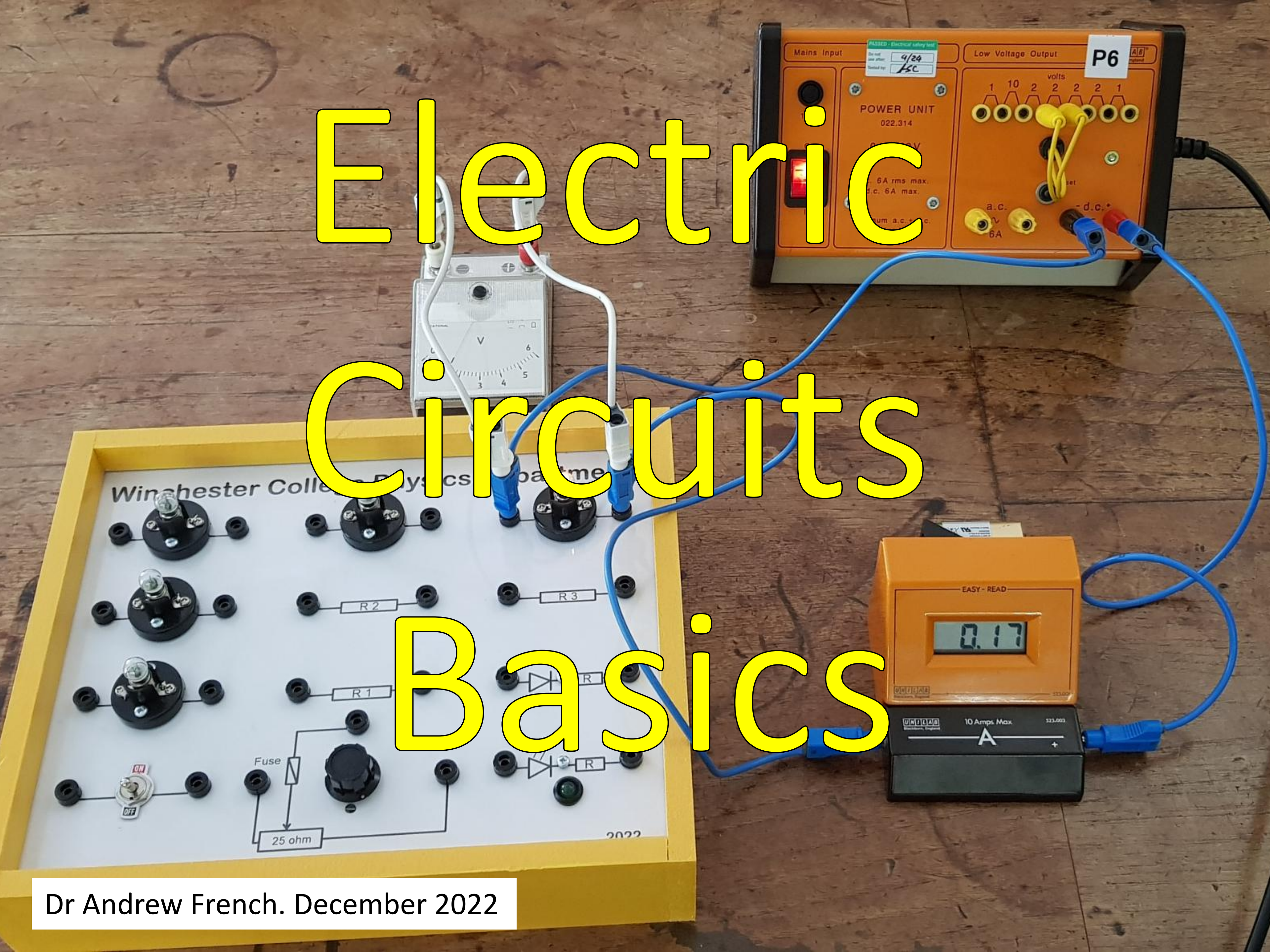
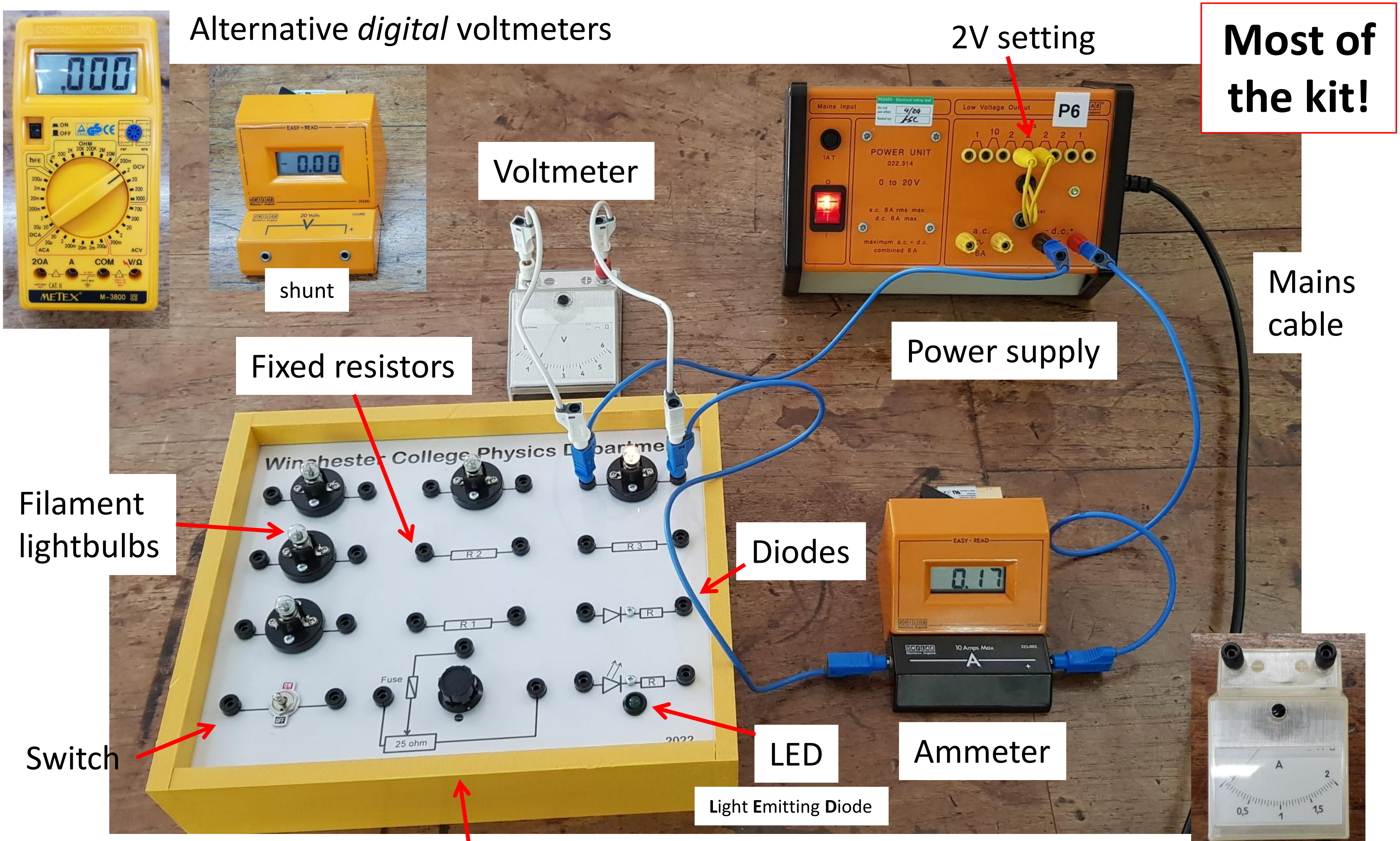
Electric Circuits Basics



Dr Andrew French. December 2022



Circuit board of electrical components

Yours might be grey or green in colour

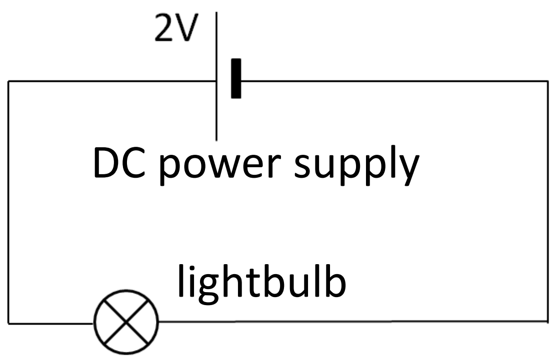
Alternative *analogue* ammeter

*** ALWAYS SET UP A MULTIMETER <u>BEFORE</u> YOU WIRE IT INTO A CIRCUIT.**
AN *AMMETER* USED AS A *VOLTMETER* WILL CAUSE IT TO BLOW A FUSE *

Circuit #1 : One filament bulb in *series* (this means a single circuit loop)

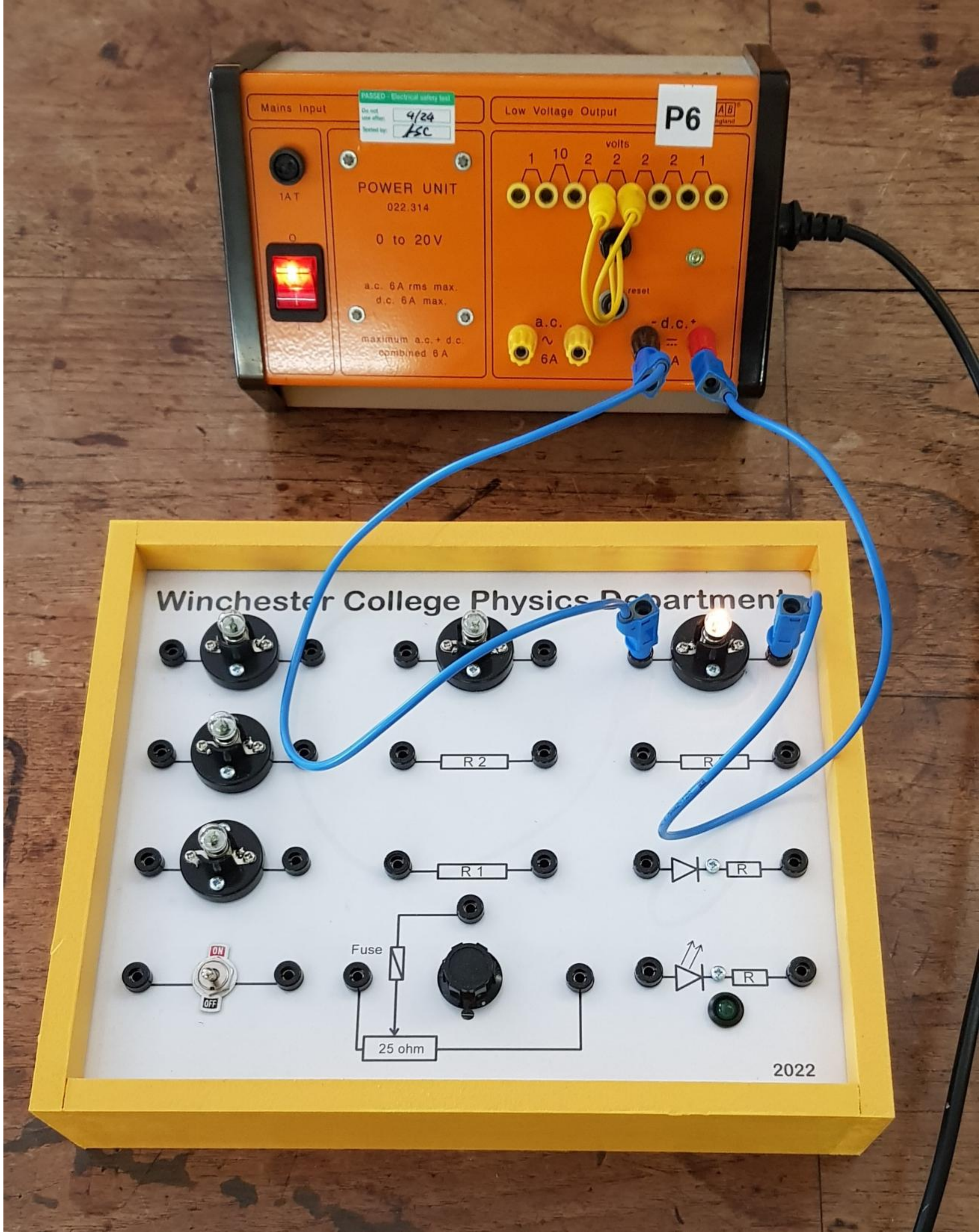
1. **Set the power supply to a 2V setting.**

2. Connect up the 2V power supply to one of the light bulbs.



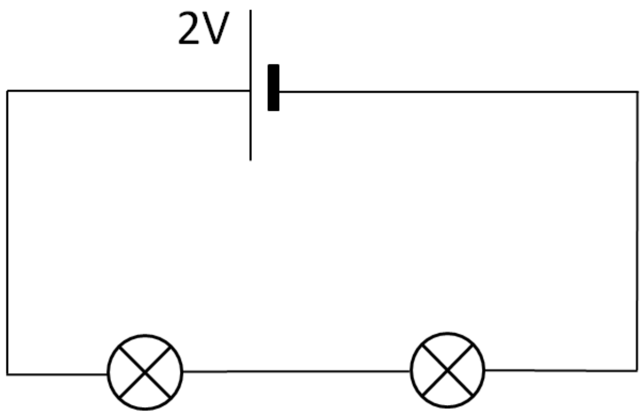
The drawing above is the equivalent **circuit diagram**.

DC means *Direct Current*
i.e. a fixed voltage is applied to the circuit, which means a constant current flows



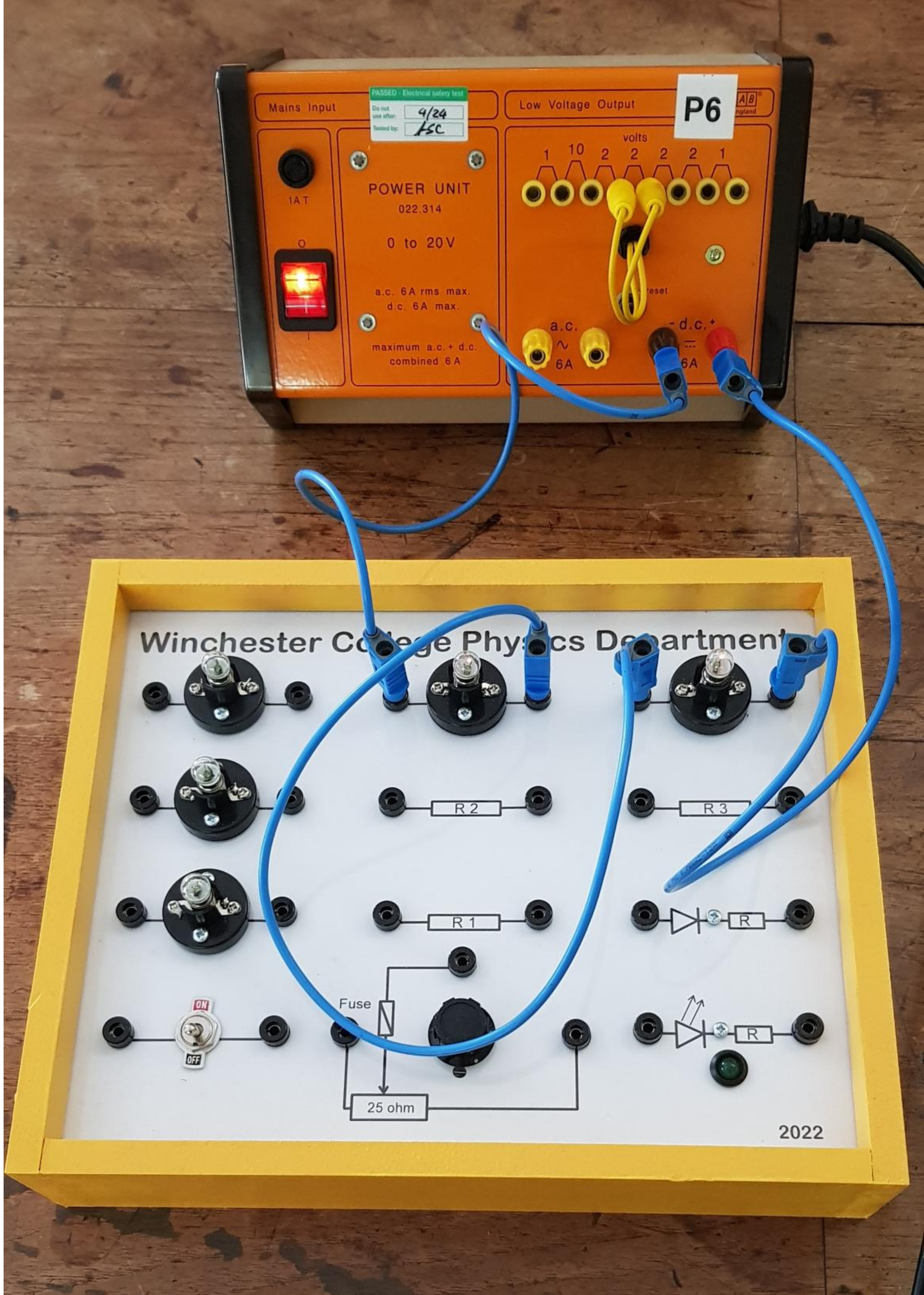
Circuit #2 : Two filament bulbs in *series*

When a second bulb is added in series, what happens to the brightness of the bulbs?



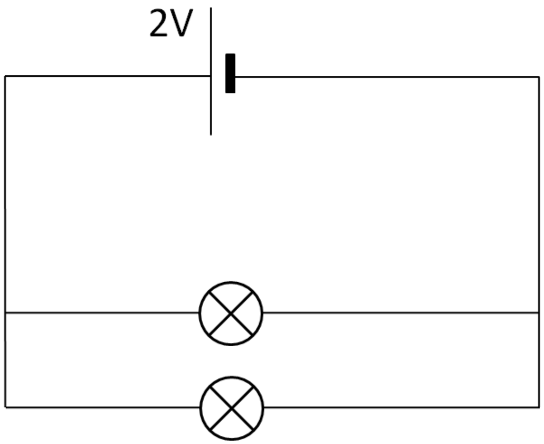
The approximately 2V is now shared evenly between each bulb.

Since 1 volt = 1 J of electrical energy transformed per coulomb of charge moved, this means *less energy per bulb* is converted into light (and heat)



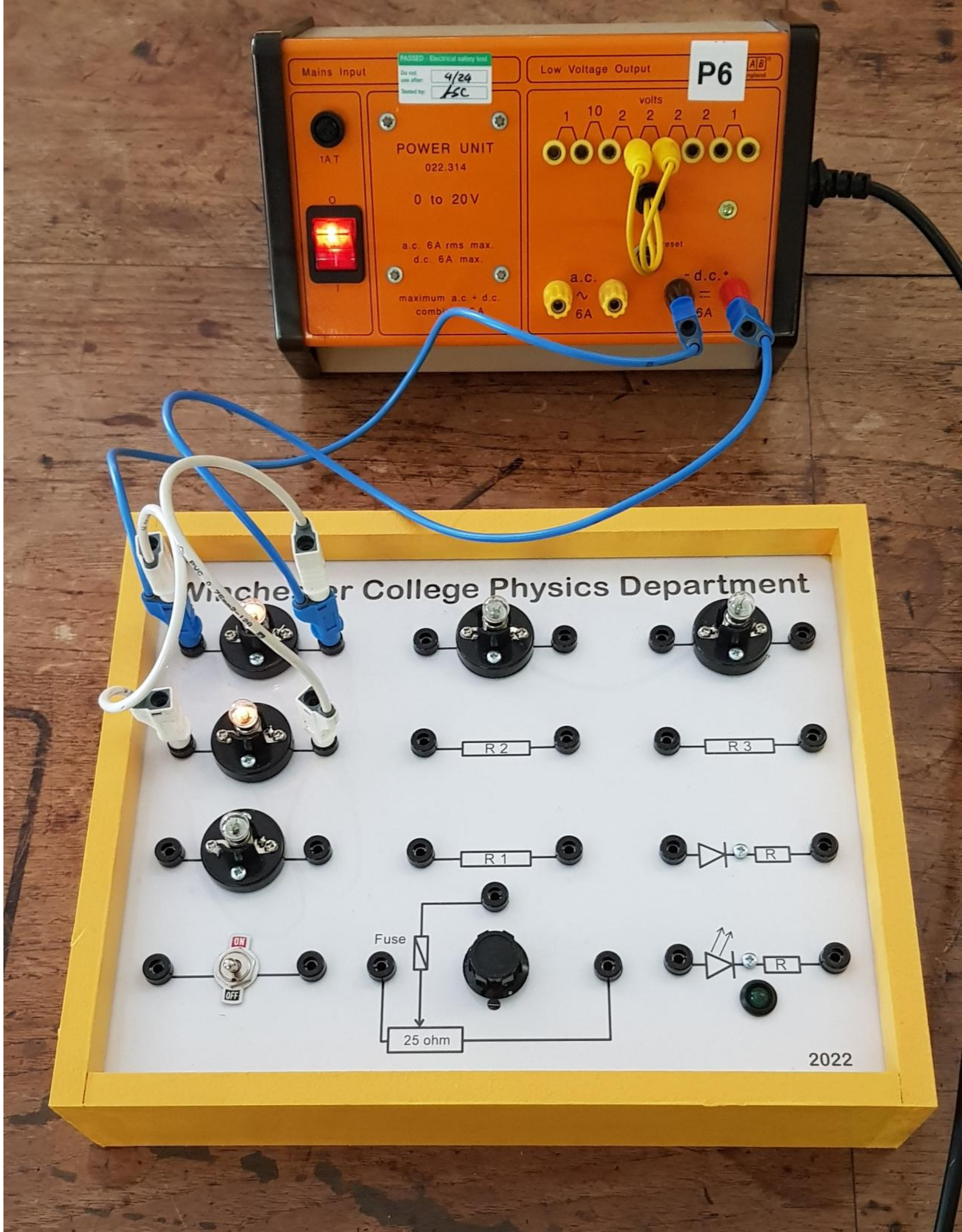
Circuit #3 : Two filament bulbs in *parallel*

What happens to the brightness of the bulbs, compared to the *series* arrangement?



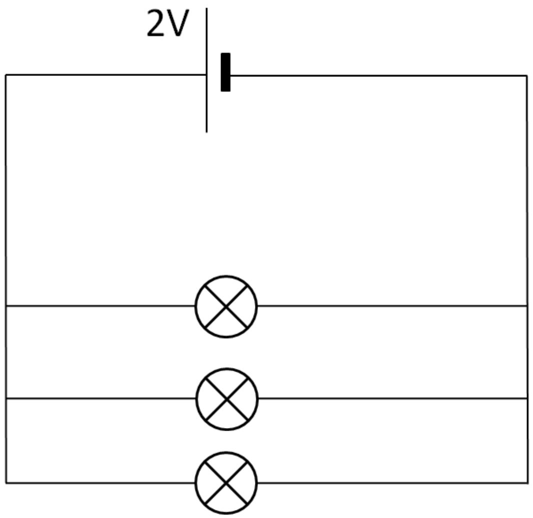
Each bulb is in a **parallel circuit branch**, and is *separately connected to the power supply*.

Therefore 2V is applied to each bulb so both should be as bright as one bulb in series.



Circuit #4 : Three filament bulbs in *parallel*

Add yet another bulb in parallel. Does the brightness change?



What do you think is happening to the amount of *current* drawn from the power supply? How does this compare to the *double* and *single* loops?

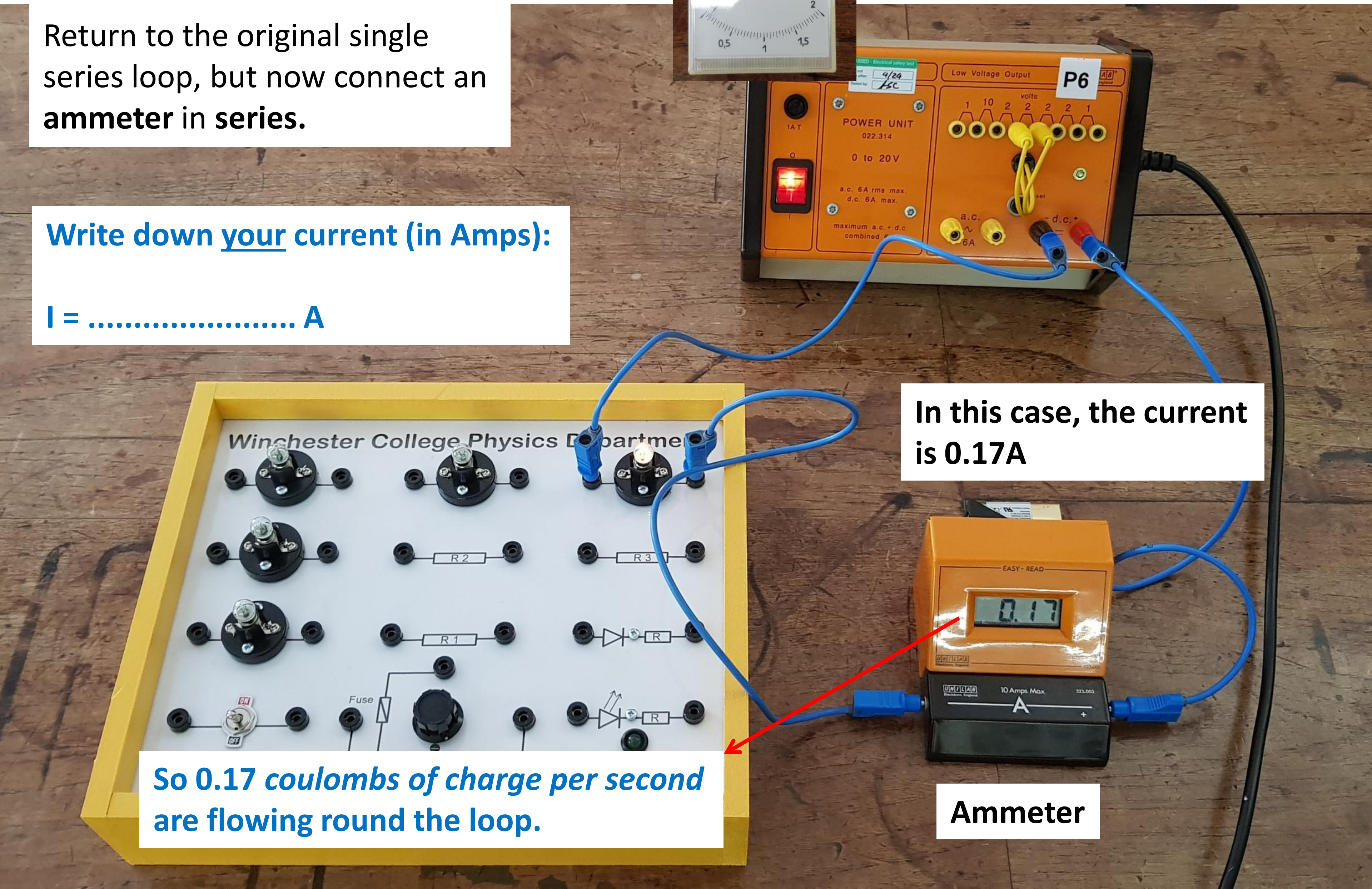
Circuit #5a : Measure current for a single bulb series circuit

Return to the original single series loop, but now connect an **ammeter** in **series.**

Note you may have an analogue ammeter instead of a digital one

Write down your current (in Amps):

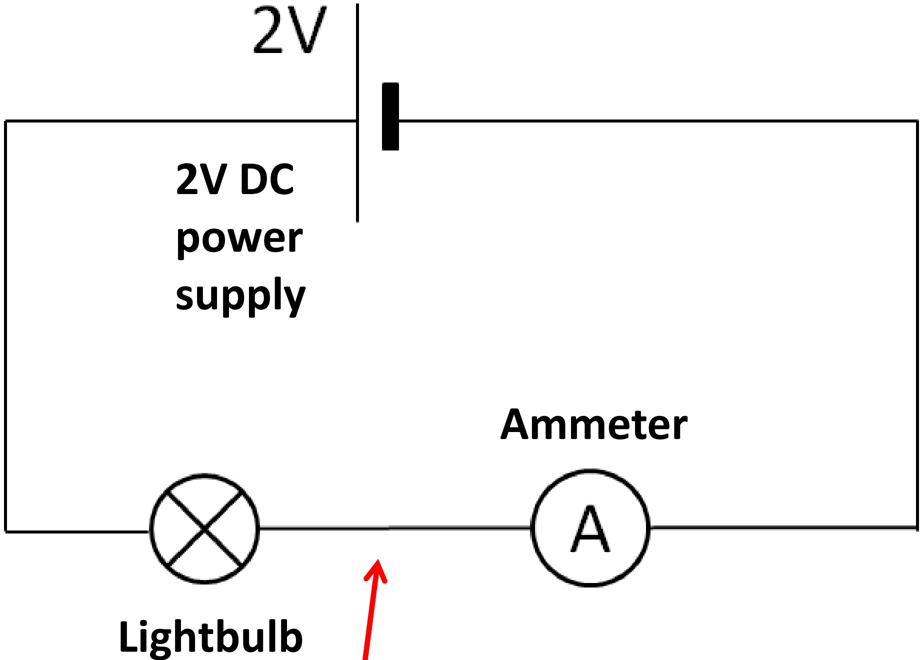
I = ... A



In this case, the current is 0.17A

So 0.17 *coulombs of charge per second* are flowing round the loop.

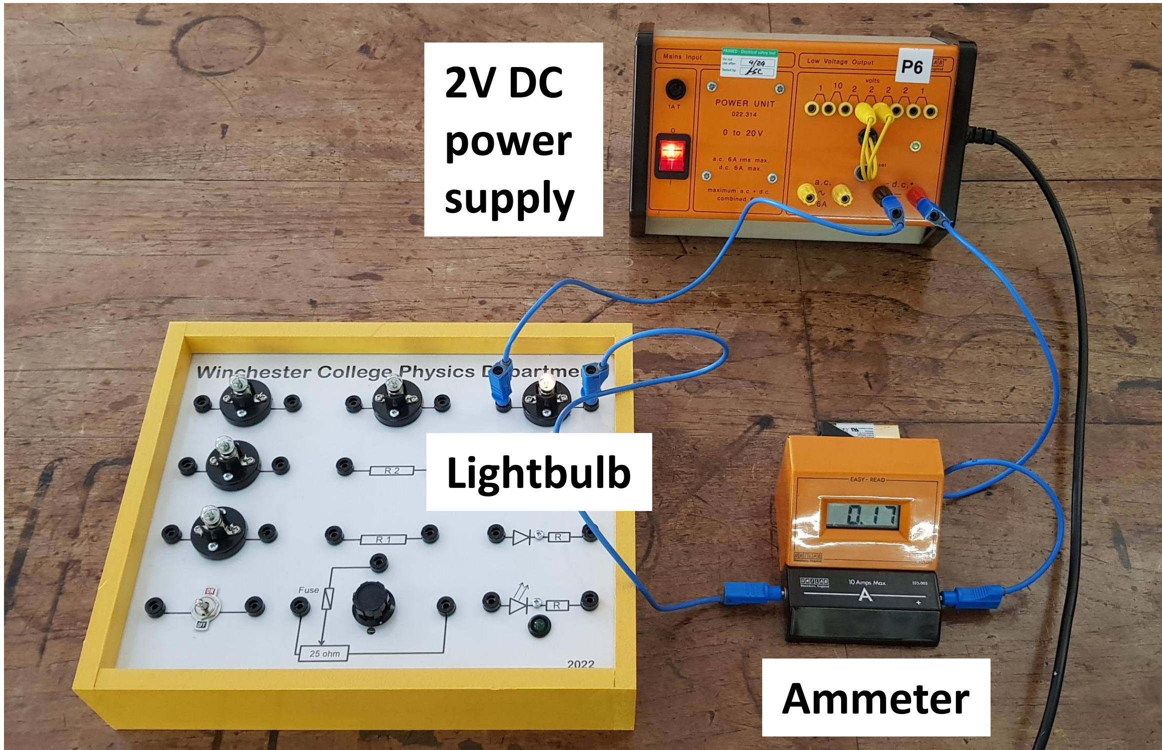
Ammeter



Circuit #5a : Measure current for a single bulb series circuit

Return to the original single series loop, but now connect an **ammeter** in **series.**

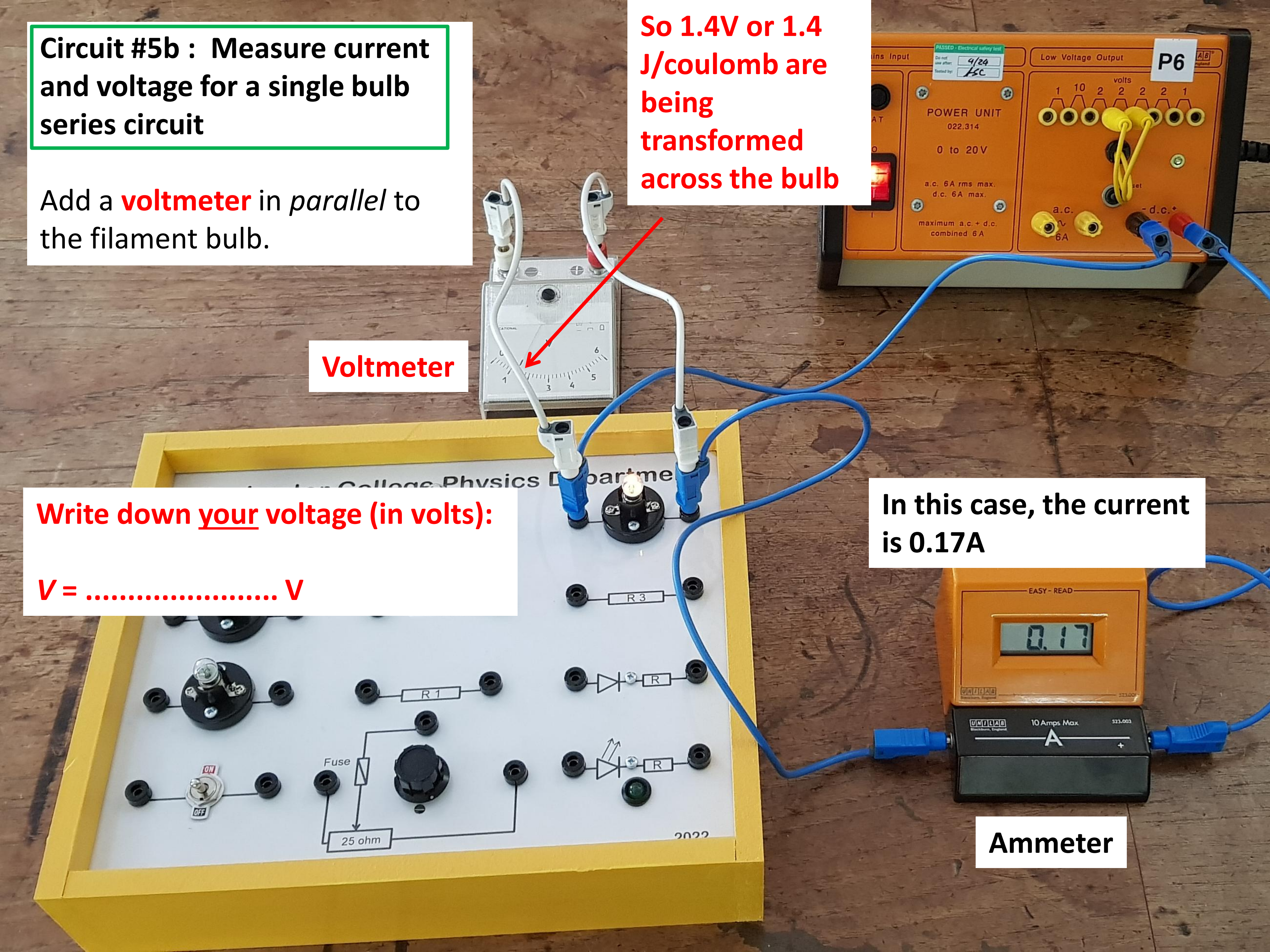
Circuit diagram (sometimes called a ‘schematic’) vs the real kit



Circuit #5b : Measure current and voltage for a single bulb series circuit

Add a **voltmeter** in *parallel* to the filament bulb.

So 1.4V or 1.4 J/coulomb are being transformed across the bulb



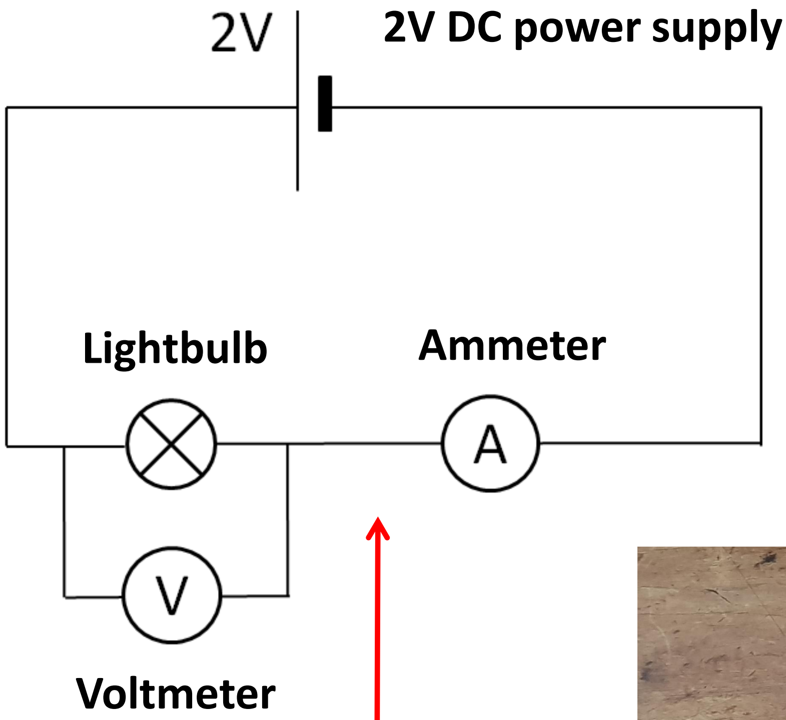
Write down your voltage (in volts):

V = ... V

In this case, the current is 0.17A

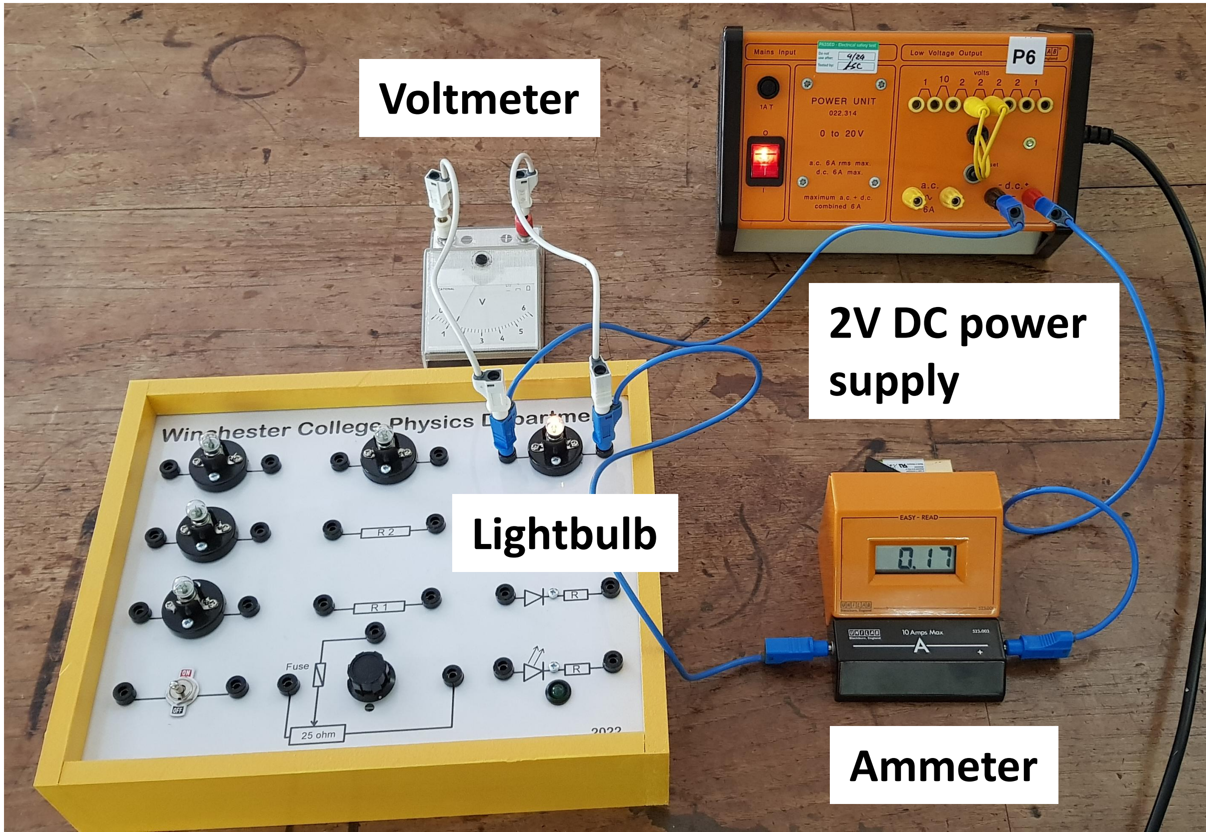
Circuit #5b : Measure current and voltage for a single bulb series circuit

Add a **voltmeter** in *parallel* to the filament bulb.



Note how this
is clearly in parallel

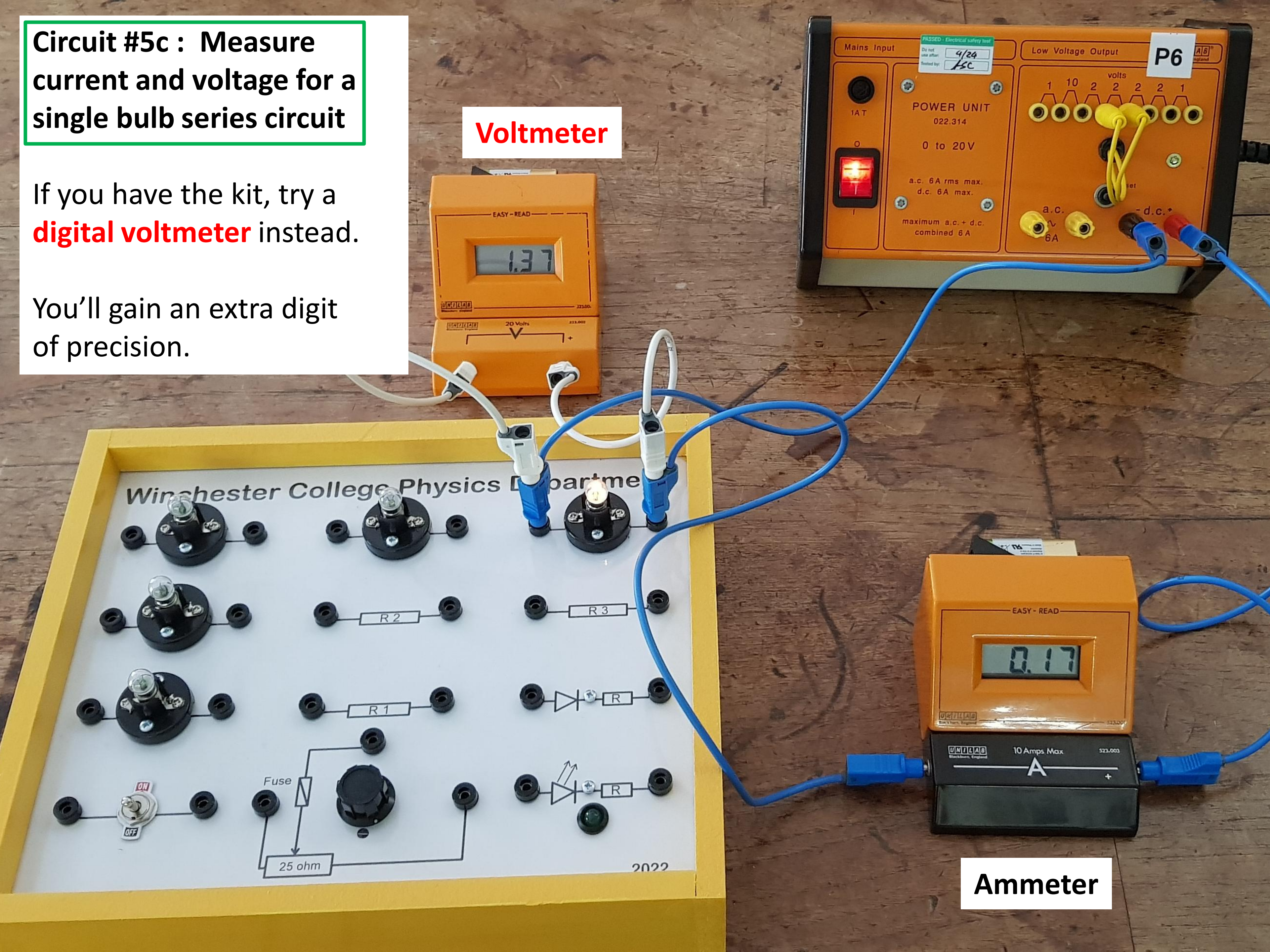
Circuit diagram (sometimes called a 'schematic') vs the real kit



Circuit #5c : Measure current and voltage for a single bulb series circuit

If you have the kit, try a **digital voltmeter** instead.

You'll gain an extra digit of precision.

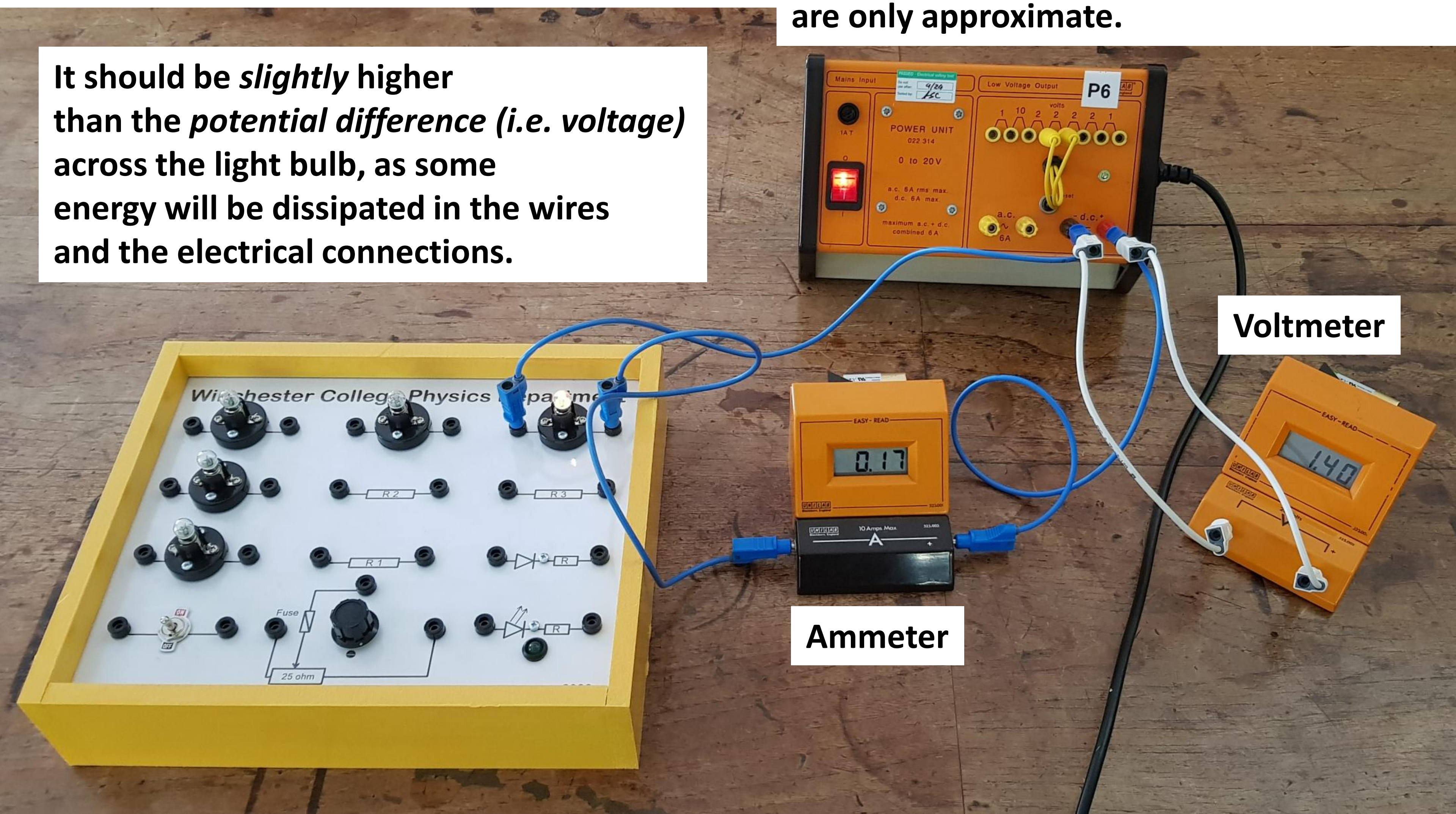


Circuit #5d : Measure current and voltage for a single bulb series circuit

Now measure the voltage across the power supply

Note the power supply provides 1.40V, *not exactly 2V*. The power unit voltage labels are only approximate.

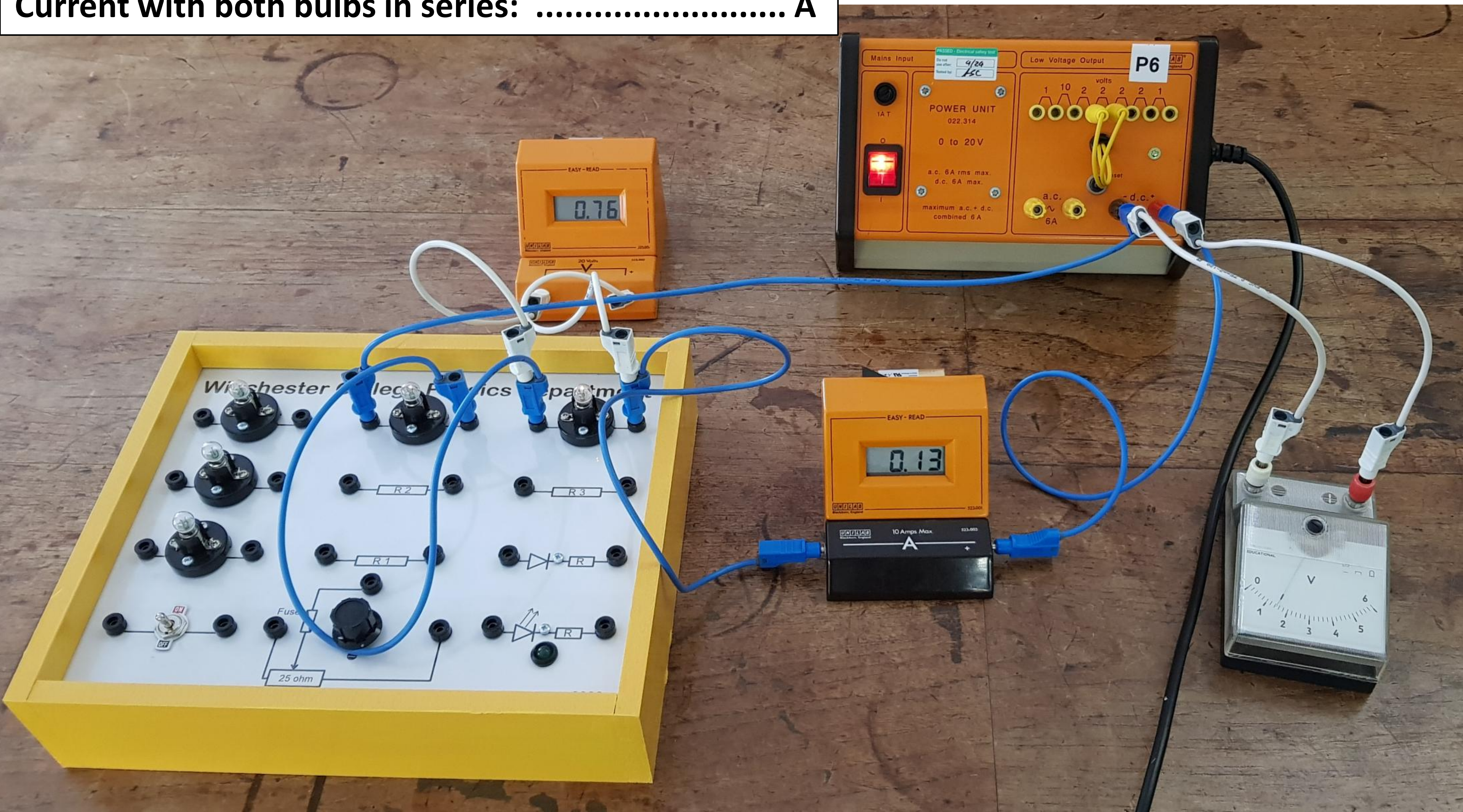
It should be *slightly* higher than the *potential difference (i.e. voltage)* across the light bulb, as some energy will be dissipated in the wires and the electrical connections.



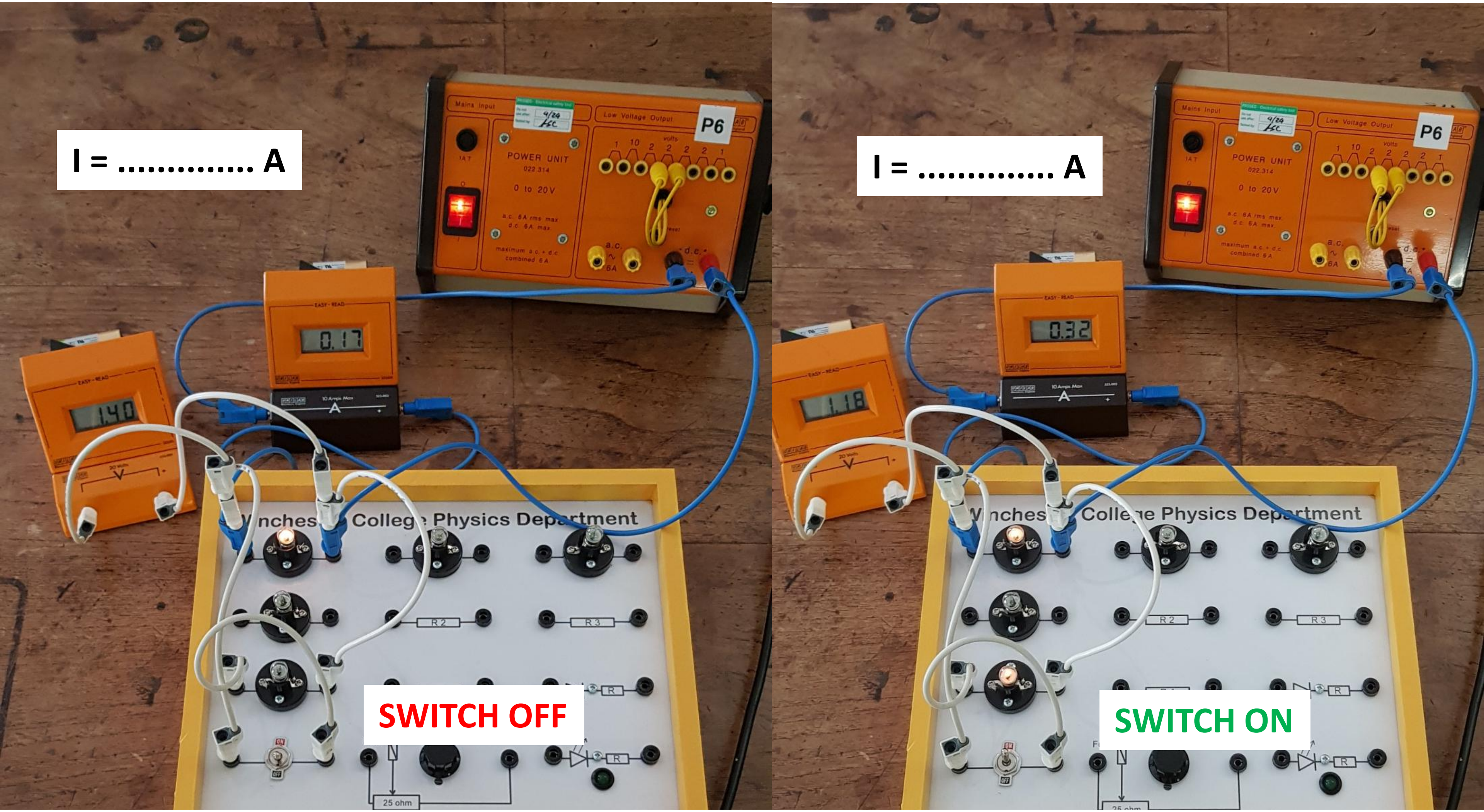
Circuit #6 : Measure current and voltage for two bulbs in series

Voltage across power supply: V
Voltage across first bulb: V
Voltage across second bulb: V

Current with only one bulb in series: .... A
Current with both bulbs in series: .... A

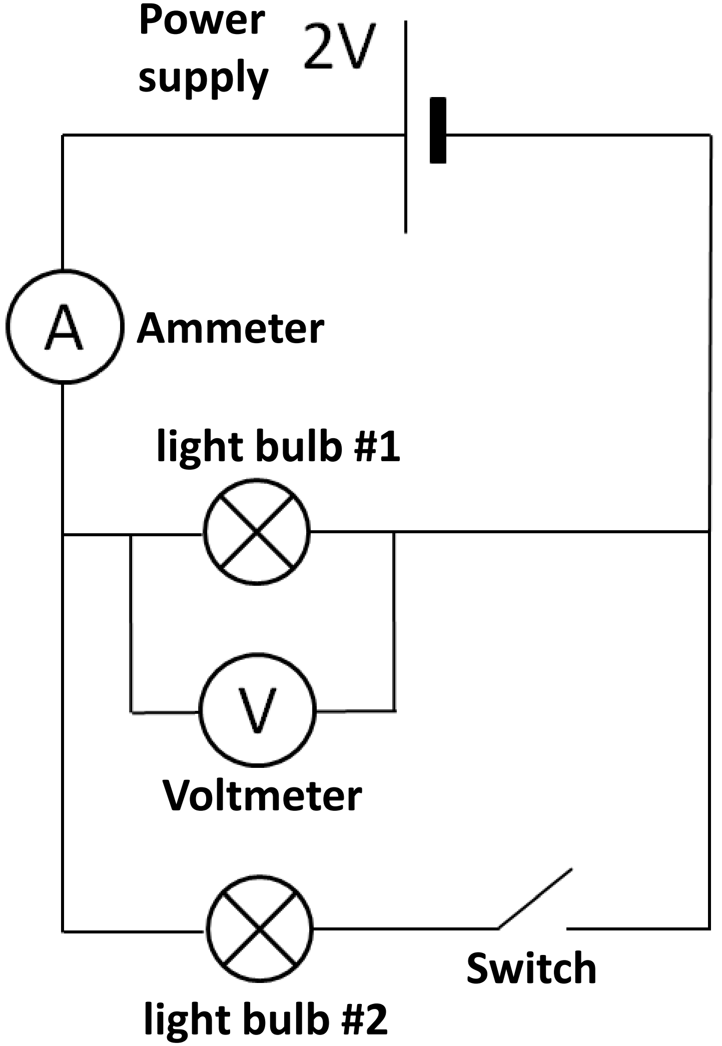


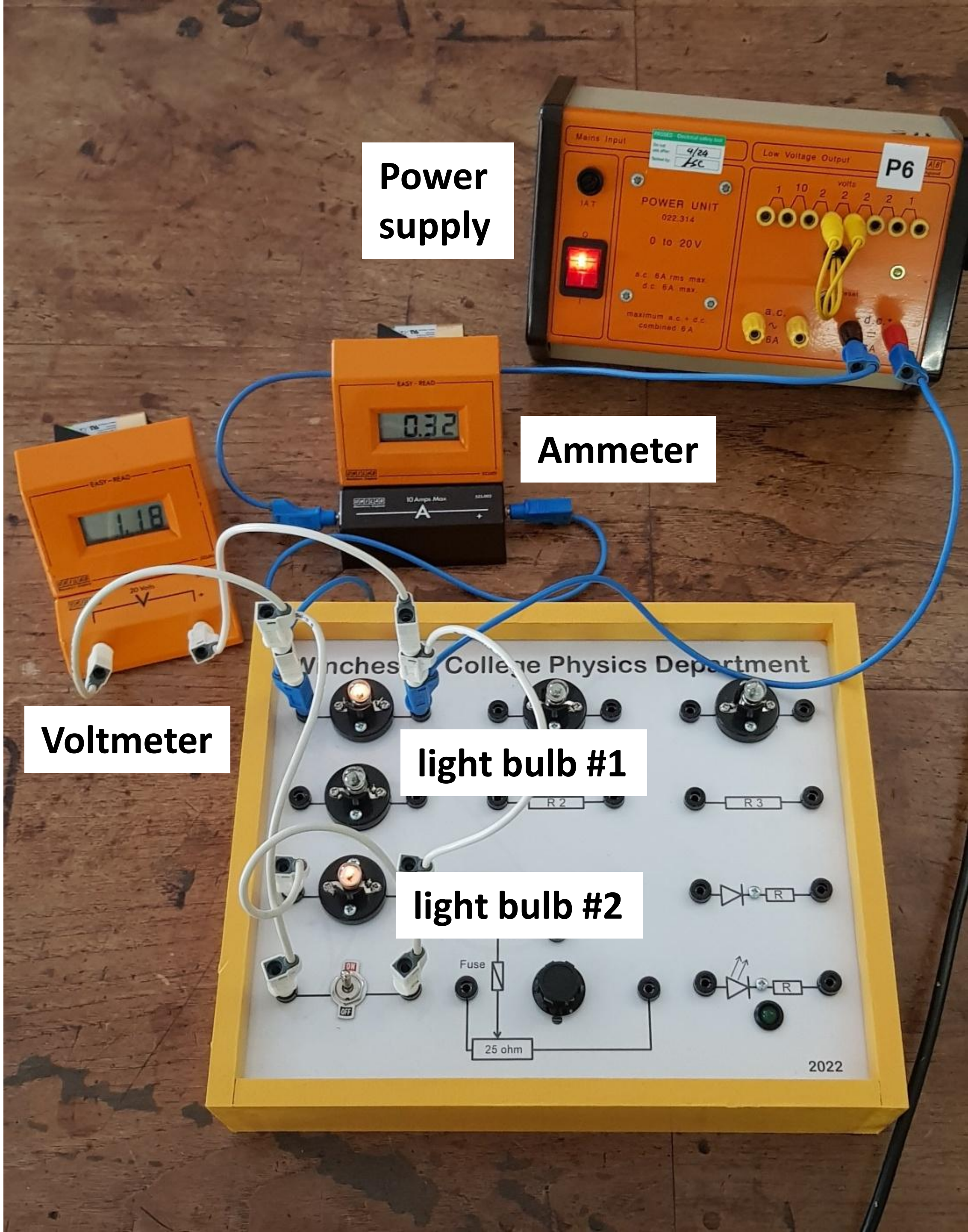
Circuit #7: Connect *two bulbs in parallel*, with the *second loop in series with a switch.* Record how the voltage across the first bulb, and the total current drawn change as the switch position is changed.



The *voltage across each bulb in parallel should be the same*, (<u>check it</u> by moving the voltmeter across the lower bulb) but you might observe a small difference before and after the switch. The total current draw should *approximately double* when the switch is ON.

Circuit #7: Connect *two bulbs in parallel*, with the *second loop in series with a switch.*

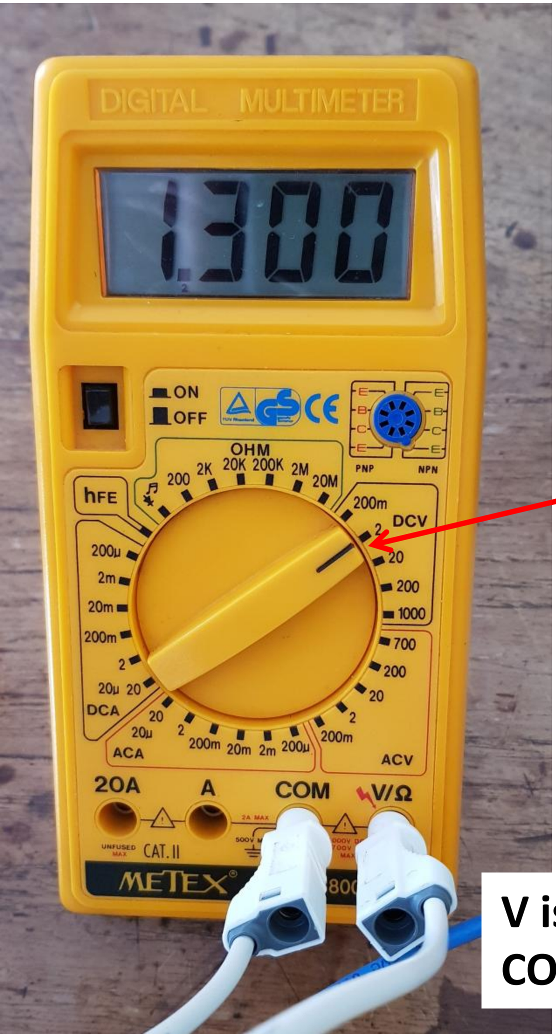




NOW YOU HAVE MASTERED THE BASICS LET'S USE SOME MORE ADVANCED EQUIPMENT!

*** Always set a multimeter to the desired setting BEFORE turning it on a plugging it into a circuit ***

An ammeter used as a voltmeter (i.e. placed in parallel to a circuit) *will cause it to blow its fuse*.

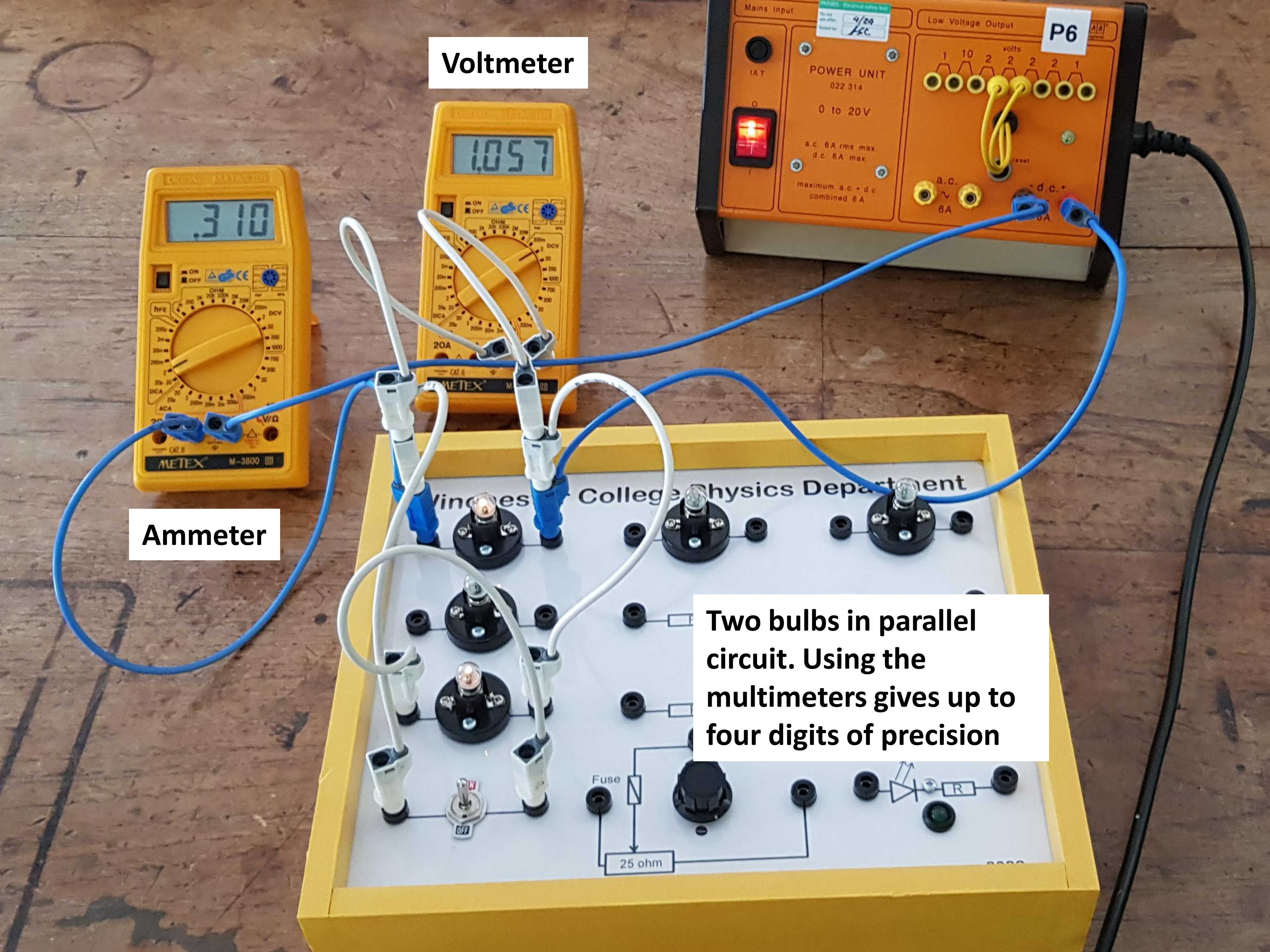


DC voltmeter setting

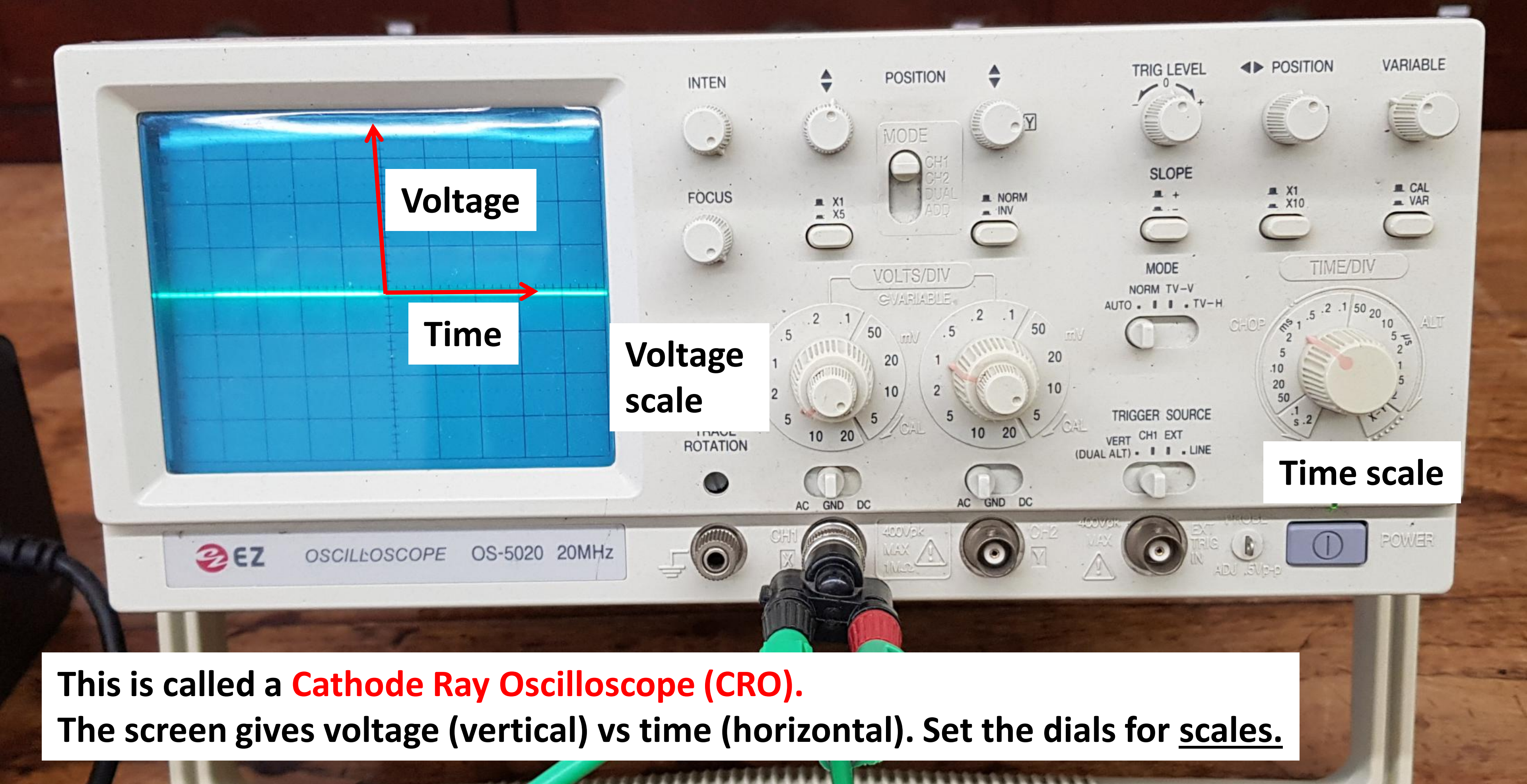
V is positive
COM is negative

DC ammeter setting

A is positive
COM is negative



Two bulbs in parallel circuit. Using the multimeters gives up to four digits of precision



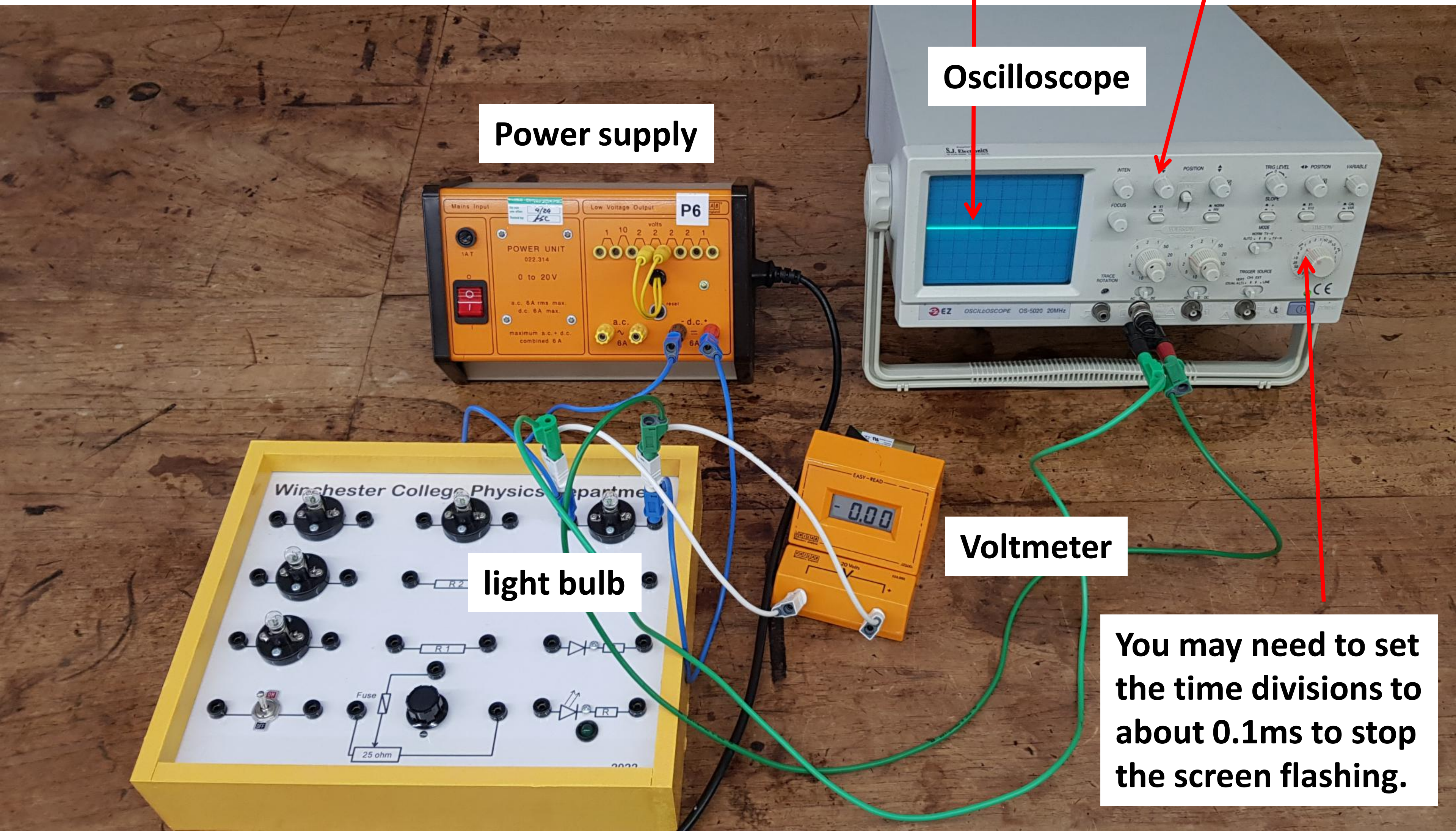
This is called a Cathode Ray Oscilloscope (CRO).
The screen gives voltage (vertical) vs time (horizontal). Set the dials for <u>scales.</u>

We'll use the CRO
like a voltmeter, using the
<u>BNC cable adapter.</u>

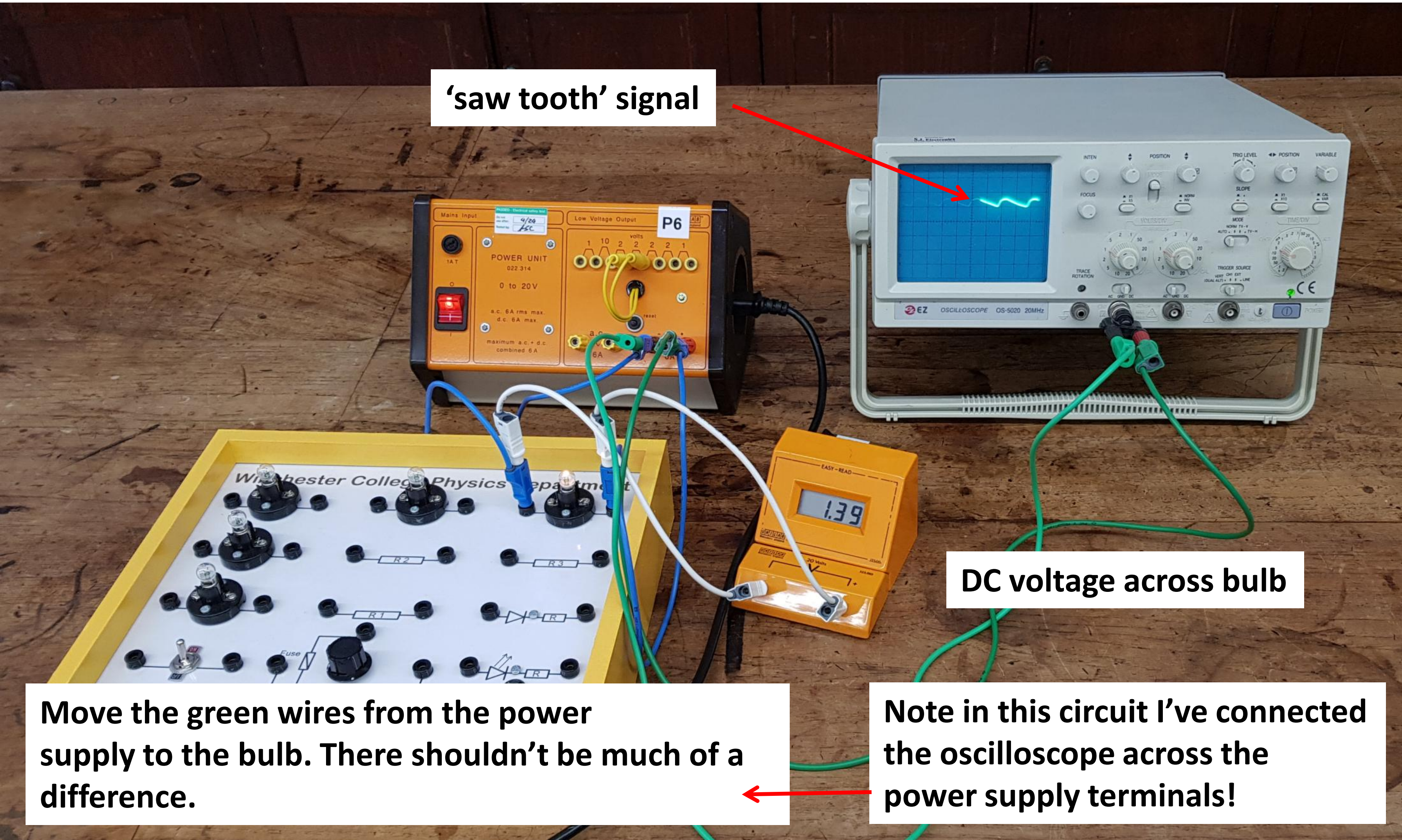
Connect to Channel 1
(CH1)

Set up the oscilloscope across the terminals of a single bulb in a series circuit. Also have a voltmeter in parallel.

Use the vertical position knob to set the horizontal signal level to zero.



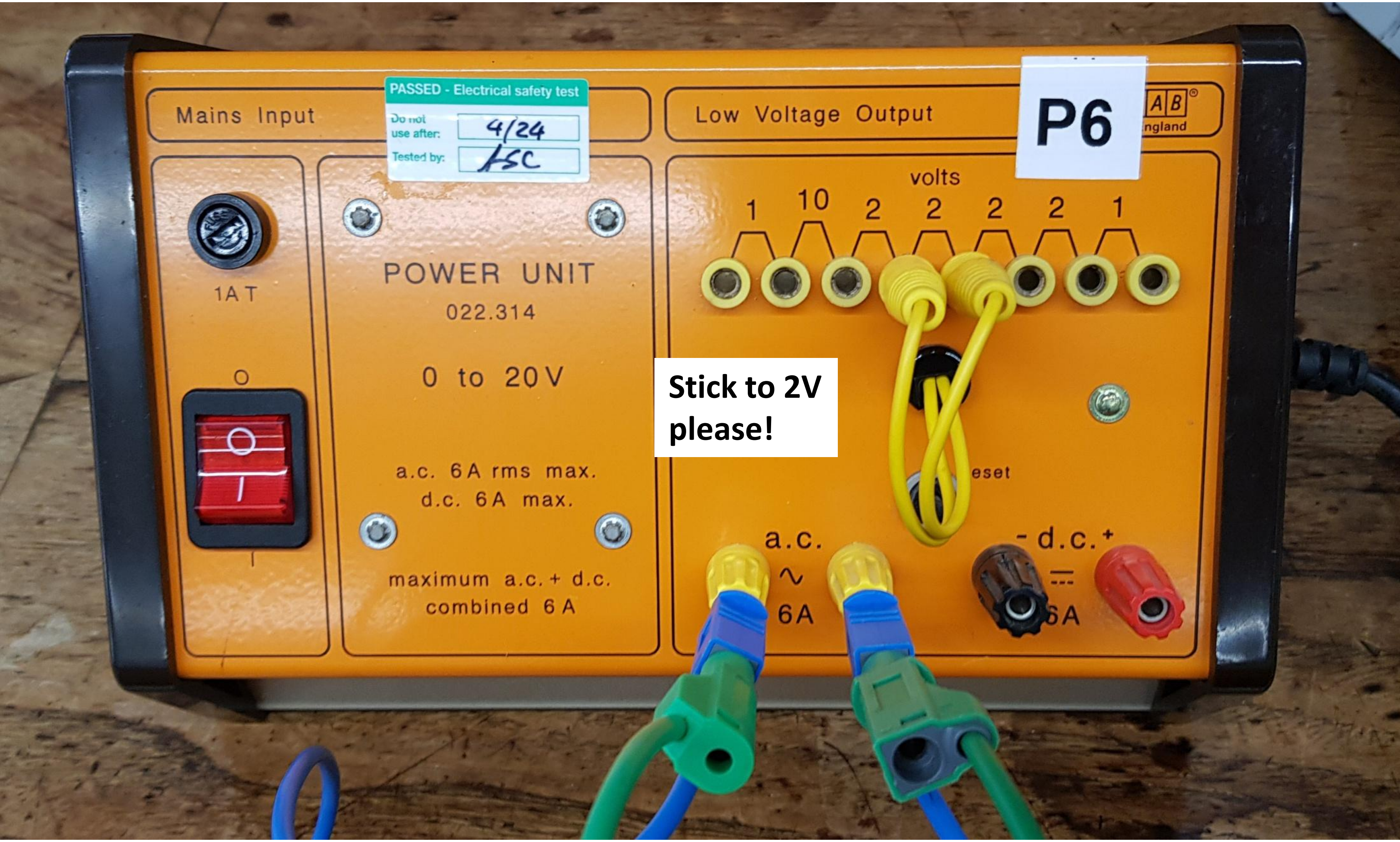
Now turn the circuit on. The oscilloscope should show a voltage which has an average of what the voltmeter reads – but you may see a bit of a 'saw-tooth' time variation. The supposedly DC voltage from the power supply may not be perfectly constant!



Move the green wires from the power supply to the bulb. There shouldn't be much of a difference.

Note in this circuit I've connected the oscilloscope across the power supply terminals!

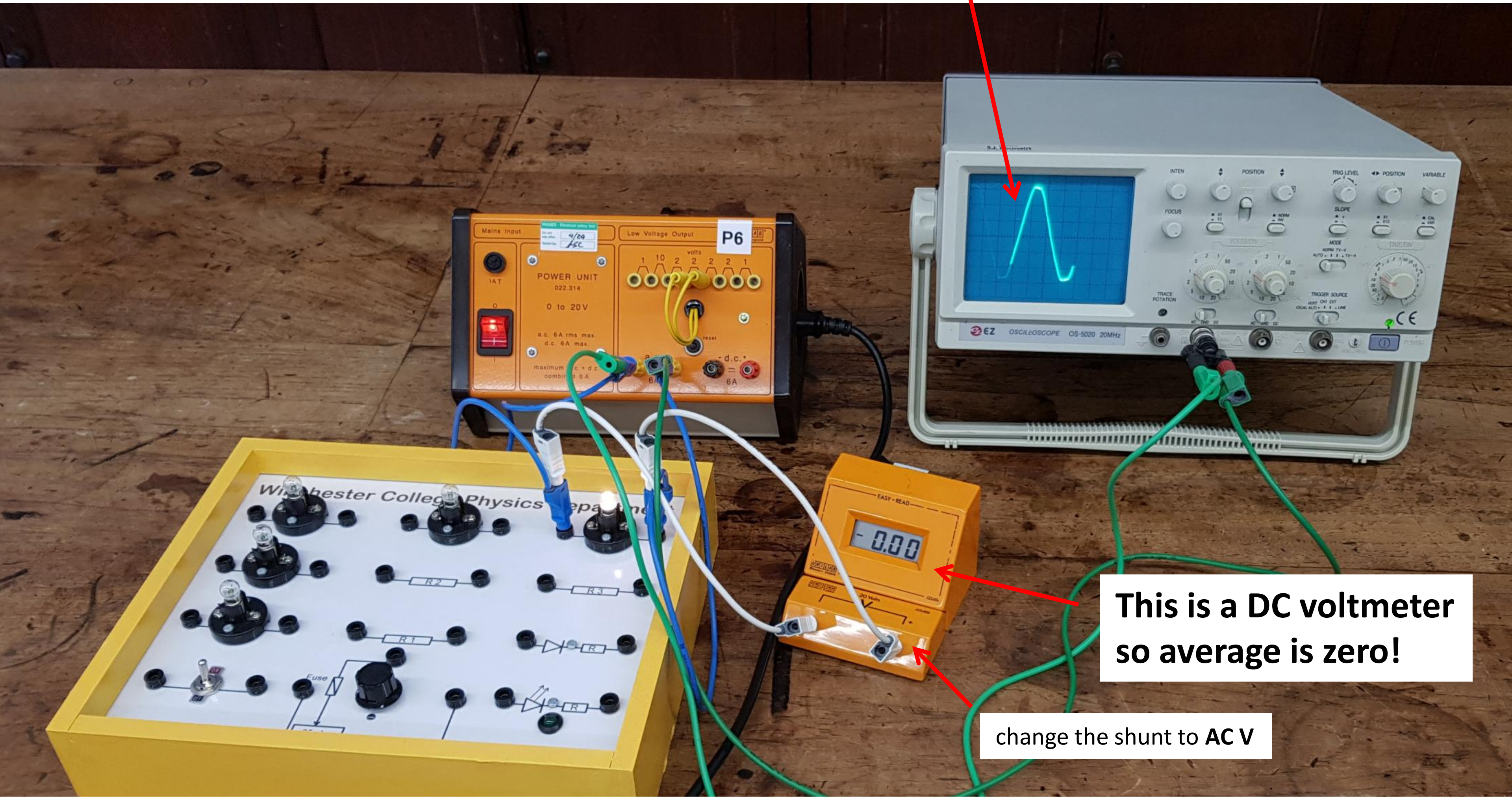
Turn the power off and swap the power supply output to AC



AC Alternating Current

DC Direct Current

You should now see a *sinusoidal* trace of *period* (time between wave peaks) of about 1/50 s = 0.02 s. This is because the AC (Alternating Current) output of the power supply is the same 50Hz frequency as mains electricity in the UK.



<u>Exchange the voltmeter for one with an AC mode</u> **and hopefully you'll see the *square root of half the square of the maximum voltage shown*. This is called the <u>RMS voltage</u>, and is equivalent to the DC voltage of the *same average power.* (More about this in a later course!)**