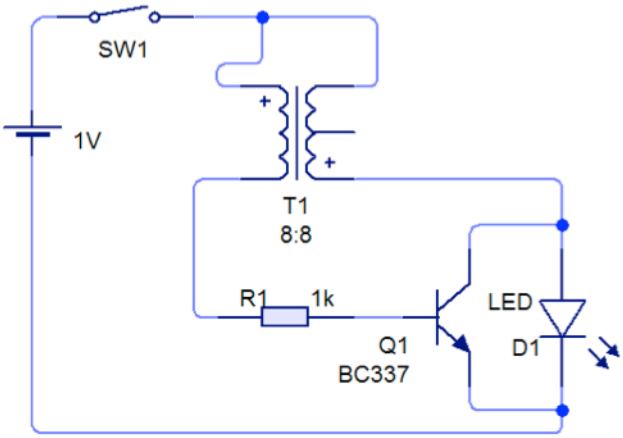
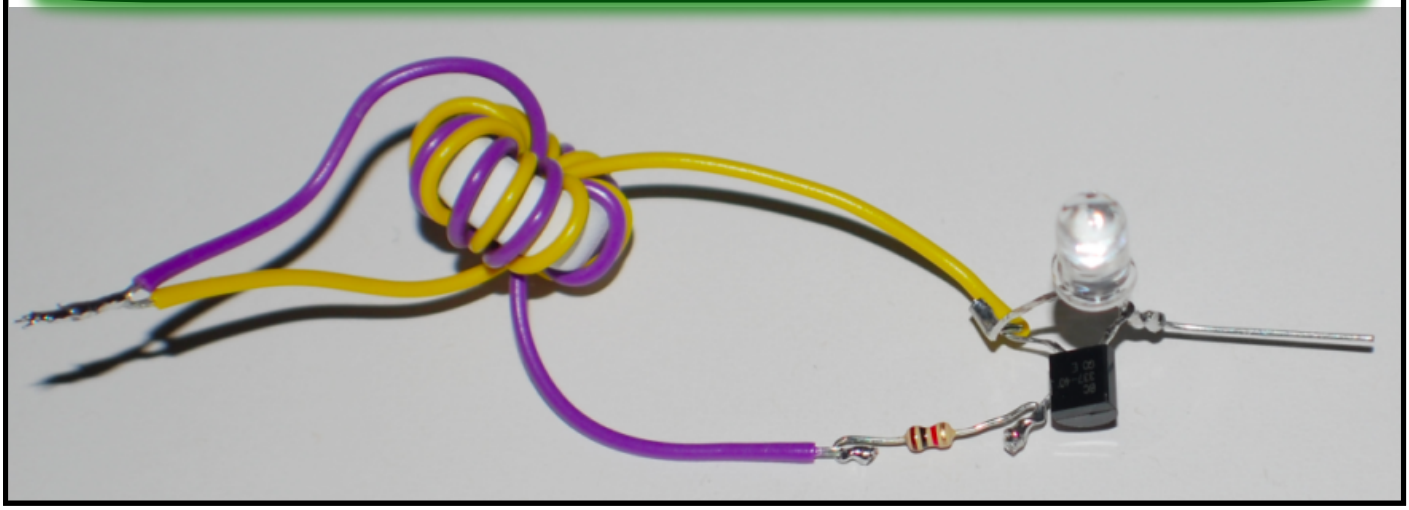
# Making a Joule Thief: step-by step

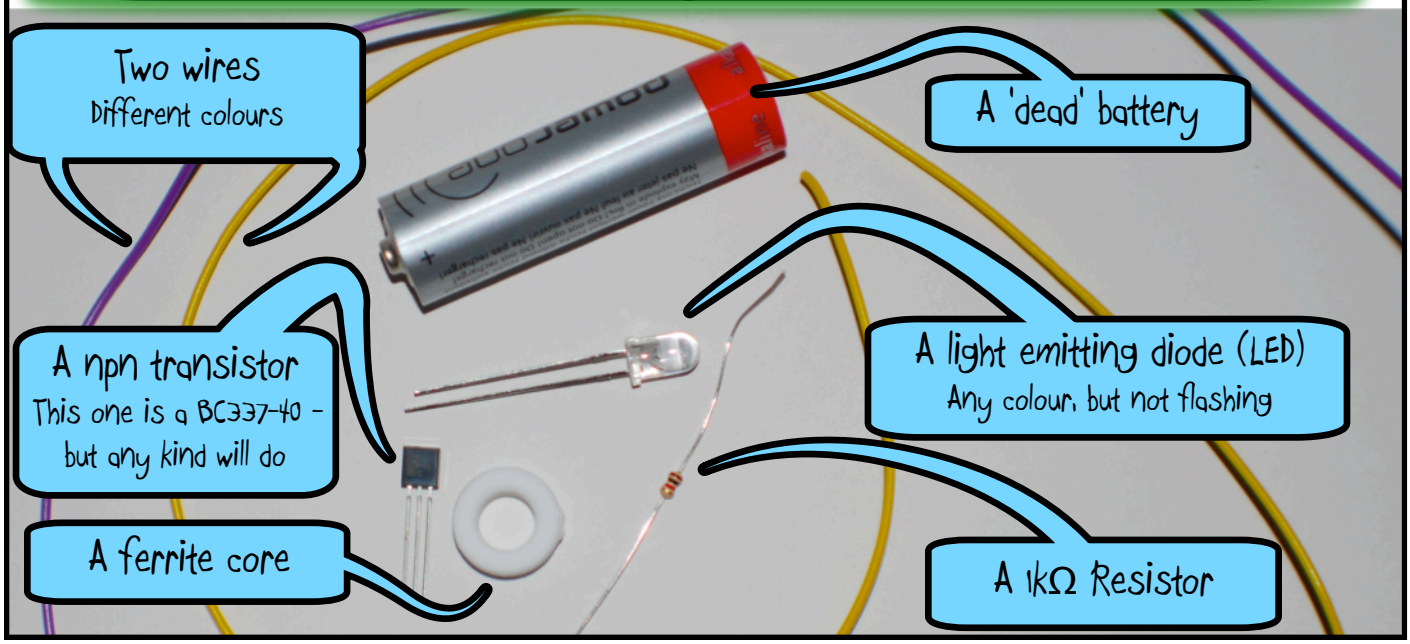
A joule thief is a circuit that allows you to use the energy (the joules) still left inside a battery that is 'dead'.
We'll describe how it works after you've built it.
The circuit diagram for a Joule Thief is shown on the right.




## This is what the final circuit will look like...

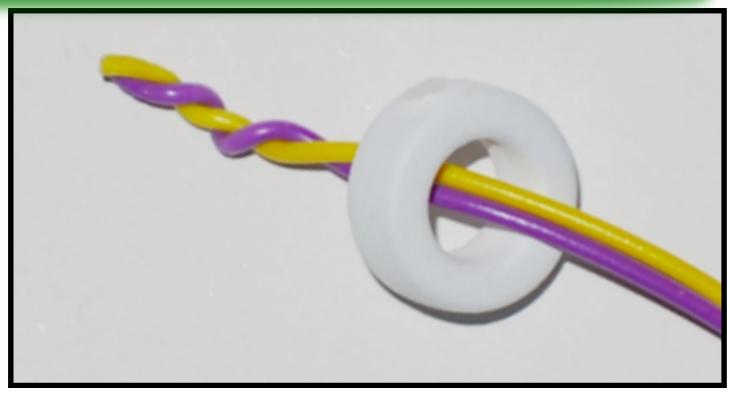


## ... and these are the components you need:



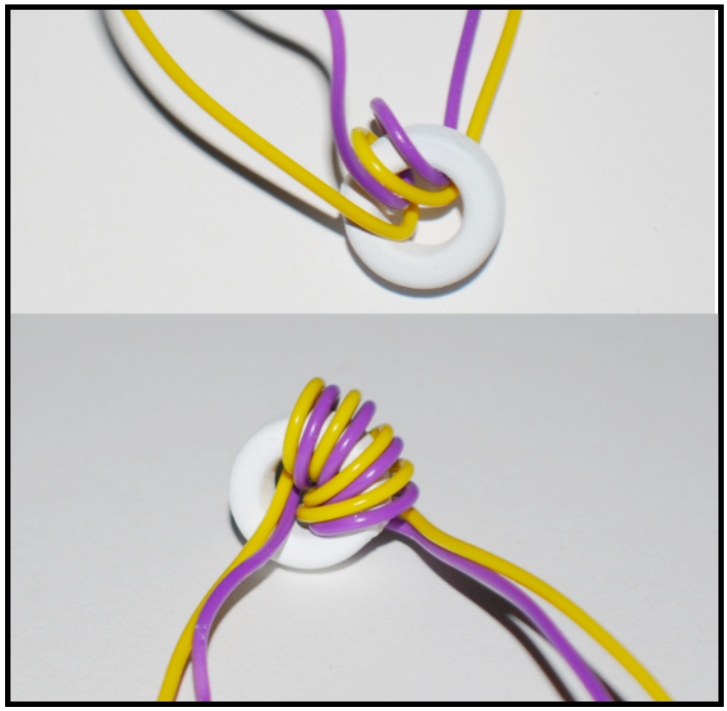
# First you make an inductor

The first step is to twist the two wires together at one end and place them through the hole in the ferrite core.



Now you need to wrap the pair of wires around the core.
Use the twisted end to thread the two wires through the hole.

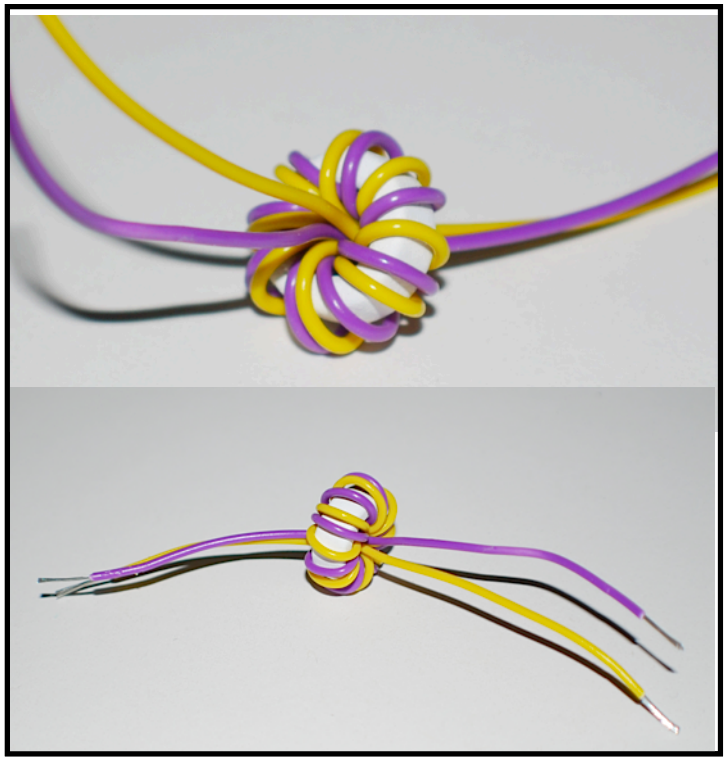
Keep it as tight and as neat as possible; this will help you get more turns of wire onto the ferrite core.



Aim for between 8 and 16 turns of the wire pair around the ferrite core.

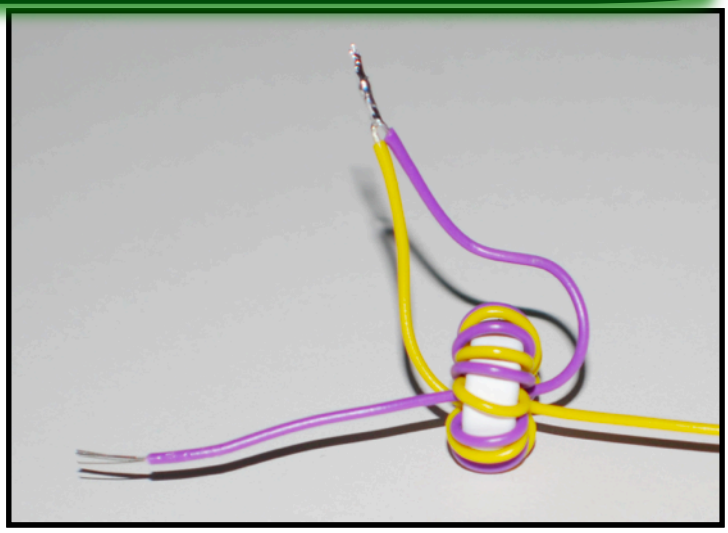
On the one shown there are only 8 turns because a small ferrite core was used and it wasn't possible to fit any more on.

You will finish with a pair of wires coming out of each side of the core.
Trim the wires so that they are 4-8cm long and strip the ends.



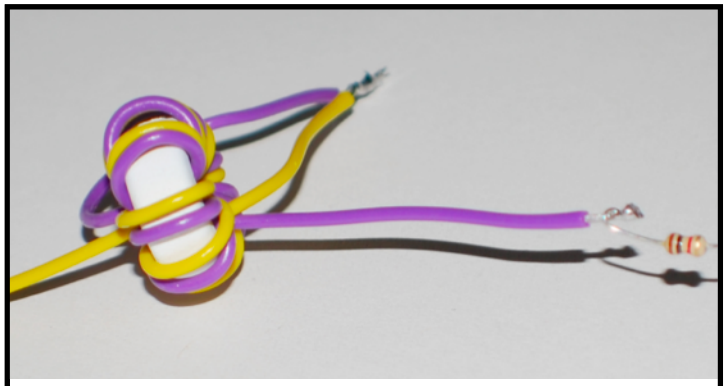
# Next assemble the circuit

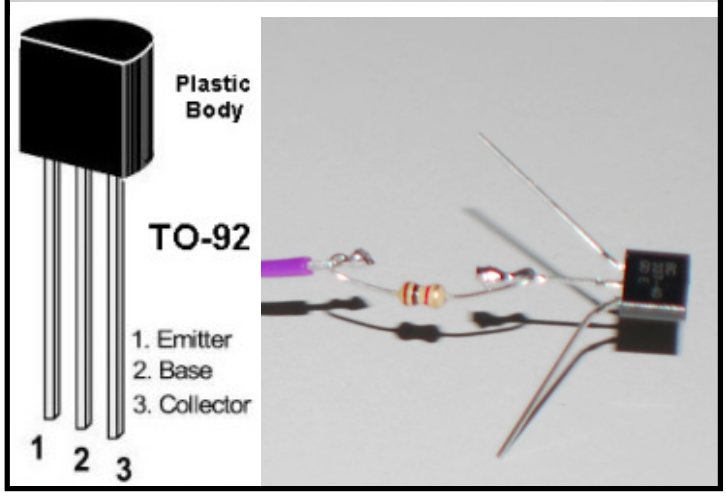
Choose any wire coming out of the inductor you have made. Then pick the wire coming out of the other side that is a different colour.
Solder these two wires together



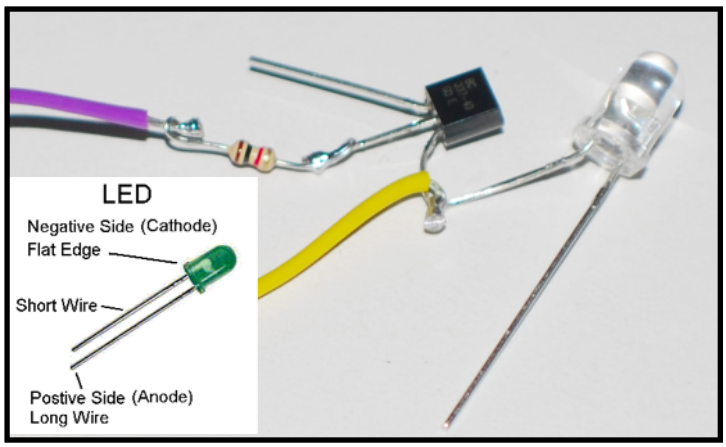
Solder the 1kΩ Resistor to either of the unsoldered wires coming from the inductor.

Solder the other end of the resistor to the base lead of the transistor.
On the transistor used here, that is the middle lead.
Cut off the spare ends of leads.

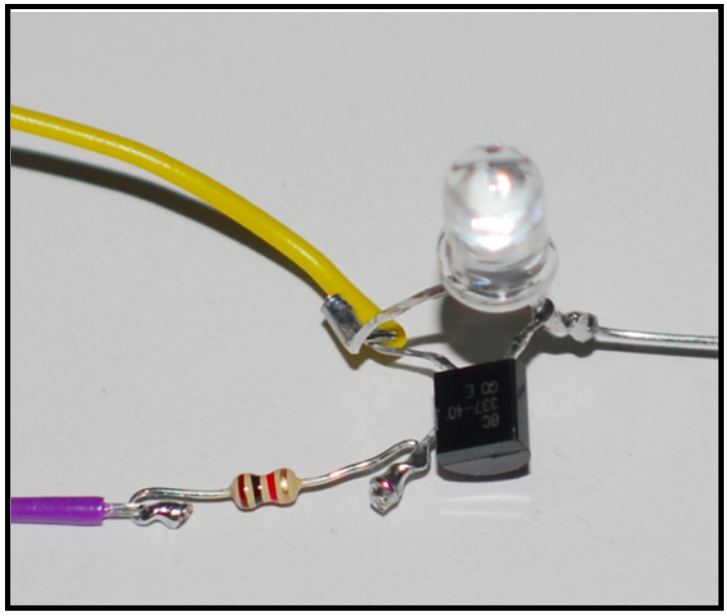





Solder the anode of the LED (the longer leg) to the collector lead of the transistor AND the remaining wire from the inductor.
Cut off the ends of the leads.

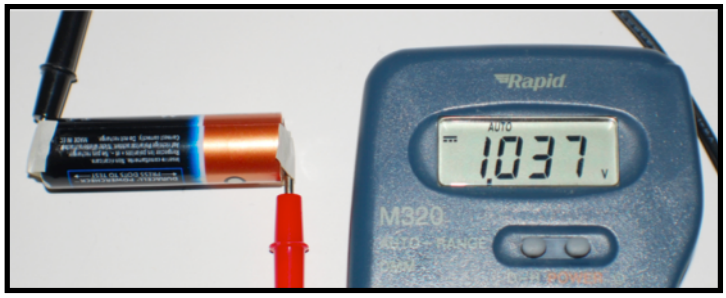


Solder the other leg of the LED (the cathode) to the emitter lead of the transistor.
Do NOT cut off the LED leg.
(Don't wory if you have cut it off - you'll just need to solder another wire to this leg so that you can connect it to the battery.)

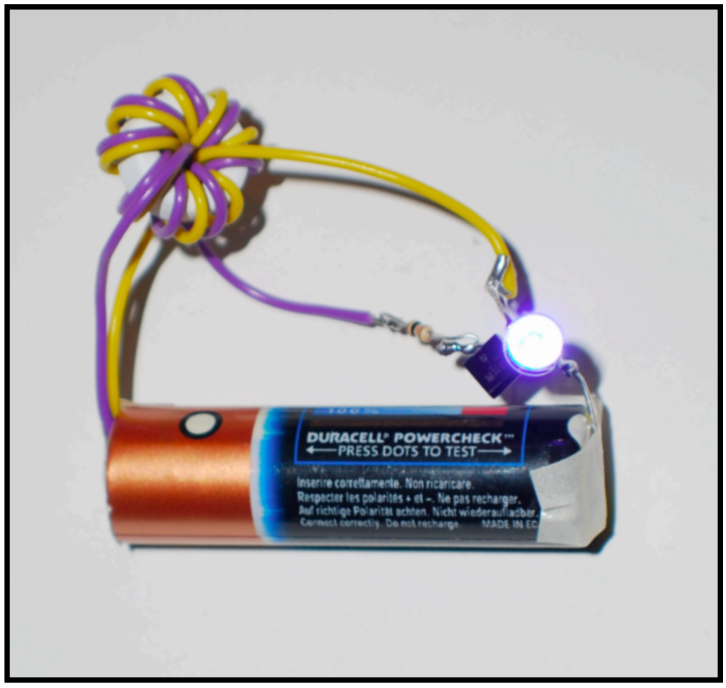


That's the circuit finished. Now use it.

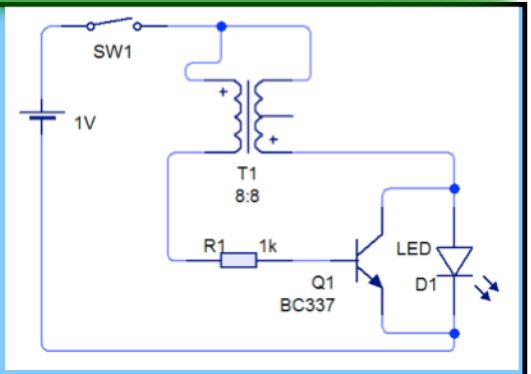
First you need a 'dead' battery - that means one where the voltage is less than 1.3V.
You can see that the battery used here has a Voltage of just over 1V.




Connect the two soldered wires coming from the inductor to the positive (+) side of the battery.
Connect the uncut LED leg (the athode) to the negative (-) side of the battery.
The LED should light brightly.



# How the circuit works (the short version)




The joule thief works at a range of voltages down to 0.35 volts. When the circuit is switched on, charge flows into the base of the transistor switching it on. (The size of this current is limited by R1). This causes a larger current in the righthand coil which bypasses the LED as it goes through the transistor. Wires that carry a current produce a magnetic field which is made stronger by coiling the wire around a ferrite core. Energy is stored in the magnetic field.

The lefthand coil, being wound on the same core as the righthand coil experiences this build up of a magnetic field in the ferrite core. This change in magnetic field in the lefthand coil generates a current pulse in it in opposition to the original base current - effectively causing the transistor to rapidly switch off, which in turn switches off the current in the righthand coil. The magnetic field collapses and, as it does so, the magnetic energy stored in the coil is converted into electrical energy resulting in a high voltage spike across the coil terminals. This voltage spike is enough to cause conduction in the LED and produce a short burst of light.

With the magnetic field collapsed, the process repeats itself. The time between the voltage spikes is shorter than the persistence of vision so the LED appears to be permanently on.

[With thanks to Paul Gardiner]

# Sources and further information

The Wikipedia entry is very thorough: http://en.wikipedia.org/wiki/Joule_thief

There are many online descriptions on how to make a Joule Thief. I found the following helpful:

http://blog.makezine.com/archive/2007/11/make-a-joule-thief-weeken-1.html

http://www.bigclive.com/joule.htm

http://mdkshareef.hubpages.com/hub/Make-A-Joule-Thief

http://www.ledsales.com.au/kits/joule_thief.pdf

Paul Gardiner has written an excellent article, "Eco nightlight", describing how he has used the Joule Thief with KS3 pupils to create a nightlight that is charged from a cheap low voltage solar panel (replacing a 'dead' battery with a different low voltage source). http://www.ecteducation.co.uk/index.php/2011/11/eco-nightlight/

# Fair use of this material

This comic has been produced by Torben Steeg. torben@steeg.co.uk

It is released under a 'Creative Commons Attribution-Noncommercial-Share Alike 2.0 UK: England + Wales' Licence. This licence lets you remix, tweak, and build upon this work non-commercially, as long as you credit Torben and licence your new creations under the identical terms.

All new work based on this comic must carry the same licence, so any derivatives will also be non-commercial in nature.

BY NC ND

TSCR Torben Steeg Consultancy & Research