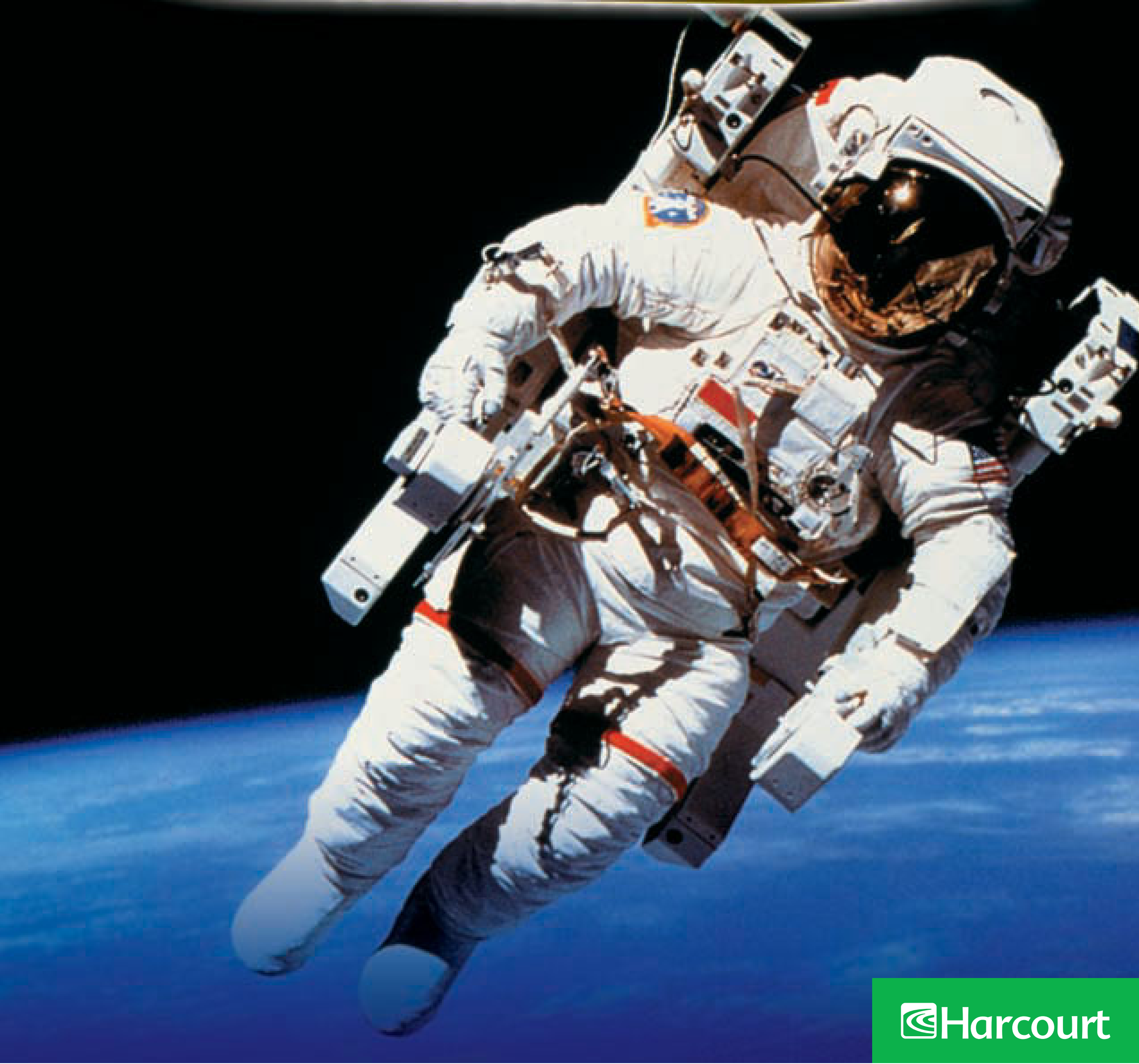
# Becoming an Astronaut



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# Spaceward Bound!

“Three, two, one, SRB ignition—liftoff!” exclaims the voice from mission control in your helmet radio. At T minus 0 seconds, the two solid rocket boosters ignite, and the space shuttle starts to move upward. (“T” refers to the time of launch.) You don’t feel much acceleration at this time, and the solid boosters do not run smoothly at all. The shuttle trembles and vibrates strongly as it blasts off into space, shaking you and the other astronauts from side to side. But you are mentally prepared for the launch, and you know by heart all of the procedures that you trained for during the preceding months and years.

“T plus 2 minutes—solid rocket boosters are spent.” The empty boosters detach from the shuttle and drop down to Earth to be recovered and used again. The ride is quieter and smoother now. The three liquid propellant main engines continue to burn. The shuttle becomes lighter as its fuel is used up. As the shuttle gets lighter, its acceleration keeps increasing.

“T plus 7 minutes and 30 seconds!” The huge external fuel tank is now 90 percent empty. The shuttle, which had weighed 2,000 tons at launch, now weighs less than 200 tons. The force pressing down on you is 3 g’s (three times the force of Earth’s gravity). Your back is being pushed against the seat, and it becomes hard to breathe. The three main engines are burning fuel at the rate of 1,000 gallons every second. The shuttle must accelerate from zero miles per hour at T minus 0 seconds to over 17,000 miles per hour at T plus 8 minutes and 30 seconds. This means that it accelerates at the rate of 2,000 mph every minute! The fuel in the external fuel tank is used up, and the tank detaches and falls back to Earth.

“T plus 8 minutes and 30 seconds—main engine cutoff (MECO).” The thrust from the engines drops off to zero. The pressure disappears from your chest, and you feel weightless. The shuttle has reached space, more than 240 miles above Earth. All is quiet.

You feel weightless because the shuttle and everything inside it are in free fall, traveling about 300 times faster than a car on the freeway. You peek out the window to get your first view of Earth from space.

"Welcome to space, and enjoy the view!" says the voice from mission control.

"Roger that. The view is absolutely breathtaking!" you reply. "Earth looks like a giant blue marble, turning slowly beneath us! It's beautiful!"

## Training to Be an Astronaut

Did you ever dream of blasting off into outer space? If you are looking for a career that combines technology with exciting adventure, then you could hardly make a better choice. In the future, there will be a need for astronauts on both the space shuttle and on the International Space Station (ISS).


At T minus 0 seconds, the solid rocket boosters ignite. At T plus 2 minutes, they are spent. By T plus 8 minutes and 30 seconds, the fuel in the external fuel tank is used up and the tank falls off.

Much innovative research takes place in space. Unique conditions exist in outer space that do not exist on Earth: microgravity, wide temperature extremes, a high vacuum, unfiltered solar energy, and unique vantage points for viewing Earth and the cosmos. The research in space that takes advantage of these conditions may lead to new medical breakthroughs, new technologies, or new industrial products.

Because so many people are fascinated with the idea of space travel, the competition for the few available astronaut positions is fierce. Among those individuals who are selected, many have multiple degrees in medicine, science, and engineering, and others have military training and aviation flight experience. All, however, are among the best in their chosen fields, and all are dedicated to expanding our scientific knowledge to help improve the quality of life on Earth and in space.

There are four different types of astronaut positions, and each requires different training. Astronauts can be commanders, pilots, payload specialists, or mission specialists. A commander is responsible for a mission, the crew, and the spacecraft. The pilot assists the commander. Mission specialists work with the commander and pilot in operating the spacecraft, performing spacewalks needed for spacecraft repairs, and conducting experiments. Payload specialists are astronauts whose major responsibility is conducting scientific experiments on board the spacecraft or handling special equipment.

If you are healthy, have a four-year college degree in math, science, or engineering, and have three years of related work experience, you can submit an application to NASA to become an astronaut. Then you might be invited to participate in a weeklong session of interviews, medical tests, and orientation. If you are lucky, you may be accepted as an astronaut candidate. Every two years, about one hundred men and women are selected to be astronaut candidates.

As an astronaut candidate, you go through a rigorous training period that lasts from one to two years. You take classes in basic science (math, astronomy, physics, geology, meteorology, and oceanography), technology (navigation, orbital dynamics, materials processing), and space shuttle systems. You are also trained in land and sea survival techniques, how to survive in microgravity and in low- and high-air-pressure environments, how to scuba dive, and how to use spacesuits. If you want to be a pilot or commander, you are trained to fly the shuttle.

At the end of the two-year training, you may be selected to become an astronaut. You continue to take classes on various kinds of space shuttle operations. After that, you begin training in simulators for pre-launch, launch, orbit, reentry, and landing. This general training continues until you are selected for a flight.

When you are selected for a mission, you begin training for it at least 10 months before the flight. This includes training in flight simulators, training with full-scale models of the shuttle and space station, and underwater training for space walks. This program of training prepares you for every type of emergency imaginable.

It takes plenty of education, hard work, and dedication to become an astronaut. But ask any astronaut, and he or she will tell you that the job is worth it!

**The International Space Station**

**The first two modules of the International Space Station were launched in 1998, and the first crew arrived in 2000.**

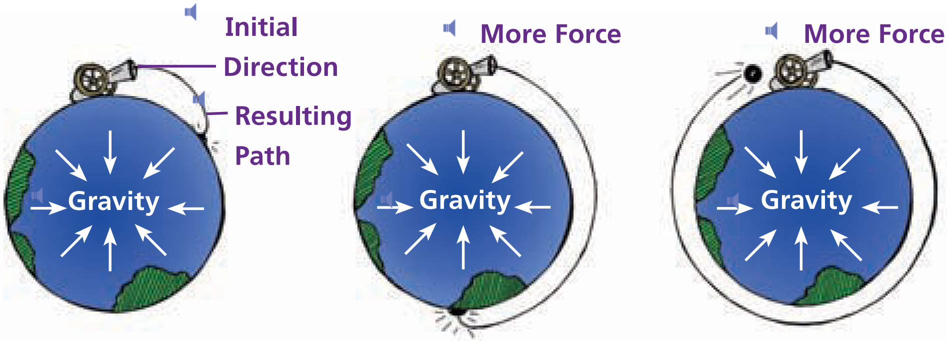
## Putting a Spacecraft into Orbit

To be an astronaut, you have to understand the basics of spaceflight. For example, you must understand how a spacecraft is launched into orbit around Earth.

More than 300 years ago, a scientist named Isaac Newton discovered the basic principles of motion that are still used in spaceflight today. Newton was the first scientist to hypothesize on how to put a spacecraft into orbit. He reasoned that the same gravitational pull of Earth that causes an apple on a tree to fall to the ground also extends into space to pull on the moon. Newton did this thought experiment to determine how to get a spacecraft into orbit: Think about Earth with a tall mountain rising from it. On top of the mountain is a cannon. When the cannon is aimed straight out and fired, a cannonball shoots out and then falls back to Earth in an arc. Earth's gravity eventually pulls the cannonball down, and it hits the ground some distance away from the mountain. Next, think about putting more gunpowder in the cannon. The next time the cannon is fired, the ball goes halfway around Earth before it hits the ground. With still more gunpowder, the cannonball goes so far that it never touches down at all. It falls completely around the Earth.

### Newton's Orbit Thought Experiment

**If Newton's cannon is fired with enough force, the cannonball goes into orbit.**



It has achieved orbit. (This process is called a thought experiment because it would not be possible in real life. The force of drag would slow the ball down and bring it back to Earth.)

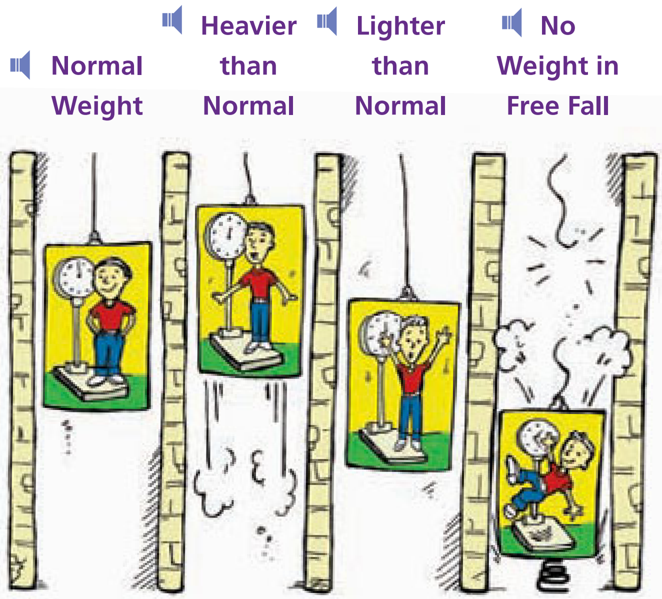
Likewise, to launch a spacecraft such as the space shuttle, NASA scientists must make sure that the vehicle is rocketed high above Earth and aimed so that it travels parallel to the ground. To get the craft into orbit, the scientists must accelerate until the vehicle is going so fast that, as it falls, its path completely circles Earth. The scientists must also raise the vehicle high enough so that Earth's atmosphere will not slow it down too much. If drag slows it down, the spacecraft will fall back to Earth.

To launch a space shuttle into orbit, NASA scientists must determine how much fuel to fire off and in exactly which direction to project it. If the shuttle reaches an altitude of 200 miles, the shuttle must maintain a speed of 17,240 mph to remain in Earth orbit. At this speed and altitude, the shuttle "falls," but the path it traces as it falls matches the curvature of the Earth. As a result, the shuttle moves in a path that is parallel, in a sense, to Earth's surface. The shuttle stays in orbit.

## Microgravity

If Earth's gravity keeps the space shuttle in orbit, then why do the astronauts inside feel weightless? If you were riding along with the cannonball from Newton's thought experiment, you would feel as if you were falling. This is called free fall. You would fall at the same rate as the cannonball, which would appear to be floating there beside you. You would never hit the ground. Likewise, the astronauts and everything else inside the space shuttle fall together, so they seem to float in relation to one another. Therefore, astronauts in orbit feel weightless. This condition of free fall is called microgravity. (It is called microgravity because extremely tiny amounts of gravity are present, on the order of one millionth of Earth's gravity.)

If you stand on a scale inside an elevator, your weight increases as the elevator starts up and decreases as the elevator starts down. You have no apparent weight in free fall.




Here is another thought experiment to help you understand why astronauts in orbit feel weightless. Imagine that you are standing in an elevator. When the elevator starts to go up, you can feel your weight pressing harder against the floor. When the elevator comes to a stop, you can feel your body lifting up from the elevator floor. Now suppose that the elevator cord is cut. Until it hits the ground, you and the elevator are falling toward Earth. Even though gravity still pulls you toward Earth, you are floating inside the elevator. In the same way, the spacecraft in orbit and the astronauts inside are falling together, so the astronauts float inside the spacecraft.

Eventually, though, the shuttle has to land. To stay in orbit, the shuttle has been moving at a speed that makes the curvature of its "falling" match the curvature of Earth's surface. If the shuttle slows down, however, the path it follows will change from a big circle going forever around Earth to a curved path that ends on Earth's surface.

## Effects of Microgravity

It's one thing to understand why you float around inside an orbiting spacecraft. It's quite another thing to get used to living and working in microgravity. Floating in space is great fun, but your body must adjust to microgravity. Here on Earth, your body knows which way is up and which way is down because your inner ear always feels gravity pulling you downward. When you are in space, your inner ear is confused by the lack of a clear "up" or "down" direction. The result is that astronauts often experience space motion sickness.

In microgravity, your body actually grows from one to two inches longer because gravity is not pushing the vertebrae in your spine together. You float around, and your legs are not really used at all. As a result, your lower back and leg muscles begin to waste away, just as muscles do in a cast. Your bones also begin to lose calcium. During a short shuttle mission, this process is just starting and at most might cause the astronauts some soreness in the first few days after they return to Earth. But for astronauts who spend months on the International Space Station, these factors can become a serious health threat. To prevent loss of muscle mass and bone strength, astronauts on the space station must exercise daily.

Living in microgravity also affects the heart and the circulatory system. On Earth, blood tends to pool in the legs. The heart has to pump against gravity to bring enough blood to the brain. In microgravity, the blood volume in the upper body and head is increased. The water in and around the body's cells shifts upward and causes the face to appear puffy. Body fluids collect in the sinuses, resulting in nasal stuffiness and difficulty in tasting food. The body's regulatory mechanisms excrete the excess fluids in the upper body. In three days, the fluid and blood volume in the body is reduced by about one-third. Upon returning to Earth, astronauts may feel lightheaded until they regain their lost body fluids.

In our daily activities here on Earth, we take gravity for granted. But many adjustments must be made when living in microgravity. Moving around and manipulating objects in microgravity takes a good deal of effort. Being weightless forces major changes in how we carry out everyday activities, including eating, sleeping, working, washing, and using the toilet. There is no dining room on the space shuttle, for example. To eat, you just strap a tray to your legs. You can consume just about any food or drink that can be restrained in a container. Otherwise, it may float off as you are trying to eat or drink it. You must be careful not to make any sudden movements that might send the food flying.

If you want to sleep, you can attach your sleeping bag to the floor, the ceiling, or the wall. You must get used to the sensation of floating in the air while sleeping. Interestingly, some astronauts have a hard time getting used to this, but others have no problem whatsoever. If you sleep with your head in an area where the air isn't moving, the carbon dioxide that you exhale can build up near your nose. This can cause the carbon dioxide level in your blood to rise, and you will wake up short of breath. However, after moving around a bit, you can catch your breath and fall asleep again.

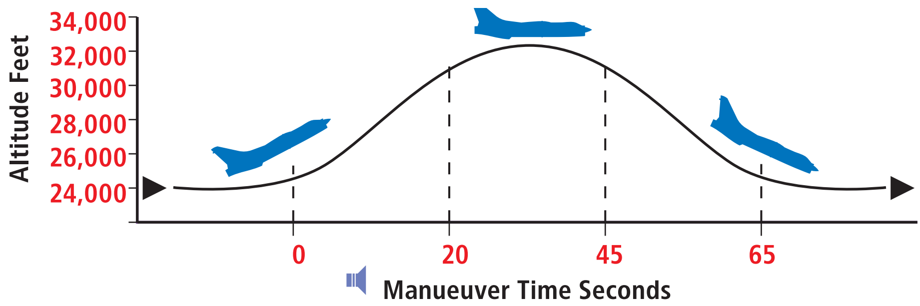
How do you use the toilet? A regular toilet would definitely not work in space because there is no gravity to pull the wastes away. Instead, flushing the toilet on the space shuttle turns on a gentle air suction to guide the wastes into a collection tank.

## Training for Microgravity

Astronaut candidates can find out what microgravity is like before they go into outer space. A modified Boeing KC-135 turbojet is used to achieve reduced gravity for short periods of time. Normal missions last about two hours and consist of flying up and down 40 times, like a roller coaster in the sky. Each time the jet flies down, the candidate experiences about 20 to 25 seconds of weightlessness. It may not surprise you to learn that the aircraft's nickname is "the Vomit Comet!"

## Roller Coaster in the Sky

**This Boeing KC-135 flight trajectory provides about 25 seconds of weightlessness.**




Astronauts also get plenty of practice in the Neutral Buoyancy Lab (NBL). This is a giant water tank about 202 feet long, 102 feet wide, and 40 feet deep. Life-size models of the space shuttle and parts of the International Space Station can fit inside it. Because the conditions under water are somewhat similar to what astronauts will experience in a weightless environment, training in the NBL is very helpful before leaving on an actual space mission.

"Neutral buoyancy" describes an object that neither floats upward nor sinks downward. You experience something like neutral buoyancy when swimming. If you take a deep breath of air and hold it, you tend to float. If you let all of the air out of your lungs, you tend to sink. Neutral buoyancy is exactly in between. The NBL is used to simulate weightlessness during a spaceflight, but it is not quite the same as real weightlessness. First, you are not truly weightless in the NBL. You still feel your weight while in the NBL. Second, water drag slows your motion. This makes some things easier to do in the NBL than in space, and some things more difficult. However, even with these limitations, the NBL is still the best available method for training astronauts to move in microgravity.

Space suits (EMUs) are worn when astronauts take space walks outside the shuttle. EMU stands for "Extravehicular Mobility Unit."

Astronauts who will go on space walks must learn how to work in a space suit, called an Extravehicular Mobility Unit (EMU). Because there is no air in space, you must bring air with you in order to breathe. If you are staying inside the spacecraft, you do not need to wear a space suit because the spacecraft cabin is filled with air. If you go outside on a space walk, however, you must wear a space suit at all times in order to survive in the vacuum of outer space. The space suit is much like a body-shaped balloon filled with air. It provides oxygen to breathe as well as atmospheric pressure over the entire body. Atmospheric pressure is the same as that found on the surface of Earth. The Manned Maneuvering Unit (MMU) is a jetpack that snaps onto the back of the EMU. It is propelled by nitrogen gas and allows an astronaut to leave the space shuttle and travel around in outer space independently.

## Think and Write

1. Explain why astronauts in a space shuttle orbiting Earth experience microgravity.
2. What are some effects of a microgravity environment on the human body?
3. How do astronauts prepare for a spaceflight?
4. **Persuasive Writing** Some people think that NASA's space program is a waste of valuable tax dollars. Write a letter explaining the value of going into outer space.

## Hands-On Activity

Build a device, propelled only by a balloon, that travels along a taut string. Use any of the following materials: a balloon, large and small paper clips, rubber bands, tape, cardboard, straws, craft sticks. Do this activity as a contest. See who can make the balloon rocket travel the farthest. Challenges you should consider include friction between your rocket and the string, the shape and weight of your rocket, and the direction of the balloon.

## School-Home Connection

Share this reader with a family member. Suppose that both of you will leave on the next space shuttle into space. List the personal items that you will bring along (for example, a toothbrush, toothpaste, shampoo, books, and so on). Then decide whether it will be possible to use each listed item in a microgravity environment. Brainstorm alternatives to those items that you determine will not work in the weightlessness of space.

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