

## CHAPTER OVERVIEW

### 33: Rockets

A rocket is a vehicle that propels itself through space by ejecting a propellant gas at high speed in a direction opposite the desired direction of motion. The German V-2 rocket was an early example, as were the United States rockets such as Juno, Redstone, Agena, and Saturn. The largest and most powerful rocket ever built is the United States Saturn V Moon rocket, which took the Apollo astronauts to the Moon in the 1960s and 1970s.

In order to place a spacecraft into low-Earth orbit, a rocket must accelerate its payload from rest to a speed of about 17,000 miles per hour. In order to reach this speed, most of the rocket's mass must be fuel. The amount of fuel required for a given mass of payload is governed by the rocket equation, which will be derived here.

Some critics of early space exploration claimed that rockets would not be able to travel in space because "they would have nothing to push against." As we'll see here, such arguments are silly—one needs only to make use of the conservation of momentum to show that rockets can work in space.

[33.1: The Rocket Equation](#)

[33.2: Mass Fraction](#)

[33.3: Staging](#)

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