Jet Propulsion Laboratory
California Institute of Technology

Education

π IN THE SKY 9

Shine a light on lunar craters, discover what Mars is made of, measure the impacts of water flowing through a dam, and track a planet-hunting telescope as it phones home. See for yourself how pi can take you to infinity and beyond!

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LUNAR LOGIC

NASA's Lunar Flashlight mission will observe and map the location of frost within permanently shadowed craters in the Moon's south polar region. Knowing how much frost is in these craters and where to find it can help us prepare for extended missions on the Moon, when water will be a valuable resource.

The spacecraft, a backpack-size cubesat, will collect data during 10 orbits over a two-month period, making repeated measurements over multiple points to map ice in these dark craters. To take measurements, Lunar Flashlight will send infrared laser pulses to the surface of the Moon and measure the signal that is reflected. The amount of light that is reflected back will help scientists determine where the lunar surface is dry and where it contains water-ice.

At 20 km altitude, the spacecraft's infrared lasers have a radius of 17.5 meters when they reach the surface of the Moon. **How much area do they cover in a single pulse?**

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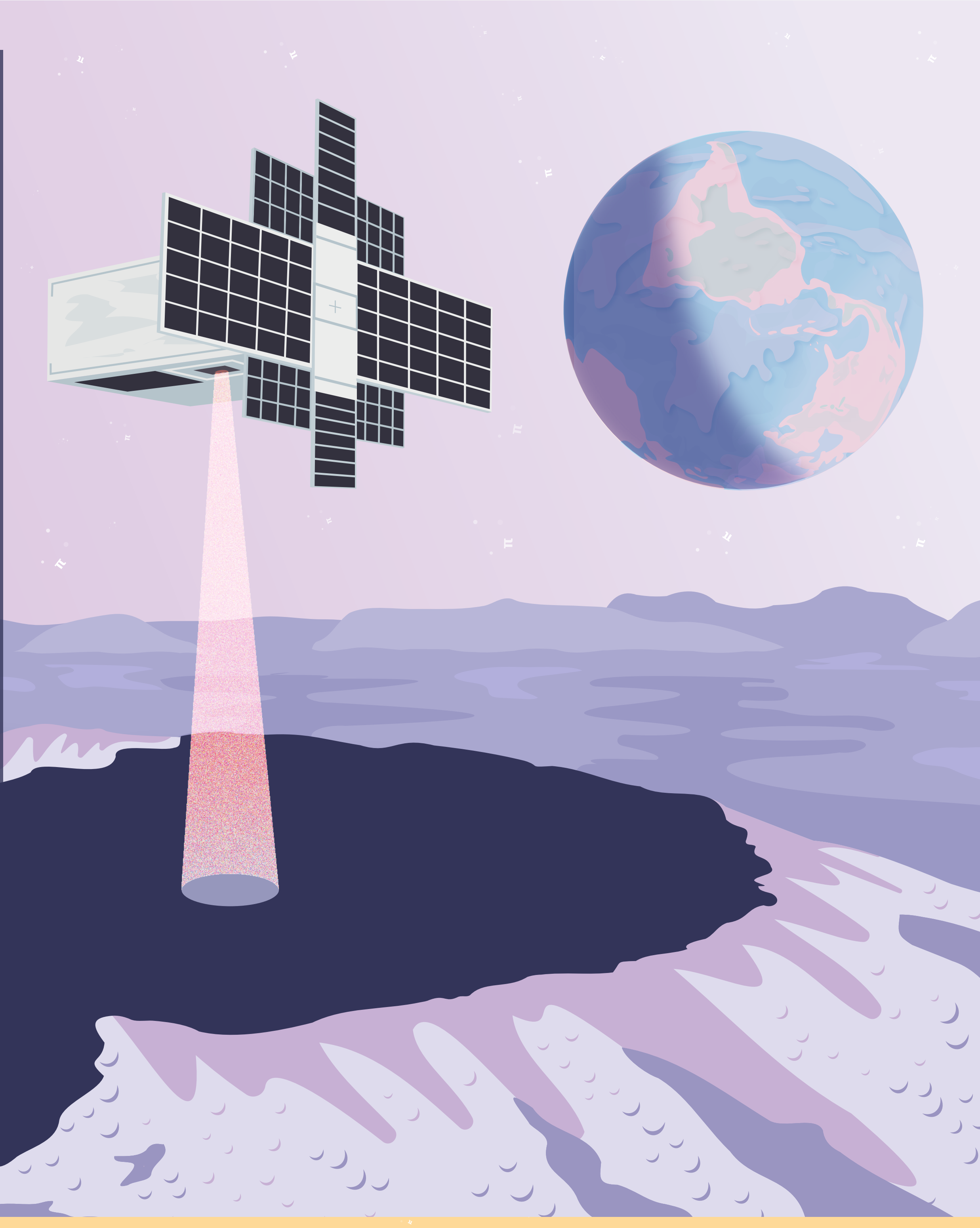
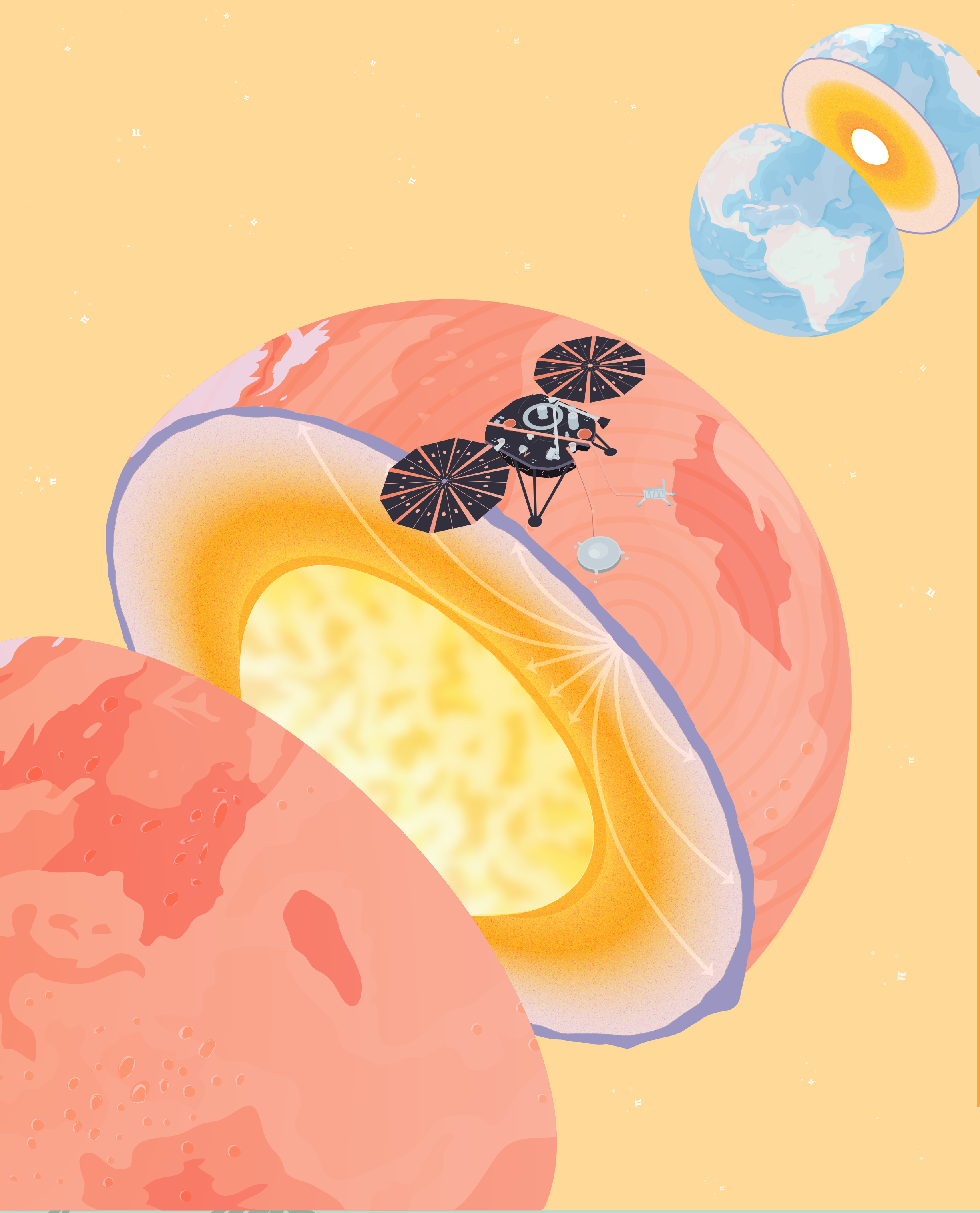
go.nasa.gov/3GpyHYe



CORE CONUNDRUM



The InSight Mars lander is equipped with several tools to help scientists learn more about the interior of the Red Planet, including a seismometer that detects marsquakes. By measuring the vibrations that travel across the surface of Mars and through its interior layers, scientists were able to accurately measure the size of Mars' liquid core and estimate its density. Knowing the size and density of Mars' core will help us learn more about how the planet formed, how its magnetic field developed, and what materials make up the core, which will ultimately lead to a better understanding of how Earth and other planets form.

If Mars' core has a mass of 1.54×10^{23} kg and a radius of 1,830 km, as measured by InSight, **what is the density of the core? How does that compare to the density of Earth's core, which ranges from 10 to 13 g/cm^3? What does that tell us about the makeup of Mars' core?**

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mars.nasa.gov/insight

DAM DEDUCTION

Water exiting a hydropower dam is called non-powered or powered outflow. Non-powered outflow exits via a spillway, on top of the dam. Powered outflow, which is used to generate electricity, travels through penstocks, pipes at the bottom of a dam. Powered outflow is usually colder and travels at a higher velocity, so it can disturb sediments, temperatures, and water quality of downstream rivers, especially when it's a high percentage of the total outflow.

The SWOT mission, a satellite designed to survey all of Earth's surface water, including lakes, rivers, oceans, and reservoirs, can help scientists better analyze these impacts.

A dam has 3 penstocks with diameters of 6.2 meters and a measured total outflow of 1,350 m^3/s. If SWOT measured the reservoir's water depth (H) at 100 m above the penstocks, **compute the velocity (m/s) of the powered outflow using $V = \sqrt{2gH}$. What is the powered outflow if 1 penstock is open? Is this a high or low percentage of the total outflow? What can this tell you about the potential environmental impacts?**

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swot.jpl.nasa.gov

TELESCOPE TANGO

NASA's TESS mission is designed to survey the entire sky in search of exoplanets, or planets orbiting stars other than our Sun. In its two-year primary mission, TESS identified more than 2,600 possible exoplanets and counting.

To locate exoplanets, the space telescope flies in a highly eccentric elliptical orbit, which had never been attempted before. This orbit, called P/2, minimizes the amount of time that light and heat from Earth and the Moon can interfere with data collection. And it still allows the spacecraft to make close passes by Earth to transmit data about its findings back to scientists. The spacecraft's 13.7 day orbit has an axis of 376,000 km at apogee and an axis of 108,400 km at perigee. Each downlink from TESS takes about three hours to complete.

While TESS actually moves at different speeds throughout its orbit – from 0.5 km/s at apogee to 4 km/s at perigee – **if its velocity stayed uniform, how many kilometers would TESS need to travel to successfully transmit its data?**

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exoplanets.nasa.gov/tess