

Rocket Trajectory Analysis

You will set up a numerical simulation to predict your rocket trajectory in this activity.

You will need:

- Rocket and engine specifications (a computer connected to the internet is useful)
- Spreadsheet or calculator
- Sharp mind and pencil

Flight Simulations

You need to have some general specifications prior to setting up your numerical simulation.

- Rocket mass, Engine mass, Fuel mass and Engine Time-Thrust data.
 - Comprehensive thrust vs time curve raw data can be found at <http://www.thrustcurve.org/>
 - General information from Estes <http://www.estesrockets.com> including Time-Thrust curves from Estes <http://www.estesrockets.com/images/page%2033.pdf> and Engine Specifications <http://www.estesrockets.com/images/page%2034.pdf>

You will use the basic laws of motion and a spreadsheet to calculate height as a function of time. Each column in your spreadsheet will be a different quantity:

- Time (pick a small increment – you can always change it if it is not small enough or too small)
- Height: $y_{\text{new}} = y_{\text{old}} + v_{\text{avg}} \Delta t$
- Velocity: $v_{\text{new}} = v_{\text{old}} + a \Delta t$
- Acceleration: $a = \Sigma F/m(t)$
- Forces: F_{thrust} , F_{gravity} and F_{drag}
- Mass: $m = m_{\text{rocket}} + m_{\text{engine}} + m_{\text{fuel}}(t)$
 - Let m_{fuel} be used up linearly over the time it takes the engine to burn – typically 0.7 seconds so you could say $m_f = m_o(0.7 - t_i)/0.7$ where m_o is the initial mass of the fuel.
- Drag: $F_{\text{drag}} = 0.5 C_v \rho A v^2$
 - C_v , the drag coefficient, is typically 0.7 to 1.4
 - ρ is the density of air 1.29 kg/m³
 - A is the cross section of your rocket (make sure to get the units correct)
-

On-line Flight Simulation Tools

Feel free to use on-line tools to compare to your own calculations.

- NASA
 - Rocket Engine Performance - <http://www.grc.nasa.gov/WWW/K-12/airplane/rktengperf.html>
 - Model Rocket Index - <http://www.grc.nasa.gov/WWW/K-12/airplane/shortr.html>
- Model Rocket Altitude Predictor (<http://webalt.markworld.com/>) at <http://www.markworld.com/>
- Rocket Simulation (how to write a numerical simulation) <http://my.execpc.com/~culp/rockets>