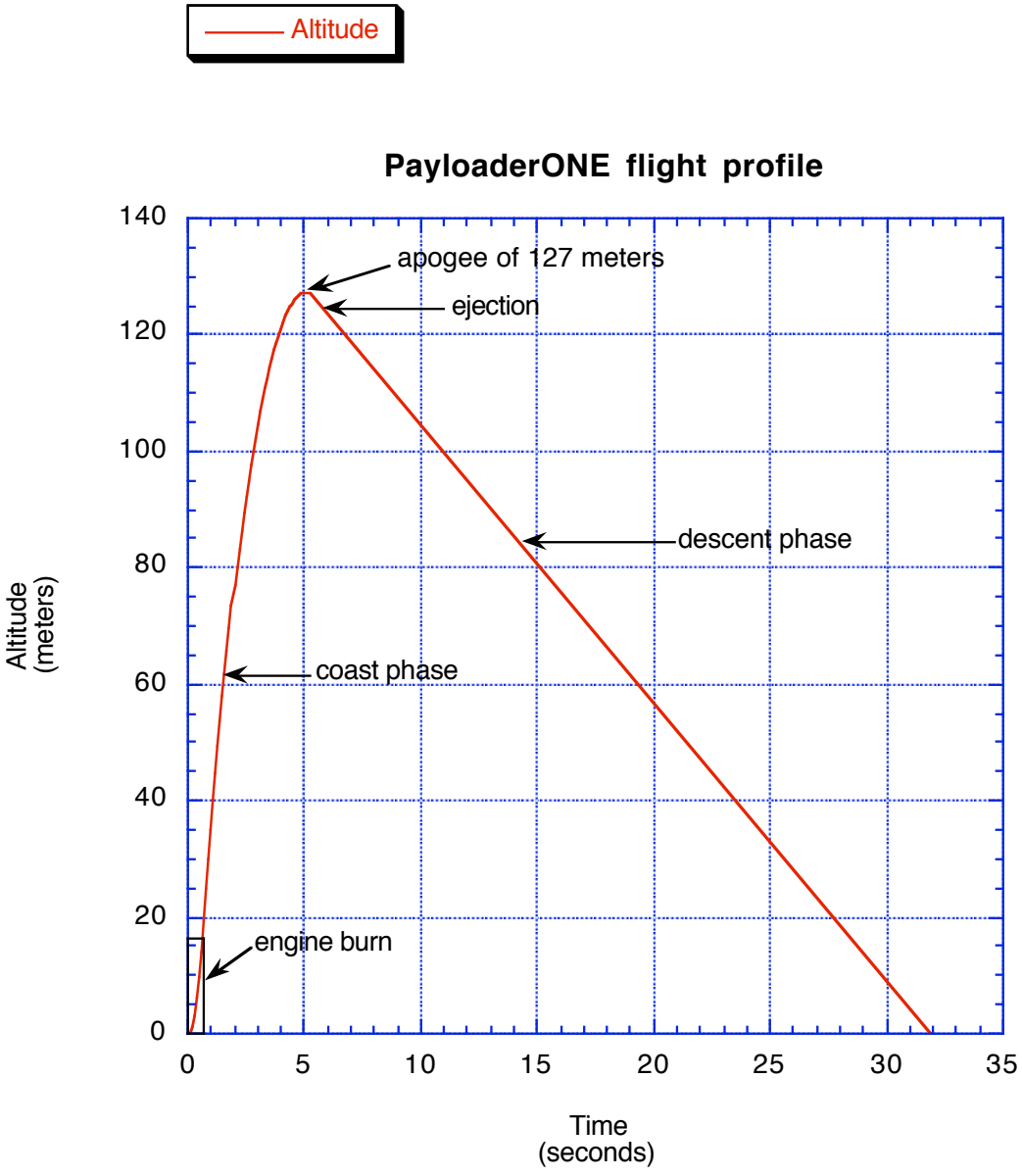
Falling Eggs

The graph below shows the altitude of versus time for a flight of a Quest PayloaderONE rocket containing a PerfectFlite A15K altimeter in its payload compartment and launched with a Quest B6-4 motor.



What is the descent velocity of the rocket after it ejects the parachute?

The parachute is ejected at about 5.3 seconds into the flight ("t plus 5.3 seconds"). The rocket is at an altitude of about 127 meters at this time. The rocket hits the ground (altitude of zero) at about 32 seconds into the flight. So the rocket descended 127 meters in (32 - 5.3 = 26.7) seconds, or

$$\text{velocity } v = \frac{127 \text{ meters}}{26.7 \text{ seconds}} = 4.76 \text{ m/s}$$

The descent velocity is constant because the parachute quickly reaches its terminal velocity - the velocity at which the drag of the parachute exactly balances the force of gravity.

If we wish to simulate the forces experienced by the rocket's payload during landing, we can drop the payload compartment without a parachute from a height sufficient for gravity to accelerate the payload compartment to a speed of 4.76 meters per second.

For a constant acceleration *a*, the velocity increases linearly over time:

$$v = a\,t$$

The acceleration of gravity is about 9.8 meters per second squared (m/s^2). Our desired velocity is 4.76 meters per second. For how long must the payload compartment fall for it to reach a velocity of 4.76 meters per second?

$$t = \frac{v}{a} = \frac{4.76 \text{ m/s}}{9.8 \text{ m/s}^2} = 0.49 \text{ s}$$

From what height must we drop the payload compartment for it to take 0.49 seconds to fall to the ground?

The distance *x* traveled by an object subjected to a constant acceleration is

$$x = \frac{1}{2} a\,t^2$$

We want our payload compartment to fall for 0.49 seconds under the acceleration of the force of gravity (9.8 m/s^2), so the distance it must travel is

$$x = \frac{1}{2} a\,t^2 = \frac{1}{2} \bullet 9.8 \bullet (0.49)^2 = 1.18 \text{ meters}$$

or about 3.9 feet.

Rocket Science Challenge of the Week: Falling Eggs

The 2009 TARC contest challenge is to loft a raw egg to as close as possible to 750 feet (228.6 meters) with a total flight time of as close as possible to 45 seconds and recover the egg intact.

A typical TARC model takes 7 seconds to reach maximum altitude and eject its parachute. What is the descent velocity needed to meet the flight time target of 45 seconds?

From what height would you have to drop a TARC egg payload compartment to simulate the impact the egg will have to survive during landing?