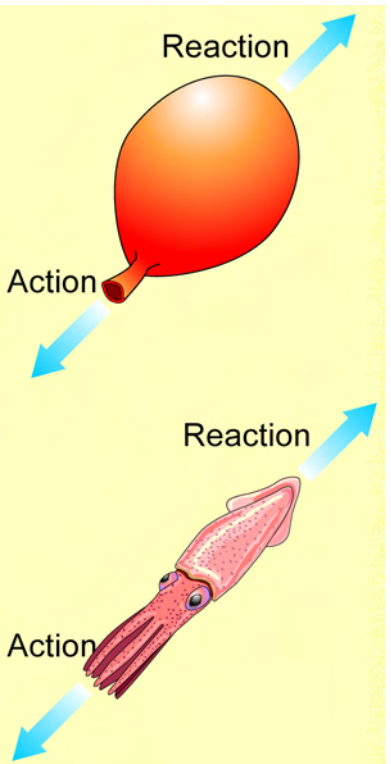
Rockets: Out of This World Travel

What if you wanted to travel to space? What type of vehicle would get you there? Your vehicle would need to reach incredible speeds to travel huge distances. Speed is also important in overcoming the gravitational pull of planets, moons, and the sun. Your vehicle would need to be able to travel in a *vacuum* because space has no air. It would also need a very powerful engine to get into space.

So what would be your vehicle of choice? A rocket, of course!

Rockets and Newton's 3r'd law

A rocket is a vehicle with a special type of engine. The basic principle behind how a rocket works is Newton's third law, *for every action, there is an equal and opposite reaction*.

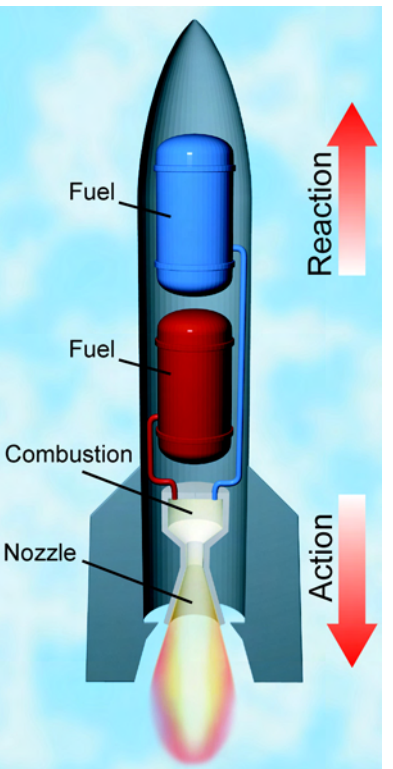


What happens when you blow up party balloon, then let it go, allowing the air to blow out the open end? The balloon darts around the room, travelling through the air. With the balloon, the *action* is the air being expelled. The *reaction* is the movement of the balloon in the opposite direction. Another example is the movement of squid. A squid takes water into its body chamber and rapidly expels it out of backward-directed tube. What are the action and reaction forces in this example?

Rocket science

The action/reaction forces demonstrated by the balloon and squid, are the main idea behind how a rocket engine works. A rocket engine forces material out the nozzle in one direction causing the rocket to move in the opposite direction.

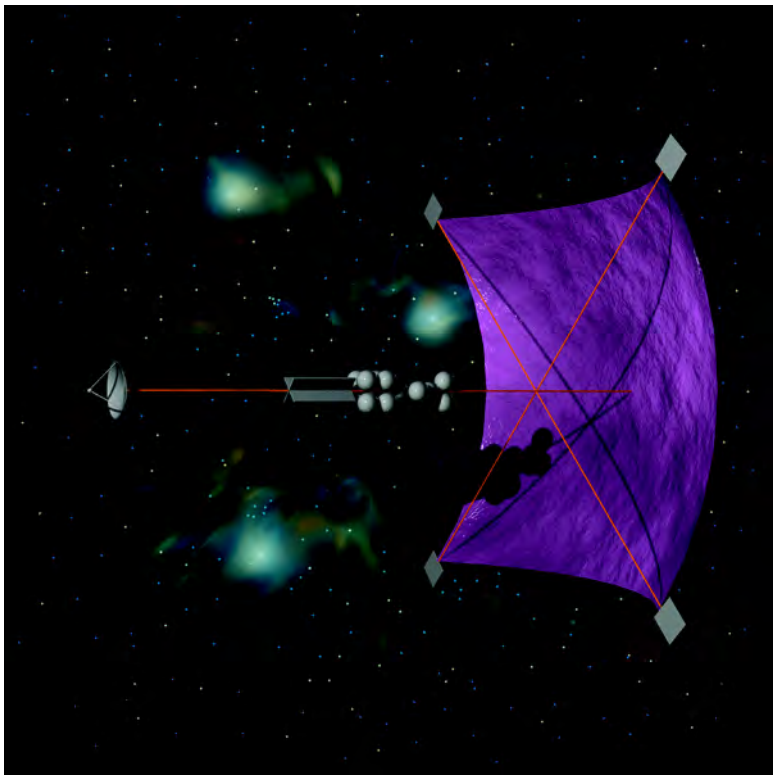
The mass that is ejected in a rocket's exhaust is the same as the mass of fuel that is burned. The speed of the fuel is very high, often more than 1,000 meters per second. Since the backward-moving fuel carries negative momentum, the rocket must increase its positive momentum to keep the total momentum constant.



To break free from Earth's gravity and get into space, a rocket must reach a speed of over 40,250 kilometers per hour (called *escape velocity*). Attaining this speed requires a rocket engine to achieve the greatest possible action force, or *thrust*, in the shortest time. To do this, the engine must burn a large mass of fuel and push the gas out as fast as possible. The fuel required to achieve this thrust weighs over 30 times more than the rocket and its payload (what it carries). Rockets that travel into space are so huge because you need to carry lots of fuel!

Rocket scientists

Robert Goddard (1882 to 1945), an American scientist, concluded that it was possible to travel to space by applying the kind of thrust demonstrated by the balloon example. Goddard was able to take his ideas beyond theory and actually designed and built rockets. In fact he launched the first liquid-fueled rocket in 1926. Perhaps more importantly, Goddard proved rockets can propel objects in a vacuum. This touched off a revolution in thinking about space travel that continues to this day. His patents and technology innovations would solve the large problems of rockets in space. There are over 200 patents from Goddard's work.



A little help from gravity

In August 2004, NASA launched MESSENGER, a spacecraft headed for the planet Mercury. The entire trip will cover almost 7.9 billion kilometers (5.9 billion miles) rounding the sun 15 times. At 1,100 kilograms, MESSENGER is considered lightweight for a rocket. While more than half of the weight is fuel, it would not be enough to cover this great distance without some external help. Thankfully, not all of the trip is to be powered by the energy of the rocket. MESSENGER will get a slight boost from the sun and different planets it passes.

While rocket technology will continue to power the space exploration industry for years to come, we need to develop newer energy sources or whole new technologies to take us deeper into space. Scientists estimate that if we were to travel to distant regions of our own solar system using today's fuel technologies, 99% of the spacecraft launch weight would have to be fuel and only 1% would be payload. Can you think of ways to do this without having to carry so much fuel on board?

The future of rockets

Some new technologies being developed and tested for deep space travel minimize the fuel storage burden, by having their energy sources located behind them. One of these technologies uses the particles from the sun as a "wind" to accelerate the spacecraft like a sail boat. Another idea uses extremely light gases for fuels to reduce the mass required and increase the distances that can be covered. Still another idea is to find ways to accelerate atomic particles to extremely high speeds, creating thrust more efficiently. Even with these advanced technologies, all rockets rely on the ideas in Newton’s laws.

Questions:

1. Is a rocket’s thrust the action or reaction force?
2. Why are rockets for deep space travel so huge?
3. How is a rocket engine different than an automobile engine?
4. What are the major obstacles to bringing humans deeper into space?