The Universe in my Pocket

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TUIMP No. 27 THE UNIVERSE IN MY POCKET

An experiment to understand the phases of the Moon

Instructions on the reverse side

credit: JPL

Artistic vision of Earth's collision with a newly formed planet called Theia.

Credit: SWRI

The Moon is thought to have formed shortly after the formation of the Earth.

Diagram of the formation of the Moon.

Credit: Wikipedia

Image of the Moon taken on January 21, 2019. The arrow shows the location of an impact flash caused by a meteoroid striking the surface on this date.

Credit: J.M. Madiedo

The origin of the Moon

The Moon is younger than the Earth and its chemical composition resembles the rocks of Mars more than those of Earth. It is thought to have formed when a newly formed planet (called Thea, after the name of the mother of Selene, the greek goddess of the Moon) collided with the Earth. As a result of the collision, material was ejected in all directions; some of it was ejected into space and a fraction of it formed a disk around our planet. The material in the disk coalesced to form the Moon.

The Moon gradually cooled down, but its interior was still molten, and lava flowed to the surface, producing the dark areas.

During its first 600 million years, the Moon was continually bombarded by asteroids and comets which formed craters that are still visible today.

Future stays on the Moon

There is little water on the Moon. At the bottom of craters and crevaces near the poles where no sunlight falls it is frozen. In the future, robots will be used to transport this water to greenhouses, where plants will not only provide fresh food, but also generate oxygen for breathing and fuel.

When the first astronauts went to the Moon, their space suits were covered with very fine, scratchy dust, and it was difficult to clean them. Astronauts used brushes which dispersed some of the dust, causing them respiratory and eye problems. Future explorers will carry dust vacuum cleaners for their suits.

Moon dust will be used to grow crops in lunar greenhouses and to manufacture equipment with 3D printers.

Lunar base prototype (ESA)

Transporting everything needed to sustain long-term missions to the Moon would be very expensive. A better approach would be to make what is needed using lunar materials.

The shell, built from lunar soil by robots using a 3D printer, would protect astronauts from meteorids, gamma radiation and temperature variations.

To produce food for astronauts, different research groups are testing ways to grow food using lunar soil mixed with bacteria and fertilizers.

(Open Agriculture, 2019)

The color of the Moon

The Moon shines because it reflects the light of the Sun. It has grey areas that are hardened lava flows. The Moon rocks brought back by the astronauts resemble lava from volcanoes. The lighter areas of the Moon are the highest in elevation; they are rich in calcium and aluminum, and reflect the most sunlight.

When the Moon is close to the horizon it appears orange - and even more so during lunar eclipses. This is because the dust in our atmosphere disperses the blue and green light from the Sun and only lets through the yellow, orange and red light. During eclipses, the Moon passes through the Earth's shadow. The sunlight first travels through Earth's atmosphere on its way to the Moon, and then the reflected light goes through the atmosphere a second time before finally reaching us on the Earth.

The gray areas of the Moon are hardened lava flows. The lighter areas are the higher elevations, rich in calcium and aluminum.

The dark rocks on the Moon resemble terrestrial volcanic rocks.

Credit: NASA

The dust suspended in the atmosphere disperses blue and green light and only lets through orange and red light. The Moon looks slightly orange when it is close to the horizon because the thickness of the Earth's atmosphere through which the reflected sunlight must pass is greater than when it is at a higher elevation.

Credit: NASA

During lunar eclipses, the Moon takes on a dark orange color.

Credit: NASA

The size of the Moon

You have probably noticed that the Moon looks bigger when it is close to the horizon than when it is high in the sky. This effect is called "the Moon illusion" and has been known since ancient times.

The way we perceive the size of an object depends on its immediate visual environment. When the Moon is near the horizon, nearby objects are seen in fine detail, which makes the Moon appear larger; while the Moon at the zenith is surrounded by large expanses of empty sky that make it appear smaller.

The ancient Greeks first estimated the radius of the Moon about 2200 years ago (see TUIMP 15). Current measurements give 1737 km, which is about a quarter of the Earth's radius.

Astronaut Eugene Cernan jumping on the moon (NASA, 1972).

More than 2 million craters with diameters greater than 1 km have been identified on the Moon's surface. The image shows a view of the Moon's south pole. (NASA/JPL/USGS)

Gravity of the Moon

If you have seen photos or videos of astronauts walking on the Moon, you have probably noticed that they do not "walk" but rather "jump". This is because the gravitational pull of the Moon is much smaller than Earth's.

A child weighing 60 pounds on Earth would weigh 10 pounds on the Moon, because the force of gravity acting on him would be 6 times less intense than on the Earth!

Because the Moon has such a weak gravity, it cannot retain any gas molecules. That is why the Moon has no atmosphere.

Asteroids and meteoroids that strike the Moon create craters. Since there is no atmosphere, there are no winds to blow the dust away, nor is there liquid water to destroy the craters as happens on Earth.

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This booklet was written in 2022 by Julieta Fierro of the Institute of Astronomy, UNAM, Mexico and Grażyna Stasińska of the Paris Observatory and revised by Stan Kurtz from the UNAM Radio Astronomy Institute in Morelia (Mexico).

Cover image: The Moon on a starry sky background reflected in the sea. Elements of this image were provided by NASA. Credit: Vovan (Ukraine)

To learn more about this collection and the topics presented in this booklet visit http://www.tuimp.org

Translation: Stan Kurtz
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The phases of the Moon

Have you noticed that the Moon changes appearance throughout the month? Sometimes it looks round like a ball and other times more as a smile.

All planets and satellites in the Solar System have their night side and their day side.

From Earth we can see the succession of the Moon's days and nights, as well as its twilight line. When the Moon's shape looks round, it is because the Sun is facing it. On the other hand, when we see only half of it illuminated, it is because the Sun is shining on it from the side.

From Earth we always see the same face of the Moon because the Moon's rotation about itself and its translation around the Earth are synchronized. The far side of the Moon was photographed for the first time in 1959 by a Soviet probe.

"Playing with the celestial ball". A photo by Laurent Laveder showing the Moon when it is near the horizon.

When we see the Moon above narrow streets or roads it also looks bigger. It is an optical illusion.

In the figure above the orange circles have the same diameter. On the right, the images of the Moon have the same diameter.

Objects appear to have different sizes depending on the sizes of nearby objects.

Views of the Moon's phases.

You can do a home experiment to understand the phases of the Moon (see pages 15 and 16).

The crescent Moon has a different tilt depending on whether you are closer to the pole (North or South) or to the Earth's equator.

Closer to the North pole (latitude +51°): Crescent moon on the Isle of Wight (United Kingdom)
Credit: Ainsley Barnett

Closer to the equator (latitude -23°) Crescent moon in the city of São Paulo (Brazil)
Credit: Ricardo Motti

Put a lamp in a dark room. Take a ping-pong ball, poke a hole in it with a pencil and hold the pencil vertically with the ball on top.

The lamp is the Sun, the ball is the Moon and you are the Earth.

Face the light and hold the ball in front of you, raising it high enough so that you can see the lamp as well. The lamp illuminates the far side of the Moon. This phase is called the new moon. From Earth, the new moon is not visible.

Turn to the left so that your moon and body are now perpendicular to their original position. The right half of the ball is now illuminated. This phase is called the first quarter.

Make another quarter turn to the left. Now your moon is directly opposite the Sun, as seen from Earth. The half as seen from Earth is fully illuminated. This is the full moon.

Make a quarter turn to the left again. The side opposite the first quarter moon is now illuminated. This is the waning quarter.