TI-RASP ReadMe file

The TI-RASP program for the TI-83+ is based on and derived from the rocket altitude simulation program RASP-79E written by G. Harry Stine and included in his classic text, The Handbook of Model Rocketry. TI-RASP calculates the acceleration, speed and altitude of a rocket based on its weight, cross-sectional area, drag coefficient, and engine thrust profile.

For teaching physics, algebra, basic aerodynamic principles, and even some engineering and chemistry (for the rocket propellants) to high school students, nothing beats model rockets. It's practical stuff that has a clear application to real life, and they can prove what they've learned at the end of the course by building, launching, and measuring the performance of their own rocket against its predicted performance. (I believe there's already a TI program out there for calculating rocket altitude with azimuth and elevation measurements using some basic trigonometry.)

TI-RASP and RASP-79E have at their core four equations to calculate drag, acceleration, velocity, and vertical distance at intervals throughout the rocket's flight:

Drag = 0.5 * air density * velocity squared * drag coefficient * cross-sectional area of the rocket, or $Drag=0.5\rho V^2 C_d A$, measured in newtons (1 newton = 1 kilogram meter per second squared). Typical guesstimate drag coefficients for a model rocket are between 0.2 and 1.

Acceleration = ((thrust force – drag force) / mass) – acceleration of gravity, or $A=((F-D)/M)-9.8$, measured in meters per second squared. Mass decreases while the engine propellant is burning.

Velocity = initial velocity + (acceleration * time interval), or $V=V_o+A\Delta t$, measured in meters per second.

Distance = initial distance + (initial velocity * time interval) + (0.5 * acceleration * time interval squared), or $D = D_o+V_o\Delta t+0.5A\Delta t^2$, measured in meters.

Air density (ρ) varies with land surface elevation, atmospheric conditions (fronts and storms), temperature, and humidity. In TI-RASP, I have included a simple calculation for ρ that considers elevation, atmospherics and temperature but **not** humidity. This simple calculation also does not consider temperature or density changes with altitude as the rocket ascends, but since the drag coefficient you assign your rocket is a guesstimate (unless you have access to a well-instrumented wind tunnel) these simplifications for ρ won't add much to the total error in the drag force. The formula I use in the drag equation for air density is ρ = atmospheric pressure / (gas constant * temperature) and includes a conversion factor to convert units from inches of mercury and farenheit degrees to kg/m3.

Also in the drag equation, the cross-sectional area is calculated as the sum of body tube area and the area of the front edges of the fins.

Variables used in TI-RASP:

Str1	Engine code (A8, B6, C6 or D12)
A	Acceleration, m/s2
B	Propellant mass, kg
C	Drag coefficient (unitless)
D	Maximum diameter, in
E	[Intentionally omitted]
F	Thrust force, newtons
G	Burn duration in 0.1 second
H	Drag force, newtons

I	[Intentionally omitted]
J	Last velocity value (V_o)
K	Distance (altitude), m
L	Loop counter for calculations
M	Weight of rocket (including engine), oz
N	Number of 0.1-second intervals between displays
O	[Intentionally omitted]
P	Pointer to engine data within ENGIN list variable
Q	Number of fins on the rocket
R	Fin span (length perpendicular to the body tube, from root to tip), in
S	Fin thickness, in
T	Time in 0.1 second increments
U	Atmospheric pressure, inches of mercury
V	Velocity, m/s
W	Atmospheric temperature, degrees farenheit
ENGIN	List variable containing engine data

The list variable ENGIN uses the following data structure for each engine:

(Burn duration in tenths of a second + 1), propellant mass in ounces, thrust at T=0.1 sec, thrust at T=0.2 sec, ... , thrust at T=n sec, 0

The A8 engine has a burn duration of 0.3 seconds and a propellant mass of 0.11 ounces, so the data in ENGIN for the A8 is {4, .11, 6, 13, 2, 0}.

Pointer variable P stores the location of the first piece of data (the burn duration) for the selected engine within the ENGIN list variable. For the A8 engine, which appears first in ENGIN, P=1. For the B6 engine, which appears second in ENGIN, P=7. Data for additional engines can be added to ENGIN using the structure described above, by appending them to the end of the ENGIN list variable and inserting additional menu lines and IF-THEN statements in the TI-RASP program to set the proper value of P for each new engine data set. Engine thrust curves and other specifications are available from the engine manufacturers.

To install TI-RASP, copy **both** the TIRASP.8xp and LENGIN.8xl files to your calculator. To use TI-RASP, just start the program and follow the prompts, making sure to use the units specified (ounces and inches). For low-powered rockets, you may want to display data every 0.1 second (N=1) to watch how acceleration starts out positive and then turns negative. For high-powered rockets with longer flight times this may become tedious, so you can set N to a larger number and skip through the data more quickly.

If you have any questions or comments, e-mail me at dgravatt@juno.com