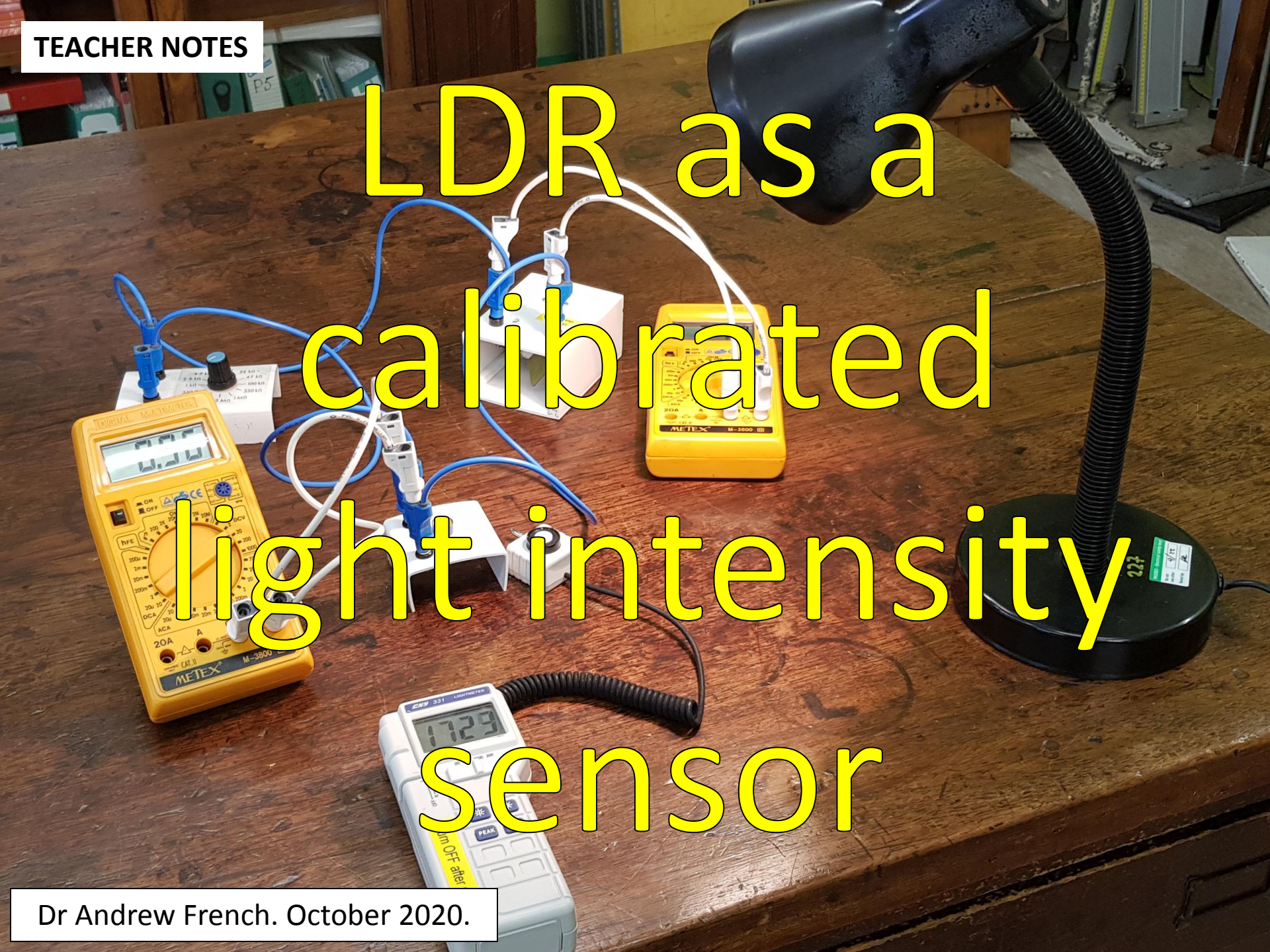
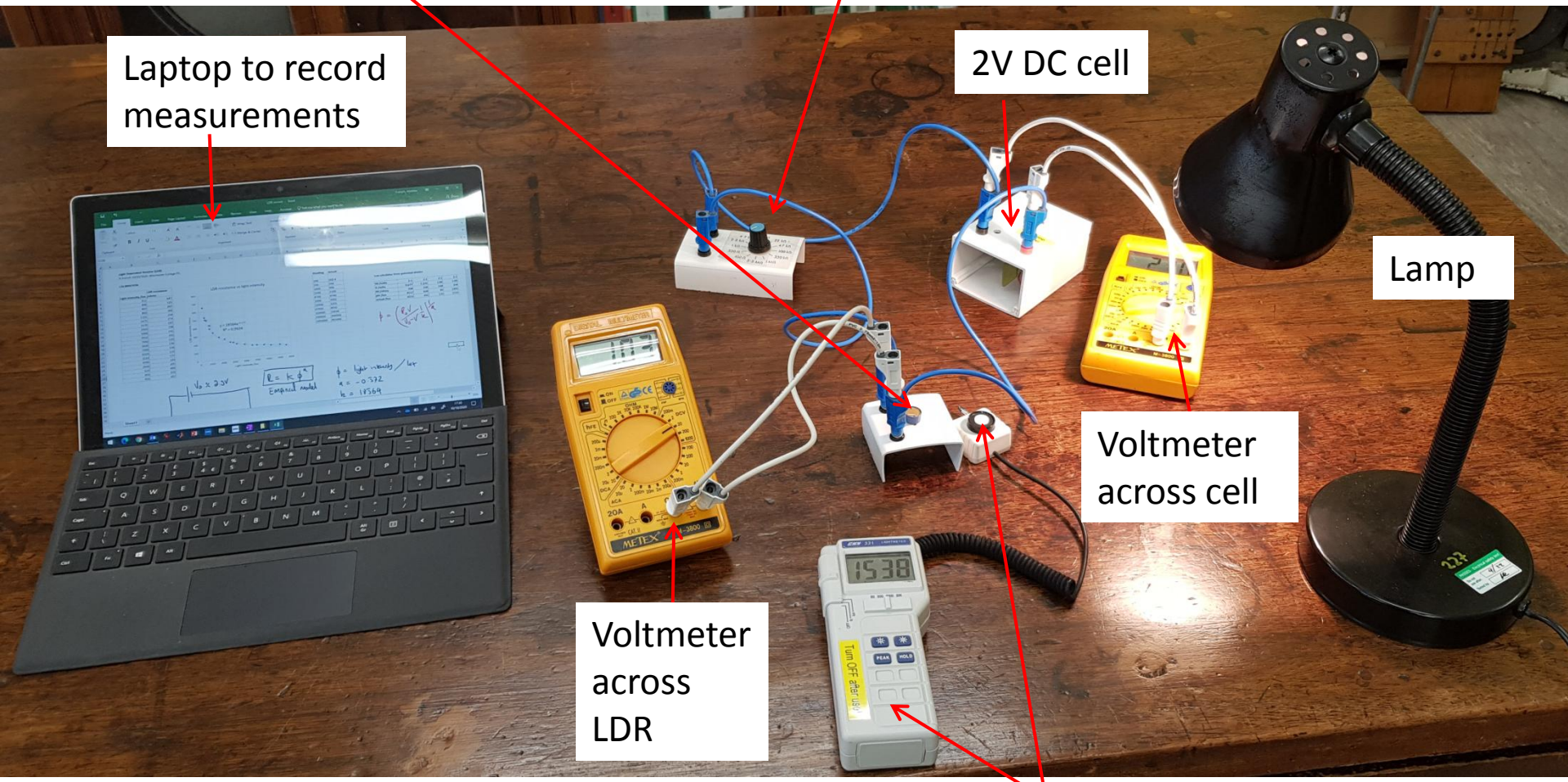
TEACHER NOTES

LDR as a calibrated light intensity sensor

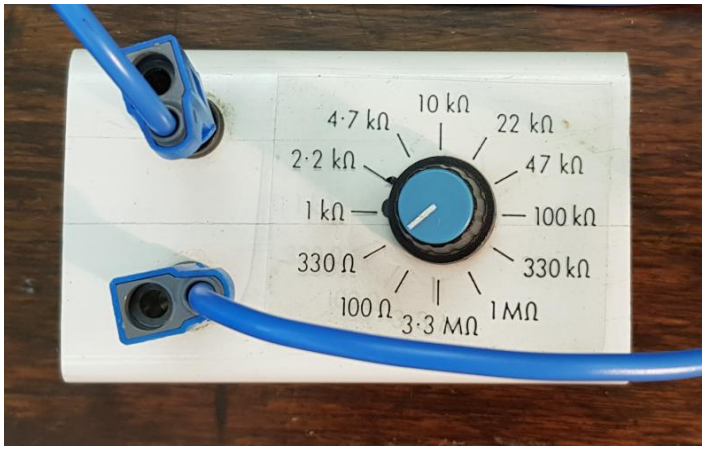


Dr Andrew French. October 2020.



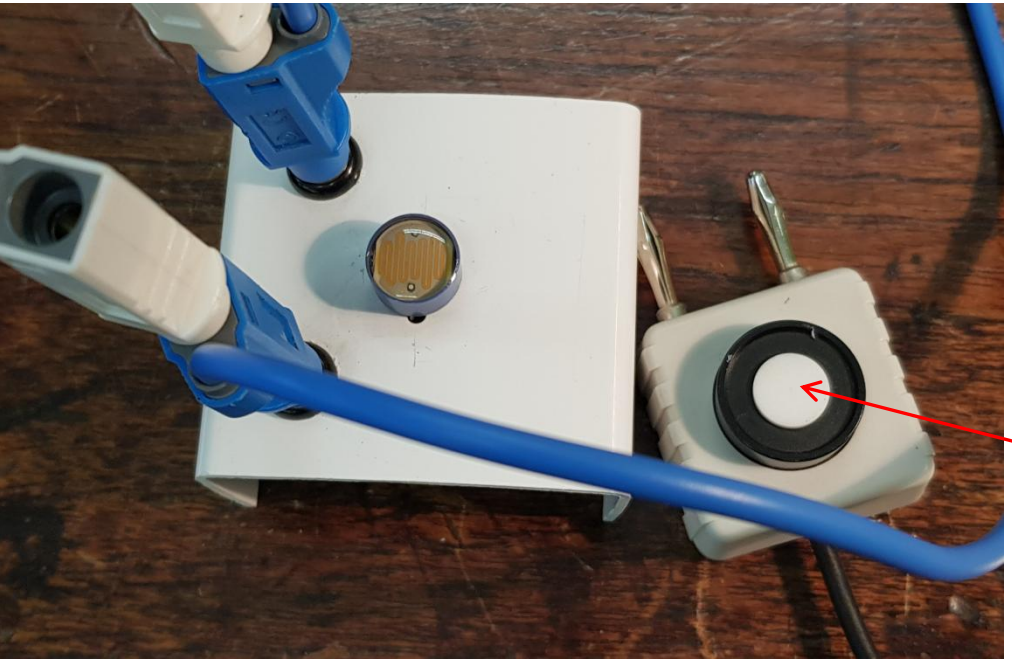
Equipment setup

LDR mounted in
a terminal block



‘Blue-top’ resistors

Light meter



Light meter sensor, co-located with LDR during calibration & testing

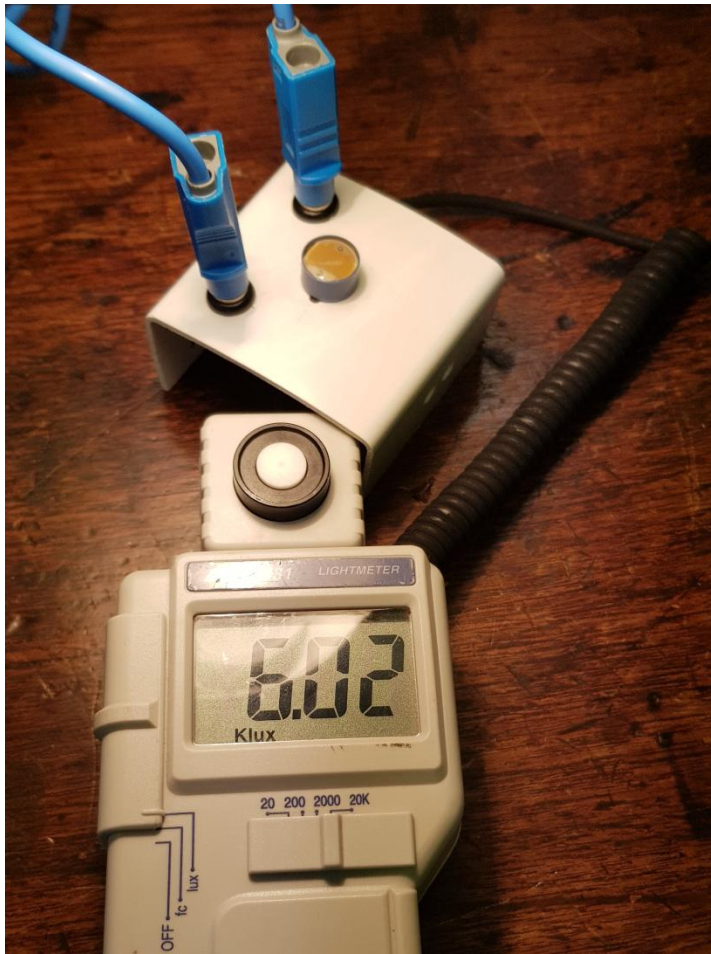
Task1: Calibrate the LDR i.e. determine resistance vs lux level

- Co-locate LDR and light sensor.
- Connect a multimeter across the LDR and turn it into OHM (i.e. resistance mode).
- Vary the light level and carefully record *simultaneous* measurements of resistance and lux level.
- Vary the light intensity by moving the lamp, and then covering the LDR with your hand.

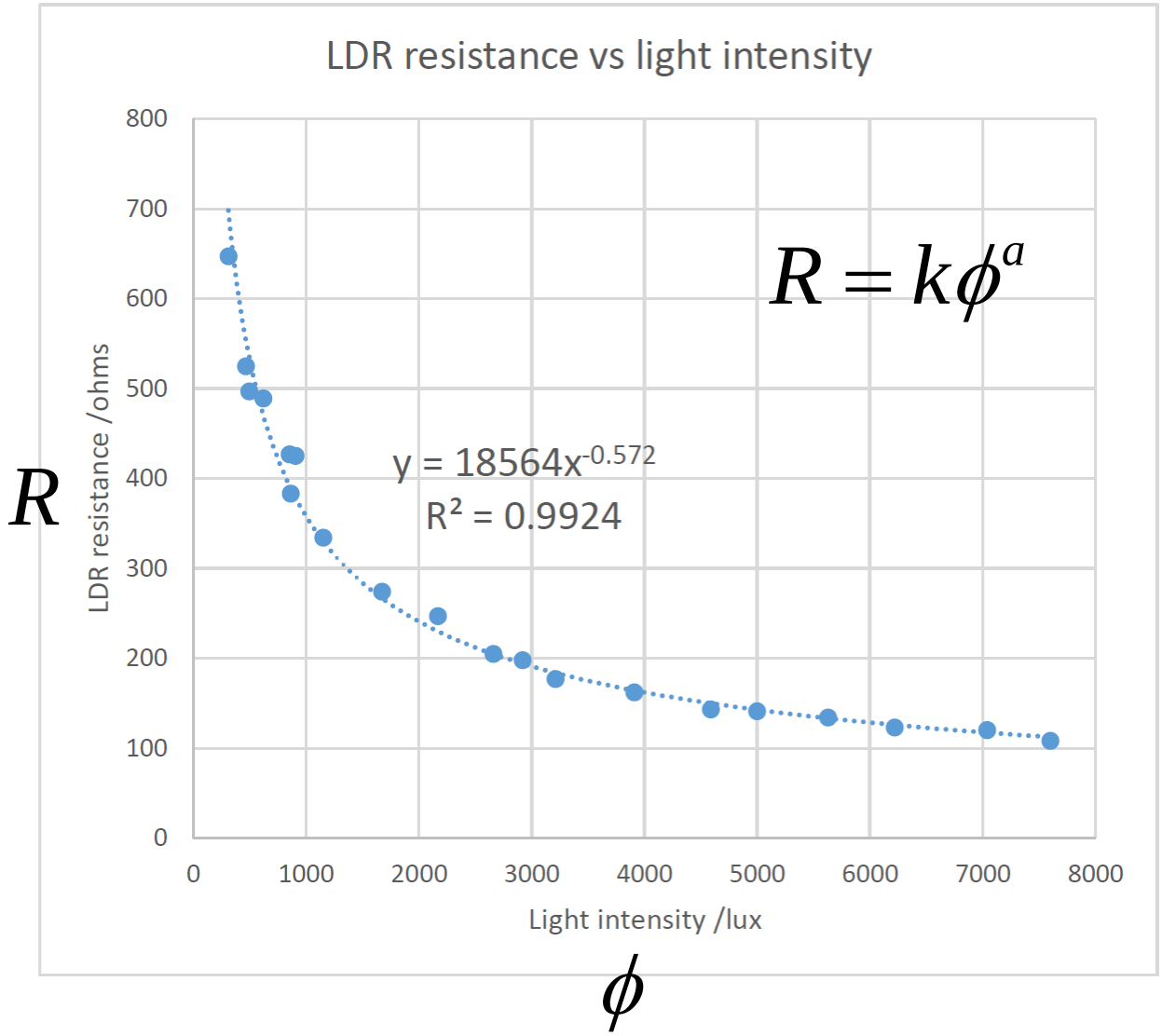
Be still when peering at the instruments – your presence will probably affect the light level.

Memorize a pair of measurements and then write them down/type into a spreadsheet.

Once you move, the measurements will probably change!



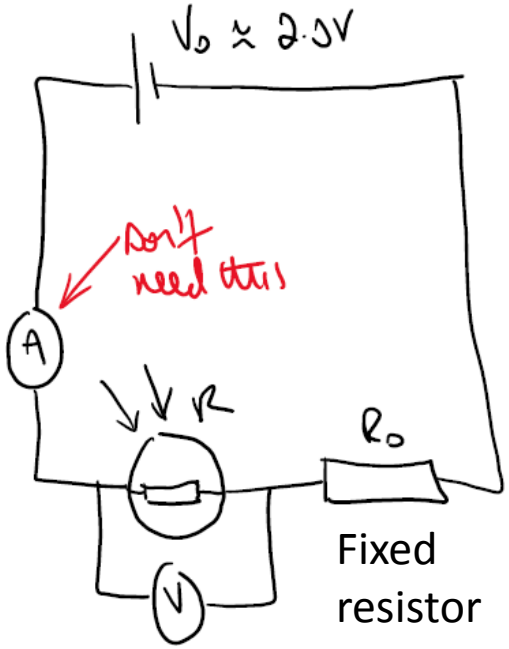
Light intensity /lux	LDR resistance /ohms
311	647
468	525
497	497
862	383
1151	334
1675	274
2170	247
2920	198
5000	141
3910	162
7040	120
5630	134
7600	108
6220	123
3210	177
4590	143
2660	205
620	489
905	425
855	427



Empirical formula (power law curve fit in Excel)

$$\left(R/\Omega\right) = k\left(\phi/\text{lux}\right)^{a} \qquad k = 18{,}564 \qquad a = -0.572$$

Task2: Set up LDR in a potential divider circuit, and use it to measure lux level from voltage



$$R = k\phi^a$$

$$\frac{V}{V_0} = \frac{R}{R + R_0}$$

$$\left(R + R_0\right)\frac{V}{V_0} = R$$

$$R_0 \frac{V}{V_0} = R\left(1 - \frac{V}{V_0}\right)$$

$$\therefore R = \frac{R_0 V/V_0}{1 - V/V_0}$$

$$R = \frac{R_0 V}{V_0 - V}$$

$$k\phi^a = \frac{R_0 V}{V_0 - V}$$

$$\phi = \left(\frac{R_0 V}{k\left(V_0 - V\right)}\right)^{\frac{1}{a}}$$

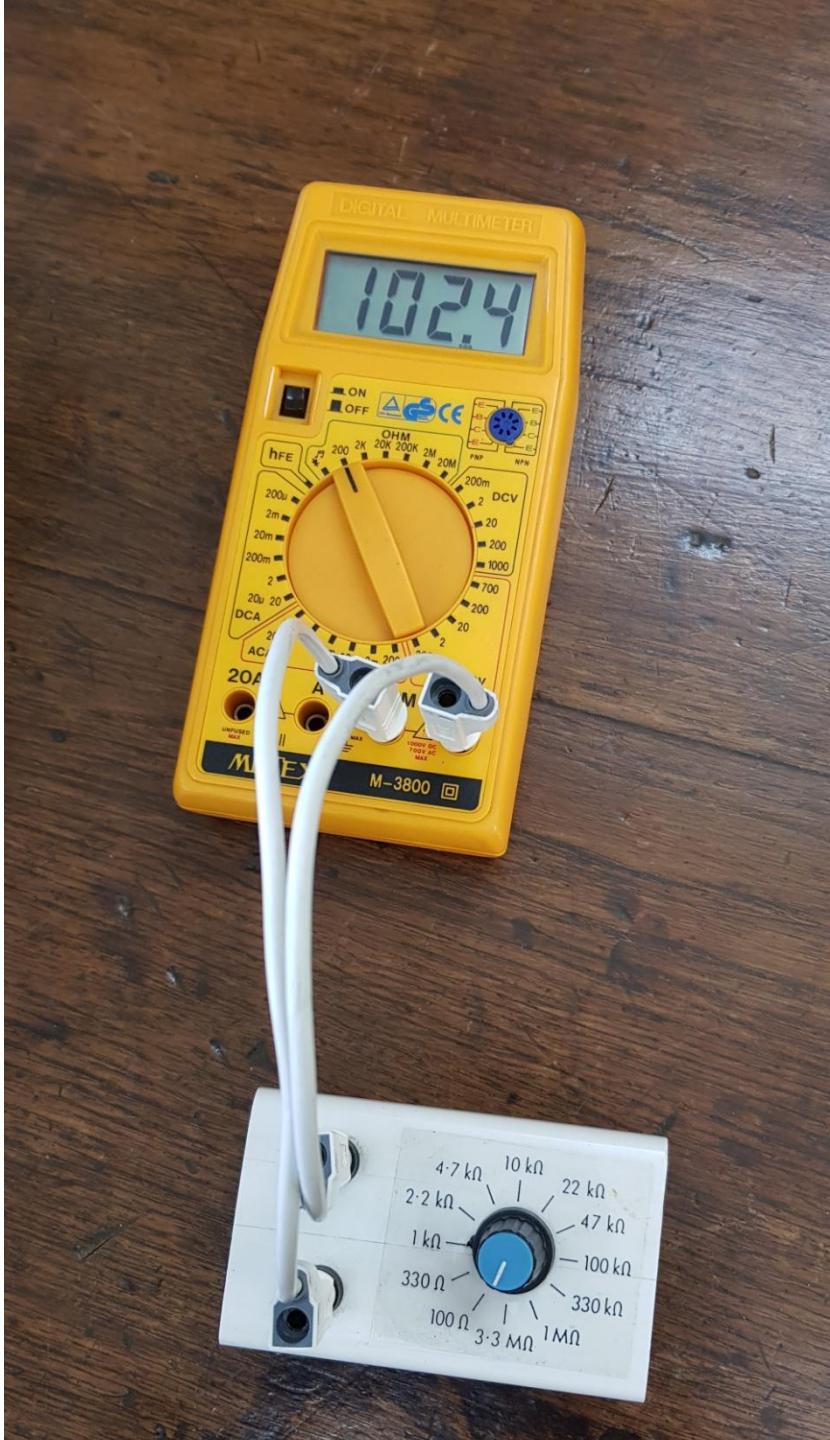
$$a = -0.572$$

$$k = 18{,}564$$

Blue top resistor resistances /ohms

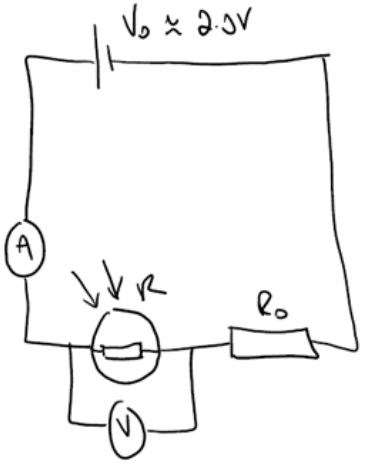
Reading	Actual
100	102.4
330	334
1000	998
2200	2190
4700	4740
1000	1002
22000	2255
47000	4650
100000	10030
330000	344000
1000000	991000

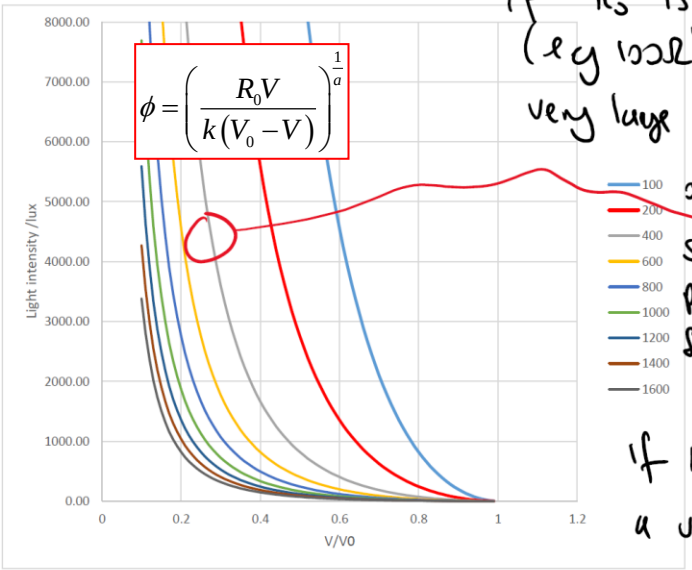
Precise measurement of ‘blue top’ resistors using a multimeter in OHM mode.



What fixed resistance should I pick?

If it is too high, most of the cell voltage will be across the fixed resistor, meaning only a small change in LDR voltage (from near zero) over a range of light levels. If it is too small, most of the voltage will be across the LDR, resulting in a small change from near V_0 over a range of light levels. There is clearly a 'happy medium' of a maximum variation of V which will correspond to the resistance of the LDR for 'typical' light levels. *There probably is no absolute optimum however*, particularly since the LDR resistance increases with a steep gradient as light levels drop.





If R_0 is too small (eg 100Ω), not a very large range in V/V_0 over 0 → 8000lux

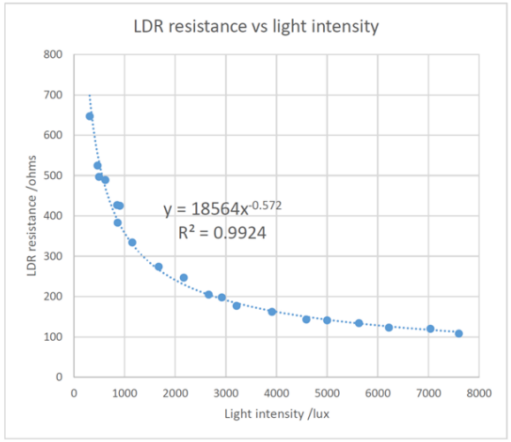
So not very precise, very sensitive!

If R_0 is too large a very large change at low light, but doesn't change much for bright light (> 1000lux)

Good $R = R_0$ optimal?

So choose R_0 carefully to offer a reasonable V range given anticipated range of ϕ.

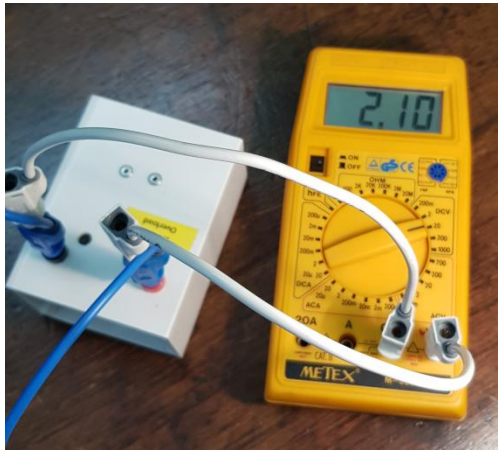
i.e. don't need an ammeter to find ϕ from V



Task 3: Try out the sensor circuit: i.e. measure voltage for a known V_0 and R_0, and calculate lux level from this. Compare to direct measurement using the light meter.

Lux calculator from potential divider

V0 /volts	2.1	2.1	2.1	2.1
V /volts	0.677	1.225	1.82	1.03
R0 /ohms	334	334	334	334
phi /lux	4117	624	43	1201
actual /lux	4050	440	120	1536



Use a voltmeter to find the cell voltage V_0

$$\phi = \left(\frac{R_0 V}{V_0 - V} \frac{1}{k} \right)^{\frac{1}{a}}$$

In this case, the model appears to work best at more intense light levels

$$a = -0.572 \quad k = 18,564$$