

SPINOFF 14A

NASA Launch Vehicle Calculations

Background

Cars and airplanes use air-breathing engines. They carry fuel on board and use the Oxygen in the air to burn the fuel and generate power. Air is about 20 percent Oxygen. Space vehicles use rocket engines which do not take in air. Oxygen must be carried on board the rocket powered vehicles along with the fuel. The oxygen and fuel are carried in separate tanks.

Space vehicles are relatively lightweight structures. To strengthen the vehicle's structure would add extra weight. Any added structural weight would decrease the payload that could be launched. Typically the payload is less than 10 percent of the total vehicle weight (including payload and fuel) at liftoff. The vehicle must be designed with the minimum amount of structure to maximize the payload capacity.

The following problems are based on actual data provided by NASA engineers.

Exercises

- 1) The Space Shuttle Orbiter weighs 165,000 pounds. The external tank weighs 1,667,000 pounds full, and the solid rocket motors weigh 2,214,000 pounds. A particular payload weighs 35,000 pounds. (a) What is the total weight of the vehicle, including the payload, on the launch pad? (b) What percentage of the total weight is the weight of the payload?
- 2) The total liftoff weight of an Atlas rocket, including the payload, is 413,000 pounds. The payload is 2.1 percent of the total liftoff weight. Assume that the rocket is redesigned so that its weight, not including the payload, is 7% less than the total liftoff weight of the Atlas rocket. (a) If the total liftoff weight of the redesigned vehicle is the same as that of the Atlas rocket, what is the new payload weight? (b) What is the percent **increase** in the payload weight?
- 3) The total liftoff weight of an Atlas rocket, including the payload, is 413,000 pounds. The payload is 2.1 percent of the total liftoff weight. Assume that the rocket is redesigned so that its weight, not including the payload, is 7% less than the liftoff weight of the Atlas rocket without a payload. (a) If the total liftoff weight of the redesigned vehicle is the same as that of the Atlas rocket, what is the new payload weight? (b) What is the percent **increase** in the payload weight?