

## Rockets

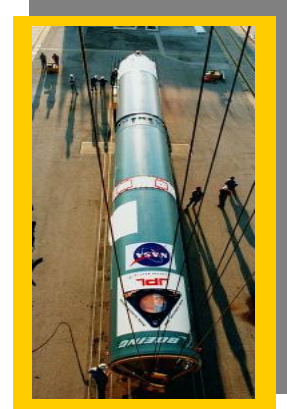
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The idea behind a rocket is rooted in basic physics principles that Isaac Newton developed about three hundred years ago. It's simple. Stand in a floating boat with a pole in your hand. If you want the boat to move, reach out with the pole and push off against something, like a nearby dock or the bottom of the pond. That's an example of the statement, "For every action, there is an equal and opposite reaction." It's also called Newton's Third Law of Motion, or more generally Conservation of Momentum. That means that forces (the push) are always balanced either by other forces or by changing the speed of some object (giving your boat momentum).

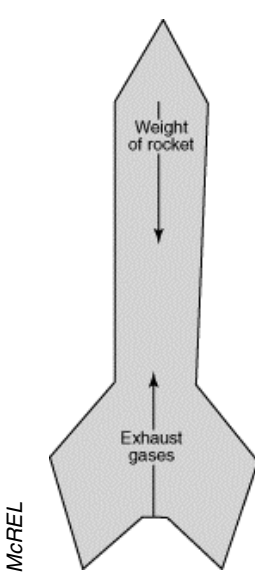
What can you do if you're floating in space, and there's nothing near you from which to push off? If there were a wrench in your tool-belt, you could take it out and throw it. Then you would be pushing off of the wrench. Its momentum would be in one direction, and you would gain momentum in the other direction. A wrench is small and doesn't have much mass compared to you, but if you threw it as hard as you could, you would achieve some small speed in the opposite direction.

What if that small speed isn't enough? Then you have to keep working, and find other things that you can throw (in the same direction) to give yourself more momentum. A constant stream of things would be ideal. That is what a rocket supplies. Rather than tiring yourself out throwing things, rockets use the energy stored in the chemical bonds of fuel. Burning fuel and oxygen (which also must be carried) makes pressurized exhaust gases. High-pressure gas squirting backward makes the rocket move forward.



Delta II Rocket being lifted into position

NASA



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Sometimes this "action-reaction" idea is misunderstood. Before NASA was created, a number of US newspapers were reporting on early tests of rockets. A newspaper editorial said it was really stupid to try to fly rockets in space. Since there was no air in space (true enough), it stated there was nothing for the exhaust to push against. It concluded that rockets couldn't possibly work. Actually, the writer didn't understand the law of action-reaction.

There are always two bodies involved in action and reaction. With a rocket, it's not the engine exhaust pushing against the air. The exhaust pushes against the rocket. Exhaust gases have mass, even though they seem insubstantial. They are being given momentum, which transfers to the rocket.

Behind all rocket design is the idea of action and reaction. There is no way to move a spaceship without applying the concept of action and reaction.



Delta Rocket Launch

NASA

