π IN THE SKY⁷

Touchdown on Mars, dig into a distant cold case, dive into a coral conundrum and pinpoint faraway planets. NASA solves these real problems to explore space and Earth and – with pi as your guide – so can you!
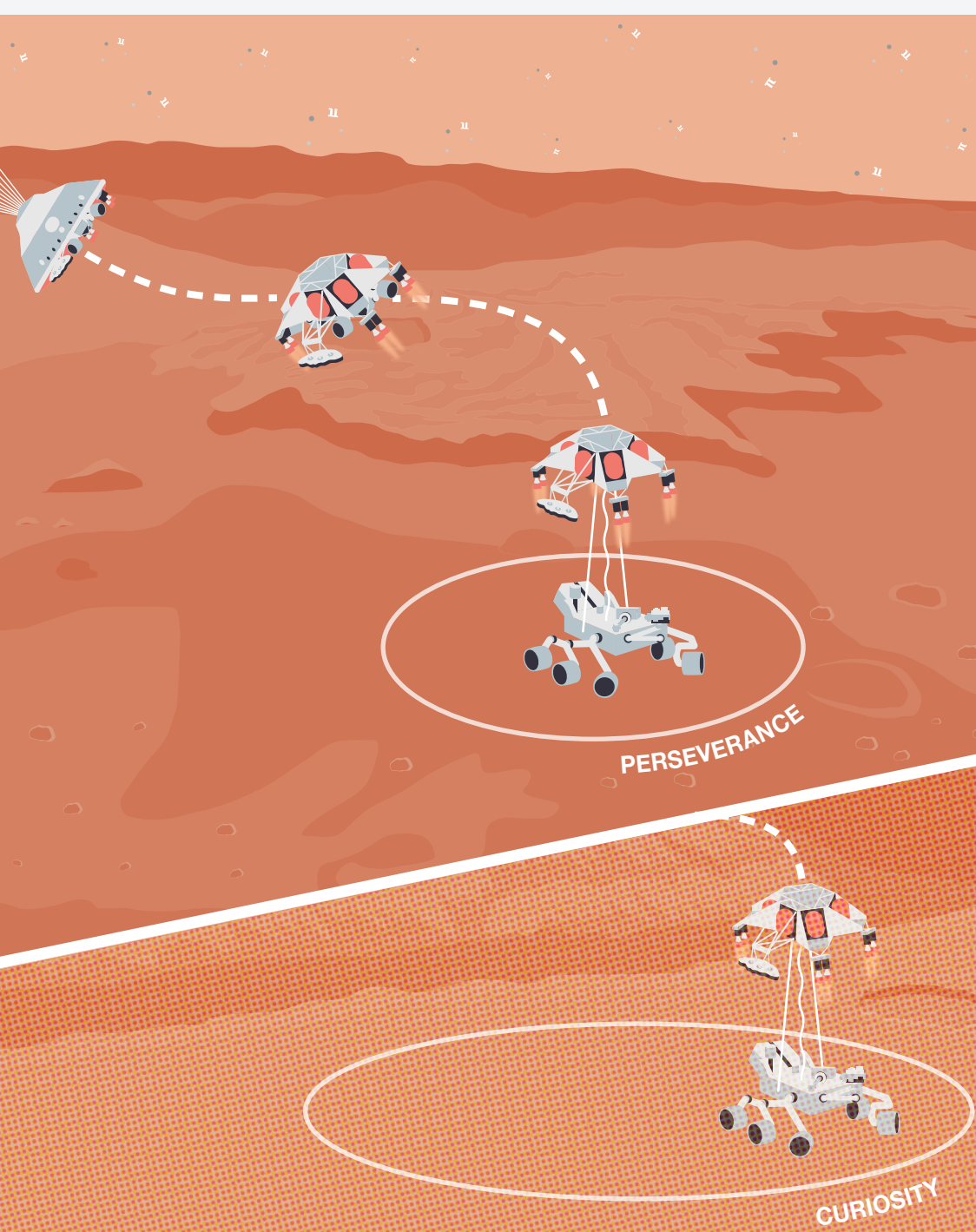
MARS MANEUVER

When we plan where to land a spacecraft on Mars, we don't choose a specific spot, but a larger area called a landing ellipse. It's like choosing a parking lot rather than a parking spot. To choose a landing ellipse, we have to compromise between getting as close as possible to interesting science targets and avoiding hazards. As we've created new technology to help direct spacecraft, landing ellipses have gotten smaller and smaller. That means that we're able to land in places we couldn't before and get closer to the stuff we want to study.

In 2012, the Curiosity rover used its sky crane landing system to touch down in a 20 km by 7 km ellipse. When the Mars rover Perseverance lands on Feb. 18, 2021, it will use the same system along with a new technique called Range Trigger that will allow the spacecraft to land in the smallest ellipse yet, **measuring just 13 km by 7 km. What percentage of Curiosity's landing ellipse is Perseverance's landing ellipse?**

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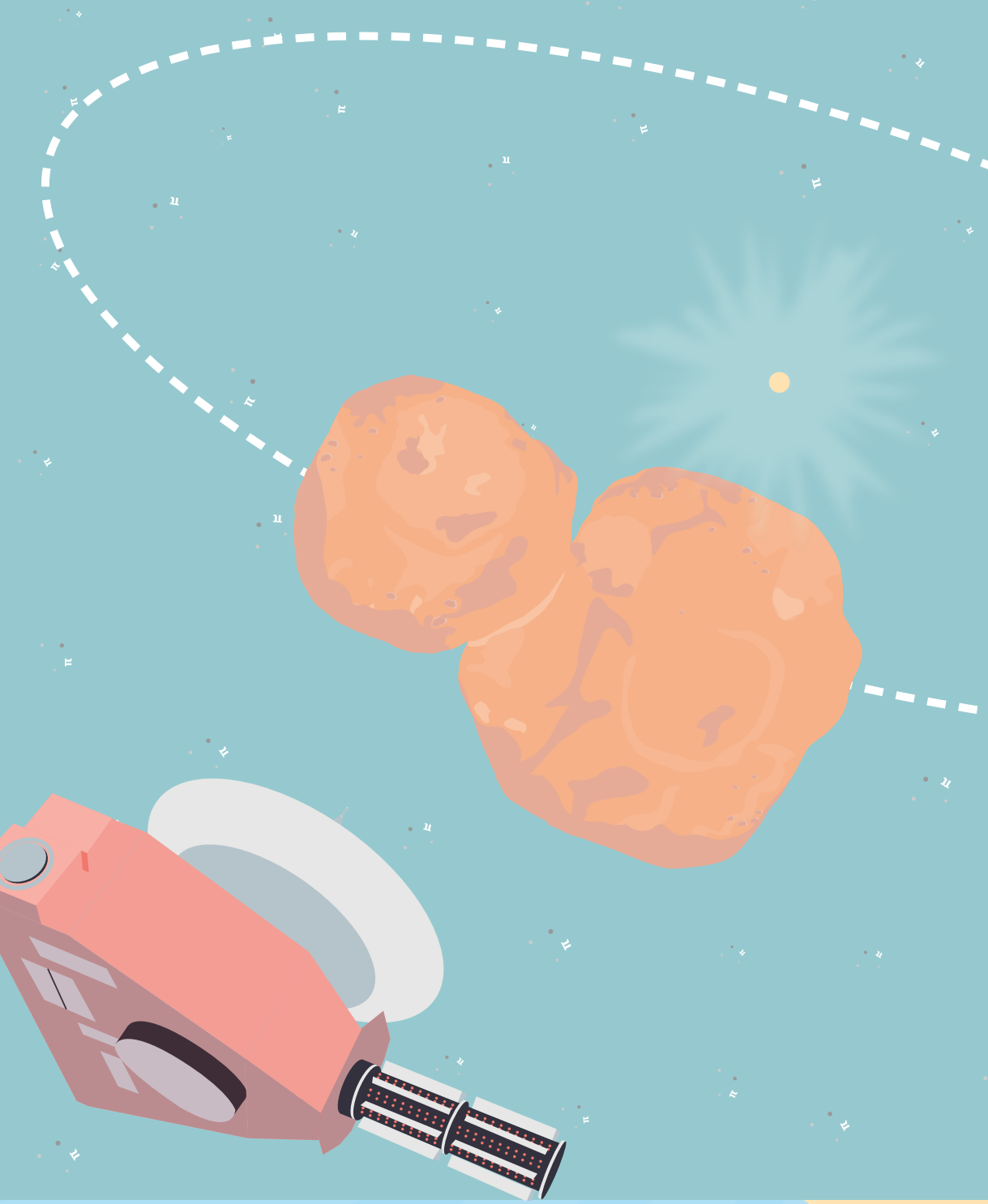mars.nasa.gov/mars2020

PERSEVERANCE

CURIOSITY

COLD CASE

In January 2019, NASA's New Horizons spacecraft flew within 3,538 km of the most distant and primitive object explored up-close by a spacecraft. The object was originally known as 2014 MU69, but it was later renamed Arrokoth. It looks like a partially flattened, reddish snowman and is made up of two objects that merged into one. Found 6.6 billion km from Earth, Arrokoth is a small "Cold Classical" Kuiper Belt object, meaning it orbits the Sun in a nearly circular path and has a low orbital inclination. Cold Classical objects make up about one-third of the Kuiper Belt.

One reason scientists are interested in studying Arrokoth and other Kuiper Belt objects is that they are thought to be well preserved, frozen samples of what the outer solar system was like at its birth, more than 4.5 billion years ago. **Learn a bit more about Arrokoth by calculating how long it takes the object to make one trip around the Sun.**

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CORAL CALCULUS

Flying aboard an aircraft, NASA's CORAL mission uses spectroscopy to study the health of coral reefs and the threats they face. To differentiate coral, algae and sand on the ocean floor, CORAL computes the depth of every point it maps. The depth of the water can be determined using the absorption coefficient, indicating how much light is absorbed through a given depth.
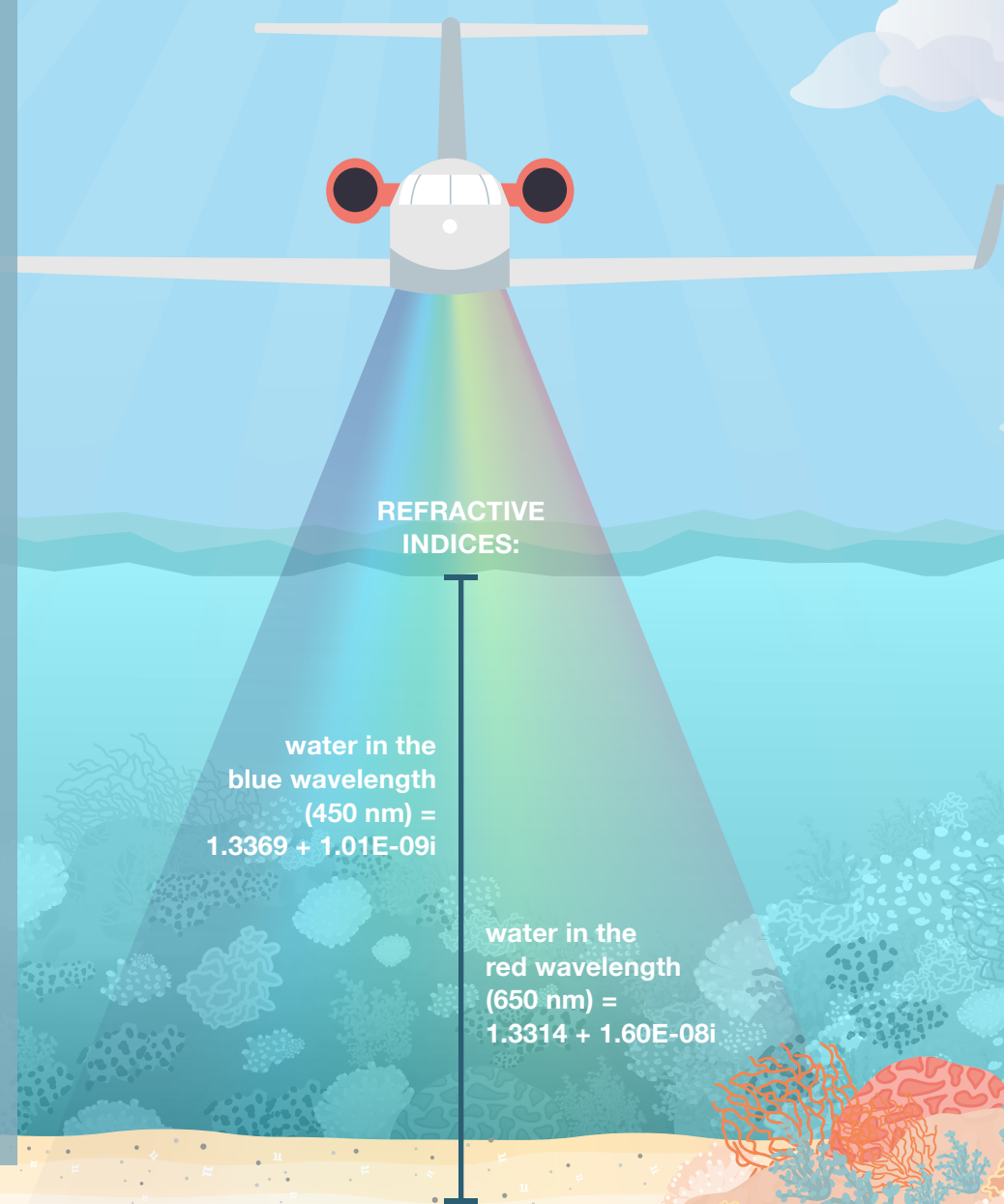
Imagine CORAL collects a light measurement reflected by white sand covered by an unknown depth of water that is 76% in the blue and 4.5% in the red. **Using the formulas below, calculate the water's depth.** Note that sunlight passes through the water twice: when traveling from the Sun to the ocean floor and when reflecting up to the aircraft.

absorption coefficient, $\alpha = (4\pi k)/\lambda$
k = coefficient of the imaginary number portion of the refractive index
λ = wavelength (meters) of light observed

Beer-Lambert law, $T = e^{(-\alpha \cdot d)}$
T = observed reflectance, or transmittance (T), of light through a distance (d) of water

LEARN MORE
go.nasa.gov/coral

REFRACTIVE INDICES:

water in the
blue wavelength
(450 nm) =
1.3369 + 1.01E-09i

water in the
red wavelength
(650 nm) =
1.3314 + 1.60E-08i

PLANET PINPOINTER

Our galaxy contains billions of stars, most of which are likely home to exoplanets – planets outside our solar system. How do scientists decide where to look for these worlds? Researchers looking at data from NASA's Spitzer Space Telescope found that giant exoplanets tend to exist around young stars surrounded by a disk of debris.

A prominent debris disk around the star Beta Pictoris, which is 6×10^{14} km away from Earth, led scientists to discover two exoplanets several times bigger than Jupiter orbiting the star! Learning more about the debris disk could give scientists insight into the formation of these giant worlds. **Given the angle of the disk's apparent size is 169 arcseconds, determine the actual distance across it using the formula for small angle approximation, below. (An arcsecond is 1/3,600 of a degree.)**

small angle approximation, $D = d\theta$
D = distance across the debris disk (km)
d = distance to Beta Pictoris (km)
θ = angle of apparent size (radians)

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