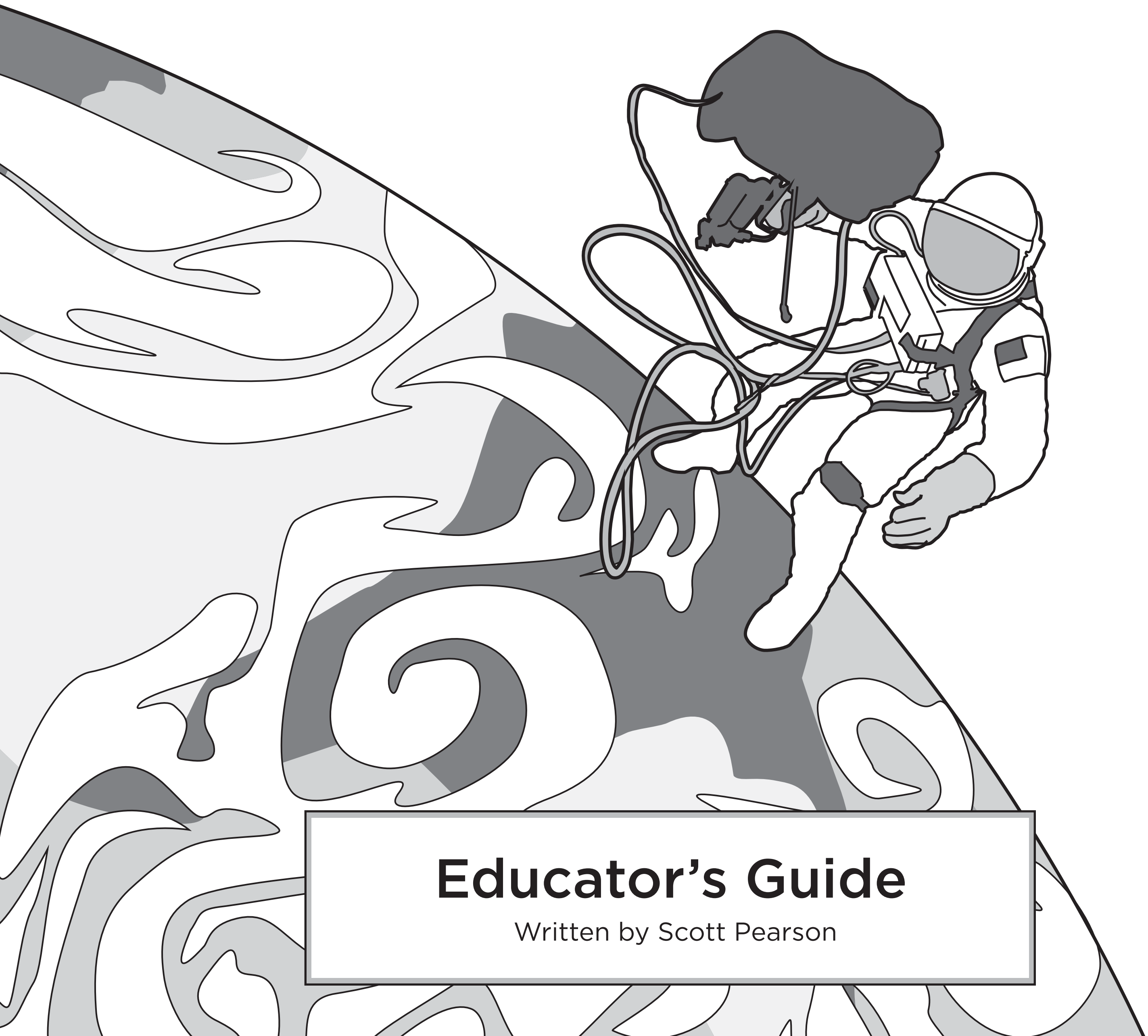
SPACE NEXT



Educator’s Guide

Written by Scott Pearson

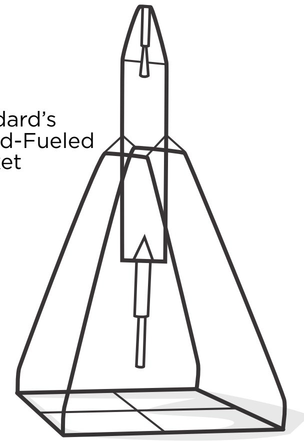
The Path to Space—
A Timeline of Highlights

Circa 1600 BC: Babylonian records indicate an understanding that the morning star and evening star are a single object, what we know as the planet Venus.

AD 800–1300: The Chinese invent gunpowder, fireworks, and rockets.

March 16, 1926: Robert Goddard launches the first liquid-fueled rocket.

Goddard's Liquid-Fueled Rocket

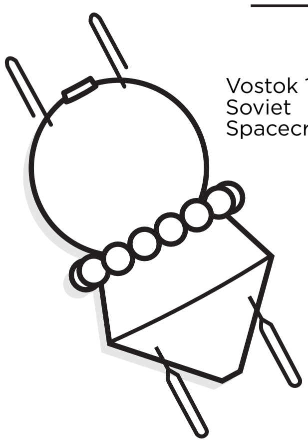


October 24, 1946: A V-2 missile launched from White Sands Missile Range in New Mexico provides first photos of Earth from space.

October 4, 1957: The Soviet Union launches Sputnik 1, the first artificial satellite of Earth. Sputnik broadcasts the first signal from space.

January 31, 1958: The United States launches Explorer 1, its first satellite. Explorer 1 returns data from orbit, confirming the existence of the Van Allen radiation belts.

October 1, 1958: The newly formed NASA, the National Aeronautics and Space Administration, takes over the US space program from the National Advisory Committee for Aeronautics.

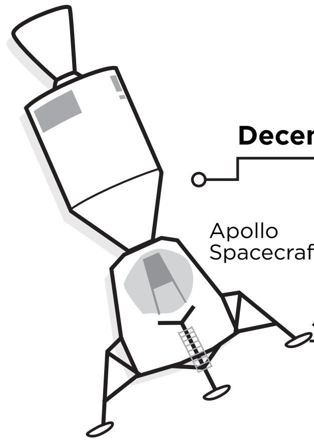


Vostok 1: Soviet Spacecraft

April 12, 1961: Cosmonaut Yuri Gargarin of the Soviet Union becomes the first man in space while orbiting the Earth a single time.

May 5, 1961: Alan Shephard's suborbital flight makes him the first American in space.

February 20, 1962: John Glenn becomes the first American to orbit the Earth, circling three times.

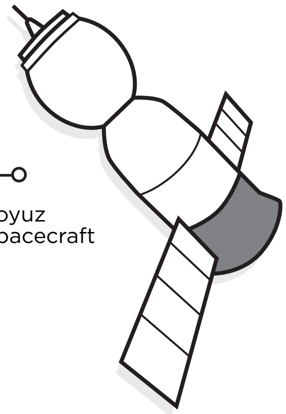


December 21, 1968: Apollo 8 launches on a six-day mission, becoming the first crewed spacecraft to the moon. Astronauts Frank Borman, James Lovell, and William Anders orbit the moon ten times.

July 20, 1969: Neil Armstrong of Apollo 11 is the first man to walk on the moon.

May 14, 1973: NASA launches Skylab, the first US space station.

July 17, 1975: The last Apollo module to travel to space docks with Soyuz 19 in the first US–Soviet joint space mission.

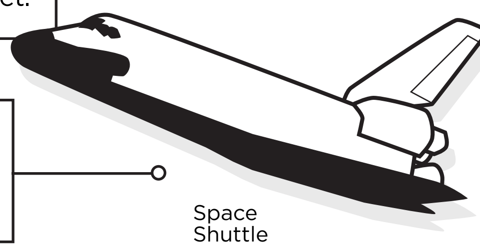


July 20, 1976: The first successful Mars lander, Viking 1, touches down on the red planet.

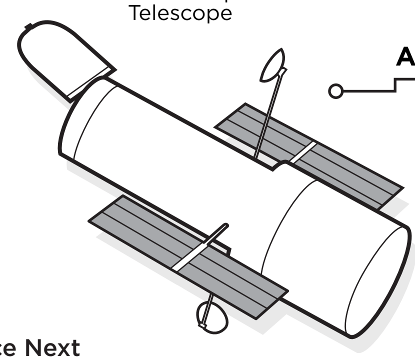
April 12, 1981: The first launch of the Space Shuttle. Columbia orbits for two days before gliding to a landing in California at Edwards Air Force Base.

January 24, 1986: Voyager 2 makes its closest approach to Uranus, the only spacecraft to have visited the seventh planet.

January 28, 1986: Loss of Space Shuttle Challenger seventy-three seconds after launch. A shuttle would not fly again until Discovery launch on September 29, 1988.



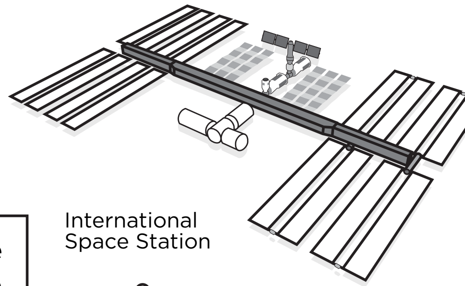
August 25, 1989: Voyager 2 makes its closest approach to Neptune, the only spacecraft to visit the eighth planet.



April 25, 1990: The Hubble Space Telescope is placed in orbit by Space Shuttle Discovery.

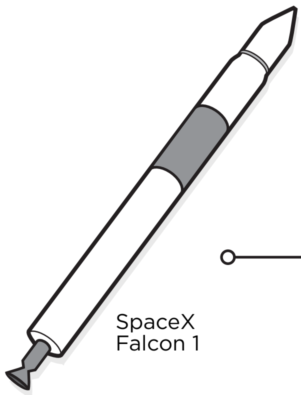
July 4, 1997: Mars Pathfinder lands on Mars with Sojourner, the first successful planetary rover (the Soviets deployed robotic lunar rovers in the 1970s).

November 20, 1998: Russia launches Zarya, the first module of the International Space Station.



April 28, 2001: Multimillionaire Dennis Tito becomes the first space tourist when he launches to the International Space Station aboard Soyuz TM-32.

February 1, 2003: Loss of Space Shuttle Columbia during reentry. The shuttle again grounded until Discovery launch on July 26, 2005.



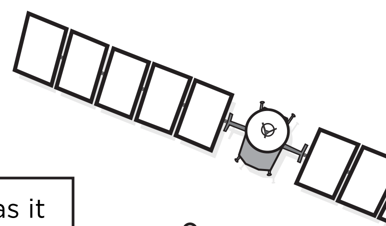
June 21, 2004: SpaceShipOne's first suborbital spaceflight is also the first privately funded crewed flight to space.

September 28, 2008: SpaceX's Falcon 1 becomes first privately funded liquid-fuel rocket to achieve orbit.

July 21, 2011: The Space Shuttle program comes to an end as Space Shuttle Atlantis touches down at the Kennedy Space Center after its final mission.

August 25, 2012: Voyager 1, which launched on September 5, 1977, officially enters interstellar space, the first spacecraft to do so. At the time it was approximately 11.2 billion miles from the sun.

November 12, 2014: The European Space Agency's robotic lander Philae makes the first soft landing on a comet.



March 6, 2015: The space probe Dawn is the first to visit a dwarf planet as it enters orbit of Ceres, the largest object in the asteroid belt.

July 14, 2015: New Horizons makes its closest approach to Pluto.

Activity:
Beating Gravity Going Up

Overcoming gravity during launches is a major challenge for space travel and exploration, as is seen in *Space Next.* As missions get more ambitious, crew modules, space probes, and rovers get larger, requiring bigger rockets to overcome gravity and leave Earth orbit.

In this activity, students experiment with lifting increasingly heavy payloads against the force of gravity using rockets fueled by their own breath . . . balloons.

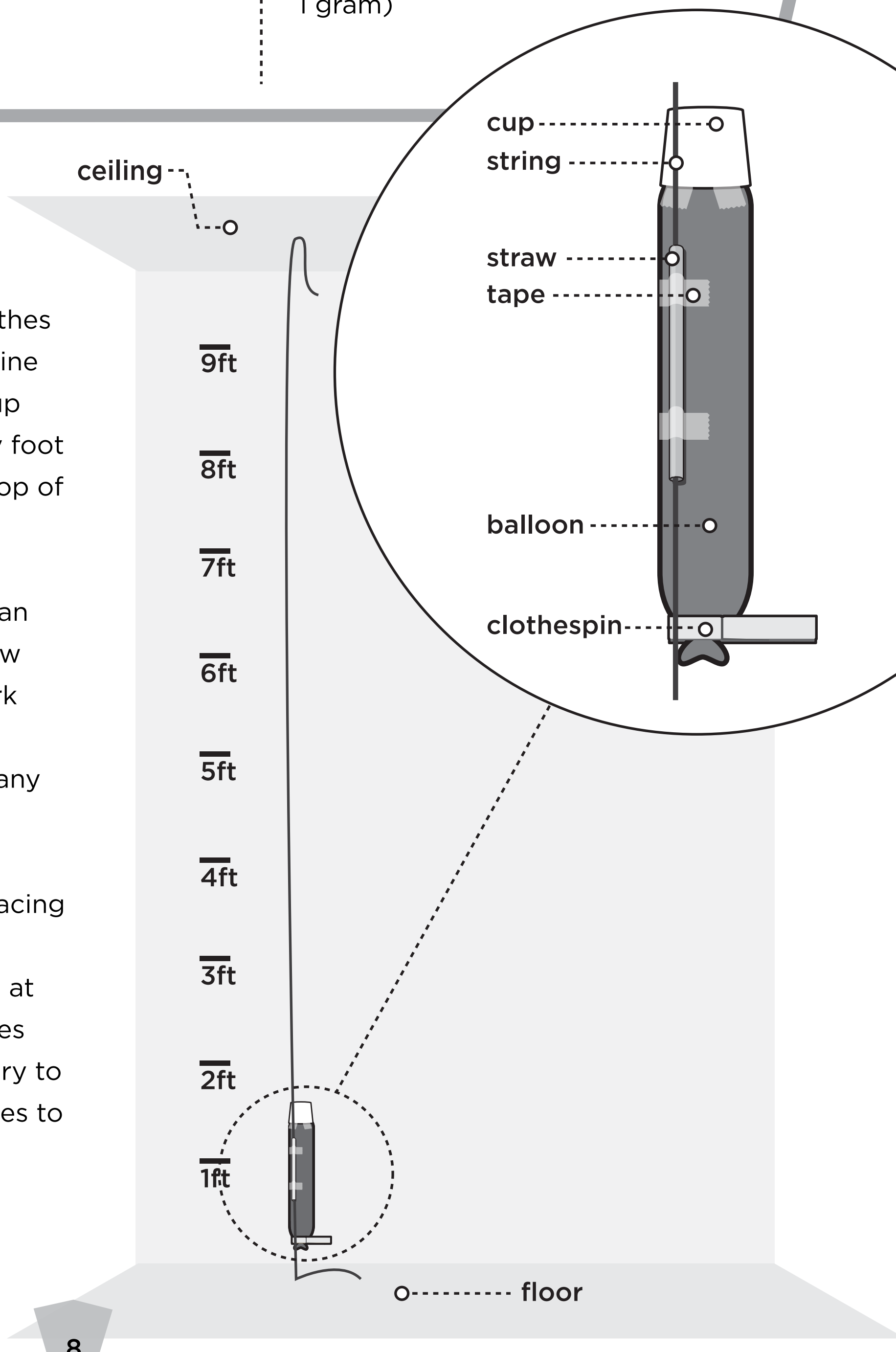
Materials needed:
long balloons, tape, clothes pins, string or fishing line, small paper cups.

Optional: a scale to determine exact weight of payloads (two small paperclips are approximately 1 gram)

Blow up a cylindrical balloon (rockets are tube-shaped, not spherical!) and seal it with a clothes pin. Tape a straw to its side. Run string or fishing line through the straw, and attach the string straight up from the floor to the ceiling. Mark the string every foot from the floor up. Tape a small paper cup to the top of the balloon. This is the payload module.

Release the clothes pin to launch the rocket with an empty payload module. Note how high it flies. Now refuel the rocket and add payload. Paperclips work nicely. Try to guess how many paperclips you can propel all the way to the ceiling, then load that many and see how high the rocket gets.

Experiment with different amounts of payload, placing a cone over the paper cup, and adding booster balloons (although releasing multiple clothes pins at the same time might be tricky). Record all variables and the heights reached. Discuss the results and try to design more effective rockets and payload modules to get maximum paperclips to the ceiling.



Activity: Modeling the Solar System

Space, as Douglas Adams said in *The Hitchhiker's Guide to the Galaxy,* "is big. Really big. You just won't believe how vastly hugely mind-bogglingly big it is."

This activity demonstrates just how big our solar system is, even though it is itself only a tiny speck compared to our galaxy, the Milky Way (not to even mention the rest of the known universe). There are two parts to this activity, on two different scales.

Materials needed:
paper, markers, scissors, drafting compass, tape, ruler

The Planets

This part models the planets in scale to one another. Students will be able to easily compare just how big—or small—Earth is compared to the rest of the planets. (Plus the dwarf planet Pluto!) Use a ruler to mark the scale size on paper, then a compass to draw a circle around that diameter. For tiny Mercury and Pluto it might be easier to draw the circle by hand. Label your planets and cut them out. We're not making the sun; that circle would be nine feet wide!

The Orbits

The second part demonstrates the vast distances encompassed by the orbits of the planets within the solar system based on an Astronomical Unit, which is derived from an approximation of the distance of the Earth from the sun, about 92,955,807 miles. Ten students will need to represent the sun, the planets, and dwarf planet Pluto. Everyone else can be asteroids! Now comes the measuring. This will need to be done outside or on a basketball court inside to have enough room. Hand out the planet and dwarf planet circles. Place the sun first, then measure out the planets. Pluto has an off-center orbit, so its distance from the sun varies wildly. Put Pluto at its closest distance to the sun if you're inside. If outside, put it all the way out to the farthest distance! Everyone else can spread themselves out in a circle as the asteroid belt. Note how close together the inner four planets are compared to the outer planets.

This activity is accessible for all ages, although younger students will probably have more fun playing planets in orbit.

Planet Measurements

Planet	Diameter in Miles	Ratio to Earth	Scale Size in Inches
Mercury	3,032	.383	3/8
Venus	7,543	.952	15/16
Earth	7,926	1.00	1
Mars	4,217	.532	1/2
Jupiter	88,732	11.2	11 1/4
Saturn	74,898	9.45	9 1/2
Uranus	31,763	4.01	4
Neptune	30,775	3.88	3 7/8
Pluto	1,429	.180	3/16

Orbit Measurements

Planet	Distance from Sun in AU	Scale Distance
Mercury	.38	13 1/2 in.
Venus	.72	26 in.
Earth	1.0	3 ft.
Mars	1.5	4 ft. 6 in.
Asteroid Belt	2.7 (average)	8 ft.
Jupiter	5.2	15 ft. 6 in.
Saturn	9.5	28 ft. 6 in.
Uranus	19.2	57 ft. 6 in.
Neptune	30.1	90 ft. 4 in.
Pluto	29.6–48.8 (closest to farthest)	89–146 ft.

Keep in mind that the planets are in scale to each other, and the orbits are in scale to each other, but the planets are not in scale to the orbits. Remember, if we'd made the sun in scale to the planets, it would have been nine feet across, which would swallow up the inner four planets on the orbit scale. If we sized the planets in scale to those orbits, they'd be too tiny to make! Space is big. Really big.

Activity:
Mining Meteorites from Your Lawn

Meteoroids are small solid natural objects moving through space. A meteor is what is often called a shooting star, a meteoroid that has entered the atmosphere and is seen burning across the sky. If a meteoroid survives all the way to the ground, it becomes a **meteorite.**

Materials needed:
strong magnet, plastic wrap or bags, magnifying glass or microscope, internet access

Meteors are much more common than most people realize. Since only the rare large ones captured on video make the news, it's easy to forget that Earth is pelted by smaller ones around the clock. Perhaps as much as 100 tons of meteorites hit the Earth every day, but most are little specks, just space dust settling quietly to the ground . . . perhaps right in your backyard.

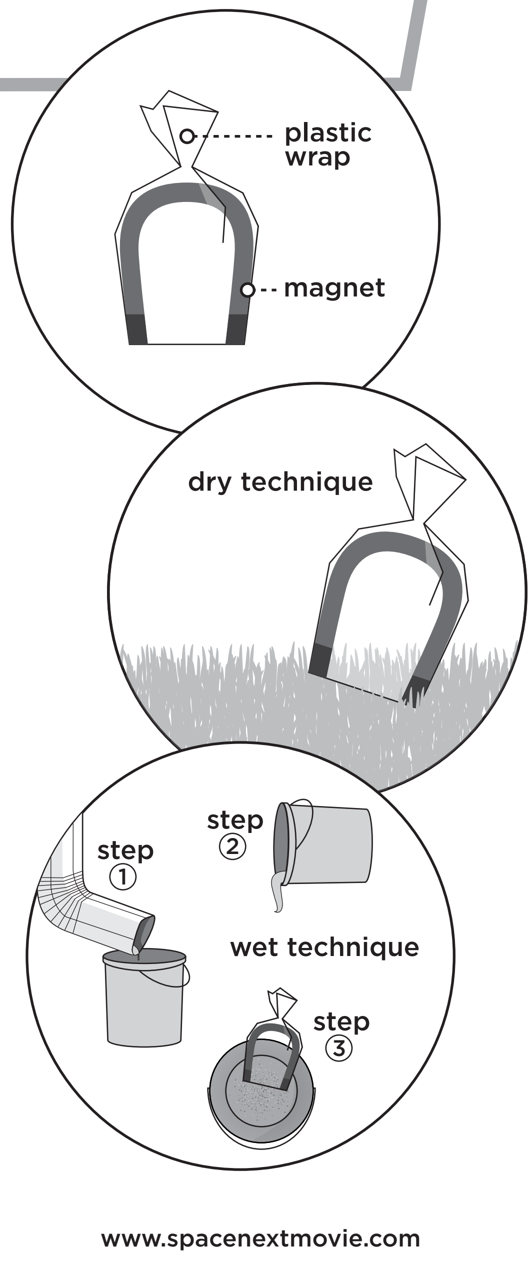
A large percentage of meteorites contain iron, which means they can be picked up with a magnet. This is how you can mine for the micrometeorites that may be right under your feet. There are two techniques you can try: dry or wet.

The dry approach is to simply drag a magnet—a strong magnet, not just something that was holding a grocery list to your fridge—through the grass.

The wet technique involves rain water. Set out a bucket or pan when it's raining, beneath a down spout from your house's gutters if possible. When it's done raining, carefully pour off the clear water, leaving the sediment at the bottom. Let this dry out. If it dries into big clumps, crush it into finer grains. Then it's time to get out your magnet.

For both techniques, put some plastic wrap around the magnet before you use it. Be careful not to rip the plastic while dragging it around. Soon, with some luck, the magnet will have attracted various particles. Slowly pull the plastic off the magnet, trapping the magnetic particles in the plastic. Now you can examine these particles with a magnifying glass or microscope. Some of them might be from outer space!

It's hard to tell the difference between a micrometeorite and other tiny metallic pieces that might originate from the exhaust of engines or factories. If you live in the city or close to a factory, there's a better chance of finding those sorts of pollutants. But if you live in the country, there could be a higher ratio of meteorites to other little bits of metal. Research micrometeorite pictures on the internet, and see if you can find close matches.



Activity:
Beating Gravity Coming Down

Safely landing rovers and landers on the surface of various planets, moons, comets, and asteroids has required a variety of approaches, as shown in *Space Next.*

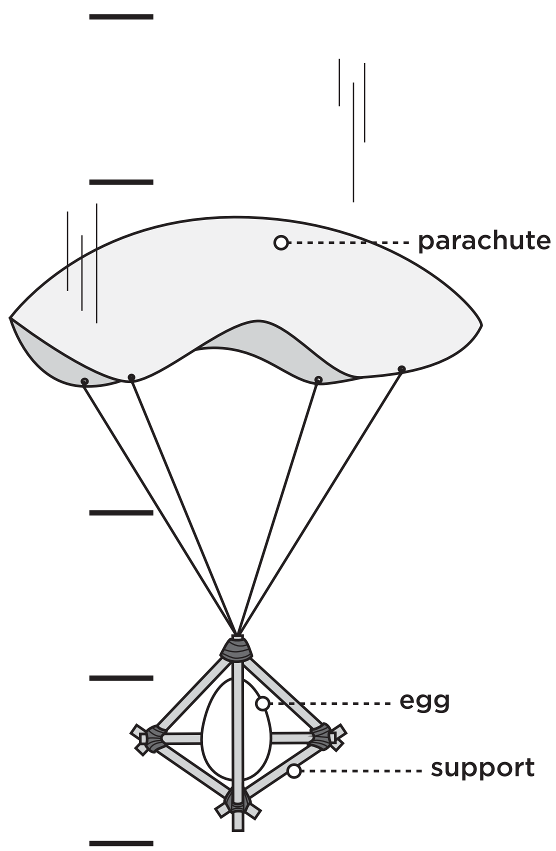
The goal of this activity is the successful touchdown of a lander—represented by a raw egg—by building a protective carrier that will prevent it from cracking when dropped to the floor. The project can be done individually, but a teamwork approach is more like NASA and provides opportunities for cooperative brainstorming.

Materials needed:
eggs, yard stick or measuring tape, various items for padding and building, glue, tape, plastic drop cloth

After designing and building the protective carrier, students will test their design by dropping the lander from increasing heights and noting the results. If the egg breaks, students can adjust their design and try again.

The carrier should be tested from heights of two feet to six feet, increasing by one foot for each test. Students can take notes and photographs to document the series of experiments. Students should try to explain what worked—or didn't work—and why.

This activity can be adjusted for various grade levels. Lower grades can keep simpler records or just give oral descriptions of their experiments. The building of the carriers can also be adjusted to age-appropriate levels. K-3 can be limited to the use of simple padding of various types. Grades 4-6 can build protective frameworks from various materials. Grades 7-9 can experiment with parachutes in addition to the protective structures. Grades 10-12 can use an uneven landing surface for an addition level of difficulty.



Recommended Reading

Ages 6 through 8

Astronauts
Hannah Wilson

Solar System for Kids for Fun and School: Stage 1
Jamie Maslen

Stars and Planets Handbook
Anne Rooney

Ages 9 through 11

Apollo 13
Kathleen Weidner Zoehfeld

Eye on the Universe: The Incredible Hubble Space Telescope
Michael D. Cole

Welcome to Mars: Making a Home on the Red Planet
Buzz Aldrin and Marianne Dyson

Ages 12 through 14

Curiosity's Mission on Mars: Exploring the Red Planet
Kathleen Weidner Zoehfeld

Flying to the Moon: An Astronaut's Story
Michael Collins

What's so Mysterious about Meteorites?
O. Richard Norton and Dorothy Sigler

Ages 15 and Up

Interstellar Age: Inside the Forty-Year Voyager Mission
Jim Bell

New Space Frontiers: Venturing into Earth Orbit and Beyond
Piers Bizony

You Are Here: Around the World in 92 Minutes: Photographs from the International Space Station
Chris Hadfield

Recommended Websites

Astronomy Picture of the Day
http://apod.nasa.gov/apod/astropix.html

Bradford Robotic Telescope
http://www.telescope.org/

Hubblesite (Hubble Space Telescope)
http://hubblesite.org/

International Space Station
https://www.nasa.gov/mission_pages/station/main/l

Kennedy Space Center Visitor Complex
https://www.kennedyspacecenter.com/

Mars Science Laboratory: Curiosity Rover
http://mars.nasa.gov/msl/

The Planetary Society
http://planetary.org/

Glossary

Apollo—NASA program that placed first humans on the Moon

asteroid—a minor planet of the inner solar system, mostly located within the asteroid belt between Mars and Jupiter, ranging in size from 20 yards to 600 miles across

astronaut—originally a spacecraft crew member of a government-trained space program; now often used for any person who travels to space, such as space tourists

cosmonaut—Russian term for astronaut

CubeSat—a cube-shaped miniature satellite just 10 centimeters (about 4 inches) wide

dwarf planet—natural object orbiting the Sun that is larger than an asteroid but smaller than a planet; currently recognized dwarf planets range from about 500 to 1260 miles in diameter, including Pluto

International Space Station (ISS)—active and still expanding space station in low Earth orbit consisting of over a dozen connected modules

lander—a spacecraft designed to land on the surface of an astronomical body such as a planet, moon, or asteroid

launch system—rocket that carries spacecraft to orbit from the surface of the Earth

low Earth orbit—an Earth orbit between altitudes of approximately 100 and 1,200 miles

meteor—a meteoroid that has entered Earth's atmosphere

meteorite—any piece of a meteor (or other natural space object) that survives burning through the atmosphere and lands on the Earth's surface

meteoroid—a small metallic or rocky space object smaller than an asteroid

Mir—low Earth orbit Soviet/Russian space station active from 1986 to 2001

module—individual section of a spacecraft or space station

orbit—the curved path of a spacecraft or natural space object around a planet, star, or moon

orbiter—a spacecraft designed to orbit space objects without landing

payload—contents of a launch system, from passengers to cargo and other equipment

probe—a robotic spacecraft designed to explore space or space objects

rover—an exploratory vehicle designed to travel across the surface of a planet or moon; can be robotic or carry human crew

satellite—natural or artificial object in orbit around a planet, star, or moon

Skylab—low Earth orbit US space station in orbit from 1973 to 1979

Soyuz—Soviet/Russian crewed spacecraft consisting of orbital, reentry, and service modules

spaceplane—a reusable spacecraft designed to take off or land like an airplane

Space Shuttle—NASA spaceplane that flew from 1981 to 2011

space tourist—person who is not part of a traditional government space program and has traveled to space primarily for recreation or private corporate business

suborbital—trajectory of missile or vehicle that reaches space but does not have the velocity to achieve low Earth orbit

SPACE NEXT

A journey of mankind's pursuit to reach the stars. From the beginning of our earliest dreams that sparked the imagination to the machines that took us there, Space Next will present the history that inspired generations and inventions that have changed the world forever. The film will reveal the possibilities of what is to come next and will explore the exciting future of private space developments, national space programs, and the latest innovations. The result is a mesmerizing display of intergalactic excellence sure to inspire the next generation of dreamers and astronomers.

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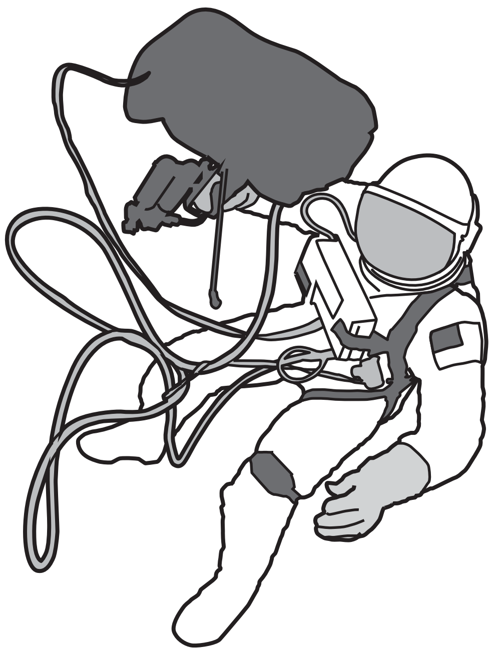

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