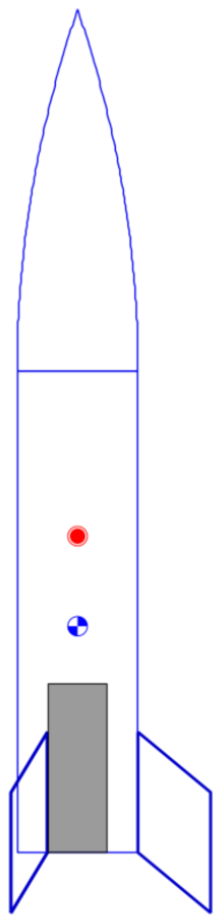
Open Rocket Experiments

Example based on assumed Response being Maximum Altitude reached by the rocket with a certain engine, and assuming no atmospheric wind disturbance.

I.e. the objective is to optimise the aerodynamic design of the rocket, using only the customisable options / shapes provided

OpenRocket provides a value known as ''The Stability Criterion'' which is measured in 'Cal'.

A rocket between 0.5 and 1.5 Cal is considered stable. Below 0.5 Cal is unstable and will be prone to spiralling out of control sending the rocket on non-vertical flight path. Anything above 1.5 Cal is considered over-stable and is prone to be guided by the weather conditions (E.g. Wind Direction). Therefore the simulations could be conducted with a wind speed of 0m/s so that over-stable rockets are unaffected by the atmospheric conditions, but this does not prevent unstable rockets from spiralling out of control and skewing results.



OpenRocket EXPERIMENT PROCEDURE (example)

- Create Generic Rocket Design in OpenRocket using: Parabolic Cone; Tubular Body; Attach Airfoil Fins to Bottom of Tubular Body; Mount Motor to Bottom of Tubular Body; Apply a 500g weight at bottom of Cone; Ensure all components are made of the same material.
- Import DoE factor levels (i.e. design your experiment)
- Adjust the Generic Rocket Design to represent the factor levels
- Double check all correct factor levels are applied
- Run Simulation
- Take note of 'Apogee' (AKA Maximum Altitude)
- Repeat for all remaining experimental design runs

Rocket Experiments: Response = Maximum Altitude

Cone	Cone Type
	Cone Parameter
	Cone Length
	Wall Thickness
Body	Body Length
	Body Diameter
	Inner Diameter
	Wall Thickness
Fins	Fin Shape/Type
	Fin Height
	Number of Fins
	Rotation
	Cant
	Root Chord
	Tip Chord
	Sweep Length
	Sweep Angle
	Relative Position
	Cross Section
General	Material
	Engine Type
	Component Surface Finish
	Applied Mass

Factors not included in the experiment:

Factor	Reason
Cone Type	Online study deemed Parabolic Cones most efficient. This was kept constant.
Wall Thickness	Effects the Weight, Not Aerodynamics.
Body Diameter	Body Diameter is the same as Cone Diameter.
Inner Diameter	Effects the Weight, Not Aerodynamics.
Wall Thickness	Effects the Weight, Not Aerodynamics.
Fin Shape/Type	Online study deemed Trapezoidal Fins most efficient. This was kept constant.
Rotation	Unknown effect on stability. Kept constant to prevent unstable designs.
Cant	Unknown effect on stability. Kept constant to prevent unstable designs.
Root Chord	Unknown effect on stability. Kept constant to prevent unstable designs.
Tip Chord	Unknown effect on stability. Kept constant to prevent unstable designs.
Sweep Length	Unknown effect on stability. Kept constant to prevent unstable designs.
Sweep Angle	Unknown effect on stability. Kept constant to prevent unstable designs.
Relative Position	Unknown effect on stability. Kept constant to prevent unstable designs.
Cross Section	Online study deemed Airfoil Cross Section most efficient. This was kept constant.
Material	Effects the weight and not aerodynamics. Material set as PVC and kept constant.
Engine Type	Type of Engine does not determine aerodynamic capability.
Applied Mass	Changing the mass helps stability but doesn’t affect aerodynamic design.

Rocket Experiments: Response = Maximum Altitude

Factors included in the experiments:

Factor	Reason	Coded Level -1	Coded Level +1
Cone Parameter	0 to 1 Setting. Makes Cone either Pointed or Curved. Effects the smoothness of the transition of air from Cone Tip to Body.	0 = Pointed	1 = Curved
Cone Length	Effects the gradient of air transition from Cone Tip to Body.	15cm	35cm
Cone Width	Effects gradient of air transition from cone tip to body. Increases total Surface Area of the rocket.	4cm	6cm
Surface Finish	Smoother the component finish, less drag acting on rocket.	Rough 600ηm	Polished 2ηm
Body Length	Length of rocket body. Effects the surface area for drag to act on.	50cm	70cm
Number of Fins	Effects the amount of surface area that can be acted on by drag forces.	3 Fins	4 Fins
Fin Height (Size)	Effects the amount of surface area that can be acted on by drag forces.	3cm	8cm

Rocket Experiments

Expectations from the Open Rocket experiments for the Modelling Coursework

1) Provide an analysis of the engineering problem you are choosing to study for the rocket design or operation, identifying the response variable of interest (e.g. maximum altitude), and the input factors that you select for the study – together with the rationale. [a minimum of 3 factors should be used, although if you use a screening experiment – more factors should be expected]
2) Outline the methodology for the study; this should provide an outline of the experiments that you plan (normal expectation is that you will be running a screening experiment followed by a multi-level DoE; you can however adopt different strategies – including a direct multi-level experiment – but you need to justify your strategy)
3) Design the DoEs, evaluate the design using the criteria discussed in class / tutorials, run the experiments (using OpenRocket) and collect the response data, fit models and select a model based on the discussion of performance.
4) Reflect on the model – judging its quality with both statistical and engineering metrics (i.e. do the trends that you observe make engineering sense?). Try to use external validation and select best options – either informally or using optimisation.
5) Discuss the overall results and reflect on your methodology – and on learning!

The normal expectation is that you use the Python tutorials for the coursework, but you can use alternative DoE software – e.g. the Matlab MBC toolbox (or Minitab).
You can choose a different case study (other than OpenRocket) – but you are advised to discuss this with the module team.