Project 3 FCCT

Overview

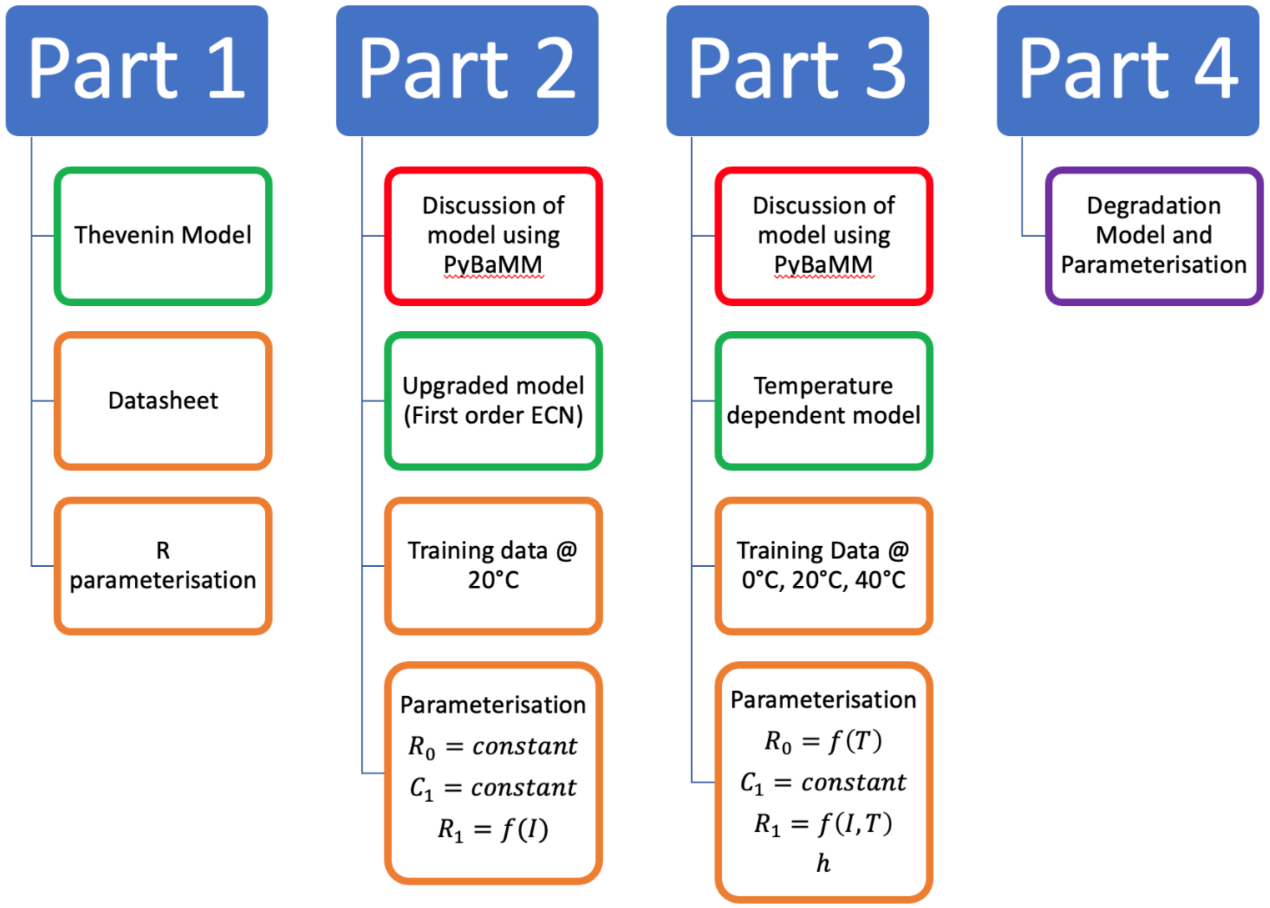
20th Feb 2024

Project relevance

- This project is based upon multiple collaborations with industry that our group did over the last few years
- The approach has been simplified a little, but is otherwise representative of what you would find yourself doing in industry
- The industry partners used these models them to validate pack and vehicle design decisions
- Often industry ends up using even simpler models than what you are creating – this is mostly due to the fact that gathering the parametrisation data is very costly (time, repeats, anew on every new type of cell)

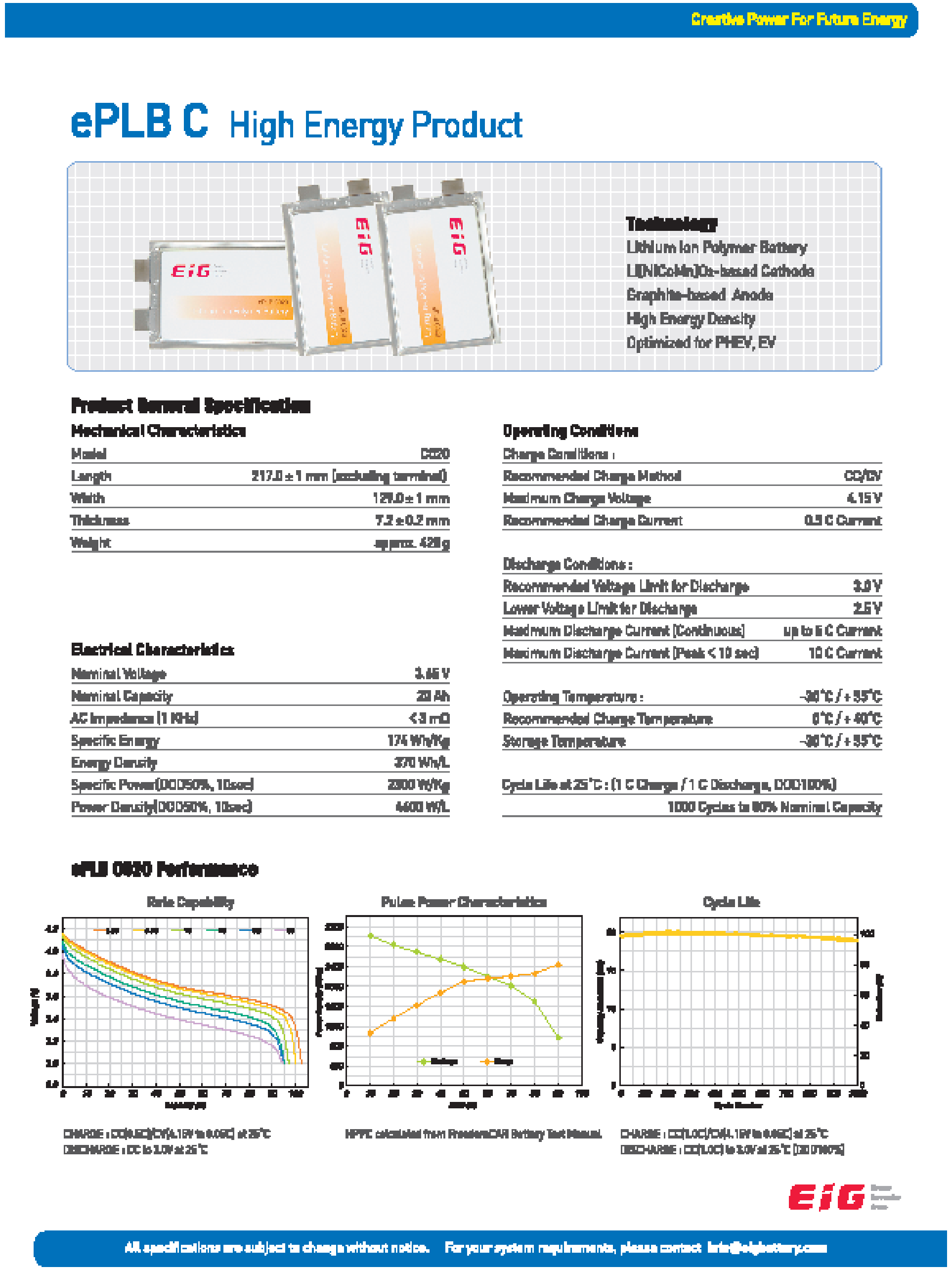
Project overview

- You will build a cell model of increasing levels of complexity
- Assessing the effect of the improvements you have made to each version of the model
- The model will be an equivalent circuit model, with resistors and capacitors
- You will use a physics-based model (PyBaMM) to support your understanding and interpretation of the data



Simple model (Part 1)

- You are given a cell datasheet
- You can parameterise a model just from this
- But is it any good?



Creative Power For Future Energy

ePLB C High Energy Product

Technology
Lithium Ion Polymer Battery
Li[NiCoMn]O2-based Cathode
Graphite-based Anode
High Energy Density
Optimized for PHEV, EV

Product General Specification

Mechanical Characteristics

Model	C020
Length	217.0 ± 1 mm (excluding terminal)
Width	129.0 ± 1 mm
Thickness	7.2 ± 0.2 mm
Weight	approx. 428 g

Electrical Characteristics

Nominal Voltage	3.65 V
Nominal Capacity	20 Ah
AC Impedance (1 KHz)	< 3 mΩ
Specific Energy	174 Wh/Kg
Energy Density	370 Wh/L
Specific Power(DOD50%, 10sec)	2300 W/Kg
Power Density(DOD50%, 10sec)	4600 W/L

Operating Conditions

Charge Conditions :	
Recommended Charge Method	CC/CV
Maximum Charge Voltage	4.15 V
Recommended Charge Current	0.5 C Current
Discharge Conditions :	
Recommended Voltage Limit for Discharge	3.0 V
Lower Voltage Limit for Discharge	2.5 V
Maximum Discharge Current (Continuous)	up to 5 C Current
Maximum Discharge Current (Peak < 10 sec)	10 C Current
Operating Temperature :	-30°C / + 55°C
Recommended Charge Temperature	0°C / + 40°C
Storage Temperature	-30°C / + 55°C
Cycle Life at 25°C : (1 C Charge / 1 C Discharge, DOD100%)	
	1000 Cycles to 80% Nominal Capacity

ePLB C020 Performance

Rate Capability

Pulse Power Characteristics

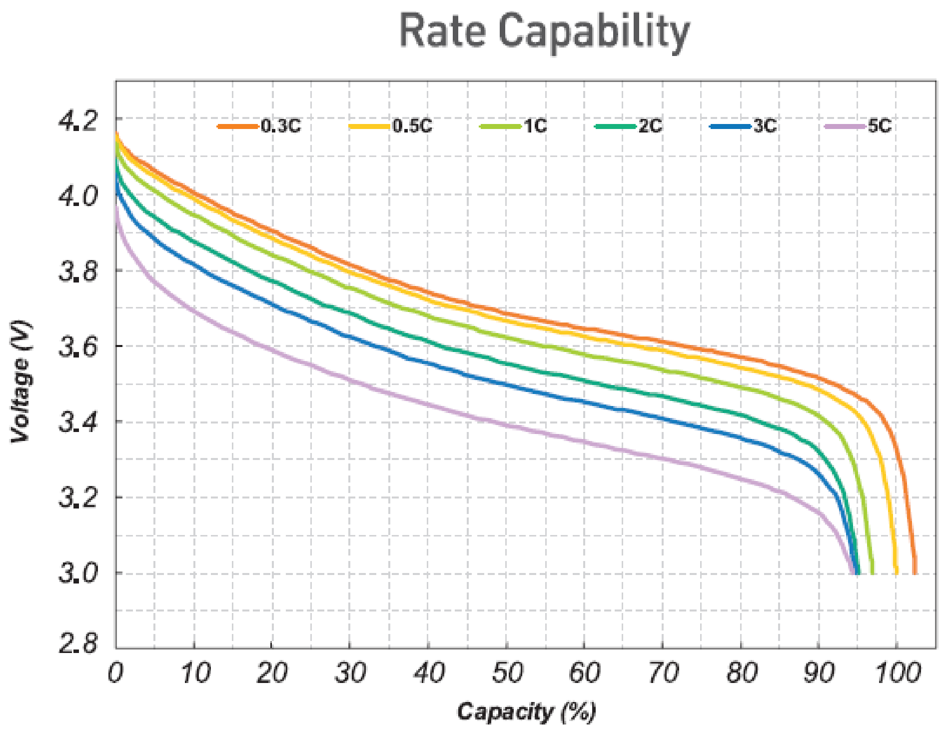
Cycle Life

HPPC calculated from FreedomCAR Battery Test Manual.

All specifications are subject to change without notice. For your system requirements, please contact info@eigbattery.com

Simple model – parametrisation (Part 1)

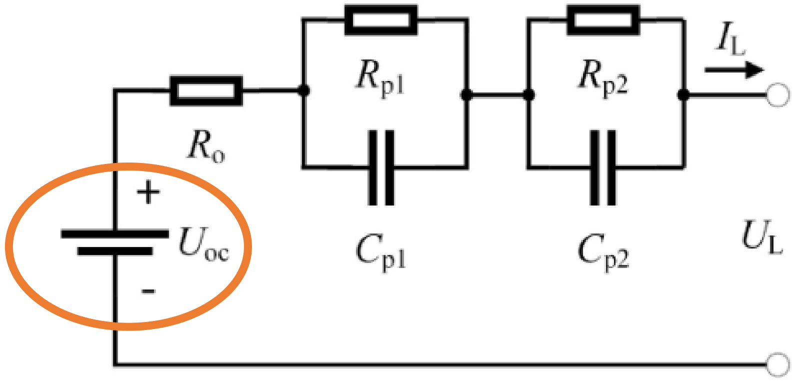
- Digitise the lowest C rate and assume it is the OCV
- Calculate R by reading off ΔV between two lines of known current which gives you ΔI
- Use Ohm's Law to get a rough estimation of R



CHARGE : CC(0.5C)/CV(4.15V to 0.05C) at 25˚C
DISCHARGE : CC to 3.0V at 25˚C

Improved models (with voltage transients)

Equivalent circuits for modelling voltage dynamics



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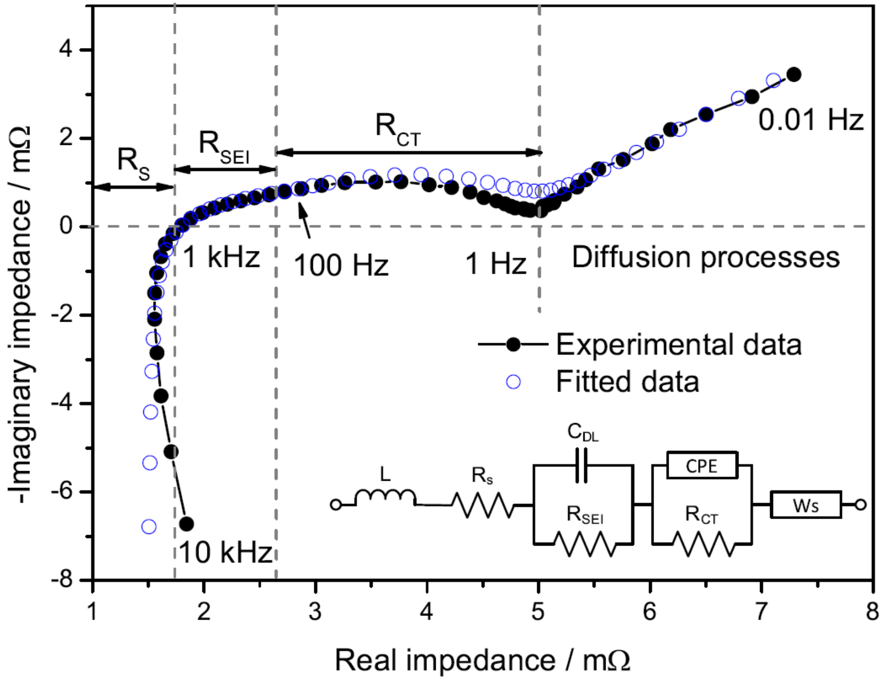
- You are building a model to predict voltage dynamics of a battery under non-zero current => you will need a voltage source added to the circuit

Equivalent circuits for EIS fitting

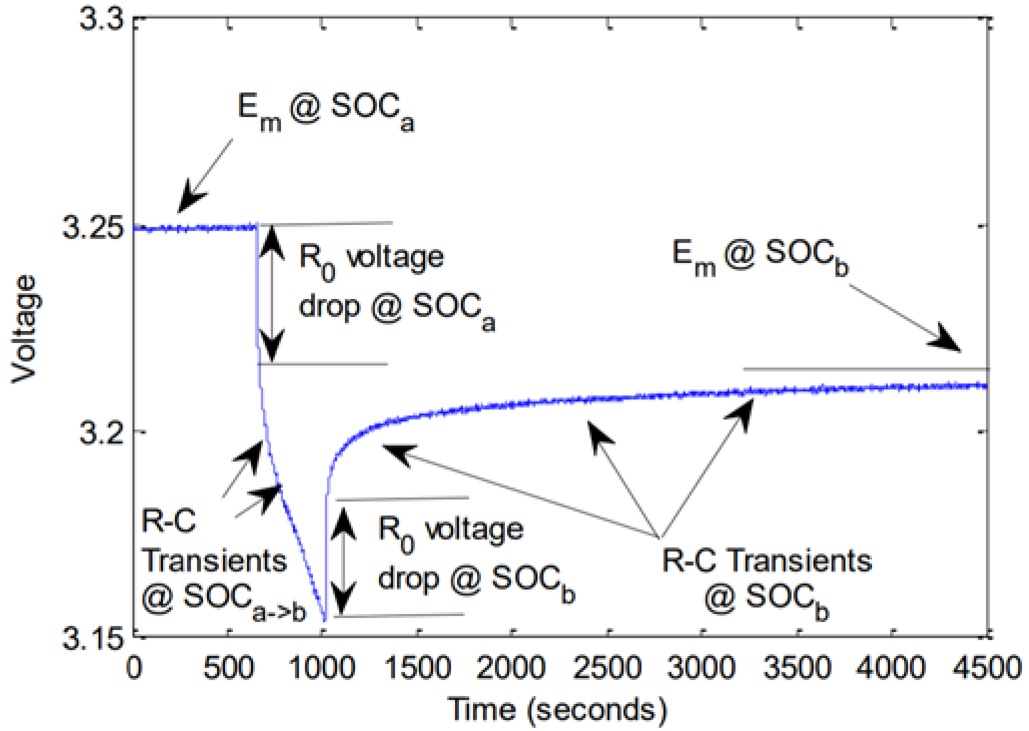


This plot is explained in section 3.3 in your lecture notes.

Parametrisation of the improved model (Part 2)

- You will start with a discussion of what physics is missing from your model in Part 1, which is aided by running the physics-based model (PyBaMM)
- A standard way of parametrising such a model is fitting the R,C component values to pulse data
- You are using the voltage sag to obtain information about what happens inside the battery

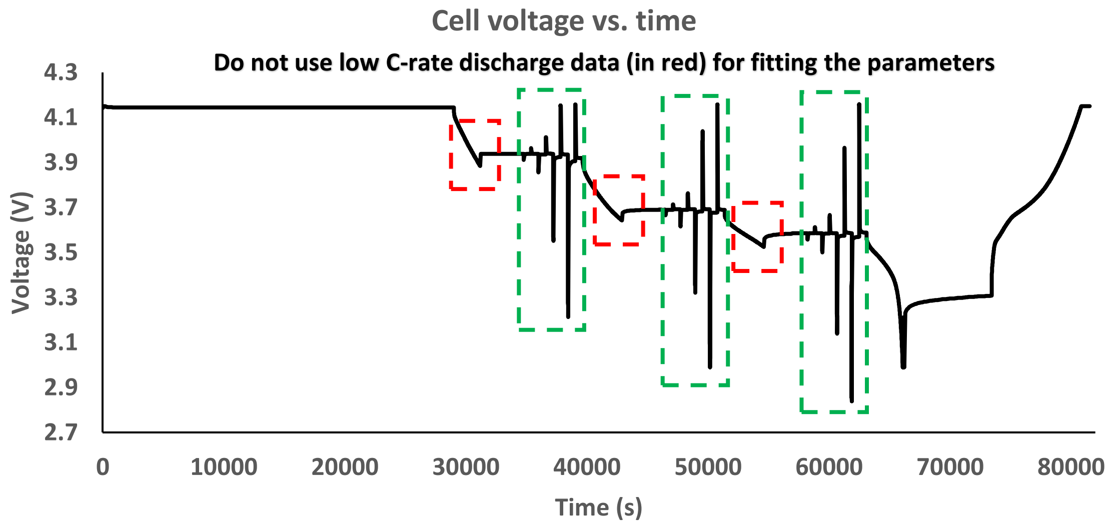
Voltage of the cell before, during and after a pulse of discharge current



https://fr.mathworks.com/tagteam/76117_SAE%203013%20-%20Battery%20Estimation%20Layered%20Technique.pdf

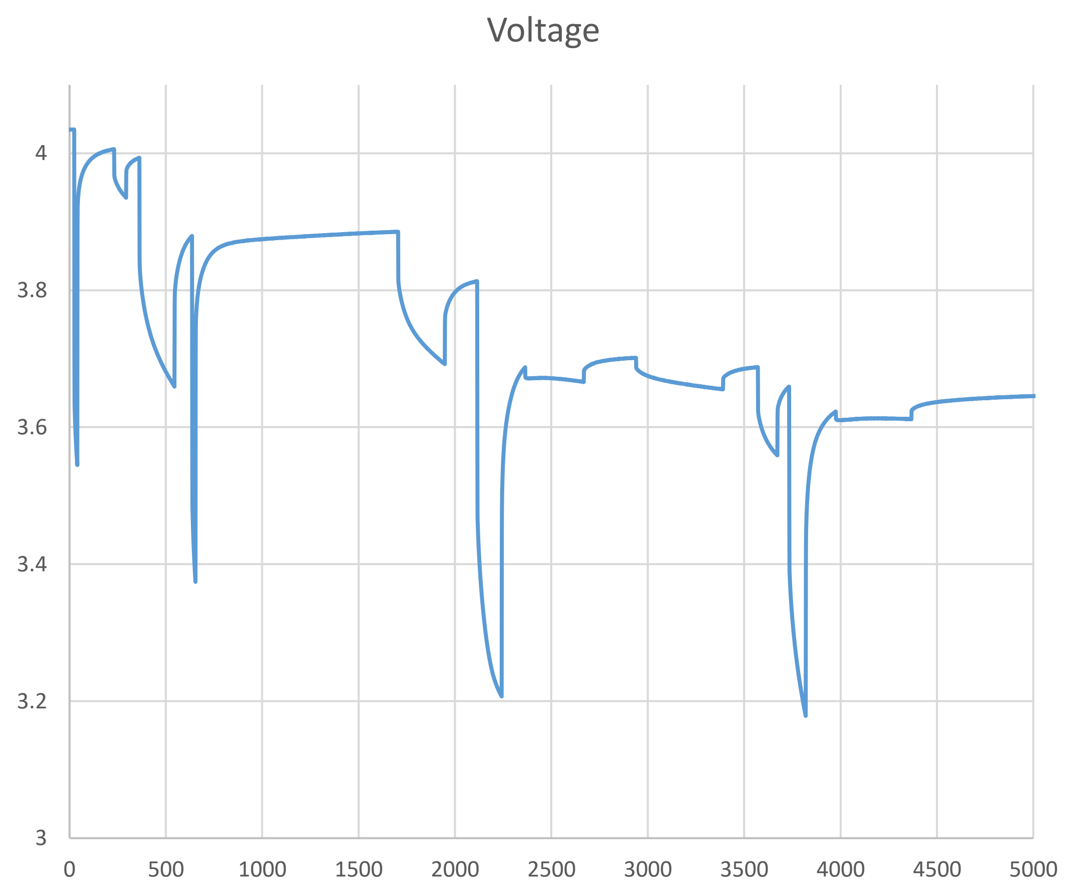
Parametrisation of the improved model (Part 2)

- You have been given pulse test data for the same cell
  - The pulses have been carried out at 3 different SOCs
  - For 8 different currents (4 charging, 4 discharging)
  - And at 4 different temperatures
- A dataset like this is very expensive to produce, the need for repeats can cost ~£100k-£1M
- **Optional**: This part could take a long time – we have provided dummy parameters to allow you to proceed with the coding and framework for the following parts of the project – remember to replace them with your parametrised values and equations before finalising those latter parts in the report



Validation data

- You have been given a different set of experimental data against which you test your model
  - This includes the voltage and temperature response to a current input
  - Put current into your model and compare your predicted voltage and temperature response to the experimental data
- You should never compare a model against the same data you used to parameterise it



Workload & timing recommendations

It is recommended you read the brief in order to understand how the different parts fit together. (Check figures 1-3 in the brief to see how the different activities are connected). This will enable you to assign tasks in parallel to the different members of the group, thus progressing much faster than if you did everything in sequence.

You are given a dummy set of parameters in Part 2d to enable you to develop and test the model in parallel with developing the parametrisation procedure.

1st tutorial

- Use it for questions on Part 2. You should have done part 1 and (at least) have a detailed plan of how you will do part 2 by this tutorial.

2nd tutorial

- Use it for any last questions of part 2 and aim to have started part 3

3rd tutorial

- Use it for questions on Part 4. You want to have done part 1-3 and have a detailed plan of how you will do part 4.