Example logbook report for Apsc 1299:
The Joule Thief

This following pages contain an example logbook that a student might have written while performing an experiment where they built a “Joule Thief” circuit.

Note that you do *not* need to write your logbook exactly like this one in order to get full marks—there is quite a bit of flexibility in how an engineer can organize and record data in their logbook. However, this example should give you an idea of what level of detail you need to aim for, and what kinds of data are important to record.

An engineer’s logbook can be used as a legal document to, for example, establish who owns an idea or innovation in the case of a patent dispute. For this reason, your logbook must be written in ink, and have each page signed (or initialed) and dated. Graphs may be done in pencil. Computer code should be permanently pasted or stapled into the book.

Your logbook also needs to be a complete record of everything you did in the lab, so even your mistakes and unwanted results should be documented fully. Never remove pages, and never obscure information from the logbook. If you make a mistake, cross out the error with a single line (so it can still be read), and write the correction nearby.

When you join the work force, you’ll often be called upon to make an estimate on how long a job will take, or to bill your clients accurately for the time you spent on their project. For this reason, you’re required to record the current time in your logbook regularly. By getting into this habit now, you’ll develop a good “feel” for how long certain tasks take, and will always have a record of exactly how long you worked on a particular project.

The annotations in this logbook will point out things an instructor would think the student did well and things they would feel were lacking. Overall, however, this logbook displays good note-taking skills and would likely receive a very good grade.

Ima-Jean Yuss

Sign and date every page

Building a "Joule Thief" Circuit — Nov 3, 2015

Equipment used:

1:54 pm

Record the time often. A good habit is to record it when you start or stop a task, and regularly during the task if it's taking a while.

Breadboard — PIC 18F4525 mcu
1 red LED — AC Adaptor
1 kΩ resistor — wires
10 200Ω resistors
2N3904 NPN transistor
hand-wrapped inductor coil

~~Programs used:~~ none this time!

Start a new experiment's write-up by recording the experiment title and all the equipment and computer programs you'll use.

Objective: To build a "Joule Thief" circuit that is supposed to run an LED off a nearly-dead battery, i.e. low voltages.

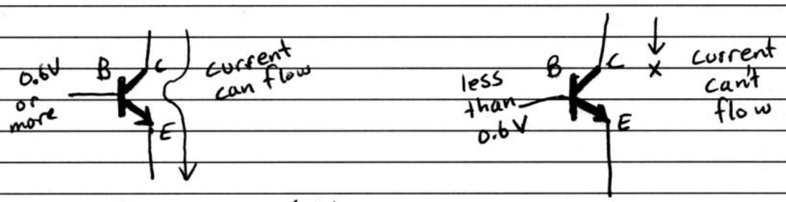
It's good practice to write an objective for the whole experiment but more important to record what you're doing as you go along.

A task list can be included instead of an objective.

Reading the manual, taking notes. 1:58 pm

Notes on transistors

For our purposes, a transistor is a switch. When there is a voltage of 0.6 V or more at the base B, then current can flow freely between the collector C and emitter E.



transistor is "closed" like a switch being closed to allow current to flow through the touching metal surfaces

transistor is "open" so current can't flow.

2:04 pm

If you don't record the time at least once per page, you'll lose marks.

Ima-Jean Yuss

Sign and date every page

Notes on Inductors

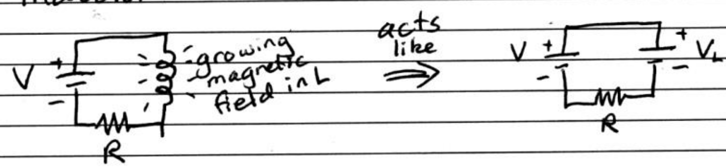
Nov 3, 2015

When charge carriers (electrons) move in a loop, they make a magnetic field. Creating a magnetic field takes energy, and this comes out of the kinetic energy of the charge carriers. 2:05 pm

The logbook needs to be self-contained, so important information from the lab manual needs to be copied into the logbook.

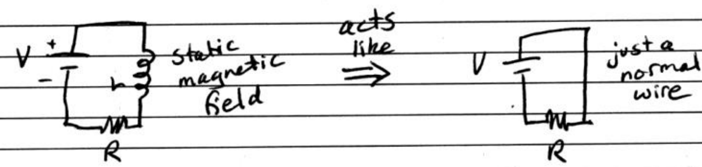
So a growing magnetic field acts like a battery that opposes the voltage that is forcing the electrons to move through the inductor.

A handy way to do this is simply to take notes in your logbook while you are reading through the theory sections.



Eventually the magnetic field reaches a maximum set by L and V. 2:09 pm
(L ← inductance; V ← voltage)

Because the field is not changing, it isn't taking the electron's energy anymore, so then it acts like just a wire.



(In this Joule Thief circuit, we have 2 inductor coils that share one magnetic field because they are wrapped around the same core.) 2:12pm

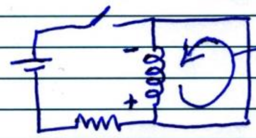
Continuing to record the time regularly.

Ima-Jean Yuss

Inductors - continued

Nov 3, 2015
2:15 pm

If the voltage driving the charge carriers is shut off and another path is provided, the inductor will act like a (weakening) battery facing the other way.

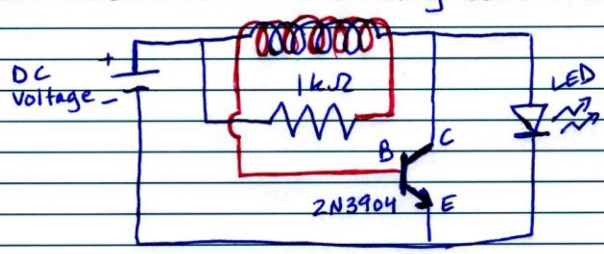


current flows this way while magnetic field collapses.

Notes on Joule Thief circuit

2:28 pm

The circuit we are building looks like this.



Current flows from the battery through the resistor and through the red inductor coil to the base B, which turns on the transistor. Current can then flow through the transistor from C to E.

The current makes the magnetic field in the inductor increase to a maximum, then both ~~wires~~ coils act like wires, so the transistor shorts itself out! No current goes through the resistor to B because so much is going from C to E.

This turns off the transistor and as the magnetic field weakens, it drives current through the LED. 2:42pm

Your lab write-up should be so self-contained that a person could re-produce the experiment based only on your notes, with *no* lab manual.

Thus, copy all important information, like circuit diagrams, from the manual into your logbook.

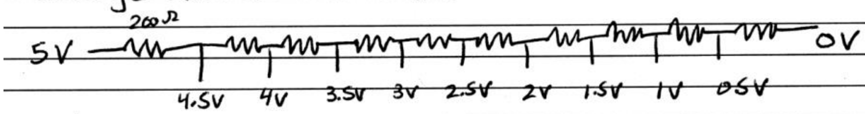
If you need to make a correction, draw a single line through the error and write the correction nearby.

Both the error and the correction should still be readable.

Ima-Jean Yuss

Starting to build the Joule Thief. Nov 3, 2015

I'm going to use a voltage divider to get low voltages instead of a dead-ish battery. The voltage divider looks like this: 2:42 pm



NOTE: Because all the resistors are the same, they have equal voltage drops across them. Each resistor has $\frac{5V}{10} = 0.5V$ drop.

Starting to build voltage divider 2:45pm

Finished building voltage divider 2:49pm

NOTE: The resistors were packed a bit too tight on the bread board, so I put post-it notes between them to prevent short-circuits

Next step is to build my inductor coil. Two pieces of wire are looped in ~~oppos~~ the same direction around the same core.

Reference: http://www.cappels.org/dproj/ledpage/leddrv.htm

↳ If you have a ferrite core, you need at least 20 turns of wire.
If you have an air core, you need at least 120 turns of wire.

Good thing I have a ferrite core! 2:52pm

Think of the logbook as a real-time diary of your work. Jot down notes on every step as you go along.

It's good practice to record the time at the beginning and end of tasks

Record outside references, but remember, the important information needs to be copied into your logbook too.

Ima-Jean Yuas

Nov 3, 2015

Continuing to sign and date every page.

Starting to build inductor 2:52 pm

Finished building inductor
NOTE I have 27 turns on my inductor.
I used green and purple wire. 3:01 pm

Building Joule Thief circuit now 3:03 pm

Finished building circuit, but it doesn't work :(3:07 pm

It's not enough to say something didn't work. Record what behaviour led you to that conclusion.

The LED only lights up at 5V input voltage, not any lower voltage, but circuit is supposed to work down to 0.6V input voltage, which is where the transistor turns on.

Trouble-shooting the circuit
3:10 pm

- LED is turning on at 5V, so LED works
- Double-checked my wiring and it looks fine. 3:11 pm
- checked resistor with ~~voltmeter~~ ~~ammeter~~ ohmmeter (multimeter) and resistance is 0.991 kΩ ≈ 1 kΩ which is what it's supposed to be, so it's okay. 3:12 pm
- Used multimeter as voltmeter to check my voltage divider is working correctly

Voltage expected (V)	Voltage measured (V) ±0.1%
0	0.000
0.5	0.495
1	0.992
1.5	1.494
2	1.991
2.5	2.490
3	2.990
3.5	3.48
4	3.99
4.5	4.48
5	4.98

Note: you have to unplug the rest of the circuit to measure the correct input voltages

3:17 pm

Trouble-shooting is a normal part of the lab. When things don't work out, methodically test each element of your circuit (or code) to track down where the problem is.

Repeated or related measurements should be put in a well-labeled table. The table headings should be written in clear English, and units and uncertainties should be included.

Note that this table would have been better if it had a clear title also.

Note the student is recording the time after each trouble-shooting step.

It's good practice to record the time on every step when you're working on something that is open-ended, or which is taking a long time, such as this.

Ima-Jean Yuss

All of those values are close to the expected value, so the voltage divider is fine. — Nov 3, 2015 — 3:17 pm

If you ask another student (or an instructor) for help, record their full name and explain their contribution to your experiment.

- I switched in Pinder Dosanjh's transistor but saw the same behaviour so transistor is probably fine — 3:19 p

- Checking the voltages that the LED is getting with multimeter

input voltage (V) ±0.1%	LED voltage (V) ±0.1%
0.000	0.000
0.495	0.495
0.992	0.668
1.494	0.690
1.991	0.704
2.490	0.716
2.990	0.731
3.48	0.751
3.99	0.785
~~4.8~~ 4.48	0.872
4.98	~~4.~~

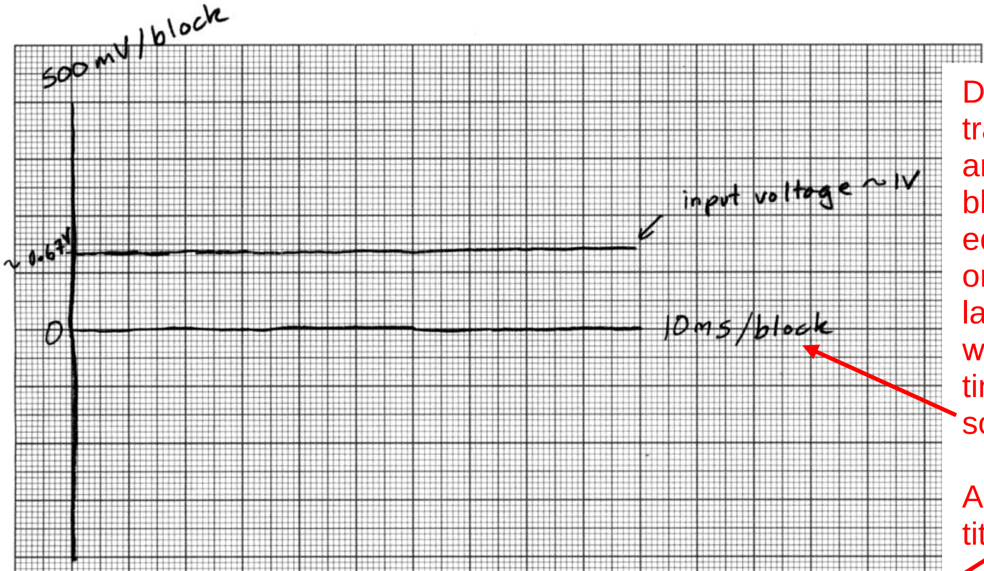
Again, this table could have used a clear title also, but the table columns have been labelled completely with a clear description, units, and uncertainties.

NOTE Oops! I burned out my LED on 5V input voltage (watched it slowly fade... kind of neat-looking). I replaced it and will only study input voltages less than the ~~2V~~ 3V? the LED can tolerate. — 3:27 pm

Jot down a note on every-thing that happens, including (and especially!) things that weren't supposed to happen.

So the LED won't light because the LED voltage is too low. I don't know why. Going to ask lab instructor Jen DeBenedictis.

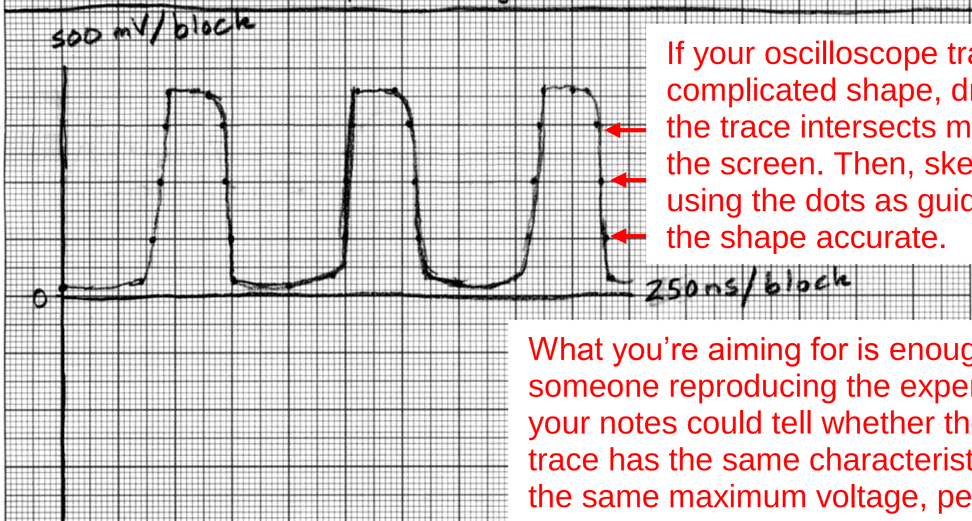
At this point, the student has identified what the problem is. Next, she'll attempt to fix it. (After the graphs on the next page.)



Draw oscilloscope traces accurately and to scale (one block on screen equals one block on the page), and label your axes with the 'scope's time and voltage scales.

Also, include a title.

Figure 1: LED output of Joule Thief (malfunctioning) for input voltage of ~1V



If your oscilloscope trace has a complicated shape, draw dots where the trace intersects major divisions on the screen. Then, sketch your trace, using the dots as guidelines to keep the shape accurate.

What you're aiming for is enough accuracy that someone reproducing the experiment based on your notes could tell whether their oscilloscope trace has the same characteristics as yours, i.e. the same maximum voltage, period, shape, etc.

Figure 2: LED output of Joule Thief (functioning!) for input voltage of ~2V

Ima-Jean Yess

Jen says a voltmeter isn't the best tool to study this circuit with because it's an AC circuit (?? I'm putting DC into it...) She says look at the signal on an oscilloscope — Nov 3, 2015 — 3:30pm

Setting up oscilloscope — 3:31 pm

Finished setting up oscilloscope — 3:35 pm

Sketching oscilloscope trace — 3:36 pm

Finished sketch

I don't know why Jen says this is an AC circuit. I see a flat line for every input voltage, and the LED voltage is pretty close to the values I measured with the multimeter. See Fig. 1 for an example.

Going to ask Jen...

Jen says if my circuit isn't oscillating, then it isn't built correctly, so I checked my wiring with her. It turns out I had my green wires swapped.

Here, you can see the student is still trouble-shooting. She records her observations on what is not working, but she will also record her observations when she finally does get it to work. Every step of her process is documented fully.

And it works now! The LED lights up visibly for 1V, 1.5V, 2V, etc, but not for 0.5V, which is too low to turn on the transistor. — 3:52pm

It's not enough to say something works. Record the behaviour that led you to that conclusion.

The trace on the oscilloscope is now definitely an AC signal. It's almost a square wave.

Drawing oscilloscope trace, Fig. 2 — 3:54pm

Finished drawing trace — 4:01pm

Ima-Jean Yuss

Analysing LED output: Nov 3, 2015

- So the peaks of the waves are 3.5 blocks x 500mV/block = 1.75V, which is enough to turn the LED on. 4:02 pm

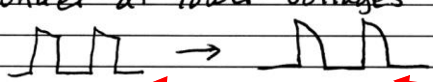
- The period is 3.25 blocks x 250ns/block = 812.5 ns

- The on-cycle (high part of wave) is 2.4 blocks wide x 100ns/block = 240ns

⇒ So the duty cycle is $\frac{240}{812.5} \times 100 = 29.5\%$

Jot down the math for even simple calculations. It's good practice to record all your data, no matter how minor, and this is a very readable way to do so. (Note: If you're doing the same calculation many times, however, feel free to record only one sample calculation for it.)

Changing the input voltage doesn't change the period ~~of~~ or duty cycle much, but the trailing edge of the "square" wave gets rounder at lower voltages



4:07 pm

Note that quasi-artistic squiggles such as the above are ONLY acceptable if you have already drawn a fully-labeled, correctly-scaled oscilloscope trace on graph paper.

Lab manual question:
What do you think will happen to the light intensity emitted by the LED as the battery drains? What is happening?

⇒ The LED only turns on when the voltage is high enough so those round shoulders on the square wave effectively decrease the duty cycle.

The LED turns on and off too fast for the human eye to detects, so it will look dimmer and dimmer as the duty cycle decreases.

4:10 pm

Done!

If this sketch had been the student's only record of what she saw on the oscilloscope screen, she would have lost marks for it.

If there are questions in the lab manual, answer them in your logbook. Make sure you include enough detail that your answer can be understood by someone who has *not* read the lab manual!

A formal conclusion is not necessary, but it's a good idea to write a mini-conclusion for each task, saying what your circuit or your code's final behaviour was.

This student did so on the previous page, when she described the behaviour of her now-working circuit.