Post-IGCSE Physics Course:
Experimental Physics using
Data Loggers and Computers

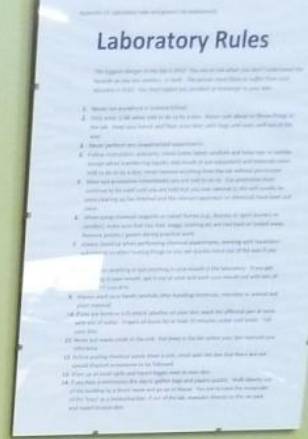# 09 Cooling curves
(Thermodynamics)

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Experimental setup

Three metal block heating setups with thermocouples feeding a single USB hub
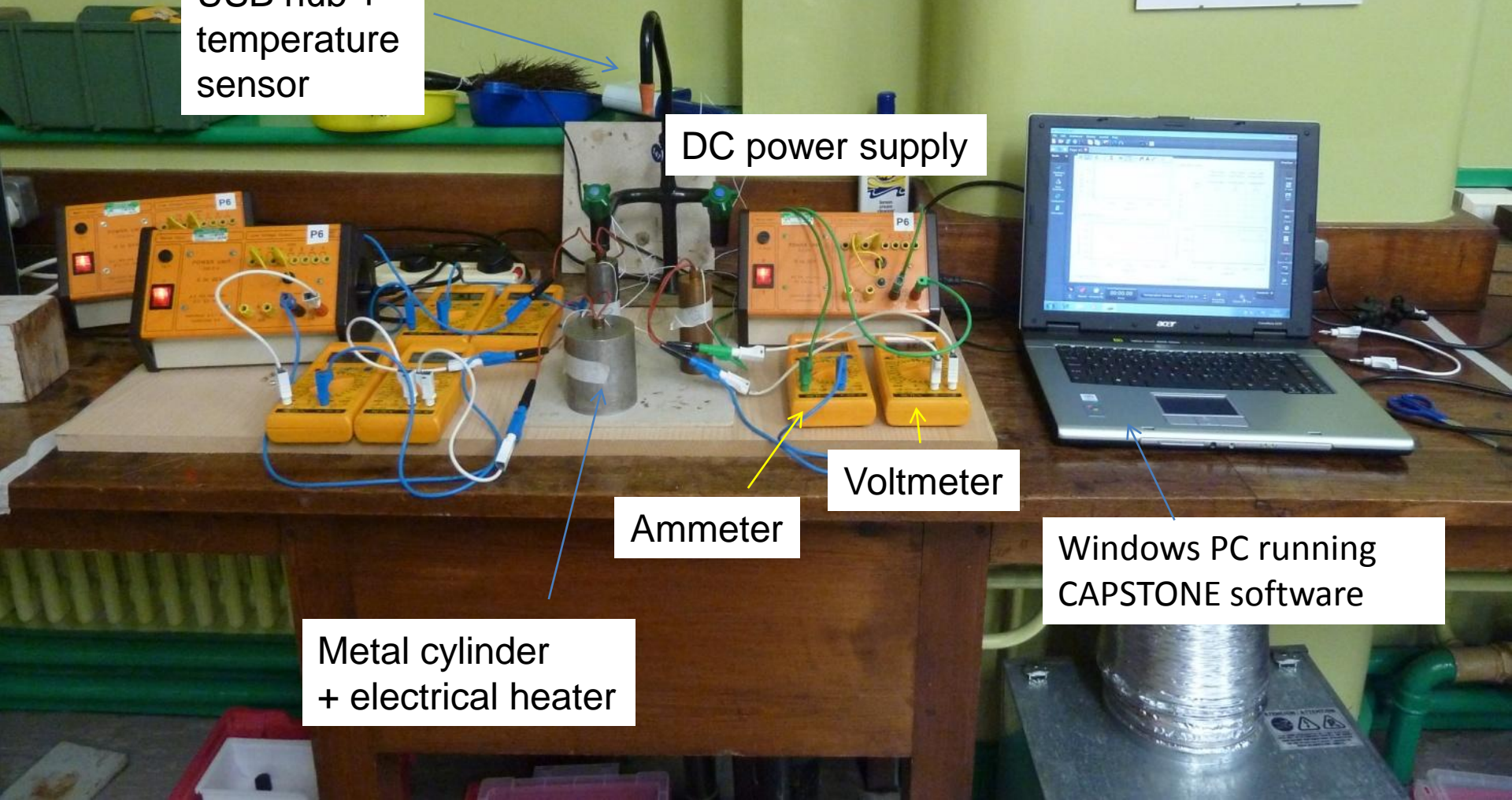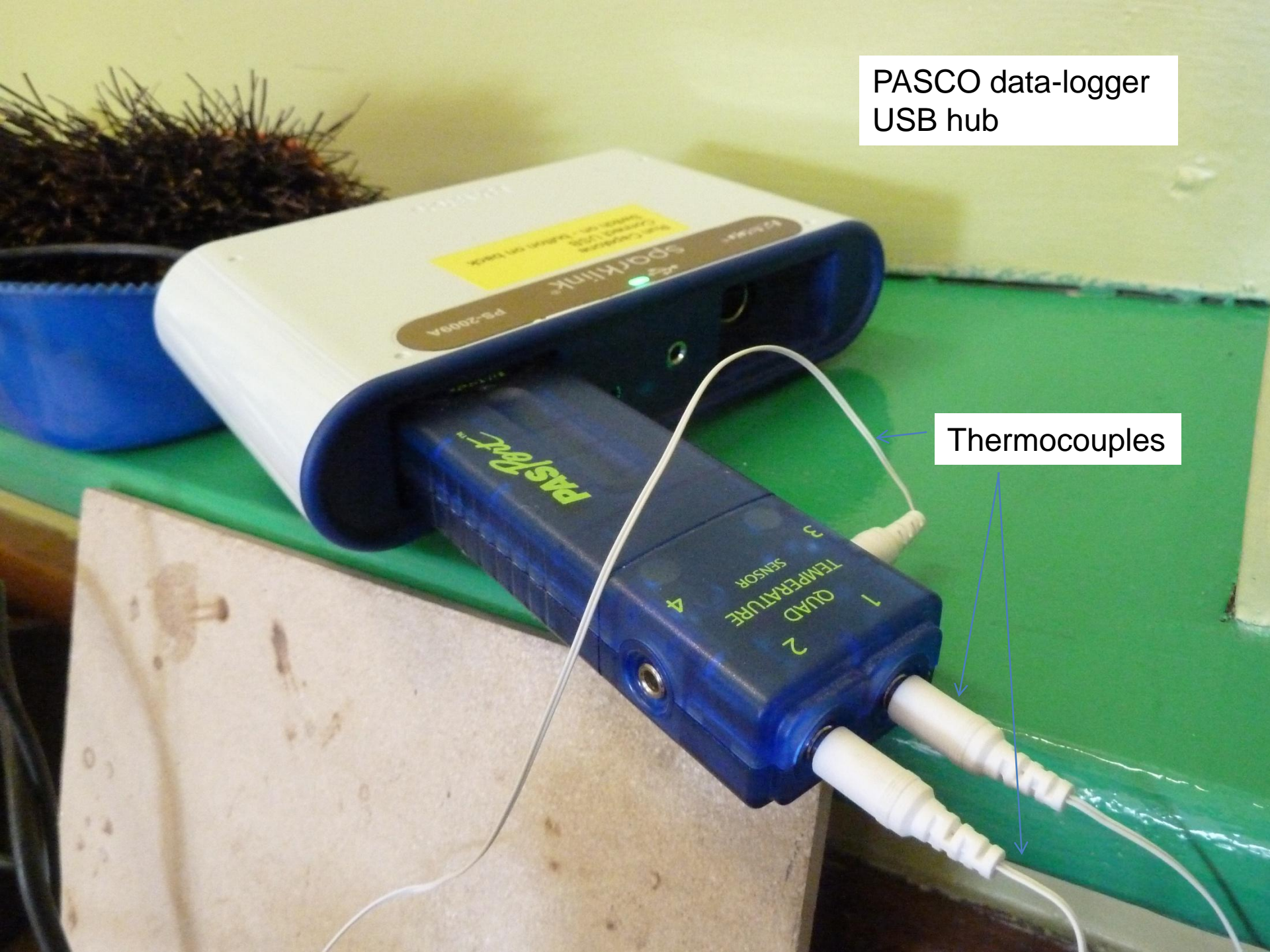
PASCO USB hub + temperature sensor

DC power supply

Windows PC running CAPSTONE software

Voltmeter
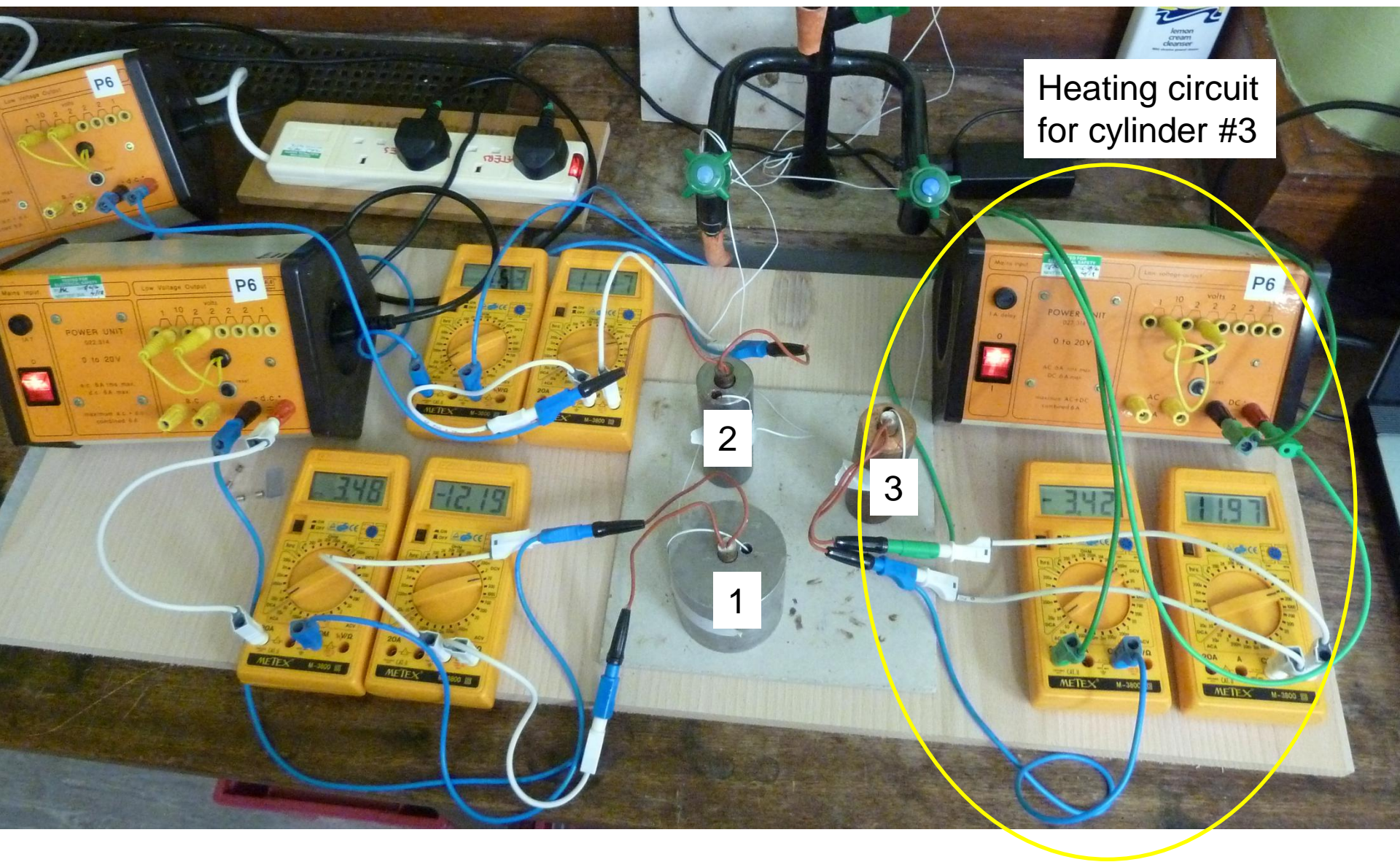
Ammeter

Metal cylinder + electrical heater

Laboratory Rules

PASCO data-logger
USB hub

Thermocouples

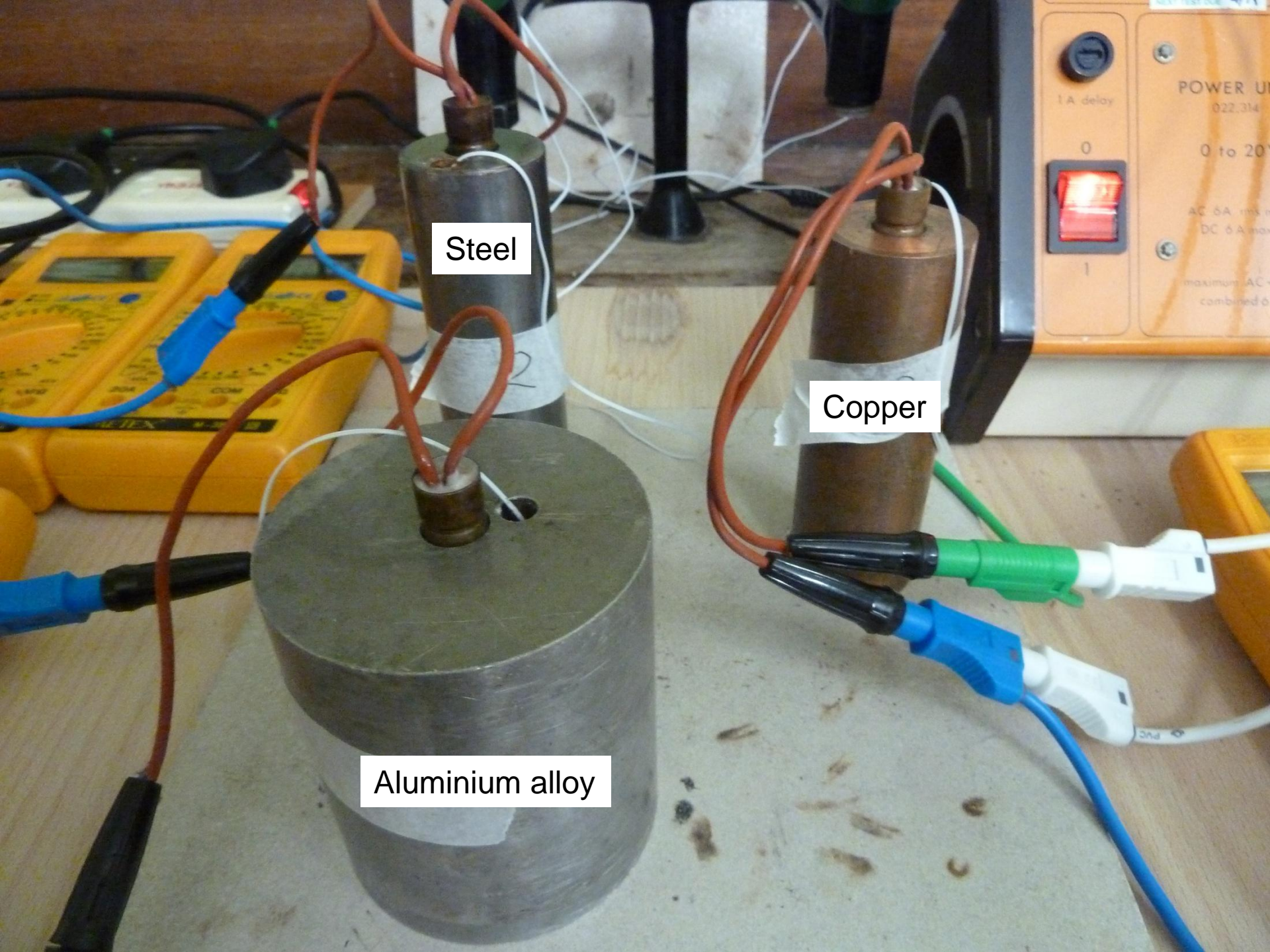Heating circuit for cylinder #3

Steel

Copper

Aluminium alloy

POWER U

022.314

0 to 20

AC 6A

DC 6A

maximum AC
combined 6

Run CAPSTONE. Set up a display with **three graphs and a single table.**
Add extra columns to the table.

Set the graph and table values to be **time /s** and the **temperature /deg Celsius**
for each of the thermocouples.

Set the **data rate at 1Hz.** The experiment will need to run for several hours
(about twenty minutes heating + several hours cooling) so too high a sample
rate will generate excessive data which may be unwieldy to process in Excel.

Heat the cylinders till one of them gets to about 100 degrees Celsius, then
switch off the power.

Don't forget to record the **input power** to each cylinder using the voltmeter
and ammeter while it is heating.

[Graph title here]

01:27.20
Recording

Temperature Sensor, Quad ▼   1.00 Hz
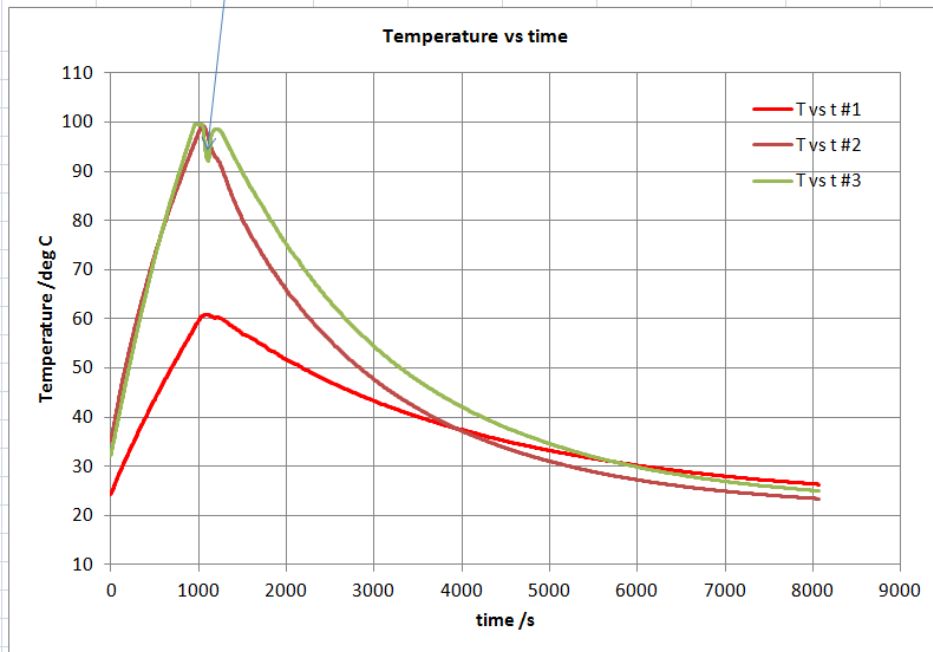
Recording
Conditions
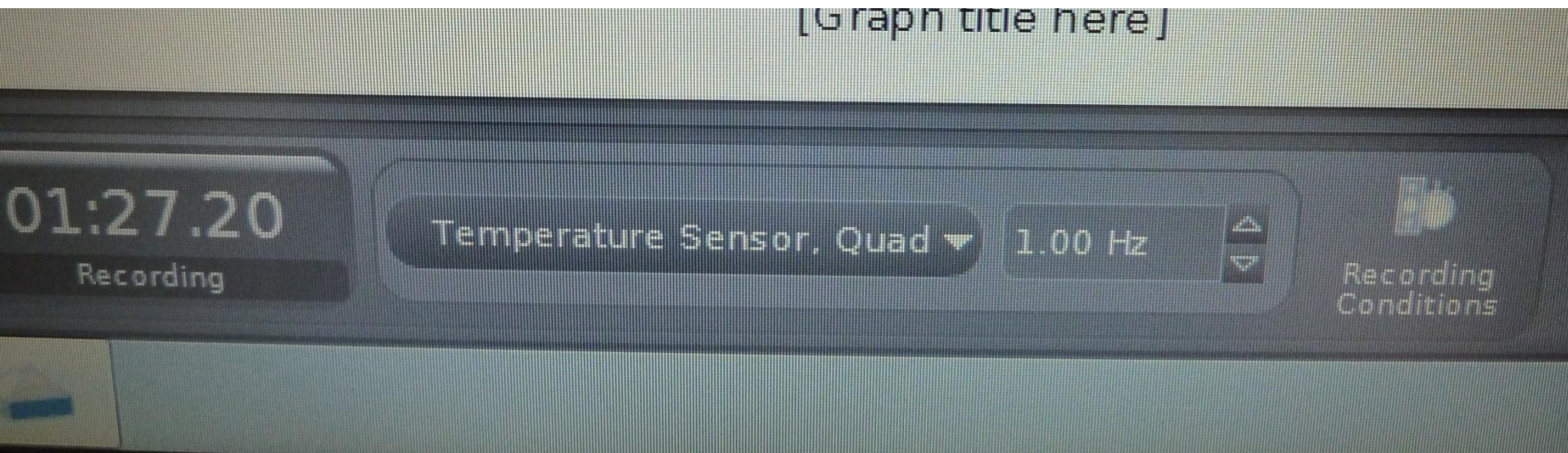
After stopping recording, copy and paste the entire table data (ctrl+a, ctrl+c, ctrl+v) into a Notepad window and save the resulting .txt file.
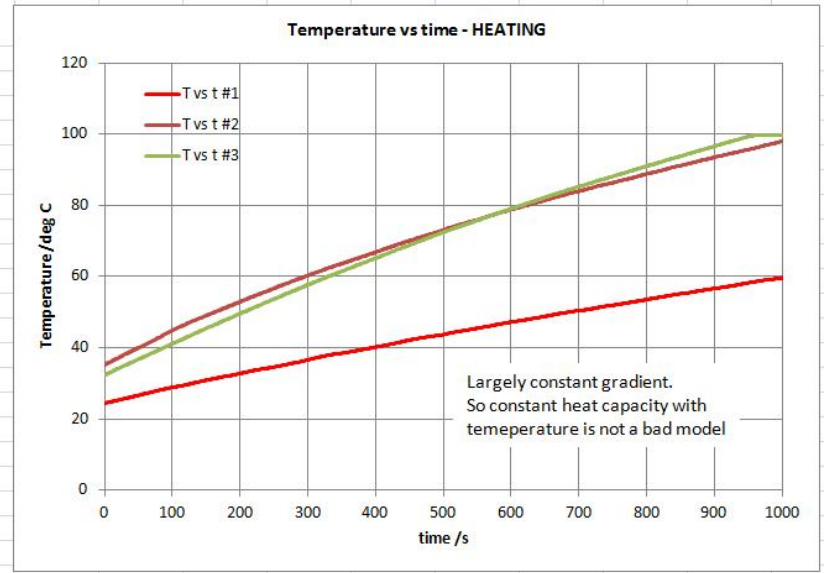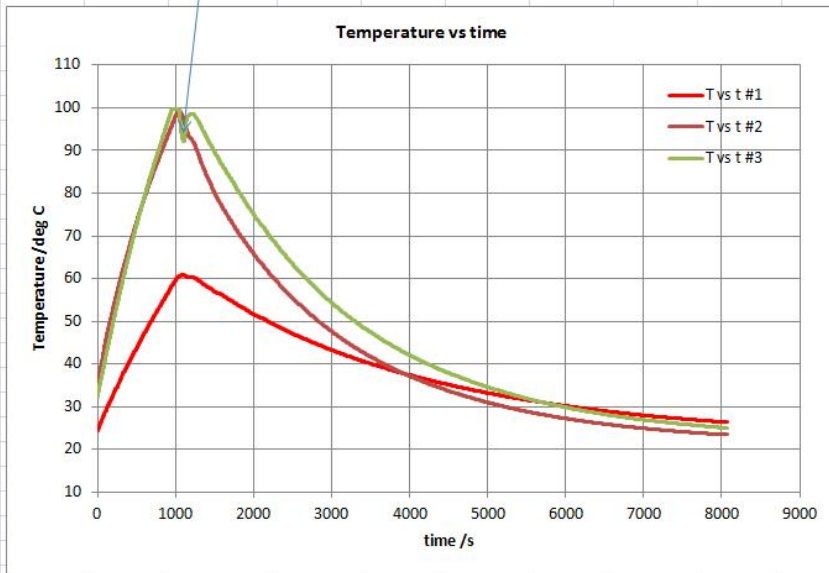
Open this file into Excel (literally drag it in!) for analysis.

Datalogging Experiment 09: Cooling curves
Winchester College. May 2nd 2017. A. French & A. Chesters

Note system was briefly switched on again to record a snapshot of I,V and therefore power to heate

Time (s)	ln(time/s)	Temperature 1 (°C)	ln(T1 - Ta)	Temperature 2 (°C)	ln(T2 - Ta)	Temperature 3 (°C)	ln(T3 - Ta)
0	#NUM!	24.37	1.85	35.18	2.84	32.3	2.66
1	0.00	24.42	1.86	35.27	2.85	32.39	2.67
2	0.69	24.46	1.87	35.37	2.85	32.48	2.67
3	1.10	24.5	1.87	35.46	2.86	32.57	2.68
4	1.39	24.54	1.88	35.56	2.87	32.66	2.69
5	1.61	24.58	1.88	35.65	2.87	32.75	2.69
6	1.79	24.63	1.89	35.75	2.88	32.84	2.70
7	1.95	24.67	1.90	35.85	2.88	32.93	2.70
8	2.08	24.71	1.90	35.94	2.89	33.02	2.71
9	2.20	24.76	1.91	36.04	2.89	33.1	2.71
10	2.30	24.8	1.92	36.14	2.90	33.19	2.72
11	2.40	24.84	1.92	36.24	2.90	33.29	2.73
12	2.48	24.89	1.93	36.34	2.91	33.37	2.73
13	2.56	24.93	1.94	36.43	2.91	33.46	2.74
14	2.64	24.97	1.94	36.53	2.92	33.55	2.74
15	2.71	25.02	1.95	36.63	2.92	33.64	2.75
16	2.77	25.06	1.95	36.72	2.93	33.73	2.76
17	2.83	25.1	1.96	36.82	2.93	33.82	2.76
18	2.89	25.15	1.97	36.92	2.94	33.91	2.77
19	2.94	25.19	1.97	37.02	2.95	34	2.77
20	3.00	25.23	1.98	37.11	2.95	34.09	2.78
21	3.04	25.27	1.98	37.2	2.95	34.18	2.78

Temperature vs time

— T vs t #1
— T vs t #2
— T vs t #3

Temperature vs time

- T vs t #1
- T vs t #2
- T vs t #3

Temperature vs time - HEATING

- T vs t #1
- T vs t #2
- T vs t #3

Largely constant gradient.
So constant heat capacity with
temeperature is not a bad model

Ambient temperature Ta /degC	18
Mass #1 /kg	
Mass #2 /kg	
Mass #3 /kg	

ln(Temperature difference) vs ln(time)

- ln(T-Ta) vs ln(t) #1)
- ln(T-Ta) vs ln(t) #2)
- ln(T-Ta) vs ln(t) #3)

gradient 1.5

$$\ln(T - T_a) \propto -\tfrac{3}{2}\ln t$$
$$\therefore T - T_a \propto t^{-3/2}$$