SPACE EXPLORATION | LESSON 26

Eyes in Orbit

What an orbit really is, and the space stations, telescopes and satellites that use one.

Grades 4-9 | About 15 minutes of narrated flight, plus discussion stops | 8 stops | Start: learn.allseeing.space/eyes-in-orbit

What students will see and do

Students start with Newton's cannonball idea, then visit the ISS, Tiangong, Hubble, the Moon, the James Webb Space Telescope and missions that watch the Sun, and finish with satellites they use every day.

Learning objectives

- Explain an orbit as continuous free fall around a planet
- Explain why astronauts float even though gravity still pulls on them
- Compare why telescopes are placed in space instead of on the ground
- Identify ways satellites affect daily life

NGSS connections

MS-ESS1-2	Gravity keeps satellites, stations and the Moon in orbit.
MS-PS2-4	Gravitational forces are attractive and depend on mass; free fall explains weightlessness.
MS-ETS1-1	Telescopes like Webb are engineering solutions with specific design criteria (cold, shielded, far from Earth).
DCI PS2.B	Types of Interactions (gravity).

40-minute class plan

1. 5 min: pre-lesson prompt. Before we fly: if you threw a ball as hard as you possibly could, what would happen to it? What if you could throw it faster than any rocket?
2. 18-20 min: run the lesson. Keep discussion stops short (1-2 minutes each) or turn them off in the Lessons menu.
3. 8 min: whole-class discussion using two of the questions below.
4. 5 min: Exit ticket: In one or two sentences, explain why the astronauts on the space station float. Then name one satellite you used today without knowing it.

Full exploration (about 60 minutes)

1. 5 min: pre-lesson prompt, recorded so students can revisit it.
2. 25-30 min: run the lesson with every discussion stop at full length.
3. 15 min: follow-up activity. Swing a ball on a string to model an orbit; discuss what happens if the string breaks.
4. 10 min: revisit the pre-lesson ideas, then the exit ticket.

Before the lesson

Before we fly: if you threw a ball as hard as you possibly could, what would happen to it? What if you could throw it faster than any rocket?

Discussion stops: timing and key points

At The International Space Station (3-4 min): The ISS orbits Earth about every ninety minutes. About how many sunrises do the astronauts see in one day? Show how you worked it out.

- 24 hours divided by about 1.5 hours per orbit is about 16 orbits.
- So the crew sees about 16 sunrises and 16 sunsets each day.

At The Hubble Space Telescope (4-6 min): Hubble needed repairs, and astronauts fixed it in orbit five times. What are the pros and cons of sending people instead of robots?

- People can solve unexpected problems and repair complex hardware.
- Human missions cost more and risk lives; they need air, food and return trips.
- Robots are cheaper and can travel much farther, but are less flexible.

At The James Webb Space Telescope (3-5 min): Webb looks at infrared light, which you feel as heat. Why does a telescope that sees heat need to be kept so cold?

- Infrared light is heat radiation; a warm telescope glows in infrared itself.
- That glow would drown out the faint heat from distant galaxies.
- The sunshield blocks heat from the Sun, Earth and Moon so the mirror stays very cold.

More questions for after the lesson

1. Why are GPS satellites placed much higher than the space station?
2. What would happen to the space station if it slowed down?
3. Name two things Webb can see that Hubble cannot, and explain why.

Vocabulary

orbit, free fall, microgravity, satellite, infrared, Lagrange point, space debris

Exit ticket

Exit ticket: In one or two sentences, explain why the astronauts on the space station float. Then name one satellite you used today without knowing it.

Follow-up activities

- Swing a ball on a string to model an orbit; discuss what happens if the string breaks.
- Design a mission patch for a new space telescope and write what it will look for.
- Track the ISS with a free online tracker and plan when it will pass over your town.

Full transcript

Introduction

Welcome to Eyes in Orbit. Right now, above your heads, people are living and working in space, and telescopes are watching the universe from above the blur of the air. In this lesson we will visit them, and learn the one big idea that keeps all of them up there: the orbit.

Keep this question in mind as we fly. If gravity pulls everything down, why doesn't the space station fall out of the sky?

1. What is an orbit?

Here is Earth from space. Imagine standing on a tall mountain and throwing a ball. It curves down and lands a few feet away. Throw it harder, and it lands farther away. Isaac Newton imagined a cannon on that mountain, firing a cannonball faster and faster.

Here is the clever part. Earth is round, so its surface curves away beneath you. If the cannonball goes fast enough, about seventeen thousand miles per hour close to Earth, the ground curves away just as fast as the ball falls toward it. The ball keeps falling, but it never hits the ground. It falls all the way around the planet. That is an orbit.

So objects in orbit are not floating beyond the reach of gravity. Gravity is pulling on them the whole time. They are falling around Earth, again and again. Thousands of working satellites are doing this right now, along with the space stations we are about to visit.

Satellites at different heights do different jobs. Most stay in low Earth orbit, a few hundred miles up. GPS satellites orbit about twelve thousand miles up. And weather satellites that need to watch the same part of Earth all the time sit about twenty two thousand miles above the equator, where one orbit takes exactly one day.

2. The International Space Station

This is the International Space Station, the largest structure people have ever built in space. It is about as long as an American football field, including the end zones, and weighs around nine hundred thirty thousand pounds. It was built piece by piece in orbit, starting in nineteen ninety eight.

The station flies about two hundred fifty miles above Earth, at roughly seventeen thousand miles per hour. That is fast enough to cross the United States in about ten minutes. It circles the whole planet about every ninety minutes, so the crew sees about sixteen sunrises and sixteen sunsets every day.

People have lived aboard the station continuously since November of the year two thousand. It is a partnership between the space agencies of the United States, Russia, Europe, Japan, and Canada, and astronauts from many countries have visited.

Getting there is a short but wild ride. A rocket reaches orbit in about nine minutes, then the capsule spends a few hours to a couple of days catching up with the station and docking. Crews fly in Russian Soyuz capsules and in SpaceX Crew Dragon capsules, while robotic cargo ships deliver food, water, experiments, and spare parts.

Why do the astronauts float? Up here, gravity is still about ninety percent as strong as on the ground. But the station and everyone inside it are falling around Earth together, at the same speed. Nothing presses them against the floor, so they float. Scientists call this free fall, or microgravity.

Life in free fall is strange. Astronauts strap themselves into sleeping bags so they do not drift. They exercise about two hours a day to keep their muscles and bones strong. And the station recycles about ninety eight percent of its water, including moisture from the air and, yes, urine, cleaned until it is drinkable.

Discussion stop: The ISS orbits Earth about every ninety minutes. About how many sunrises do the astronauts see in one day? Show how you worked it out.

3. Tiangong

This is Tiangong, which means Heavenly Palace. It is China's space station. Its first module, Tianhe, launched in twenty twenty one, and two laboratory modules were added in twenty twenty two. It is smaller than the International Space Station, roughly a quarter of its mass.

Tiangong orbits at a similar height, a few hundred miles up. Crews of three astronauts, called taikonauts, live aboard in rotations of about six months. They run experiments in biology, materials, and physics, many of which can only be done in microgravity.

Having two stations in orbit at once shows how much space has changed. In the nineteen sixties, only two countries could put people in space. Today several nations and private companies can, and more people are traveling to orbit than ever before.

4. The Hubble Space Telescope

This is the Hubble Space Telescope. It was carried into orbit by the Space Shuttle Discovery in nineteen ninety. Hubble orbits about three hundred forty miles above Earth, and its main mirror is seven point nine feet wide.

Why put a telescope in space? The air above you is always moving. It bends starlight back and forth, which is why stars twinkle. Twinkling looks pretty, but it blurs a telescope's view. The atmosphere also blocks some kinds of light, like most ultraviolet. Above the air, Hubble sees the universe sharp and clear.

Hubble had a rough start. After launch, scientists discovered its mirror had been ground to slightly the wrong shape, smaller than the width of a human hair, but enough to blur every image. In nineteen ninety three, astronauts flew up and installed corrective optics, like giving the telescope glasses. Astronauts visited five times in all to repair and upgrade it.

Hubble has changed what we know about the universe. It helped measure the age of the universe at about thirteen point eight billion years. It helped show that the expansion of the universe is speeding up. And its Deep Field images, taken by staring at tiny, empty-looking patches of sky, revealed thousands of distant galaxies.

Hubble has watched history happen. In nineteen ninety four it saw the fragments of a comet slam into Jupiter, leaving dark scars bigger than Earth. In nineteen ninety five it photographed the towering Pillars of Creation in the Eagle Nebula. It has even helped discover small moons orbiting Pluto. After more than thirty years, it is still working.

Discussion stop: Hubble needed repairs, and astronauts fixed it in orbit five times. What are the pros and cons of sending people instead of robots?

5. The Moon, our first destination

Now we leave low Earth orbit behind. This is the Moon, about two hundred thirty nine thousand miles away, roughly a thousand times farther than the space station. Getting here takes about three days.

Between nineteen sixty nine and nineteen seventy two, NASA's Apollo program landed twelve astronauts here. They collected about eight hundred forty pounds of Moon rock. Those samples helped show that the Moon probably formed from the debris of a giant collision with the young Earth.

Today, NASA's Artemis program aims to return astronauts to the Moon for the first time since nineteen seventy two, and to build toward a long-term presence there. Other countries, including China and India, have landed robotic spacecraft on the Moon in recent years. The Moon is becoming a busy place again.

Why go back? Near the Moon's south pole there are craters so deep that sunlight never reaches their floors. Spacecraft have found signs of water ice hidden there. Ice could give future explorers drinking water, oxygen to breathe, and even rocket fuel, made by splitting water into hydrogen and oxygen.

Living on the Moon will be hard. There is no air, the temperature swings by hundreds of degrees between day and night, and there is no magnetic field to block radiation from the Sun. Moon dust is a problem too. It is sharp like tiny pieces of glass, and it clings to everything.

6. The James Webb Space Telescope

Now we travel much farther, about nine hundred thirty thousand miles from Earth, four times farther than the Moon. This is the James Webb Space Telescope, the most powerful space telescope ever built. It launched on December twenty fifth, twenty twenty one.

Webb's golden mirror is twenty one feet across, made of eighteen hexagonal segments of beryllium coated in a thin layer of gold. It was too big to fit in a rocket, so it launched folded up like origami and unfolded itself in space. Under it is a sunshield about the size of a tennis court, made of five layers as thin as a human hair.

Webb sees infrared light, which is the kind of light your skin feels as heat. Infrared can pass through clouds of dust that hide newborn stars. It also lets Webb see the oldest galaxies, whose light has been stretched into infrared by the expansion of the universe during its long journey.

Webb is already making discoveries. It has found galaxies that formed only a few hundred million years after the Big Bang. It has also studied the air of planets orbiting other stars, detecting gases like carbon dioxide and water vapor, as light from the star passes through each planet's atmosphere.

Because Webb is looking for faint heat, it must be very cold itself, below minus three hundred thirty degrees Fahrenheit. That is why it sits near a spot called the second Lagrange point, where it can keep the Sun, Earth, and Moon all behind its shield at once.

Discussion stop: Webb looks at infrared light, which you feel as heat. Why does a telescope that sees heat need to be kept so cold?

7. Watching the Sun

Some of humanity's eyes in space are pointed at the Sun. The Sun is not perfectly calm. It throws out bursts of energy called solar flares, and huge clouds of charged gas called coronal mass ejections. When those reach Earth, they can create beautiful auroras, but they can also damage satellites and power grids.

To give warning, spacecraft watch the Sun all the time. The SOHO observatory has been studying the Sun since nineteen ninety five from a point about nine hundred thirty thousand miles toward the Sun, where it can stare at it without ever being blocked by Earth.

NASA's Parker Solar Probe goes much closer. It dives through the Sun's outer atmosphere, the corona. In December twenty twenty four it passed only about three point seven million miles from the Sun's surface, moving at nearly four hundred thirty thousand miles per hour, the fastest speed ever reached by anything humans have built.

Parker survives thanks to a heat shield about four point three inches thick. The side facing the Sun gets hotter than two thousand three hundred degrees Fahrenheit, while the instruments behind the shield stay close to room temperature.

8. Satellites in your daily life

Let us come home. You may never travel to space, but you use space every day. When a phone map finds your location, it is listening to signals from GPS satellites. Those satellites carry atomic clocks so precise that engineers even have to correct for Einstein's theory of relativity, or the positions would drift by miles each day.

Weather satellites watch hurricanes form and track storms. Earth-observing satellites measure ice sheets, forests, sea level, and crops. Communication satellites carry television, internet, and phone calls to places with no cables at all.

There is a problem too. Thousands of old satellites and pieces of broken rockets are also in orbit, all moving faster than bullets. Even a tiny fleck of paint can damage a spacecraft at those speeds. Scientists and engineers are working on ways to track this space junk and clean it up.

Wrap-up

So here is the answer to our question. The space station does not fall out of the sky because it is already falling, around Earth, fast enough to keep missing it. That single idea keeps astronauts, telescopes, and thousands of satellites in place above you.

If you could design a new space telescope or station, what would you want it to discover? Press L to choose another lesson.

Positions are computed live from real orbits. Narration is checked against public scientific sources; full credits at learn.allseeing.space/credits.html. Standards are listed as connections to NGSS, not formal alignments. Report an issue: info@allseeing.space