power! This means that brighter LEDs will drain your batteries faster, but also that you're able to control them by the amount of current that flows through. Give them less than required and the LED will glow not as bright as it could. This can be useful in many ways.

3. If you like your LEDs, don't grill them! LEDs are hungry, tiny things - like Gremlins! If you give one as much power as it wants, it will try to eat everything until it destroys itself. That's why it's important to limit the amount of energy flowing trough the LED – and we can easily do that with another component (more later). So keep in mind not feeding them too much. Especially after midnight.





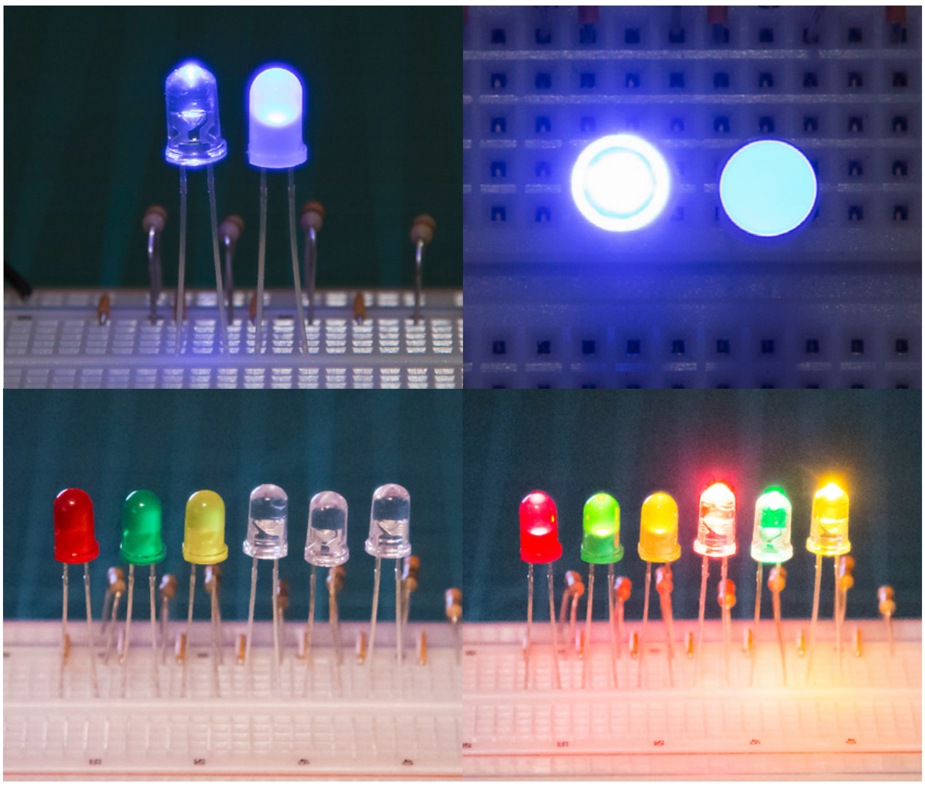


The most common sizes you'll find are 3mm, 5mm and 10mm. 3mm aren't as bright as 5mm, while 10mm are a bit rare to find and emit the same amount of light as a 5mm. It may be hard to see in pictures but let's try it either way.

Diffuse and clear LEDs

In addition you'll also find LEDs with clear and tinted glass. Imagine using them in a car. The clear-glass LEDs would be great to light up the street in front of you since they shine bright and strong, but only in one direction. Placed on the back of the car you would easily blind the driver behind you, so it's a better choice to use the colored-glass LEDs for the back. While they shine just as bright, they are diffuse, soft and spread the light to be seen well from any angle.

You can find LEDs in a huge variety of colors. Some of them are clear, some of them have tinted glass. Since colored glass actually absorbs some light, they won't be as bright as their clear counterparts and therefore are mostly diffuse. So think about which colors, brightnesses and sizes you need before you order your LEDs.



Note:

It's actually pretty easy to diffuse clear-glass LEDs with sanding paper. Just roughen the LED with a fine grid like 400 until the glass turns completely white. The better your sanding work is, the better the light spreads.

Now check the label!

Now that we know what kind of LEDs we may get, let's take a look at a label from a LED package I ordered from the Internet. There are a few units we need to get familiar with, before we can start soldering our own circuits.

As we can immediately see, the package contains ten diffuse blue 5mm LEDs. We already know what that means. So far so good, but what about the other numbers and letters?

Voltage (V)

The letter (V) stands for voltage. The LEDs in our package require 2.9 - 3.4V, which describes the range of voltage it needs to get its maximal brightness. With less V it won't be as bright or even won't light up. More V will give it a short bright burst of light until it pops and then is dead forever (like a Gremlin!). So the V on your LED tells you how much voltage your light needs and which battery is the best choice for your circuit.

Different colors of LEDs actually require a different amount of voltage. For this book however, let's keep it simple: Most common LEDs will work fine with a 3V power source, even red ones with a range of 2.1V – 2.4V. So all LEDs in this book will get 3V to keep circuits and calculations understandable.

Milli Ampere (mA)

The next measure you'll find is current, which is measured in (A) like ampere but described as (I) in physical formulas. On a battery the amount of ampere actually tells you how much energy is stored inside. Written in the description of the LED however, this number tells you just how hungry your little beast is. Since our lights require only small amounts of energy we mostly work in mA (milli-amperes). Keep in mind: 1A = 1000mA and 1mA = 0.001A.

Milli Candela (mcd)

As you'll notice, brightness is described by mcd or milli candela (to remember just think „milli candela" stands for „very tiny candle"). Usually a well sorted electronic shop can offer you LEDs in a brightness range from 10mcd up to 25.000 mcd (which is lot of tiny candles!). While white is shining really bright, it's hard to find other colors who pack the same punch. I would mostly recommend getting bright LEDs, because the chance of people noticing them during daylight is higher.

60° is the angle in which the light is visible. The bigger the angle, the better you can see the light from each side.

Explaining Voltage and Current

To understand how to light up an LED, it's necessary to know what electricity actually is. For that let's talk about voltage, charge and current. But don't worry, I'm also not a rocket scientist and won't try to turn you into one.
It's time for some theory!

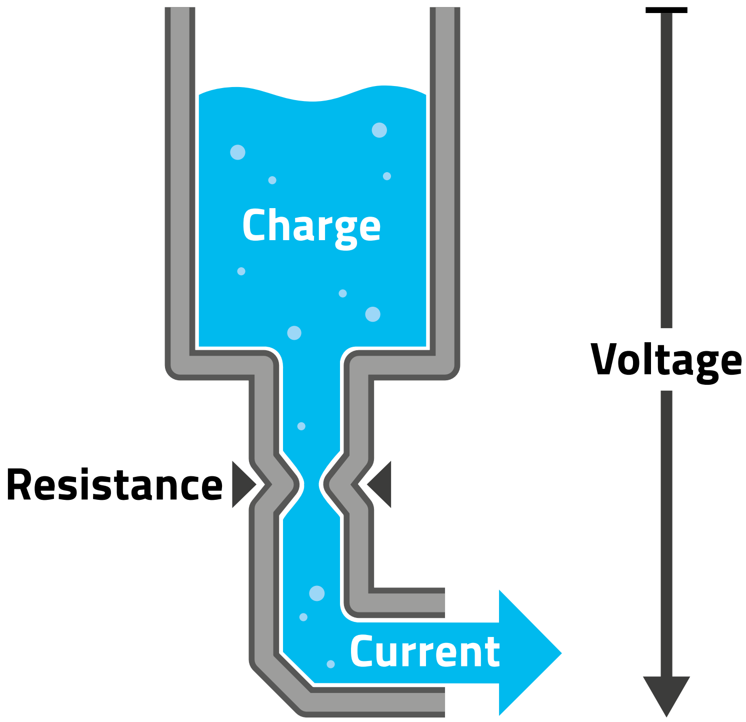
Electricity is the movement of electrons. Electrons are tiny things that run from one pole of your battery to the other while lighting up every LED they are passing on their way. Once you let them out of the battery they "do work" (as your physics teacher would say). By turning a switch for example, they start running. Once the very last electron hits the other pole your battery is empty.

To better visualize the process let's compare the battery to a water tank. The pressure at the end of the hose represents the voltage. The water inside the tank represents the charge. The more water is inside, the higher is the charge and the higher also is the pressure at the end of the pipe. More water also means a bigger tank (so a bigger battery).

If you are thirsty and drink a few cups, you'll have less water inside and the rest of it will flow slower since now the pressure is lower.

The amount of water running through the hose while you get your drink represents the current. You can reduce the amount of water flowing through the pipe by tightening it. You add resistance. In a circuit this job would be handled by a resistor.

So just remember:
Water = Charge
Pressure = Voltage
Flow = Current
Pipe Width = Resistance



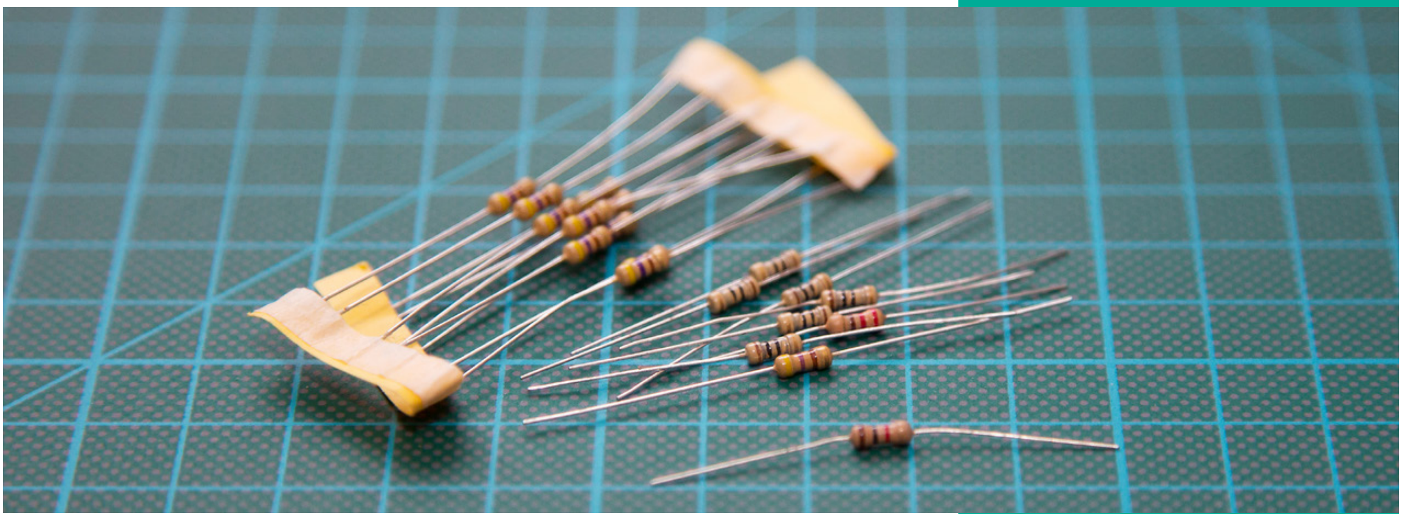
V = Voltage in Volts (V)

I = Current in Ampere (A)

R = Resistance in Ohm (Ω)

What are resistors?

What happens if you want to use one 3V LED, but with a 9V battery?
For that let me introduce you to the world of resistors!



Resistors are tiny, but nevertheless very important electronic parts. They may not look like much, but are in fact super useful. You could see them as guardians of the LEDs. Let's say you have one LED, but don't want to burn it in a circuit with a 9V battery, you can just use a resistor to get rid of the annoying 6V that you don't need. Unlike LEDs, resistors can "eat" different amounts of voltage. This is described by their amount of "Ohm" (like in "Ohmnomnomnom!"). But just like you when eating hot soup, they will get warm when they eat energy. Since we only work with small batteries the heat however is minimal. With the law of Ohm (the letter for Ohm is R like resistor) and a little bit of math it's even pretty easy not only to give your LED the exact amount of voltage it needs, but also to dim your lights by absorbing any unwanted energy.

The calculation - don't be scared - looks more complicated than it is:

$$\text{Resistance(Ohm)} = \frac{\text{Voltage}}{\text{Current}} \quad \text{or} \quad R = \frac{V}{I}$$

So if you have a 9V block battery and your LED is described with 3V and 20mA, your resistor needs to absorb 6V, since 9V (your battery) minus 3V (your LED) equals 6V. This now is the 6V we need for our calculation. (Remember: 20mA is 0.02A since 1000mA = 1A).

$$\text{Resistance(Ohm)} = \frac{6V}{0.02A} = 300\ \Omega\ \text{(Ohm)}$$

As you can see, we need to buy a 300 Ω (Ohm) resistor to eat the unnecessary 6V. If your calculated value is not available as a resistor it's okay to pick the next bigger size, which in this case would be 330 Ohm. Easy right?

Note:

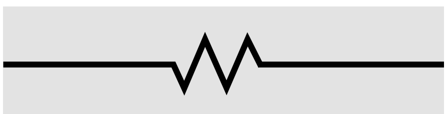
If you don't like this math formula (which is understandable) you can also just use an online resistor calculator. By searching for „LED resistor calculator" on Google you'll find many programs that should turn out to be great, helpful tools for all of your projects. There is also probably an App for that.

Many of these calculators even show you what the resistor you need looks like. In fact these colorful rings - small and sometimes hard to differentiate - tell you which resistor it is. These colors are a code that you'll find online or on the package of your resistors.

Note:

Keep in mind that when working with more power your resistors will also get hotter. In that case it's necessary to get resistors with a higher power rating. For our LED work however you don't need to worry about that.

The sign for resistors looks like this:



Current, voltage and resistance - so far so good!

To build a shiny circuit however it is also necessary to know how to give your LED enough power, how to turn it on and off and how to connect all of these lights with each other.

So let's dig a bit deeper and take a look inside a few costume pieces!

Safety Disclaimer:

In this book we only work with small 3V - 9V batteries. Please do not use bigger batteries before doing more research or consulting a professional. Safety always comes first.

Series Connections

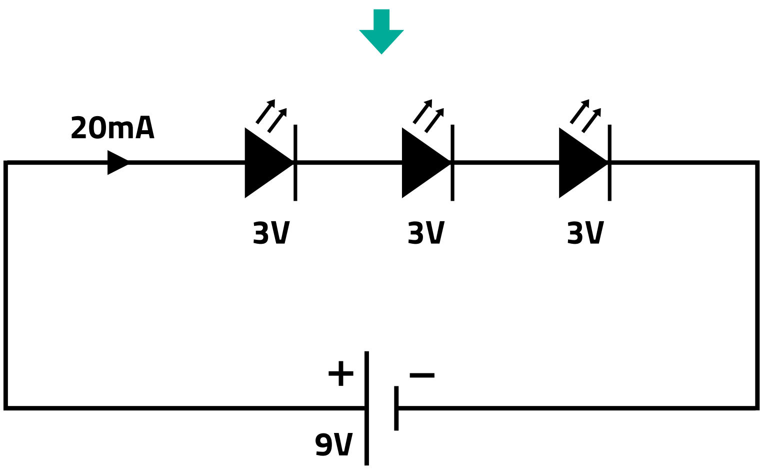
Back to our LED. It glows and while that's really cool, more lights would clearly be more awesome - right? We need more of them, so let's talk about Christmas lights!

Christmas lights are pretty, bright and make everybody happy. They are a great example to understand so called "series connections". In general, LEDs in Christmas lights are wired up one after the other, just like in a chain. The same electrical current flows from one pole of the battery trough every single LED back to the other pole. Since they are sharing the total voltage between each other, every LED has the same brightness. The total current however stays the same and is not split. Why? Well, that's a physical law thing.

So, remember:

$$V_{Battery} = V_{LED1} + V_{LED2} + V_{LED3}$$

$$I_{Battery} = I_{LED1} = I_{LED2} = I_{LED3}$$



Note:

The helmet of my Protoss Wizard costume is a good example for a series connection. Each glowing gemstone has one LED inside, which is soldered into a chain. All LEDs are powered by a single 9V battery, no resistors were required for this example. So the circuit is power efficient and easy to wire up – a simple circuit for many shiny projects.

Parallel Connections

Now, what's better than one Christmas light? Two Christmas lights! So once we plug a further light chain in the same multi-plug, we basically created a parallel connection.

Since we have doubled the amount of LEDs, we also draw double the current. In a parallel connection the amount of voltage stays the same, while the current grows with every additional chain of lights. Also a physical law thing. Cutting out a single LED from a series circuit would destroy the whole series but connected in parallel it's totally fine just to unplug one branch because the other will still be working fine.

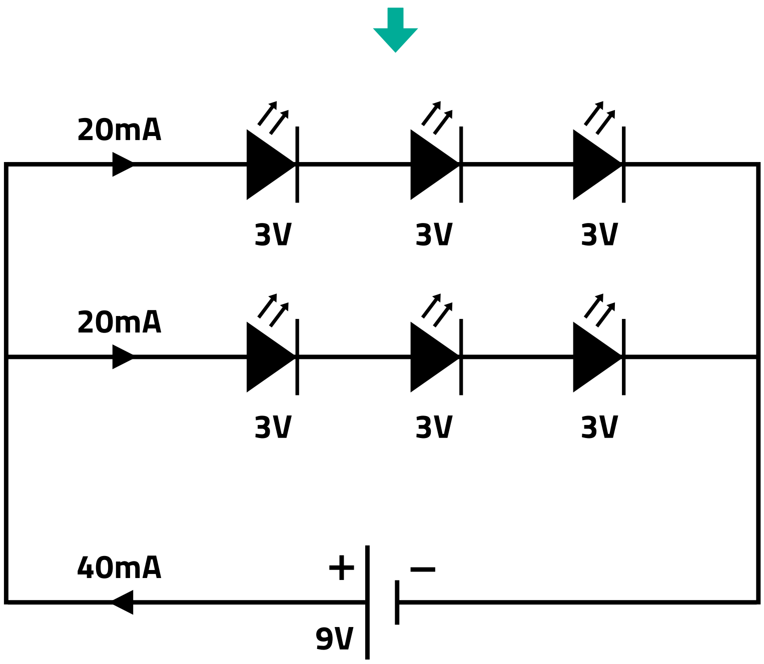
So, remember:

$$V_{Battery} = V_{LED1} = V_{LED2} = V_{LED3}$$

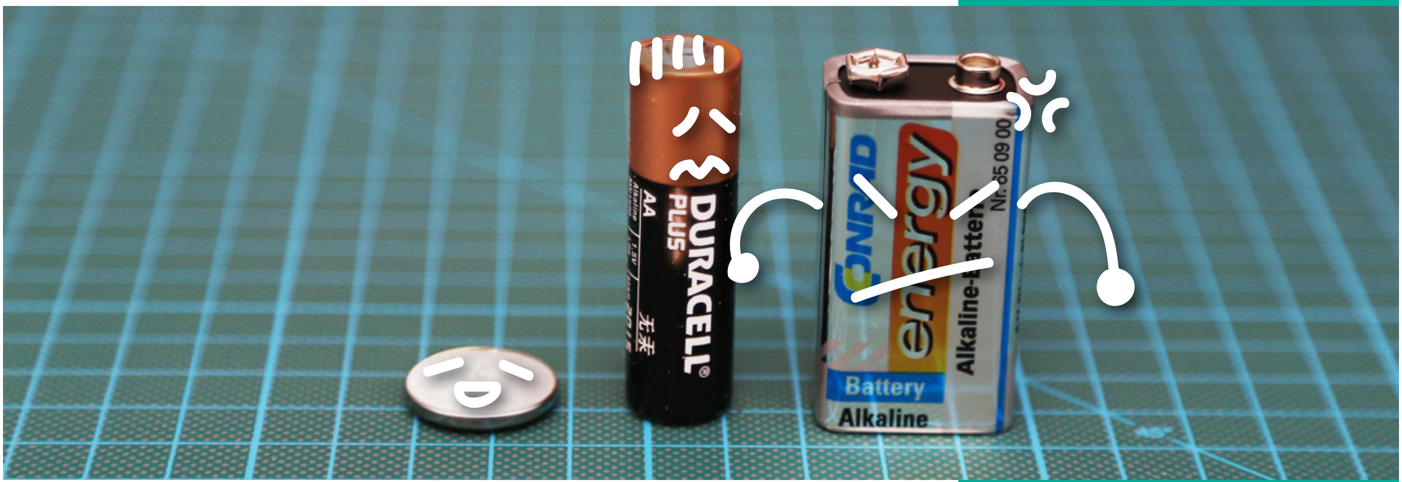
$$I_{Battery} = I_{LED1} + I_{LED2} + I_{LED3}$$

Note:

You already see, I like grabbing my Protoss Wizard costume for some examples. Another one is the breastplate with a parallel connection built in. The large gemstone carries 3 LEDs in its core, all in series while the other three stones are a further chain. Both branches together build a parallel circuit with six LEDs in total. The design is still pretty simple, but an easy way to add more and more lights if you need them.



Estimating Battery Time



So how long does a battery survive the feast? My 9V alkaline battery stores 550mAh of charge (that's milli-ampere-hours). There are many types of batteries and they all have different charges so check your label to know what you have. A circuit with 20mA (one LED) will only use 20mA per hour.

$$20\text{mA} \cdot 1\text{h} = 20\text{mAh}$$

The math you need to use to calculate the time is not that hard. It's this formula:

$$\frac{\text{mAh provided by battery}}{\text{total mA required by your LEDs}} = \text{Battery Lifespan (in h)}$$

If you apply your numbers to this formula you will find out that, if you let your LED run until the battery dies, you can watch your happy, shiny light for around 27 hours and 30 minutes.

$$\frac{550\text{mAh}}{20\text{mA}} = 27.5\text{h}$$

Let's apply the numbers of our parallel circuit example from the last page to see how it would last:

We have one 9V battery as well as two "branches" with three 3V (20mA) LEDs each.

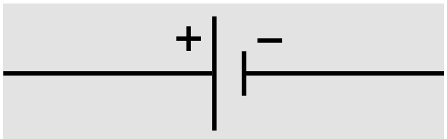
$$\frac{550\text{mAh}}{(2 \cdot 20\text{mA})} = 13.75\text{h}$$

Remember: Parallel connection means "current is added" so you need to take 20mA for every branch.

Note:

A battery that runs out of charge will slowly dim your LED instead of just "turning off" after a while. So even if your calculation tells you that your battery should still be fine, it's possible that your costume won't be very bright anymore. For this case always have some emergency batteries with you.

The sign for a battery looks like this:

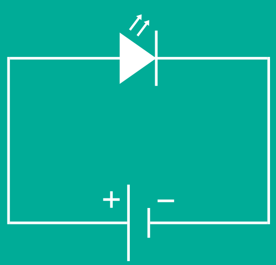


How to choose the right circuit type

At this point you might ask: How do I decide which connection to use? When it comes to cosplay, you'll find the answer by figuring out how many lights you need:

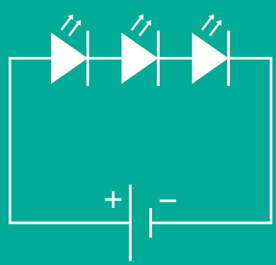
One LED

Circuits with one LED are super easy to make since you can use a 3V battery and no resistor. Just solder the parts together with a simple switch and you have a working light!



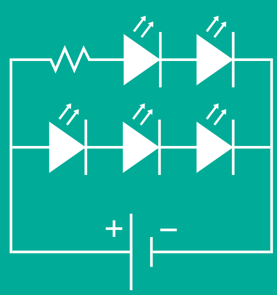
Two or three LEDs

For two and three LEDs I recommend using a series connection. Two LEDS are easy to run with a 9V battery and a resistor in series, while you even won't need any resistors if you use three of the 3V LEDs with the same battery.



Four or more LEDs

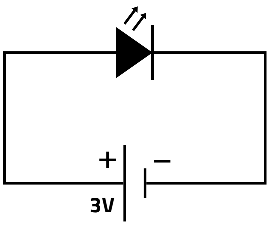
With more than four LEDs I would recommend using two series circuits connected in parallel, since 9V are usually not enough for 4 LEDs and using a more powerful battery can open the door to even greater problems.



Most common circuit examples

Here is a short list of the most common LED circuits. I've pre-calculated resistors and approximate lifetime so you can just pick one and build it without having to do any math!

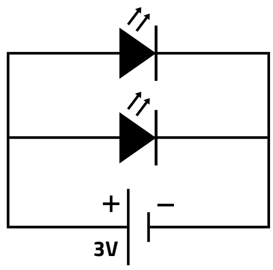
1. One 3V LED - 3V Button Cell Battery



Lifespan

$$\frac{225\text{mAh}}{20\text{mA}} = 11.25\text{h}$$

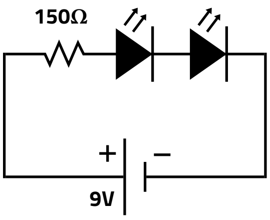
2. Two 3V LED - 3V Button Cell Battery



Lifespan

$$\frac{225\text{mAh}}{2 \cdot 20\text{mA}} = 5.625\text{h}$$

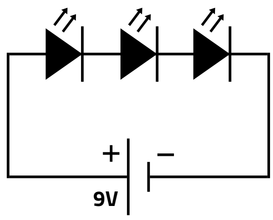
3. Two 3V LED - 9V Battery (brighter)



Lifespan

$$\frac{550\text{mAh}}{20\text{mA}} = 27.5\text{h}$$

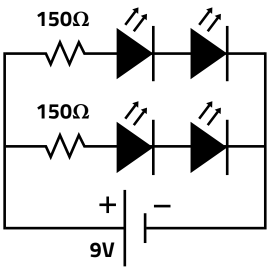
4. Three 3V LED - 9V Battery



Lifespan

$$\frac{550\text{mAh}}{20\text{mA}} = 27.5\text{h}$$

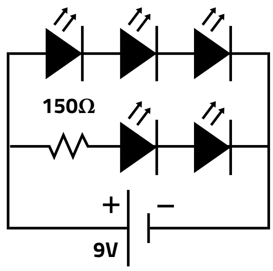
5. Four 3V LEDs - 9V Battery



Lifespan

$$\frac{550\text{mAh}}{2 \cdot 20\text{mA}} = 13.75\text{h}$$

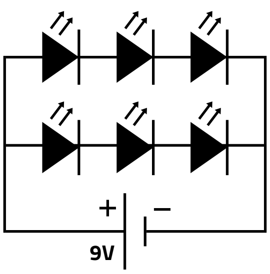
6. Five 3V LEDs - 9V Battery



Lifespan

$$\frac{550\text{mAh}}{2 \cdot 20\text{mA}} = 13.75\text{h}$$

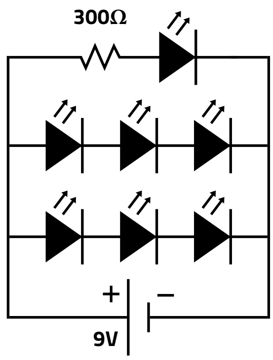
7. Six 3V LEDs - 9V Battery



Lifespan

$$\frac{550\text{mAh}}{2 \cdot 20\text{mA}} = 13.75\text{h}$$

8. Seven 3V LEDs - 9V Battery



Lifespan

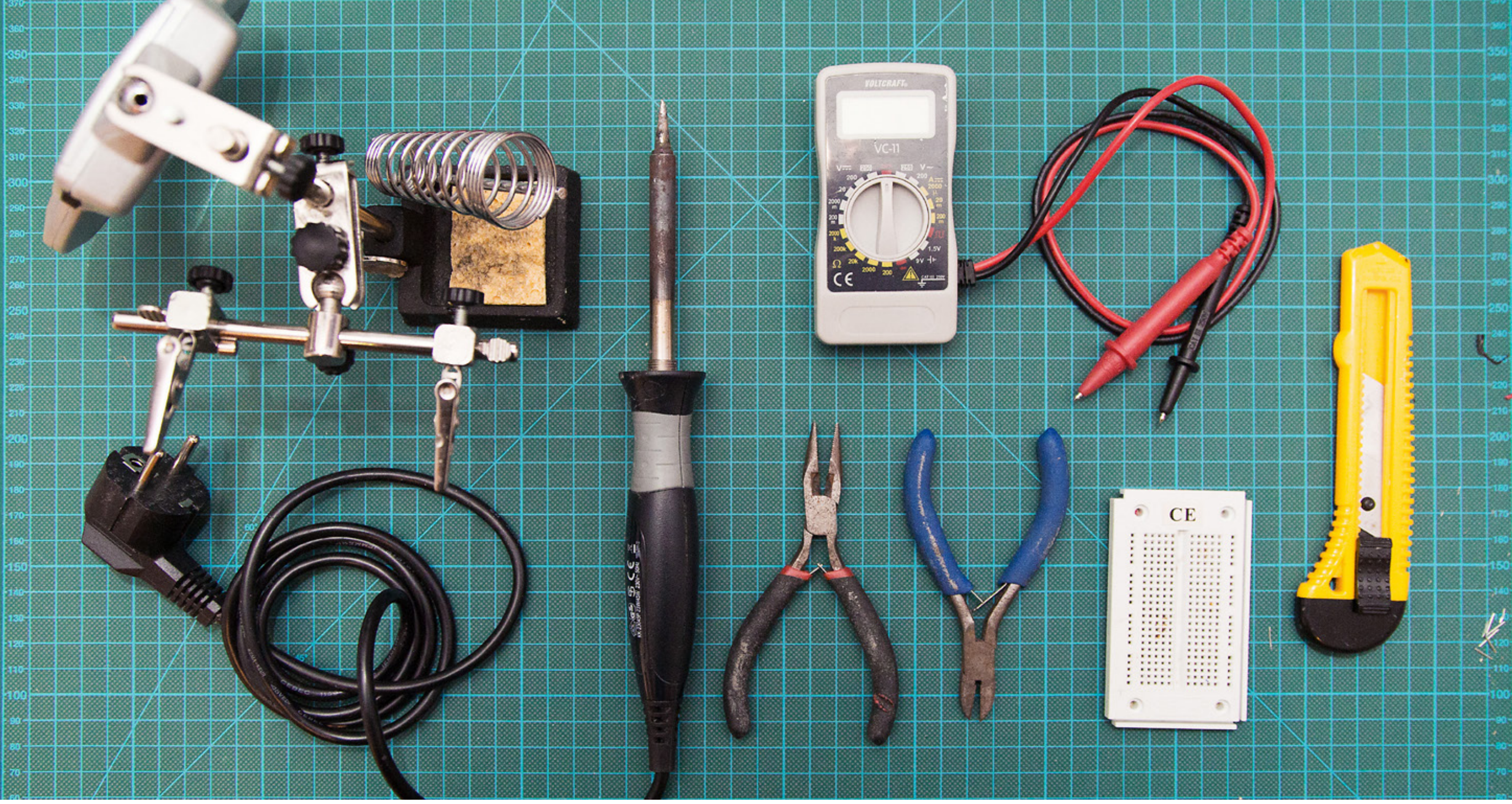
$$\frac{550\text{mAh}}{3 \cdot 20\text{mA}} = 9.166\text{h}$$

I hope all these electronic schematics, formulas and calculations weren’t too complicated. However, it is always a good idea to actually understand what you’re doing, right?

Luckily – and I’m sure you’ve been waiting for this – we’re done with the theoretical part and it’s finally time to move on to some real action!

Be prepared to swing your soldering iron, untangle your cable chaos and to create some glowing gems.

It’s time to get our hands dirty!

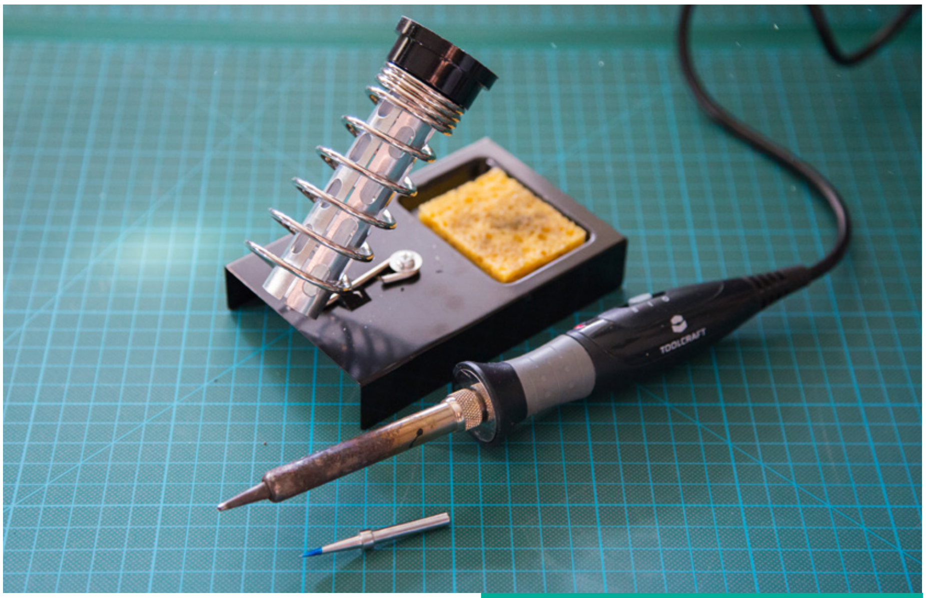


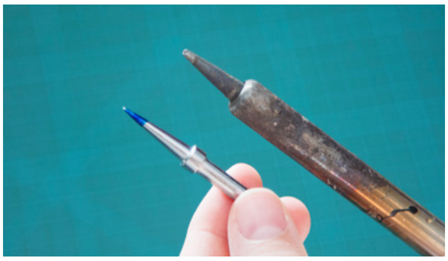
The right tools for the job

Your costumes can cost hundreds and hundreds of dollars and torture your bank account quite heavily. Luckily your LED equipment is less expensive. As always you will need to buy a few tools to start working, but everything you need for the actual circuits is super affordable!

Soldering Iron

Your most important tool will be your soldering iron that you'll use to connect your circuits, wires and switches with hot solder. It's not necessary to buy a high quality product and maybe you'll even find one by asking somebody crafty in your family. Just like the heat gun for Worbla you'll need your soldering iron for every LED project. It is used to heat up solder and connect your circuit parts with the liquid metal. You can also use it to „draw" on wood, burn trough fabric or even to cut Worbla by the way.



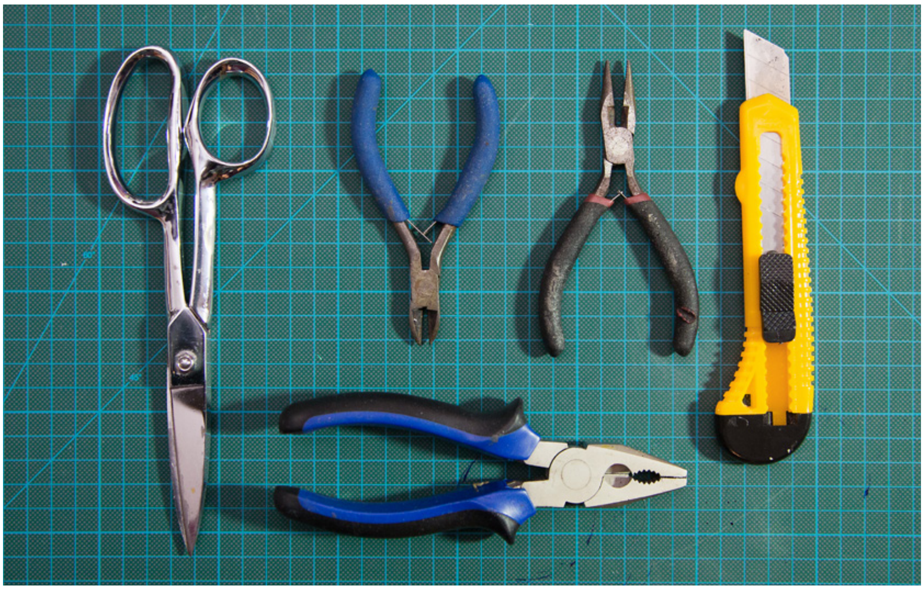


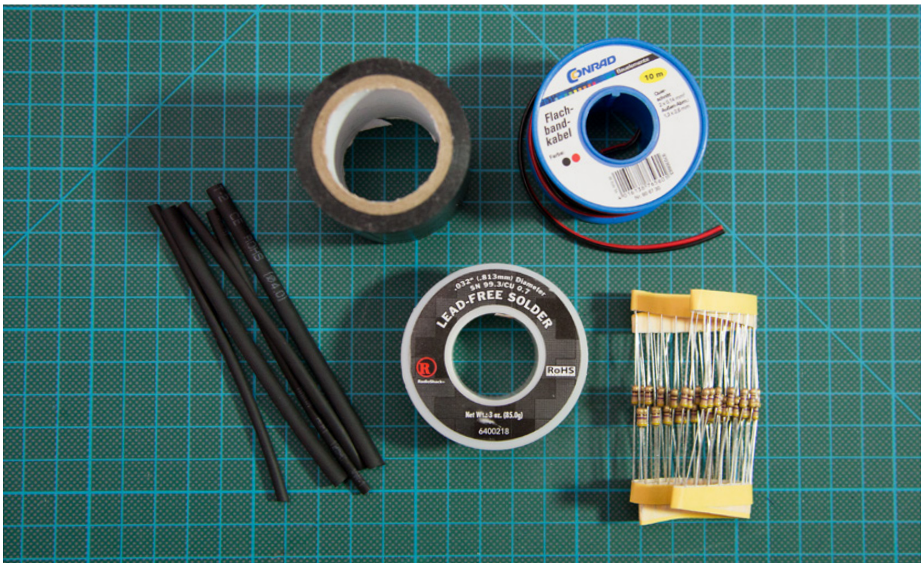
Note:

Some soldering irons have detachable tips. Use a screwdriver to change your standard soldering tip for a newer one. If you've soldered for a long time it is recommended to switch to a new tip after a while.

Since you'll be working with wires, having some sharp knives, scissors or tongs on hand would be useful. I've collected a few cheap tongs over the years and never had the urge to buy more professional tools since they are good enough to work with. In fact you just need something to cut wires with and something to get rid of their rubber coatings. This also works with a cheap hobby knife, little scissors or a professional cable stripper for 30USD, it really is your choice! Good equipment can speed up your work a lot, makes things easier to handle and can safe some anger and frustration. Luckily it's easy to find "ready to solder" sets or cheap electronic sets which provide all the tools you'll need for your first projects. Just make sure they include some tongs, a screwdriver and maybe a "Helping Hand". As usual products may last longer if you buy more expensive ones, so keep that in mind.

Additionally to tools there are a few materials you'll need for every project and which you always should have in stock: Solder, shrinking tube, electrical tape, wires, switches, resistors, batteries and of course a few LEDs. All of these are cheaper in larger amounts and especially online shops like ebay or Amazon offer great deals for whole sets. Remember: In cosplay we don't buy for only one project, so stock up while you can. Don't worry if you don't immediately need all of it. The next project will come eventually!





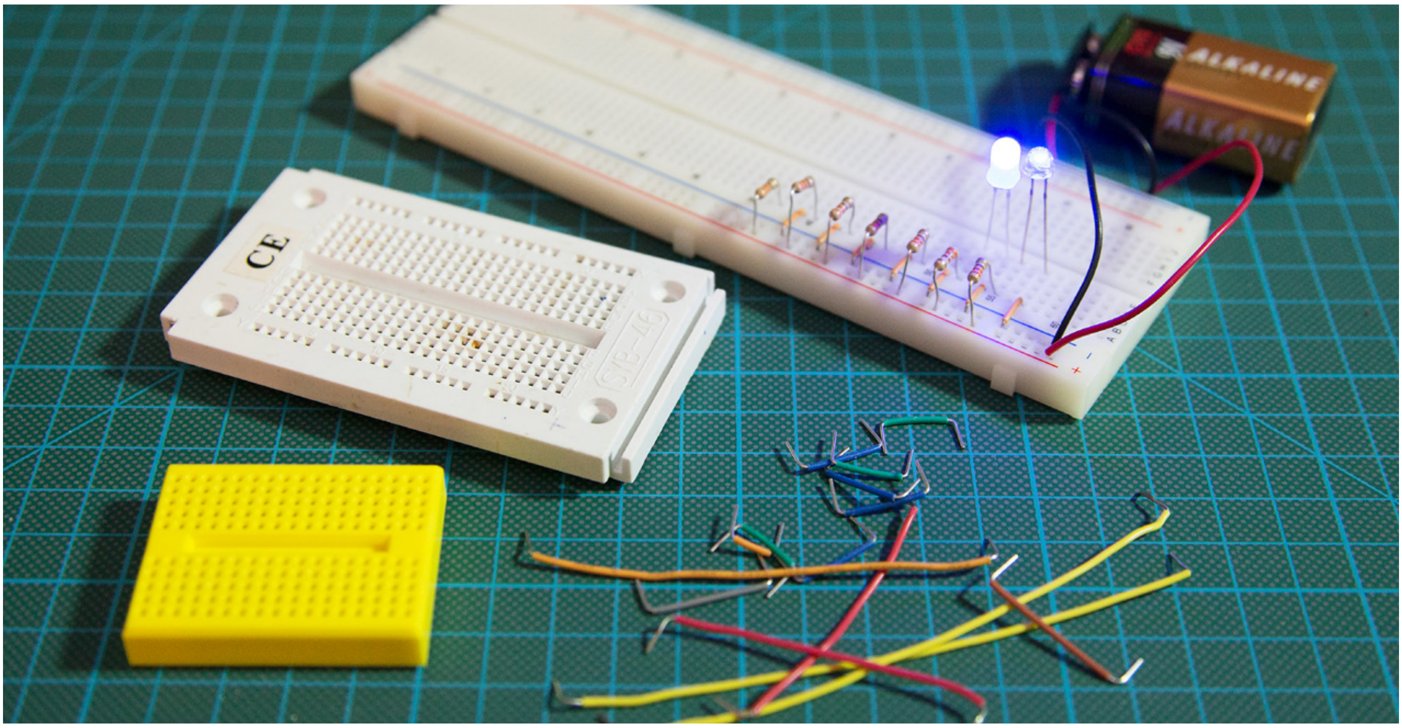
Note:

Finding the right solder is not that easy. For LED projects you're usually fine with solder of 0.75 to 1.00 mm². There is lead solder and lead free solder. Lead solder is very easy to work with and establishes a good connection, while lead-free solder is harder to handle but healthier since lead is supposed to be toxic. Both work in the end so just try to find out what you like more.

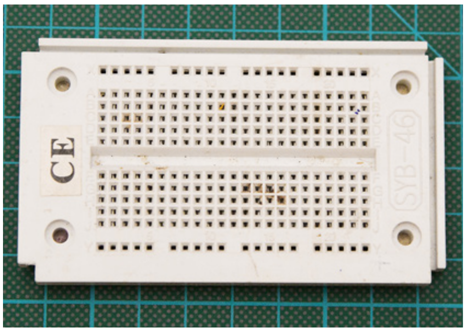
Note:

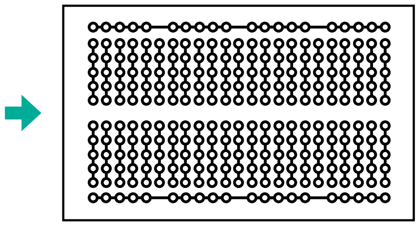
If you do not feel comfortable to work with hot tools, it's a good idea to buy gloves to protect your fingers. You'll never need them if you work carefully though, safety first, right?

Breadboards



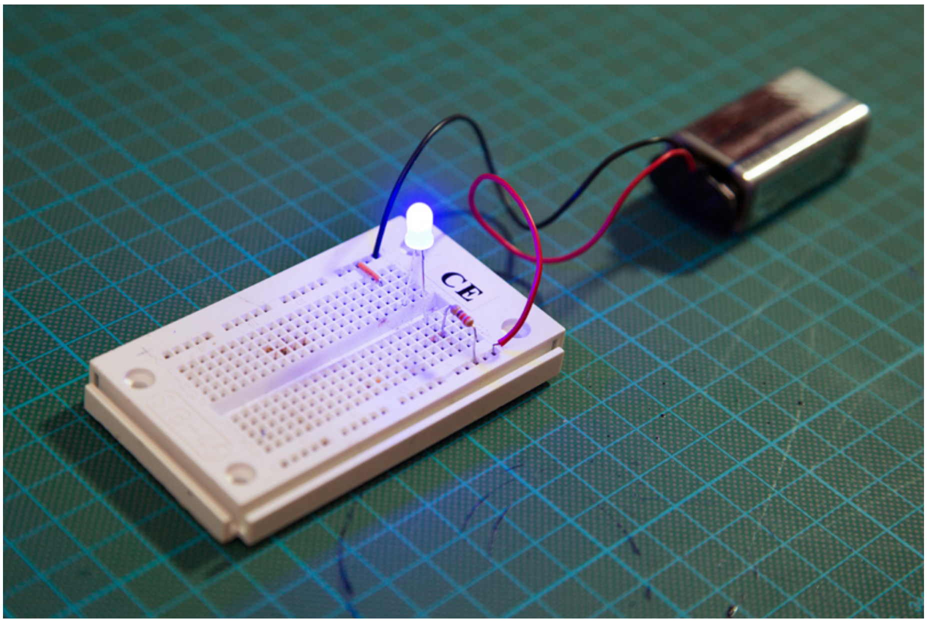
Not really necessary but quite helpful are breadboards and jump wires. This quite cheap kit (around 5USD) allows you to test all kind of circuits without soldering. Just by plugging in different electronic elements you are able to test LEDs, experiment with different circuit designs and build whole circuits from the ground up. So it's not necessary to put a lot of work into a construction that maybe won't even work.



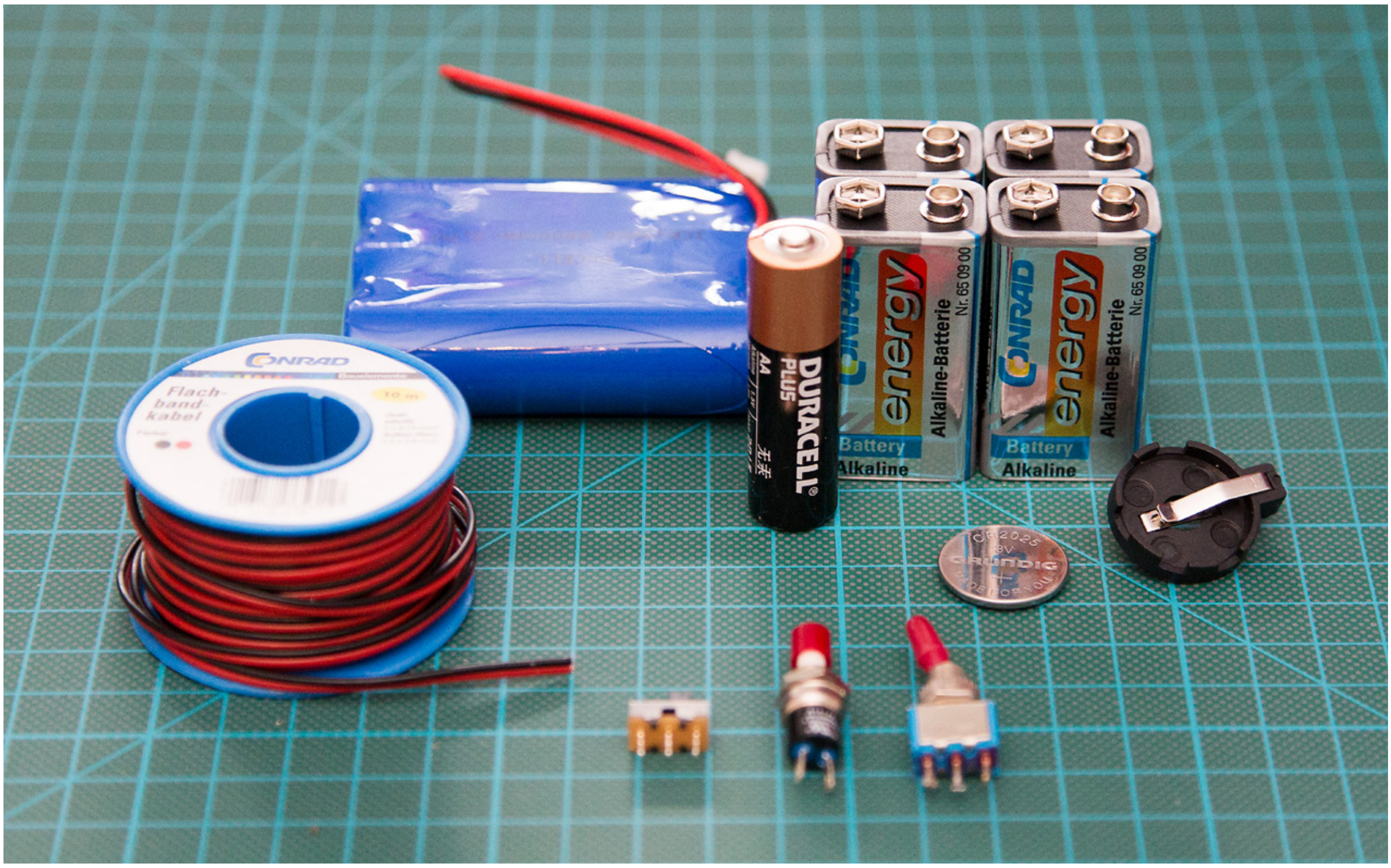


Using a breadboard for the first time might seem a little tricky, but in no time you'll have the hang of it and will be able to experiment with circuits very quickly and very easily – you just need to know what this thing looks like from the inside.

As you can see, all holes, or better contacts, are connected through rows with each other. They are basically just like wires, but since you can plug in LEDs, resistors and everything else on every point on the "wire", it's not necessary to solder. So a circuit with a 9V battery, a fitting resistor and a single LED would look like the picture to the right. Just get a breadboard and try it out for yourself. There are a lot of different "layouts" but they all work the same way.



It's always a good idea to breadboard a new circuit before soldering it together for permanent installation in your cosplay.

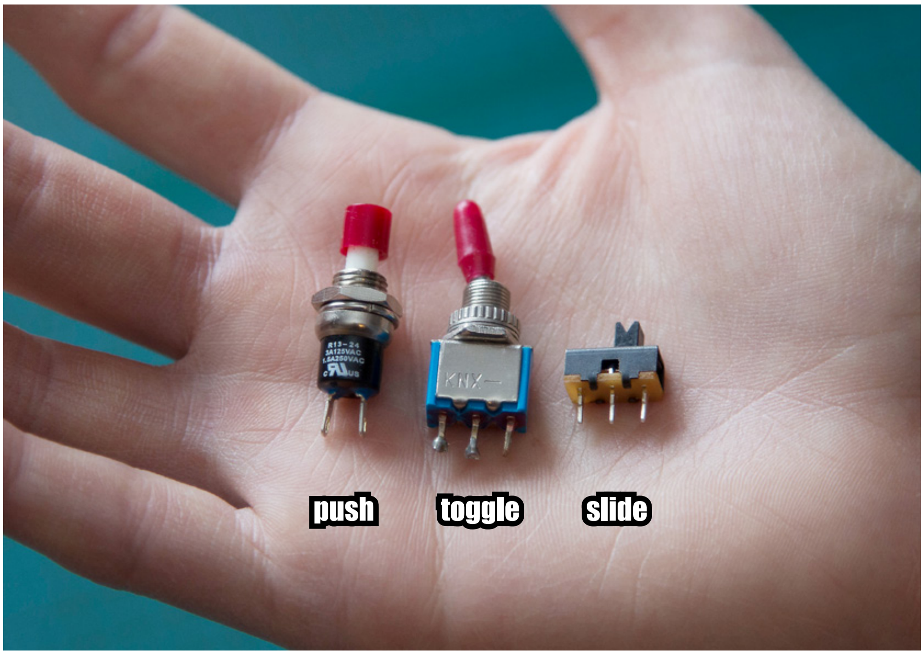


Materials (Switches, Cables, Batteries)

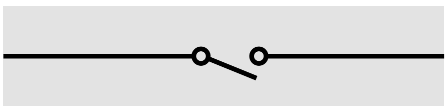
Switches

If you want to be able to turn your LEDs on and off, a switch is a must have on your shopping list. A switch is an electronic element that is able to interrupt an electrical circuit and close it at the push of a button. Once you visit your hobby store of choice you'll find out that there are tons of different switches. For becoming a professional Christmas tree the following are a good choice: Push buttons, toggle switches and slide switches – all of them in the smallest size you can get.

What you prefer is pretty much your choice, since they all work for LED circuits and are easy to handle. Push buttons work - well - by pushing the button. It is easy however to press them by mistake and turn your lights off in bad situations. It needs a bit more force to activate toggle switches, but they have a weird shape which makes them hard to hide. Slide switches, my personal favorite, work the same way as toggle switches, but are much smaller. You can buy them everywhere and all they need is a little slide. All three should cost less than a dollar, so just try them all to find your favorite. In this book you'll find all circuits wired up with a slide switch.



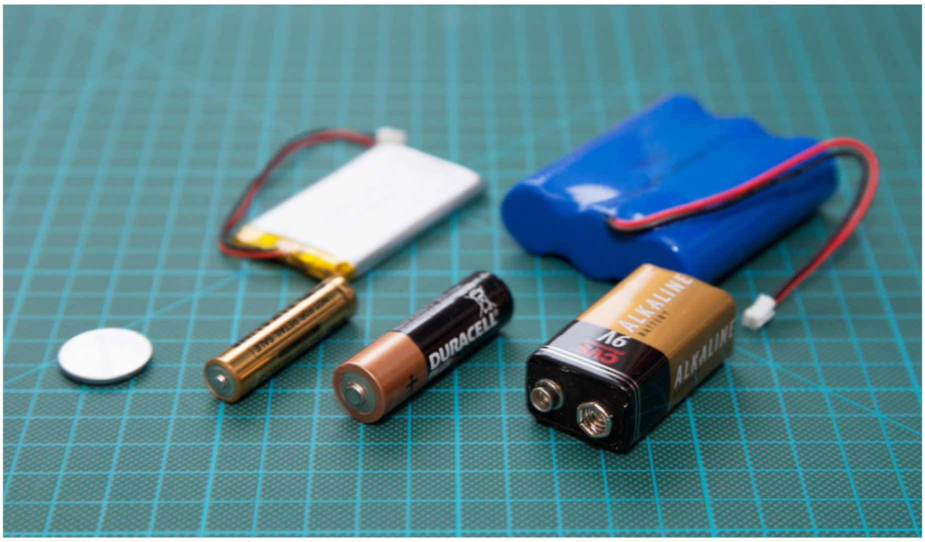
The sign for a switch looks like this:



Batteries

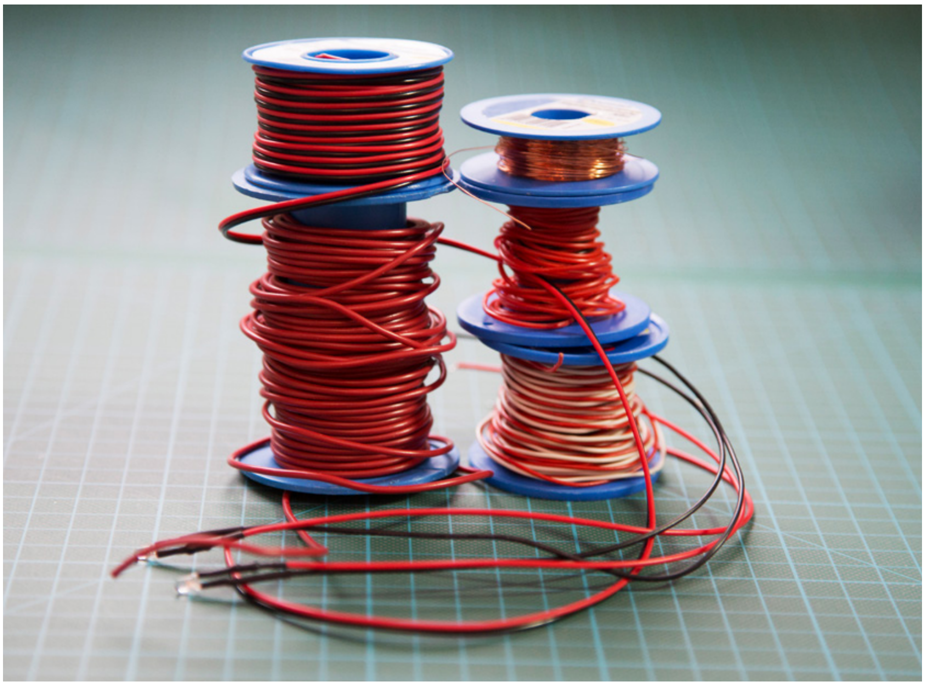
You'll find batteries in pretty much every size and shape. From tiny power sources for watches up to little reactors for monster trucks. When it comes to cosplay however you will need them to be as small and long lasting as possible. For simple LEDs we luckily do not need that much power, so those simple Alkaline batteries you'll find in every supermarket will suffice. My favorite are 9V block batteries as well as 3V button cell batteries (CR2015/CR2032). Both are super easy to wire up, aren't that large and also are affordable. During your own experiments you'll surely find batteries you may prefer more.

If you start to research a little bit more about batteries you'll find out that there are Alkaline, Li-Ion, Li-Po as well as SLA and other types of batteries. All of them have different strengths and weaknesses. Some are really powerful but need to be recharged with a special charger. Some drain faster than others. Usually Alkaline is the most common type. They are cheap to produce but not that energy efficient. Since we do not need that much energy to begin with I will not dive into explaining the differences too much - it would only stir confusion. For now, just buy what you find in the supermarket and remember to dispose of them the right way. Also don't forget to buy a few battery holders to connect your batteries to your circuits.



Cables

When it comes to cables, you mostly need to look for the right cable cross section. For simple LED circuits 0.14 mm² works best, is affordable and available in different colors. I mostly work with double wire in red and black, since it is easier to remember the poles. You can also choose from cables that are more or less flexible, are thicker and even have a lacquer instead of a rubber insulation. Right now a standard 0.14 mm² color coded cable is enough for the projects I'll show you.



Learning how to solder

A soldering iron is a pen like tool with a metal tip, hot enough to melt solder. Hot like in 650°F (340°C) hot! It's like working with a hot glue gun - except only with metal.

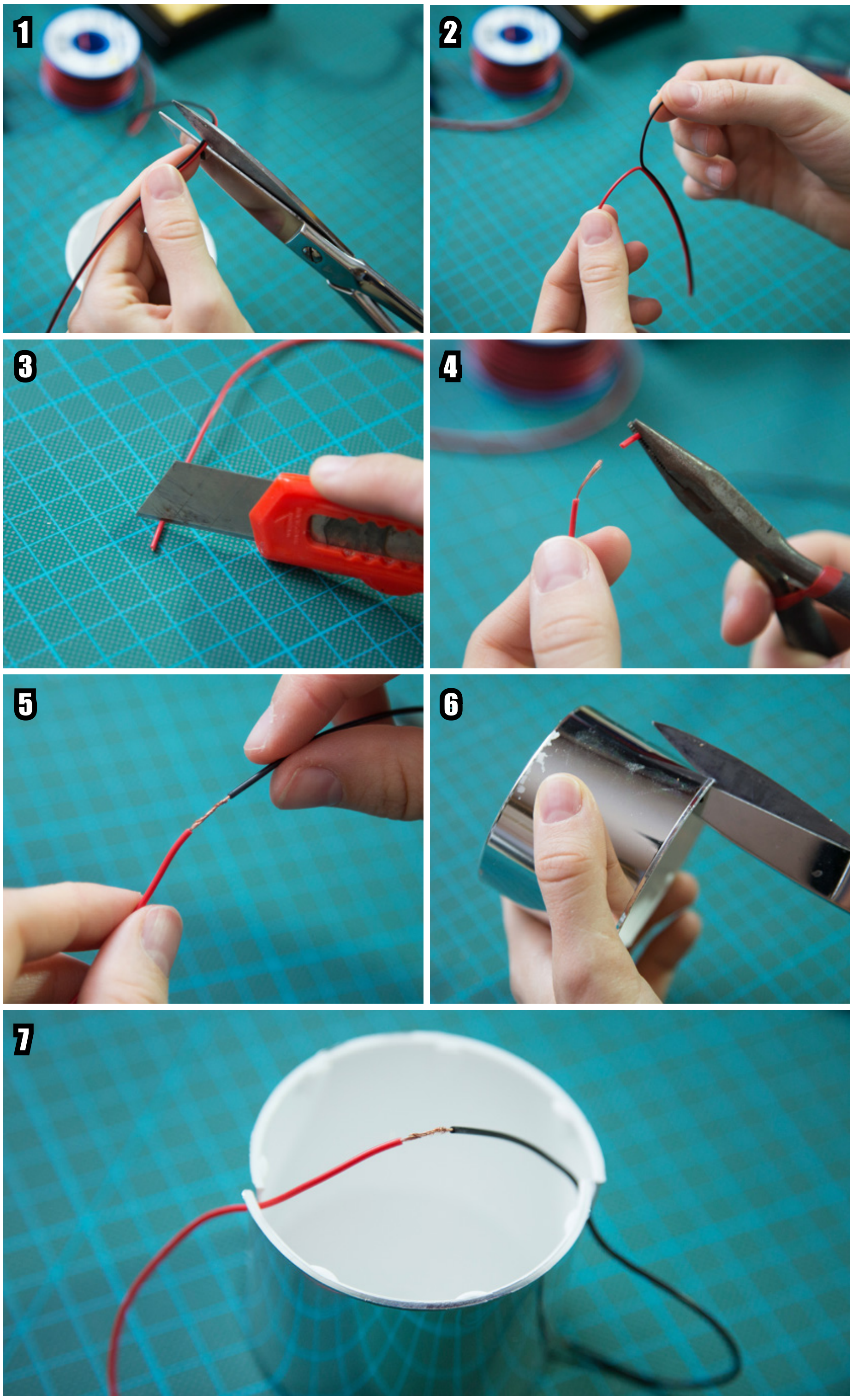
Just like with a hot glue gun, there are also different qualities of soldering irons. While you can get a working one for around 15USD, it's worth to invest a bit more to buy a product that allows you to regulate heat. This will make it useful for a couple of other applications as well.

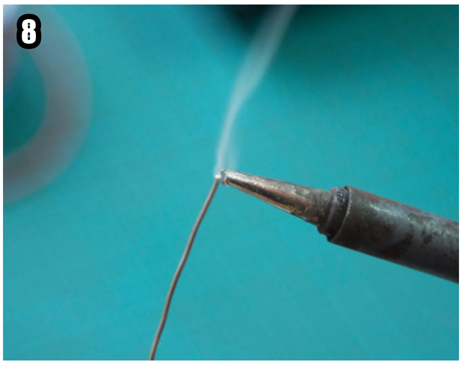
Instead of hot glue sticks though we will need to work with solder. Solder comes in a lot of different varieties and usually looks like a silver wire rolled up in spools. It consist of a metal mix, which is easy to melt – just like hot glue sticks. Now let me heat up my soldering iron to show how it works.

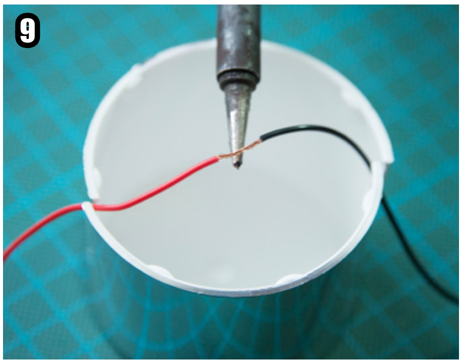
At first turn on your soldering iron and set it to medium heat. You'll soon notice if you need a higher temperature, but if it's too hot your solder will run like a waterfall and we don't want that. Wet your cleaning sponge, but don't soak it completely with water. Your tool will take a couple of minutes to heat up, so keep some distance for now. It's important to know the solder will release fumes when heated. Since they are harmful to your eyes and lungs, choose a well ventilated area, use protective gear or just add a fan to your workspace that blows the fumes away from you.

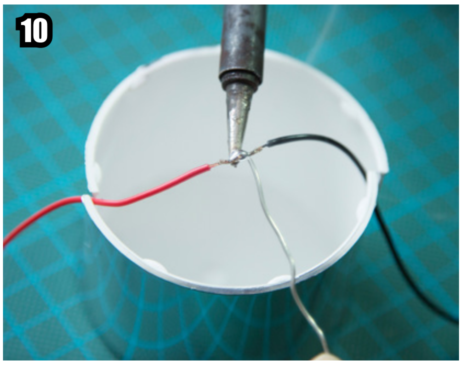
First cut a piece of wire in two **(1)**. Separate the cables **(2)**. Then use scissors or a knife to cut into the plastic coat of the wire around 0.4inch (1cm) away from the end **(3)**. Be careful not cut too deep to damage the wire itself but just enough to drag the plastic off the wire **(4)**. If you damage the wire, just try again - it's long enough! A professional wire stripper can be pretty useful at this point, but with a bit of practice it's not really necessary for small projects.

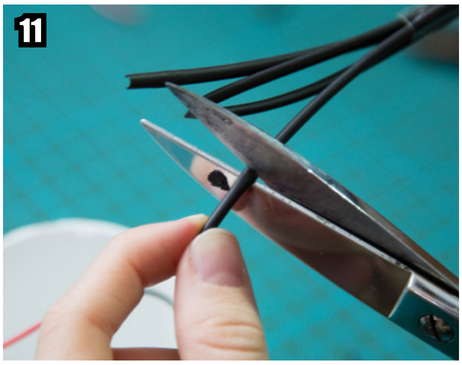
Once the inside is exposed, take the soft metal ends and twist them together with your fingers **(5)**. The connection doesn't need to be super strong, but the metal should be making good contact before we solder it. Now fix your wires into position to have free hands again. You can use a helping hand tool or just cut two slits into a spray can cap and use this one to hold your wires for you **(6+7)**.

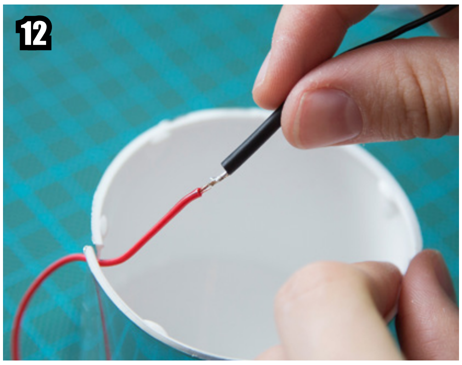


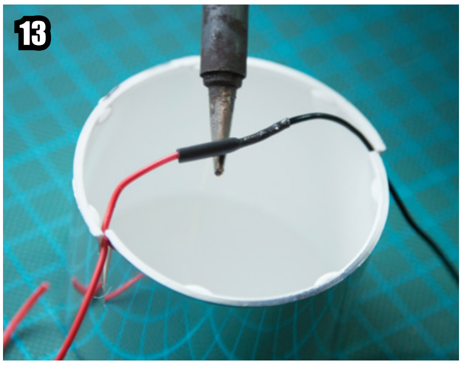


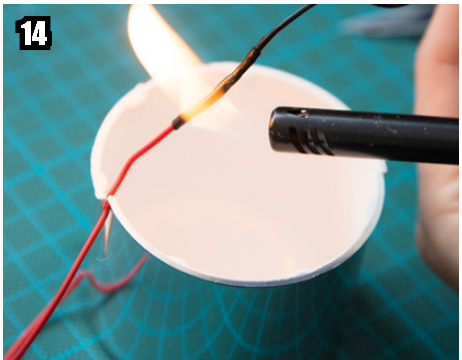


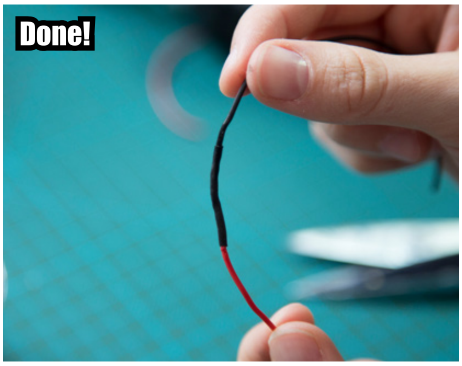


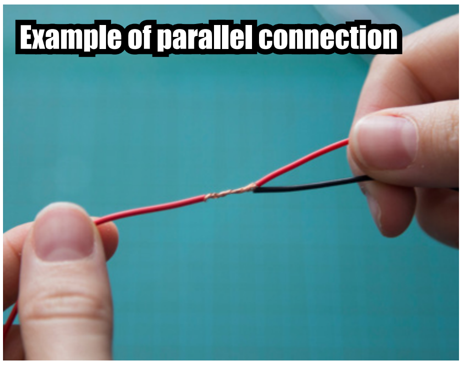












Grab your soldering iron, clean its tip carefully by drawing it over the wet sponge and put a tiny bit of solder on it **(8)**. This tins the tip so when you connect the wires the solder does not stick to your iron but just peels off. Get rid of too much solder by using the sponge and your tip is ready and prepared for the soldering work.

Now this is the important part: The trick is not to heat the solder, but the wires instead. Place the tip of your iron under the twisted wires to heat them up from below **(9)** and then put a bit of solder on your wires from above **(10)**. The gravity will drag the solder through the wires and establish a nice and even connection. It's best to use a minimum of solder.

The connected part gets solid immediately but need a few moments to cool down completely. Clean your tip and put the soldering iron back in its holder. You are able to get rid of any unnecessary metal by reheating it again. Voilá! Your first soldering job is done!

Since the metal is still exposed, it needs to be insulated with shrinking tube. Like the name implies, it shrinks when heated up. Cut a long enough piece and drag it over the wire to the desired spot **(11 + 12)**. It's also important to add it into your circuit before you close all the connections, since we cannot add it anymore when all is closed. You can use your soldering iron **(13)**, a lighter **(14)** or a heat gun to shrink the tube.

Note:

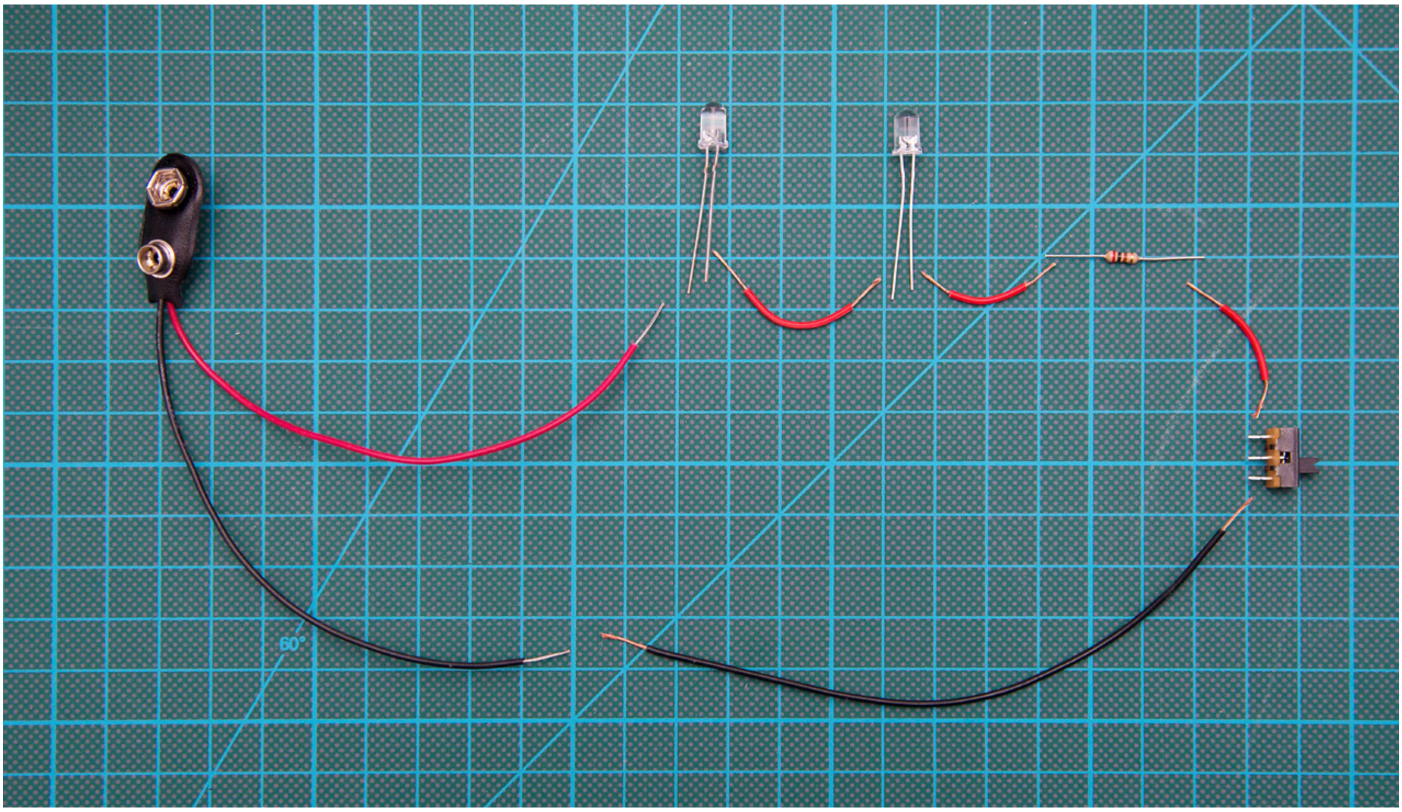
While wearing your circuits in a costume, the soldered parts are weak points. Since they are more stiff than the rest of the wire, they will break apart once you bend them too many times. To prevent that, it's important to use enough shrinking tube and to add additional tape.

Our first LED circuit

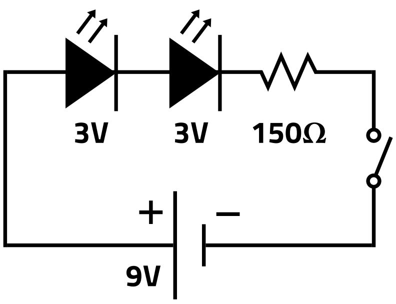
Once you got the hang of soldering, building whole LEDs circuits is no challenge anymore!

Before the fun begins we first need a circuit plan. A couple of pages ago I introduced you to simple series and parallel connections. Let's build a series circuit with two LEDs, a resistor and a switch to turn the lights on and off.

Since a single LED requires 3V, we'll need 6V for both of them. A 9V battery would be a great choice as long as we remember to get rid of the unnecessary 3V. Since you've already fallen in love with these few formulas I gave you (oh, I know you did), it's no problem to calculate the resistor we need, right? We are using example circuit number (3.) from page 18 so you know we need a resistor with 150 Ohm.



So this would be our circuit plan. Let's solder this thing!



The circuit we've chosen is pretty simple, but if you try to build this project by yourself you'll notice it won't be easy to keep all the poles in mind. It helps to add some notes to your electrical parts or to remember a few rules:

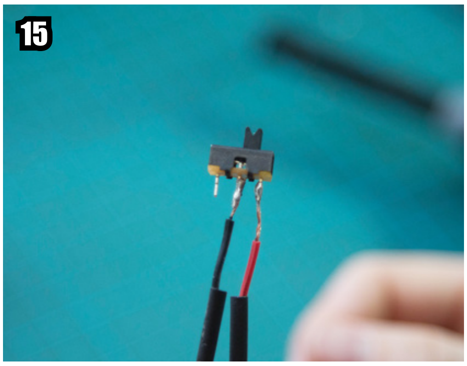
LEDs: short leg = negative, long leg = positive
Battery wires: black = negative, red = positive

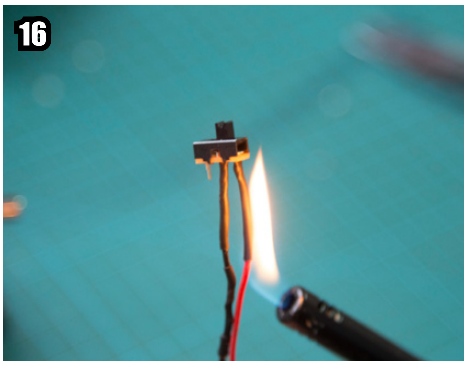
Resistors and switches do not have any poles, so don't worry about them!

The length of your wires usually depends on how you want to hide the circuit in your costume but for now around 8inches is enough. (If you want to build this circuit for a costume already, try to find out how long your cables need to be.) I'll talk about this topic in more detail when we come to hiding circuits in costumes (page 41). As you can see in my drawing you'll need four wires in total. If you follow the circuit plan the arrangement of your electronic parts will look something like the image above.

Not too complicated, right?

Now turn on your soldering iron, get the ends of your wires stripped and show them some love! All you need to do is to connect the pieces. Twist the wires together, add some solder and protect your connections with shrinking tube. The switch we are using for this example is a slide switch. Slide switches have three pins we can solder. We just have to solder our wires to the middle one and the other to either the left or the right pin **(15)**.





Once you are done you're able to turn your lights on an off. Don't forget to insulate your connections with some shrinking tube **(16)** to avoid a short circuit. Since your switches are very fragile you can use tape to reinforce the connections even more.

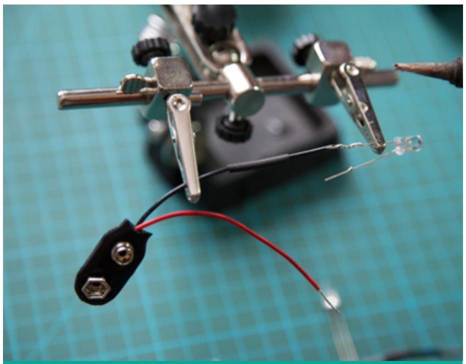
Your circuit also needs to survive the convention - so bring enough tape to hold everything together! Lots and lots of tape **(17)**! Its also totally fine to cover your circuit in Worbla. Usually LEDs just sit around and glow all day - bored to death, but costume LEDs are put to the test with every movement you make. You run, jump, dance and shake (depending on the amount of consumed energy drinks) and your circuit will have a hard time holding together. Fortify your circuit and try to make it as durable as possible. Make sure your circuit works even after hours upon hours of torture!

Note:

The colors of the wire have nothing to do with the poles in the circuit. Wire is wire. It just helps you to remember better. In a series circuit however even the colors won't help, since you'll have a positive pole on one end and a negative pole at the other end of the same wire. At this point it can be really helpful to add little tags to your wires.

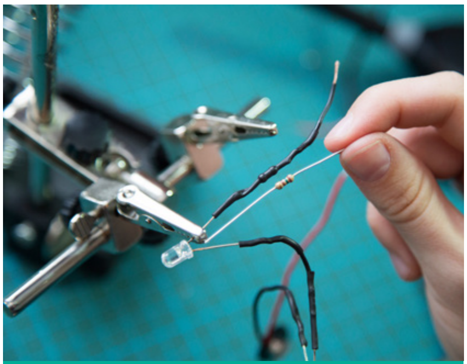
Note:

The positions of the LEDs, the switches and the resistors are not fixed. Resistors can be places in front of, after or between LEDs, as long as they are in the same series connection. Switches need to be able to interrupt a circuit, but it does not matter where they are (just don't put them in a branch of a parallel circuit). Also their poles do not matter - only LEDs need the right polarity to light up. It's always important to see circuits as a whole.



Note:

To wire up LEDs a helping hand is quite useful. Just fix wire and LED, twist both together solder everything. But don't forget to add shrinking tube in advance. Once you're done make sure your soldered parts are completely insulated and no metal can be seen anywhere.



Note:

A resistor can be soldered just like a wire, since it has long, flexible silver arms. Connect them either in front or after your LEDs in a series circuit, cover it with a long piece of shrinking tube and give it some heat. Congratulations, your LEDs won't get grilled anymore!

What to do if your circuit does not work?

Even as an "experienced" Christmas tree there will come a point where your LED just stop working and you will not know why. Believe me. It will happen sooner or later, and it will drive you nuts. So here is a little checklist to spot the source of (t)error:

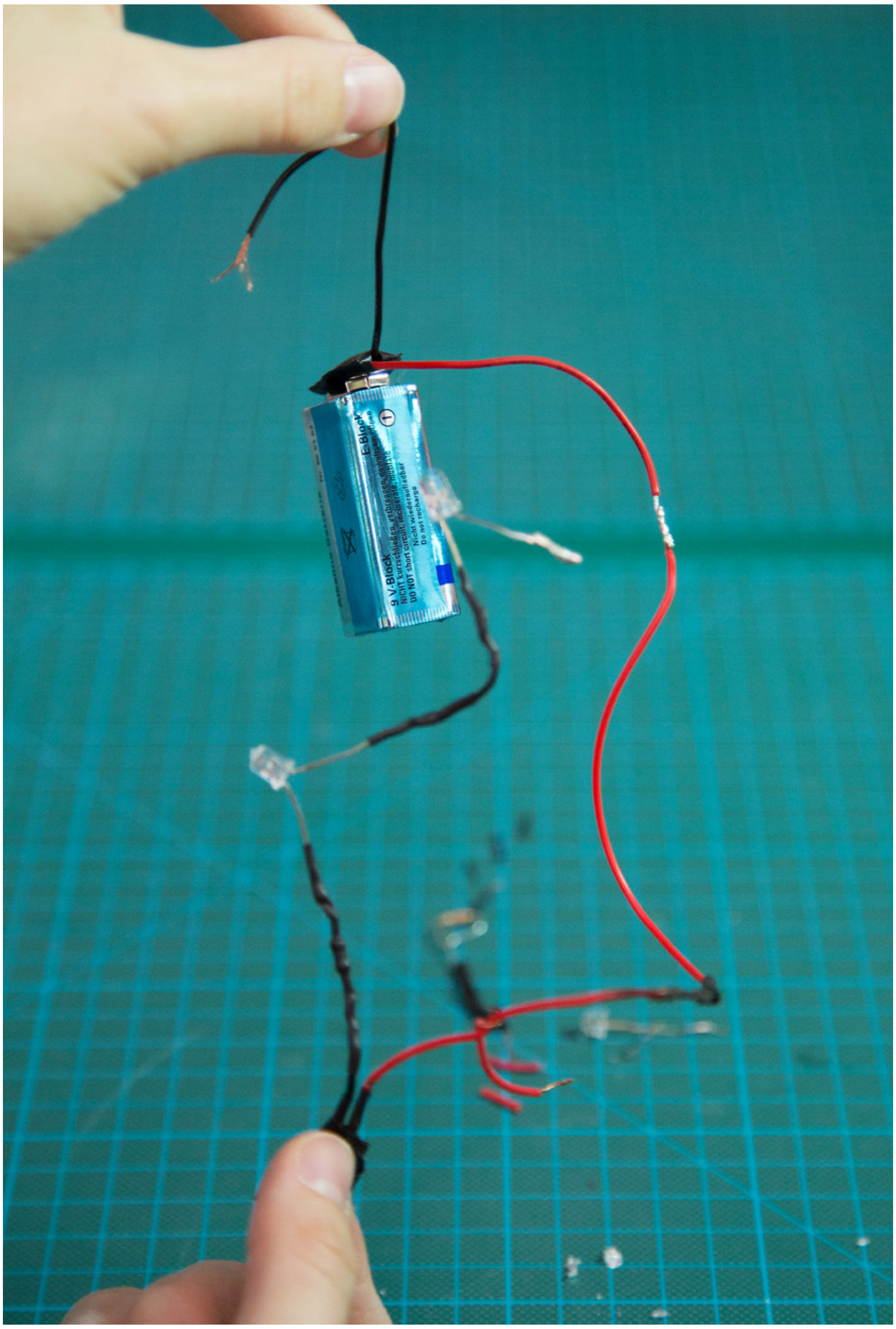
1. Polarization: The most common trouble-makers are the poles. Try to follow the poles to see if positive and negative are where they are supposed to be. Change wires and open up soldered parts again. It's quite possible that one of your LEDs is attached the wrong way.

2. LEDs: Are your LEDs not working even though they clearly should? Maybe they got damaged during one of your tests. To find that out, exchange your LED for one you know that works. Test them by using a 3V button cell battery.

3. Battery: Nothing lights up, even after you've checked everything several times and it also already worked before? Maybe your battery is empty. It's a dumb mistake, but it happens more often than you think it would. Drove me crazy during a long, long night, too.

4. Soldering: Still no lights? Connections can break - especially when they move a lot. It takes time to re-solder everything again, but sometimes it's the only way to get rid of errors you just cannot seem to find. This is especially true if the soldering work is already old and got a lot of convention-time.

5. Short circuits: Sometimes when you solder a connection and there are still metal parts exposed, you turn it on, move a tiny bit and then POP! - it stops working. In this case it's very likely that one of your LEDs just exploded. This happens when parts of a circuit are bridged and your lights get more power than they should. There is nothing you can do except finding the culprit and replace the dead LED. Poor guy.



Incorporating lights into your costume

There are so many different ways to give your costumes nice light-effects. You can add fancy orbs, magical blades or mystical gemstones. There is no limit for your creativity and a whole new world of materials is waiting for you to experiment with. Let me show you the three most common examples:

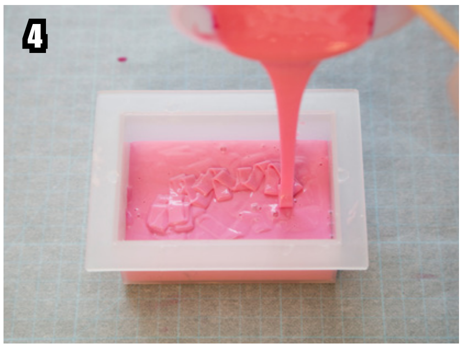
Resin Gemstones

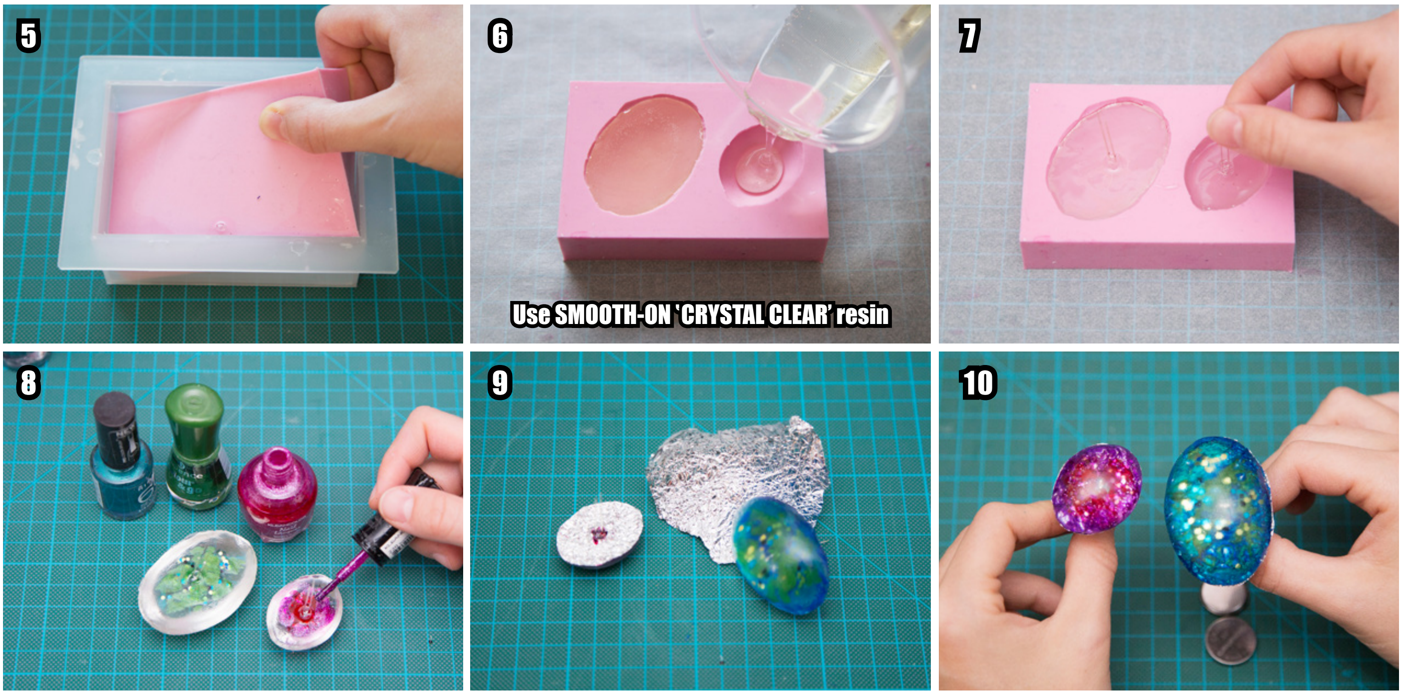
This is probably the reason you are reading this book: illuminated gemstones is the most popular way to install lights in your costumes. The variety of applications is infinite. Use gemstones as a nice glowing highlight in your armor, to light up your props or place them into waving robes or decorative magical accessories. Their circuits can be built so tiny that you can even use them to light up gemstones for earrings or necklaces.

To create resin gemstones for the very first time you need to buy some additional materials that may not be that easy to find. You will need modeling clay to shape your blanks, silicone for mold making and resin to cast your gems.

For my example I used Apoxy Sculpt to create gems in different sizes that I can put in all kinds of present and future projects **(1)**. You can also make molds of existing gems from a hobby store or choose other shapes you find around your house. Safety first – making molds requires some protection like plastic gloves, a respirator and a well ventilated room. Place your gem in a fitting container (you can also use Lego bricks) and spray everything in a thin coat of mold release **(2)**. This makes it easier to release your gems and the mold afterwards.

The get a silicone mold, mix the chemicals according to their label **(3)** and pour the resulting fluid slowly over your gems. Start pouring very slowly but steadily in a corner of the cup to avoid getting air trapped under the silicone **(4)**. Steadily but carefully pour all of your silicone over your gem until it is fully covered and you have a nice, even surface. Don't worry if there are lots of tiny bubbles, those will start to work their way to the top to release the trapped air until there are no more bubbles left.





Make sure to check for Youtube tutorials on mold-making if you are still scared - but it's really not that hard.

Once our silicone has cured, take your mold and the original gem out of the cup **(5)**. Now mix your resin according to the label and slowly pour it into your mold **(6)**. After a few minutes test how solid your resin has become by using a toothpick. You need to wait for the right moment to stick your LED in, so that it is hold upright without sinking to the bottom. My resin needs around 15 minutes. This step will require some tests, so don't worry if it doesn't work the first time. To balance the LED it also helps to put chicken wire over the resin and attaching the LED legs to it. After a few hours your resin should have cured completely.

I bet you'll enjoy the next step: Grab some cheap glittery nail polish and apply some layers of color on the back of your gemstone **(8)**. The shiny, metallic and glittery effects of nail polish are just perfect to create tiny galaxies in the center of your gemstones. Once everything is dry, add a last thin layer of polish and cover the paint job with wrinkled aluminum foil to reflect and scatter the light of the LED inside **(9)**. As the very last step you can also add a dark gradient around the border with some glass paint to make them look more three-dimensional. Finally our shiny radiant gemstones are done **(10)**!

Now we only need to provide them with electricity. Be careful that the aluminum doesn't touch the legs of the LEDs at *any* point, since the circuit will be messed up otherwise. Avoid that by scratching away the aluminum foil around your LED and cover the soldered contacts with enough insulation material. The rest is just a standard LED circuit you now know how to build. Easy peasy!

By following this link you'll find my video tutorial:
http://youtu.be/pszN08KCNUc

Note:

You can buy molding container/cups online, build them yourself or use other similar boxes you find in your workshop. To find out how much silicone and resin you need just pour water into your container or mold and measure the amount using a measuring cup.

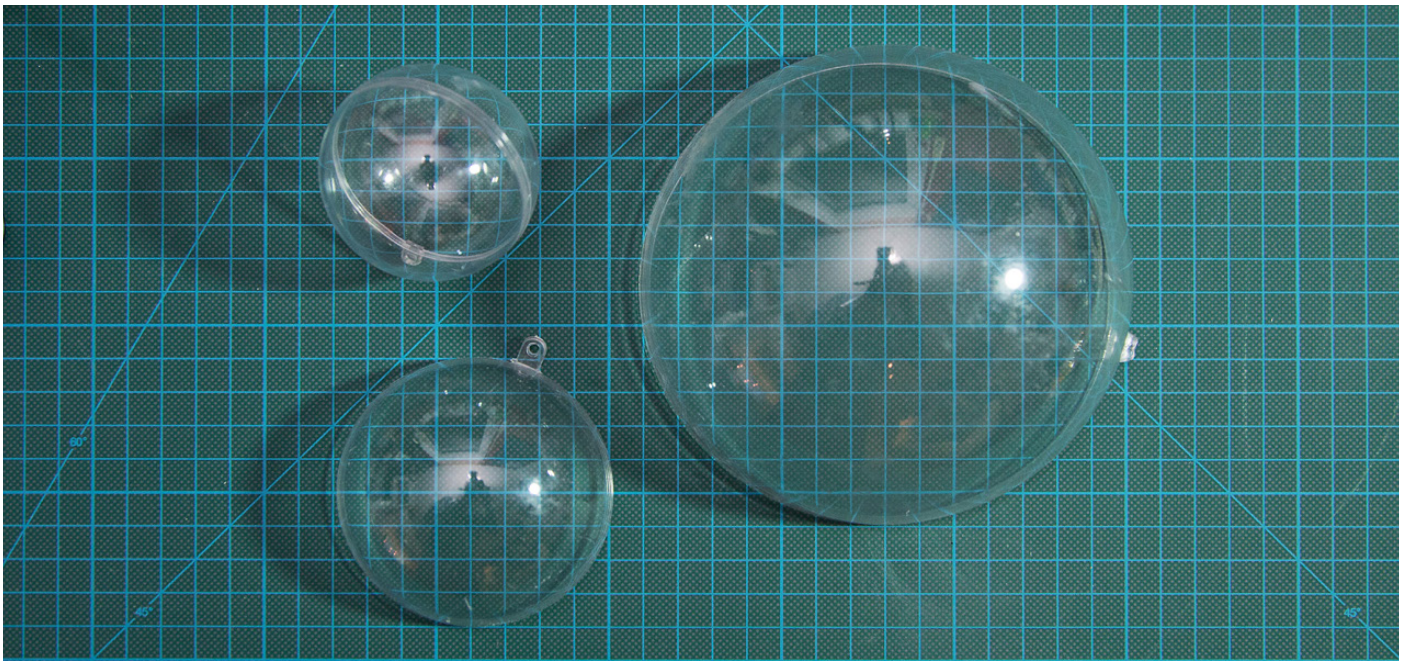
Note:

Please forgive me that I won't go into more detail about mold making here. There are a lot of different ways and products for mold making and explaining everything properly would take up a whole new book. Besides, every product is a bit different and so are the instructions to work with. The explanations on the labels usually help a lot. Study them to make sure you're doing it right in case you're using other products than me.

Note:

You can just hot glue the gemstones to your costume. However it's possible that the thin aluminum foil won't be strong enough to hold everything together. To avoid that use ticker metal foils or any other reflecting material as an alternative.

Acrylic Spheres

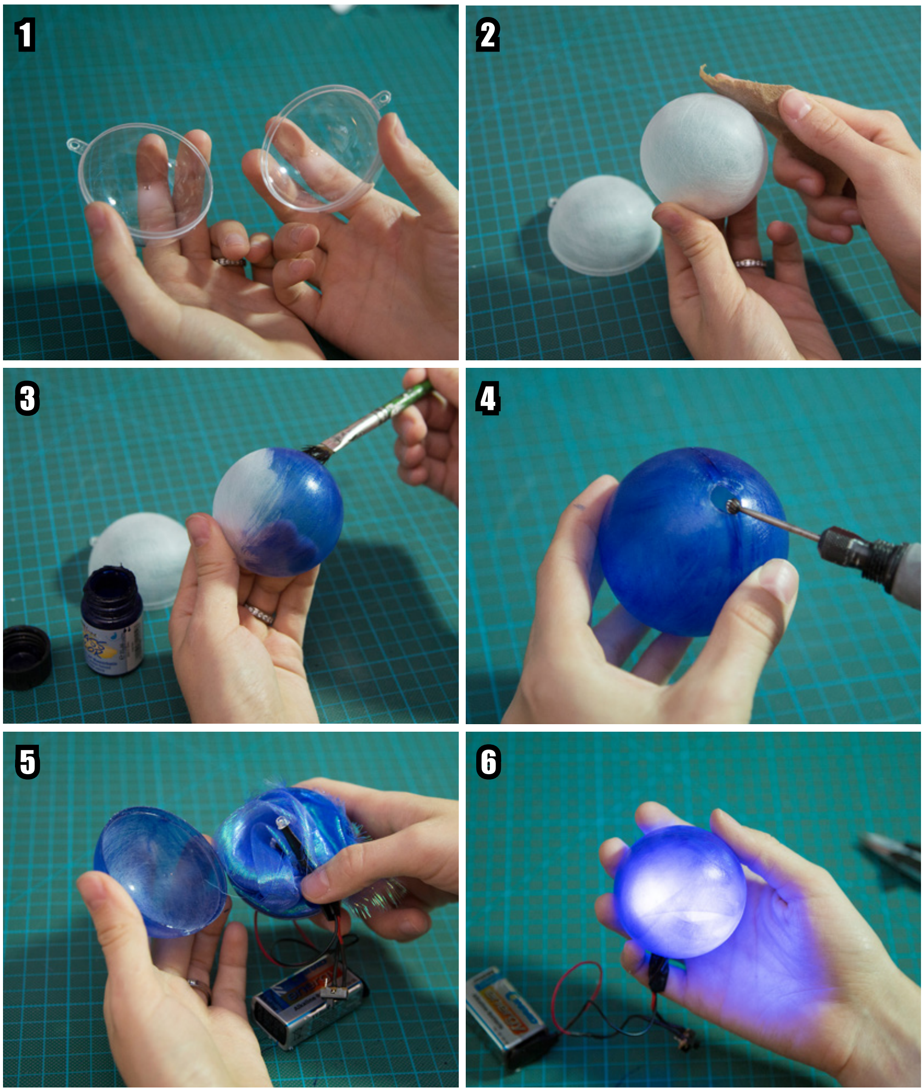


You'll find a huge variety of acrylic shapes in every well organized hobby or online shop. With LEDs you can create glowing orbs, mystical radiant boxes or shining hearts. Give your prop an extra eye-catching highlight.

Once you found the object of your desire, alter it to your hearts content. Add paint, fabric, glitter or any other kind of decoration. Just keep in mind that we will install a LED inside, so it still needs to be transparent enough for the light to be visible. Materials like organza, colored plastic foils or glass paint are a good choice. In addition, think about which LED color would fit best, since it should compliment your costume.

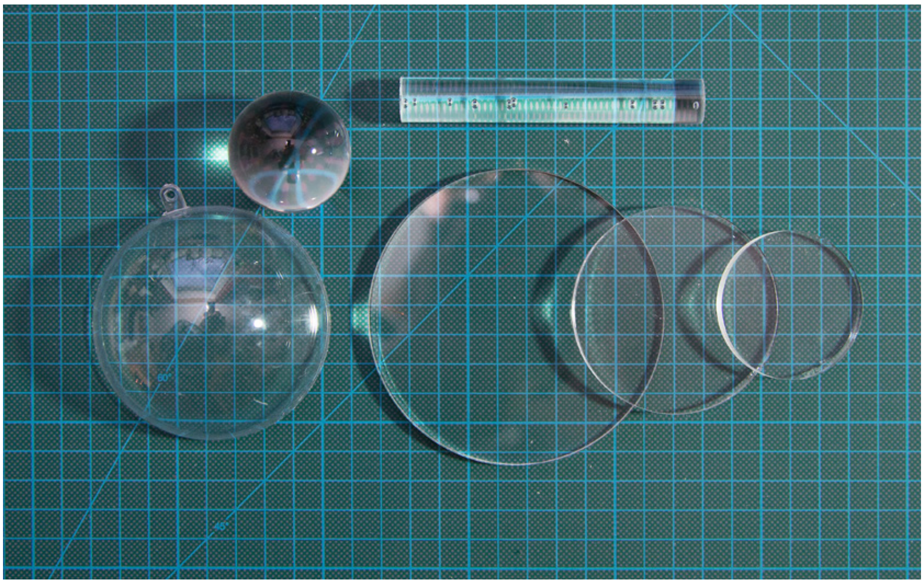
To diffuse and spread the light it helps to sand the surface of your shape on the inside as well as the outside **(1 + 2)**. Add a layer of glass paint on top **(3)** to keep it colorful when you've turned the lights off during the day. The more you sand, the more you spread the light. If you want to keep your sphere nice, shiny and reflective, only sand the inner side of the shape.

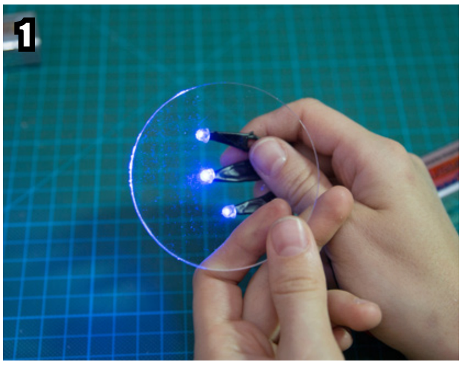
For the next step it's necessary to install the light on the inside. First drill a hole into your globe **(4)** and try to find a place where it shall be hidden. If you do not have a dremel it's also possible to use your new soldering iron to melt into the plastic. Now all you need to do is to connect your light(s) to a circuit, put some fabric or wax paper inside to spread the light **(5)** and hide the cables and your switch. Ready is your glowing sphere **(6)**!

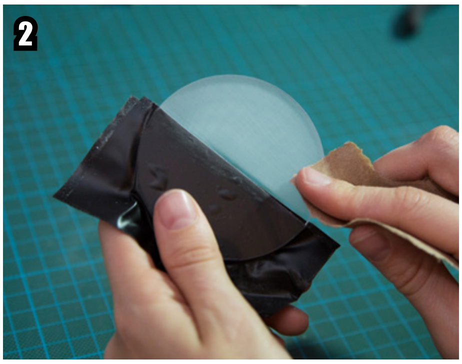


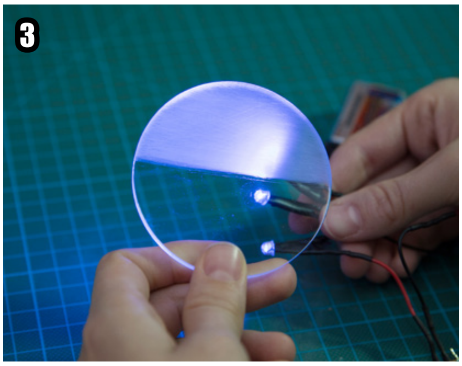
There are many ways to incorporate glowing spheres into your costumes. The most important part is to hide the battery pack connected to it as well as placing the switch at a convenient but well hidden position.

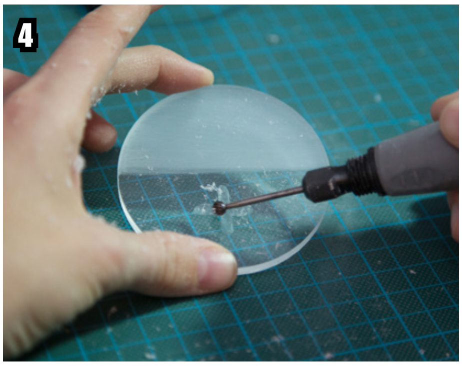
Plexiglas

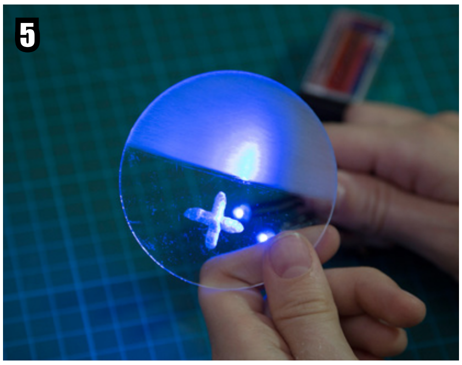


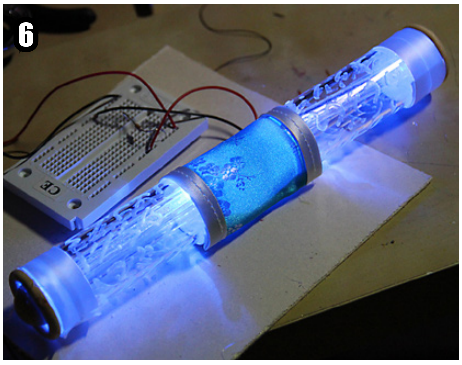












When hearing Plexiglas, most people think of regular standard sheets. However just like acrylic, you can find Plexiglas in many different shapes like poles, pipes, plates, cubes and even orbs. All of these shapes spread light in their own unique way and it's quite exiting to turn on a circuit that you've build into Plexiglas for the very first time. Be prepared for a bit of research though, since different countries offer different varieties of Plexiglas.

Working with this material - again - requires some additional tools: a dremel, drills, electronic saws and even heat guns. It all depends on what you want to build. A creative cosplayer however is able to find solutions without buying all that. For example: Many shops that sell Plexiglas also offer cutting the material on request. Ask for that. It's sometimes not easy to calculate ahead that much, but if you've planned your costume piece or prop thoroughly you can often order a perfect piece of Plexiglas online. In addition it's possible to rent a lot of tools in your local hardware store without the need to buy them.

For ornaments, runes, signs and any other forms of glowing details an ordinary dremel is completely sufficient. It's even possible to solder thin sheets of Plexiglas, just try it out. The process is pretty slow compared to a jig saw, but a soldering iron allows you to cut out free forms and gives you much more creativity with the material (if you use very thin sheets). Keep in mind that melting Plexiglas as well as other plastics will release toxic fumes, so go to a well ventilated area and wear a respirator.

Once you brought your Plexiglas into the right shape and added some lights, you'll love the effects. Unaltered, Plexiglas will just let the light through without a hitch **(1)**. But sand it **(2 + 3)**, burn it or dremel details **(4 + 5)** and they will light up, while the rest of the "unharmed" Plexiglas will just transport light to the outer edges. So if you want to light up a whole sheet, sand the entire surface with sanding paper or maybe even create a pretty gradient from transparent to shiny. So many possibilities! I'll talk more about my shining Plexiglas scrolls **(6)** later in this book.

If you’ve been following my past books you know it’s finally time for some work examples!

They are probably not as fancy as all the impressive ideas you already have in mind for your next projects. This is however the book to introduce you to LEDs so I’m going to keep it simple.

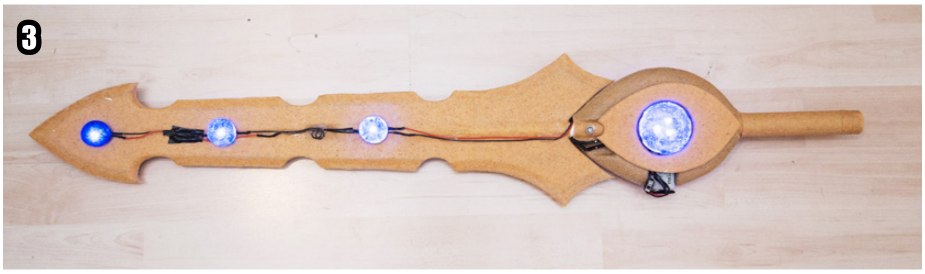
While building a working circuit already needs some knowledge, hiding one inside a costume is a completely different story. That’s the point where the magic happens. So exciting!

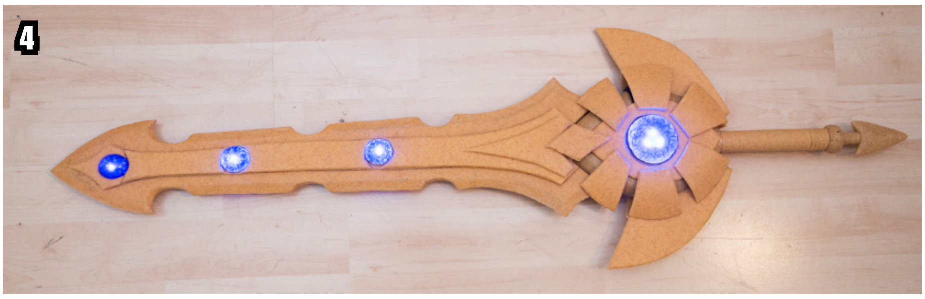
Work examples: Dani Moonstar's Sword

Dani Moonstar's sword includes a total of 12 LEDs inside of several resin gemstones. Having to travel a lot with my costumes I wanted to be able to split the prop as well as the circuit inside into two parts.

Dani's blade was a challenge because of two important reasons: First I had to find out how to detach the blade from the grip. Second, I also had to install a whole bunch of LEDs inside a relatively tiny space. After building the base mainly out of balsa wood, EVA foam and a PVC pipe **(1)** I started thinking about the upcoming circuit and the proper way to hide wires, switches, LEDs and the power source.

To give everything some extra space I carved "paths" into the wood and cut a whole block of foam out of the massive grip part to make space for the battery **(2)**. After I've covered wood, foam and plastic with a coat of Worbla, I glued the pre-soldered circuit directly on the material. Once every light was set, I've build up the rest of the prop. **(3+4)**. This way my wiring disappears, but more importantly it helps save the electronics from external damage.





Note:

Make sure your wiring is flawless before you begin covering it. Once your wires are stored inside your prop, it will be hard to get them out again without damaging your piece. If everything works out, your circuit is safe and you don't need to worry about breaking soldered connections.

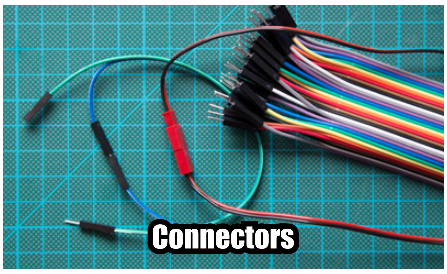
The circuit itself was made out of twelve 3V LEDs in total, three LEDs each in series connected parallel in four branches. The power source was a 9V block battery, so as you can see no resistors at all were necessary. However the battery would be drained a bit quicker than usual due to the parallel connection.

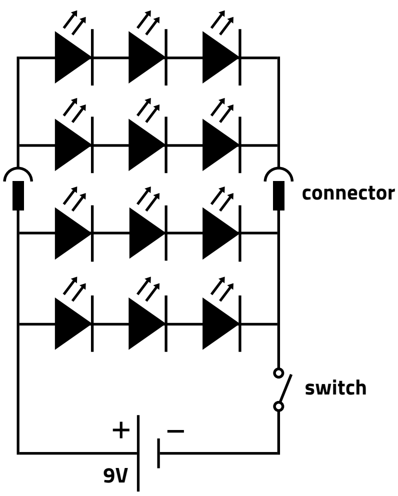
A connector between the battery and the LEDs had to be implemented as well **(5)** to make it possible for the circuit to be separated into two parts.

Hiding the battery was a bit semi-professional since I was in a rush to get the costume done - but it worked nevertheless: A rubber band, glued to one of the Worbla pieces, wrapped around the battery holding everything together. Then the Worbla piece was attached to the sword itself using magnets. The design of the hilt made it possible for a single piece to be detached. This was what I used to hide the battery and the switch. Luckily it was not necessary to change the 9V power supply that often. With around 550mAh the calculation for the sword "lifespan" looked like this:

$$\frac{550\text{mAh}}{4 \cdot 20\text{mA}} = 6.875\text{h}$$

Since we have four series connections in parallel, it's necessary to multiply 20mA (per series connection) by four. So I still got 6.875h which is 6h and 52 minutes. Not too shabby!





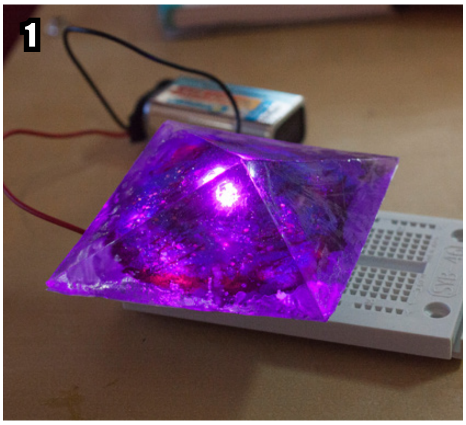
Note:

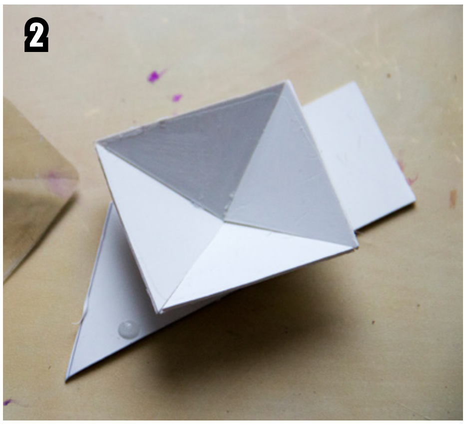
Always take a few extra batteries along. You never know how long your convention day will be and it would be too bad if you would have to save energy during the day to still be glowing in the evening. Also bring scissors and some tape. Broken circuits can be fixed temporarily by exposing more metal wire and taping it together.

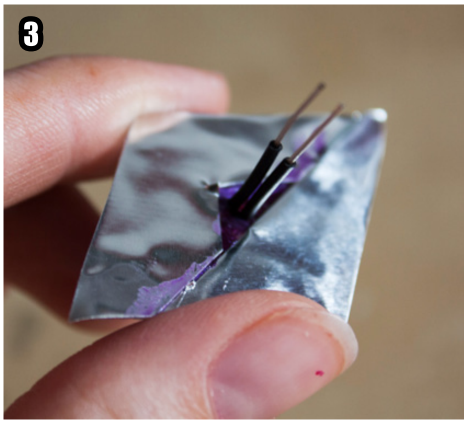
Photographer - Benjamin Schwarz

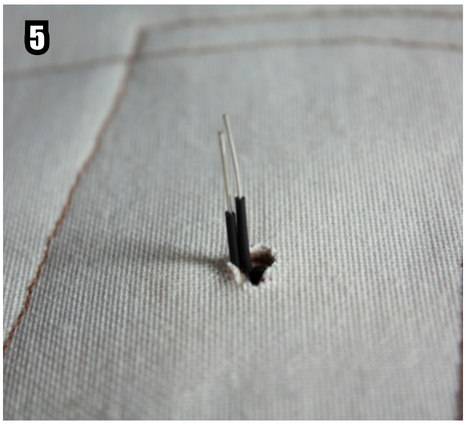
Work examples: Druid T9

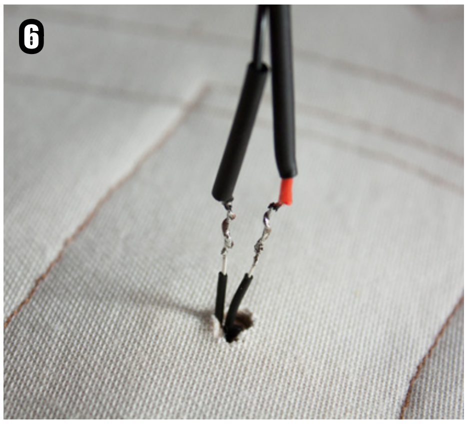
Done in 2010 my Druid Tier 9 costume is one of my older projects, but with around 16 LEDs gemstones, a lit-up leather robe and additional glowing armor parts it's clearly still an interesting example.









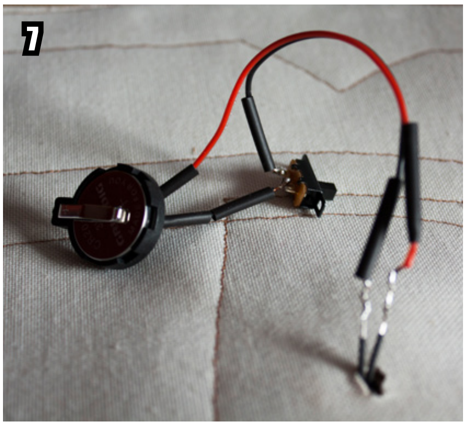


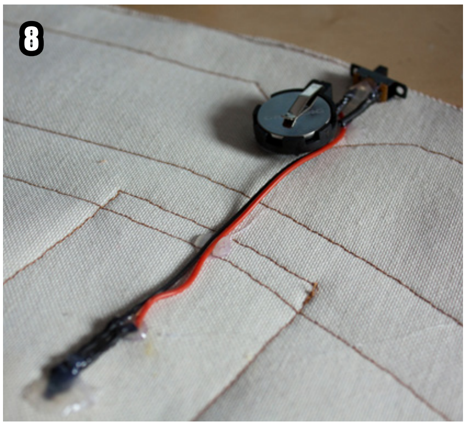
Hiding a circuit in a prop is quite easy. Cables, wires and batteries can be stored under layers of foam, plastic and paint. Lighting up a dress that you'll run and jump around in for a whole day at a convention is a bit more challenging though. It's also quite educational – no matter if your circuit survives or not.

The sources of light were LED gemstones spread all over my costume **(1)**: Six on the skirt, one in each bracer, four in each pauldron. 16 gems in total that had to be cast first. This time however I wanted them in the shape of a pyramid. Since I had nowhere to buy the right shaped blanks I had to create them myself. With the help of some math and my super old school formula collection (the only thing I kept from school) I calculated the surface of a pyramid. Then I transferred the measurements to 0.03inch (1mm) thick plastic sheet, cut everything out and glued all parts together. This was the mold for my upcoming gemstones **(2)**. It's a good thing that you already know how the rest works, right?

With thick metallic foil on the back instead of fragile aluminum foil it was much easier to hot glue the gems to the fabric of my costume **(3)**.

For that I've marked the right spots for the LED legs, cut a hole **(4)** into the fabric and let the cables glide in **(5 - 6)**. Now I just needed to connect it to the rest of my circuit.





Building a circuit into a costume often means providing as much cable as possible. You need to think of where you have to stretch and where you require more space for movement. Cables are not elastic so they will rip apart when pulled. At the same time you have to hide all these wires.

It's different if you want to add a circuit to a skin tight bracer however. In my example I had to save as much wire length as possible **(7)**. First I hot glued on the LED **(8)** and then soldered the connections directly over the inner side of the fabric. Once everything worked **(9)**, I attached it to the bracer (you can also use tape or stitch it directly to the fabric) and covered the circuit with a layer of thick fabric to protect my skin from scratching.

After that my glowing bracer was done **(10)**! Now everything that was left were the other 15 LEDs I had to connect!

Note:

If you have many identical LEDs to solder, it's quite helpful to combine work steps. Cut, solder and insulate your LEDs one after the other. That way, you will not only get faster, but also make fewer mistakes. Since you don't need to calculate every new connection, circuit building gets much more relaxed.

Where to hide your cables

Hiding wires, batteries and all the rest you don't want to show, is a new challenge with every costume. You need patience, creativity and especially time to try your construction before a convention. It's better if something breaks a week before than at the big day, right? A hot glue gun is - like aways - a huge help. Once the circuit works and all soldering parts are covered by at least ten layers of tape, I mostly glue my wires directly to the inside of my costume. You can also hide them between two layers of fabric. The result will not look pretty, but nobody will check your costume from the inside as long as you can distract them with all those LED lights from the outside.

If you want to have a glowing headpiece, wigs are awesome for battery storage. Helmets, masks, tiaras and all the other stuff you want to place on your head often don't have space for bigger parts of the circuit. So just keep your wires long and use your wig cap or your wig as comfy place for your power sources. Aside from that, it's totally fine to use anything you'll find to hide your electronics. Be creative, use small batteries and don't cut wires too short. A tiny backpack, the inner side of your armor, foam caves or even your hat could be the perfect solution. Just try it out and don't forget your hot glue!

Note:

The circuit of my Druid Tier 9 robe was in fact directly glued on the inner side of the costume. Since some gemstones were nowhere near the rest of the circuit, wires ran through the whole dress. My 9V battery and the switch made some trouble until I finally sewed a little pouch between two costume layers at my hips.

Note:

We all know how useful hot glue can be. Keep in mind however, that wires covered with hot glue are hard to reach again. So test and solder your circuit well, before you cover everything with glue. Repair work could become difficult otherwise.


Photographer - Benjamin Schwarz

Work examples: Protoss Wizard

The Protoss Wizard was one of my largest projects yet and was already shown in my other books. Because of the amount and the difficulty of the LED circuits that I used, it was tricky and also very educational. It's totally useful to bring it up as another example here.

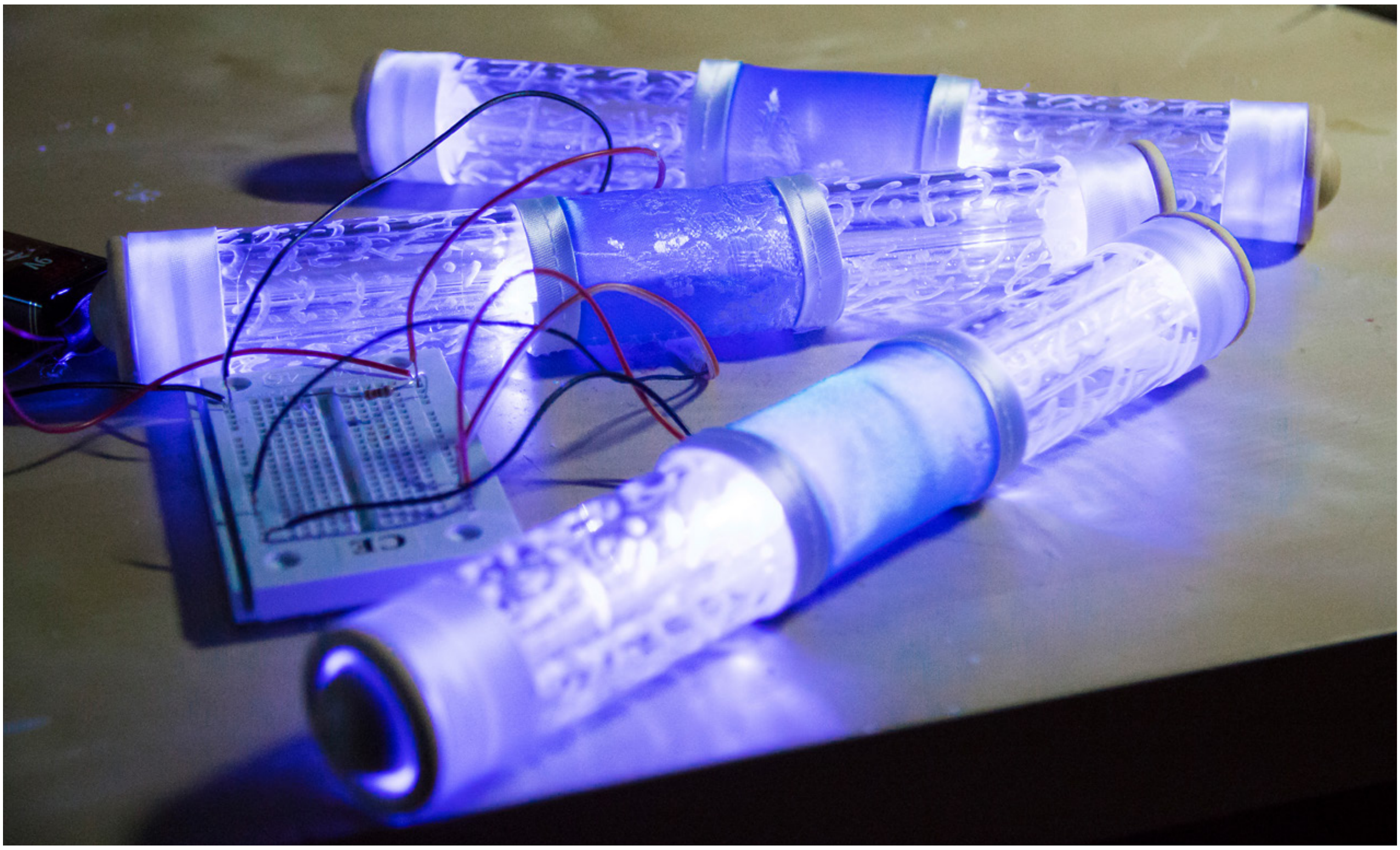
Maybe not noticeable at first, my Protoss Wizard had in fact almost 200 LEDs built in. Around 120 blinking and pulsing lights hidden behind six resin blades in my staff - as well as another 50 LEDs in the costume. It truly required a lot of wiring. The biggest challenge however was to hide all these cables somewhere!

When you plan a project as big as the Protoss Wizard you really have to take your time and plan ahead. You want to have everything laid out in perfect detail before you even start thinking about buying LEDs and cables. I did several drawings of the areas I wanted to light up and made multiple complete circuit plans. Since this costume was based on my own design, I really enjoyed to be free and tried to find out what would look good and what would end up as a weird mess of blinking lights and cables. It was important for me to create a silhouette and set highlights on certain spots. So I tried to illuminate my body by spreading the lights evenly and not just to concentrate on one area of the costume.

The wiring required some experimentation as well. I almost had no space for batteries and switches. For my bracers a 3V flat battery cell did the job. They are not only really small and easy to hide in comparison to their massive 9V siblings - they are also great for circuits with only one or two LEDs. These little cuties are just perfect to use for armor. I mainly use them for bracers and leg armor, since I had no other option to hide a bigger power source.

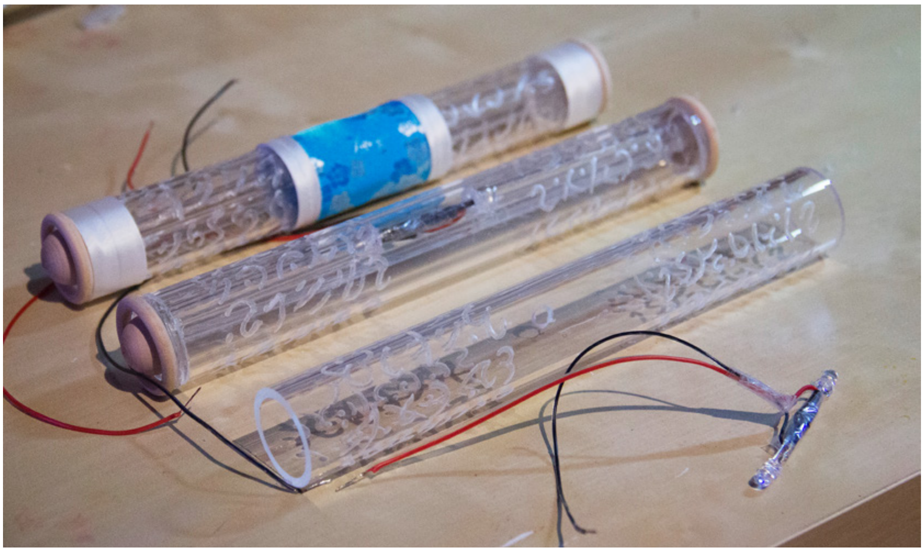
As you can see in the image on the left I basically "dug" into the material of my bracer, got rid of layers of Worbla and craft-foam to create space for the circuit. It doesn't look that nice from the inside, but that doesn't really matter. Since the battery is often completely built in into my props and costume parts, it requires strength, brutality and a heat gun to change the power source. In addition sometimes there is just no better option, especially if you work on your costume last minute and have no idea how to finish all that in time. When it comes to cosplay it's often more important to get the costume done than to get it done in a very clean fashion - but you probably knew that already.

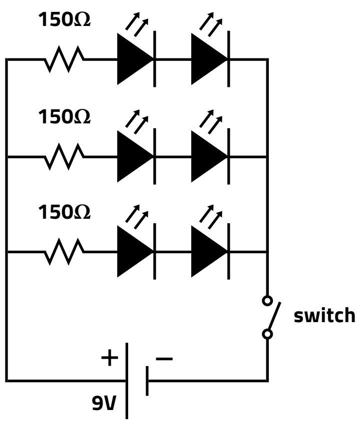
I still recommend to start with a project as early a possible. For my Protoss Wizard even *two years* seem to be a too short time span.



I had to experiment a lot during this project. One of my results were magical scrolls that I lit-up with blue LEDs. The base of these scrolls were Plexiglas pipes in which I carved runes using a dremel. To give them their radiant special look I drilled a hole in the middle and set a pair of two 3V LEDs plus a fitting resistor in each scroll. Every LED had a smaller Plexiglas pipe on its top to spread the light better throughout the whole construction. At the end I added fabric, details and soldered the circuits – three series connections in parallel. Since the switch and the battery (9V) were placed on the outside and attached to my robe, it was no problem to hide wires and the rest of the circuit under the fabric. You see, this time it was not necessary to add tons and tons of hot glue.

The whole costume in fact was a huge experiment, mixed with bright days full of success and weeks and months of failing, tears and pure depression. To tell you the truth: When I was finished with all of the circuits and all of its gemstones, resistors, switches, batteries and cables - I ripped it all out again. Just because I was not satisfied with the result and wanted to make the costume even better. I wanted my lights to move, to pulsate, to "live". But that's a story I will tell you in the second part of my LED books.





$$\frac{550\text{mAh}}{3 \cdot 20\text{mA}} = 9.166\text{h}$$


Photographer - Benjamin Schwarz

A look ahead!

At this point you see, it's not really about "knowing" how to build a working circuit - it's about experimenting to get exactly the result you want. There are many possible solutions for each project and there is no right or wrong way. As long as everything is glowing and shining, you've done a good job! You will look *awesome*!

Hopefully LEDs do not seem that scary anymore. Now we can breathe in and move on to more elaborate, more complicated and clearly more amazing projects. There are so many more cool things we can do with electronics. We basically opened the door to a whole new world of possibilities: animated lights, sounds, moving parts, animatronics - as long as you don't give up there is nothing can stop you from creating truly outstanding costumes that will blow away even the most experienced Hollywood costume makers! Until then I'll see you in my second book where we will tap into programming animated lights that will breath new life into your beautiful yet static costume LEDs.

Note:

Congratulations! You have now the knowledge to create simple LEDs. Just open Google and search for more tutorials if you feel comfortable with what I covered in this book. I'm sure you'll become a LED master in no time!

Thank you!

This concludes my fourth book! I was quite scared of this issue since LEDs can be a really complicated topic. I hope I was able to explain everything in an understandable and down-to-earth manner.

I tried to write this book to my former self that was scared of electronics years ago. If you have the same worries as I did, I truly hope I was able to show you that there is no reason to avoid electronic shops anymore. Wiring up costumes and giving them some cool light effects is truly no rocket science, but takes some courage to start with it.

So congratulations, now you're ready! Grab your pocket calculator and swing your soldering iron. I'll expect to see you shining like the sun at the next convention!

TO BE CONTINUED...

Print Formulary

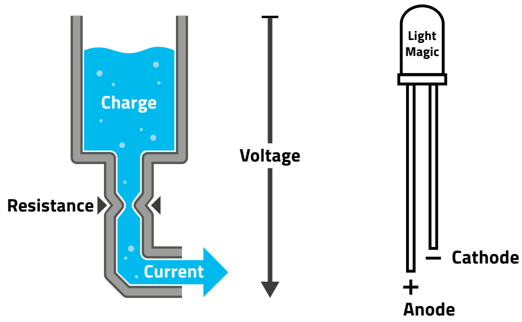
This page is meant to be printed out. Use it to quickly look things up.
Always remember: **You can do this- I believe in you!**

Units

V = Voltage in Volts (V)

I = Current in Ampere (A)

R = Resistance in Ohm (Ω)



Resistance

$$\text{Resistance(Ohm)} = \frac{\text{Voltage}}{\text{Current}}$$

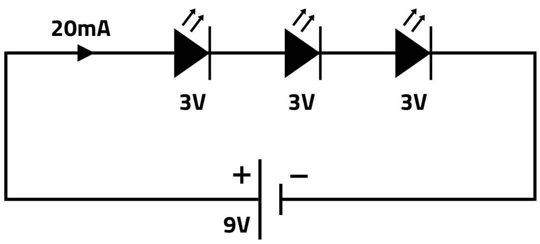
or

$$R = \frac{V}{I}$$

Battery Life-Span

$$\frac{\text{mAh provided by battery}}{\text{total mA required by your LEDs}} = \text{Battery Lifespan (in h)}$$

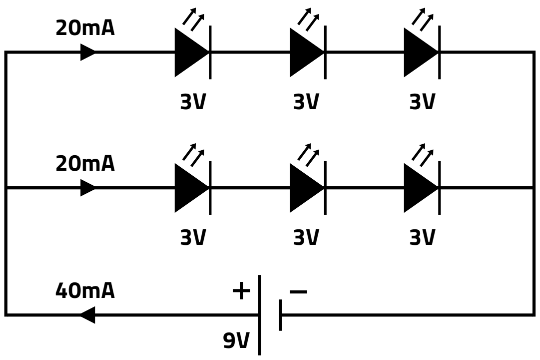
Series Connection



$$V_{Battery} = V_{LED1} + V_{LED2} + V_{LED3}$$

$$I_{Battery} = I_{LED1} = I_{LED2} = I_{LED3}$$

Parallel Connection



$$V_{Battery} = V_{LED1} = V_{LED2} = V_{LED3}$$

$$I_{Battery} = I_{LED1} + I_{LED2} + I_{LED3}$$

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Germany

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