A Taste of Real Rocket Science

Naturally, launching rockets into space is more complicated than Newton's laws of motion imply. Designing rockets that can actually lift off Earth and reach orbital velocities or interplanetary space is an extremely complicated process. Newton's laws are the beginning, but many other things come into play. For example, air pressure plays an important role while the rocket is still in the atmosphere. The internal pressure produced by burning rocket propellants inside the rocket engine combustion chamber has to be greater than the outside pressure to escape through the engine nozzle. In a sense, the outside air is like a cork in the engine. It takes some of the pressure generated inside the engine just to exceed the ambient outside pressure. Consequently, the velocity of combustion products passing through the opening or throat of the nozzle is reduced. The good news is that as the rocket climbs into space, the ambient pressure becomes less and less as the atmosphere thins and the engine thrust increases.

Another important factor is the changing mass of the rocket. As the rocket is gaining thrust as it accelerates upward due to outside pressure changes, it is also getting a boost due to its changing mass. Every bit of rocket propellant burned has mass. As the combustion products are ejected by the engine, the total mass of the vehicle lessens. As it does its inertia, or resistance to change in motion, becomes less. As a result, upward acceleration of the rocket increases.

In practical terms, Newton's second law can be rewritten as this:

$$f = m_{exit}V_{exit} + (p_{exit} - p_{ambient})A_{exit}$$

("A" refers to the area of the engine throat.)

When the rocket reaches space, and the exit pressure minus the ambient pressure becomes zero, the equation becomes:

$$f = m_{exit}V_{exit}$$

In real rocket science, many other things also come into play.

- Even with a low acceleration, the rocket will gain speed over time because acceleration accumulates.

- Not all rocket propellants are alike. Some produce much greater thrust than others because of their burning rate and mass. It would seem obvious that rocket scientists would always choose the more energetic propellants. Not so. Each choice a rocket scientist makes comes with a cost. Liquid hydrogen and liquid oxygen are very energetic when burned, but they both have to be kept chilled to very low temperatures. Furthermore, their mass is low, and very big tanks are needed to contain enough propellant to do the job.

In Conclusion...

Newton's laws of motion explain just about everything you need to know to become a rocket scientist. However, knowing the laws is not enough. You have to know how to apply them, such as:

- How can you create enough thrust to exceed the weight of the rocket?
- What structural materials and propellant combinations should you use?
- How big will the rocket have to be?
- How can you make the rocket go where you want it to?
- How can you bring it back to Earth safely?