

Rockets

Software

- VPython, Python and the graphical user interface (GUI) IDLE

Objective

Gain experience writing VPython programs

- Create and use graphics windows to plot variables
- Use a function

Learn how to animate an object with multiple non-constant forces

Learn how to effectively search for help in tutorials and reference manuals

Models are only as valid as the physics used to create them.

Flight Simulation

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 to calculate height as a function of time. Initially ignore the drag force and use a constant mass for your rocket.

- Time (pay attention to your Δt)
- Forces: F_{thrust} , F_{gravity} and F_{drag}
- Thrust: The magnitude is given by a piece-wise function and the direction can be determined by using the *norm(velocity.vector)* command in Python to give you the unit vector direction that the rocket is traveling.
- Drag: $F_{\text{drag}} = 0.5C_v\rho Av^2$
 - C_v , the drag coefficient, is typically 0.7 to 1.4
 - ρ is the density of air 1.29 kg/m^3
 - A is the cross section of your rocket (make sure to get the units correct)
- Determine momentum from the net force and velocity from the momentum and height from the velocity
- Mass: $m = m_{\text{rocket}} + m_{\text{engine}} + m_{\text{fuel}}(t)$
 - To 1st order m_{fuel} is a linear function over the engine to burn time (typically 0.7 s) – so use an *If* statement and let $m_f = m_o(0.7 - t_i)/0.7$ where m_o is the initial fuel mass.

On-line Flight Simulation Tools

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

- 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/shorttr.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>