Rocket Launch Lab Report

1. Use the rocket equations spreadsheet to compute heights and velocities. You need to measure the preburn mass of the rocket.

2. Compute the height from trigonometry (need distance of observer away from launch site and the angle called off by the sighter).

3. Compute average velocity up and average velocity down (using height from #2 and measured times up and down).

4. Force Analysis of the 3 stages of the flight:

a) Thrust phase

$F_{net} = ma = F_{air} + F_g + F_a$ Note that this is a 2d VECTOR equation.

m is the average of the preburn and afterburn mass of the rocket.
a can be computed since we know v_1, v_2 and the burn time (from rocket equations spreadsheet)
$\boldsymbol{F_{air}}$ is air drag, $\boldsymbol{F_g}$ is weight, $\boldsymbol{F_a}$ is rocket thrust (from engine spec which is available from the rocket equations spreadsheet or the *Estes Manual*).

You can compute F_{air} from this VECTOR equation.

b) Coasting phase

$F_{net} = ma = F_{air} + F_g$ Note that this is a 2d VECTOR equation.

m is the afterburn mass of the rocket.
a can be computed since we know v_1, v_2 and the coast time (from rocket equations spreadsheet)
$\boldsymbol{F_{air}}$ is air drag, $\boldsymbol{F_g}$ is weight.

You can compute $\boldsymbol{F_{air}}$ from this VECTOR equation.

You should compare the $\boldsymbol{F_{air}}$ from part (a) and part (b)

c) Descent phase

$F_{net} = ma = F_{air} + F_g$ You could probably treat this as a 1d problem

m is the afterburn mass of the rocket.
$\boldsymbol{a} = (v_2 - v_1)/t$ ($v_1 = 0$, $v_2 = ?$, t is measured)

Here, we have a problem. The best we can do is to estimate v_2 from the average velocity down.

$$Vavg = (v_1 + v_2)/2 = (0 + v_2)/2 = v_2 / 2$$

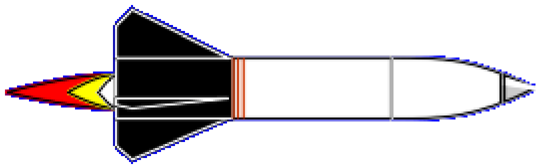
Therefore

$$v_2 = 2\ V_{avg}$$

Web References of use to you:
Rocket Equations Spreadsheet
Estes Rocket Manual
Available at: http://homepage.usask.ca/~llr130/
Click on Physics Pages

File: rocketlab.wpd

Rocket Equations Quick Reference



Equations for finding your rocket's peak altitude and motor delay.

$$k = \frac{1}{2}\rho C_d A$$

$$q = \sqrt{\frac{T - mg}{k}}$$

$$x = \frac{2kq}{m} = 2\frac{\sqrt{(T - mg) \cdot k}}{m}$$

$$t = \frac{I}{T}$$

$$v = q\frac{1 - e^{-xt}}{1 + e^{-xt}}$$

$$y_1 = \frac{-m}{2k}\ln\left(\frac{T - mg - kv^2}{T - mg}\right)$$

$$y_c = \frac{m}{2k}\ln\left(\frac{mg + kv^2}{mg}\right)$$

$$q_a = \sqrt{\frac{mg}{k}}$$

$$q_b = \sqrt{\frac{gk}{m}}$$

$$t_a = \frac{\tan^{-1}\left(\frac{v}{q_a}\right)}{q_b}$$

Definition of Terms

m = rocket mass in kg (see below)
g = acceleration of gravity = 9.81 m/s^2
A = rocket cross-sectional area in m^2
C_d = drag coefficient = 0.75 for average rocket
ρ (rho) = air density = 1.22 kg/m^3
t = motor burn time in seconds (NOTE: little t)
T = motor thrust in Newtons (NOTE: big T)
I = motor impulse in Newton-seconds
v = burnout velocity in m/s
y_1 = altitude at burnout
y_c = coasting distance
Note that the peak altitude is $y_1 + y_c$
t_a = coasting time => delay time for motor

Note on the rocket mass: you usually know the empty (no motor) mass of your rocket m_r. You can usually find the loaded mass of your motor, m_e, and the mass of the propellant, m_p. Both Estes and Aerotech provide these numbers in their spec sheets and with the motors. Then

average mass during boost is $m_r + m_e - m_p/2$
use this value for all but the y_c, q_a, and q_b calculations.

mass during coast is $m_r + m_e - m_p$
use this value for the y_c, q_a, and q_b calculations.

- You can use the spreadsheet rockets.wks to do these calculations

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